JEH RHE
Journal of Energy History
Revue d'Histoire de l'Énergie

#2

Light(s) and darkness(es)

Special issue

Dossier

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Lumière(s) et obscurité(s)

NUMBER 2 - JUNE 2019

JEH RHE

Journal of Energy History
Revue d'histoire de l'énergie

SUMMARY

SPECIAL ISSUE

LIGHT(S) AND DARKNESS(ES): SHIFTING HISTORICAL RELATIONS

OUT OF THE BOX

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ISSN 2649-3055

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ENERGY SOURCES

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ISSN 2649-3055

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Journal of Energy History
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Light(s) and darkness(es): Shifting historical relations

Coordinated by

Stéphanie Le Gallic
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ISSN 2649-3055

JEHRHE

Journal of Energy History
Revue d'histoire de l'énergie

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POST DATE
01/07/2019
ISSUE NUMBER
JEHRHE #2
SECTION
Special issue
THEME OF THE SPECIAL ISSUE
Light(s) and darkness(es): Shifting historical relations
KEYWORDS
Gas, Light, Pollution, Electricity
DOI
in progress

TO CITE THIS ARTICLE
Stéphanie Le Gallic, Sara B. Pritchard, "Light(s) and darkness(es): Looking back, looking forward", *Journal of Energy History/Revue d'Histoire de l'Énergie* [Online], n°2, published 01 July 2019, consulted XXX, URL: energyhistory.eu/en/node/137.

Light(s) and Darkness(es): Looking Back, Looking Forward

Abstract
In this special issue, we argue that light(s) and darkness(es) should be understood in their multiplicity, and that they constitute two aspects of the same phenomenon. They should, therefore, be studied in relation to each other. The complex dynamics of light and dark are more integral to the history of art than other fields, thus offering models for a relational approach to empirical studies beyond this discipline. Drawing on this work, this special issue aims to challenge reductionist frameworks that focus on light alone, without reference to darkness. It explores some of the nuances of light/darkness created by candle, kerosene, oil, gas, and electricity, teasing out the diverse, sometimes contradictory meanings and experiences of light(s) and darkness(es) in the past. It thus aims to study the juxtaposition of light and dark, placing this seeming contrast in dialogue with broader conversations in the history of energy, environmental history, the history of science and technology, as well as the history of representations.

Acknowledgments
We would like to thank the authors, the members of the journal's editorial board (especially Alain Beltran, Léonard Laborie, and Céline Berrier-Lucas), and the anonymous reviewers for their support of this special issue.

Plan of the article

ISSN 2649-3055

INTRODUCTION

1 Today more than ever, light is the subject of considerable contemporary debate. On the one hand, access to artificial light is increasingly assumed to be a human right. For many, its absence or irregularity—often called "lighting poverty"—is no longer acceptable. For instance, protests in May 2003 in Dhaka, Bangladesh demanded water, gas, and electricity,[1] while more recently, a major blackout struck Venezuela in March 2019, depriving its inhabitants of light, water, and transportation, and subsequently crippling much of the country. On the other hand, some have begun to denounce excess light in urbanized and industrialized territories, or argue for limiting light to conserve energy. Poorly designed or superfluous light is now suspected of not just wasting energy and contributing to global warming, but also of "polluting"[2] the night and disrupting the biological rhythms of both humans and non-humans. The growing popularity of "Earth Hour" reflects such new critiques of artificial light. Founded in Sydney, Australia in 2007 to raise awareness about climate change, this grassroots movement encourages people to turn off their lights between 8:30 and 9:30 p.m. on the last Saturday of March. By reducing artificial light and restoring night closer to celestially-lit conditions—even for just a brief period—this initiative reminds us that light and darkness have complex relations, evolve over time and with cultural assumptions, and are closely connected to the history of energy.

2 Light(s) and darkness(es) are also expanding areas of scholarship in the humanities and social sciences, with important new work on the history of night. Pioneering research includes that of Anne Cauquelin,[3] Wolfgang Schivelbusch,[4] and A. Roger Ekirch,[5] all of whom have made significant contributions by exploring nocturnal cultures in Western Europe and North America since the 18th C., and by demonstrating how the night—formerly a time generally associated with rest—was gradually appropriated. European researchers[6] have also examined night before the spread of public lighting, in an effort to show that the boundaries between day and night were not clear-cut, and that the division of nocturnal activities and roles was similarly complex and sometimes ambiguous.[7]

3 In this special issue, we build on and extend this avenue of research by arguing that light(s) and darkness(es) should be understood in their multiplicity, and that they constitute two aspects of the same phenomenon. They should, therefore, be studied in relation to each other. The complex dynamics of light and dark are more integral to the history of art than other fields, thus offering models for a relational approach to empirical studies beyond this discipline. Drawing on this work, this special issue of *JEHRHE* aims to challenge reductionist frameworks that focus on light alone, without

1 Fondation EDF (ed.), *Mondes électriques* (Issy-les-Moulineaux: Beaux Arts-TTM éditions, 2012), 59.

2 Not surprisingly, there is debate over terminology here. One can consider the differences between "nuisance" and "pollution" both historically and politically. On the framing of the problem, see Samuel Challéat, Dany Lapostolle, and Rémi Bénos, "Consider the Darkness: From an Environmental and Sociotechnical Controversy to Innovation in Urban Lighting," *Articulo–Journal of Urban Research*, vol. 11, 2015 (online since 24 November 2016). Url: http://articulo.revues.org/3064 (accessed 15/11/2018); and more generally the work of the RENOIR Collectif de recherche. See also Sara B. Pritchard, Erin McLaughlin, and Michelle Shin, "Describing Artificial Light at Night: Keywords in Light Pollution Literature and Why They Matter," *Lighting Research & Technology*, under review.

3 Anne Cauquelin, *La Ville la nuit* (Paris: Presses universitaires de France, 1977).

4 Wolfgang Schivelbusch, *Disenchanted Night: The Industrialization of Light in the Nineteenth Century, trans. Angela Davies* (Berkeley: University of California Press, 1988); Wolfgang Schivelbusch, *La Nuit désenchantée* (Paris: Gallimard, 1993).

5 A. Roger Ekirch, *At Day's Close: Night in Times Past* (New York: Norton, 2005).

6 Elisabeth Crouzet-Pavan, "Recherches sur la nuit vénitienne à la fin du Moyen Âge," *Journal of Medieval History*, n° 7, 1981, 339-356; Mario Sbriccoli (dir.), *La Notte. Ordine, sicurezza e disciplinamento in età moderna* (Florence: Ponte alle Grazie, 1991); Jean Verdon, *Night in the Middle Ages* (Notre Dame: University of Notre Dame Press, 2002).

7 Ezequiel Borgognoni, "El dinamismo en la vida nocturna en el munda urbano castellano a fines de la edad media," *Miscelànea Medieval Murciena*, vol. 36, 2013, 9-26. For earlier time periods, see also Mario Dowd and Robert Hensey, *The Archeology of Darkness* (Oxford: Oxbow Books, 2016).

reference to darkness. It explores some of the nuances of light/darkness created by candle, kerosene, oil, gas, and electricity, teasing out the diverse, sometimes contradictory meanings and experiences of light(s) and darkness(es) in the past. It thus aims to study the juxtaposition of light and dark, placing this seeming contrast in dialogue with broader conversations in the history of energy, environmental history, the history of science and technology, as well as the history of representations.

4 In our initial call for papers, we posed four main questions:

5 - How are light and darkness in tension with one another, juxtaposed, and/or concomitant? Are the borders between light and dark stark, or are there examples in which these distinctions blur and fall apart?

6 - How did various factors—political, economic, cultural, environmental, technological, etc.—shape the understandings and experiences of light/dark in diverse contexts (urban/rural, metropole/colony, etc.) and for different social groups (class, race, gender, sexuality, etc.)?

7 - How, why, and when did (some) people and societies shift from fearing darkness to valuing it?

8 - How can the examination of light(s) and darkness(es) inspire and provide new insights with respect to the history of energy, and vice versa? In other words, how can the history of energy enrich our understanding of the complex relationships of light and dark in diverse contexts? And how does the exploration of light(s)/darkness(es) raise new questions for the history of energy?

9 As these broad, thematic, and analytical questions suggest, we decided not to restrict this special issue to a particular time period or geography in order to acknowledge and appreciate diverse experiences, avoid naturalizing one norm, and facilitate comparisons across time, place, and culture. Our call for papers was largely successful, given that we received proposals evoking the relations between light(s) and darkness(es) from Antiquity to the present from three continents: Europe, North America, and Asia. Although we had hoped for more proposals from more parts of the globe, the Western world still remains overrepresented. We also felt that it was important for our call to be open to all scales of analysis: building, street, city, nation, and planet—all of which can teach us about the links and interactions between light(s) and darkness(es). For instance, in this special issue, Bastien Rueff reconstructs the interior and exterior lighting environments of edifices from Bronze Age Crete, while Benjamin Bothereau explores the streets of late 18th-C. Paris and Barcelona within a revolutionary context. Trish Kahle tackles industrial democracy, urban blackouts, and the U.S. energy crisis during the second half of the 20th C.

10 In addition, these articles invite us to move beyond the simple sensorial (and specifically visual) dimension of the light/darkness pair to consider their linguistic, symbolic, and even psychological dimensions. For example, beyond literal light, the term “bright” can refer to a rational and comprehensible person, whose remarks are “clear” or “illuminating”; conversely, the term obscure (from the Latin *obscurus*, dark) can refer to statements that are unintelligible. In fact, in French, the expression “obscure person” is a synonym for “unknown person.” Some of these meanings are connected with Latin etymological roots and remain more or less explicit by language. The word “clear” (from the Latin *clārus*, meaning bright, clear, apparent, or evident) in French is closer to its original Latin roots than it is in English. On the symbolic level, *lumière* or light (and by extension *Les Lumières*, the French term for the Enlightenment) has referred to the progress (or supposed progress) made by a certain form of civilization. According to this reading, it brought an end to the “obscurantism” of the *Ancien Régime*, and served as a key element during revolutionary periods. Historically, this idea has been applied to other contexts, especially colonialism, empire, and colonized peoples. This issue is explored by Ute Hasenöhrl, who focuses on the unequal spread of lighting in Bombay (British India), the British Empire’s second largest city.

11 These assumptions have also been present in modern architecture, which for hygienist reasons favored light, with darkness being synonymous with unhealthiness and even regression.[8] The article by Mathilde Thouron examines the work required to rehabilitate darkness that accompanied the development of architecture for cinemas. Nona Schulte-Römer's study further complicates "darkness" by suggesting how history and culture shape perceptions of and preferences for light/dark in European contexts. Nick Dunn's contribution looks to both the past and the future, exploring how the history of lighting in Manchester (England) has mediated the experiences of light and darkness in the contemporary city. Linking history and auto-ethnography, Dunn invites us to consider how we do—and might—experience light/dark in urban landscapes today. In her accompanying essay, Sara B. Pritchard shares elements of Dunn's ethnographic approach, reflecting upon light, darkness, energy, and their entanglement in the endscape of the high Arctic during polar night, based on her recent experience in Longyearbyen (Norway).

RECENT HISTORIOGRAPHICAL RENEWAL: FROM LIGHT TO DARKNESS

12 Historians have ably examined the history of light, lighting, lighting technologies, and lighting industries, especially for the period from the 19th C. to the present. Such studies are particularly well represented in the history of technology and urban history.[9] In general, this research suggests a gradual disappearance of darkness due to control over light—what is sometimes called the "colonization" of the night[10] (a metaphor that requires serious reflection). This process enabled an appropriation of the night, which was long considered *terra incognita*: for instance, during the Middle Ages, curfews required city dwellers to stay home, leaving darkness to creatures of the shadows, whether real or imagined.

13 With its simultaneously technical[11] and entrepreneurial[12] dimension, innovation represents a large swath of this historiography. The development of lighting systems has also been central to scholarship over the last four decades; the history of electricity networks has received much of this attention,[13] although other forms of lighting, such as gas, were not forgotten.[14] Scholars have shown how these systems took considerable political, economic, and cultural work to realize.[15] The history of public lighting offers a classic illustration of

8 For the U.S. case, see Daniel Freund, *American Sunshine: Diseases of Darkness and the Quest for Natural Light* (Chicago: University of Chicago Press, 2012).

9 Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore: Johns Hopkins University Press, 1983); David E. Nye, *Electrifying America: Social Meanings of a New Technology* (Cambridge, MA: MIT Press, 1990); David E. Nye, *When the Lights Went Out: A History of Blackouts in America* (Cambridge, MA: MIT Press, 2010); David E. Nye, *American Illuminations: Urban Lighting, 1800-1920* (Cambridge, MA: MIT Press, 2018).

10 Murray Melbin, *Night as Frontier: Colonizing the World After Dark* (New York: Free Press, 1987); Sandy Isenstadt, Margaret Maile Petty, and Dietrich Neumann (eds.), *Cities of Light: Two Centuries of Urban Illumination* (New York: Routledge, 2015), XVII.

11 For instance, see Robert D. Friedel, *Edison's Electric Light: Biography of an Invention* (New Brunswick: Rutgers University Press, 1986); Brian Bowers, *Lengthening the Day: A History of Lighting Technology* (New York: Oxford University Press, 1998); Robert Friedel and Paul Israel with Bernard. S. Finn, *Edison's Electric Light: The Art of Invention* (Baltimore: Johns Hopkins University Press, 2010).

12 Robert Fox, "Edison et la presse française à l'exposition internationale d'électricité de 1881," *in* Cardot Françoise (ed.), *Un siècle d'électricité dans le monde, 1880-1980* (Paris: Presses universitaires de France, 1987), 223-235; Paul Israel, *Edison: A Life of Invention* (New York: John Wiley, 1998); Jill Jonnes, *Empires of Light: Edison, Tesla, Westinghouse and the Race to Electrify the World* (New York: Random House, 2003); Ernest Freeberg, *The Age of Edison: Electric Light and the Invention of Modern America* (New York: Penguin Press, 2013).

13 On systems and networks (including, but not limited to, electrical systems), see Hughes, *Networks of Power*; Harold L. Platt, *The Electric City: Energy and the Growth of the Chicago Area, 1880-1930* (Chicago: University of Chicago Press, 1991); Jean-Pierre Williot, "Naissance d'un réseau gazier à Paris au XIXe siècle : distribution gazière et éclairage," *Histoire, Économie et Société*, n°4, 1989, 569-591; Sophie Reculin, "'Le règne de la nuit désormais va finir'. L'invention et la diffusion de l'éclairage public dans le royaume de France (1697-1789)" (Ph.D diss., Université Lille-3, 2017).

14 Jean-Pierre Williot, *Naissance d'un service public : le gaz à Paris au XIXe siècle* (Paris: Éditions Rive droite, 1999); Alain Beltran, *La Ville-Lumière et la Fée Électricité. L'énergie électrique dans la région parisienne : service public et entreprises privées* (Paris: Éditions Rive droite, 2002).

15 Hughes, *Networks of Power*.

infrastructure: extensive, often invisible, technological systems that are taken for granted—at least until they fail.[16] Finally, more popular histories have shared some of these insights with wider publics.[17]

14 Together, these studies—focused primarily on large metropolitan centers of Europe and North America—have underscored the tension between an intention to evenly light urban territories, and the reality of this lighting, which was usually concentrated along the central roads of cities at the expense of the periphery or narrower streets. This segregation of light and space was often accompanied by social segregation: the best-lit spaces were generally those where the wealthy (aristocrats or bourgeoisie) lived, worked, walked, and entertained, while peripheries inhabited by immigrants, laborers, and more generally those referred to as the "working classes" had to be content with dim or unpredictable lights—when not deprived of lighting altogether. Histories of lighting in colonial or quasi-colonial metropoles shared similarities with major cities in the global North, from associations between light and power to social inequities in the distribution of light.[18]

15 In contrast, lighting technologies and practices continued in many rural areas or smaller cities for decades—in some places a century (or longer) after the development of public lighting first based on gas and then on electricity. In this sense, urban/rural and class divides may be more significant in the history of lighting than those of metropole/colony. National narratives based on major metropoles may therefore exaggerate change, obscure continuity, and fail to capture the persistence of "old" technologies.[19] As these points begin to suggest, this history is still incomplete. Much less is known about smaller, provincial cities, rural spaces, and peripheral areas.[20] Studies of cases in Africa,[21] Asia,[22] and Latin America[23] remain rare. Historical generalizations based on empirical sites to date may, therefore, ultimately not hold in many other contexts, including for a significant share of the world's population—both past and present.

16 Taken together, this scholarship has largely focused on the history of light and its various dimensions. However, over the past decade, more scholars have begun to attend to darkness and night, often entwined phenomena that are, in fact, more complex than either term suggests at first glance. Night may be—to borrow

16 Nye, *When the Lights Went Out*. For a few key pieces on infrastructure in STS, see Susan Leigh Star, "The Ethnography of Infrastructure," *American Behavioral Scientist*, vol. 43, n° 3, 1999, 377-391; Paul N. Edwards, "Infrastructure and Modernity: Force, Time, and Social Organization in the History of Sociotechnical Systems," *in* Thomas J. Misa, Philip Brey, and Andrew Feenberg (eds.), *Modernity and Technology* (Cambridge, MA: MIT Press, 2003), 185-226; Paul N. Edwards, Geoffrey C. Bowker, Steven J. Jackson, and Robin Williams, "Introduction: An Agenda for Infrastructure Studies," *Journal of the Association for Information Systems*, vol. 10, n°5, 2009, 364-374.

17 For instance, see Jonnes, *Empires of Light*; Jane Brox, *Brilliant: The Evolution of Artificial Light* (New York: Houghton Mifflin Harcourt, 2010).

18 See some of the current research of Ute Hasenöhrl. See also Ronen Shamir, *Current Flow: The Electrification of Palestine* (Stanford, CA: Stanford University Press, 2013).

19 David Edgerton, *The Shock of the Old: Technology and Global History Since 1900* (New York: Oxford University Press, 2011).

20 Panu Savolainen, "Les débuts de l'éclairage à Turku, 1805-1827," *Histoire urbaine*, n°50, 2017, 13-28.

21 Céline Ardurat, "L'électrification du Sénégal de la fin du XIXe siècle à la Seconde Guerre mondiale," *Outre-mers*, n° 334-335, 2002, 439-457; Robert Lekoulekissa, *L'électrification en Afrique : le cas du Gabon, 1935-1985* (Paris: L'Harmattan, 2011); Stéphane W. Mehyong, Robert E. Ndong, "L'électrification de l'Afrique équatoriale française (AEF) dans la période de l'après Seconde Guerre mondiale : aménagements hydroélectriques et rivalités interterritoriales," *Revue historique*, n° 657, 2011/1, 93-118; Jules Kouosseu, William Pokam Kamdem, "L'électricité et le fédéralisme au Cameroun : la West Cameroon Electricity Corporation" (POWERCAM), 1962-1975, *Journal Gabonais d'Histoire Économique et Sociale*, n° 1, 2013, 27-42; Salif Diedhiou, "L'énergie électrique au Sénégal de 1887 à 1985," *e-Phaïstos* [online], V-1 2016 | 2018, published online January 21, 2018. Url: http://journals.openedition.org/ephaistos/1209 (accessed 05/11/2018)

22 Pierre Lanthier, "Les quatre phases de l'histoire de l'électricité en Inde, de 1890 à nos jours," *in* Alain Beltran, Léonard Laborie, Pierre Lanthier, and Stéphanie Le Gallic (eds.), *Electric Worlds / Mondes électriques. Creations, Circulations, Tensions, Transitions (19th-21st C.)* (Brussels: Peter Lang, 2016), 575-594. Ian J. Miller's current book project, *Tokyo Electric: Japan in the Age of Global Energy, will help expand work on electrification in Asia*.

23 R. Maranhao, "Le groupe Light au Brésil de 1947 à 1948," *in* Monique Trédé (ed.), *Electricité et électrification dans le monde, 1880-1980* (Paris: PUF, 1990), 401-410.

Ekirch's phrase—at day's close. Yet, as he and other scholars have shown, it still has a social and cultural history.[24] Historians and geographers have begun exploring nocturnal life: from shift work and the night-time economy to pleasure, transgression, and liberation.[25] Geographer Robert Shaw has proposed four specific directions for research under his call for "nightology," while an interdisciplinary team of scholars has argued for a broader, more interdisciplinary approach to "night studies."[26] In the process, these and related studies have helped to complicate narratives about night and dark, revalorize darkness, and critique artificial light, thereby challenging powerful narratives dating back at least to the Judeo-Christian tradition and the Enlightenment in the Western context.[27]

17 Cultural geographer Tim Edensor has dedicated the most sustained attention to light(s) and darkness(es) simultaneously, exploring art, atmosphere, affect, sensory experience, cultural meanings and performances, and urban space.[28] Susanne Bach and Folkert Degenring have spearheaded work exploring this interconnection in literary studies.[29] Yet little historical scholarship, including work in the history of energy, has tackled light/dark at once. We hope this special issue helps inspire future studies.

RECONSIDERING LIGHT(S) AND DARKNESS(ES)

Given recent research and contemporary concerns, this is a timely moment to consider light(s) and darkness(es). It also reflects our own interests in the history of darkness and 18

24 Ekirch, *At Day's Close* (cf. note 5). It is noteworthy that while the subtitle of Ekirch's book is "Night in Times Past," almost all of his empirical sites are European and North American. Verdon's Night in the Middle Ages (cf. note 6) and Koslofsky's Evening's Empire (cf. note 13) also focus on Europe, the medieval and early modern periods, respectively.

25 Bryan D. Palmer, *Cultures of Darkness: Night Travels in the Histories of Transgression* (New York: Monthly Review Press, 2000); Peter C. Baldwin, *In the Watches of the Night: Life in the Nocturnal City, 1820-1930* (Chicago: University of Chicago Press, 2012); Jacques Galinier, Aurore Monod Becquelin (eds.), *Las cosas de la noche. Une mirada diferente* (Mexico: Centro de estudios mexicanos y centroamericanos, 2016); Robert Shaw, "Night as Fragmenting Frontier: Understanding the Night that Remains in an era of 24/7," *Geography Compass*, vol. 9, n° 12, 2015, 637-647; Robert Shaw, *The Nocturnal City* (New York: Routledge, 2018).

26 Shaw, *The Nocturnal City*, 110-121; Christopher C.M. Kyba *et al.*, "Night Matters," *Proceedings of the National Academy of Sciences*, under review.

27 Nick Dunn, *Dark Matters: A Manifesto for the Nocturnal City* (Washington DC: Zero Books, 2016); Matthew Gandy, "Negative Luminescence," *Annals of the American Association of Geographers*, vol. 107, n° 5, 2017, 1090-1107; Taylor Stone, "The Value of Darkness: A Moral Framework for Urban Nighttime Lighting," *Science and Engineering Ethics*, vol. 24, n° 2, 2018, 607-628; Taylor Stone, "Re-envisioning the Nocturnal Sublime: On the Ethics and Aesthetics of Nighttime Lighting," *Topoi* (May 31, 2018). Url: https://doi.org/10.1007/s11245-018-9562-4 (accessed 02/12/2018)

28 On light/darkness, see especially Tim Edensor, *From Light to Dark: Daylight, Illumination, and Gloom* (Minneapolis: University of Minnesota Press, 2017); Tim Edensor, "Introduction: Sensing and Perceiving with Light and Dark," *The Senses and Society*, vol. 10, n° 2, 2015, 129-137; Tim Edensor and Hayden Lorimer, "'Landscapism' at the Speed of Light: Darkness and Illumination in Motion," *Geografiska Annaler: Series B, Human Geography*, vol. 97, n° 1, 2015, 1-16; Tim Edensor, "The Gloomy City: Rethinking the Relationship Between Light and Dark," *Urban Studies*, vol. 52, n° 3, 2015, 422-438; Tim Edensor, "Aurora Landscapes: Affective Atmospheres of Light and Dark," *in* Karl Benediktsson and Katrin A. Lund (eds.), *Conversations with Landscape* (London: Routledge, 2010), 227-240. Other Edensor works tend to examine either light or dark. For instance, see Tim Edensor, "Seeing with Light and Landscape: A Walk around Stanton Moor," *Landscape Research*, vol. 42, n° 6, 2017, 616-633; Matthew Cook and Tim Edensor, "Cycling through Dark Space: Apprehending Landscape Otherwise," *Mobilities*, vol. 12, n° 1, 2017, 1-19; Tim Edensor and Emily Falconer, "Dans Le Noir? Eating in the Dark: Sensation and Conviviality in a Lightless Place," *Cultural Geographies*, vol. 22, n° 4, 2015, 601-618; Tim Edensor, "Introduction to Geographies of Darkness," *Cultural Geographies*, vol. 22, n° 4, 2015, 559-565; Tim Edensor, "Light Design and Atmosphere," *Visual Communication*, vol. 14, n° 3, 2015, 331-350; Tim Edensor, "Light Art, Perception, and Sensation," *The Senses and Society*, vol. 10, n° 2, 2015, 138-157; Tim Edensor, "ON: A Re-Imagining of Blackpool Illuminations," *Senses & Society*, vol. 8, n° 3, 2013, 367-377; Tim Edensor, "Reconnecting with Darkness: Gloomy landscapes, Lightless Places," *Social and Cultural Geography*, vol. 14, n° 4, 2013, 446-465; Tim Edensor, "Illuminated Atmospheres: Anticipating and Reproducing the Flow of Affective Experience in Blackpool," *Environment and Planning D: Society and Space*, vol. 30, n° 6, 2012, 1103-1122.

29 Susanne Bach and Folkert Degenring (eds.), *Dark Nights, Bright Lights: Night, Darkness, and Illumination in Literature* (Berlin: De Gruyter, 2015).

its representations (Le Gallic),[30] as well as the history of light pollution and light-pollution science (Pritchard).[31]

19 Light and dark are prominent dualities in a wide range of thought—from art to religious traditions. Moreover, as lighting technologies have developed, the more it seems that light and dark are entangled with and map onto other powerful, often problematic dualisms. For example, darkness seems natural because it is associated with night, whereas light suggests the artifice of culture; similarly, light is the privilege of so-called "civilized" societies, while darkness remains the prerogative of "primitive" societies. The latter association is epitomized by Conrad's novel *Heart of Darkness* (1899). In short, light is often associated with and helps to purportedly define culture, civilization and modernity, the "West," whiteness, the urban, and the interior, while darkness is frequently associated with nature, the "primitive," the global South, race as non-white, the rural, and the exterior. Of course, all of these dichotomies are laden with strong cultural associations, not to mention hierarchies. These binaries are, of course, crude, often false, Western-biased, and implicated in violence, oppression, and empire. Yet they remain persistent, powerful ideas. Nonetheless, old dichotomies and assumptions can also be read in new ways. For instance, bright cities of Western Europe and North America can be reframed as over-illuminated. In this sense, light does not signal development, but *over*development.[32] Moreover, overlit, urban, industrial areas contrast with large parts of the world that are desperately dark, a duality often also present in the "city/country" binary. In this sense, light pollution places lighting poverty into sharper relief.[33]

20 Yet, as is the case with most dichotomies, the dualism of light/darkness inadequately describes complex phenomena. Dawn and dusk are ambiguous periods in Earth's daily cycles. They are liminal times of light and darkness—simultaneously both and neither.[34] The onset of day and night (concurrently the end of night and day, respectively) is even more ambiguous in polar regions during the late fall and earliest days of spring, when dawn and dusk bleed briefly into one another before the sun descends below the horizon again for yet another long night.[35] Similarly, although night is normally darker than day, public lighting was not always dependent on this temporality. For instance, during the 19th C., in the middle of the Industrial Revolution, when London smog was too thick, gas lighting was needed even during daytime. Conversely, when urban lighting developed beginning in the late 17th C., it was adapted according to natural luminosity. It might be turned off entirely during summer, or on nights with a full moon. In each illuminated city, light tables calculated the exact time of sunrise, sunset, and moonlight for every month, a practice that remained in place until the mid-19th C. Taking advantage of natural (moon)light during the lunar cycle to reduce the use of artificial lighting may have been motivated primarily for economic reasons. Nonetheless, it reflected awareness of natural cycles, the adaptation of artificial systems to natural rhythms, and a

30 Stéphanie Le Gallic, "When Light was Creating Darknesses: Oil Lighting in Bordeaux in the 19th Century," *International Conference on the Urban Night: Governance, Diversity, Mobility*, *(Sofia University, Sofia, Bulgaria, June 7-8, 2018)*; Stéphanie Le Gallic, *Lumières publicitaires, Paris, Londres, New York* (Paris: CTHS, 2019).

31 Sara B. Pritchard, "The Trouble with Darkness: NASA's Suomi Satellite Images of Earth at Night," *Environmental History*, vol. 22, n° 2, 2017; Sara B. Pritchard, "On (Not) Seeing Artificial Light at Night: Light Pollution or Lighting Poverty?," *Discard Studies: Social Studies of Waste, Pollution, & Externalities*, 2017. Url: https://discardstudies.com/2017/06/12/on-not-seeing-artificial-light-at... (accessed 13/05/2019)

32 On the concept of overdevelopment, see Maria Mies, "Deceiving the Third World: The Myth of Catching-Up Development," *in* Louis P. Pojman and Paul Pojman (eds.), *Environmental Ethics: Readings in Theory and Application, 5th edition* (Belmont, CA: Thomson, 2008).

33 Pritchard, "Trouble with Darkness"; Pritchard, "On (Not) Seeing Artificial Light at Night."

34 Ben Gallan and Christopher R. Gibson, "Commentary: New Dawn or New Dusk? Beyond the Binary of Night and Day," *Environment and Planning A*, vol. 43, n° 11, 2011, 2509-2515.

35 On polar "northscapes," see Dolly Jorgensen and Sverker Sorlin (eds.), *Northscapes: History, Technology, and the Making of Northern Environments* (Vancouver: UBC Press, 2013).

fascinating moment when some cities relied on a hybrid system designed around both natural and artificial light.[36]

21 Light within purported darkness, as well as persistent dark within light, also confound simplistic dualisms. As astronomers, outdoor enthusiasts, and dark-sky tourists know, remote locations with little anthropogenic light may be dark, especially for city residents used to extensive public and private lighting. Yet a variety of celestial phenomena brighten the night sky, depending on location, season, and time of night. The moon, stars, airglow, zodiacal light, and Milky Way all illuminate the nightscape.[37] The same principle governs movie theaters: darkness actually reveals the screen and its animated images. Conversely, light can also create a well-known form of darkness: shadows. In this case, the sensation of darkness is all the more powerful when lighting—natural or artificial—is intense and cannot be separated from it. Simply opposing light and darkness cannot acknowledge the ways in which the two phenomena exist simultaneously. Both natural and artificial "light" regimes therefore actually combine light and darkness in complex, unevenly experienced ways.

22 The borders of light/dark can be fluid, fragile, and impermanent. Artificial light, regardless of type, extends day and shortens night, but extinguishing the lights can quickly bring about the return of night—whether a simple act at bedtime or a political demonstration, as in the case of Earth Hour. Such "greenouts" are forms of political protest, but they are also limited, symbolic, and reflect privilege. After all, one has to have lights in order to choose to extinguish them. At other times, structural breakdown, whether technical or political, limits individual agency with respect to regimes of light/dark. In his history of blackouts in modern America, David E. Nye has shown how the sudden onset of darkness can be caused by war, overconsumption, technical glitches, and systemic complexity.[38] Yet in some contexts, rolling blackouts—planned interruptions in service—actually enable systems to keep functioning, albeit not 24/7 for all residents. Crises, in particular, demonstrate the limits of progress narratives that track supposedly linear, permanent shifts from darkness to light. During World War II, energy shortages and blackouts spurred by fears of nighttime aerial bombing temporarily darkened European skies. More recently, satellite imagery reveals how civil war in Syria is manifested in light at night—or, rather, its expanding absence—as the political crisis tragically worsened.[39]

23 Some of these examples suggest the political valences of light and darkness—power, prestige, progress, empire. But other cases of light/dark are seemingly banal or products of culture, leisure, and pleasure. Dylan Mulvin has described how technologies of "media prophylaxis" seek to darken ubiquitous self-illuminated screens. "Night mode," or dark(er) light, thus attempts to address concern for human health and sleep, while nonetheless permitting continued use of electronic gadgets at all hours.[40] Another example of the complex relations between lights and darknesses, between lighting and non-lighting (which is also different from opting to turn off lights), is closed spaces. In the absence of a window, or in cases of narrow openings, we might think that artificial lighting would always

36 Literature at the intersection of environmental history and the history of technology is now too considerable to list comprehensively here. Works explicitly theorizing this nexus—"Envirotech"—are less common. One starting point, as well as an example of a hybrid system, is Sara B. Pritchard, *Confluence: The Nature of Technology and the Remaking of the Rhône* (Cambridge, MA: Harvard University Press, 2011), especially the Introduction. For another example, see Daniel Schneider, *Hybrid Nature: Sewage Treatment and the Contradictions of the Industrial Ecosystem* (Cambridge, MA: MIT Press, 2011).

37 For an effective overview, see Paul Bogard, *The End of Night: Searching for Natural Darkness in an Age of Artificial Light* (New York: Little, Brown and Company, 2013).

38 Nye, *When the Lights Went Out* (cf. note 8). See also Charles Perrow, *Normal Accidents: Living with High-Risk Technologies* (New York: Basic Books, 1984).

39 Earth Observation Group, "Blackout in Syria," 2019. Url: https://payneinstitute.mines.edu/1773-2/ (accessed 26/03/2019)

40 Dylan Mulvin, "Media Prophylaxis: Night Modes and the Politics of Preventing Harm," *Information & Culture*, vol. 53, n° 2, 2018, 175-202.

be favored. However, the gradual darkening of theaters illustrates how darkness can also be the norm or objective sought. Until the 17th C., both the theater hall and stage were lit, with chandeliers adorning and lighting both spaces equally. The evolution toward darkness began during the 18th C. with the marking of a boundary, which was characterized by the decrease and gradual ban of chandeliers in the theater hall, whereas the stage took advantage of advances in lighting. This process culminated in the film projector, which required the hall to be dark in order to be fully effective.

24 Moreover, even human perception of light/darkness is dynamic and contingent. In well-lit conditions, humans see according to photopic vision; in low lighting, according to scotopic vision. Mesopic vision combines elements of both. However, it takes the human eye time to adjust to "darkness"—a misnomer since, in most cases, darkness refers to low-light levels, not pitch-black conditions. Scientists at the U.S. National Park Service studying night skies in American national parks recommend allowing a minimum of 30 minutes, preferably 90 minutes, for this process of "dark adaptation" to take place. Humans therefore see less light within supposed darkness early in this dark-adaption phase than if they are fully dark-adapted. In addition, children can usually see better in "darker" environments than adults. Younger eyes usually perceive more stars in the night sky. The biology of light, darkness, and sight thus defies simplistic characterization, further problematizing a tidy light/dark dualism. Moreover, this focus on human perception of light/dark entirely neglects the host of non-human species, for whom vision and sensory experiences of light/dark (bats, owls) can be radically different.

LIGHTS(S) AND DARKNESS(ES): DIVERSE EXPERIENCES

25 We have purposefully chosen to refer to light(s) and darkness(es) in the plural for several reasons. For starters, pluralizing these terms serves as an important reminder of the instability and multiplicity of the concepts, both individually and together, in some of the ways outlined above. In addition, the diversity of energy sources that have been used to produce light since humankind mastered fire renders use of the plural for "light" self-evident. The experience of a candle is not the same as that of electric light, with respect to intensity, ambiance, or regularity; the candle is more intimate and distills a light that is "warmer" than the incandescent lamp. The intensity of a flame burning around its wick is also extremely variable, whereas the light from a bulb is uniform. Already during Antiquity, the possibility of choosing between a number of fuels (beeswax, pork fat, olive oil) could be made not just according to their technical performance, but also on the sensory perception of and preference for the light emitted.

26 Contemporaries often remarked upon changes in lighting regimes. For instance, when gas lighting began to spread in the first half of the 19th C. in major European and North American cities, it was accompanied by commentaries on its brightness. Its glow was described as being "dazzlingly white" and "bright as day," while traditional sources of light seemed to offer no more than a dim, warm glimmer. This phenomenon is all the more complex given that preferences (in terms of intensity, color, etc.) are not universal. In short, history and culture matter. More recently, there has been criticism of LEDs, which have been accused of diffusing light that is too white and cold, in part due to cultural expectations of what "light" should look like, based on norms developed over the previous century. Of course, natural light is not uniform either, differing by latitude, season, time of day, weather, and even ground cover—something that was well understood by Impressionist painters, who were sensitive to and aimed to depict these variations and nuances of light. The singular term "light" thus seems deficient when it comes to capturing its many dimensions and characteristics.

27 In addition, it seems particularly appropriate to refer to these terms in the plural, as we are co-editors from different national and linguistic contexts. We are using light/*lumière* and darkness/*obscurité* interchangeably here, but

translation is never perfect. Other cultural and linguistic contexts may have richer vocabularies to capture experiences of both light and dark—or, more accurately, light(s) and darkness(es). It would be interesting in this respect to know whether the First Nations of northern Canada, Nordic countries, other people living in the High or Low Arctic, and scientists working in Antarctica, all of whom have a more intimate knowledge of light during at least several consecutive months per year, have a subtler and richer vocabulary for distinguishing among darknesses.[41] We imagine that even polar nights—extended periods of no sunlight—are not monolithic to those who actually experience them.

28 On the contrary, dark/*obscurité* is more difficult to perceive in its plurality, especially if it is defined by the negative, in other words by the absence of light—as the *Oxford English Dictionary* does: "Characterized by (absolute or relative) absence of light; devoid of or deficient in light; unilluminated; said *esp.* of night." For that matter, in our view, the French language is particularly poor in describing darkness, simply evoking an atmosphere that is "s*ombre*," or an "*ombre*" or "pén*ombre*." The etymological root of these terms—*umbra*, shadow—is the same, whereas there is a wider range of terms to describe light, which can "*illumine*," "*éclaire*," "*brille*," "*allume*," "*luit*," or "*flamboie*." Light can also be "*luminescente*," "*incandescente*," and even "*éclatante*," and come from a bulb, lighthouse, torch, or streetlamp, or it can simply be a "*lueur*," a "*flash*," or a "*halo*." It appears that only "*ténèbres*" and "*opacité*" can independently depict the field of darkness, although these terms have strong connotations. English seems to establish a nuance between "dark" and "darkness." "Dark" is both a noun and an adjective in English, "darkness" a noun alone. Moreover, "darkness" in English offers a rich lexical field: "black," "blackness," "candlelight," "dark," "dimness," "dusk," "gloom," "murk," "night," "nighttime," "nightfall," "obscurity," "penumbra," "shade," "shadow," "twilight," and "umbra." As an adjective, "dark" is "black," "dim," "dusky," "gloomy," "lightless," "murky," "obscure," "pitch-black," "shadowy," "shady," "somber," and "unlit"—and, less commonly, "caliginous," "rayless," "stygian," "tenebrific," and "tenebrous."[42] Singular terms—light and dark—thus obscure this linguistic nuance and complexity.

RELATIONAL STUDIES OF LIGHT(S)/ DARKNESS(ES)

29 As the authors in this special issue seek to show, examining light(s) and darkness(es) *together* is more illuminating, so to speak, precisely because doing so calls attention to their juxtaposition, presumed opposition, and the ways in which they are, in fact, more complicated than a reductionistic binary. For example, a recurring problem in urban lighting during the early modern period was the "cluttering" of lanterns: wax from candles would melt and pool at the bottom of lanterns, ultimately altering the quality of the lighting, especially as it was already dimmed by dirty glass panes. Ironically, then, the source of light in this case (candles) contributed to its very diminishment (soot, wax). Keeping candle lanterns closer to their maximum intensity therefore required regular maintenance and repair.[43] Should the street therefore be considered *dark*, despite the dim, warm glare of a lantern, or *lit*, even though the lantern no longer entirely fulfilled the role for which it was intended, or both? This brief example suggests how assessment of light/dark likely depends on the observer and her expectations.

30 We hypothesize that changes in human-produced light, including its intensity, color, duration, reliability, geographical reach, and so forth over the past two centuries contributed to shifting understandings and meanings of darkness over time. In other words, understandings of

41 For a starting point on "extreme" environments, see Steve Pyne, "Extreme Environments," *Environmental History*, vol. 15, n° 3, 2010, 509-513.

42 See https://www.merriam-webster.com/thesaurus/darkness; https://www.merriam-webster.com/thesaurus/dark.

43 Andrew L. Russell and Lee Vinsel, "After Innovation, Turn to Maintenance," *Technology and Culture*, vol. 59, n° 1, 2018, 1-25.

light/darkness are fundamentally relational and co-produced. For one, environmental psychologists assert that brighter light regimes alter standards of "darkness," because those familiar with these lighting levels have never experienced "true night."[44] More immediately, amid relative darkness, sudden exposure to light, even at low levels, *seems* brighter as a result of the dramatic contrast.

31 This is, in fact, another reason that prompts us to reject the systematic opposition between light and darkness. Both of these phenomena include a striking similarity in their effects: they can be blinding, preventing the legibility of one's surroundings. For those who are sighted, darkness can be incapacitating. Yet notably, those with visual impairments may not face similar challenges in these conditions. Scholars have shown how, as artificial lighting developed and shifted, observers and users had to be educated with respect to their gaze at new forms of light. A light source that is too powerful actually becomes blinding, which is why it is important to look at the lit object, rather than at the light source itself. Curtains and lamp shades also mediate the gaze physically and technologically by softening and diffusing a light perceived as too intense.

32 Rather than focusing on the history of light in isolation, we suggest that thinking about the *making* of light/darkness is fruitful. Of course, the production of artificial light, regardless of type and energy source, seems obvious and self-evident. In contrast, darkness may seem natural. Yet assumptions about light/darkness shape even scientific studies. Most assessments of "natural night-sky brightness" are taken during the new moon (little lunar light) and under clear sky conditions (which darken the night sky in low artificial-light areas), which together contribute to "darker" night skies.[45] Furthermore, the dark can also be *made* for diverse reasons—from war to political protests. It is worth noting that at the very moment urban lighting was developed in major European cities, often through royal impetus, many city residents resisted their systematized surveillance. This could take the form of breaking lanterns, especially in France, as well as through nocturnal movement without lanterns in violation of rules, or, in Catalonia, by burning threatening emblems, paper lanterns painted with effigies, and gallows. These political meanings and uses of light/dark are also significant in the U.S. context, as laws required slaves over the age of 14 to carry lanterns at night. As Simone Browne argues, "black luminosity" facilitated the surveillance and oppression of African-American people—a trend that continues to the present-day.[46] In other cases, the political and ethical implications of darkness are disturbing and unsettling. Utilities shutting off the electricity because a family is unable to pay their bill—or lack of access to artificial lighting altogether—reveal economic disparities at various political scales, from the home to the globe. Overall, regimes of light/dark depend on a complex matrix of natural-cultural conditions.[47]

AVENUES FOR FUTURE RESEARCH

33 We hope future scholars will build on some of this work and develop new directions for scholarly inquiry. Already, we acknowledge the need for more scholarship analyzing light/dark in diverse cultural contexts, particularly beyond the so-called West and the modern era. Other

44 On "environmental generational amnesia," see Peter H. Kahn, Jr., "Children's Affiliations with Nature: Structure, Development, and the Problem of Environmental Generational Amnesia," *in* Peter H. Kahn, Jr., and Stephen R. Kellert (eds.), *Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations* (Cambridge, MA: MIT Press, 2002), 93-116.

45 Although we do not yet have specific quantitative numbers here, we identified this trend during our research for Pritchard *et al.*, "Describing Artificial Light at Night."

46 Simone Browne, "Everybody's Got a Little Light under the Sun: Black Luminosity and the Visual Culture of Surveillance," *Cultural Studies*, vol. 26, n° 4, 2012, 542-564; Simone Brown, *Dark Matters: On the Surveillance of Blackness* (Durham: Duke University Press, 2015).

47 "Nature-culture" is from Bruno Latour, *We Have Never Been Modern, trans. Catherine Porter* (Cambridge, MA: Harvard University Press, 1993), 7. "Naturecultures" is from Donna Haraway, *The Companion Species Manifesto: Dogs, People, and Significant Otherness* (Chicago: Prickly Paradigm Press, 2003), 1; Donna Haraway, *When Species Meet* (Minneapolis: University of Minnesota Press, 2008), 16.

scholars might propose a chronology of light/darkness. For example, we might consider how different energy types have enabled, afforded, and/or transformed different light/dark regimes over *la longue durée*.

34 As this last point suggests, we are interested in thinking about light/darkness *together* in relationship to the history of energy—a growing subfield that has been catalyzed by concern about global climate change over the last decade. We highlight three questions here. *First, how is energy foundational to light/darkness?* It seems obvious that different kinds of light require more or less energy. Yet whose? The labor and energy behind lighting are also differentially visible to consumers—and scholars. A rural family making their own candles has closer, more direct ties to the sources of energy, both human and non-human, embodied in the candles. Furthermore, candles or lighting using oil were highly intimate, as their low luminous power was just enough to light the immediate surroundings. On the contrary, the emergence of gas lighting was marked by a dual distancing: a first distance relating to the fuel, which now came from industrial gas facilities usually far removed from the place of consumption; and a second distance relating to the light intensity of the gas flame, which was so powerful that one could no longer look at it directly.

35 *Second, how do shifts in the history of energy have implications for light and darkness?* In the contemporary moment, growing concern over climate change and the drive for more sustainable sources of energy have spurred the adoption of LEDs in the public and private sector. Here, the relationship between energy and light is clear and direct. Yet just as history is filled with examples of unintended consequences, recent studies have demonstrated that the ability to produce more light through LED technology has resulted in not only brighter but also whiter cities. The LED revolution is readily visible from airplanes or astronaut photos in the lightscapes of many cities, as older, yellow lights have been replaced with white LEDs. In other cases, cities have lobbied for nocturnal darkness out of concern for both ecology and economy. In France, towns in the center-west of the country, such as Saint-Junien or Panazol, have experimented with the voluntary extinguishing of public lighting between 11:30 p.m. and 5:30 a.m. since the fall of 2018, while those in the south (Aveyron) chose the time slot between midnight and 5:00 a.m.

36 *Third, how do perceptions, meanings, and uses of light/dark have implication for energy and its history?* Historical scholarship has traced how light—and by extension new energy sources—was often associated with progress, modernity, and civilization. Although some critiques have challenged this utopian vision, it persists in other ways. The colossal ITER project, an international project for a nuclear fusion reactor, hopes to "bottle the sun."[48] This vision seems to mark continuity with earlier ideas (and ideologies), thereby placing ITER within a longer trajectory of ever growing energy consumption since the 19th C. However, recent protests to challenge or limit the project also suggest that light and progress are not an inevitable pair, and prompt us to explore similar challenges in the past.

37 Overall, we hope that this Introduction, and the entire special issue, foster new conversations and insights at the intersection of light(s), darkness(es), and the history of energy.

48 Jacquinot Jean, Marbach Gabriel, "ITER: l'enjeu d'une grande collaboration internationale," *Revue internationale et stratégique*, n° 55, 2004, 93-97. See also Anna Åberg, "Fusion nucléaire et utopie d'une énergie sans fin : la coopération transnationale autour du projet ITER," conference held on February 12, 2015 as part of the Histoire des sciences, histoire de l'innovation seminar (Université Paris Sorbonne, UPMC, LabEx EHNE). The summary is available here: https://europeflux.hypotheses.org/508

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JEHRHE

Journal of Energy History
Revue d'histoire de l'énergie

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ENGLISH TRANSLATION OF
"L'organisation de l'espace et du temps au Quartier Mu de Malia (Crète, âge du Bronze, 3200 – 1100 av. J.-C.), à la lumière des lampes" *by Arby Gharibian.*

POST DATE
03/05/2019

ISSUE NUMBER
JEHRHE #2

SECTION
Special issue

THEME OF THE SPECIAL ISSUE
Light(s) and darkness(es): Shifting historical relations

KEYWORDS
Light, Town, Housing, Mobility

DOI
in progress

TO CITE THIS ARTICLE
Bastien Rueff, "The organization of space and time in the quartier Mu of Malia (Crete, bronze age, 3200-1100 BC), in light of lamps," *Journal of Energy History/Revue d'Histoire de l'Énergie* [Online], n°2, published 03 May 2019, consulted XXX, URL: energyhistory.eu/en/node/127.

The organization of space and time in the quartier Mu of Malia (Crete, bronze age, 3200-1100 BC), in light of lamps

Abstract
In recent decades, the development of virtual reality has allowed us to propose realistic reconstructions of lighting in Bronze Age buildings of the Eastern Mediterranean and Aegean world. However, light and darkness have been studied separately: the former in relationship to everyday life, the latter in connection to night activities, rituals and religion. Studying a Middle Bronze Age Cretan city and its corpus of lamps, we can identify several lighting devices, of various kinds and functional qualities, the analysis of which contributes to revealing a Minoan lived space where light and darkness cannot be segregated.

Plan of the article

ISSN 2649-3055

INTRODUCTION

1 During the Bronze Age (3200-1100 BC), the Eastern Mediterranean was marked by the dual emergence of the first states and cities. In Crete, urbanization trends led to the emergence of what could be called "towns"[1] according to the definition of geographers.[2] This development was accompanied during the Middle Minoan by the rise of palaces, which most certainly served an economic function for storing and redistributing wealth,[3] even though their precise political and/or religious nature remains unclear.[4]

2 Recent research has given greater attention to the importance of light in constructing urban reality in the Eastern Mediterranean.[5] Architectural studies in particular have used virtual reality in order to offer realistic reconstructions of natural and artificial lighting. Based on data about light properties recorded in experimental research programs,[6] those reconstructions often use luminosity as a criterion for the identification of areas of activity, and as an indicator as to the temporality of their occupation.[7]

3 Those studies, as highlighted by David Petrut, Monica Gui and Horea Trinca[8] in another chrono-cultural framework, dissociate light from darkness, linking the former with the understanding of everyday life during the daytime[9] and the latter with nighttime,[10] that has often been studied in connection with rites and beliefs.[11] No one any longer imagines—as Philippe Bruneau[12] once did regarding Delian houses—interior spaces immersed in darkness in the middle of the day, or on the contrary lighting systems on the exteriors of buildings at night.

4 However, the notion that one could transition from darkness to light within the same space at a given moment, both during the day and at night, calls for further exploration as it can shed light on our understanding of societies, regarding their organization and their relationship with domestic place and daily time. Our approach, that aims at achieving such a demonstration, is based on a homogeneous collection of lamps discovered in the *Quartier Mu* of Malia, a complex dating from the second millennium BC. Given

1 Raphaël Orgeolet, Maia Pomadère, "Formes et déformations de la ville égéenne. Akrotiri et les villes minoennes au prisme de l'historiographie récente," *in* Stéphane Bourdin, Michel Paoli, Anne Reltgen-Tallon (eds.), *La Forme de la ville de l'Antiquité à la Renaissance* (Rennes: PUR, 2015).

2 Jacques Levy, Michel Lussault (dir.), *Dictionnaire de la géographie* (Paris : Belin, 2003), 1010.

3 Kostis Christakis, *The Politics of Storage: Storage and Sociopolitical Complexity in Neopalatial Crete* (Philadeplphia: INSTAP Academic Press, 2008), 183.

4 Jan Driessen, Isle Schoep, Robert Laffineur (eds.), *Monuments of Minos: Rethinking the Minoan Palaces* (Liège, Austin: Université de Liège, University of Texas Program in Aegean Scripts and Prehistory, 2002), 248.

5 Mary Shepperson, *Sunlight and Shade in the First Cities: a Sensory Archaeology of Early Iraq* (Göttingen: Vandenhoeck & Ruprecht, 2017), 263.

6 Ioannis Roussos, Alan Chalmers, "High Fidelity Lighting of Knossos," *in* David A. Arnold, Alan Chalmers, Franco Niccolucci (eds.), *The 4th International Symposium on Virtual Reality, Archaeology and Intelligent Cultural Heritage* (Aire-la-Ville: Eurographics Association 2003).

7 Constantinos Papadopoulos, Yannis Sakellarakis, "Virtual Windows to the Past: Reconstructing the 'Ceramics Workshop' at Zominthos, Crete," *in* Francisco Javier Melero Columbrí, Francisco Contreras, Mercedes Farjas (eds.), *Fusion of Cultures. Proceedings of the 38th Annual Conference on Computer Applications and Quantitative Methods in Archaeology, Granada, Spain, April 2010* (Oxford: Archaeopress 2010).

8 David Petrut, Monica Gui, Horea Trinca, "Lighting Roman military Barracks. An interdisciplinary Approach Based on Evidence from Dacia," *Archaeologica Bulgaria*, vol. XVIII/3, 2014.

9 Constantinos Papadopoulos, Yannis Sakellarakis, "Virtual Windows to the Past: Reconstructing the 'Ceramics Workshop' at Zominthos, Crete," *in* Francisco Javier Melero Columbrí, Francisco Contreras, Mercedes Farjas (eds.), *Fusion of Cultures. Proceedings of the 38th Annual Conference on Computer Applications and Quantitative Methods in Archaeology, Granada, Spain, April 2010* (Oxford: Archaeopress 2010).

10 Marion Dowd, Robert Hensey (eds.), *The Archaeology of Darkness* (Oxford: Oxbow Books, 2016), 143 ; Nancy Gonlin, April Nowell, *Archaeology of the Night: Life after Dark in Ancient World* (Boulder: University Press of Colorado, 2018), 442.

11 Lucy Goodison, "From Tholos Tomb to Throne Room: Perceptions of the Sun in Minoan Ritual," *in* Robert Laffineur, Robin Hägg (eds.), *Potnia: Deities and Religion in Aegean Bronze Age* (Liège, Austin: Université de Liège, University of Texas, Program in Aegean scripts and prehistory, 2001) ; Constantinos Papadopoulos, Graeme Earl, "Formal Three-dimensional Computational Analyses of Archaeological Spaces," *in* Elefteria Paliou, Undine Lieberwirth, Silvia Polla (eds.), *Spatial Analysis in Past Built Spaces – Workshops (Berlin, 1-2 april 2010)* (Berlin : De Gruyter, 2014).

12 Philippe Bruneau, "La Maison délienne," *Revue d'Archéologie moderne et d'Archéologie générale*, vol. 12/4, 1994-1995.

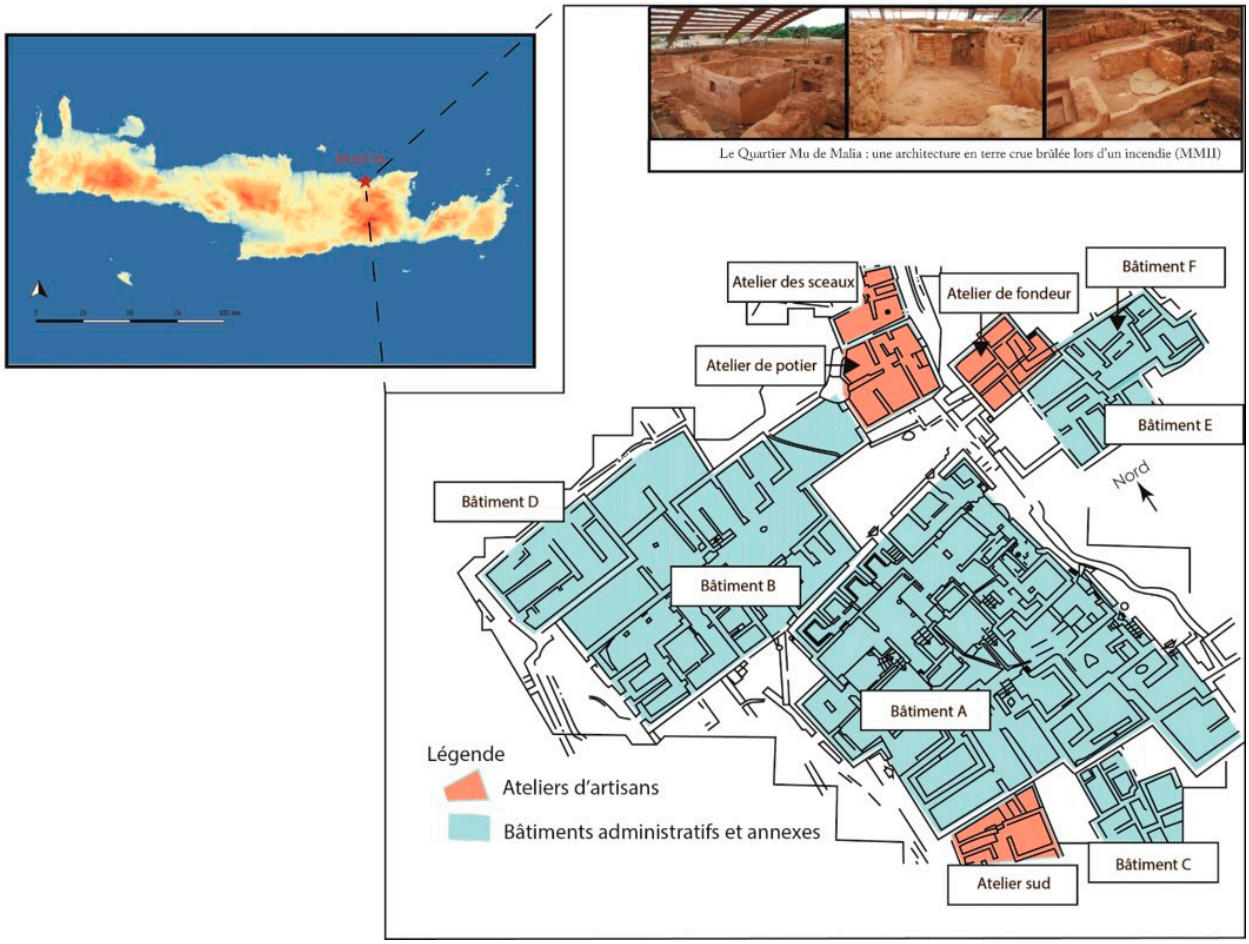

Figure 1: Localization of the *Quartier Mu* of Malia. Based on Poursat, 2013. CAD: Bastien Rueff.

that one of the distinctive architectural features of this area is its highly dense built space, one can assume that certain areas, particularly in the center, were immersed in darkness both by day and by night. This would partly explain the use of artificial sources of light, whose spatial distribution will be analyzed below. The experimental and statistical data analyzed suggest a space that was unequally lit, with respect to both light ambiances and the techniques implemented. A quantitative approach is significantly different from three-dimensional qualitative models, as it can examine the connection between light, darkness, and activities on the scale of the neighborhood, and not just the room. This preliminary reflection deserves to be subsequently extended, in a further study, to other light sources (hearths, braziers and openings).[13]

PRESENTATION OF THE SITE AND LAMP COLLECTION

Quartier Mu of Malia, a Middle Minoan urban space

This area measuring over 3,000 m² belonged to the Minoan city of Malia, located in the Mirabello plain along the Northeastern coast of Crete (fig. 1). The excavations conducted in Malia since 1915 have gradually unearthed a Bronze Age city organized around a first (2000/1900–1700 BC) and later a second palace (1700–1450 BC) (fig. 2). 5

In a number of respects, the excavation of the *Quartier Mu* conducted between 1965 and 1991 proved decisive to the understanding of the history of the protopalatial period in Northeast Crete. In addition to the chronological ambiguities resolved by the study of ceramics,[14] this 6

13 Windows, doors, light wells, porticoes, inner courtyards (Calliopi Christofi, "L'Éclairage et l'aération dans les constructions de l'âge du bronze en Crète" (Ph.D diss., Université Paris 1 Panthéon-Sorbonne, 1993), 530).

14 Jean-Claude Poursat, Carl Knappett, *La Poterie du minoen moyen II : production et utilisation : fouilles exécutées à Malia : le quartier Mu. IV* (Athènes: École française d'Athènes ; Paris: De Boccard, 2005), 193-194.

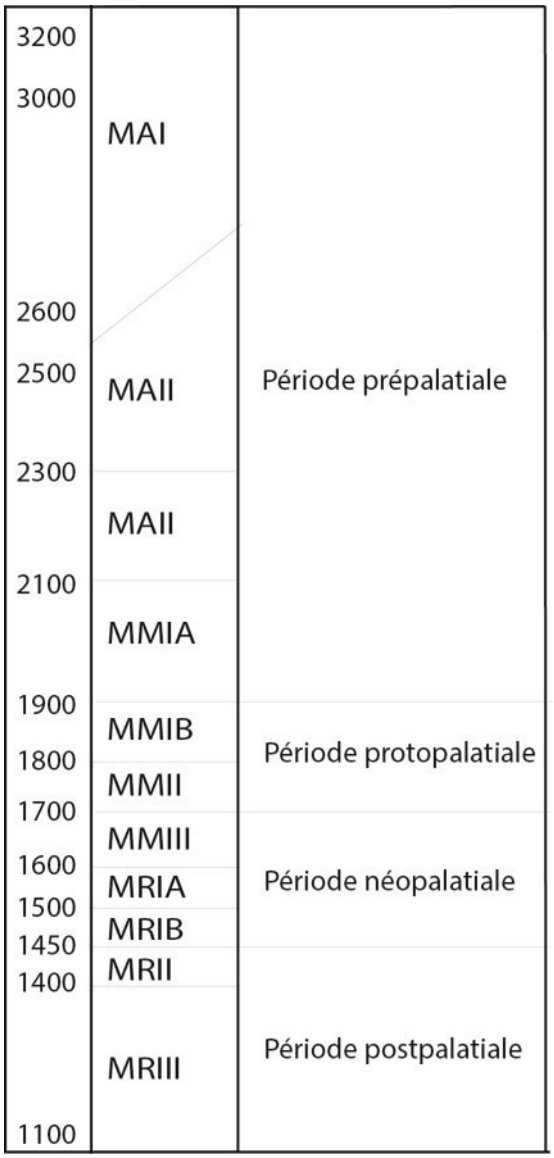

Figure 2: Chronology of Minoan Crete. Based on René Treuil, *et al.*, *Les civilisations égéennes du Néolithique et de l'âge du Bronze* (Paris: Presses Universitaires de France, 2008), 559 : 32. DAO : B. Rueff.

excavation also revealed a first for the island, a craft and administrative center. Both the architecture and objects are in an excellent state of preservation. The buildings, which were made of mudbrick and perishable materials, melted during the fire that destroyed the site and created a solid clay lid "protecting" the remains from agricultural activity and erosion.[15] Ceramic material, which is a relevant chronological and cultural marker in archeology, made it possible to date this complex to the MMII.[16] Despite the numerous architectural phases, notably between the north and south portions of building A,[17] the destruction by fire at the end of the MMII period provides a snapshot of the site's final moments of occupation.[18]

The function of buildings is relatively well known. 7
The monumentality of buildings A and B (840 and 540 m²), along with the existence of a "palatial" architecture and the presence of certain archival material in Cretan hieroglyphics, clearly suggest that these buildings had an administrative function linked to the first palace, which was located only 140 meters away.[19] Craftsmen's houses were also discovered, and represent a unique example for Minoan Crete (Potter's Workshop, Seals Workshop, Smelter's Workshop, South Workshop). Analysis of the distribution of the objects found suggests that craft activities took place in the basement and on the ground floor, in addition to the floors on which families lived.[20] Finally, a number of buildings, which at first glance appear to have multipurpose functions, have been identified as annex-storehouses, including buildings C and F.[21] The commonly accepted model for the *Quartier Mu* depicts craftsmen in the service of the palace, receiving in exchange the raw materials they needed for their daily life and production.[22]

Lighting Devices in Crete

Research has revealed the existence of two par- 8
allel lighting systems in Minoan towns: openings

15 Jean-Claude Poursat, *Guide de Malia au temps des premiers palais : le quartier Mu* (Paris: De Boccard, 1992), 10.

16 Poursat, Knappett, *La Poterie du minoen moyen II*, 194 (cf. note 14).

17 Jean-Claude Poursat, *Le Quartier Mu. 1, Introduction générale / Écriture hiéroglyphique crétoise* (Paris: P. Geuthner, 1978), 23.

18 Jean-Claude Poursat, *Vie quotidienne et techniques au minoen moyen II* (Athènes: École Française d'Athènes, 2013), 3.

19 Poursat, *Guide de Malia au temps des premiers palais*, 10 (cf. note 15).

20 Jean-Claude Poursat, *Fouilles exécutées à Malia : le quartier Mu. III, Les artisans minoens : les maisons-ateliers du quartier Mu* (Athènes: École française d'Athènes ; Paris: De Boccard, 1996).

21 Poursat, *Guide de Malia au temps des premiers palais*, 9 (cf. note 15).

22 Poursat, *Fouilles exécutées à Malia*, 152-153 (cf. note 20).

that provided natural light,[23] and devices for the production of artificial light, namely stationary and mobile hearths[24] and lamps.[25] While other artificial lighting systems were certainly used, given the observations made in various ethnographic contexts,[26] there is no proof of their use within the archaeological record. Devices such as a candlestick have not been discovered or identified so far (there is yet no functional study for items such as the possible "chandelier" from the protopalatial levels of Phaistos that is exhibited at the Heraklion Archeological Museum). We do not have, as we do for the Levant, examples of wall fixtures that could have served as lamp holders.[27] Finally, if torches existed, they have not been conserved. The only possible example was found on the levels dating from the Late Minoan III (LMIII) in another area of Malia, the *Quartier Nu*,[28] namely at the very end of the Bronze Age. In this context, the iconographic and textual evidence offers limited help. Cretan wall paintings, seals and sealings do not depict lighting devices. The texts in Linear B from the fourteenth to the twelfth centuries BC mention vegetable oils, although the use of these products as fuel can only be guessed at, as no specific function is mentioned.[29]

Lamps among the lighting devices of the Quartier Mu

In the *Quartier Mu* of Malia, lamps are the most common object among artificial sources of light. The great chronological homogeneity of this collection prompted our exclusive focus on these objects in this article. The analysis will then be extended to the other sources of artificial light that were found (hearths, braziers), as well as to openings for the best preserved buildings. During our research at Malia we studied 168 lamps, of which 159 are made of clay and 9 of stone (serpentine).[30] The excavator classified these objects according to their morphometric characteristics.[31] This typology proposes 9 types, sometimes divided into sub-types. Types 1 to 5 are clay hand lamps. Types 6 to 9 are clay lamps equipped with a tall stand, also referred to as pedestalled lamps (fig. 3). Stone lamps are not included in this typology, belonging instead to vase type 24 as published by Peter Warren,[32] although out of convenience we will refer to them as type 10.

23 Christofi, "L'Éclairage et l'aération," 530 (cf. note 13); Vasiliki Fotou, "Architecture néopalatiale en Crète : les bâtiments en dehors des palais et leurs fonctions" (Ph.D diss., Université Paris 1 Panthéon-Sorbonne., 2013), 1439.

24 Catherine Kopaka, "Aménagements intérieurs des habitations et activités domestiques en Crète et à Thera à l'âge du bronze" (Ph.D diss., Université Paris 1 Panthéon-Sorbonne, 1984), 416. Sandra Prevost-Dermakar, "Les Fours et les foyers domestiques en Égée au Néolithique et à l'âge du Bronze" (Master thesis: Université Paris 1 Panthéon-Sorbonne, 1993).

25 Richard P. Evershed, *et al.*, "Fuel for Thought? Beeswax in Lamps and Conical Cups from Late Minoan Crete," *Antiquity*, vol.71, n°274, 1997. Birgitta P. Hallager, "Some Light in LMIII Hand Lamps," *10th International Cretological Congress, Khania, 1-8 octobre 2006* (Khania, Φιλολογικός Σύλλογος "Ο Χρυσόστομος," 2011), 71-80. Joseph A. MacGillivray, *Knossos: Pottery Groups of the Old Palace Period* (London: British School at Athens, 1998), 153. Liliana Mercando, "Lampade, lucerne, braccieri di Festos," *Annuario della Scuola archeologica di Atene e delle missioni italiene in Oriente*, vol. 52-53, new series 36-37, 1978. Poursat, *Fouilles exécutées à Malia*, 268 (cf. note 20). Jeremy Rutter, "What Happened to the Lights? Changes in the Usage of Ceramic Lamps at Neopalatial and Early Postpalatial Kommos," *in* Giampaolo Graziado, *et al.* (eds.), *Φιλική Συναυλία. Studies in Mediterranean Archaeology for Mario Benzi*, (Oxford: Archaeopress, 2013), 31-38. Peter Warren, *Minoan Stone Vases* (Cambridge: University press, 1969), 280.

26 Laurent Chrzanovski, *De Prométhée à la Fée Électricité. Pour une sociologie de l'éclairage à travers les âges, les croyances et les continents* (Cluj: Académie Roumaine, Centre d'Études Transylvaines ; Cluj-Napoca: Argonaut, 2013), 327.

27 Ünsal Yalçin, Cemal Pulak, Rainer Slotta, *Das Schiff von Uluburun: Welthandel vor 3000 Jahren: Katalog der Ausstellung des Deutschen Bergbau-Museums Bochum vom 15. Juli 2005 bis 16. Juli 2006* (Bochum: Deutsches Bergbau-Museums, 2005), 332.

28 Jan Driessen (personal oral communication, August 2015), to whom I would like offer special thanks.

29 José L. Melena, "La Produccion de plantas aromaticas en Cnoso," *Estudios Clasicos*, 78, 1975. José L. Melena, "Olive Oil and Other Sorts of Oil in the Mycenaean Tablets," Minos: Revista de filologia egea, 18/1-2, 1983. Françoise Rougemont, "Oil at Nuzi and in the Linear B Records. A First Step Towards a Comparative Study," *in* Manfried Dietrich, Oswald Loretz (dir.), Ugarit-Forschungen. Interationales Jahrbuch für die Altertumskunde Syrien-Palästinas (Münster: Ugarit Verlag, 2011), 345-410.

30 A new research mission raised this number to 184 lamps, 169 of which are made of clay, and 15 of stone. This information was not considered in the spatial analysis, as it does not appear to modify the proportions represented by each group.

31 Poursat, *Fouilles exécutées à Malia*, 121-123 (cf. note 20).

32 Warren, *Minoan Stone Vases*, 49-60 (cf. note 25).

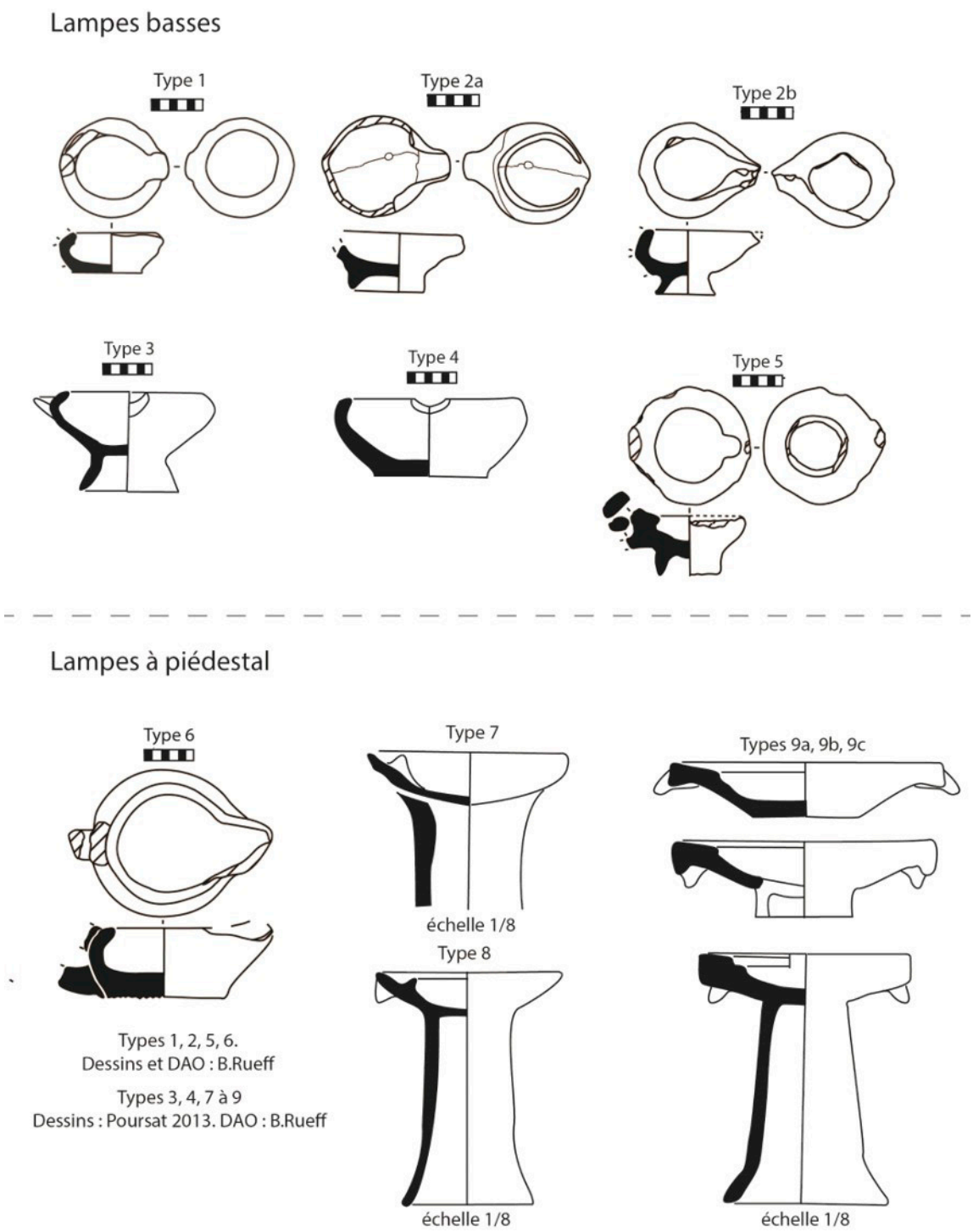

Figure 3: Typology of clay lamps from the *Quartier Mu* of Malia.

10 Within this group, types 2 and 9 include a broader range. Type 2 includes lamps with a low base, straight truncated spout, and loop handle opposite the spout. This group is further divided into two sub-categories: type 2a whose base is columnar in shape, and type 2b whose base is conical. Type 9 includes three sub-types: pedestalled lamps with a concave rim below, equipped with vertical lugs and two wick cuttings (type 9a), pedestalled lamps with a concave rim below, equipped with two diagonal lugs and two wick cuttings (type 9b), and finally pedestalled lamps with a raised edge, equipped with vertical lugs and two wick cuttings (type 9c). If we do not take into consideration these morphological details, which apparently did not have an impact on how the lamps were used, one could say that four categories of forms exist: hand lamps with a spout, handle, and rim turned inwards; hand lamps with a spout, handle, and

Figure 4: Spatial distribution of lamp types and functional characterization of buildings. Based on Poursat 2013. CAD: B. Rueff.

hollow rim; lamps with two spouts, two handles, and an open form; and finally pedestalled lamps with one or two spouts, one or two lugs, and a flat rim.

11 Publications offer no clear distinction between objects discovered *in situ* on the ground floor and the semi-basement, and those fallen from upper floors.[33] We will therefore propose a distribution by building, following Jean-Claude Poursat's approach (fig. 4). Distribution analysis of each lamp type in the environment shows that there are many hand lamps of type 1 and 2 in building A. Their association with tableware in this space could indicate their use during feasts or ceremonies.[34] Types 3 to 7, which are fairly rare, can be found in buildings A, B and D, craftsmen's houses, and in the east and west outdoor areas.[35] Type 8 and 9 lamps, which had hitherto been discovered in funerary contexts[36]—and for type 8 in the "MMII sanctuary" contemporary with the *Quartier Mu*—were very present in the ceremonial areas of building A,[37] but were also found in buildings B, D, and E, in addition to the South Workshop and Potter's Workshop. Building B also provided a few stone specimens.[38]

33 Roxane Dubois, "Le Quartier Mu (Malia, Crète). Étude fonctionnelle d'un important complexe archéologique du Minoen Moyen IIB" (Master thesis, Université catholique de Louvain, 2017).

34 Poursat, *Fouilles exécutées à Malia*, 124 (cf. note 20).

35 *Id.*

36 Pierre Demargne, *Fouilles exécutées à Mallia : exploration des nécropoles, 1921-1933* (Paris: Libr. orientaliste P. Geuthner, 1945), 71.

37 Poursat, *Fouilles exécutées à Malia*, 124 (cf. note 20).

38 *Id.*

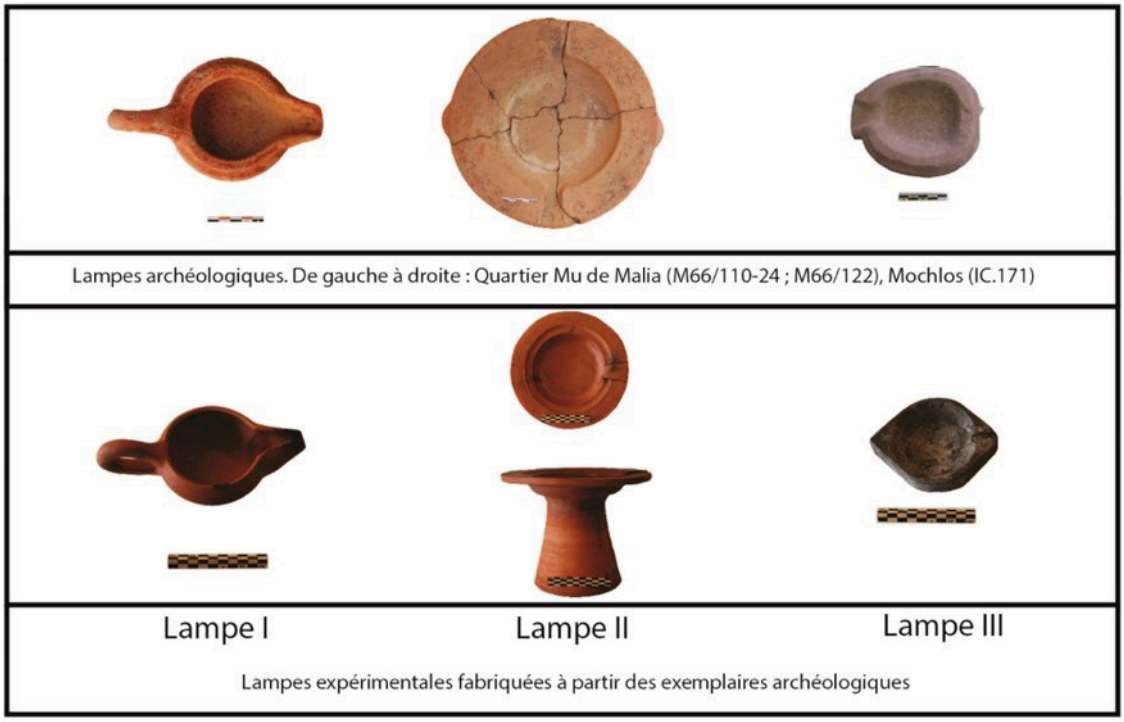

Figure 5: Archaeological and experimental lamps.

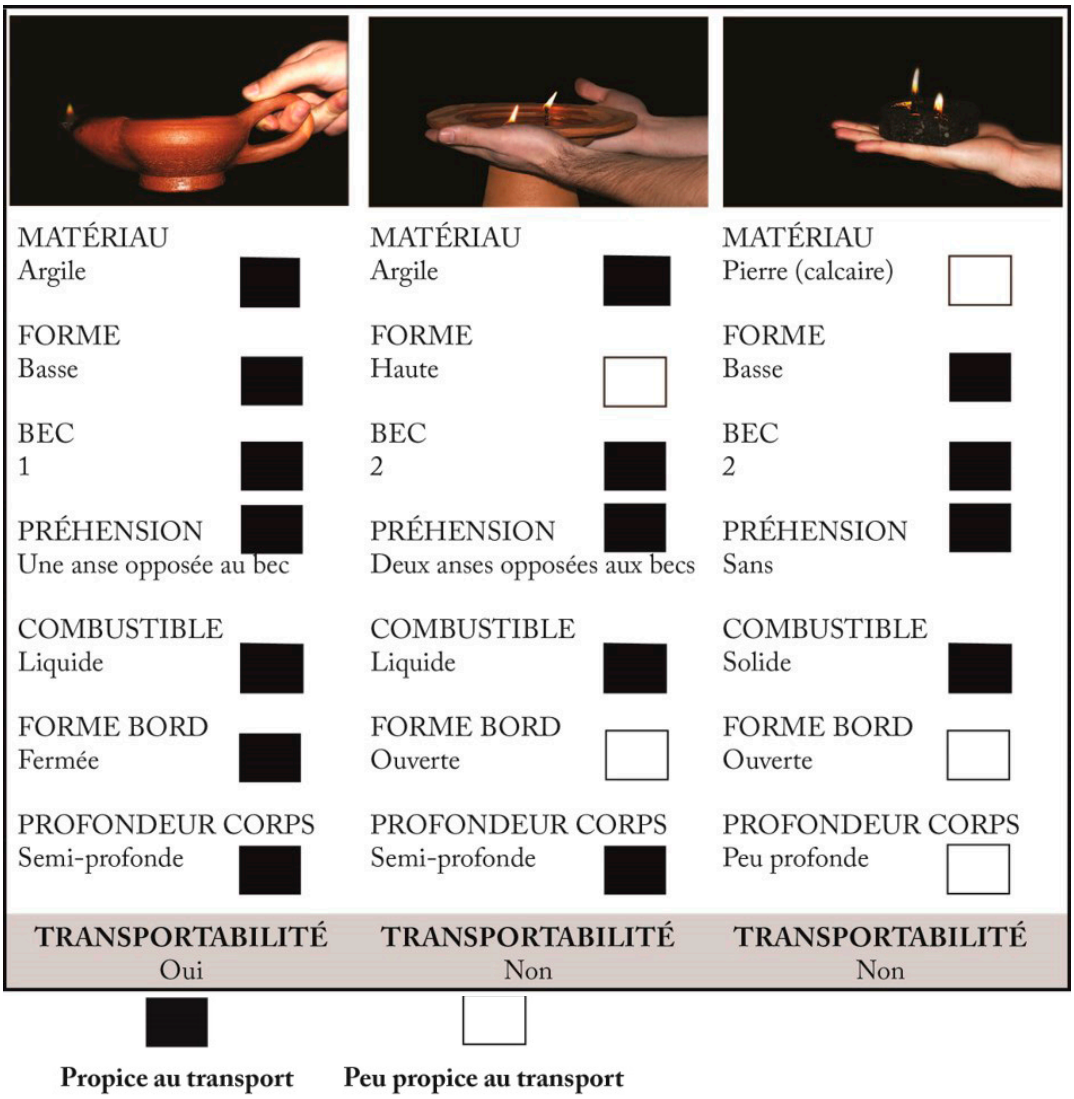

Figure 6: Mobility criteria observed during experimental tests of lamp mobility.

DEFINING THE FUNCTIONING OF LAMPS: BURN TIME AND TRANSPORTABILITY

12 As part of an experimental program, we studied both how lamps function as artificial lighting devices, as well as how they were used in the context of everyday life activities. Three replicas (one made of stone and two of clay) were produced, based on specimens discovered in the archeological record (fig. 5): type 2 (Lamp I) and type 10[39] (Lamp III) hand lamps, and a type 9 pedestalled lamp (Lamp II).

Transportability

13 Assuming the traditionally adopted division in typologies between hand lamps and pedestalled lamps, we firstly tried to define criteria of transportability for these objects. An initial experiment, conducted with manually held lamps, involved moving with each of the experimental copies through the dark inside a Parisian apartment, while using two types of fuel attested in the paleoenvironmental record, namely olive oil[40] and pork fat.[41] The use of these two materials, one liquid and the other solid, helped to explore the impact of fuel consistency on transportability. Linen, which is mentioned among other vegetal substances in Linear B tablets,[42] was used to produce twisted wicks based on a process validated by a number of experimental programs.[43]

14 This experiment showed that a lamp is easily transportable when only one hand is needed to hold it, which allows for simultaneously completing other actions (opening a door for instance). The orientation of the lamp's body and/or bowl depth also emerged as discriminating criteria. The body must be sufficiently deep and/or the rim must curve inward to prevent the fuel from spilling. Finally, in order to be moved, the lamp must be relatively compact, which is to say its weight and dimensions must not be a constraint during transport. When these characteristics are all present, the nature of the fuel does not make a major difference. The initial solidness of animal fat and beeswax, which could at first glance seem to be a factor suitable for mobility, is not very useful in reality, as the flame's heat melts the materials. According to these observations, lamp A is suitable for transport, as it can be moved with one hand and has a closed rim, thereby preventing the fuel from spilling over. On the contrary, type 9 and 10 lamps are difficult to move due to their open form, and bulky size (Lamp II) and weight (Lamps II and III) (fig.6).

Burn Time

15 In the second experiment, we sought to measure burn time (fig. 7). The parameters affecting this technical aspect were defined in a series of

39 Jeffrey Soles, Kostis Davaras (eds.), *Mochlos IC: Period III. Neopalatial Settlement on the Coast: The Artisans' Quarter and the Farmhouse at Chalinomouri. The Small Finds*, (Philadelphia: INSTAP Academic Press, 2004) ; Photograph taken from Élise Morero, "Artisanat lapidaire en Crète minoenne. Les techniques de fabrication des vases en pierre" (Ph.D diss., Université Paris 1 Panthéon-Sorbonne, 2009), 22. Élise Morero, *Méthodes d'analyse des techniques lapidaires. Les vases de pierre en Crète à l'âge du Bronze (IIIe-IIe millénaire av. J.-C.)* (Paris: Publications de la Sorbonne, 2016), 311.

40 Harriet Blitzer, "Olive Cultivation and Oil Production in Minoan Crete," *in* Marie-Claire Amouretti, Jean-Pierre Brun (dir.), *La production de vin et d'huile en Méditerranée. Actes du symposium international organisé par le centre Camille Jullian (Université de Provençe –C.N.R.S.) et le Centre archéologique du Var (Aix-en-Provençe et Toulon, 20 -22 November 1991)* (Paris: De Boccard, 1993), 55-64. Sytze Bottema, Anaya Sarpaki, "Environmental Change in Crete: a 9000-Year Record of the Holocene Vegetation History and the Effect of the Santorini Eruption," *The Holocene*, vol. 13, n° 5, 2003.

41 Katerina Trantalidou, "Animals and Human Diet in the Prehistoric Aegean," *in* David A. Hardy (eds.), *Thera and the Aegean World III, volume two, earth sciences. Proceedings of the third international congress, Santorini, Greece, 3-9 September 1989* (London: The Thera Foundation, 1990), 392-403.

42 Marie-Louise Nosch, "The Textile Logograms in the Linear B Tablets: Les idéogrammes archéologiques des textiles», *in* Pierre Carlier, *et al.* (dir.), *Études mycéniennes 2010 : actes du XIIIe Colloque international sur les textes égéens, Sèvres, Paris, Nanterre, 20-23 septembre 2010* (Pise: F. Serra, 2012), 305-346. Françoise Rougemont, "Flax and Linen Textiles in the Mycenaean Economy," *in* Carole Gillis, Marie-Louise Nosch (eds.), *Ancient textiles: production, craft and society: Proceedings of the first International conference on ancient textiles, held at Lund, Sweden, and Copenhagen, Denmark, on March 19-23, 2003* (Oxford: Oxbow books, 2008), 46-49.

43 Dorina Moullou, *et al.*, "Lighting in Antiquity," *Balkan Light 2012, 3-5 October 2012,* (Belgrade: s.m., 2012), 237-244.

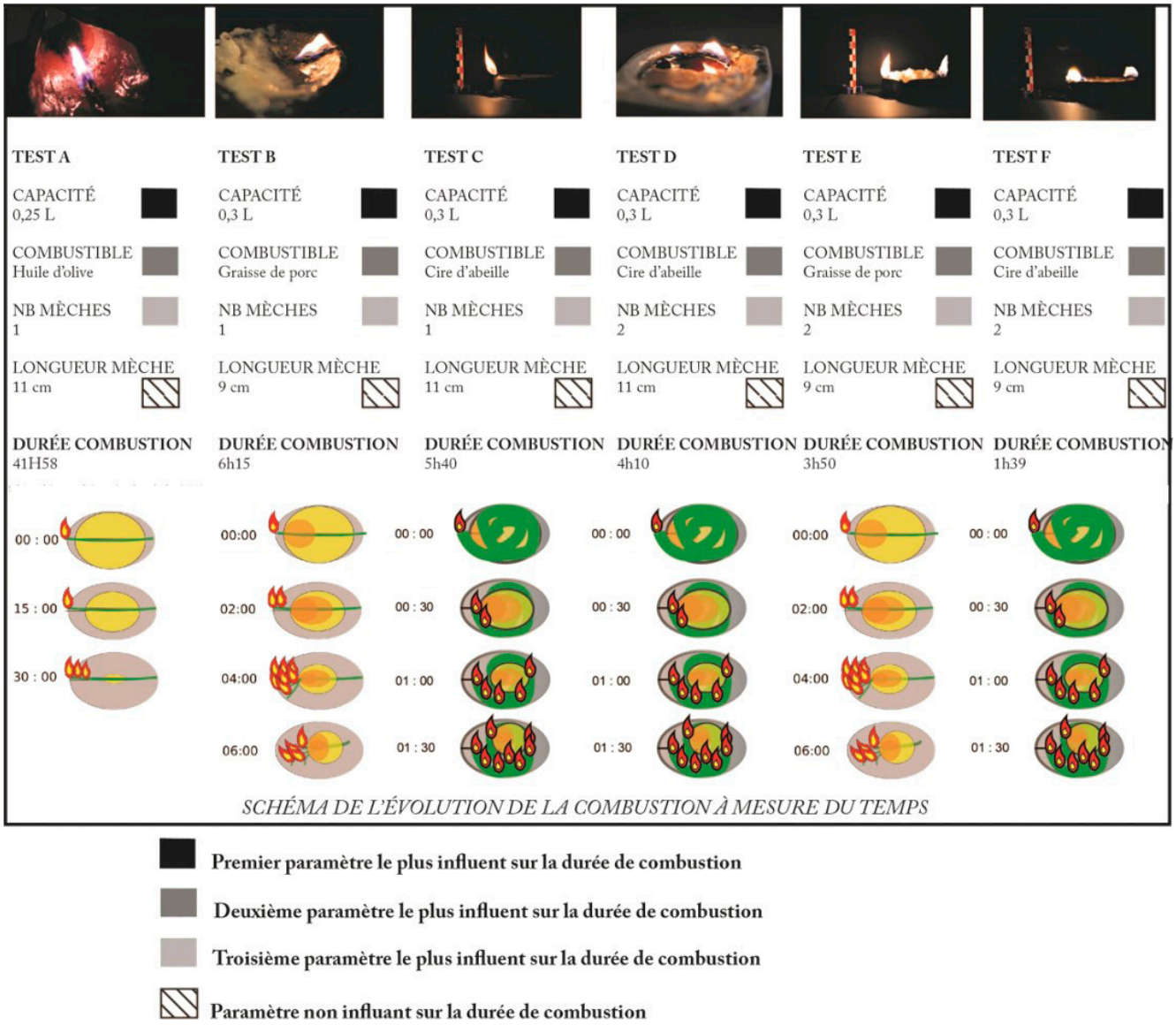

Figure 7: Evolution of the burning process observed during the experimental reproduction of burn time.

six tests, noted A to F. The materials used were the same as in the previous experiment, with the addition of beeswax. This substance was identified by residue analysis in lamps from the Minoan site of Mochlos.[44] The experiment consisted of allowing combustion to proceed without intervening on the flame. Photographs were taken every twenty minutes to document the evolution. The results show that lamp capacity is the primary parameter affecting a flame's lifespan. Capacity was measured using styrofoam balls,[45] which indicated that lamp I has a capacity of 0.25 liters, while lamp III has a capacity of 0.03 liters.[46] In test A, in which lamp I was used with olive oil, burn time measured 41:58, while in test C, in which lamp III was used with olive oil, it was limited to 5:40. The type of fuel also had an impact, for with an equal number of wicks (1), animal fats (tests B and C) ran out more

44 Evershed, *et al.*, "Fuel for Thought?" (cf. note 25).

45 Styrofoam balls, whose usefulness has been proven by a number of functional analyses of ceramic objects, have the distinctive characteristic of adopting physical behavior similar to that of water. For the protocol used, cf. Cydrisse Cateloy, "Trade and Capacity Studies in the Eastern Mediterranean: the First Levantine Trade Amphorae," *in* Bernard Knapp, Stella Demesticha (eds.), *Mediterranean Connections: Maritime Transport Containers and Seaborne Trade in the Bronze and Early Iron Ages* (New York: Routledge, 2017), 39-55.

46 In this experiment, lamp II was not used, as two bowls of different size were enough to measure the importance of capacity as a parameter (I = deep; III = shallow).

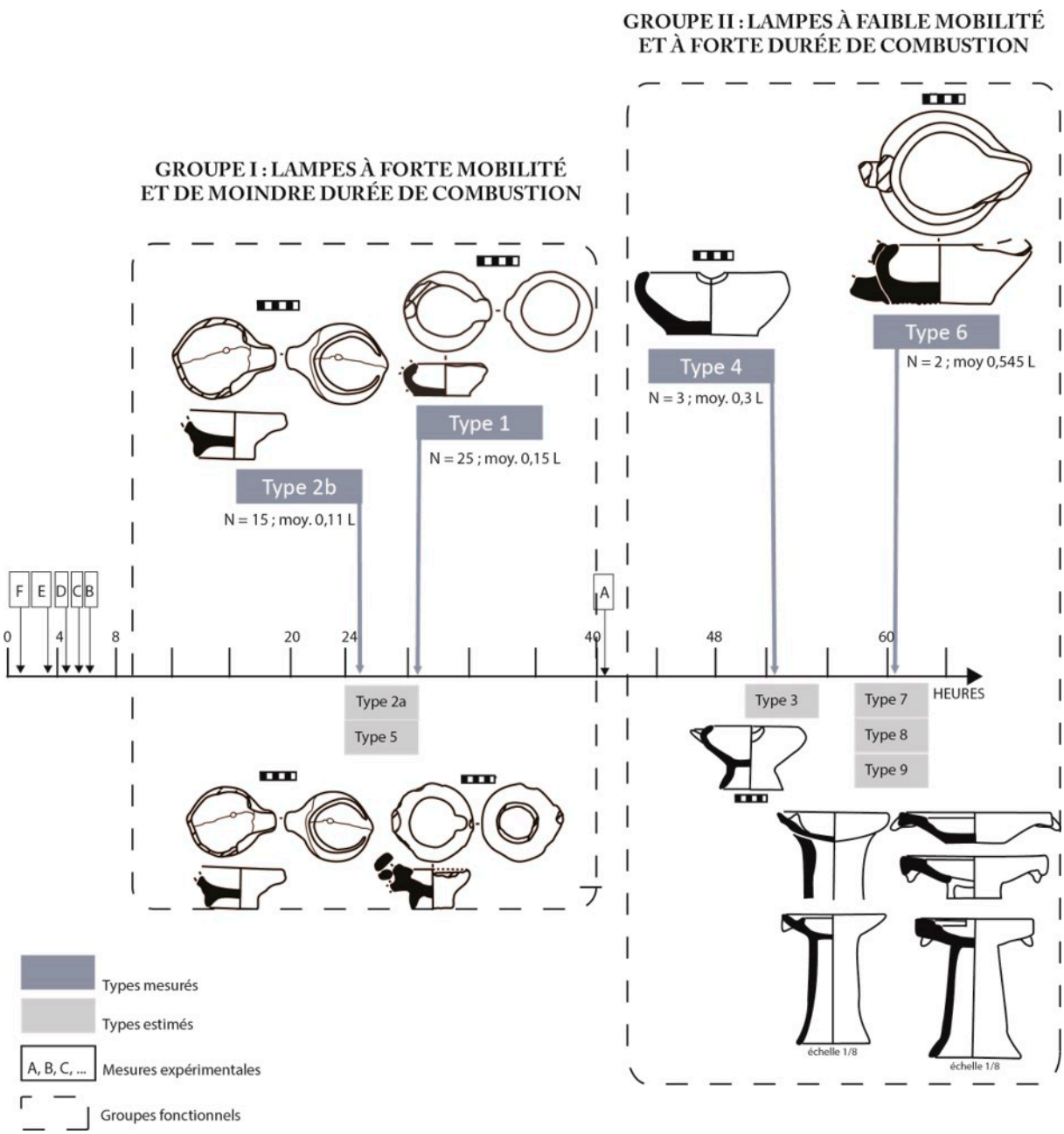

Figure 8: Burn time at the *Quartier Mu* of Malia based on measurements obtained through experimental reproduction. Capacity measurements were carried out with styrofoam balls, whose physical behavior is similar to water.

slowly than beeswax (test D). The same results were obtained for lamps using two wicks (tests E and F), as suggested by the presence of two spouts. The differential lifespan of a flame for two fuels of the same type is related to how the fuel is absorbed. The wick's capillary action is greater with liquid materials than solid ones. For instance, the flame lasts longer near the spout when olive oil is used, as the fuel "rises" regularly along the length of the wick. Conversely, the flame has a tendency to "move" along the wick in order to reach the required fuel when animal fats or beeswax in particular are used. Melting takes place randomly, which consequently distributes the flame along the entire wick, thereby reducing burn time.

Despite these "poor" technical characteristics, 16
beeswax was indeed used as fuel in the lamps of Mochlos. One may assume that this material offered other qualities, for instance its odor. Along the same lines, light measurements conducted with a photometric cell in a series of 23 tests with vegetable oils, animal fats, and beeswax, using wicks made of linen, hemp, jute and papyrus demonstrated that the type of fuel determined the color

of the flames produced.[47] This information suggests that light perception could also have influenced the choice of materials used to produce it.

17 The experimental program conducted on transportability and burn time helped explore how lamps from the *Quartier Mu* of Malia functioned. The use of styrofoam balls to measure the capacity of a group from this collection (N=45) established the average capacity for a number of morphometric types (1, 2b, 4, 6). The results, which are supported by the experimental tests, demonstrate that the average burn time for lamps from the *Quartier Mu* of Malia, using a liquid fuel and with no human intervention on the wick, ranged from 20 (type 2b) to 60 hours (type 6) (fig. 8). According to our experiment, the burn time for type 4 (48h) was closer to that of type 6 (60h) than to types 1 and 2 (respectively 25h and 29h). As a result, functional analysis suggests that the strict division between lamps both without (types 1 to 5) and with (types 6 to 10) a stand must be reconsidered. Two functional groups appear: lamps with low capacity and high transportability (types 1, 2, 5), and lamps with high capacity and low transportability (types 3, 4, 6, 7, 8, 9) (fig. 8).

18 This assessment is based on the assumption of exclusive use of vegetable oils, which is naturally a simplification. A study of soot deposits, which are powerful indicators of fuel type, is currently underway. Modelization based on solid and semi-solid fuels can be conducted where required. For the time being, the results differ in particular from those published by Marie-Claire Amouretti,[48] who estimates a burn time of approximately 2h30 for ancient lamps with bowls of much smaller capacity. This data proved useful in grasping the spatial organization of lighting devices in the *Quartier Mu* of Malia.

ARTIFICIAL LIGHTING AND SPACES IN THE QUARTER

A luminous division of space?

19 The preferential associations of lamp types and buildings were depicted using a *matrigraphe Pourcentages de Valeur d'Indépendance,* called a matrigraphe PVI (fig. 9). In this type of representation, black squares indicate numerical overrepresentation, and white squares numerical underrepresentation. The gray squares indicate the average value of the number in question.[49]

20 The analysis included a relatively small group (N = 168) and encountered a major bias, namely the proportional inequality of groups by building (fig.10). However, these exploratory statistics seek to prove the relevance of transforming qualitative data (a lamp's function) into quantitative data (spatial distribution of morpho-functional types). We are aware of the limits of this approach, and plan to increase group size in a future study, notably by including collections from other sites from the same period.

21 In the *Quartier Mu*, lamp types 5 to 10 are overrepresented in the outdoor areas (north space, east and west roadways, west walkway, small east plaza, space IV1), buildings B and D, and the Potter's and Seals Workshops. Lamp types 1 to 4 are overrepresented in buildings A, C, E and F, the South Workshop, and the Smelter's Workshop. In view of the results from the experimental program, this means that lighting devices functioned in a binary manner within each of the buildings, by combining stationary lamps with medium or long burn time, and mobile lamps with shorter burn time. Type 1 to 4 hand lamps tend to be excluded in outdoor areas, buildings B to F, the South Workshop, and the Potter's Workshop, as do type 5 to 10 lamps with and without a stand. There are therefore two groups that correspond to Jean-Claude Poursat's typology.

47 Bastien Rueff, "Characterizing Lighting Ambiances through the Study of Lamps in Kommos City (Crete) during the Bronze Age (3200 – 1100 B.C.)," *in* Laurent Chrzanovski (eds.), *Vth ILA Congress, held at Sibiu (Romania), September 2015* (forthcoming).

48 Marie-Claire Amouretti, *Le Pain et l'huile dans la Grèce antique : de l'araire au moulin* (Paris: Les Belles Lettres, 1986), 190.

49 Bruno Desachy, "Explographe 1.0. Application de traitement graphique de tableaux de données sous LibreOffice Calc. Mode d'emploi. Document provisoire," [online], available at https://abp.hypotheses.org/le-programme-bassin-parisien/les-projets/les... (consulted on 30/03/2018), (n.p., September 2016)

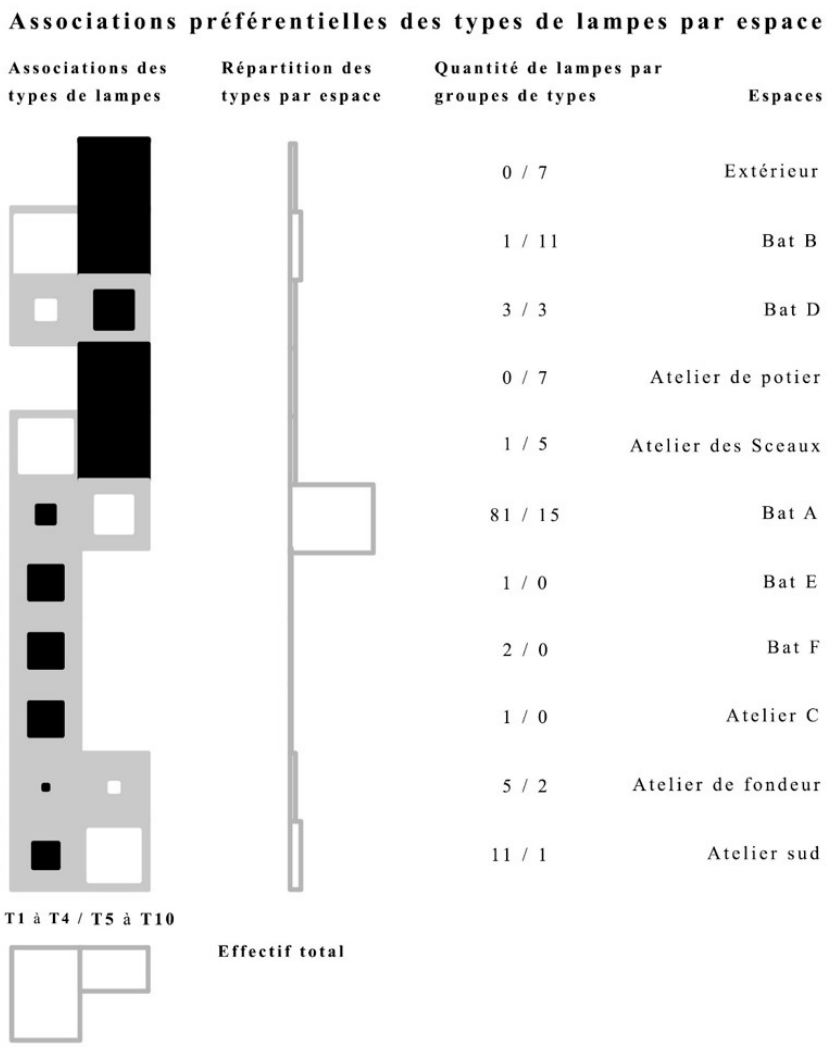

Figure 9: *Matrigraphe* of lamp type association per space. N = 168.

	Types 1 à 4	Types 5 à 10
Extérieur	0	7
Bâtiment A	81	15
Bâtiment B	1	11
Bâtiment D	3	3
Bâtiment E	1	0
Bâtiment F	2	0
Atelier C	1	0
Atelier de fondeur	5	2
Atelier de potier	0	7
Atelier des Sceaux	1	5
Atelier Sud	11	1
TOTAL	106	51

Figure 10: Distribution of the two functional lamp groups per space.

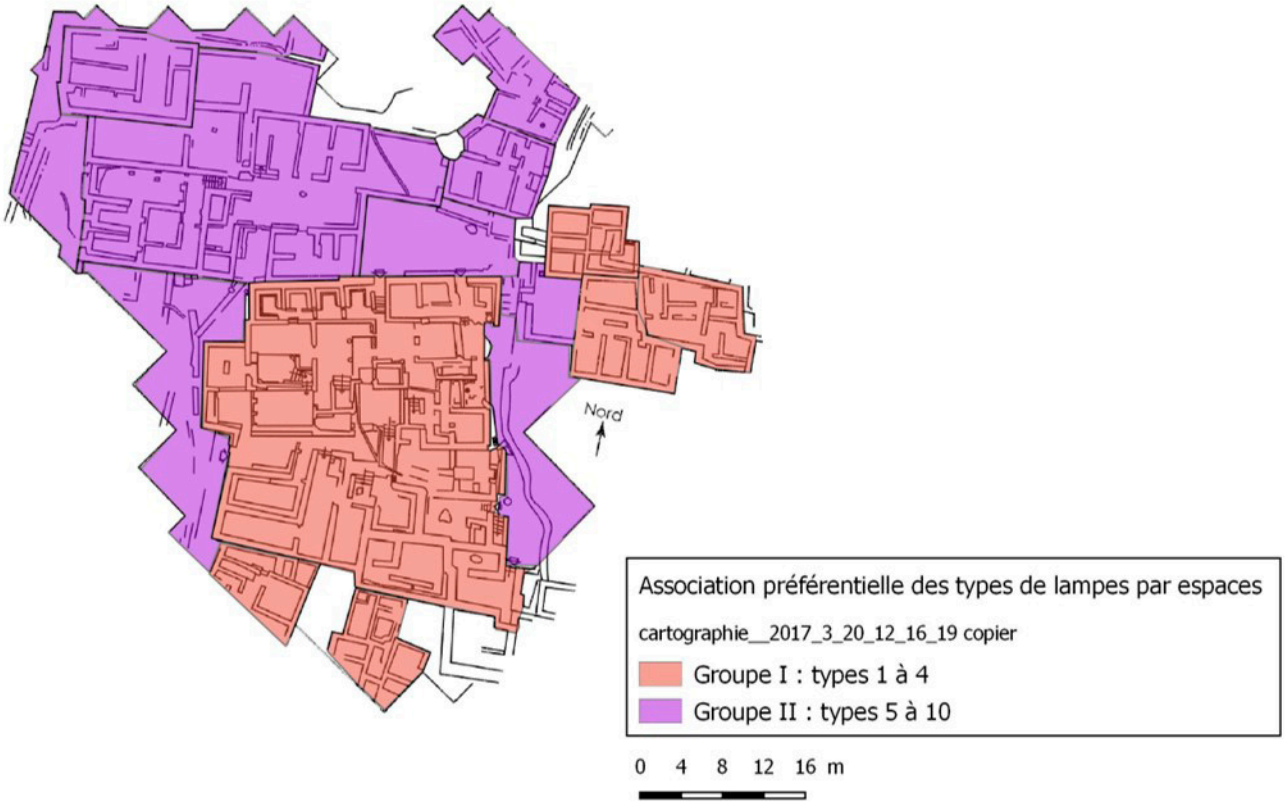

Figure 11: Spatial distribution of the preferential association of lamp groups in the *Quartier Mu* of Malia.

22 The cartography of these associations reveals two distinct areas (fig. 11). Group I (types 1 to 4) is located in the south of the quarter, while group II (types 5 to 10) can be found in the north, as well as in outdoor areas. This north area was therefore probably home to spaces where people spent time and engaged in activities, thereby requiring lighting that was both stationary and of long duration. The south of the quarter was most likely occupied occasionally, for instance in order to get supplies from storerooms, or for activities that did not require mobile or long lasting lighting. This analysis will be further developed in our research. We are notably interested in the north section of building A, where a number of pedestalled lamps were found. The ceremonial and staterooms identified here suggest activities that were more similar to those in the north of the quarter than in the south.

Light and darkness in the activities of the Quartier Mu. Initial results

Type 1 to 4 Lamps

23 The many occurrences of lamp types 1 and 2 in building A were analyzed in light of the "feast" activities that took place in this structure, based on the presence of vases for serving and consumption.[50] The overrepresentation of type 1 to 4 hand lamps in the South Workshop and Workshop C is noteworthy. The objects found in the South Workshop indicate that this space was the site of various craft activities, notably the production of stone and metal vases, and possibly objects made of bone.[51] Workshop C has been identified as a second smelter's workshop, notably due to the presence of a schist mold in a semi-basement, along with three oven tuyeres and two saws with schist blades, all located in the small courtyard VI4.[52] A cache beneath the floor of storeroom VI1 yielded three tripod bronze vases and a lead weight.[53] Hand lamps were nevertheless also present in the Smelter's Workshop. Given the apparent links between hand lamps and metallurgic activities within the three spaces discussed here, one can imagine

50 Poursat, *Fouilles exécutées à Malia*, 268 (cf. note 20).
51 Poursat, *Guide de Malia au temps des premiers palais*, 37 (cf. note 15).
52 *Ibid.*, 39. Poursat, *Le Quartier Mu*, 69 (cf. note 17).
53 *Id.*

that the lamps were used in the production of metal objects. The experimental research of Romain Prévalet,[54] in conjunction with ethnographic analogies,[55] suggests the use of lamps as blowtorches in goldsmithery.

24 With regard to buildings E and F, the objects discovered indicate that the former was an outbuilding of building A used for storing food supplies, and the latter a domestic building for both food storage and preparation.[56] In the absence of semi-finished and finished products, the discovery of two crucibles is not sufficient to attest to specialized metallurgic activity in building F.[57] The links between lamps with low-to-medium capacity and high-to-medium transportability with domestic buildings and annexes could indicate that these spaces were not intended to be living spaces frequented by many people. At this stage of research, it is possible to imagine rooms that were visited occasionally in order to stock up on raw materials and store objects.

Type 5 to 10 Lamps

25 The overrepresentation of stationary light sources outside is interesting, for it suggests nocturnal lighting. It could also help identify "public" and "private" spaces, the former within buildings, and the latter outside. These notions have been explored by Clairy Palyvou,[58] who has used research by modern architects[59] to propose a distinction between "public" and "private" Minoan spaces from the viewpoint of administrators and users. Surface area, access, and situation (interior or exterior) emerge as determining elements. According to this model, the road located outside of buildings can be seen as a "public urban" space, which is to say a space used by all without restriction of access, whereas the interior of buildings pertains to the family unit, and is therefore "private." The inner courtyard of building B is designated, according to this typology, as a "public group" space to which access is not limited, even though it can be used only by a restricted number of individuals, owing to its particular position within a small enclosed block.

26 Building D is identified as a storehouse and annex of building B.[60] Vases with Egyptian-inspired patterns, along with fruit dishes and stone pedestalled lamps were found coming from the upper floor in room VII4. As things stand, it is impossible to determine whether the pedestalled lamps were stored and/or used here. The overrepresentation of pedestalled lamps in the Seals and Potter's Workshops seems to indicate that stationary and long-lasting lighting was sought here. With respect to the Potter's Workshop, it has been suggested than the pedestalled lamps could have been produced by the craftsman.[61] However, soot deposits found in two of the four pedestalled lamps[62] indicate that they may also have been used to provide light for the potter while working (fig. 12).

54 Romain Prévalet, "La Décoration des pièces d'orfèvrerie-bijouterie en Méditerranée orientale à l'âge du Bronze : techniques, productions, transmissions" (Ph.D diss., Université Paris 1 Panthéon-Sorbonne, 2013).

55 Olivier Untracht, "L'Orfèvre indien," *in* Laurence Mattet (dir.), *Inde : Bijoux en or des collections du musée Barbier-Mueller* (Paris: Somogy éditions d'art, 2004), 62-73.

56 Poursat, *Guide de Malia au temps des premiers palais*, 48 (cf. note 15).

57 Dubois, "Le Quartier Mu (Malia, Crète)," 108 (cf. note 33).

58 Clairy Palyvou, "Outdoor Space in Minoan Architecture: 'Community and Privacy'," Gerald Cadoga, Eleni Hatzaki, Adonis Vasilakis (eds.), *Knossos: Palace, City, State. Proceedings of the conference in Herakleion organized by the British school at Athens Studies and the 3rd Ephoreia of prehistoric and classical antiquities of Herakleion, in November 2000, for the centenary of Sir Arthur Evans' excavations at Knossos* (London: British School at Athens studies, 2004), 207-217.

59 Serge Chermayeff, Christopher Alexander, *Community and Privacy: toward a New Architecture of Humanism* (Hardmondsworth, Ringwood: Penguin Books, 1966), 255.

60 Poursat, *Le Quartier Mu*, 198 (cf. note 17).

61 Poursat, *Vie quotidienne et techniques au minoen moyen II*, (cf. note 18).

62 A hand lamp (80A80) and two pedestalled lamps (80A107 ; 80A103-106) were published (respectively nos. A101, A143, and A163 in Jean-Claude Poursat, *Vie quotidienne et techniques au minoen moyen II,* 216-218 (cf. note 18); however, after visual examination, we propose recognizing an additional pedestalled lamp (80A107_bis) and hand lamp (80A107_ter).

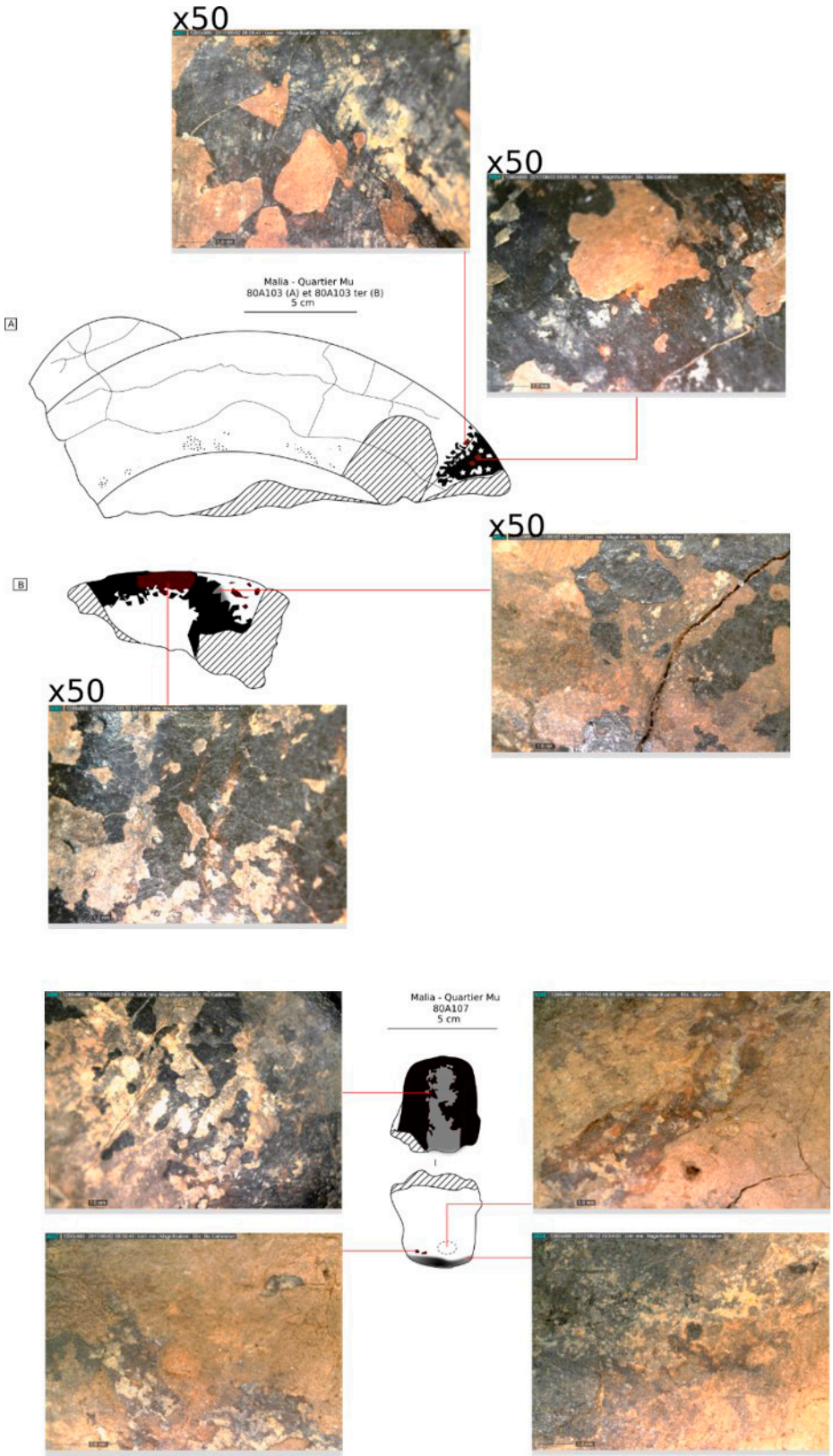

Figure 12: Carbon deposits on the two pedestalled lamps found within the Potter's workshop (80A103 ; 80A106). These use-wear traces provide information regarding the use of the lamps, perhaps for the potter's production. Their shininess is due to a thin layer of engobe.

CONCLUSION

27 The very numerous lamps of the *Quartier Mu* in Malia and their spatial distribution suggest that they were used both during the daytime and nighttime.

28 Our experimental program revealed two functional groups. The first includes lamps that are easy to transport, but whose burn time is limited. The second includes lamps whose use was more stationary, but whose lighting duration could be very long (up to two consecutive days). The statistical and cartographic analysis of lamp distribution in the environment helps to establish a view of two spaces that correspond to this functional distinction, strongly suggesting that we interpret them as having been occupied in different fashion. In the south of the quarter, there is an overrepresentation of mobile lamps offering limited burn time. One can assume that this space was frequented occasionally, with short stays. Stationary lamps offering longer burn times are overrepresented in the north of the quarter, including in outdoor areas. This space could therefore have been much more suitable for daily use.

29 From the point of view of craft activities, a few suggestions have been made: hand lamps could have been part of metallurgic production, with pedestalled lamps lighting seated activities, such as the production of clay vases. These hypotheses of course call for subsequent testing, however they highlight a promising avenue of investigation in determining the location of production zones within Minoan settlements, which still remains a major problem.[63]

30 In any case, in buildings with confined rooms clustered together, the transition from darkness to light was instantaneous. It is an aspect that should be taken into account when exploring lived spaces in ancient societies. This dialectic deserves to be explored further through an ethnoarcheological approach. In a number of areas in the world, there are places without electricity where people continue to use oil lamps and candles for lighting. How do darkness and light accompany everyday activities (cooking, working, etc.)? Further ethnographic studies would help answer this question.

63 Don Evely, “Minoan Craftsmen: Problems of Recognition and Definition,” Elizabeth Bayard French, Kenneth Wardle (eds.), *Problems on Greek Prehistory, Papers presented at the Centenary Conference of the British School of Archaeology at Athens, Manchester, April 1986*, (Bristol: Bristol Classical Press, 1988), 397-415.

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JEHRHE

Journal of Energy History
Revue d'histoire de l'énergie

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ENGLISH TRANSLATION OF
"Jeux de lumières et d'obscurités de la lanterne publique : entre renforcements sécuritaires, extinctions par économie et limites des innovations techniques (Paris, Barcelone, 18e siècle)" *by Arby Gharibian.*

POST DATE
22/05/2019

ISSUE NUMBER
JEHRHE #2

SECTION
Special issue

THEME OF THE SPECIAL ISSUE
Light(s) and darkness(es): Shifting historical relations

KEYWORDS
Ville, Territoire, Lumière, (éclairage), Innovation

DOI
in progress

TO CITE THIS ARTICLE
Benjamin Bothereau, "The public lantern's interplay of light and darkness: between security-based expansions, savings-based extinguishings, and the limitations of technical innovation (Paris, Barcelona, 18th C.)", *Journal of Energy History/Revue d'Histoire de l'Énergie* [Online], n°2, published 22 May 2019, consulted XXX, URL: energyhistory.eu/en/node/132.

The public lantern's interplay of light and darkness: between security-based expansions, savings-based extinguishings, and the limitations of technical innovation (Paris, Barcelona, 18th C.)

Abstract
The gap between the early modern policing ideal of a homogeneous—"geometric"—perception of the urban fabric thanks to street lighting, and the persistent reality of dark areas, was particularly clear during periods of turmoil in the public order. In both Paris and Barcelona, the revolutionary episodes of the eighteenth century severely tested the new streetlamps, known as reflector lanterns ("lanternes à réverbères"). This article will explore, by adhering as closely as possible to the object, the limitations of technical innovation in public lighting.

Plan of the article

ISSN 2649-3055

INTRODUCTION

1 The intention of evenly lighting the entire city, through the continual installation of lanterns in accordance with the growing urban fabric, drove Paris lighting policy since the institutionalization of public lighting in 1667. In the early eighteenth century, the decision of the Conseil from July 26, 1704 reaffirmed this objective: "for both the convenience and safety of the public, as well as the adornment and decoration of the city, all streets, plazas, and other public spaces must be evenly lit and cleaned.[1] This should be connected to the new policing practices of the time, which recommended a systematic approach to the urban territory.[2] Through the division of the city–its "geometric abstraction"[3]–the street became disconnected from its social uses and locality. Space was treated as a "neutral" variable. This desire to neutralize space through lighting was actually part of a larger reality of developing the territory, which was understood as a homogeneous space for economic and political action. The new administrative culture of the state based on rational thought, on abstraction and mathematics,[4] brought about changes in scale, both national and local. It spread toward the city, the capital in particular. The systematic lighting of all Parisian streets was therefore the expression of a rational interpretation and understanding of space, in this case of urban space.

2 A cultural history of the night has been conducted since the 1990s. Initiated by Wolfgang Schivelbusch[5] and Simone Delattre for nineteenth-century Paris,[6] and followed by the work of Alain Cabantous[7] and Craig Koslofsky,[8] it has included the early modern period within a broader temporal study of nightlife in royal courts, nocturnal sociabilities, and the impact of lighting on criminality—what is generally referred to as the nocturnalization(s) of societies. In keeping with this work, we will use an approach rooted in the history of technology to explore the materiality of lighting measures, and the effect it had in terms of casting both light and shadow, in short of illumination and darkening.

3 While the invaluable work of Auguste-Philippe Herlaut[9] took an early interest in this technical dimension of urban lighting, it suffered from a linear approach to progress, and was based solely on institutional sources. The issues that opposed the general contractor for public lighting in Paris and its adversaries played a central role. Our goal is not at all to update this institutional history, but rather to propose a technical history of lighting that is fully situated within its context, which is to say inclusive of not just institutional aspects, but also social, political, and cultural ones.[10]

4 The renewal of French historiography on the early modern police, led by Vincent Milliot, Brigitte Marin, and Vincent Denis, provides crucial interpretive keys to this end.[11] Jean-Luc-Laffont and

1 Bibliothèque nationale de France (BNF), Département des manuscrits, Français 21684: "il est nécessaire, tant pour la commodité et la sûreté du public, que pour l'embellissement et la décoration de la ville, que toutes les rues, places et autres lieux publics soient également éclairés et nettoyés."

2 On this approach to the police and urban space, see Paolo Napoli, *Naissance de la police moderne. Pouvoir, normes, société* (Paris: La Découverte, 2003).

3 Brigitte Marin, "Administrations policières, réformes et découpages territoriaux (XVIIe-XIXe siècle)," *MEFRIM*, 115/2, 2003.

4 Marc Desportes, Antoine Picon, *De l'espace au territoire. L'aménagement en France XVIe-XXe siècle* (Paris: Presses de l'ENPC, 1997).

5 Wolfgang Schivelbusch, *La Nuit désenchantée* (Paris: Gallimard, 1993).

6 Simone Delattre, *Les Douze heures noires. La nuit à Paris au 19e s.* (Paris: Albin Michel, 2000).

7 Alain Cabantous, *Histoire de la nuit (17e-18e s.)* (Paris: Fayard, 2009).

8 Craig Koslofsky, Evening's Empire. *A History of the Night in Early Modern Europe* (Cambridge: Cambridge University Press, 2011).

9 Auguste-Philippe Herlaut, "L'Éclairage des rues à Paris à la fin du 17e et au 18e siècles," *Mémoire de la Société de l'Histoire de Paris et de l'Île de France, vol. XLIII, 1916, and by the same author, L'Éclairage de Paris à l'époque révolutionnaire* (Paris: Mellotée, 1933).

10 A dissertation was recently defended on eighteenth-century public lighting on a national scale (outside of Paris): Sophie Reculin, "L'Invention et la diffusion de l'éclairage public dans le royaume de France (1697-1789)" (Ph.D dissertation, Université Charles-de-Gaulle Lille 3, 2017).

11 Vincent Milliot, "Histoire des polices. L'ouverture d'un moment historiographique," *Revue d'histoire moderne et contemporaine*, vol. 54, n°2, 2007.

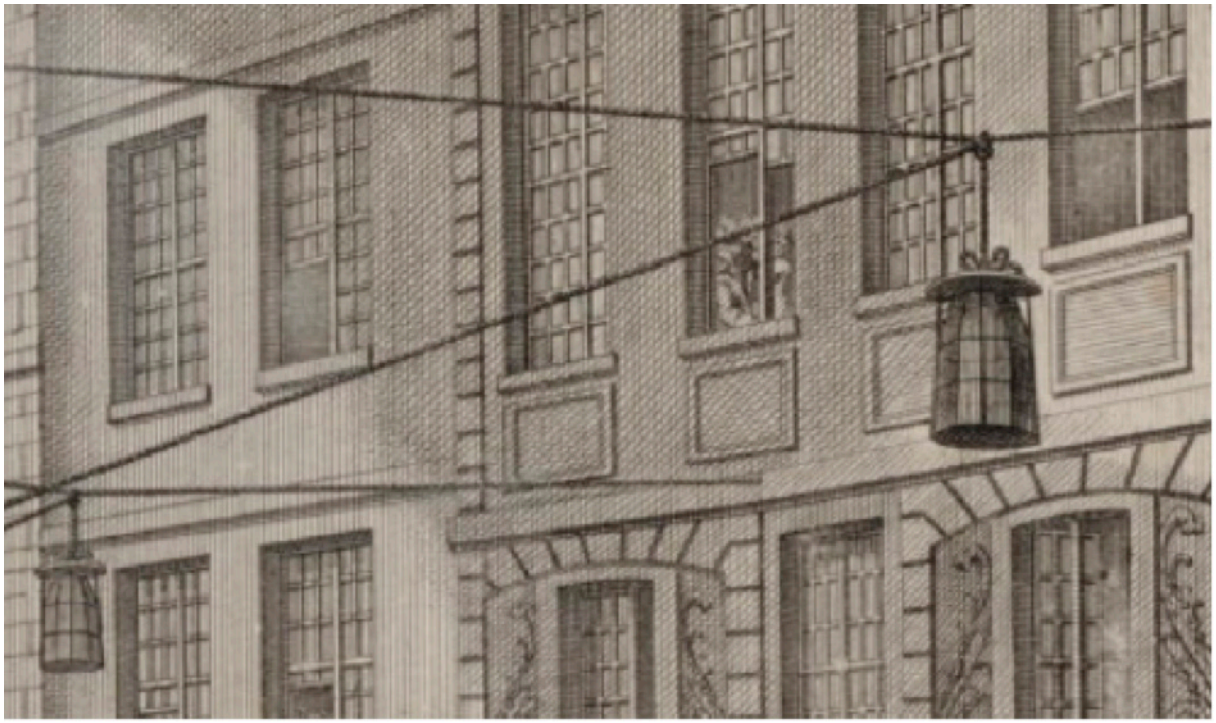

Figure 1: Bucket Lantern. Detail from an engraving by Antoine Humblot, Rue de Quincampoix, made at G. Duchange engraver to the King, rue Saint-Jacques, Paris, 1720. Source: Bibliothèque Nationale de France, Paris [RESERVE FOL-QB-201]).

Catherine Denys, who devoted a sub-chapter to public lighting in their respective theses on Toulouse and the cities along the French-Belgian border, have clearly demonstrated that illumination was a major instrument of police control.[12] We will compare Paris and Barcelona[13]–two cities that had a chronological gap (public lighting appeared in 1757 in Barcelona, nearly one century after Paris), but were connected due to French influence on the technical administration of Bourbon Spain–and identifying what was shared by as well as unique to each context. This comparison will especially include moments of disorder, with the major episode of the *avalot de las quintes* Catalan revolt in 1773, and the French Revolution in 1789. We will more specifically explain why and how hopes of uniformly lighting the territory failed, allowing for light and dark areas to exist side by side, despite the innovative development of the *réverbère* lantern.

FROM THE BUCKET LANTERN TO THE *RÉVERBÈRE* LANTERN: THE PROBLEM OF SHADOWS IS SHIFTED

The first two technical lantern models installed in the streets of Paris from the 1730s onward were the bucket lantern, which later came in a range of varieties, and the *cul-de-lampe* lantern.[14] 5

These lanterns are octagonal in shape, with eight panes of lead glass, totaling 24 pieces of glass. This increase in the glass interface and the 6

12 Catherine Denys, *Police et sécurité au 18e s. dans les villes de la frontière franco-belge* (Paris: L'Harmattan, 2002); Jean-Luc Laffont, "Policer la ville. Toulouse, capitale provinciale au siècle des Lumières" (Ph.D dissertation in history, université de Toulouse II Le Mirail, 1997).

13 For a connected history of public lighting between Paris, Barcelona, and Madrid, see Benjamin Bothereau, "À la lanterne ! Modes d'existence d'un objet banal, entre imaginaire technique et politique. Invention, économie urbaine, publics et circulations du 'réverbère', Paris, Barcelone, 18e s.," (Ph.D dissertation, EHESS Paris, 2018).

14 Reconstructions of these models based on technical descriptions and a few technical drawings were made by the Centre de recherches sur les monuments historiques de France: CRMH, *Lanternes d'éclairage public : 17e-18e s.. Potences d'enseignes et de lanternes du 15e au 19e s.* (Paris: Ministère de la Culture et de la Communication, Direction du Patrimoine, 1986).

thickness of the lead–"five lines wide including the center, which measures one line"[15]–obstruct the light emitted by the candle. Furthermore, a plate and two candle rings were attached to the bottom of the lantern to hold the two types of candles used, whose weight varied according to needs in lighting duration, which themselves varied depending on the season and moonlight. This "cluttering" of the lantern bottom was a second obstacle to light radiation. The combination of dark cones projected by the candleholders, and the shadow cast by the thick lead of the many glass panes, generated a great deal of variation in light intensity on the street.

7 Descriptions of moving shadows can be found in both general and technical literature. For the former, Louis-Sébastien Mercier provides an invaluable account: "Formerly, 8 thousand lanterns, with poorly-placed candles that the wind blew out or made to gutter, offered dim and unsteady light, interspersed with shifting and dangerous shadows."[16] This description matches the more technical one from the treatise by the glazier Le Vieil: "The candles, which could not be snuffed out, maintained a shifty daylight, while the lead cast large shadows on the street, which increased with the number of lanterns."[17] Police chief Delamare explained the limits of ordinary lanterns to lieutenant de La Reynie, questioning their effectiveness on the street for the same reasons:

> Yet as all things have their perfections and flaws, regardless of the care and caution applied to them, one nevertheless does not find the full effect that was proposed, as experience has shown that the great number of lanterns installed at the outset, and subsequently increased, have not produced as good an effect as expected, with no great improvement in brightness or the advantage to be drawn therefrom; they amount to providing lights similar to those found in ports and along the coast, which are used to indicate but not to light paths.[18]

8 The lighthouse analogy proposed by the police chief is especially revealing: the lantern is visible because it is illuminated, although its local field of action–in terms of lighting capacity–is limited, for there is a shadowy cone beneath where it hangs.

The réverbère directs useful light, but does not eliminate shadows

9 The competition "for the best method for lighting the streets of a major city at night, by combining brightness, ease of service, and economy,"[19] jointly established by the police force and the Académie des Sciences in 1763, expressed the desire to centralize and improve technical knowledge related to lighting, in order to transition from the network of occasional light markers described by Delamare to a system offering more even and continuous light.

10 For Bourgeois de Chateaublanc, the inventor-mechanic who won the competition, resolving the problem involved a device, a concave metallic mirror (a *réverbère* or reflector) that would counteract natural propagation–the freedom of light rays "to escape based on their natural direction" and "become lost in the haze of air"–and to direct the rays, knowing that otherwise "a certain

15 BNF, Département des manuscrits, Français 21684 fol 334 335: Devis pour la fabrication et l'entretien des lanternes publiques des quartiers du Louvre, du Palais Royal, de Montmartre et de Saint Eustache du 6 avril 1730 (Estimate for the production and maintenance of public lanterns in the Louvre, Palais Royal, Montmartre, and Saint Eustache neighborhoods, 6 April 1730: "de cinq lignes de large, compris le cœur qui sera d'une ligne."

16 Louis-Sébastien Mercier, *Tableau de Paris*, chapter 54 (Paris, 1782-1788).

17 Pierre Le Vieil, *L'Art de la peinture sur verre et de la vitrerie* (Paris, 1774).

18 BNF Msfr 21684: "Mais comme toutes choses ont leurs perfections et leurs défauts, quelque soin et quelque précaution que l'on ait pu prendre en celles-ci, l'on n'y rencontre pas néanmoins tout l'effet que l'on s'en était proposé, car l'expérience fait voir que toute cette grande quantité de lanternes qu'on a mises d'abord et l'augmentation qu'on en a faite depuis ne produit pas un si bon effet que l'on en attendait, la clarté n'en étant pas de beaucoup augmentée et tout l'avantage qu'on en tire, c'est de faire voir des feux semblables à ceux qui sont sur les ports et les cotes de la mer pour marquer et non pas pour éclairer les chemins."

19 The Lighting prize of the Académie des Sciences (1763-1766), also called the "Sartine Prize" or "Sartine Competition."

quantity (...) travels into places where it is not useful."[20] The reflector increased light intensity. In the submission by Lavoisier, another winner of the competition, a metallic reflector directs the light flow toward the ground, or generally toward the object one wants to illuminate, such that "all of the rays emanating from the light source are directed toward this object, with none of them dissipating or moving toward another."[21] Lavoisier insisted on harnessing and rationalizing light. For the inventor, the "reflector" was the only way of maximizing the system's luminous potential: "the total light emitted by the reflector is equal to the sum of direct rays and reflected rays." While other innovations appeared during this competition, and were integrated starting in 1768 with the new models installed on public streets–oil lamps, hexagonal cages, chimneys, etc.–the reflector was the primary vector for eliminating shadows, by optimizing and guiding light rays toward the useful surface of the street, in other words the pavement.

11 In his first submission for the competition, Lavoisier worked on the reflector's shape by geometrically simulating its effects on light. He concluded his study on the elliptical reflector by noting that its interest varied according to the conditions of local use and urban topography: "The elliptical spheroid spreads light equally, forming a circle of light of considerable size on the ground. This arrangement is highly advantageous for intersections, wide streets, and other spacious locations, but not so much for narrow streets."[22] In this final configuration, the light rays that fall on either side of houses–"largely useless"– are lost for the public street. How to prevent this? In order to "carry in length what is lost in width," Lavoisier explains that one can modify the spheroid's parameters so that the circle of light cast on the ground is as close as possible to a (more or less stretched) ellipse. This lengthening of the range of light does not produce shadows, on the condition of course that the fields of two successive lanterns are superimposed on one another.

12 The problem is that the administration took advantage of the doubled light range offered by the new models with reflectors to space out lanterns in the streets as much as possible. As a result, the transition from the old to the new model did not eliminate shadowy areas, but instead shifted them, as parts of the street still remained outside the cones of light. A perfectly even and continuous lighting remained out of reach.

SHADOW AND LIGHT: DIVERSE METHODS FOR EVALUATING LIGHT PERFORMANCE

13 Visual sensibilities varied across time periods, in accordance with the hierarchy of the senses,[23] and as the gaze became accustomed to new generations of lanterns, especially with the integration of the reflector. This makes the retrospective evaluation of the light performance of lanterns in street situations difficult. However, it is both possible and useful to explore the evaluation methods for this performance used by contemporaries themselves, in order to understand how they distinguished between shadow and light.

14 The hanging of new technical models in streets provided contemporaries with an opportunity to compare–whether quantified or not–between these new devices and the lanterns used formerly: "brighter," "x times superior," "equivalent to x ordinary lanterns," etc. But what is being measured and/or evaluated? And on what basis?

20 Archives de l'Académie des Sciences (Paris), *Mémoire de Chateaublanc* (Submission by Chateaublanc), 1765: "de s'échapper selon leur direction naturelle" et "de se perdre dans le vague de l'air," "une certaine quantité (...) se porte dans des endroits où ils sont inutiles."

21 Archives de l'Académie des Sciences, *Mémoire de Lavoisier* (Submission by Lavoisier), 31 December 1765: "tous les rayons qui partent du point lumineux tournent au profit de cet objet, qu'il n'y en ait aucun qui se dissipe ou qui se porte vers un autre."

22 *Id.*: "Le sphéroïde elliptique répand également la lumière et forme sur le plan un cercle lumineux d'une étendue très considérable. Cette disposition si avantageuse pour les carrefours, les rues larges et tous les endroits spacieux, ne l'est pas tant pour les rues étroites."

23 Robert Mandrou, *Introduction à la France moderne. Essai de psychologie historique. 1500-1640* (Paris: Albin Michel, 1961).

15 First, some submissions use the terms "brightness," "brilliance," "lighting," "luminosity," and "lighting power" without distinguishing between them. These notions are quite vague. The terminology is important, because it partially conveys the evaluation method used for this light. Luminosity applies to primary light sources (the light produced by the lantern), while the term brightness applies to secondary sources of light (reflected light). As a result, the central question is to identify where the person conducting the experiment is focusing their eye: on the technical object or the street? The direct emission of light by the lantern (luminosity), or the actual light reflected by the street (lighting)? In his entry for the competition, Chateaublanc dismissed criticism of the glare created by these reflectors, indicating that the public's gaze must be educated, so that it knows where to direct its gaze.[24] The same argument was used by the commissioners from the Académie in their *Avis* (Notice), when they clarified evaluation methods for two distinct systems (two lamps in a single lantern, or two lanterns with a single lamp each):

> In order to judge the actual illumination effect, one must look not at the lantern but at the street, which is where it is important to see clearly. This remark results from what was said in the submission, although the public is flattered to see powerful light coming from lanterns.[25]

16 It is therefore important to distinguish between the gaze of a curious person, who stares at the primary source, and evaluation of the object, which also assumes a street-level observer, someone who is not interested in novelty (the reflector lantern), but is instead considered as a pedestrian walking, in other words someone concentrated solely on utility, the light reflected on the street.

17 In their respective essays, both Lavoisier and Le Roy–another inventor who won the competition–used the ability to read characters as a criterion for evaluating light. The eye is drawn to the printed paper, and it is therefore the light reflected by this sheet that is being evaluated, in other words its brightness. Nevertheless, there is no normalization for the type character or the font–"small" for Le Roy,[26] no precise details for Lavoisier–in addition to the sheet's distance from the reader, the color of the sheet, etc. The visual sensation of whether a surface seems to emit more or less light, which itself already depends on the observer's eye, makes it difficult to compare the "real value" of light. Chateaublanc chose as a criteria of evaluation the distance (in steps) at which a person is recognizable. This is once again a matter of measuring brightness, which is to say light as it is reflected by a surface, in this case the face. This attempt at quantification is based on a fairly subjective criterion, one that is ultimately surprising given that Bourgeois de Chateaublanc wrote a *Traité d'Optique* in 1760 in which he used a device, the lucimeter, which tries to objectify the measurement, with Lavoisier mentioning in his submission that he drew inspiration from it.

18 The commissioners also discussed the best method for evaluating the luminous performance of lanterns. While one member of the Academy proposed the ability to see a coin as a criterion, another colleague rectified this by replacing the *sou* with a small silver coin (a metal that is shinier and therefore more reflective). In any event, the eye is drawn to the street, once again an evaluation of brightness. However, in the same *Avis des commissaires*, the chapter on bridge lighting suggests comparing the light of the old and

24 Archives de l'Académie des Sciences, *deuxième Mémoire de Chateaublanc,* Mémoire sur les matières combustibles qui peuvent servir à éclairer les rues d'une ville (second Submission by Chateaublanc, Submission regarding the fuels that can be used to light a city's streets), 13 March 1766.

25 Archives du Musée des Arts et Métiers, *Réserves de Saint-Denis*, N89, Avis des Commissaires: "Pour juger du bon effet d'une illumination il ne faut pas comme on fait communément regarder la lanterne mais le pavé qui est l'endroit où il est important de voir clair. Il est vrai que cette remarque est une conséquence de ce qui est dit dans le mémoire mais le public est flatté de voir sortir des lanternes une grande lumière."

26 Archives de l'Académie des Sciences, *Supplément au Mémoire Le Roy* (mémoire original 25 décembre 1765 présenté à de Sartine) (Supplement to Le Roy's submission, original submission presented to de Sartine on December 25, 1765).

new lanterns in the following manner: "the lanterns would have five panes in order to illuminate all sides, and to have the same effect at a distance as ordinary lanterns." Here the eye is drawn directly to the lantern, or the primary source of light, with the "effect" evaluated by the commissioners being luminosity rather than brightness. Yet here once again, as shown by the comparison of "brilliance" (direct luminosity of the source) between the devices proposed by Bailly, the placement of the eye is not normalized. The measurement methods and results vary accordingly. The different evaluation criteria used by competitors, which is expected, was also present within the commissioners' institution. The measurement of lantern "light" was not settled. In fact, this instability was not shocking, as long as it wasn't questioned. As shown by Shapin and Schaffer, the development and evaluation of experimental knowledge–the terms "exactitude" and "objectivity"–are the result of conventions and agreements, in other words they are productions and judgments specific to historic actors.[27]

EXPANDED LIGHTING IN PARIS AND BARCELONA DURING REVOLUTIONARY PERIODS: EXTENDED ILLUMINATION AND PRIORITY LIGHTING ZONES

19 In both Barcelona and Paris, the revolutionary unrest of the late eighteenth century translated into extended lighting hours and schedule, as well as the installation of new lanterns in areas deemed to be sensitive. More light for more order, such was the principle that seemed to guide authorities.

Extended lighting schedule: extension of lights

20 In 1773, the revolt known as the "*avalot de las Quintes*" took place in Barcelona. The protests were chiefly driven by the obligatory random selection of young men for enlistment in the royal army.[28] A list of the lighting measures taken on a day-to-day basis can be established using the "Acuerdos" series in the archives of Barcelona, and the *Ephemérides comentáreas de la Quinta del Principado de Cataluña* manuscript from 1773.

21 While tensions began on April 18, the massive revolt did not begin until May 4. On that date Captain General O'Connor O'Phaly gave the order to keep lanterns lit all night until June 10. There was thus a dual expansion–in terms of both hours and the schedule–as normal service stopped at 10:00 p.m., and in mid-April. In his *État des dépenses pour le service spécial du 4 mai au 11 juin*[29] (State of expenses for the special service from May 4 to June 11), the quartermaster for lighting oil, Pablo Fochs, shows the material impact of this measure: 1,569 pounds of oil were needed, double the normal average monthly consumption compared, for instance, to the previous season–6,177 pounds from October 1, 1771 to late-April 1772,[30] or 882 pounds per month. Similarly, a presentation of accounts from June 26–which was released publicly–made this official, and provided visibility to this expanded lighting by calculating its cost at 17,000 Catalan *libras*, an amount that included supplemental lighting costs (back-up torches and mobile lanterns for patrols) and "other things for maintaining order in the city."[31]

22 In Paris, an "extraordinary service" for lighting was established following riots, in the immediate aftermath of the days of July 1789. An assessment by the Comité de Police from September 23, 1789 confirmed that the contractor Tourtille Sangrain had been performing an "extraordinary service since July 14." In the summary tables for lighting expenses submitted by the contractor to the municipality for payment, an entry clearly mentions "special service during the riots."[32]

27 Simon Schaffer, Steven Shapin, *Léviathan et la pompe à air. Hobbes et Boyle entre science et politique* (Paris: La Découverte, 1993).

28 Santalo i Peix Jaume, "L'Avalot de les quintes de 1773...," *in* Ramon Arnabat (ed.), *Moviments de protesta i resistencia a la fi de l'Antic Régim* (Barcelona: Publicacions de l'Abadia de Montserrat, 1997).

29 Arxiu Historic de la Ciutat de Barcelona AHCB, series Accords 1D.I-56 fol 376.

30 AHCB, series Accords 1D.I-55 fol 580.

31 *Id.*: "autres choses pour maintenir le calme de la ville."

32 Archives Nationales (AN) F 13 351 "Récapitulation des dépenses annuelles" (Summary of annual expenses), December 1789 and December 1790.

23 The method for inscribing this excess is particularly interesting. Instead of traditionally presenting and dividing the expenses for each lease year between ordinary and extraordinary forms of lighting, Sangrain produced a special document in late 1790 entitled "Récapitulation des dépenses annuelles[33]" (Summary of annual expenses), in which expenses are organized based on the event: "before the revolution" and "after the revolution." Lighting methods (ordinary or extraordinary) are combined:

> Before the Revolution, the illumination of Paris cost, accessories included, the sum of 389,537 pounds per year. Ordinary lighting, along with extraordinary lighting due to the Revolution from July 1789 to July 1790, cost 606,622 pounds.[34]

24 The causal relation between the excess lighting (+55.7%) and the political event is clearly marked by the phrase "due to."

25 The consideration of natural phenomena was eliminated when the new schedule was established. While maintaining extended lighting "from daylight to daylight," the city of Paris also sought to take advantage of the savings provided by moonlight: "authorizing them to continue this lighting in the same manner as they have since July 14, although during periods of strong moonlight, lighting will be halved to two *réverbères* each."[35] City authorities requested that alternate lighting be applied on naturally lit evenings, without taking the street's topography into consideration, which is to say without considering
29 whether the moonlight penetrates within narrow streets. This measure was deemed insufficient two months later. In a letter dated November 20, 1789, lighting master Damour mentioned police instructions, which contradicted the usual lighting schedule based on the lunar month:

> We will cease on Wednesday the 26th of the present month given the moon's power, during which time we will light only one lantern out of two, and by specific order. However, given present circumstances, you have deemed it appropriate to light everything from daylight to daylight.[36]

26 The evaluation of natural lighting, which considered the utility of moonlight, was the result of negotiations and conventions between attempts to save on the part of the city, and security priorities on the part of police authorities, which were based on the course of the sun rather than the moon.

Prioritization of lighting sites

27 The expanded lighting in response to social and political unrest also had an effect on lighting equipment.

28 While license requests in Barcelona for the installation of new lanterns in June 1772 "along the wall from La Puerta del Mar to the Convent of St Francisco" set a goal of "maintaining public entertainment and convenience, with the wall promenade remaining open until 11:00 p.m. in warm weather,"[37] the installation orders from military authorities for the year 1773 were purely based on security. For example, an order to install four additional lanterns in front of the military quarters and buildings of Barceloneta (la Ciutadella) were given by Captain General O'Connor O'Phaly on May 4, the very day of the massive revolt, in addition to the extension of lighting hours.

In Paris, lighting prioritization appeared from the beginnings of the Revolution, independent of any extension of the urban fabric. On October 14, 1789, the Capucins Saint-Honoré district sent a letter to the Comité de Police requesting the installation of lanterns to compensate for the

33 AN F 13 351 "Récapitulation des dépenses annuelles," Decmeber 1790.

34 *Id.*

35 AN F 13 351, Rapport du Comité de Police (Police committee report), September 23, 1789: "les autorise à continuer cette illumination à la manière faite depuis le 14 juillet, cependant que dans le fort de la lune, la dite illumination ne se fera qu'à moitié de deux réverbères un."

36 AN F 13 351, lettre de l'inspecteur de l'illumination Damour (Letter from lighting inspector Damour) dated November 20, 1789.

37 AHCB, series Accords 1D.I-55 fol 288, request for installation license, June 22, 1772: "le long de la muraille depuis La Puerta del Mar jusqu'au Couvent de St Francisco"; "maintien, la diversion et la commodité du public, la liberté de la promenade de la muraille jusqu'à 23h les temps chauds."

lack of patrols on the Champs-Elysées: "The king's stay at the Tuileries requires particular surveillance on the Champs Elysées, where ill-intentioned people can meet thanks to the darkness, and also calls for these streetlamps to be installed as quickly as possible."[38]

30 The royal presence was one reason used to request additional lighting, in order to secure the area. In the middle of the Revolution, in May 1792, the Comité de Salut Public requested lighting for the most sensitive and vulnerable areas: chiefly warehouses for storing flour and arsenals, along with the homes of precinct captains. Four years later, the *Mémoire des sommes réclamées par Fricault pour l'éclairage de divers ateliers* (Entry for the sums requested by Fricault for the lighting of various workshops)[39] from July 18, 1796, mentions the cost of lighting provided for various manufacturing sites: the small coins office in the rue de Tournon, the saltpeter transformation plant in Saint-Germain des Prés Abbey (21 burners), the weapons workshop in rue Feydeau, and finally the bayonet factory on the "*Le Républicain*" boat, docked beneath the Pont-au-Change (10 burners). Lighting was always a part of the security measures used to protect production sites, military ones in particular. As a result, lighting measures can provide a map of sensitive sites, which were either locations linked to the authorities, or areas marked by tension.

31 This expansion of urban lighting–via the lighting schedule or equipment–is a reminder of the major security concern of eighteenth century police, the legibility of space and individuals.[40] In this sense, the technical goal was part of the broader instrument of identification (identifying mobility, the circulation of individuals, etc.).

SCHEDULED EXTINGUISHINGS: WHEN DARKNESS WON OUT DUE TO SAVINGS

32 There was a tension between the desire to systematically and evenly light the entire urban territory, and the need to save, given the extraordinarily high price of fuel (plant and animal oils), notably during periods of unrest. The "*réverbère* revolution," which provided better lighting for an equal or lesser amount of fuel, was not enough to offset increased lighting needs due to the development of the urban fabric and the security emergencies of revolutionary episodes. Authorities therefore had to program a schedule and geography for extinguishings. The *État du nombre de lanternes et de becs qui n'ont pas été éclairés pendant la cessation du 24 au 30 mars 1790, conformément aux ordres de M. Cellerier, lieutenant de maire* (The State of the number of lanterns and burners that were not illuminated during the suspension between March 24-30, 1790, pursuant to the order of M. Cellerier, lieutenant mayor),[41] lists the first scheduled extinguishings in March 1790.

33 While quays, plazas, and bridges were foreseeably given priority for these extinguishings, the decision to plunge the thoroughfare between the gates Saint-Antoine and Saint-Honoré into total darkness is more surprising, as is that of the sensitive sites that were the city's gates. It is also striking that an alternating system was not proposed for the locations that were extinguished, which would have limited the impact on each one. For each of the seven nights in March 1790, 395 lanterns were voluntarily extinguished, or 11% of total lighting units (3,554 lanterns). However, the urban sections concerned (paths, quays, plazas, courtyards, and bridges) were plunged into total darkness, as this was not an alternating extinguishment–one lantern out of two–but an overall suspension of all installed lanterns. Conversely, this list informs us of the locations where lighting

38 AN F13 351, Lettre du district des Capucins St Honoré au Comité de Police (Letter from the Capucins St Honoré district to the Comité de Police), October 14, 1789: "Le séjour du roi aux Tuileries exige une surveillance particulière dans les Champs Elysées, où les gens mal intentionnés peuvent se réunir à la faveur de l'obscurité, demande que l'on fasse placer le plus promptement possible des réverbères."

39 AN F 13 1032, Mémoire des sommes réclamées par Fricault pour l'éclairage de divers ateliers, 30 messidor year IV.

40 See the research conducted in the history of the police by Vincent Milliot (dir.), *Les Mémoires policiers, 1750-1850. Écritures et pratiques policières du Siècle des Lumières au Second Empire* (Rennes: Presses universitaires de Rennes, 2006); and Paolo Napoli, *Naissance de la police moderne,* (cf. note.2).

41 AN F13351, Mémoire "État du nombre de lanternes," April 1790.

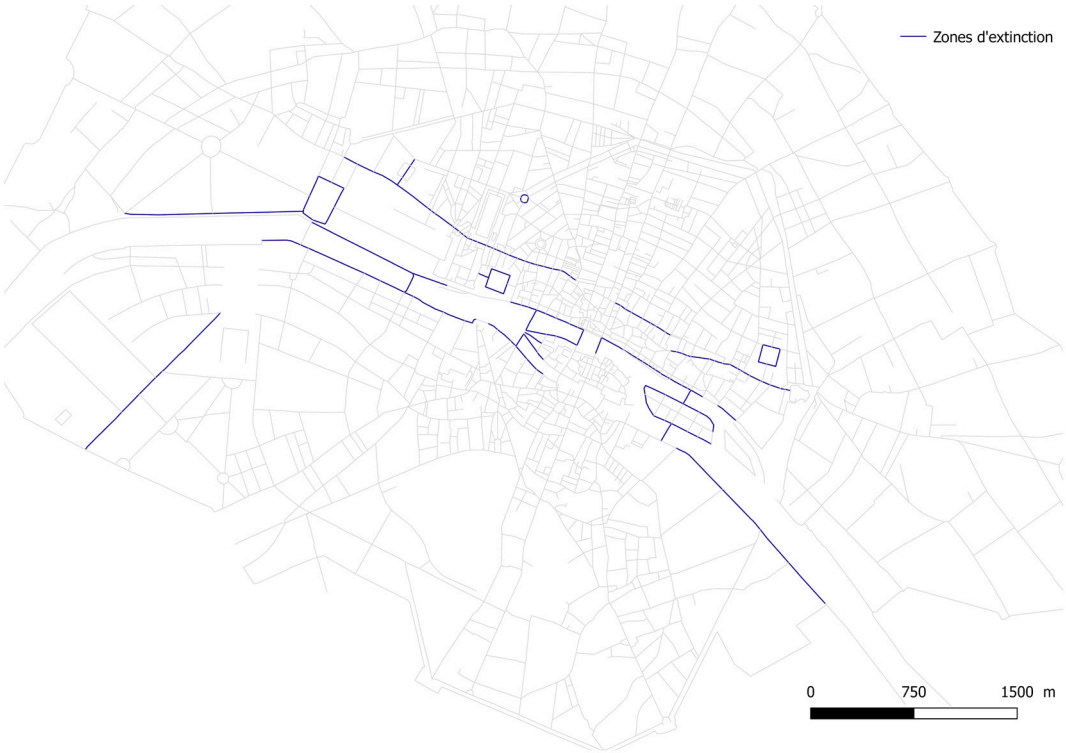

Figure 2: Map of scheduled extinguishings of public lanterns in Paris for March 1790. © B. Bothéreau (QGIS).

was expanded, such as the place Louis XV, where all of the lanterns had four wicks. Unlike the lanterns for the new posts planned during those same years, which systematically had two burners, here we see multi-wick lanterns, which provided more light but also consumed more oil, and were associated with sites of power, and therefore had a highly symbolic dimension.

NON-SCHEDULED EXTINGUISHINGS

34 The first reports regarding unscheduled or early extinguishings of lanterns date from the implementation of the expanded lighting schedule immediately after July 14, 1789. While there were many of them,[42] and they were centralized by district assemblies in order to be sent to Bailly's city hall, they nevertheless include little numerical data. For all that, the quantity of the reports bears witness to the powerful connection for contemporaries between artificial illumination and the security of an area. For instance La Fayette, commander of the garde nationale, collected the complaints and reports of his subordinates, and wrote to Bailly early during the winter of 1789 to criticize his "negligence with respect to *réverbères*," which he associated with a threat to the city's security: "It is impossible to ensure the security of Paris if we add the extinction of streetlamps on top of all the differences that exist between this winter and the last."[43] Cellerier then wrote to Minister of the Interior de Gouvion, a genuine architect of expanded illumination, to announce the measures taken to address the criticism that "*réverbères* remain lit only until one in the morning." The corrections made included increasing the number of employees in the lighting office: "I required the contractor to dispatch fifty lamp-lighters each night, in order to repair premature extinguishings." Yet according to city hall, what was most important was to obtain perfect knowledge of the problem, notably topography: "It is important to have daily reports on the state of illumination

42 The series AN F13 351 includes numerous district reports.

43 AN F13 351, Lettre du commandant La Fayette au maire Bailly (Letter from Commander La Fayette to Mayor Bailly), December 1789: "Il est impossible de répondre de la sûreté de Paris si, à toutes les différences qui existent entre cet hiver et l'hiver dernier, on joint l'extinction des réverbères."

in all streets, in order to determine, based on the number of extinguished *réverbères,* whether the contractor is truly reprehensible."[44]

35 According to the City, there was a need to quantify the problem, in order to gain leverage over the street-lighting company. The question arose regarding which agents would be the most appropriate for performing this control, it being undesirable of course to have the lighting company provide them. The City asked de Gouvion to require the Commander General and patrol captains to "carry out this surveillance objective" and "provide daily reports indicating the number of extinguished *réverbères*, as well as the streets and times at which they observed it." The City thus wanted to establish an actual map and chronology for extinguishings, in other words a quantification that could serve as a valuable tool for the company in alleviating the faults it dared not admit.

36 The *Rapport de l'illumination pour la nuit du 4 au 5 mai 1790* (Lighting report for the night of May 4-5, 1790) for the four neighborhoods of Saint-André-des-Arts, Place Maubert, la Cité and Saint-Benoît[45] was prepared by detective Le Roux, and certified by mounted detective Bruneseau. It quantified the lanterns that were totally or partially extinguished–with a precision down to each extinguished burner–by specifying the location and time of the extinguishment observed, with a precision down to every fifteen minutes.

37 On that night in that area, 29 total extinguished streetlamps were observed, distributed across 35 streets. It is difficult to compare this with other reports, as the counting methods (listing by street or neighborhood, patrol during one or more nights) were not normalized. This data nevertheless provides use with a representation–on the scale of the neighborhood and the duration of one night–of the distribution of shadowy areas, which challenged the police's desire to treat the territory in a neutral and even manner. The change in the number of extinguished burners according to the time of night shows that the share of shadowy areas increased over time.[46]

localisation de l'extinction (rue concernée)	lanternes totalement éteintes	lanternes partiellement éteintes (nombre de becs)	Heure d'extinction
Rue Judas		1	12H30
Fbg St Jacques		5	12H45
des Sansonnets	1		1H
des Bourguignons	1		1H
de l'Oursine		1	1H
des Anglaises	1		1H30
Mouffetard	1		1H30
neuve d'Orléans		1	1H30
en gris	1		1H30
jardin du roi	1		1H30
faubourg st Victor	2		1H45
en face st Victor	1		1H45
rue st victor	2		1H45
place Maubert		1	1H45
Galande	1		1H45
de la juiverie	1		2H
du haut moulin	1		2H
vieille draperie		3	2H
st Eloy	1		2H
de la calandre	1		2H
Barillerie		1	2H
Marché neuf	1		2H15
St Louis		1	2H15
en face st André des Arts	1		2H45
Jardinet	1		2H45
de l'epron	1		2H45
du cimetière St André des Arts	2		2H45
St André des Arts	2		2H45
contrescarpe	1		2H45
Christine	1		3H
St Avoye		2	3H
quai des Augustsins		3	3H15
Gilles Cœur	1		3H30
Haute Feuille	1		3H30
des cordeliers	1	4	3H45
TOTAL	**29**	**23**	

Figure 3: Early extinguishings for the night of May 4-5, 1790 for the four neighborhoods of Saint-André-des-Arts, Place Maubert, la Cité, and Saint-Benoît (Paris). Source: AN F13 351.

44 AN F13 351, Lettre du maire Bailly (Letter from Mayor Bailly), January 1790: "Il serait important d'avoir chaque jour des rapports sur l'état d'illumination dans toutes les rues afin de pouvoir juger si d'après le nombre de réverbères éteints l'entrepreneur est vraiment répréhensible."

45 AN F13 351, Rapport de l'illumination pour la nuit du 4 au 5 mai 1790 sur quatre quartiers, May 5, 1790.

46 In order to quantitatively process this data, we weighted the extinguishings, considering that a total extinguishing corresponded to two burners, as the vast majority of lanterns installed in the streets of Paris consisted of two lights.

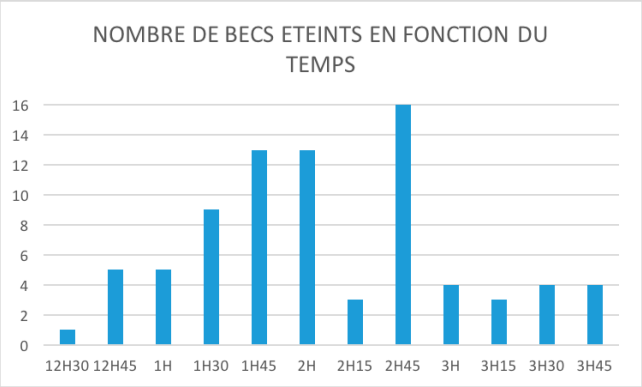

Figure 4: Number of burners extinguished in Paris during the night (4-5 May 1790) according to time, for the neighborhoods Saint-André-des-Arts, Place Maubert, la Cité and Saint-Benoît. Source: AN F13 351.

38 There were three peaks at 1:45 a.m., 2:00 a.m., and 2:45 a.m., when practically all of the extinguishings involved lanterns that were totally extinguished, with these times resulting in the creation of genuine black areas. The different extinguishing times can be explained by different parameters, including the quality of the oils used, the positioning of the wicks, the care taken by the different lantern keepers, the punctuality of lighting times, etc.

39 We doubly change scale with the list of extinguishings in the *Rapport de l'illumination du mois de vendémiaire de l'an IV* (Lighting report for month *vendémiaire*, year IV):[47] this time the report lists the production of all 20 detectives who made their rounds, and reported the number of extinguishings during an entire month (*vendémiaire*) rather than a night. This year was chosen as a case study because we have a coherent series of reports that can be used to reconstruct a count of extinguishings, which are of course less accurate with regard to location (streets do not appear), but are on the scale of the entire city. The spatial distribution of extinguishings during the month was carried out by neighborhood.

40 The most extinguishings for the month studied were in the second lighting arrondissement.[48] Once again there was no homogeneity, as there were four times more extinguishings in the second arrondissement as in the one consisting of the Luxembourg, Germain-des-Prés, and gros Caillou neighborhoods.

41 The second interesting aspect of this report is to compare the number of extinguishings between 1790 and 1795-1796 (year IV). We observed the transition from an average of three totally extinguished lanterns to one extinguishing per night. The consistency between the established lighting schedule and the reality in the field was thus reinforced between 1790 and 1796. This shows the results of the campaign to identify the system's shortcomings–jointly conducted by the City and the Ministry of the Interior (Cellerier and de Gouvion)–which mobilized the forces of the Commander General and patrol captains. However, improvements in burning time for lamps should also include other parameters, such as oil quality, the awareness and training of lamp-lighters, and weather conditions.

42 Reports on the lighting service at any rate show a gradual improvement over the long term. The first report was created on September 18, 1790 by the Petits Pères Place Victoire police precinct. It mentions a number of volunteer citizen national guards, sergeants, and corporals who complained to the comité de graves dysfonctionnements (committee for major dysfunctions):

> For over eight days now, and once again tonight, all of the patrols they respectively command were required to make their rounds in the shadows, as three-quarters of the *réverbères* were extinguished at 2:00 a.m., and those that were lit cast such dim light that the patrols could not make out anyone during their rounds.[49]

47 AN F13 351, Rapport de l'illumination du mois de vendémiaire de l'an IV.

48 The neighborhoods of l'Égalité (formerly Saint-Honoré), Eustache, the Louvre, Faubourg Honoré, and Chaillot.

49 AN F13 351, Rapport du département de police de la section des Petits Pères (Report by the Petits Pères police precinct), September 18, 1790: "Depuis huit jours et plus, nouvellement cette nuit, toutes les patrouilles qu'ils ont respectivement commandées ont été obligées de marcher dans les ténèbres, les réverbères se trouvant aux trois quarts éteints à deux heures et ceux qui ont été trouvés allumés, rendaient une lumière si sombre que les patrouilles ne pouvaient apercevoir qui que ce fut dans leurs marches."

Quartiers	Nombre LANTERNES	Nombre BECS	LANTERNES en %	BECS en%
1er arrondissement d'éclairage : Denis / Martin/Montmartre/Jacques la Boucherie/les Halles/opportune	18	61	14%	12%
2eme arrondissement d'éclairage : Egalité (Honoré)/Eustache/Louvre/Fbg Honoré/Chaillot	52	159	41%	32%
3eme arrondissement d'éclairage : Luxembourg/Germain des Prés/gros Caillou	12	46	10%	9%
4ème arrondissement d'éclairage : Cité/andré des arcs/place Maubert/Benoit/l'isle de la Fraternité	18	129	14%	26%
5ème arrondissement d'éclairage : Marais/Paul/antoine/Fbg Antoine/la Grève/avoye	26	102	21%	21%

Figure 5: Spatial distribution, by neighborhood, of extinguishings during one month (october 1795). Source: AN F13 351.

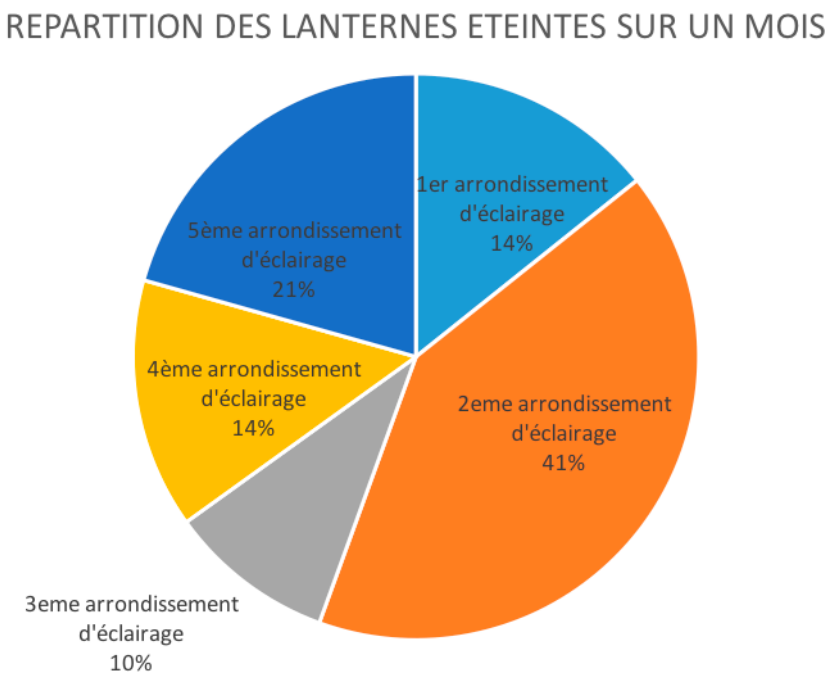

Figure 6: Distribution of extinguishings in Paris during one month (october 1795). Source: AN F13 351.

43 In the later reports examined above, extinguishings were occasional, not consecutive in time, and less than eight days in duration. The repetition of the event, and the high percentage of the units involved, were not favorable statistics for the service, as the phenomenon could no longer be ascribed to weather-related or external events. Police authorities subsequently requested penalties against the contractor, with the revolutionary situation calling for greater reliability:

> The lighting contractor should provide for such malfunctions, from which an infinite number of unfortunate events can result for the national guard while on patrol, as well as for public order and security; in a moment of ferment, with streetlamps unlit, the enemies of public peace and the revolution may subsequently take advantage to attack peaceful citizens with impunity, as well as patrols that are exposed to attack at intersections, who due to their care and zeal for the Republic, end up becoming the first victims.[50]

44 Another report from the Bureau du Comité in 1790 bears witness to the extent of the problem: "The patrol captains that I sent out last night reported that all of the *réverbères* within the precinct were extinguished before 1:00 a.m., contrary to all regulations."[51] This was therefore a global extinguishing, which plunged an entire area–in this case one precinct–into total darkness. Unlike the previous case, whose causes could depend on various parameters both technical and human, an overall extinguishing of so many units could only have been caused by oil of poor quality, or by a mixing error in the depot that prepared lighting oil for this geographic sector. The lighting company was in the hot seat:

> This mistake on the part of the lighting contractor can have the gravest consequences under the current circumstances, which is why I call for informing both the police tribunal and the administrators of public works.[52]

45 In view of this body of reports on lighting, what distinguished acceptable from insufficient lighting? Acceptability, or the tolerated number of extinguished lanterns, was the product of conventions–negotiated agreements between the different parts of the lighting administration–and was a function of sociopolitical events. Lighting inspectors transmitted a report to the national agent in order to assess a penalty against the contractor Fricault, observing that "a large number of streetlamps were extinguished in the night of messidor 11-12 of the year II (June 29-30, 1794) between 1:30 and 2:00 a.m.."[53] However, the administration and its control auxiliaries did not produce a quantification of extinguishings. Fricault used this as leverage to prove that his service was not perfect but tolerable, by conducting an investigation the following night, accompanied by a lighting inspector: at 2:00 a.m. they counted "a maximum of twenty-four or thirty extinguished lanterns." The number of defective lanterns is of course acceptable compared to the *Rapport de l'illumination pour la nuit du 4 au 5 mai 1790*, which mentions 29 extinguishings for one night

50 *Id.*: "L'entrepreneur d'éclairage doit pourvoir à pareil inconvénient d'où il peut résulter une infinité d'événements très fâcheux, soit pour la garde nationale en patrouille, soit pour l'ordre et la sûreté publique ; que dans un moment de fermentation, les réverbères n'étant pas allumés, il peut s'en suivre que les ennemis du repos public et de la révolution, en profiteraient pour attaquer impunément les citoyens paisibles, et les patrouilles exposées à être assaillies dans un carrefour, et devenir les premières victimes de leur soin et de leur zèle pour la chose publique."

51 AN F13 351, Rapport du Bureau du Comité du 10 septembre 1790, émis par le Bureau du Comité à la Caserne de la section de la rue Beaubourg (Report by the Bureau du Comité from September 10, 1790, issued by the Bureau du Comité at the rue Beaubourg station): "Les commandants des différentes patrouilles que j'ai fait sortir la nuit dernière m'ont rapporté que tous les réverbères qui sont dans l'étendue de la section étaient éteintes avant une heure du matin, ce qui est contraire à tous les règlements."

52 *Id.*: "Ce défaut de la part de l'entrepreneur de l'illumination peut devenir de la plus grande conséquence dans les circonstances actuelles, ce pourquoi je requiers d'en informer tant le tribunal de police que les administrateurs des travaux publics."

53 AN F13 352, Rapport des inspecteurs de l'illumination (Lighting inspectors' report), August 1, 1794.

and for just four neighborhoods:[54] by conducting a quick estimate to make the data comparable, this would mean that for the entire territory–all twenty neighborhoods–there were five times fewer lanterns extinguished in 1794 than in 1790. This comparison, which was not established by the contractor, would indeed make the extinguished rate "acceptable." Armed with this quantification, Fricault wrote to the administrator of public works Avril on 17 messidor (July 5, 1794): "I therefore assure you, Citizen, that aside from being the Supreme Being, we cannot defend against such minor faults."[55]

46 "Minor faults" or "unacceptable" dysfunction, the subjectivity of how extinguishings were described could only lead to rhetorical jousting and a succession of contradictory discourses, as long as the administration did not generate a threshold of acceptability for the number of prematurely extinguished lanterns.

CONCLUSION

47 During the Enlightenment, lighting was one of the favored instruments within the policing ideal of an even perception of urban space. This ideal of lighting nevertheless had to contend with its limits.

48 The causes of lighting asymmetries were primarily technical, connected to the very structures of the first lantern models.[56] While other innovations[57] were integrated within the new model that grew out of the Academy prize for lighting (1763-1766), it was truly the *réverbère* reflector device–by rationalizing the optical path and guiding rays toward the useful surface of the street (the pavement)–that would become the driver for both the increase of lighting intensity, and the decrease of shadowy areas. However, what was gained on the surface of luminous action was lost through unit density, this time driven by attempts to balance between performance and economy. As the establishment of the *réverbère* lantern took hold only in proportion to its dissemination, new shadowy spots were created at the edges of the luminous cones. In the end, luminous asymmetry simply underwent a change of scale.

49 Furthermore, as we have shown, this interplay of shadow(s) and light(s) was accentuated by the diverse methods for evaluating light performance.

50 Finally, lighting asymmetries appeared throughout the urban fabric, amid both expanded lighting–through a special schedule or a hierarchization of sites to be lit during periods of revolutionary unrest in Paris and Barcelona–and the darkness generated by extinguishings, which were scheduled to generate savings or due to technical shortcomings.

51 It would now be worthwhile to compare the lighting asymmetries produced by the subject of our study, the autonomous and self-sufficient unit of the lantern, with that of gas lighting, in other words a "system" or a "networked"[58] infrastructure, in order to reveal new interactions and scales between shadow and light.

54 St-André-des-Arts, Place Maubert, la Cité and St-Benoît.

55 AN F13 352, Lettre de Fricault à l'administrateur des travaux publics Avril le 17 messidor an II (Letter from Fricault to the administrator of public works Avril on 17 messidor year II): "Je vous assure donc Citoyen, à moins d'être l'Etre Suprême, qu'on ne peut parer à des défauts aussi légers."

56 The models known as "bucket" and "cul-de-lampe."

57 Oil lamps, hexagonal shape of cages, chimney, etc.

58 Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore: Johns Hopkins University Press, 1983); Pierre Musso, (dir.), *Réseaux et société* (Paris: Presses universitaires de France, coll. La politique éclatée, 2003); Antoine Picon, *La Ville des réseaux : Un imaginaire politique* (Paris: Editions Manucius, 2014).

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JEHRHE

Journal of Energy History
Revue d'histoire de l'énergie

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POST DATE
20/06/2019
ISSUE NUMBER
JEHRHE #2
SECTION
Special issue
THEME OF THE SPECIAL ISSUE
Light(s) and darkness(es): Shifting historical relations
KEYWORDS
Light, Gas, Electricity, Territory, Power,
DOI
in progress

TO CITE THIS ARTICLE
Ute Hasenöhrl, "Contested Nightscapes: Illuminating Colonial Bombay", *Journal of Energy History/Revue d'Histoire de l'Énergie* [Online], n°2, published 20 juin 2019, consulted XXX, URL: http://energyhistory.eu/node/130.

Contested Nightscapes: Illuminating Colonial Bombay

Abstract
In the British Raj, colonial lighting oscillated between "Tool of Empire" and everyday technology. While the British used modern lighting to visualize power and accentuate social differences, it was also a contested object of appropriation and protest. In fact, both colonial light and darkness were ambivalent. Focussing on Bombay, the "second city of the Empire," the paper explores ambivalences of colonial light and darkness in a series of short vignettes, investigating the often contentious development of lighting infrastructures in British India, but also different perceptions and experiences of light and darkness.

Acknowledgments
The author thanks the Journal of Energy History editors, the guest editors, the two anonymous reviewers, and my colleague, Irene Pallua, for their helpful reflections and comments on previous versions of the paper. University of Innsbruck's Faculty of Humanities 1 (Philosophy and History) has kindly provided funding for proof-reading and language editing.

Plan of the article

INTRODUCTION

1 The British Empire consisted of manifold empires of light and darkness – both materially and symbolically. Even before the "lighting revolution" of the 19th and early 20th centuries gained momentum, the British framed their empire as an empire of light, supposedly bringing progress and enlightenment to the "dark" places of the world as part of their "civilizing mission."[1] However, his lofty ambition did not necessarily translate into better lighting services. In most parts of the empire, modern lighting technologies – and electric light in particular – remained exclusive luxury goods, often restricted to European quarters and, at times, the indigenous upper and middle classes.[2] Shaping later decisions on who should (and could) benefit from services and who might be excluded, the colonial history of lighting had far-reaching consequences. On the macro level, the uneven electrification of the British Empire contributed to current disparities between Global North and South in energy access and availability.[3] Colonial grid designs and blueprints set the trajectory for post-independence infrastructural developments, either by following in colonial footpaths or by deliberately adopting alternative policies.[4] While large parts of the inhabited globe, particularly in the Global North, are subject to light pollution today, many former British colonies, especially in sub-Saharan Africa, are still shrouded in darkness.[5] Colonial legacies can also be traced on the micro level, within specific municipalities and communities. As the hybrid result of formal urban planning, capitalist market economy, and constant societal (re)negotiations, the distribution of urban light and darkness reflected a social geography of inequality that, in some cases, has lasted until the very present.

2 However, the history of artificial light in the British Empire is not as clear-cut as this dichotomy between light pollution and lack of light, energy dissipation and energy deprivation might suggest.[6] Building on recent research in urban colonial history that has challenged traditional

1 E.g., in general, Harald Fischer-Tiné, Michael Mann, *Colonialism as Civilizing Mission: Cultural Ideology in British India* (London: Anthem, 2004); on visual cultures of illumination in the Netherland Indies see Susie Protschky, "The Empire Illuminated: Electricity, 'Ethical' Colonialism and Enlightened Monarchy in Photographs of Dutch Royal Celebrations, 1898-1948," *Journal of Colonialism and Colonial History*, vol. 13, n° 3, 2012, https://doi.org/10.1353/cch.2012.0040 (accessed 28/11/2018); for an example of British colonial rhetoric of light and darkness, see Woodhouse and Rawson's advertisement "What is wanted in Darkest Africa is the Electric Light" from the 1890s, discussed in Ute Hasenöhrl, "Rural Electrification in the British Empire," *History of Retailing and Consumption*, vol. 4, n° 1, 2018, 14-15.

2 E.g., Moses Chikowero, "Subalternating Currents: Electrification and Power Politics in Bulawayo, Colonial Zimbabwe, 1894-1939," *Journal of Southern African Studies*, vol. 33, n° 2, 2007, 287-288; Srinivasa Rao, John Lourdusamy, "Colonialism and the Development of Electricity: The Case of Madras Presidency, 1900-1947," *Science Technology & Society*, vol. 15, n° 1, 2010; Kate B. Showers, "Electrifying Africa: An Environmental History with Policy Implications," *Geografiska Annaler*, Series B, vol. 93, n° 3, 2011; Ronen Shamir, *Current Flow: The Electrification of Palestine* (Palo Alto: Stanford University Press, 2013); Julia Tischler, *Light and Power for a Multiracial Nation: The Kariba-Dam Scheme in the Central African Federation* (Basingstoke, New York: Palgrave Macmillan, 2013); Fredrik Meiton, "The Radiance of the Jewish National Home: Technocapitalism, Electrification, and the Making of Modern Palestine," *Comparative Studies in Society and History*, vol. 57, n° 4, 2015; Hasenöhrl, "Rural Electrification" (cf. note 1).

3 As argued earlier in Ute Hasenöhrl, "Denn die einen sind im Dunkeln und die andern sind im Licht…: Globalhistorische Perspektiven auf Lichtmangel und Lichtverschmutzung," *in* Konrad Scheurmann, André Karliczek (eds.), *Gesprächsstoff Farbe: Diskurse aus Wissenschaft, Forschung und Kunst* (Wien: Böhlau, 2017), 436-441, and Hasenöhrl, "Rural Electrification" (cf. note 1).

4 On India's post-independence electrification policies, see Sunila Kale, *Electrifying India: Regional Political Economies of Development* (Stanford, CA: Stanford University Press, 2014).

5 On global light pollution, see Ben Panko, "Nighttime Light Pollution Covers nearly 80% of the Globe," *Science Online*, 10.06.2016. Url: http://www.sciencemag.org/news/2016/06/nighttime-light-pollution-covers… (accessed 07/02/2018); see also Josiane Meier *et al.* (eds.), *Urban Lighting, Light Pollution and Society* (New York, London: Routledge, 2015); Sara B. Pritchard, "The Trouble with Darkness: NASA's Suomi Satellite Images of Earth at Night," *Environmental History*, vol. 22, n° 2, 2017.

6 This paper is part of my Habilitation project, "Empires of Light, Empires of Darkness: Technology, Politics and Culture in Colonial History," at Innsbruck University. Looking at different regions of the British Empire (e.g., India, Gold Coast, Sudan), the project investigates key resources, institutions, and actors involved in the global transfer and appropriation of lighting technologies as well as their impact on society and the environment.

views on the dualistic nature of colonial space and society,[7] the paper argues that there was no monolithic "Indian" or "European" experience of urban light and darkness in the British Raj, as complex (and shifting) mixtures of ethnicity, status, and wealth – as well as sometimes sheer determination – decided on who might gain access to modern infrastructures and energies over time. The colonial history of lighting was closely intertwined with municipal electrification efforts. However, it is important to bear in mind that electric light was not the only, or even the most important, source of artificial light available. Wood and beeswax, fish and vegetable oils, and later kerosene were used as "everyday energies" for domestic purposes in both European and indigenous households, while gaslights had been employed for street lighting since the 1860s.[8] This heterogeneous mix of fuels, energies, and technologies that reflected social disparities between rich and poor, urban and rural, was typical for the lighting situation of the time (and not only in colonial contexts[9]) – and continues to shape India's energy landscape and urban fabric of light and darkness.[10]

Focussing on the "lighting history" of Bombay[11] in the 19th and 20th centuries, the "second city of the Empire" and figurehead of "Indian modernity," the paper explores the makings and ramifications of an elemental urban infrastructure and household technology that has received little attention so far in urban colonial history, energy history, and global history of technology. While there is considerable literature on the history of lighting (and its related infrastructures and energies) in Europe and North America, there is very little known about the "lighting revolution" – if there ever was one –, its energy resource base and its effects on nocturnal practices and perceptions in the non-Western regions of the world.[12] Likewise, most works on colonial cities, including Bombay, have focussed on sanitary and transport infrastructures[13] – and rarely differenti-

7 E.g., William Cunningham Bissell, "Between Fixity and Fantasy: Assessing the Spatial Impact of Colonial Urban Dualism," *Journal of Urban History*, vol. 37, n° 2, 2011; Eric Lewis Beverley, "Colonial Urbanism and South Asian Cities," *Social History*, vol. 36, n° 4, 2011; Douglas E. Haynes, Nikhil Rao, "Beyond the Colonial City: Re-Evaluating the Urban History of India, ca. 1920-1970," *South Asia*, vol. 36, n° 3, 2013.

8 See Henry Coneybeare, "Appendix K: Report on the Introduction of Gas Illumination at Bombay," *in* Henry Coneybeare, *Report on the Sanitary State and Sanitary Requirements of Bombay* (with Appendices) (Bombay: Bombay Eduction Society's Press, 1855), 1-22; P.R. Cola, *How to Develope Productive Industry in India and the East: Mills and Factories* (London: Viertue and Co, 1867), 184-188; Pestoniji D. Mahaluxmivala, *The History of the Bombay Electric Supply and Tramways Company, Limited, 1905-1935* (Bombay: Times of India Press, 1936).

9 See, e.g., Ruth Sandwell, "The Coal-Oil Lamp," *Agricultural History*, vol. 92, n° 2, 2018, on the persistence of kerosene lighting in (rural) Canada.

10 Simron Jit Singh et al. have argued that India is still "in the early phases of a socio-metabolic transition from an agrarian to an industrial resource regime." Singh Simron Jit *et al.*, "India's Biophysical Economy, 1961-2008: Sustainability in a National and Global Context," *Ecological Economics*, vol. 76, 2012, 60.

11 As this paper exclusively discusses the British colonial period, the city will be referred to by its contemporary name, Bombay, instead of its present denomination, Mumbai.

12 See Ute Hasenöhrl, "Neue Perspektiven auf die Geschichte der Beleuchtung und der Nacht: Ein Forschungsbericht," *Neue Politische Literatur*, n° 1, 2014, and Hasenöhrl "Rural Electrification" (cf. note 1) for an overview on the state of the art. For Europe and North America, notable works include Wolfgang Schivelbusch, *Lichtblicke: Zur Geschichte der künstlichen Helligkeit im 19. Jahrhundert* (München, Wien: Hanser, 1983); Murray Melbin, *Night as Frontier: Colonizing the World after Dark* (New York: Free Press, 1987); Harold L. Platt, *The Electric City: Energy and the Growth of the Chicago Area, 1880-1930* (Chicago: Univ. of Chicago Press, 1991); Joachim Schlör, *Nachts in der großen Stadt: Paris, Berlin, London 1840-1930* (München, Zürich: Artemin und Winkler, 1991); Craig Koslofsky, *Evening's Empire: A History of the Night in Early Modern Europe* (Cambridge: Cambridge Univ. Press, 2011); and Jean Brox, *Brilliant: The Evolution of Artificial Light* (Boston: Mifflin Harcourt, 2010). Among the few publications explicitly discussing colonial lighting projects are: Eric Tagliacozza, "The Lit Archipelago: Coast Lighting and the Imperial Optic in Insular Southeast Asia, 1860-1910," *Technology and Culture*, vol. 46, n° 2, 2005; Protschky, "Empire" (cf. note 1); Isenstadt *et al.* (eds.), *Cities of Light: Two Centuries of Urban Illumination* (Stanford: Stanford University Press, 2014); and Rudolf Mrázek, *Engineers of Happy Land: Technology and Nationalism in a Colony* (Princeton, Oxford: Princeton University Press, 2015).

13 E.g., on Bombay/Mumbai: Dinsha Edulji Wacha, *Rise and Growth of Bombay Municipal Government* (Madras: G.A. Natesan & Co., 1913); Mariam Dossal, *Imperial Designs and Indian Realities: The Planning of Bombay City, 1845-1875* (Bombay: Oxford University Press, 1991); Prashant Kidambi, *The Making of an Indian Metropolis: Colonial Governance and Public Culture in Bombay, 1890-1920*

ated between daytime and nocturnal experiences of urban spaces or specific night-time practices.[14]

4 Taking up this lacuna, this paper argues that colonial lighting and darkness were ambivalent phenomena, the former oscillating between "Tool of Empire"[15] and "everyday technology".[16] While the British used modern lighting to visualize power and accentuate social differences,[17] it was also an object of appropriation and protest. As a "weapon of the weak,"[18] it could be utilized to challenge power structures by appropriating "European" amenities by legal or illegal means (e.g. electricity theft),[19] declining colonial illumination projects,[20] or using the cover of darkness for subversive activities beyond the watchful eyes of the authorities.[21] All in all, modern lighting was a contested commodity, both sought after and spurned, and decisions for (or against) illumination projects were influenced by a variety of actors, motives, and factors – within and beyond colonial power politics.[22] The paper explores these ambivalences of colonial light and darkness in a series of short vignettes, starting with Marc Twain's description of nocturnal Bombay in 1895, and then tracing the city's lighting history from the 1830s to the 1940s. In doing so, the paper investigates the often contentious development of lighting infrastructures in British India but also different perceptions and experiences of urban light and darkness.[23]

(Aldershot: Ashgate, 2007); or Gyan Prakash, *Mumbai Fables: A History of an Enchanted City* (Princeton, Oxford: Princeton University Press, 2010). A growing number of publications addresses the electrification of Indian cities (albeit most do not focus on issues of lighting), including: Pierre Lanthier, "L'électrification de Bombay avant 1920: Le projet de Jamsetji N. Tata," *Outre-mers, revue d'histoire*, vol. 89, n°334-335, 2002; Tilman Frasch, "'Empowering the City': Indische Städte und Elektrizität, ca. 1880-1920," *in* Ravi Ahuja Christiane Brosius (eds.), *Mumbai – Delhi – Kolkata: Annäherungen an die Megastädte Indiens* (Heidelberg: Draupadi, 2006); Rao, Lourdusamy, "Colonialism" (cf. note 2); Kale, *Electrifying* (cf. note 4); Suvobrata Sarkar, "Domesticating Electric Power: Growth of Industry, Utilities, and Research in Colonial Calcutta," *The Indian Economic and Social History Review*, vol. 52, n° 3, 2015; Leo Coleman, *A Moral Technology: Electrification as Political Ritual in New Delhi* (Ithaca: Cornell University Press, 2017); Animesh Chatterjee, "'New Wine in new Bottles': Class Politics and the 'Uneven Electrification' of Colonial India," *History of Retailing and Consumption*, vol. 4, n° 1, 2018.

14 Both Dossal and Kidambi, for example, do not explore the nocturnal history of Bombay, even though Kidambi touches upon night-time issues such as sleeping arrangements in worker's quarters or night schools. Prakash explores topics such as Bombay cinema and entertainment, but does not discuss nocturnal activities systematically. Neither do the authors of the edited volume Bombay: Mosaic of Modern Culture. One of the few exceptions is Woods's short article on Mumbai as an illuminated city, published in an edited volume on Cities of Light. – Dossal, *Imperial Designs* (cf. note 13); Kidambi, *Making* (cf. note 13); Prakash, *Mumbai Fables* (cf. note 13); Sujara Patel, Alice Thorner (eds.), *Bombay: Mosaic of Modern Culture* (Delhi, Calcutta, Madras: Oxford India, 1996); Mary N. Woods, "Mumbai: Illuminating first Bombay and then Mumbai: Urbs Prima in Indus from the 1800s to the 2000s," *in* Sandy Isenstadt *et al*. (eds.), *Cities of Light: Two Centuries of Urban Illumination* (New York, London: Routledge, 2015), 37-44.

15 Daniel Headrick, *The Tools of Empire: Technology and European Imperialism in the Nineteenth Century* (New York: Oxford University Press, 1981); see also: Michael Adas, Machines as the Measure of Men: Science, Technology, and Ideologies of Western Dominance (Ithaca, NY: Cornell University Press, 1989).

16 Mikael Hård, Andrew Jamison, *Hubris and Hybrids: A Cultural History of Technology and Science* (New York: Routledge, 2005); David Edgerton, *The Shock of the Old: Technology and Global History since 1900* (Oxford: Oxford University Press, 2007); David Arnold, *Everyday Technology: Machines and the Making of India's Modernity* (Chicago: University of Chicago Press, 2013).

17 E.g., Chikowero, "Subalternating" (cf. note 2); Shamir, *Current Flow* (cf. note 2); Hasenöhrl, "Denn die einen" (cf. note 3).

18 See James C. Scott, *Weapons of the Weak: Everyday Forms of Peasant Resistance* (New Haven: Yale University Press, 1985).

19 See Tanja Winther, "Electricity Theft as a Relational Issue: A Comparative Look at Zanzibar, Tanzania, and the Sunderban Islands, India," *Energy for Sustainable Development*, vol. 16, n° 1, 2012, 111-119.

20 Rao, Lourdusamy, "Colonialism" (cf. note 2).

21 Bryan D. Palmer, *Cultures of Darkness: Night Travels in the Histories of Transgression* (New York: Monthly Review Press, 2000); A. Roger Ekirch, *In der Stunde der Nacht: Eine Geschichte der Dunkelheit* (Bergisch Gladbach: Lübbe, 2006).

22 For a similar discussion on how imperial ideologies were both driving and limiting electrification in British colonies, and how they were negotiated, see, e.g., Fredrik Meiton, "Electrifying Jaffa: Boundary-Work and the Origins of the Arab-Israeli Conflict," *Past & Present*, vol. 231, n° 1, 2016. For comparative research on Indians embracing colonial infrastructures and the discriminations that shaped their extension, see Ritika Prasad, *Tracks of Change: Railways and Everyday Life in Colonial India* (Delhi: Cambridge University Press, 2015), on the Indian railway.

23 It should be noted that the majority of sources utilized in this paper are British (e.g., Indian Office records; newspaper articles; travelogues). As a result, "Indian" voices

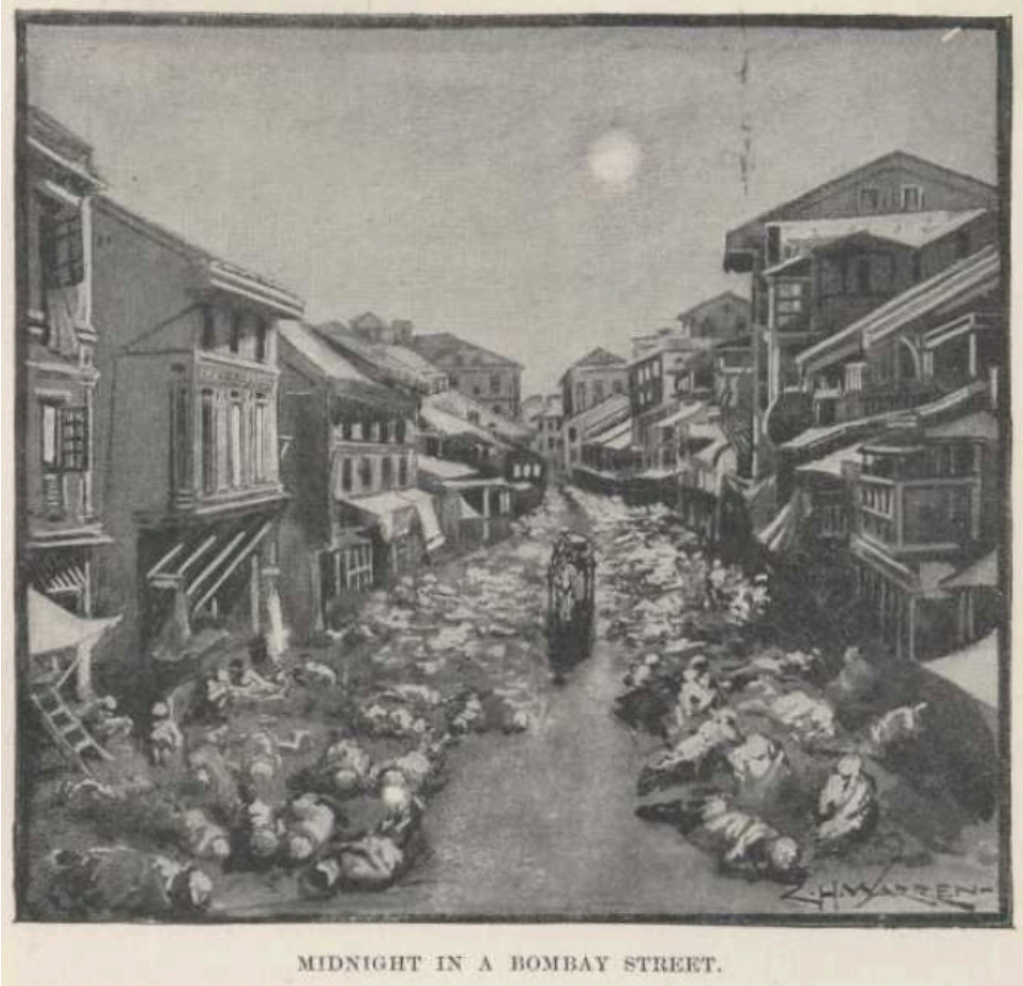


Figure 1: C.H. Warren (illustrator), "Midnight in a Bombay Street," 1898. Plate from Mark Twain (1898), Following the Equator A Journey around the World. Urbana, Illinois: Project Gutenberg. Retrieved February 10, 2019, from http://www.gutenberg.org/files/2895/2895-h/2895-h.htm#ch38.

FLASHES OF BRIGHTNESS IN THE GLOOM?

5 Bombay, 1895: the Empire's second city has received a sharp-tongued visitor: Marc Twain (1835-1910), the American author. Plagued by financial troubles, Twain had embarked on a year-long lecture tour across the British Empire, a journey later to be immortalized in his travelogue "Following the Equator" from 1897. One night in Bombay, Twain was invited to a Hindu betrothal ceremony, celebrated at midnight. The trip to his host took him through a city at sleep (fig. 1):

> We seemed to move through a city of the dead. There was hardly a suggestion of life in those still and vacant streets. [...] But everywhere on the ground lay sleeping natives – hundreds and hundreds. They lay stretched at full length and tightly wrapped in blankets, heads and all. [...] The shops were but sheds, little booths open to the streets; and the goods had been removed, and on the counters families were sleeping, usually with an oil lamp present.[24]

are often mediated through British commentary, limiting our insights into the Indian side of the story. I have strived to counterbalance this bias through a careful and critical analysis of British sources. The larger project will include a greater variety of sources from Indian archives. However, research in India has not yet been completed.

24 Marc Twain, *A Tramp Abroad; Following the Equator; Other Travels* (New York: Library of America, 2010), 667.

6 The scene changes once Twain has reached his destination. The visitor is blinded by a great glare of light: "It was the home of the bride, wrapped in a perfect conflagration of illuminations, – mainly gas-work designs, gotten up specially for the occasion. Within was abundance of brilliancy – flames, costumes, colours, decorations, mirrors – it was another Aladdin show."[25] Twain's account of Bombay at night plays with oppositions and premonitions: the deathly silence and gloom of the streets with the corpse-like sleepers, foreshadowing the bubonic plague epidemic of 1896/97, is contrasted with the colour, noise, and light of the betrothal celebrations; the poverty and constriction of the "native town" with the opulence of its social elite; and the bleakness of ordinary nightlife with the abundance of special festivities – according to Twain, the betrothal ceremonies would last all night, for a week or more.

7 Twain's travelogue, hinting at the importance of illuminations in Indian society, offers only a glimpse at the richness and variety of Indian nightlife. His vignette of nocturnal Bombay is especially noteworthy for its vivid depiction of the encompassing nocturnal darkness and abysmal living conditions in the city's Indian quarters at the end of the 19th century. At the time, "large sections of the labouring poor were forced to appropriate the street for their needs. It was estimated in the 1890s that around 100,000 labourers usually slept on roads or footpaths."[26] Twain's account on Bombay's limited state of illumination was not the only one. Stanley Reed, the English editor of the *Times of India*, recalling his arrival in Bombay in 1897, also expressed his shock "to find the empire's second city plunged into such darkness at night given that his hometown of Bristol had been electrified for many years,"[27] – although his description, as a foreword to an anniversary publication of the Bombay Electric Supply and Tramways Company (B.E.S.T.), was probably not without bias.[28] Bombay's electrification did not really take off until the early 20th century; however, the city was not without light at night. Twain himself remarked upon private lights situated next to sleepers or attached to house-fronts:

> Close at hand on house-fronts on both sides of the narrow street were illuminations of a kind commonly employed by the natives – scores of glass tumblers (containing tapers) fastened a few inches apart all over great latticed frames, forming starry constellations which showed out vividly against their black backgrounds. As we drew away into the distance down the dim lanes the illuminations gathered together into a single mass, and glowed out of the enveloping darkness like a sun.[29]

8 And these private oil lamps were not the only lights illuminating the city at night at the time of Twain's visit to India. Since the 1860s, Bombay had also had a public lighting infrastructure, namely gas lights, that complemented its traditional lighting technologies and everyday energies.

A FOOL'S ERRANT? INTRODUCING GASLIGHTS IN BOMBAY

9 Bombay, 1865: the "great day" has arrived. On Saturday, October 7, Bombay's streets are lighted with gas for the first time, illuminating the Esplanade, Church Street, and Bhendy Bazaar with 133 lamps.[30] Reflecting patronizing assumptions about colonial subjects at the time, the *Times of India* raves about this event and its supposed effect on Bombay's inhabitants:

> The lamps were lighted during the afternoon, and as the lamplighters went from lamp to lamp they were followed by crowds of inquisitive natives who gazed in mute astonishment at the new Western wonder that had appeared

25 *Ibid*.
26 Kidambi, *Making*, 38 (cf. note 13).
27 Woods, "Mumbai," 38 (cf. note 14).
28 Stanley Reed, "Foreword," *in* Pestoniji D. Mahaluxmivala, *The History of the Bombay Electric Supply and Tramways Company, Limited, 1905-1935* (Bombay: Times of India Press, 1936), v-vii.
29 Twain, *A Tramp*, 668 (cf. note 24).
30 Wacha, *Rise*, 90 (cf. note 13).

Figure 2: George M. Woodward, "A Peep at the Gas Lights in Pall Mall," 1808. Retrieved February 10, 2019, from https://commons.wikimedia.org/wiki/File:A_Peep_at_the_Gas_Lights_in_Pall_Mall.png, Public Domain US expired.

> in their midst. Until a late hour in the night this feeling had not subsided; and in the native town around nearly every gas-lamp crowds of the native population were collected, who contemplated the lights with evident astonishment.[31]

10 Disregarding the condescending description of Bombay's citizens marvelling at the latest Western benefaction (which, by the way, largely matches earlier accounts of public reactions to the introduction of street lighting in European cities[32] [fig. 2]), the new gas-lamps apparently were a great public success. "[The] idea of gas-lighting caught on so well that several well-to-do citizens donated large ornamental gas-lamps for being put up at some important spots in the city."[33] By the end of 1865, 220 public gas-lamps were installed, three years later, numbers had risen to 700.[34] Bombay was the second city in India to be equipped with such installations, following Calcutta's lead in 1857.[35]

11 Putting into practise Bombay's gaslight infrastructure was a bumpy, tedious, and contested process. Bombay's first gaslights appeared as early as 1834 at the private residence of Ardeseer Cursetjee (1808-1877), a member of the city's

31 "Lighting of Bombay with Gas," *Times of India*, 9 October 1865, 2.

32 Compare, for example, the famous caricature "A Peep at the Gas Lights in Pall-Mall" by George M. Woodward, from 1808, https://commons.wikimedia.org/wiki/File:A_Peep_at_the_Gas_Lights_in_Pal... (accessed 29/11/2018)

33 BEST Company, "History," n.d. Url: http://www.bestundertaking.com/in/page.asp?i=2 (accessed 14/03/2018); see also Cola, *How to Develope*, 185 (cf. note 8).

34 Karing Doyle, *Bombay: A Historical Review and Travel Guide* (Bombay: New Book Co., 1952), 50.

35 Ministry of Law and Justice, "The Oriental Gas Company Act, 1857 (Act N° 5 of 1857): An Act to Confer Certain Powers on the Oriental Gas Company, Limited," 13.2.1857, http://indiankanoon.org/doc/333275/ (accessed March 18, 2016)

Parsi elite and scion of the wealthy Wadia family of shipbuilders. The first Indian to be elected as fellow of the Royal Society, London, Cursetjee was famous for introducing a number of engineering novelties to Bombay, including the sewing machine, photography, electro-plating – and gas-lights. On March 10, 1834, he lighted his bungalow and gardens at Mazagoan with gas, in the presence of the Governor of Bombay, John FitzGibbon.[36] According to legend, Bombay's first gas-lighted dinner party did not go well. As gas was not purified at the time, "[some] of the invitees were so overcome by the noxious smell that they had to be removed and the party itself had to be given up."[37] Bombay's first gas-lights were a mere curiosity, prestige objects to demonstrate both the prominent status of the Wadia family and the manifold possibilities of technical modernity, and they were not translated into urban infrastructures. Bombay's first street lights were fuelled with kerosene and not gas, installed in 1843 in public streets after ten years of arduous administrative debates.[38] It is difficult to gauge how much light those early street lights provided. Later descriptions of the lighting situation of the time speak of

> primitive *oil buttee* which shed its most indifferent light according to the interest of the contractor entrusted with the work. The older generation will tell us how it was unsafe to drive or walk after nine or ten in the evening on the Esplanade Road. People were often robbed and sometimes even murdered. [...] As to lanes and bylanes there was nothing. Houseowners, especially Parsis, [therefore] used to have a lantern hung up in the *otla* or verandah of their houses, a practice still observed here and there.[39]

12 Whether because of insufficient public security and/or technical improvements in gaslight technology, in the early 1850s, proposals for implementing gas illuminations accumulated at a time of intense discussions on urban reform and Bombay's future infrastructural development. The thirty years between 1845 and 1875 have been termed Bombay's "second phase of urbanization," a time of rapid economic and population growth that "created severe strains on the already limited civic facilities of Bombay town" and resulted in numerous plans and proposals for public works improvements.[40] Eliciting mixed reactions from both the colonial municipal administration and the public, the debates of the 1850s not only show how different urban infrastructures competed with each other for scarce resources, but also how notions of "Indian consumers" and supposed "native customs" were instrumentalized in these arguments – a constant thread in colonial discourses on "native" infrastructural requirements.

Four companies had offered to light Bombay with 13
gas in the early 1850s, demanding an exclusive municipal privilege in return. In response, C. F. Collier, Acting Clerk to the Board of Conservancy, appointed the English civil engineer and architect Henry Conybeare (1823-1892)[41] to investigate the soundness of these offers in 1853.[42] Conybeare, recently appointed as Superintendent of Repairs, had just finished his report on the sanitary state and requirements of the city, urging the Bombay Board of Conservancy to install efficient water and sewage systems.[43] Conybeare did not look upon gaslights as sympathetic. Considering the relative cheapness of lamp oils (fish oil, refuse castor oil, coconut oil), differences in prices would severely limit demand for gas-lighting he argued, rendering the enterprise unprofitable. As an alternative to gas-works based on expensive import coal, Conybeare suggested utilizing

36 Woods, "Mumbai," 38 (cf. note 14); "Ardaseer Cursetjee Wadia, first Indian Elected to Royal Society," n.d. Url: https://web.archive.org/web/20180419183803/http://www.auspostalhistory... (accessed 30/11/2018)

37 Doyle, *Bombay*, 50 (cf. note 34).

38 BEST Company, "History" (cf. note 33).

39 Wacha, *Rise*, 90-91 (cf. note 13).

40 Both citations from Dossal, *Imperial Designs*, 2 (cf. note 13). Dossal's Ph.D. thesis offers a detailed account of the urban planning discourses and projects of the time.

41 On Conybeare, see Murali Ranganathan, *Govind Narayan's Mumbai: An Urban Biography from 1863* (London: Anthem Press 2009), 335; Dossal, *Imperial Designs*, 47-50 (cf. note 13).

42 Coneybeare, "Appendix K," 1-2 (cf. note 8).

43 Henry Coneybeare, *Report on the Sanitary State and Sanitary Requirements of Bombay* (with Appendices) (Bombay: Bombay Education Society's Press, 1855).

local resources and everyday energies, namely vegetable oils, for production of illuminating gas and to think small, starting with experimental installations first.[44] India's large domestic coal deposits in Bengal and Bihar did not factor into his equation as these reserves were situated on the opposite side of India (and would, in fact, soon be utilized in nearby Calcutta for production of illuminating gas).[45]

14 Conybeare's argument was primarily economic and rested on a mismatch of demand and costs. The author identified three potential major consumers of illuminating gas: public street lights, large commercial customers, and private households. He dismissed all of them on both economic and cultural grounds. Public street lighting in Bombay, he argued, was negligible, with only fifty public kerosene lamps lighted from dusk to midnight during the four rainy months on each night, and on all but the bright moonlight nights during the fair season, accumulating to 1,680 hours annually.[46] With scarce financial leeway, Conybeare saw little chances for additional public lights. Even if all kerosene lamps were converted to gas and operated all night, street-lighting would only consume about 5,500 rupees per annum, an insufficient amount for the profitable operation of gas-works.[47] As for other large consumers, he stated categorically that "no manufactories, public offices, theatres, or churches, would require to be lighted in Bombay" as it would not be economical to employ gas where only occasional lighting was needed.[48] So, profitability of gas-works would rest on the shoulders of private consumers, particularly the "native population." Conybeare took great pains to dissect the notion of a "native market" for illuminating gas. His description of Bombay at night is a picture of seclusion and early retirement:

> [A] very good idea of the probable gas-consuming power of a town population might be formed by going through the streets of the town to be supplied between the hours of 9 and 10, and observing the extent to which the houses were lit up: at these hours there are very few lighted houses to be seen in the streets of Bombay, except on Duncan Road and Bhendy Bazar. In fact, the domestic expenditure of the middling and lower classes of Hindoos is proportionably as small in light as in food: they begin to light their lamps at dusk, usually one in the verandah of their houses, one in the hall or general sitting-room, and a third in the eating-room. [...] In general, all three lights are extinguished at about 10½ o'clock.[49]

15 Conybeare emphasized that many Bombay inhabitants did not have the budget for lavish illuminations, and would find the switch to new light sources with high initial costs for installations hard to bear. In other words, Conybeare argued that Bombay's non-European citizens neither required additional nocturnal illuminations, nor would they be able to afford their costs. Commonly used everyday energies and technologies would do. While not stated explicitly in the text, the crux of the matter was not only lacking demand or ability to pay for better illuminations, but also the question of how – and which – urban infrastructures should be developed with limited municipal means.

16 Conybeare's primary concern was sanitation, and with good reason. Urban hygiene was one of the most pressing issues of the 19th century.[50] Cholera or typhus epidemics were claiming thousands of lives, in 1833 more than 10,000 in London alone, resulting in the formation of public health movements in Europe.[51] Urban conditions in India were

44 *Ibid*.

45 Charles K. Ebinger, *Energy and Security in South Asia: Cooperation or Conflict?* (Washington, D.C.: Brookings Institution 2011), 16, 20; on the parallel gaslight debate in Calcutta, see Thomas Jones, *Advantages of the Use of Gas in Private Houses in Calcutta, with a Description of the Manufacture of Coal-Gas* (Calcutta: Calcutta Gazette Office, [1854]).

46 Coneybeare, "Appendix K," 4 (cf. note 8).

47 *Ibid*., 5-6.

48 *Ibid*., 7.

49 *Ibid*., 9.

50 E.g., Dieter Schott, *Europäische Urbanisierung (1000-2000): Eine umwelthistorische Einführung* (Köln: Böhlau, 2014).

51 Michael Mann, "Delhi's Belly: On the Management of Water, Sewage and Excreta in a Changing Urban Environment during the Nineteenth Century," Studies in History, vol. 23, n° 1, 2007; Colin McFarlane, "Governing the Contaminated City: Infrastructure and Sanitation in Colonial and Post-Colonial Bombay," International Journal of Urban and Regional Research, vol. 32, n°2, 2008, 416; Dossal, Imperial Designs (cf. note 13).

even more challenging. In Bombay, seven times more people were living on the same amount of space than in London.[52] Not only population density, but also climatic conditions enhanced health risks. European colonizers lived in constant fear of tropical diseases, expecting contagion from hazardous "miasma."[53] Conybeare's report was part of this larger discourse. His recommendations were clear: by installing efficient water and sewage systems, mortality rates might be reduced by at least twenty percent.[54] Compared to this vital and costly task, installing gaslights which might divert precious funds and manpower from essential water and sanitary works was not exactly high up on his agenda.

17 Few of the civic improvements discussed in the early 1850s actually saw the light of day, the most prominent exception being the Vihar project (1856-60), also initiated by Coneybeare, India's first municipal water project that served 7,500 houses primarily in the European quarters of the town with fresh water. Additional plans for water, drains, and street lighting were deferred on financial grounds, primarily for two reasons. On the one hand, military expenses had rocketed since 1857, first to curb the Indian Rebellion, then to prevent a recurrence, resulting in a drastic reduction in the financial allocations to public works in all presidencies.[55] Municipal funds for infrastructural works, on the other hand, were also scarce as ratepayer associations often opposed costly public health schemes. It was not before Bombay's Municipal Act of 1865 had vested first municipal commissioner Arthur Travers Crawford (1835-1911) with extra powers and revenues that urban reform gained momentum again in an almost Haussmannesque fashion.[56] Crawford was a controversial figure – today as well as at the time. He was both hailed as "the most gifted [...] of Municipal Commissioners"[57] and condemned as a "lavish spender"[58] of municipal funds. Crawford simultaneously embarked on a number of civic projects, including road repairs, sanitation, drainage, garbage disposal, and street lighting. Municipal revenues for these projects were to be obtained from a number of additional taxes vested on house owners, including a lighting rate of not more than two percent on the annual value of houses, buildings, and land.[59]

18 Crawford's municipal reforms came at a turning point in Bombay's history. In the early 1860s, the city had first experienced an unprecedented economic boom, fuelled by the soaring British demand for Indian cotton during the American Civil War from 1861 to 1865. The "cotton boom" of the time not only skyrocketed export figures, but also led to frenzied speculations on the Bombay stock exchange – resulting in a severe market crash in May 1865, after the American Civil War had ended, depleting both the city's finances and its population.[60] Against the backdrop of this disastrous financial crash and the accompanying trade depression, Bombay's mounting municipal expenditure encountered growing resentment. In 1870, two petitions signed by five thousand ratepayers accused Crawford of wasteful expenditure and unreasonably high levels of taxation. Petitioners argued that "there was no adequate return for ratepayer's money, as improvements were confined to a few select localities, and not shared by the greater portion of the town

52 Michael Mann, *Geschichte Indiens: Vom 18. bis zum 21. Jahrhundert* (Paderborn: Schöningh UTB, 2005), 317.

53 James Beattie, *Empire and Environmental Anxiety: Health, Science, Art and Conservation in South Asia and Australasia* (Basingstoke: Palgrave Macmillan, 2011); see also Robert Peckham, *Empires of Panic: Epidemics and Colonial Anxieties* (Hong Kong: Hong Kong University Press, 2015); Harald Fischer-Tiné (ed.), *Anxieties, Fear and Panic in Colonial Settings: Empires on the Verge of a Nervous Breakdown* (New York: Palgrave Macmillan, 2016).

54 Coneybeare, *Report*, 1-2 (cf. note 43).

55 Dossal, *Imperial Designs*, 74 (cf. note 13).

56 Tristram Hunt, *Ten Cities that made an Empire* (Milton Keynes: Penguin, 2015), 286-291.

57 Samuel T. Sheppard, *Bombay*, 133, cited in Dossal, *Imperial Designs*, 218 (cf. note 13).

58 Christine Dobbin, *Urban Leadership*, 132, cited in Kidambi, Making, 44 (cf. note 13).

59 Dossal, *Imperial Designs*, 85 (cf. note 13).

60 Within a few years, Bombay lost almost a quarter of its former inhabitants. – Nissel Heinz, "Bombay/Mumbai: Stadterweiterung und Stadtumbau einer 'Globalizing City'," *in* Ravi Ahuja, Christiane Brosius (eds.), *Mumbai – Delhi – Kolkata: Annäherungen an die Megastädte Indiens* (Heidelberg: Draupadi, 2006), 22.

occupied by the ratepayers."[61] Crawford was forced to resign in October 1871, and municipal investments in urban infrastructures were curtailed until the plague epidemic of 1896/97 initiated a new phase of municipal reforms.

18 Implementing Bombay's first gaslights in 1865 had been part of the short infrastructural boom of the 1860s – and street lighting one of the items in question on ratepayer's list of complaints regarding inappropriate expenditure.[62] As a result of the subsequent reduction in municipal investments, extension of Bombay's gaslight infrastructure largely rested on private individuals who donated additional lanterns near their places of residence and business. Most of "Crawford's Fireflies" were placed at the junction of large roads.[63] However, Bombay's gaslights were not an exclusively European and upper-class affair. Despite Conybeare's dictum that "native shops and dwellings" required and desired no brighter lights,[64] Bhendi Bazaar, the traditional commercial hub of the Muslim quarter north of Fort George, was also amongst the first to receive gaslights in 1865.[65] While gaslights were not utilized as extensively in Bombay as they were in Calcutta, they became and remained an important part of its lighting infrastructure, some surviving until 1968 (fig. 3).[66] The debate of the 1850s on the lighting requirements of Indian citizens, instrumentalizing supposed cultural patterns of illumination as justification for maintaining the status quo, also lingered on, resurfacing in the early 20th century when the introduction of electric lights was being discussed.

Figure 3: Maintenance of Gas Light: Worker Cleaning Old Street Lights, Fort, Bombay, 1946. Dinodia Photos / Alamy Stock Photo https://www.alamy.com/stock-photo-maintenance-of-gas-light-worker-cleaning-old-street-lights-fort-bombay-3663223.html.

(NO) NEED FOR A "BETTER CLASS OF LIGHT"? NEGOTIATING ELECTRIC LIGHT AND POWER

19 London, 1914/15: A peculiar debate unfolded between the British War Office and India Office. The 3rd Mountain Battery of the Royal Garrison Artillery had applied for free lighting of the quarters of "native personnel" serving in Egypt. The issue quickly turned into a matter of principle. While Indian troops serving in India had to pay for their own light, Indian Revenues had covered the costs for troops quartered in Burma, the Andaman or Nicobar Islands, a practice that had spread to other foreign stations in China, Ceylon, or the Straits Settlements.[67] The War Office was disinclined to continue this practice. The Secretary of State for India, in contrast, cautioned against actions that might invoke resentment of Indian troops. He identified two lighting

61 Kidambi, *Making*, 45 (cf. note 13).

62 E.g., Christine Dobbin, Urban Leadership, 132, cited in Kidambi, *Making*, 44 (cf. note 13).

63 Dossal, *Imperial Designs*, 198 (cf. note 13).

64 "I believe, that by far the greater portion of the private lights supplied by the London Gas Companies would be found to be used for lighting shops, and there would be no demand of this sort at Bombay – no 'early closing moment' is wanted here, for all shops save two or three chemists are habitually closed immediately after sunset." Coneybeare, "Appendix K," 7 (cf. note 8).

65 Woods, "Mumbai," 38 (cf. note 14).

66 *Ibid.*; see also: "Bombay's Street Lighting: Factors Underlying the Basis of Illumination – Artistic Lighting Foreshadowed," *Times of India*, 12 January 1933, 14.

67 British Library, IOR/L/MIL/7/7181, Secretary, War Office, to Under Secretary of State, India Office, 19/01/1914.

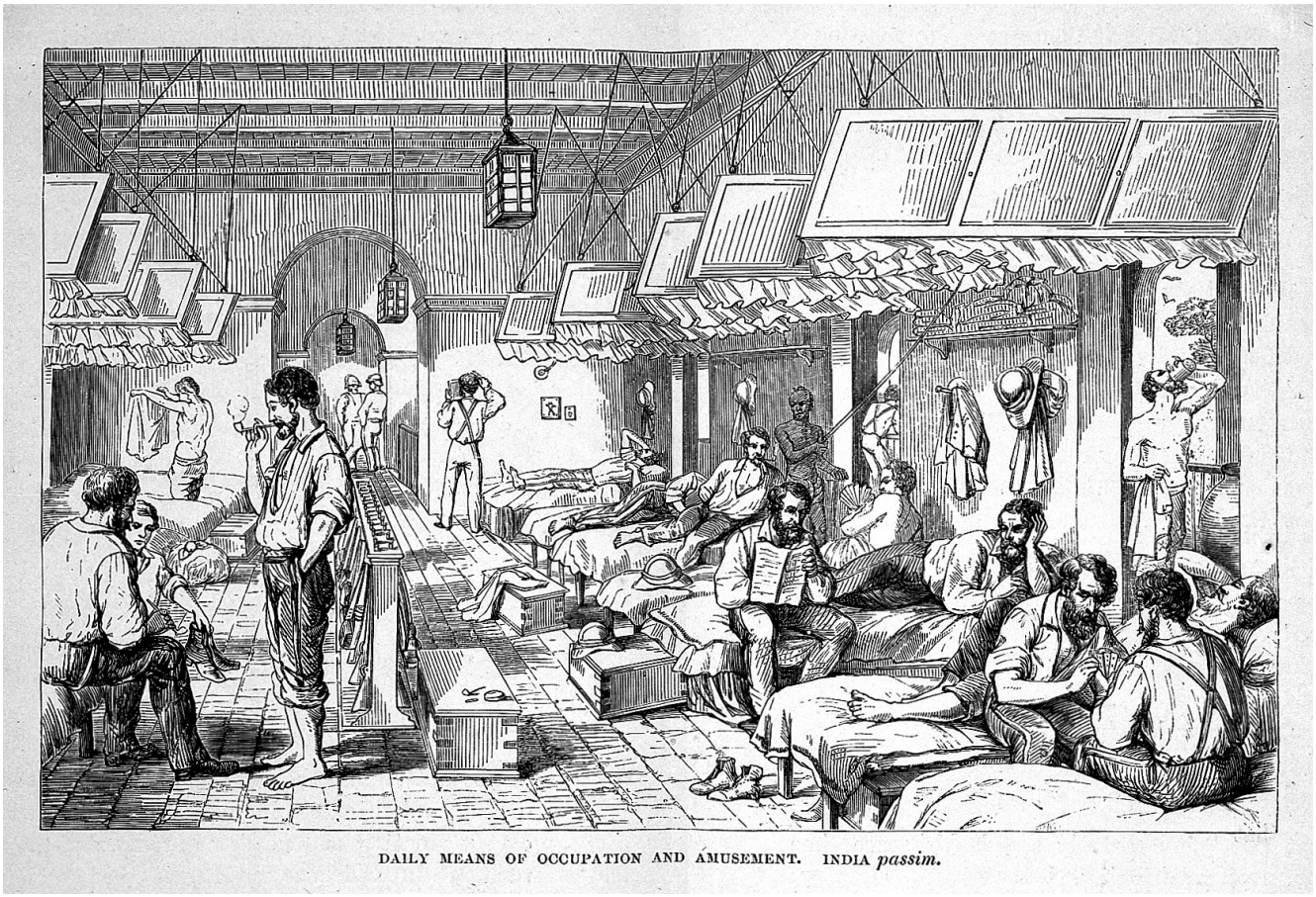


Figure 4: Illumination of British Troops Barracks in India, n.d. The British Army at rest in their barracks; Wellcome Collection (2018-04-03): https://wellcomecollection.org/works/x9t2xex9; CC-BY.

situations: temporary mat sheds, where special lanterns were required to reduce fire risk; and Government barracks equipped with permanent gas, or electric, lighting installation (fig. 4):

> In neither case [...] would it be either fair or politic to require Indian troops to defray the cost of light: for the first case the need of a better class of light arises from the character of the lines, for which the Indian troops are not responsible, and in the second case light is provided of a better and more expensive kind than they are accustomed to [first draft: which they do not require, and the convenience of which they cannot appreciate].[68]

20 It was precisely because Indian troops did not require "a better class of light" that it would be unreasonable to charge them for unwanted amenities. For a change, the trope "natives need/desire no modern lighting" was utilized to sanction and not withhold access to topical infrastructures.[69] The latter, of course, was far more common as many studies on colonial lighting have pointed out.[70] In this vein, when the Army Department had finally expanded the principle of free lighting of Indian troops barracks to India itself in 1921[71], its implementation was delayed for years by the Government of India, excusing this protraction once again with the soldiers home situation: "I suppose that the men who enlist in

68 *Ibid*., draft letter India Office, Military Department, to Secretary, War Department, 05/01/1915.

69 One exception was the Mountain Battery in Egypt whose request had initiated the debate. Judging that, in this case, quarters were equipped on the same lines as in India, the War Office refused free issue of artificial light to "native" personnel. *Ibid*., Secretary, War Office, to Under Secretary of State, India Office, 14/03/1915.

70 In particular: Chikowero, "Subalternating" (cf. note 2); Showers, "Electrifying" (cf. note 2); Shamir, *Current Flow* (cf. note 2); Tischler, *Light and Power* (cf. note 2).

71 British Library, IOR/L/MIL/7/10005: Army Instruction (India) 732 of 27th September 1921.

the Army are seldom accustomed to anything but a minimum of lighting in their villages, and as a result are unaccustomed to do reading of any sort after daylight. It is indeed doubtful if the Indian soldier will read much, even when he gets electric light in his barracks."[72] This line of argumentation caused the India Office great irritation. While the latter advocated the concurrent electrification of British and Indian barracks to avoid charges of benefitting British soldiers first,[73] the Government of India rather suggested transferring second-hand oil lamps from now-electrified British quarters to Indian units.[74]

21 These episodes, once again, nicely illustrate the persistent British view on the lighting needs of Indian citizens (and soldiers), equating the status quo with actual desires, and instrumentalizing supposed Indian customs to postpone costly reforms. The clash of positions between India Office and Government of India also hints at a tentative change of policies in the interwar period due to the ambivalent political situation of the 1920s. Improvements of infrastructures were regarded as a promising measure to increase legitimacy and pacify public discontent. But it was not before the Colonial Development and Welfare Act of 1940, that Britain actually committed to spending more metropolitan resources in its colonies.[75] Indian voices were missing in the archival records on the provision of (free) lighting for Indian troops, giving direct evidence to their wishes and habits. Still, concurrent discussions on urban lighting and electricity indicate that there was not only a need for a "better class of light," but also how local customers and stakeholders contributed in shaping India's urban fabric, adding another mosaic stone to recent research in colonial urban history that has challenged traditional views on the dualistic nature of colonial cities.

22 In the British Raj, there was no monolithic "Indian" or "European" experience of urban light (or darkness) as a complex mixture of ethnicity, status, and wealth determined who might gain access to modern technologies and energies over time. From the very beginning, demand for electric light and power by Indian consumers, particularly from the urban upper and middle classes, by far exceeded supply. As the capital of India until 1911, Calcutta had been the first Indian city to be electrified. Here, commercial generation of electricity took off in 1899, drawing on Bengal's rich coal deposits. At first, each new household connection required a joint application of consumer and undertaker to the Bengal government, and the responsible department was flooded with applications from Indian customers.[76] Affluent Indian citizens had utilized electricity even before urban infrastructures were installed. Electrically illuminated marriage processions powered by portable generators had already become fashionable in the early 1890s, showing once again how "traditional" practices flexibly incorporated new technologies.[77] However, the enthusiasm for electricity was not universal. Similarly to many European and North American households and businesses[78], electricity – as an unfamiliar commodity – had to be popularized first through precedent, advertisements, door-to-door canvassers or electricity showrooms, and exhibitions. As Suvobrata Sarkar has shown, some potential Indian customers initially assumed that household connections would require a hole in the wall of their houses or feared danger from overhead wires.[79] Deadly accidents provided ample fodder for newspaper headlines, sometimes even globally as in the case of an incident in Mysore in 1909 where a *mahout* (elephant

72 British Library, IOR/L/MIL/7/10005: extract from a private letter from Lord Irwin (Viceroy of India) to Lord Birkenhead (Secretary of State for India), 07/09/1927.

73 *Ibid*., Lord Birkenhead (India Office) to Governor General of India, 30/09/1926 (Military n°. 19); minute 30/06/1927.

74 *Ibid*., extract from a private letter from Lord Irwin (Viceroy of India) to Lord Birkenhead (Secretary of State for India), 07/09/1927.

75 On the developmental colonialism of the 1940s and 1950s, see also Jonas van der Straeten, Ute Hasenöhrl, "Connecting the Empire: New Research Perspectives on Infrastructures and the Environment in the (Post)Colonial World," *NTM*, vol. 24, n° 4, 2016, 366; Frederick Cooper, *Africa since 1940: The Past of the Present* (Cambridge: Cambridge University Press, 2002).

76 Sarkar, "Domesticating," 367-368 (cf. note 13).

77 *Ibid*, 366.

78 E.g., Brox, *Brilliant* (cf. note 12); Sandwell, "The Coal-Oil Lamp" (cf. note 9).

79 Sarkar, "Domesticating," 361 (cf. note 13).

keeper) of the palace guard was electrocuted when jokingly touching overhead wires.[80] But most of these concerns were soon alleviated: insulation improved, underground cables were laid in crowded areas, and architects accommodated building designs to conform to the electricity supply plan.[81]

23 Compared to Calcutta, Bombay was an electric latecomer. First attempts to electrify the city can be traced back to the early 1880s, but had been of limited success. In 1882, a private company installed a generator to supply Crawford Market (Bombay's wholesale market) with electric lights. When visiting the market in the same year, Bhagvatsinhji, the Maharaja of Gondal, was so impressed by the display that he decided to introduce electricity in his new palace. Despite its dazzling effect on spectators, the utility soon went bankrupt, as did its successor, the Eastern Electric Light and Power Company.[82] The city government took over and constructed a municipal generating plant in 1894, but the plant's small motors were prone to break down.[83] Most utilities in India were commercial enterprises as English municipal law did not encourage the formation of municipal companies but favored allocation of licenses to private businesses instead.[84] Private generation of electricity was also quite common. Due to lacking or insufficient supply, some wealthy homes, hotels, and factories had taken matters into their own hands and installed private generators since the 1890s. The Taj Hotel, owned by the prominent Tata family, was the first public building in Bombay to be lit by electricity in 1903. It was supplied by a steam-powered electric generator in the hotel garden, with a back-up system for gas-lighting.[85] In the early 20th century, complaints about lack of electricity were getting louder and louder, from both private citizens and businesses. For the rich, electricity had great potential for improving living conditions in the tropics, e.g., by powering mechanical *punkahs* (fans) or refrigerators. During the hot months of May and June, electric lights also promised a respite from the heat emanated by candles, oil, or gas-lamps.[86] Even more important than these private conveniences, Bombay's major industries, particularly its jute and textile mills, were eager to modernize in order to remain competitive with British textile production, uniting British colonial and Indian elites in their quest for more power.[87] In addition, with Bombay rapidly expanding its territory, the municipality was also looking for new ways of transport to connect its bourgeois and working-class suburbs to the city via a network of horse-drawn and electric tramways.[88]

24 The question of who might supply the lucrative Bombay market and how this should be accomplished was controversial. Jamsetji Nusserwanji Tata (1839-1904), "father of Indian industry" and one of the founders of today's TATA Group, applied for a concession for utilizing the waterfalls at Marble Rocks, Jubalpore, as early as 1875, but the concession was not granted.[89] In the end, the municipal government awarded the contract for generating electricity to the British company B.E.S.T. (Bombay Electric Supply and Tramways) in 1905. With its thermal plant, B.E.S.T. primarily supplied power for electric trams, with little electricity left for private or commercial customers even though its license granted the company an exclusive right to distribute electricity in the city.[90] To resolve this unsatisfactory situation and cater to growing demands for an opening of the domestic energy market for Indian vendors, the new Governor of

80 Frasch, "Empowering," 36 (cf. note 13).
81 Sarkar, "Domesticating," 358, 361-365 (cf. note 13).
82 Frasch, "Empowering," 38 (cf. note 13).
83 Woods, "Mumbai," 38 (cf. note 14).
84 Frasch, "Empowering," 39 (cf. note 13).
85 *Ibid*, 39.
86 Reed, "Foreword," V-VI (cf. note 28).
87 S. M. Rutnagur, *Electricity in India: Being a History of the Tata Hydro-Electric Project with Notes on the Mill Industry in Bombay and the Progress of Electric Drive in Indian Factories* (Bombay: Proprietors, 1912), 12.
88 Mahaluxmivala, *The History* (cf. note 8); Frasch, "Empowering," 40-44 (cf. note 13).
89 Rutnagur, Electricity, 4 (cf. note 87); on the Tata's business and family history, see also R.M. Lala, *The Creation of Wealth: The Tatas from the 19th to the 21st Century* (New Delhi: Penguin Books India, 2004).
90 Kale, *Electrifying*, 72 (cf. note 4); Mahaluxmivala, *The History* (cf. note 8).

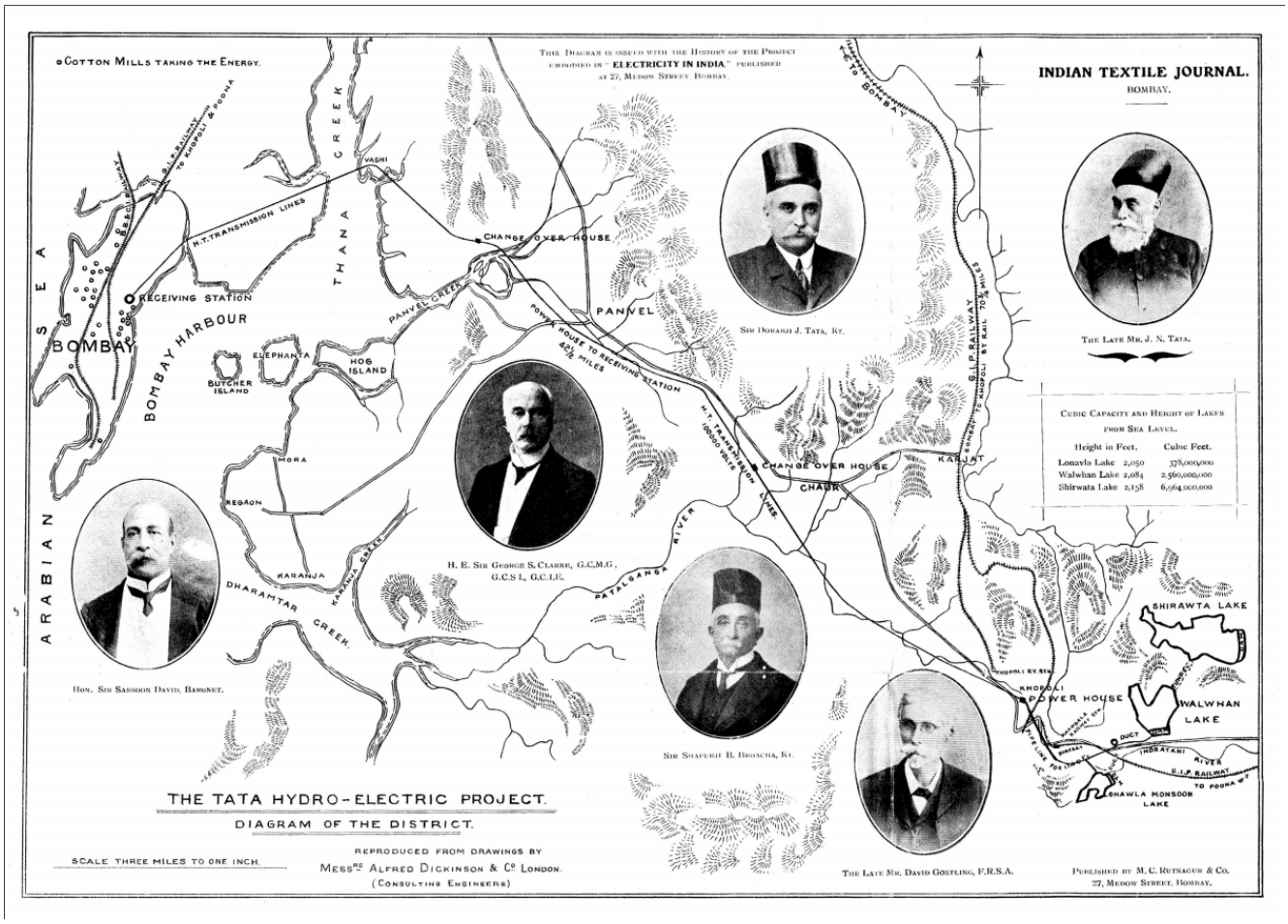
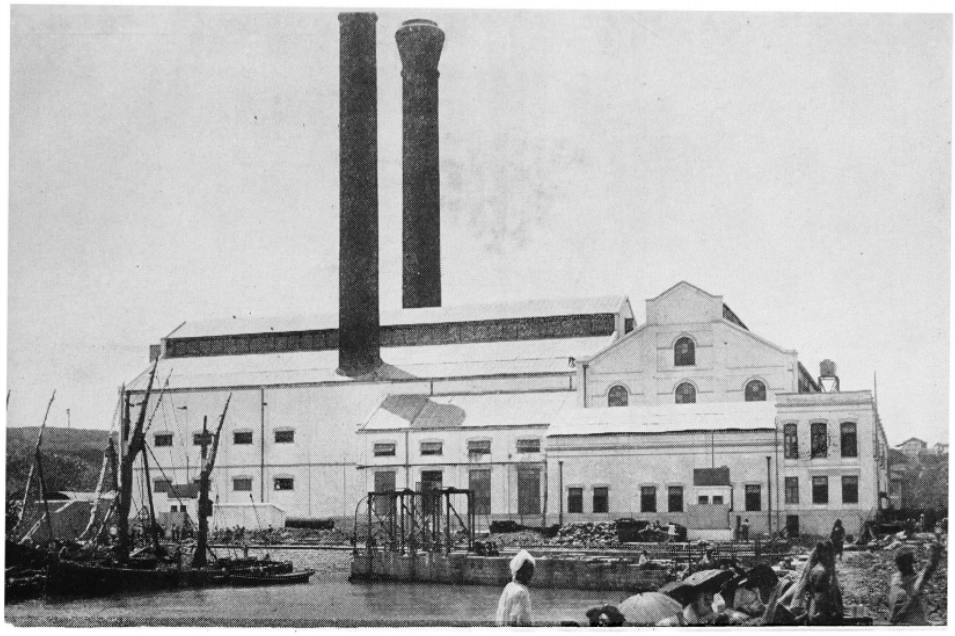


Figure 5: The Tata Hydro-Electric Project, 1912. S.M. Rutnagur (ed.), Electricity in India. Being a History of the Tata Hydro-Electric Project with Notes on the Mill Industry in Bombay and the Progress of Electric Drive in Indian Factories. Prop. India Textile, Bombay 1912, supplement; Retrieved February 10, 2019, from https://archive.org/details/ElectricityIndia/page/n95 (Public Domain Mark 1.0).

Bombay, Sir George Clarke (1848-1933), encouraged another electricity scheme for Bombay, the Tata Hydro-Electric Project (fig. 5).[91] First considered in 1895, it was comprised of two reservoirs collecting monsoon waters at the Lonavla and the Wahlwan in the Western Ghats, a mountain range east of Bombay (with storage capacity of 380 resp. 2,800 million cubic feet), a 72-MW-generating plant at Khopoli, and 43 miles of transmission lines to Bombay. Licensed in 1907, Khopoli station was brought online in 1915, one of the first "Swadeshi" utilities, financed entirely by Indian capital and providing power solely to Indian enterprises.[92] In order not to infringe on the B.E.S.T. license, Khopoli station was only allowed to supply customers requiring more than 500,000 units of electricity annually (equivalent to 250 horsepower per hour) and not the general public.[93]

The Tata Hydro-Electric Project was a turning point in Bombay's energy history. It was so successful that in 1925, B.E.S.T. abandoned its own thermal plants (fig. 6) and simply purchased power from the Tatas.[94] Tata hydroelectricity indirectly allowed broader public access to electricity as well. Starting with 107 consumers in 1905, B.E.S.T.'s number of costumers rose significantly in the interwar period, from 12,041 in 1918 to 30,485 in 1923, reaching 65,412 in 1935.[95] At a time when the city's population roughly numbered 1.4 million,[96] this meant that about 4.5

91 In detail: Lanthier, "L'électrification" (cf. note 13).
92 Rutnagur, *Electricity* (cf. note 87).
93 *Ibid*, 16; Kale, Electrifying, 72 (cf. note 4).
94 Woods, "Mumbai", 39 (cf. note 14).
95 Mahaluxmivala, *The History*, 437 (cf. note 8).
96 Population numbers according to https://de.wikipedia.org/wiki/Mumbai_City (accessed 30/11/2018)



THE POWER STATION OF THE BOMBAY TRAMWAY AND ELECTRIC SUPPLY COMPANY, LIMITED, BOMBAY.

Figure 6: The Power Station of Bombay Tramways and Electrical Supply Company, Limited, Bombay. https://archive.org/details/ElectricityIndia/page/n75 (Public Domain Mark 1.0).

percent of Bombay's citizens had legitimate access to electricity in the mid-1930s, leaving out the great majority of the population. Particularly for the urban poor, electricity was still nowhere near an everyday energy. "Unofficial" access was probably much higher. Omitted from grid design and/or unable to pay tariffs, potential customers frequently took matters into their own hands, tapping wires or tampering with meters, as clauses on electricity theft in lighting acts and bills suggest.[97] Preparing the Indian Electricity (Amendment) Act of 1922, the Official Report of the Council of State Debates commented on this practice: "Section 39 penalises theft of energy, but in actual practice it has not proved very effective; usually impossible to prove who actually made an illegal connection; yet unless we succeed in doing this, it is usually impossible to obtain a conviction".[98]

While most Indian households and businesses still relied on traditional forms of energy and illumination, electricity started to become an increasingly familiar item of Bombay's urban spaces and culture in the interwar years. Electric tramways specifically targeted young urban professionals and "white collar workers" commuting to their workplaces.[99] Night schools and "modern" nocturnal entertainments such as cinemas, theatres, and nightclubs catered to diverse audiences, and often utilized (or even relied on) electric light and power.[100] Electric street lighting also increased moderately in the 1920s and 30s, from 156 electric lamps in 1921 to 1,433 in 1935, the majority now operating throughout the whole night.[101] For the most part, Bombay remained a gas-lit city, showing once again that "new" technologies did not necessarily take over "old" ones.[102] From 8,523 street lamps in use

97 E.g., Calcutta Electric Bill 1895 (British Library, IOR/L/PJ/6/412, File 85); The Indian Electricity (Amendment) Act 1922 (British Library, IOR/L/PJ/6/1744, File 2394).

98 British Library, IOR/L/PJ/6/1744, File 2394, extract from Official Report of the Council of State Debates, 23/01/1922, 647.

99 Frasch, "Empowering," 40-44 (cf. note 13).

100 See Kidambi, *Making* (cf. note 13), on Bombay's working class culture; Prakash, *Mumbai Fables* (cf. note 13), on the city's entertainment industry and culture.

101 Mahaluxmivala, *The History*, 377-380 (cf. note 8).

102 See Edgerton, *The Shock* (cf. note 16).

in 1933, nearly 7,000 were gas-lamps.[103] At the time, the *Times of India* raved about the quality of lighting achieved in Bombay, "superior to that of any other city in India, and [...] not inferior to that of cities of a similar size in other countries."[104] With lamps converted from one-light to two-light design to ensure a wider diffusion of light, and combined with domestic and commercial lighting, illumination in some streets was even described as excessive.[105] The enhanced nocturnal brightness even elicited complaints about what today would be called light pollution as "the light of our electric lamp-posts erected near their houses came straight into their bedrooms."[106] This conflict could at least be resolved easily: the Municipality covered the expenses of fitting glare guards.[107] Bombay seemed to have transformed itself into an Indian "city of light," albeit one with a clear distinction between rich and poor quarters.

TOWARDS A BRIGHT(ER) FUTURE? IMAGINATIONS OF LIGHT AND DARKNESS

27 Bombay, 1950: newly independent India is in a process of redefining itself. One of the questions up for debate is how the young nation should present itself to attract visitors and encourage tourism. In an article published in the *Sunday News of India* in the same year, Bombay is painted as a sublime mixture of Western and Asian lifestyles:

> Bombay, as the port by which tourists are most likely to enter India, is an impressive and beautiful city to approach. Should the ship arrive during the night or at dawn, the jeweled slenderness of the Rajabai Tower, the Queen's Necklace of lights outlining the sea-front and hiding the sordidness of the box-flats, the Gateway of India backed by the massive façade of the Taj, are spread before the newcomer in invitation and welcome; it seems, more even than by day, an enchanted city.[108]

Much of Bombay's "architecture of the night,"[109] 28
which played such a major role in defining (and explaining) its public appeal, dated back to colonial times, particularly the interwar period. At the time, not only the city's daytime character, but also its nocturnal face was "modernized" by both its European and Indian citizens. Since the late 19th century, Bombay had turned into India's most important industrial city, a soaring center of commercial activity with a diverse population that had exceeded the one-million-mark during WWI.[110] Living conditions differed widely across the city – from the elitist residential areas of Colaba or Malabar Hill with their Neo-Gothic or Art Deco buildings, to the idyllic middle-class settlements of Matunga, Dadar, and Sion that had been constructed according to Garden City principles, to the overcrowded, dark and ill-ventilated houses of the Fort Area and New Town, and, finally, the modernist multi-apartment blocks (*chawls*) that the City Improvement Trust had constructed as part of its public housing program.[111] With many of its poor inner city quarters razed and their former inhabitants dislocated,[112] "modern" Bombay framed itself as

103 "Bombay's Street Lighting" (cf. note 66). – With its reliance on gas-lamps, Bombay was no exception. In Europe, there were also a number of cities that continued to utilize gas for urban lighting purposes in the interwar period. Particularly cities that had invested strongly in municipal gasworks tended to continue on this technological path. Berlin, for example, only switched to electric street-lighting on a larger scale after WWII had wrought havoc on its gas infrastructure. On Berlin's history of lighting, see Ute Hasenöhrl, "Die Stadt im Licht: Städtische Beleuchtung als Infrastruktur," *Informationen zur modernen Stadtgeschichte*, n° 1, 2015.

104 "Bombay's Street Lighting" (cf. note 66).

105 *Id.*

106 Mahaluxmivala, *The History*, 380 (cf. note 8).

107 *Id.*

108 "Come to India," *The Sunday News of India*, 2 July 1950, 8.

109 Woods, "Mumbai", 39-42 (cf. note 14).

110 Nissel, "Bombay," 25-26 (cf. note 60).

111 See Kidambi, *Making* (cf. note 13), on Bombay's disparate urban fabric; on its architecture, see Norma Evenson, "An Architectural Hybrid," *in* Sujata Patel, Alice Thorner (eds.), *Bombay: Mosaic of Modern Culture* (Delhi, Calcutta, Madras: Oxford India, 1996).

112 As Kidambi has shown in detail, the activities of the City Improvement Trust, initiated in 1898 in the aftermath of the plague epidemic of 1896/97 to improve public health, were at best ambivalent. Destruction of houses often aggravated living condition in remaining dwellings as dislocated residents rather moved in with their neighbours that to newly-constructed tenements far from their places of work. Kidambi, *Making* (cf. note 13).

a cosmopolitan city of dreams. Art Deco was its architectural style of choice, reflecting the aesthetic ambitions and international inclination of Bombay's upper and middle classes, as well as their fascination with rational, functional technologies.[113] By the mid-1930s, most of these well-to-do neighborhoods were also connected to water mains, sewage canals, telephone and electrical lines – and well-lit at night.

29 Public and private lighting was not just a pleasant convenience and a matter of public security that facilitated urban life, but also ideologically charged from the very beginning.[114] As Susie Protschky has shown for the Netherlands Indies, electric lights and nocturnal illuminations were a vital part of the symbolic politics of European colonial powers, showcasing the "enlightenment" and modernity of their rule.[115] In the British Empire, the illumination of colonial buildings, monuments, and events also worked as visual manifestations of imperial might, distinguishing between "modern" and "backwards" lifestyles.[116] As a consequence, representative or administrative buildings such as the Viceroy's lodge in Simla, governor's mansions, telegraph offices, or railways stations were amongst the first to be equipped with electric light and power.[117] Dazzling illuminations provided British colonial rule with a seductive luster of brilliance and sophistication. At the Imperial Durbar of 1903, Viceroy Curzon (1859-1925) illuminated the European encampment "with more than a hundred arc lamps [...], while ninety-three hundred incandescent lightbulbs were supplied to light the tents. The electricity for the Central Camps was provided by a power station situated near the Viceregal Logde."[118] Lady Curzon's famous peacock gown was inwrought with glittering metal threads and sparkling jewels so as to attract attention in the electrically illuminated ballroom.

30 Not only did the British play the illumination game, but also Bombay's Indian inhabitants, particularly its wealthy business elite. At the forefront was the Tata family. Keen on producing and transmitting electricity, the family built the Taj Hotel as a showcase of electrical modernity [Figure 7], equipped with the latest amenities such as electric fans, lights, and elevators. For special events, its façade was illuminated with a string of electric light bulbs.[119] When King George V visited Bombay in 1911, illuminating the building cost over 9,000 rupees – a powerful demonstration not only of the Tata's loyalty to the crown, but also of their economic prowess, modernity, and confidence as British citizens. Jamsetji Tata conceived the Taj "as a grand and modern hotel where Indians and European could meet as equals at the entrance to Bombay's harbour,"[120] ostensibly a response to the insult of being denied entry to a European-only hotel. The Taj was Bombay's prime location for cultivated, slightly frivolous night-time entertainment. It was the "Mecca for the city's jazz aficionados"[121] and hosted an upscale nightclub and cocktail bar.

31 More socially encompassing than the exclusive Taj were Bombay's cinemas. Bombay's film industry started in 1896 with the exhibition of imported films, but, starting in 1913, also produced movies of its own.[122] Culturally and architecturally, Bombay cinema soon turned

113 Prakash, *Mumbai Fables*, 95-104 (cf. note 13).
114 For Europe, see Schivelbusch, *Lichtblicke* (cf. note 12).
115 Protschky, "Empire" (cf. note 1).
116 E.g., Rao, Lourdusamy, "Colonialism" (cf. note 2); Chikowero, "Subalternating" (cf. note 2); Showers, "Electrifying" (cf. note 2).
117 E.g., Public Works Department, *Completion Report of the new Viceroy Lodge in Simla* (Calcutta: Government Printing, 1890); Tanja Winther, *The Impact of Electricity: Development, Desires and Dilemmas* (New York: Berghahn Books, 2011).
118 Coleman, *Moral Technology* (cf. note 13); Frasch, "Empowering," 43 (cf. note 13).
119 Woods, "Mumbai", 39 (cf. note 14).
120 *Ibid*.
121 Prakash, *Mumbai Fables*, 104 (cf. note 13).
122 On Bombay cinema, see Kaushik Bhaumik, "A Brief History of Cinema from Bombay to 'Bollywood'," *History Compass*, vol. 87, n° 2, 2004, 1; Annemarie Hafner, "Die frühe Kinokultur in indischen Großstädten," *in* Ravi Ahuja, Christiane Brosius (eds.), *Mumbai – Delhi – Kolkata: Annäherungen an die Megastädte Indiens* (Heidelberg: Draupadi, 2006).

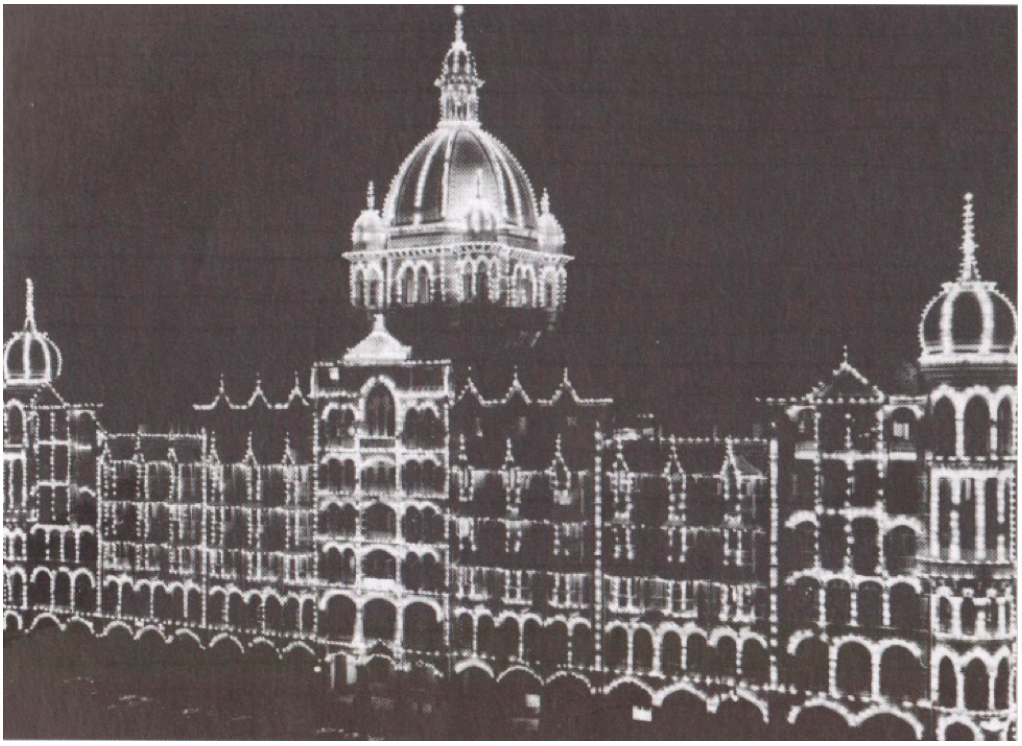


Figure 7: The Taj Hotel, Bombay, 1953 (from: Woods: Mumbai). Copyright Taj Mahal Palace Hotel Collection, Mumbai.

into an icon of Indian modernity, contributing a new facet to urban nightlife, as well as to Bombay's architecture of the night. Figurehead was the Regal, established by Parsi showman Framji Sidhwa in 1933. The Art Deco building at Colaba Causeway was the first air-conditioned theatre of India and the first to introduce neon lighting to Bombay.[123] Bombay's cinemas give a vivid impression of the city's two-tier society. While elegant venues such as the Regal catered to the tastes of Europeans, Anglo-Indians and the Indian social elite by broadcasting international films to the sound of the Wurlitzer organ, the great majority of movie theatres increasingly playing domestic productions since the late 1920s were Spartan, overcrowded affairs. Bombay cinema had considerable influence on Indian social practices and values, reflecting India's quest for national identity, as well as acting as a vehicle for social reform. Cinema had also altered night-time habits. In the 1920s and 30s, many workers congregated twice a week between 20:00 and midnight for *bhajans*, chanting religious and mythological songs. As cinemas became more and more popular, this practice almost disappeared, as did other nightly leisure activities, such as amateur theatre, poetry readings, or musical gatherings.[124]

Bombay's third emblem of the illuminated 32
night was Marine Drive, the promenade curving along the Arabian Sea constructed between 1935 and 1940. As Gyan Prakash has pointed out, at night Marine Drive presented the city at its finest, both a "spectacle of modernity" and an incarnation of the "good life."[125] As a living and working space, the apartment and office buildings lining Marine Drive were amongst the most costly and exclusive of the time. In contrast to the Colonial Gothic style of Esplanade Road with its row of government and institutional buildings, Marine Drive with its stylish

123 Woods, "Mumbai," 39-40 (cf. note 14); "Bombay's New Theatre Opened by the Governor," *Times of India*, 16 October 1933, 11.

124 Hafner, "Kinokultur" (cf. note 122); see also: Jim Masselos, "Spare Time and Recreation: Changing Behaviour Patterns in Bombay at the Turn of the Nineteenth Century," *South Asia*, vol. 7, n° 1, 1984, on changing recreational patterns in Bombay at the turn of the 19th C.

125 Prakash, *Mumbai Fables*, 75-79 (cf. note 13).

Art Deco architecture represented the glamorous, cosmopolitan dreams of Bombay's Indian elite.[126] The "Queen's Necklace," however, was more than an exclusive social space. It soon became a popular site for recreation at the city's shore. At night, large crowds promenaded along Marine Drive or went for a ride – and later moved on to nearby Churchgate Street, the epicenter of Bombay's nightlife with its restaurants, bars, and jazz clubs.[127]

33 In the 1930s, Bombay was perhaps "the most completely electrified city in Asia,"[128] a vibrant showcase of Indo-Western modernity. Its electric lights epitomized a bright(er) future – not just for the city itself, but for all of India. In this vein, modernizers such as later Indian Prime Minister Jawaharlal Nehru (1889-1964) framed electricity as a fundamental of life and demanded vigorous national electrification to improve the standard of living.[129] This vision of modern India mirrored Western as well as socialist notions of energy modernity – and, after independence, turned into one of the guiding principles of India's economic and social policies.[130] It was not uncontested. Traditionalists such as Gandhi (1869-1948) regarded large-scale modernization with skepticism, including "mass production" of life essentials such as light or water, and emphasized the benefits of traditional, village-level, labor-intensive technologies, and decentralized solutions instead.[131] Non-profit groups and environmental organizations later revived this narrative as the ecological and social impact of energy projects (e.g., resettlements, pollution) became ever more apparent. But as early as the 1920s, villagers launched a (ultimately unsuccessful) *satyagraha* campaign against the Mulshi scheme of Tata Power Company (in Pune district near Bombay) as the proposed reservoir threatened to submerge their ancestral lands and homesteads – probably the first anti-dam movement in India.[132] Since the late 19th century, public debates on the design of and access to modern energies and technologies such as lighting had put not only colonial policies into question, but also helped to sharpen and reframe visions of India's future as a "modern," "traditional" or "hybrid" society.

CONCLUSIONS

34 The colonial history of artificial light and darkness is an ambivalent one – and its Bombay thread only one of numerous narratives. As "Urbs Prima in Indis," Bombay was the exception rather than the rule, not least because it actually turned into an Indian "city of light" during colonial times. Even though Bombay's lighting history in many ways resembles the "classic" expansion story of artificial light, there were, however, more variables in play in a colonial than in a Western setting. While in Bombay ethnicity did not factor as heavily as, for example, in Northern Rhodesia, where access to electric lighting was systematically segregated on racial lines,[133] supposed "native habits" were still instrumentalized by the British to excuse lack of modern infrastructures in Indian quarters. Nevertheless, there was no monolithic "Indian" experience of urban light and darkness. Bombay's wealthy and influential business elite also exerted a significant influence on municipal decisions, both advancing and impeding infrastructural developments

126 Sidharth Bhatia, "The Making of Marine Drive," The Indian Quarterly, [2015]. Url: http://indianquarterly.com/the-making-of-marine-drive/ (accessed 29/11/2018)

127 *Id*; Woods, "Mumbai," 40-41 (cf. note 14); "Night Driving Risks," Times of India, 15 September 1939, 13.

128 Reed, "Foreword," VI (cf. note 28).

129 E.g., "Premier Opens Rs. 100-Crore Hirakud Dam: Era of Plenty Ahead for Orissa – Power for Villages, India's Objective," *Times of India*, 14 January 1957, 1, on the inauguration of the multi-purpose Hirakud Dam in Odissa in 1957.

130 In detail: Kale, *Electrifying*, 1-61 (cf. note 4).

131 "While it is true that you will be producing things in innumerable areas, the power will come from one selected centre. That, in the end, I think would be found disastrous. It would place such limitless power in one human agency that I dread to think of it. The consequence, for instance, of such a control of power would be that I would be dependent on this power for light, water, even air and so on. That, I think, would be terrible." Gandhi, "Mass Production" (1934), cited in: Kale, *Electrifying*, 28 (cf. note 4).

132 Rajendra Vora, *The World's First Anti-Dam Movement: The Mulshi Satyagraha 1920-1924* (Ranikhet: Permanent Black, 2009).

133 E.g., Chikowero, "Subalternating" (cf. note 2).

with donations and ratepayer's veto rights – although not even the powerful Tata family was able to obtain licenses for electrifying Bombay at first. A mixture of wealth, status, and race thus decided on who might benefit from modern amenities, with more and more Indian citizens gaining access since the interwar period. The prosperous elite (both European and Indian) "clustered along the south and west side of the city while the poor were shunted together amid ill-planned and insanitary alleys north of the fort."[134] Unsurprisingly, Bombay's slums were amongst the last to receive modern infrastructures, if at all.

35 Lack of light should not be confused with lack of interest in (modern) lighting as many contemporary Western voices discussing the nocturnal darkness of Indian quarters did. On the contrary, in Hindu culture and religion, light is highly venerated as an auspicious life-force, while darkness is related to death. One of the few Hindu gods associated with (and worshiped in) darkness is the goddess Kali, the "ultimate destroyer," while Lakshmi, the goddess of prosperity, is celebrated with lavish illuminations during Diwali, the Hindu festival of lights – interestingly enough both on the same night.[135] And even outside special occasions and festivities such as Diwali, clearly not everybody was asleep at night as recurring European comments on Bombay's supposed lack of nightlife suggested.

36 So far, historical research – including this article – has only touched upon this rich area of study. Many questions are still up for debate: (how) did urban (lighting) infrastructures and technologies turn into objects of everyday, or rather, everyNIGHT, life in different strata of society? How did gender come into play? Which kind of "everyday energies" was utilized for lighting purposes and how did this resource base change over time? How did artificial light alter perceptions of light and darkness, and, last but not least, how did lighting impact on different areas of nocturnal society, e.g. religious processions, safety and crime, night-time entertainment or night work? To answer these questions, we need to look beyond "traditional" archival materials on the development of infrastructures and colonial urban planning, to capture more than just the voices of the European and Indian elites – an endeavour of increasing difficulty as we go back in time. There is still much to be learned about the nocturnal history of Bombay, the Raj, and the British Empire, whether dark or illuminated.

134 Hunt, Ten Cities, 274 (cf. note 56).

135 Ralph W. Nicholas, *Night of the Gods: Durga Puja and the Legitimation of Power in Rural Bengal* (New Delhi: Orient Black Swan, 2013), 44, 48, 143-144.

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JEHRHE

Journal of Energy History
Revue d'histoire de l'énergie

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ENGLISH TRANSLATION OF
"Apprivoiser l'obscurité : un nouveau programme pour l'architecture des salles de cinéma parisiennes entre 1914 et 1921" *by Arby Gharibian.*

POST DATE
10/07/2019

ISSUE NUMBER
JEHRHE #2

SECTION
Special issue

THEME OF THE SPECIAL ISSUE
Light(s) and darkness(es): Shifting historical relations

KEYWORDS
Electricity, Innovation, Light, Business, Heritage

DOI
in progress

TO CITE THIS ARTICLE
Mathilde Thouron, "Taming darkness: A new program for Paris cinema architecture between 1914 and 1921", *Journal of Energy History/ Revue d'Histoire de l'Énergie* [Online], n°2, published 10 July 2019, consulted XXX, URL: energyhistory.eu/en/node/139.

Taming darkness: A new program for Paris cinema architecture between 1914 and 1921

Abstract
During the 19th C., the Industrial Revolution and technical advances from the modern era led to the massive use of glass in architectural constructions, which contributed to the transparency of volumes as well as the entrance of natural light within the built environment. By contrast, the "electricity fairy" generated a new kind of darkness. Science and stage-related artistic fields used the inherent qualities of darkness through devices that acted on the status of both the image and the observer. While it was a period in which openings were emphasized in building exteriors, architecture also had to integrate the component of darkness, spurred by the emergence of a large number of machines requiring darkness between the early 19th C. and late 20th C. Prompted by the renewal of energy, darkness quickly became a part of architectural productions designed for projecting film.

Plan of the article

INTRODUCTION

1 During the 19th C., the role of the darkness-light duo within architecture was modified through the massive industrialization of glass, as well as numerous discoveries in optics and hygiene. Roberto Casati, the philosopher of perception, made the following observation in his research on shadows: "The 19th C. did not just defeat shadows, it also created new ones."[1] While artificial light tended toward definitively eliminating shadows, as pointed out by Jun'ichirō Tanizaki in *Éloge de l'ombre,*[2] the stability of the electrical source and what it allowed in terms of plastic manipulation of the space nevertheless opened the way for new practices.

2 This shift, which was brought about by the electrification of light in the late 19th C., can be seen more specifically in the relation to nocturnal urban space than within architectural design. As artificial light took hold in the nocturnal urban space, hygienist doctors prescribed a maximal entry of its natural counterpart in architecture. This new obligation regarding the penetration of natural light within the built environment, which was more clearly imposed by hygienist decrees in Europe between the late 19th C. and the early 20th C., had a lasting influence on architectural design. The German architect and theorist Gerhard Auer had the following thought on the subject: "Blinded by their own metaphors of light and transparency, the avant-gardes of modernity chased away all deceptive shadows, and condemned any black emotion as a suspicious regression."[3] Modern architecture thus initiated, for chiefly hygienist reasons, a fight that ultimately ascribed negative connotations to darkness for designers of the period.

3 However, by further anticipating sunlight right from the design phase, designers had to integrate the effects produced by shadows within architectural volume. Light was thus invited by the designers to strike the volumes of structures so as to project distinct shadows that visually structure the space.[4] This approach was promoted by an increased awareness of the need for natural light. Solar projection as a factor in architectural composition was firmly present in design, but what of the relation to artificial light?

4 In parallel to this considerable introduction of natural light in architecture, there was a need for dark spaces associated with the appearance of projectors. In this essay we will explore the first spaces in which projection and the luminous image as a source of light came to terms with an interest for dark environments. These devices combined the technologies of the magic lantern and the *camera obscura*. A number of these devices such as Emile Reynaud's (1844-1918) praxinoscope (1877) or Thomas Edison's (1847-1931) kinetoscope tried to combine the production and projection of images, before leading to the cinematograph (1895) of the brothers Auguste (1862-1954) and Louis (1864-1948) Lumière. The creation of black boxes and later of black spaces, which were not based on the same logic of open volumes as residences oriented toward natural light, took hold at the time. These technological advances promoted the use of darkness in a context celebrating the duo of glass and natural light. How did the stage design effects enabled by the contribution of electrical light modify the role of darkness within space through means other than architectural composition?

1 Roberto Casati, *La découverte de l'ombre: de Platon à Galilée, l'histoire d'une énigme qui a fasciné les grands esprits de l'humanité* (Paris: Librairie générale française, 2003), 23.

2 Jun'ichirō Tanizaki, *Éloge de l'ombre* (Lagrasse: Verdier, 2011).

3 Personal translation of "Geblendet von den eigenen Licht-und Transparenz-Metaphern haben die Avantgarden der Moderne jeden taüschenden Schatten vertrieben, jede dunkle Emotion als finstere Regression verurteilt," *in* Gerhard Auer, "Bauen als Yersenken [Building as Sinking]," *Daidalos*, n° 48, 1993, 20-33.

4 Referred to as "optical architecture." See Daniel Siret, "Les sensations du soleil dans les théories architecturales et urbaines. De l'hygiénisme à la ville durable," *in* Ulrike Krampl, Robert Beck et Emmanuelle Retaillaud-Bajac (dir.), *Les cinq sens de la ville du Moyen Âge à nos jours* (Tours : Presses universitaires François-Rabelais, 2013), 105-117.

5 To explore this question, we will compare environments connected to the use of darkness within the fields of theater, art, and later auditoriums for projecting film, focusing less on the types of shows featured, than on the impact they had on the conception of space. We will pay special attention to the late 19th and early 20th C. design process for using the dark to manipulate representation through photography and film. The period under consideration is one that saw the rise of optical and later electrical inventions that affected the staging of images, and that gradually led to the more global concept of the auditorium.

6 With regard to architecture, in 1889 the European community refocused – following the international congress of hygiene – on the issue of housing. The growth of the "*bas-fonds*" (slums) in European capitals since the Industrial Revolution called for new ways of conceiving the urban environment. In fact, spaces that integrated darkness for both its plastic and optical qualities rarely appeared in modern architectural theories, which more easily sided with natural light in devising theories for modern construction. The diversity of light, successively provided by gas and electricity, had a simultaneous influence on architectural thinking from the very beginning. Initially present in the fields of theater, art, and technology, the architect was ultimately confronted with this question during the creation of the first cinemas. What emerges is a history of darkness as a tool for accentuating or eliminating the environment, one that was no longer limited to a dichotomy of shadows versus divine light.

FROM A DARKNESS THAT MANIPULATES THE IMAGE TO ONE THAT MANIPULATES THE GAZE

The elaboration of the image and the dark space: between perception and reception

7 The magic lantern, which appeared in the 17th C., is a projection device that, when positioned in a dark space, can make an image appear on a larger scale. The image is produced by a light source traveling through a lens. In order for it to function, it has to be partly isolated by a screen or a box, so that the only source of light is concentrated within the projection. This invention was notably perfected around 1797 by Étienne-Gaspard Robert (1763-1837), known as Robertson, under the name "phantasmagoria." The phantasmagoria prefigured a relation to the performance in which the appearance of the luminous image is staged by a camouflaging of the projection device, in addition to the immersion of the space in darkness. In order to make this figure appear, such performances had to create their own spatial conditions of reception, with the primary one being darkness. While the image of the phantasmagoria is not strictly speaking "animated," it can amplify the image in a dark environment, thereby giving the impression that the projection is floating in space. In Robertson's phantasmagoric performances, darkness was equal parts technical means and instrument for generating fear when combined with a macabre iconography (fig. 1).

8 Laurent Mannoni, a specialist of pre-cinema, has presented this genealogy of the magic lantern, which albeit tinged with the sensational register under Robertson, explored many other avenues.[5] Its increased use allowed this projection device and the darkness that accompanied it to leave behind its connotation with fairgrounds. With this in mind, Noam Elcott's *Artificial Darkness: An Obscure History of Modern Art and Media* endeavors to show that this darkness from the second half of the 19th C. and early 20th C. marked a turning point in relations to the dark.[6] Human vision and the physical place of the observer were integrated in the conception of visual devices such as dark rooms, cinemas, and black screens. The exploration of the image's production, manipulation, and context of reception worked hand in hand to make the most of the dark space and the black surface. The darkening of the space so that it does not reflect light created contrasts that accentuated

5 Laurent Mannoni, *Le Grand Art de la lumière et de l'ombre: archéologie du cinéma* (Paris: Nathan, 1995).

6 Noam Elcott, *Artificial Darkness: An Obscure History of Modern Art and Media* (Chicago: University of Chicago Press, 2016).

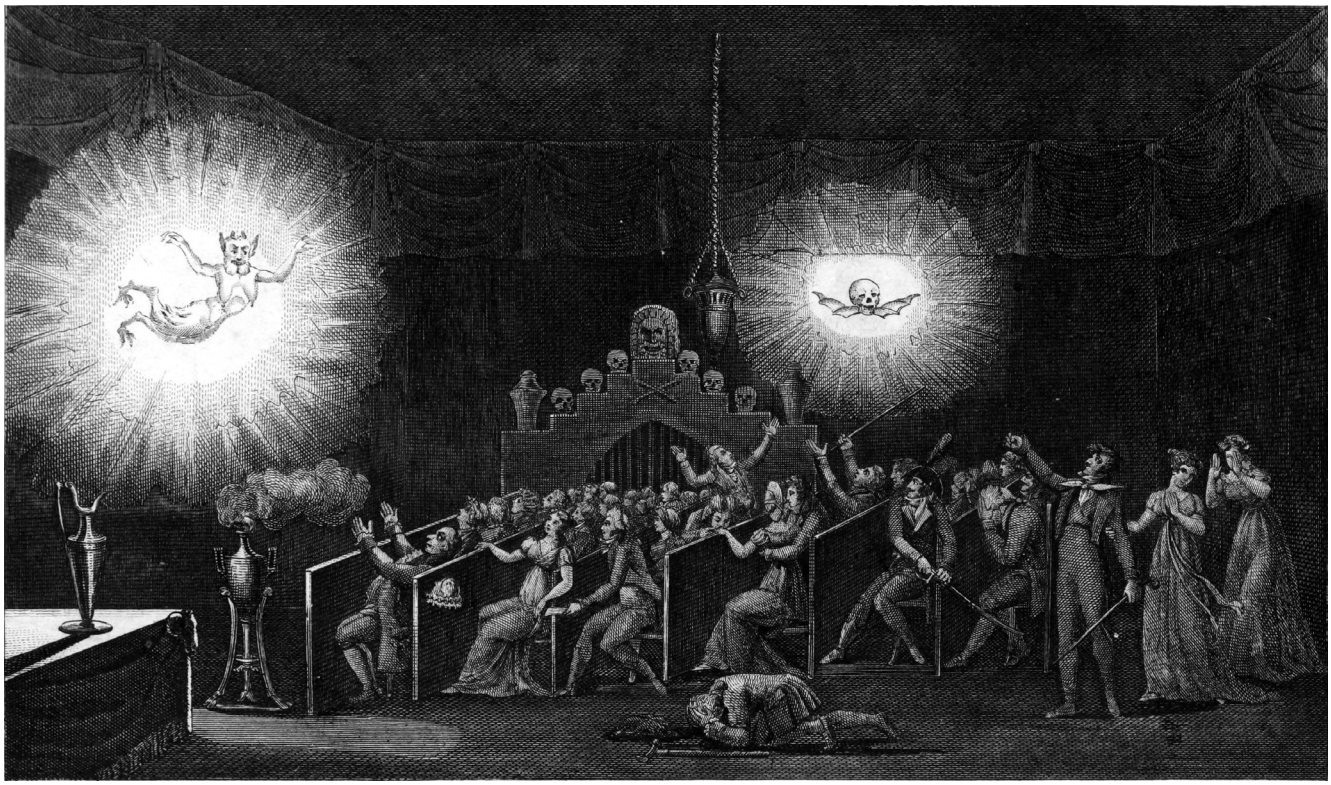

Figure 1: Étienne-Gaspard Robert (known as Robertson), taken from *Mémoires récréatifs scientifiques et anecdotiques* (vol. 1), 1831.

light-hued or illuminated elements. The use of darkness and black was no longer reduced to the simple evocation of the night or the devil. This integration made it possible to consider darkness from a plastic point of view, rather than being reduced to cultural representations. The use of darkness took on new forms thanks to the abundance of optical inventions for recording reality, combined with spatial arrangements that explored the conditions of both perception and reception.

9 The production of images generated by technologies for recording "reality" (photography and later cinema) used this darkening of the space and surface, as demonstrated by the first studio for recording film, Thomas Edison's *Black Maria* (1893), as well as the chronophotography (1885-91) of Étienne-Jules Marey (1830-1904), or the dramatizations of Oskar Schlemmers (1888-1943) in the field of live performance circa 1928.

10 Edison's studio formed a microarchitecture that depended chiefly on internal needs for darkening in order to produce images. It is interesting to note that from its very appearance, film recording did not necessarily seek to imitate real landscapes. In the first shoots at *Black Maria*, the recorded image concentrated on human bodies and their movement, rather than the retranscription of a realistic space. Unlike *L'Arrivée du train à La Ciotat* (1895), which has a documentary aspect, the film captures produced at *Black Maria* exhibited ritualized gestures (dance, the movement of laborers, playing an instrument) that give rise to quasi-abstract forms against a black ground. More so than any documentary aim, these recordings were in keeping with an attraction for plastic potential, as well as the gap that could be produced with "reality."

11 Similarly, around 1885 Étienne-Jules Marey used his physiological experimentation to reveal the continuity of movement with his chronophotography, by combining a shed painted black and the outfit of his walking model in order to emphasize some of the body's joints (fig. 2). According to the analysis of Philippe-Alain Michaud, the body's visibility was actually an obstacle for Marey; he succeeded in representing movement

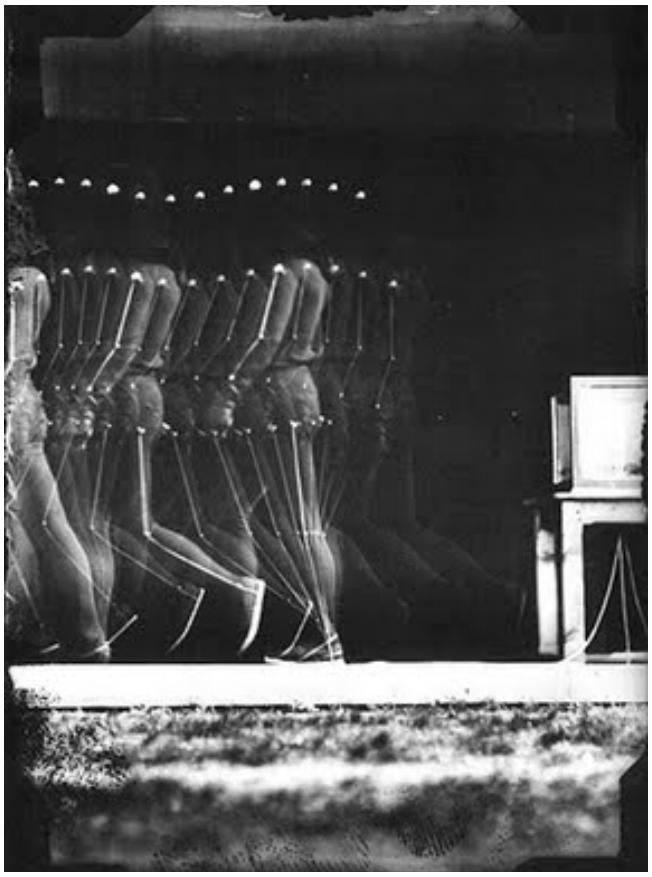

Figure 2: Etienne-Jules Marey, graphic representation based on the Marche de l'homme, *in La méthode graphique dans les sciences expérimentales et principalement en physiologie et en médecine*, Masson, 1885.

only by virtually eliminating the body by covering it in black.[7] In similar fashion, the Théâtre Noir (or *Black-art*) invented in Paris by the illusionist from Lyon, Buatier de Kolta, which was patented in 1886, plays on this same polarity between the black screen and fixed light.[8] Such shows, which were especially present in fairground environments, tended to guide one's reading of the space and objects through a draping of surfaces in black, and lighting aimed toward the front of the stage. The optical effect was based on a sharp contrast that conceals anything black and unlit from the eye. In addition, as pointed out by Tabet, "the *Magie noire moderne* was based on suppressing depth perception as well as the relative indiscernibility between the cover and the ground."[9] The optical inventions of the Théâtre Noir used the complementarity of darkness and the black surface in order to accentuate the optical effects of the dark. Similarly, the first special effects in the films of Georges Méliès were created using the same methods in order to have a head, body, or arm disappear at will.

Darkness and the black surface subsequently emerge more as conditions for processing the recording of the image than as the reflection of a more plasticist attitude that distinguishes itself from the strict recording of reality. However, this desire to modify the perception of reality using contrast, here connected to the appearance of film and photography devices, arose during the 17th C. in the world of theater. 12

From the stage to the cinema: darkening as a gradual condition of performance

Today it is common for theatrical stage design to use darkness and black as dramatic and symbolic mediums. The role of the dark in this field is nevertheless symptomatic of an evolution: from black as symbolic indication to black that becomes a condition for performance, darkness acts as a signal as much as it serves to focus the gaze toward the stage. 13

For all that, the latter element is not a component immediately inscribed within the time of the performance. The theater's relation to the "dark" as en entity of the space is a central topic in recent research, for instance Véronique Perruchon's *Noir: lumière et théâtralité*.[10] This work notes that before the dark was more widely admitted within the auditorium, it was not the extinguishing of lights but actually their increase that signaled the beginning of the performance. Before the 19th C., alternation between light and darkness was still primarily connected to material conditions: the performance was interrupted each time the candles stopped glowing, until the "*moucheurs*" came to resupply the chandeliers; it was this temporary darkness that "brought 14

7 Philippe-Alain Michaud, *Aby Warburg et l'image en mouvement* (Paris: Macula, 1998), 86.

8 Frédéric Tabet, "Entre art magique et cinématographe : un cas de circulation technique, le Théâtre Noir," 1895, n° 69, 2013.

9 *Ibid.*

10 Véronique Perruchon, *Noir : lumière et théâtralité, Arts du spectacle. Images et sons* (Villeneuve-d'Ascq: Presses universitaires du Septentrion, 2016).

spectators back to the contingencies of reality."[11] While it occurred outside the temporality of the performance, the darkness of these intermissions (inevitable at the time) was part of the performance, and the dramatic action remained dependent on the burning time of candles. The alternation between moments of lighting and half-light that punctuated the time of the performance were dictated by candles.

15 The joint use of these visual effects and increasingly substantial machinery revealed contrasts that had hitherto been pushed away. Previously, the component of darkness bore a metaphoric burden (night, devil, death) whose intervention beyond this framework was seen as a limitation of the stage's visibility. It was only during the 18th C. – which was a period of transition with respect to the use of machines in stage direction – that theaters began to use darkening.[12] This was done to heighten what could be called "special effects," which would be combined during the 19th C. with other successful immersive devices such as the panorama.

16 As effects of light and shadow were brought to the stage in accordance with the technical conditions provided by candle bulb, the space where the audience sat was not for all that dark, as "darkness extending to the edges of the theater was not welcome: people came to see and be seen. People made a spectacle of themselves."[13] This is precisely what the "Wagnerian" revolution of the darkening of the theater borrowed from the auditorium: "[...] the audience disappears from the room; it represents public life, and while it is living and breathing, life appears only in the work of art, on the stage, which appears as the world [for it]."[14] The Festival Theater at Bayreuth imagined by Richard Wagner in 1876 moved in this direction, offering a reworking of classical theater architecture. The architect who designed the plans for this new type of theater, Otto Bruchwald, proposed a configuration in which the orchestra disappears inside a pit, while the slope of the floor beneath the seats and the elimination of balconies channel the gaze toward the stage.

17 However, well before Wagner acted on the theater's architecture, Pierre Patte made similar recommendations in his *Essai sur l'architecture théâtrale* [Essay on Theater Architecture] from 1782,[15] in which the architect demonstrated that certain forms were linked to the propagation of both sound and the gaze. In the second part of his work, *Des causes qui mettent obstacle à la vision, & des moyens de la favoriser dans une salle de spectacles* [Causes that Present Obstacles to Vision, and Methods to be Promoted in an Auditorium], he proposed principles of proportion for the angles between the seats and the stage, as well as the elimination of architectural elements.[16] Richard Wagner nonetheless added the darkening of the theater to Pierre Patte's considerations, which made the arrangements for guiding the gaze toward the stage all the more efficient.

18 Adolphe Appia, a Swiss stage designer who followed in the tradition of Richard Wagner's theater, took up these stage design principles and extended them to the space where the audience was seated. For example, instead of increasing lighting effects, he used them occasionally and combined them the complete darkening of the theater. While he could not always create the total darkness ideally recommended by Wagner, which was difficult to achieve due to the gas lighting that was still dominant at the time, Appia nevertheless succeeded in creating the illusion

11 *Ibid.*, 56.

12 The work of the pioneering Italian stage designer Nicola Sabbattini (1574-1654) also bears mentioning, who beginning in 1638 endeavored to invent systems of mechanical covers to modulate the light atmosphere. *Ibid.*, 25-52.

13 *Ibid.*, 30.

14 Richard Wagner, *Œuvres en prose de Richard Wagner : 1849-1850*, vol. 3 (Paris: Libr. Delagrave, 1913), 219.

15 Pierre Patte, *Essai sur l'architecture théâtrale, ou De l'ordonnance la plus avantageuse à une salle de spectacles, relativement aux principes de l'optique et de l'acoustique* (Paris : Libraire imprimeur Moutard, 1782).

16 These principles are the same as those presented by Eugène Vergnes dans *Cinémas. Vues extérieures et intérieures. Détails. Plans. Avec notice sur la construction et l'aménagement des cinémas* (Paris : Ch. Massin, sans date [vers 1920]).

of darkness. Gas lighting and the implementation of stage switchboards[17] made it possible to lower the light in centralized and gradual fashion, in order to produce more flexible light variations. Due to the attenuation of light in the theater and its minor presence on the stage, the sensation of darkness could spread, without actually being absolute.[18]

19 The practice of darkening the theater opened the way for integrating the audience within the performance space by seeking to generate a felling of immersion. The latter combines with the formal refining of the staging, which emphasized these contrasts with a view to drama. What resulted was a reorientation of the internal structure of the theater's architecture, which became isolated from the exterior, and streamlined within its spatial arrangement.

Between optical inventions and the centralizations of a lighting system

20 While this experiment in staging continued, the construction of cinemas did not necessarily take the Festival Theater at Bayreuth as a reference point, still preferring the architectural model of the classical theater, with its lighting that continued during the performance and its balconies. This can be explained by a number of reasons, chiefly connected to custom and equality of access to the performance: the space had to preserve the separation between different social categories, which should not encounter one another as they move about the theatre. The separation of the two worlds of the "stage" and the "auditorium" began to be challenged in the 1950s, with the coming of the happening and movements emerging from other live performances. In addition to eliminating the frontal functioning of the stage-auditorium, these practices turned toward the public space, seeking to free themselves from these institutions, whose more materially rigid arrangement limited the very conditions of the show. Yet before freeing itself from the institution in this way, during the 19th C. it initially proceeded with a modification of space through light and darkness. These changes were dependent on a convergence between optical inventions and the centralization of lighting effects. Some companies seized upon these considerations early on, thereby quickly reaching architectural design.

21 Stage design modifications were accompanied by technological advances, which were themselves driven by companies who, from the mid-19th C. onward, turned toward optical machines and gas lighting systems. In France, the optical technician Louis-Jules Duboscq, who took over Jean-Baptiste François Soleil's company with the latter's son, produced special effects devices for the theater stage.[19] The inventions sought especially to offer a variety of proposals for special effects relating to optics, playing on color and the projection of the image.[20] These inventions were closer in spirit to magic lanterns, and allowed for varying the atmosphere in accordance with dramatic effects, which were highly focused on stage effects.[21]

22 In a somewhat different direction, the establishments of the Clémançon family, which was created in 1828, took a large part of the market for overall lighting equipment. While Duboscq's inventions preceded them by a few years, they included a broader system that was present beyond the stage, in the remainder of the auditorium. They were especially present in the market through their anticipation of electrical lighting systems, for which public authorities

17 The stage switchboard is a centralized system for modulating the general lighting of a performance hall. The first switchboards operated on gas, and were gradually replaced by ones running on electricity around 1890 in major European capitals. Still today, the term switchboard refers to the lighting component of stage management.

18 Notes for the staging of Für der Ring des Niebelungen by Adolphe Appia dans *Œuvres complètes, édition établie et commentée par Marie-Louise Bablet-Hahn*, vol. 1 "La mise en scène du drame wagnérien" (Lausanne : L'Âge d'homme, 1983 [1895]), 127.

19 Mannoni, *Le Grand Art de la lumière et de l'ombre*, 214 (cf. note 6).

20 Jules Duboscq, *Catalogue systématique des appareils d'optique construits dans les ateliers de J. Duboscq* (Paris: A. Hennuyer, 1876).

21 Reproductions of Jules Duboscq's devices can be found in Adolphe Appia, *Œuvres complètes*, 360–365 (cf. note 18).

issued ordinances after the fire at l'Opéra-Comique in 1887.[22] However, while the company was in charge of a multitude of locations that hosted both theatrical and cinematic performances, it was up to the architect to anticipate the integration of lighting devices. In fact, from 1908 onward, it was the architect who appropriated these inventions and integrated them within buildings from the very beginning. In view of *l'Ordonnance du Préfet de police, en date du 10 août 1908, concernant les théâtres, cafés-concerts et autres spectacles publics* [Ordinance of the Police Commissioner dated August 10, 1908, regarding Theaters, Cafés-Concerts, and other Public Performances], the plans for construction permits relating to this integration included a great amount of detail.

23 With respect to projection machines, the fire that destroyed the Bazar de la Charité in 1897 also led to the creation of ordinances regarding the opening and ventilation of theaters. Even though the Lumière brothers had since improved the security of their devices, this regulation was imposed on architects beginning with the design of the first cinemas. How were artificial lighting and projection devices, which formed a new program for these locations, integrated within architecture?

CINEMA ARCHITECTURE: ABSORBING TECHNICAL CONSTRAINTS AND EVOLUTIONS

The emergence of a program specific to cinemas

24 In France, the year 1896 was marked by a race for patents, whose starting signal was the presentation of the Lumière brothers' *Cinématographe* at the Salon indien in December 1895. Subsequently, from the *café-théâtre* to the darkened museum, different types of locations were arranged for the projection of luminous images. Yet if the invention of the first projectors such as the *magic lantern* had already imposed the creation of a dark environment during the 17th C., this plurality of sites entailed an occasional and hence more improvised placement of these machines within the space welcoming them.

25 The work of Jean-Jacques Meusy regarding the history of these initial projection sites in France helps identify the moments of latency and rupture in the implementation of spaces used for projections. The first official construction permits for buildings to serve as cinemas were issued in 1907. While there was a need to erect sites that could accommodate this new type of light projection, the programs relating to the optimal conditions for viewing them were just beginning:

> *In almost all cases, its function as a cinema does not take priority in the theater's design. Booths located just about anywhere, with deflector mirrors if needed, overly large projection angles causing deformations, seats too far from the screen or too far off to the side, stage frame pompously loaded with decorative motifs enclosing screens that are too small, are so many recurring anomalies. The cinematic performance is not conceived and integrated as such, with its own distinctive features.*[23]

26 The first programs appeared around 1913, six years after the first construction permits.[24] The low power of projections and their still mediocre quality made the darkening of theaters an essential condition for viewing. To provide these ideal spatial conditions, isolation from the exterior (which enabled greater control over artificial light and projection) became inevitable. Cinema architecture was thus caught in a network of constraints, in which light conditions conflicted with the security conditions put in place after the fires of 1887 and 1897. Improved projection and the implementation of lighting systems used solely during the projection had to accommodate a new architectural form that adhered to respecting the constraints relating to theater ventilation and the concealment of electrical networks.

22 Guy Richard, "Naissance et évolution des entreprises d'installations électriques," *Culture technique*, n° 17, 1987, 17-19.

23 Jean-Jacques Meusy, *Paris palaces ou Le temps des cinémas, 1894-1918* (Paris: Nouveau monde éditions, 2014), 432.

24 Shahram Hosseinabadi, "Une histoire architecturale de cinémas : genèse et métamorphoses de l'architecture cinématographique à Paris" (Ph.D. diss., Université de Strasbourg, 2012).

A composition still close to the theater model

27 In these spaces that were increasingly closed onto themselves, and also limited by constraints relating to acoustics and visibility, the manipulation of light effects opened new possibilities for the conception of space and the decoration of auditoriums. While projections were held in less diffuse locations than during its beginnings, cinematic performances nevertheless had to share their space with theater. Habits in construction were closer to the theater, given its already long history using darkness and light.

28 Cinema thus had to free itself from the esthetic codes and social rituals of theater, all while producing a modern representation of the world that could respond to new demands in programming. However, film projection was still secondary in the production of theaters, as the directors of these locations did not want to place this activity at the center of their program.[25] In addition, the darkness of theaters and the content of films were highly criticized from the standpoint of morals.[26] Louis Jalabert, a fervent critic of cinema, believed the movie theater to be a place of perversion with regard to the subjects of films as well as the environment in which they were screened: "And when one thinks that it is in the complicit darkness that such troubling lessons break free [...]."[27] Despite such reprobation and the hesitation of wealthier audiences, projection activity very quickly gained in importance, reaching a broad public after the First World War.

29 Contrary to theater, the darkening of these auditoriums was not so much a response to the demands of a director seeking to control the state of receptivity for their work, but a necessary condition for being able to enjoy the show. In order for the image to appear, it was vital for the room to be dark, at least partially and especially in the areas surrounding the screen. Another distinctive feature of the film projector in relation to theater was the introduction of a projection booth, whose positioning was adjusted according to the screen's location, in order to ensure visibility for all spectators. This room was not always located in front of the screen, and in certain cases could even be located behind it, in order to prevent the projection beam from being intercepted by cigarette smoke. On this topic, Ernest Coustet's *Traité pratique de cinématographie* [Practical Treatise on Cinema], published in 1913, enabled both establishments and architects to assess the optical considerations relating to projection. In 1914, *Comment on installe et administre un cinéma* [How to Establish and Manage a Cinema] by Emile Kress, provided an overview of the material conditions that must be taken into account, from lighting of the front to the positioning of the screen. These recommendations regularly discussed the organization of space: "One must also avoid bulky columns, especially repeating ones; large overhangs for balconies, thin and smooth partitions made of boards, whose vibrations distort sounds [...]."[28] For that matter, at a time when cinema was still silent, auditoriums were still designed with a space reserved for an orchestra. Yet an orchestra needs light in order to play, and so following the same logic as Bayreuth, it had to be placed in a pit, and contain "light in special consoles that do not allow the light rays to escape and cast a damaging glow under the screen, which must be surrounded by shadows."[29] All of these parameters made the auditorium a space caught between old and new technical constraints.

Toward an integration of artificial light in the composition of space

30 There was such a variety of screening sites in the early 20th C. that it is difficult to summarize the situation by focusing on a few examples. However, we can observe a few variations that played on the technical constraints imposed by the design of buildings devoted to projection. As emphasized by Jean-Jacques Meusy, there was no genuine cinema architecture before the

25 Meusy, *Paris palaces*, 422 (cf. note 23).

26 Louis Jalabert, "Le film corrupteur," *Action populaire*, n° 68, 1921.

27 *Ibid*., 6.

28 Émile Kress, *Comment on installe et administre un cinéma*, 2e éd., Bibliothèque générale de cinématographie n° 2 (Paris: Charles-Mendel, 1914), 20.

29 Vergnes, *Cinémas. Vues extérieures et intérieures*, 7 (cf. note 17).

Second World War. Yet in the aftermath of the First World War, certain cinemas already revealed different strategies used by architects.[30] Eugène Vergnes (1872-1925), Marcel Oudin (1882-1936), and Henri Sauvage (1873-1932) were among the French architects who proposed various stances for cinema architecture, visible through how they integrated lighting systems and projection requirements. These few figures made way for a new generation of architects with the coming of talking and sound movies during the early 1930s.

31 The work *Cinémas. Vues extérieures et intérieures. Détails. Plans.* [Cinemas: Exterior and Interior Views. Details. Architectural Plans] published in 1920 and edited by Gaston Lefol, is one of the rare works in France written by an architect (Eugène Vergnes) that takes stock of a few film-specific creations from the period. The book, which appeared in a new edition in 1925, included plans as well as exterior and interior views of cinemas, along with a few pages on the regulatory ordinances for these establishments. As highlighted by the work of Shahram Hosseinabadi, Vergnes tried at the time to theorize this typology of architecture by approaching the ordinances from a constructive and sensible point of view.[31] In fact, right from the book's introduction, Gaston Lefol stressed these program-related difficulties for architecture:

> Lighting should, in fact, be both bright during intermissions, and soft enough not create too violent a contrast with the almost complete darkness of the auditorium during the performance. The issue of ventilation was apparently a particularly difficult problem to solve, as one had to allow the audience to smoke in a room in which the requirement of darkness prevented using the usual methods of ventilation. Entirely new devices had to be used.[32]

32 In view of the different recommendations made by Vergnes and the projects presented in the publication from 1920, it is possible to divide these productions into different architectural attitudes with regard to the handling of lighting.

33 One of the first architectural stances is that of the Montrouge Palace (1921) cinema in Paris's 14th arrondissement and the Gergovia (1920) in Clermont-Ferrand, both imagined by Marcel Oudin. They still had a marked presence of lamps as decorative objects, positioned independently from the architecture and the project for the atmosphere. While in the description for the Montrouge cinema Vergnes mentions the presence of "light fountains" within the angles, which were supposed to give a "distinctive and artistic appearance to the theatre," it was more so the openings in the form of skylights (located on the upper sides and serving to ventilate the theater) that lightened the importance of the structure through natural light. Jean-Jacques Meusy has pointed out that the Montrouge Palace underwent profound transformations in 1951, as part of the installation of indirect light.[33] So even though the skylights were opened to obtain what one imagined to be sufficient light for photography, artificial light was little present in the structuring of space, and its integration remained incidental (fig. 3).

34 Less spectacular in its volumes, the Gergovia cinema in Clermont-Ferrand offered a better logic in the positioning of light fixtures in relation to the rows. While lights were still treated as objects, they tended to be positioned in balance with the space's structure. The Madeleine cinema (1921) in Paris's 8th arrondissement, by the same architect, exhibited a closer collaboration between the idea of the space and the introduction of light fixtures within it. The light fixtures highlighted certain architectural gestures, such as the curves of the balconies and the bas-relief arches on the sidewalls. However, the inspiration for the space closely conformed to that of a theater, notably through the presence

30 Meusy, *Paris palaces*, 434 (cf. note 23).

31 Hosseinabadi, "Une histoire architecturale de cinémas," 191 (cf. note 24).

32 Gaston Lefol's introduction to *Cinémas. Vues extérieures et intérieure de Vergnes*, 3 (cf. note 17).

33 Jean-Jacques Meusy, *Écrans français de l'entre-deux-guerres - L'apogée de l'art muet*, vol. 1, Histoire culturelle (Paris: Association française de recherche sur l'histoire du cinéma, 2017), 80.

Figure 3: Marcel Oudin, Cinéma Montrouge (1921), interior views, taken from Lefol, Gaston (dir.) Cinémas, vues extérieures - détails - plans, Paris Ch. Massin, 1920. © Collection La Cinémathèque de Toulouse.

of balconies extending outward from the continuity of the story.

35 The Splendid-Cinéma (1920) in Paris's 15th arrondissement, which also included chandeliers, produced an esthetic convergence between the lights and the more or less somber wall motifs: the tapestry motif grew lighter as it neared the vaulted ceiling, which featured different types of lights, as well as "three large rosettes made of decorative latticework."[34] These two elements located at the highest point of the vault were both wrought in the same Art Deco style. The lighter hue and luminosity contributed to a sense of brightness in the upper part of the auditorium, in order to arrange for a darker layer toward the lower part (fig. 4).

36 In these different projects, other types of lighting were often added for functional reasons in the sections beneath the gallery, which were generally where the entrance to the auditorium was located. These entrances were treated independently from the lighting for the rest of the auditorium.

37 The Danton (1920) cinema by Eugène Vergnes in Paris's 6th arrondissement offered a specific lighting configuration that grew out of the architect's explorations with the positioning of the projection booth, which was hidden within the ceiling at the level of the dome (fig. 5). This space included both the ventilation grating and much of the artificial lighting that produced this dome effect. In fact, Vergnes indicated that the lighting was "controlled through resistors that ensured a gradual transition from darkness to light, and shielded the eye from the fatigue that

34 Vergnes, *Cinémas. Vues extérieures et intérieures*, 14 (cf. note 17).

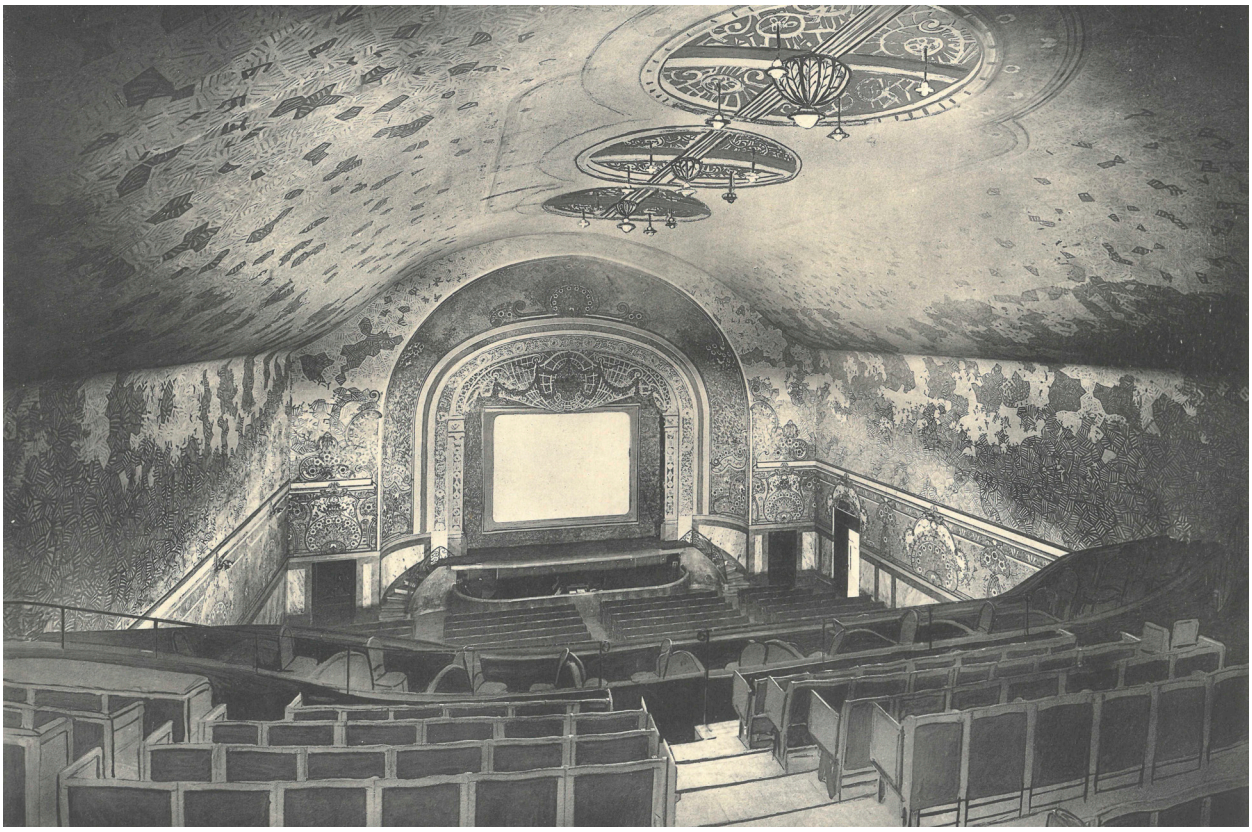

Figure 4: Eugène Vergnes, Cinéma Splendid (1920), interior views, taken from Lefol, Gaston (dir.) *Cinémas, vues extérieures - détails - plans*, Paris Ch. Massin, 1920. © Collection La Cinémathèque de Toulouse.

Figure 5: Eugène Vergnes, Cinéma Danton (1920), interior views, taken from Lefol, Gaston (dir.) *Cinémas, vues extérieures - détails - plans*, Paris Ch. Massin, 1920. © Collection La Cinémathèque de Toulouse

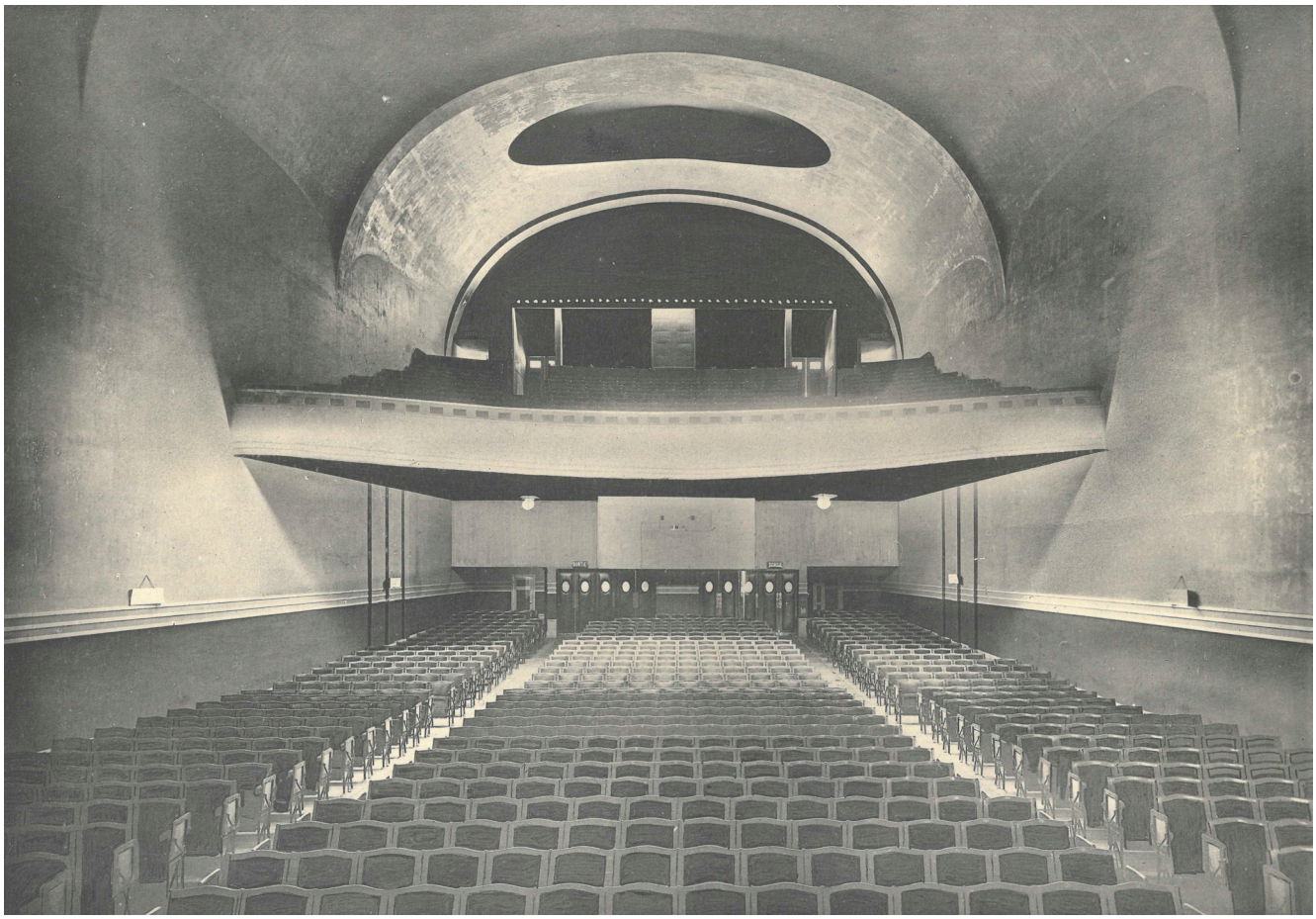

Figure 6: Henri Sauvage, Cinéma Sèvre (1921), interior views, taken from Lefol, Gaston (dir.) *Cinémas, vues extérieures - détails - plans*, Paris Ch. Massin, 1920. © Collection La Cinémathèque de Toulouse.

comes from an overly abrupt transition."[35] The windows, which were visible in the background of the auditorium, supplemented the dome's ventilation system during intermissions, but it was indirect lighting that retained the function of lighting the auditorium.

38 Finally, the Sèvres cinema (1921) created by Henri Sauvage, in Paris's 7th arrondissement, used electrical lighting in such a way as to accentuate the building's volume (fig. 6). The sidewalls were relatively bare, and allowed for a staging of light effects. The boards of the Sèvres presented a more radical project than its predecessors, in that the light dramatized the volumes. While the images of the Sèvres are touched-up photographs, they express the architect's desire to use electrical lighting in the building. The placement of lighting revealed the volumes constituting the architecture, by combining a light that skimmed the sidewalls with another one that directly emphasized architectonic elements by playing on contrast. This project reflects a desire to curve the auditorium's shape into a kind of funnel more appropriate for viewing a screen. For that matter, the description provided by Vergnes notes that the thickness of the dividing walls hides "electrical projectors whose light projects various images onto the walls and the vaults, thereby making it possible to endlessly renew the decoration."[36] These projections were intended to emerge in ovals, which were interpretations of the dome that would slowly close, making way for darkness and the interplay of light.

39 This last project, not yet finalized when the book was published in 1920, involved an appropriation of these light effects in response to the staging of the architecture, which exists outside the

35 *Ibid.*, 14.

36 *Id.*

time of the performance. This appropriation took the form of an exploitation of artificial light for the plastic effects it offers within a dark space. Artificial light was therefore no longer necessarily associated with an object, and became a tool for design, for which darkness is a prerequisite.

40 Light subsequently left behind its role as the dominating chandelier, and settled in the folds of the architecture. Shadows took more unexpected directions than those normally provided by irradiant light. This interplay of shadows tended to accentuate the types of surface and their impact, which sometimes became contradictory through the effect of double projections. This effect of shadow and light disturbed perception of the interior space, thereby renewing its design. Through the program imposed by the movie projector, the integration of darkness prompted architects to absorb artificial light within design, in an effort to highlight the structural framework by working from a more stage design standpoint.

CONCLUSION

41 The manipulation of artificial darkness was decisive for both the reception and production of the image. According to Noam Elcott, it was toward the late 19th C. that artificial darkness was controlled thanks to the image, in order for darkness to cancel out the physical dimension and favor the surfaces produced for the eye. This observation is in accordance with Jonathan Crary's regarding the modern observer, whose visual attention "must therefore increasingly exclude or engulf whatever presents an obstacle to its functioning."[37] In the examples presented here, this attention was handled by reducing the impact of the material space beyond the stage through the management of lighting effects and the darkening of the auditorium. The succession of projection machines and centralized lighting systems ultimately concentrated the viewer's attention. In this sense, the use of darkness was, from the outset, invested in the relation to illusion and performance. Having become a technical condition for the appearance of the luminous image, it was a factor in the viewer's conditioning, who disregarded his or her own environment in order to be immersed in what was being presented for viewing.

42 Truly instituted within architectural practice during the 20th C., artificial darkness was driven by technical and optical discoveries, as well as increasingly controllable light sources. In the construction of cinemas, the latter also emerged as a means for elaborating the appearance of the projection, as well as the space. As modern artificial darkness became a programmatic condition, it combined with control over artificial light to offer a tool for navigating between the revealing and elimination of space.

43 While locations for projections and the luminous image are more widespread today, darkening is not as necessary as it once was to showcase them. Nevertheless, dark stage designs are increasingly present whenever screens are present. The arrival of luminous images within museums with the emergence of video art required the design of a "Black Box" within the "White Cube," the apex of modern space.[38] In addition, beyond the reproduction of cinematographic equipment within the museum, installation-projections pursue this project by playing on the ambiguity between the boundary of the work and the architecture. Space is modulated by the intervention of light and dark parameters that are not necessarily based on material aspects. While artistic practices spontaneously seized upon the plastic potential of the complementarity between artificial light and darkness, it was the surpassing of this programmatic constraint that enabled architects to fully consider and accept this element.

37 Jonathan Crary, *Techniques de l'observateur : vision et modernité au XIXe siècle* ; suivi de *Spectacle, attention, contre-mémoire*, trad. par Frédéric Maurin (Bellavaux: Dehors, 2016 [1990]), 150.

38 Brian O'Doherty, *White Cube: L'espace de la galerie et son idéologie* (Paris: JRP Ringier, 2008).

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JEHRHE

Journal of Energy History
Revue d'histoire de l'énergie

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POST DATE
26/06/2019
ISSUE NUMBER
JEHRHE #2
SECTION
Special issue
THEME OF THE SPECIAL ISSUE
Light(s) and darkness(es): Shifting historical relations
KEYWORDS
Light, Environment, Pollution, Electricity
DOI
in progress

TO CITE THIS ARTICLE
Nona Schulte-Römer, "What is French about the 'French fear of darkness'? The co-production of imagined communities of light and energy", *Journal of Energy History/Revue d'Histoire de l'Énergie* [Online], n°2, published 28 juin 2019, consulted XXX, URL: http://energyhistory.eu/node/134.

What is French about the "French fear of darkness"? The co-production of imagined communities of light and energy

Abstract

This essay takes expert assumptions about light preferences as a starting point for a historical inquiry into what I call imagined sociotechnical communities of light and energy. My argument is that historical energy supply systems produced these imaginaries and vice versa, shifting the scales at which public lighting was envisioned and darkness was acceptable. While in the 17th C. dark streets were the norm and even the illumination of single streets was publically contested, innovators of the 18th C. imagined gas light and energy on an urban scale. In the 20th C., electric lighting promoted electrification and the electricity supply systems in countries like France allowed experts to think and standardize lighting at a national level. In the 21st C. the expert imaginary of a light-loving French people is challenged by public environmental concern.

Plan of the article

ISSN 2649-3055

Figure 1: Looking from outer space, France is all but homogeneously lit, NASA 2015. See URL: https://svs.gsfc.nasa.gov/30693, last access 2019-05-14

INTRODUCTION

1 It is considered common sense among lighting professionals that the demand for lighting varies significantly not only across the globe but also within Europe. For instance, it is a widely held expert opinion that people in the warmer Mediterranean regions prefer bright, cool-white lighting, whereas Scandinavians in the north will insist on warm and comparatively dim illuminations. Others observe that light preferences can even differ between neighboring countries like Germany and France. A renowned French lighting designer even told me, not without provocation, that unlike Germans, "the French fear the dark."[1] Estimates of the energy consumption for lighting, rough data on light points per inhabitant and maximum radiance measures based on satellite pictures support his claim, suggesting that France is indeed more brightly lit than Germany.[2]

2 Nevertheless, the idea of a nationwide fear of darkness is somehow peculiar. On the one hand, physiological factors speak against it. As humans we heavily rely on our eyesight, which explains a general preference for lit environments. On the other hand, nationwide preferences do not correspond with the fact that countries like France are not homogeneously lit. Brighter lights are usually found in populated and prosperous urban areas, while remote areas are often the last bastions of darkness. So, where does the idea of a French nation of light lovers come from?

3 Looking at France, there are no obvious geographical explanations like "Nordic lighting" or "Mediterranean culture."[3] Instead, lighting professionals often point to the socio-technical relationship between brightly illuminated French cities and off-peak nuclear energy. So did the above-mentioned French lighting designer, who linked the alleged French preference for light and German tolerance for darkness to hard infrastructural facts: Germany does not have 58 nuclear power reactors.

4 This sociotechnical explanation of lighting preferences adds a new dimension to existing arguments that highlight the important role of cultural aspects like nightlife and light uses or geographical physical or physiological dispositions like daytime light intensity and the climate relative to the equator. At the same time, sociotechnical explanations are well-established in the history and social study of science and technology. In particular, the idea of nationwide light preferences in relation to nuclear power makes it hard not to think of Gabrielle Hecht's seminal work on the nuclear program of post-war France. Her guiding question, "What is French about the French nuclear program?" taken together with the lighting designers' statement, also inspired the title and question of this article: What is French about the French "fear of darkness," or more positively formulated, the alleged nationwide love of artificial light? To answer it, I draw on Hecht's work, which highlights the performative power of national identity politics in shaping technopolitical pathways.[4] Exploring this relationship further, I use Sheila Jasanoff's and Sang-Hyun

1 The conversation took place in Lyon in 2012 during my ethnographic research on the introduction of LED lighting in European cities. See Nona Schulte-Römer, "Innovating in Public" (Ph.D diss., Technische Universität Berlin dx.doi.org/10.14279/depositonce-4908, 2015), 135.

2 *Ibid*. and https://www.lightpollutionmap.info/LP_Stats/?year=2019, last access 2019-05-14

3 Mikkel Bille, *Homely Atmospheres and Lighting Technologies in Denmark* (London: Bloomsbury, 2019).

4 Gabrielle Hecht, "Technology, politics, and national identity in France," *in* Michael Thad Allen and Gabrielle Hecht (eds.), *Technologies of Power* (Cambridge, MA: MIT Press, 2001).

Kim's notion of "sociotechnical imaginaries," which allows me to link expert assumptions about collective lighting preferences to past, present and future infrastructures of light and energy. My thesis is that infrastructures and innovators' imaginaries are co-produced. More precisely, sociotechnical energy systems define the scale on which demand for and provision of a certain type of artificial light are enacted.

5 To explore this co-production in the long-term perspective, I draw on historical primary sources and secondary historical accounts of the evolution of outdoor lighting in Europe. To contrast the past with the present, I draw on field observations and expert interviews with municipal light users and lighting professionals, including the above-mentioned interview with a lighting designer in 2012. This ethnographic research covers a period of ten years, starting with my ethnographic Ph.D project on the introduction of LED lighting in Berlin and Lyon to a current transdisciplinary project on light pollution.[5]

6 Based on this data I argue that the establishment of national electricity infrastructures in the 20th C. and the imaginary of French lighting preferences were mutually constitutive. The imagined sociotechnical community of French light lovers can thus be understood as both a historical and performative construct that has long been enacted by experts and is now being challenged by a French love of darkness.

CONCEPTUAL BACKGROUND: IMAGINED SOCIOTECHNICAL COMMUNITIES OF LIGHT AND ENERGY

7 Lighting experts offer different explanations for why lighting preferences differ. One plausible argument is that solar radiation differs geographically and also affects the ways in which people attune to artificial light at night. Others argue that nightlife differs across cultures and so do lighting practices. This argument is supported by sociocultural perspectives. For instance, a famous historical example is Jun'ichiro Tanizaki's essay "In Praise of Shadow" (1933), which described the clash of Western light and Japanese culture and design.[6] The social scientists Mikkel Bille and Tim Flohr Sørensen explored Danish lighting practices, concluding that warm, white lighting contributes substantially to a specific sense of conviviality and coziness called *hygge*.[7] More recently, Bille rejected what "may be described as *geographical determinism*" arguing that so-called "Nordic lighting" is related to community-oriented lighting practices rather than lines of longitude.[8] This brings him closer to sociotechnical, practice-oriented explanations like Elisabeth Shove's argument that sociotechnical systems, the symbolic and material qualities of lighting products and the actual uses of and preferences for lighting technology co-evolve.[9] Bille further argues that lighting practices in Denmark can constitute "atmospheric communities," which are not necessarily based on "a collective 'we', or moral codex, [...] but on "a sense of togetherness."[10]

8 The notion of "imagined communities" thereby goes back to Benedict Anderson, who famously

5 Schulte-Römer, "Innovating in Public" (cf. note 1) and Nona Schulte-Römer, *Etta Dannemann, Josiane Meier, Light Pollution – A Global Discussion* (Leipzig: UFZ, 2018 - www.lightpollutiondiscussion.net).

6 At a time when Tokyo was not yet flooded by the light of media screens, the Japanese writer elaborately describes how the brilliance of Western lighting threatened the aesthetic appeal of Japanese traditional objects and architecture, including lacquerware dishes and toilet designs. Jun'ichiro Tanizaki, *In Praise of Shadows* (Stony Creek, CT: Leete's Island Book, 1977 [1933]).

7 "To achieve hygge the amount of light should be sufficient for the members of the social group to see and gain eye contact with each other, while not illuminating the room completely." Mikkel Bille and Tim Flohr Sørensen, "An Anthropology of Luminosity: The Agency of Light," *Journal of Material Culture*, vol. 12, n° 3, 2007, 275.

8 Bille, *Homely Atmospheres and Lighting Technologies in Denmark*, 97-98 (cf. note 3).

9 Elisabeth Shove, *Comfort, Cleanliness and Convenience: The Social Organization of Normality*, (Oxford, UK: Berg, 2003), 57, drawing on Wiebe Bijker, "The Social Construction of Fluorescent Lighting, or How an Artifact Was Invented in Its Diffusion Stage," *in* Wiebe Bijker and John Law (eds.), *Shaping Technology. Building Society* (Cambridge, MA: MIT Press, 1992).

10 Bille, *Homely Atmospheres and Lighting Technologies in Denmark*, 99 (cf. note 3).

outlined that nations do not have to meet in person to form, share and reproduce a sense of belonging.[11] The concept is also used to describe national technopolitics and experts' future-making activities in historical and social studies of science and technology. In particular, Gabrielle Hecht describes how the French nuclear program shaped both the national identity of post-war France and its technological paths:

> National-identity discourse constructs a bridge between a mythologized past and a coveted future [...]. This process naturalizes change; it makes proposed novelties appear to be logical outgrowths of past achievements.[12]

9 Moreover, Ulrike Felt highlights the "continual exercises need[ed] to maintain shared imaginations" and describes how such exercises helped integrate Austrian identities and "technoscientific futures."[13] Sheila Jasanoff's and Sang-Hyun Kim's notion of sociotechnical imaginaries captures the co-production of imagined communities and sociotechnical realities in a long-term perspective and with a special focus on country-specific institutional patterns. In their words, sociotechnical imaginaries can be understood as "collectively held, institutionally stabilized, and publicly performed visions of *desirable futures*, animated by shared understandings of *forms of social life and social* order attainable through, and supportive of, *advances in science and technology*."[14] Sociotechnical imaginaries thus link individual and collective visions, pasts, presents and futures, occupy territories and travel in space. They are powerful because they encode visions of what is scientifically and technologically attainable, as well as "how life ought, or ought not, to be lived."[15]

10 Based on this work, I propose the notion of imagined sociotechnical communities to make a conceptual link between lighting professionals' public statements about their clients' preferences and past, present and future lighting practices. This co-productionist approach allows me to explore the emergence and performativity of sociotechnical imaginaries—including the idea of a French fear of darkness—as they are publically enacted and evaluated by lighting experts and innovators. My focus is on outdoor lighting, where light installations are planned and operated by *experts*. Other than in Bille's cases of "homely atmospheres," where people light their living rooms in accordance with their preferences, expert outdoor lighting is not always in line with residents' expectations and demands.[16] In public spaces, *actual* light preferences can be diverse and are thus not identical with lighting professionals' assumptions and statements *about* what their clients like and want. Nevertheless, expert imaginaries of collective lighting preferences are crucial as they are likely to materialize in public space—in the form of specific light colors, levels of brightness, uniformity or diversity. Against this background, it seems worthwhile exploring how such expert assumptions about light preferences relate not only to culture and geography, but also to the sociotechnical energy systems that made artificial light imaginable and real.

EUROPEAN HISTORIES: THE CO-PRODUCTION OF LIGHT IMAGINARIES AND ENERGY

11 Looking back at the past 500 years, it becomes obvious that lighting preferences are relative. The imagined French love of light thus appears as a historically contingent notion at a specific moment in the European history of light and energy.

11 Benedict Anderson, *Imagined communities* (London: Verso, 1983).

12 Hecht, "Technology, politics, and national identity in France," 255 (cf. note 4).

13 Ulrike Felt, "Keeping Technologies Out: Sociotechnical Imaginaries and the Formation of Austria's Technopolitical Identity," *in* Sheila Jasanoff and Sang-Hyun Kim (eds.), *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power* (Chicago: University of Chicago Press, 2015), 103.

14 Sheila Jasanoff and Sang-Hyun Kim (eds.), *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power* (Chicago: University of Chicago Press, 2015), 4, my emphasis. Co-production is defined "as a shorthand for the proposition that the ways in which we know and represent the world (both nature and society) are inseparable from the ways in which we choose to live in it." *Ibid*., 3.

15 *Ibid*., 21-23.

16 For a worldwide map of lighting conflicts see Schulte-Römer *et al*., *Light Pollution – A Global Discussion* (cf. note 6), 185-186.

12 Since the introduction of the first dim streetlights, baselines for acceptable levels of light and darkness have shifted considerably. Energy provision thereby plays a significant role for both the enactment and evaluation of adequate lighting. In preindustrial times when darkness was the rule, oil lanterns in the streets of Paris were celebrated as little suns. Around the year 1800, gaslights began to outshine them. But in the 1880s, gaslit streets looked dim by comparison when the first electric arc lights entered the scene. Furthermore, we see that the availability and price of energy used for lighting affected actual and assumed preferences for light and darkness.[17]

13 In this situation, imagined communities of light emerged alongside new energy systems. In this narrow sense of co-production, the promise of more and better light was a key argument for energy transitions, while the establishment of new energy systems created demand for the promised light. As I will show, energy system expansion was reflected in the changing scale of the imagined and then actually illuminated communities—and in the receding darkness.

Premodern imaginaries of honest citizens in candle light and outcasts in dark streets

14 To better understand the profound transformations brought by the 18th and 19th centuries, we need to begin with European nightlife before public lighting entered the scene. In premodern times, darkness was the norm and light an expensive luxury. As a result, the nocturnal experience and use of artificial light was confined to specific, mostly indoor spaces and limited to shorter or longer periods of time, e.g., to the moment when a torch bearer passed or to the duration of a celebration or church service.

15 The best lit places were churches. In homes and on public streets, lighting was scarce and a luxury as it consumed costly primary energy resources like bees wax, plant oil or whale spermaceti.[18] In the absence of lighting, nightlife in medieval Europe was eerie, intimate and even mystical.[19] Nighttime, explains Roger A. Ekirch, "embodied a distinct culture, with many of its own customs and rituals." Nocturnal public spaces were unruly and uncontrolled: Cities closed their gates at nightfall and imposed curfews on their inhabitants. As Ekirch further remarks, "[i]t would be difficult to exaggerate the suspicion and insecurity bred by darkness."[20] Whoever did still go out onto the dark streets at night raised suspicion and risked being mistaken for a hobo, burglar or prostitute. People caught out on the streets without an important or life-saving mission, i.e., anyone except doctors, midwives, garbage collectors, latrine cleaners or mourners of the dead, risked fines or incarceration.

16 In the Middle Ages, imagined communities of light were thus restricted by precious resources like candles and oil and confined to homes and churches. Honest citizens were well aware that nocturnal activities ought to take place behind closed doors and gates, and they adapted their nightlife to the lack of visibility and orientation but also to curfews, fears and prejudices.

17 In the face of the negative social connotations of urban darkness it is not surprising that reformers in cities like Paris already began to envision and implement schemes for stationary street lighting in the 16th C. However, these street lighting schemes were doomed to fail as long as they relied on the collaboration of citizens who were asked to illuminate the public space in front of their houses on their own initiative and at their own expense.[21]

17 Wolfgang Schivelbusch, *Disenchanted Night. The Industrialisation of Light in the Nineteenth Century* (Oxford: Berg, 1988) and Jane Brox, *Brilliant: The Evolution of Artificial Light* (Boston, New York: Houghton Mifflin Harcourt, 2010).

18 Jane Brox also outlines in great detail how whaling in the Atlantic Ocean increased dramatically with the demand for spermaceti candles and whale oil for lighting purposes.

19 Roger Ekirch, *At Day's Close: Night in Times Past* (New York: WW Norton & Company, 2005).

20 *Ibid*., xxv and 8.

21 In 1551 a parliamentary decree required the citizens of Paris to illuminate their windows from November to January before six o'clock in the evening. Auguste-Philippe Herlaut, "L'Éclairage des rues à Paris à la fin du 17e et au 18e siècles," *Mémoire de la Société de l'Histoire de Paris et de l'Île de France*, vol. XLIII, 1916, 132.

Baroque illuminations and contested royal imaginaries

18 The nocturnal streets of European cities changed in the 17th C. when absolutist rulers chose to "let there be light." Paris was thereby exemplary. In 1667 Louis XIV had the first stationary streetlights installed as part of a police reform. Wolfgang Schivelbusch argues that these first candle-lit lanterns were not much more than "orientation lights or position markers," which by no means dispelled the darkness but instead imposed the king's rule and order on the citizens of Paris.[22] Nevertheless, these first public lights were groundbreaking because they institutionalized the provision of street lighting, candles and oil supplies in the form of a public maintenance service and a public financing scheme. Yet the new "mud and lanterns tax" (*taxe des boues et lanterns*), "the only significant direct tax on householders in Paris under the Old Regime," was not well received by Parisians.[23]

19 Comparing the case of Paris with other places in Europe, it seems as though the success of these early street-level public light installations depended on the local authorities' power and their will to establish and finance costly energy supply and maintenance systems. As Craig Koslofsky reports, Frederick William I, the Great Elector of Brandenburg-Prussia, "ordered in 1679 that the residents of Berlin should hang a lantern light outside every third house at dusk each evening from September to May." When the citizens argued that they could not afford it and failed to comply, he nevertheless installed 1,600 lanterns at their expense. In Leipzig, the absolutist king Augustus II also "followed the general pattern of royal provision of street lighting seen in Paris, Berlin, and Vienna," with the exception that in the merchant city a "fee collected to enter the city after dark" covered the maintenance costs of the new streetlights.[24] However, rulers' imaginaries did not necessarily resonate with their subjects' preferences and were far from nationwide. Louis XIV's imaginary was only enacted in some Parisian streets, whereas France's second city Marseille did not see the value and benefits of costly lanterns and opposed the royal will to introduce street lighting.[25] The Parisians' incapability to illuminate the streets in front of their houses, the unpopularity of light-related taxation or the actual restoration of darkness through lantern smashing—which was especially popular in France[26]—can be considered a contestation of the absolutist royal imaginary of light.[27] Apparently the benefits of light did not outweigh its costs, the cumbersome task of providing oil and keeping the flame alive.

20 While the first public street lighting made urban communal nightlife at least imaginable, albeit contested, the "nocturnalization" of baroque court culture, as Koslofsky calls it, made it socially acceptable.[28] As the European nobility began to schedule its public activities and festivities later in the evening and at night, the demand for luxurious illuminations and fireworks arose.[29] Again, the French *roi soleil* was a leading figure. In 1688 Louis XIV had his park of Versailles illuminated by 24,000 wax candles, which were luxury goods at the time[30] and thus well suited to reflecting "the

22 Schivelbusch, *Disenchanted Night*, 95 (cf. note 18).

23 Herlaut, "L'Éclairage des rues à Paris...," 140-143 (cf. note 22) and Craig Koslofsky, "Court Culture and Street Lighting in Seventeenth-Century Europe," *Journal of Urban History*, vol. 28, n° 6, 2002, 754.

24 *Ibid*., 754-757.

25 In Marseille, public lighting was eventually introduced in 1785. Pierre Echinard, "De la lanterne au laser: deux cent trente ans d'éclairage public à Marseille," unpublished LUCI conference paper (Marseille, 2013).

26 Schivelbusch offers an interpretation of the political dimension and consequences (punishment) of lantern smashing, which were particularly severe in France. He concludes that premodern lantern smashing was not just vandalism but a political act of opposition against the absolutist king, and was accordingly severely punished. Wolfgang Schivelbusch, "The Policing of Street Lighting," *Yale French Studies*, n° 73, 1987.

27 *Ibid*., 63 and 68.

28 "At court and in the cities, nocturnalization is most apparent in the years 1650–1750, when mealtimes, the closing schedules of city gates, the beginning of theatrical performances and balls, and closing times of taverns all moved several hours later." Craig Koslofsky, "Princes of Darkness: The Night at Court, 1650–1750," *The Journal of Modern History*, vol. 79, n° 2, 2007, 236.

29 *Ibid*., see also Alewyn Richard, Sälzle Karl, *Das grosse Welttheater: die Epoche der höfischen Feste in Dokument und Deutung* (Reinbeck bei Hamburg: Rowohlt, 1959).

30 Schivelbusch, *Disenchanted Night*, 7 (cf. note 18).

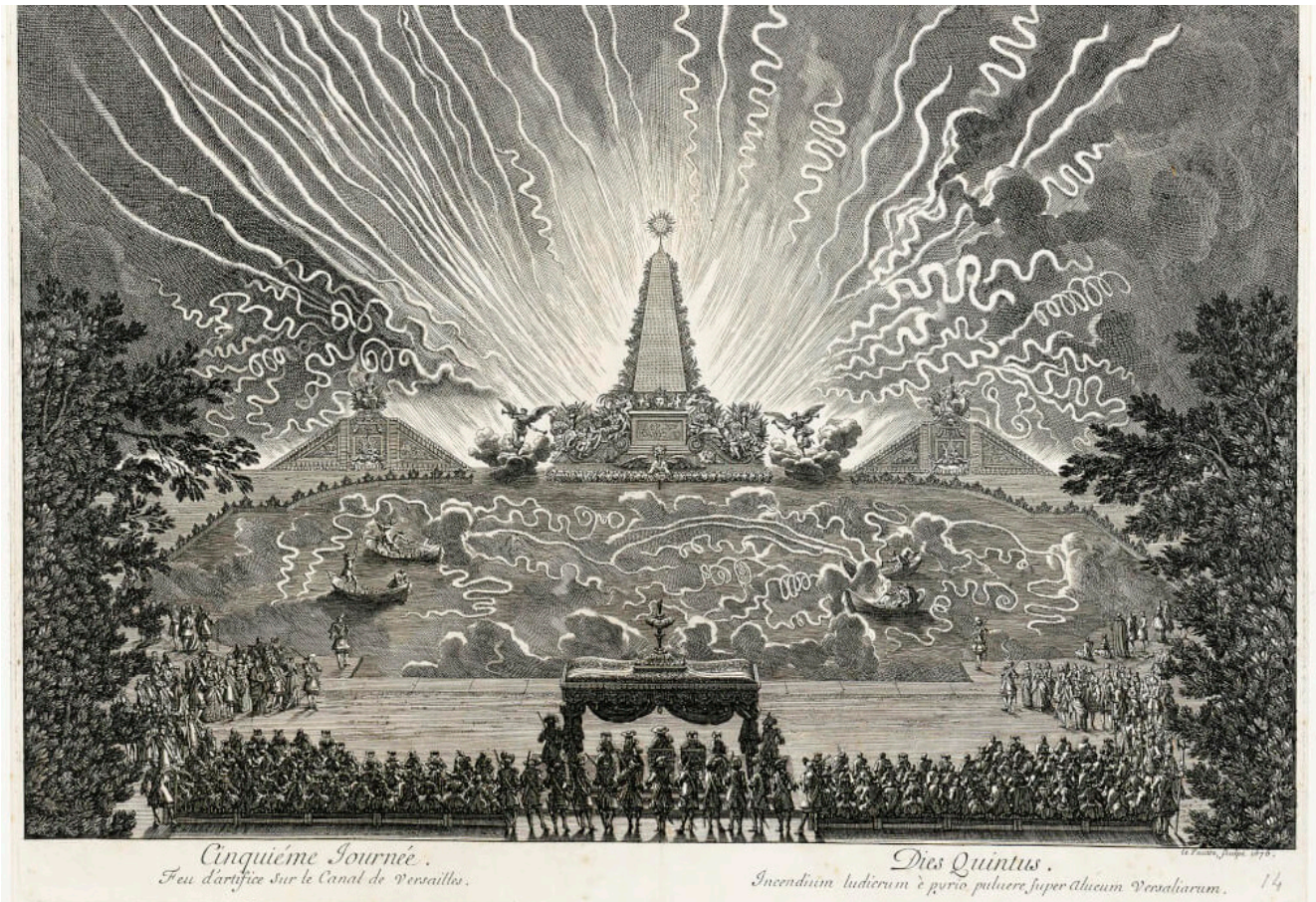

Figure 2: Louis XIV' festive fireworks at Versailles in 1674 depicted by Jean Le Pautre © Paris, musée du Louvre/RMN-GP/ Thierry Le Mage. Source URL: http://www.lescarnetsdeversailles.fr/2016/11/jours-de-fete/, last access 2019-05-12

grandeur of a ruler" and to "bedazzling" his subjects.[31] In his political *Mémoires* the king describes his aesthetic politics, which aim to seduce his people by pleasure and not by force: "Our subjects are delighted to see that we [the king] love what they love, or what they are most successful in. We thereby hold their hearts and soul."[32] Obviously, the king's imaginary of a "society of pleasures," as Kathryn A. Hoffmann describes it, did not match the lived reality of ordinary people who critically observed or even condemned the luxurious nightlife of the nobility. In this sense, it seems too early in this period to speak of a French love of artificial light. In the 17th C., artificial light seems to have been more an absolutist royal imaginary.

Industrial and enlightened imaginaries of urban lights, gas and air

In the 18th C. the contrast between royal imaginaries and the ideals of new urban elites began to erode during the course of industrialization. In this process, the scale of imaginable communities of light and energy developed from the street level and court context to an urban scale. Entrepreneurs, merchants and tradesmen began to engage in the politics of illumination. They echoed the aesthetic politics of baroque court culture, but the communities they had in mind were the populations of growing industrial cities

31 Koslofsky, "Court Culture and Street Lighting in Seventeenth-Century Europe," 748 (cf. note 24).

32 My shortened translation. The French original reads: "Cette société de plaisirs, qui donne aux personnes de la cour une honnête familiarité avec nous, les touche et les charme plus qu'on peut dire. Les peuples, d'un autre côté, se plaisent au spectacle, où au fond on a toujours pour but de leur plaire; et tous nos sujets, en général, sont ravis de voir que nous aimons ce qu'ils aiment, ou à quoi ils réussissent le mieux. Par là nous tenons leur esprit et leur coeur, quelquefois plus fortement peut-être, que par les récompenses et les bienfaits" (The Mémoires of Louis XIV, (ed.) by Jean Longnon). See Kathryn A. Hoffmann, *Society of Pleasures: Interdisciplinary Readings in Pleasure and Power during the Reign of Louis XIV* (New York: St. Martin's Press, 1997), 30.

and European metropolises.Lighting played a significant role in this development, which started in England and soon spread to the continent and France.

22 By 1730, urban elites in northern English cities had already illuminated their streets with oil lanterns.[33] Toward the end of the 18th C. the "spirit of coal" provided the means to really illuminate industrial cities[34] and coproduced a gentlemanly imaginary of air and light. The new source of energy changed the relationship between lighting demand and energy supply as well as the temporal and spatial patterns of light and darkness. As a by-product of charcoal,[35] coal gas was cheap enough to allow the decoupling of lighting practices from the seasons and the lunar calendar so that lighting became more permanent and part of an industrial work regime—first in factories and then in public streets.[36] In terms of space, gaslight had upscaling effects as it depended on the establishment of costly infrastructures. The installation of gasworks and mains required large upfront investments that needed to be refinanced so that the average cost per light point was lower when many gas users were connected to the gas grid. The gaslight pioneer Samuel Clegg describes this shift toward the first economies of scale in lighting as follows:

> The supplying of light to the street or parish lamps alone can never be undertaken with economy in any district, the most beneficial applications being in those situations where a quantity of light is wanted in a small space. Where the light is required to be more diffused, the profit is less, owing to the greater extent of services and fittings.[37]

23 Since lighting was no longer provided by absolutist rulers but by businessmen, technical feasibility and refinancing became decisive factors in the distribution of light and darkness on an urban scale.[38] Industrialists set the conditions for the expansion of gaslight, not just in England but also on the European continent, based on English capital and know-how. The Imperial Continental Gas Association (I.C.G.A.), founded in 1824, first held the monopoly on illuminating cities. Following the new rationale of lighting economies of scale, gas mains were only built in areas where private households could afford the installation costs and high monopolized gas prices so that lighting remained the privilege of wealthier and commercial urban districts.[39]

24 The urban divide between light and darkness was intensified by the (quite literally) dark sides of industrial production. Deprived areas had no gas and light but were often situated close to urban gasworks, exposing their citizens to the

33 Jon Stobart links this new "cultured urban life" to a "need for social integration within the growing middling ranks of these towns and their desire to differentiate themselves from ordinary working people." Jon Stobart, "Culture versus commerce: societies and spaces for elites in eighteenth-century Liverpool," *Journal of Historical Geography*, vol. 28, n° 4, 2002, 473.

34 Samuel Clegg, *A practical treatise on the manufacture and distribution of coal-gas, its introduction and progressive improvement...* (London: Weale, 1853).

35 For a detailed description see Thomas Cooper, *Some Information Concerning Gas Lights* (John Conrad & Company J. Maxwell, printer, 1816), 16-17.

36 The first gaslit street was Pall Mall in London, which was illuminated as a public display in 1807. It was soon followed by the illumination of more affluent streets in the growing metropolis. Clegg, *A practical treatise*, 6 and 19 (cf. note 34).

37 *Ibid.*, 107. Falkus points out that gaslight was only cost-effective when supply infrastructures could be shared by many consumers. Malcolm E. Falkus, "The Early Development of the British Gas Industry, 1790–1815," *The Economic History Review*, vol. 35, n° 2, 1982.

38 In 1813 the English Crown and its Parliament supported the founding of the Westminster Gas-light and Coke Company with a capitalization of £1 million in 80,000 shares. This corresponds to about £9 billion in 2005 prices. The high infrastructural costs became a vehicle for public investment in industrial ventures, adding an economic dimension to the notion of "public" lighting. Charles Bazerman, *The Languages of Edison's Light* (Cambridge, MA: MIT Press, 1999), 149.

39 See Klaus Kühnel, *Der Pionier des Lichts: Vom Klempnergesellen Zum Großindustriellen ; Die Lebensgeschichte Des Carl Friedrich Julius Pintsch* (Berlin: Trafo, 2015) and Jean-Michel Deleuil, "Du bec de gaz à l'halogène. Les enjeux de l'éclairage public à Lyon," *Bulletin du Centre Pierre Léon d'histoire économique et sociale*, vol. 1, 1995.

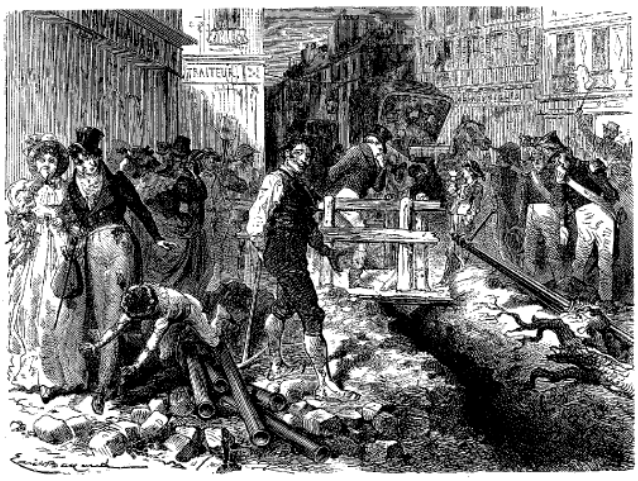

Figure 3: The implementation of gaslight in Paris, described by Louis Figuier. Louis Figuier, *Les Merveilles de la science ou description populaire des inventions modernes*. [4] *Éclairage, chauffage, ventilation, phares, puits artésiens, cloche à plongeur, moteur à gaz, aluminium, planète Neptune* (Paris: Furne, Jouvet, 1870), 129. URL: https://gallica.bnf.fr/ark:/12148/bpt6k24677k/f133.image, 2019-05-12

risk of gas explosions as well as the associated environmental burdens. In the poor quarters of European industrial cities, coal particles blackened the air, house facades, and their residents' lungs. As Jane Brox points out, gasworks contaminated soils with amonia and sulfur, polluted water supplies, and drove the surrounding area into decline. She quotes a contemporary who complained that "[w]hereever a gas-factory [...], there is established a centre whence radiates a whole neighbourhood of squalor, poverty and disease."[40]

25 The social inequalities and problems did not escape the attention of enlightened gentlemen and educated urban elites. Already in the early 19th C., a report by French scientists highlighted the "relative influence of gas lighting on public health." It also criticized the insufficient environmental assessment of gas lighting in Marseille and pointed to the possible contamination of soil and water and potential negative effects on flora, fauna and public health.[41]

26 Mark J. Bouman suggests that the new "status- and class-based segregation" generated and popularized a sensibility for the "contrast of areas at once poor and dark with others that were wealthy and bright."[42] This "'darkness and light' sensibility" also "entered the language of urban reformers."[43] In their gentlemanly imaginaries, demand for more comprehensible illumination schemes was spurred by a mix of liberal, humanist and commercial ideals. Lighting was associated with casting out vice and crime from shady districts, a "competitive urge" to boost and boast about one's city, and a desire to improve public health and well-being.[44] In a similar vein, Chris Otter highlights 19th C. liberal ideals of "air and light," understood as a reflection of social order, rationalization and urban improvement.[45]

27 The reformers' new concern with the wellbeing of imagined urban communities is also reflected in public regeneration programs and the establishment of public gas utilities. For instance, in the industrial city of Lyon, the first gaslights were introduced in the 1830s in commercial streets. But it was only in 1847, after the city was granted an official monopoly, that the gas

40 Brox, *Brilliant*, 69, and Schivelbusch, *Disenchanted* Night (cf. note 18).

41 The report starts with a description of the status quo, which privileges risk management of accidents over the management of creeping environmental pollution and health risks : "Dès l'année 1817, l'Autorité avait rangé les manufactures des gaz hydrogène pour l'éclairage, dans la 2e classe des établissements insalubres, incommodes ou dangereux. Des mesures sévères avaient été prescrites en vue des dangers d'incendie et d'explosion, les seuls dont on se fut préoccupé d'abord. Quant à l'influence de cette industrie sur la salubrité, elle semble avoir été longtemps négligée..." (Jean-Baptiste-Léonce Malherbe *et al.*, *Rapport sur un mémoire de M. Bertulus, de Marseille, relatif à l'influence de l'éclairage au gaz sur la santé publique* (Nantes: impr. de Vve C. Mellinet 1855), 1).

42 Mark J. Bouman, "Luxury and Control," *Journal of Urban History*, vol. 14, n° 1, 1987, 12.

43 Bouman gives the example of an "American Progressive" who suggested that "light put a stop to the unsanitary practice of throwing garbage, waste materials, broken crockery, ashes, dead cats and other refuse into the streets under cover of darkness." *Ibid.*, 13.

44 *Ibid.*, 12-13.

45 In this context, environmental issues were tackled, too. Gas distilleries were developed for purifying coal gas and to get rid of bad fumes and "noxious elements" like tar, carbonic acid or ammonia. Chris Otter, *The Victorian Eye: A Political History of Light and Vision in Britain, 1800–1910* (Chicago: University of Chicago Press, 2008), 138.

network expanded beyond the city center.[46] In German cities too, the I.C.G.A. built gas infrastructures and sold expensive gaslight. When the company's contract for Berlin ended in 1843, the Prussian Ministry established its own gasworks offering its citizens much cheaper gas prices.[47]

28 In France, Georges-Eugène Haussmann transformed Paris between 1853 and 1870 with urban designs and infrastructural innovations that are still pertinent today. Appointed by the French emperor Napoleon III, who himself had been inspired by the enlightened urban designs of London, Haussmann gave Paris the image of a *ville lumière*.[48] Wide boulevards replaced dark and narrow streets. The installation of approximately 20,000 public gaslights, where there had only been approximately 9,000 lights before, transformed the city at night. Together with illuminated public buildings, *grand magasins* and Parisian arcades, gaslights shaped the identity of the French capital, as is documented and represented in the arts and literature.[49] Yet there were also less visible but nonetheless profound institutional and infrastructural changes. Under Haussmann's supervision, the six private gas companies were merged into the *Compagnie parisienne d'éclairage et de chauffage par le gaz*, with a 50-year license to supply Paris with gas. Moreover, he oversaw the modernization of Paris's urban infrastructures underground, including the gas mains.

29 While Paris was an outstanding example, these developments were not unique. As Hernandez Gonzalez points out, an imaginary of social order and commercial display accompanied the introduction of municipal gaslight systems in many French cities.[50] Bouman observes that "by the time of Thomas Edison, lights did *necessarily* come with the modern urban territory."[51]

30 In this sense, the Parisian reformers' enlightened rational plans and humanist ideals seem more metropolitan than national. Nevertheless, the worldwide appeal of Paris as City of Light in an increasing competition between cities also updated French grandeur and planted the seed of a national imagined community of French *éclairagists* and light lovers. Electrification provided the basis for national visions and competitions in Europe.

The normalization of artificial lighting and national imaginaries of electrification

31 In the late 19th C., the co-production of imagined illuminated communities and sociotechnical energy systems entered a new phase and began to develop on a national scale. This process was closely tied to electrification and can be observed in industrialized countries worldwide. It also facilitated the imaginary of a French nation of light lovers as outlined in this section.

32 With electrification, the world of lighting was transformed. Innovators exploited the lure and convenience of electric lighting to promote the establishment of large technological systems. Light sources diversified, creating an excess of light for the first time. As electricity infrastructures expanded beyond the urban centers, illuminated communities became imaginable on a national scale. Innovators enacted such visions most visibly and in most appealing form in electric illuminations during national festivities and international exhibitions, which allowed lay and expert audiences to celebrate and compare their nations' technological progress.[52] Although the revolutionary new

46 Jean-Michel Deleuil, "Du bec de gaz à l'halogène" (cf. note 39).

47 From 1825 to 1828, it built gas infrastructures in Hannover, Berlin and Dresden. See Kühnel, *Der Pionier des Lichts*, 78-88 (cf. note 39).

48 Patrice de Moncan, Claude Heurteux, *Le Paris d'Haussmann* (Paris: Ed. du Mécène, 2002).

49 See, for instance, Walter Benjamin, "Paris, die Hauptstadt des XIX. Jahrhunderts," *in* Siegfried Unseld (ed.), *Illuminationen. Ausgewählte Schriften* 1 (Frankfurt/Main: Suhrkamp, 1977), 170-184.

50 Edna Hernandez Gonzalez, "Comment l'illumination nocturne est devenue une politique urbaine: la circulation de modèles d'aménagement de Lyon (France) à Puebla, Morelia et San Luis Potosí (Mexique)" (Ph.D diss., Université Paris-Est, 2010).

51 Bouman, "Luxury and Control," 30 (cf. note 42, my emphasis).

52 David E. Nye, "The transformation of American urban space. Early electric lighting, 1875–1915," *in* Josiane Meier, Ute Hasenöhrl, Katharina Krause and Merle Pottharst (eds.), *Urban Lighting, Light Pollution and Society* (New York: Routledge, 2015); Bazerman, *The Languages of Edison's Light* (cf. note 40).

Figure 4: The Eiffel Tower illuminated at the occasion of the world exhibition 1889, by Georges Garen. © Photo RMN Grand Palais – J. Schormans.The image title is: Embrasement de la Tour Eiffel pendant l'Exposition universelle de 1889. Source URL: https://www.histoire-image.org/fr/etudes/visions-tour-eiffel, last access 2019-05-12

energy source offered many more advantages than just lighting, enchanting and sublime illuminations seemed the perfect means to publicly display innovation.[53] Especially arc lamps exceeded all previous light sources in brightness, and they received great attention in public discourse.[54] During the 1881 Exposition International d'Électricité in Paris Thomas A. Edison's incandescent lamps celebrated their European debut,[55] In 1889, the Eiffel Tour was erected and spectacularly illuminated at the occasion of the *Exposition Universelle* (fig. 4). Thanks to such public displays electric lights were able to conquer the world before electricity infrastructures were in place. Indeed, the bright and steady electric light surpassed gaslight not only in terms of light quality but also in terms of cleanliness and the absense of smell. As Beate Binder argues, the sensory advantages of electric light contributed to its victory over well-established gas lighting and incentivized the establishment of urban then regional power stations.[56]

33 Sociotechnical imaginaries soon outgrew urban contexts and reached a national scale. The first power stations in Europe were erected in the 1880s in and around cities. While municipalities hesitated to render their gas works obsolete and still discussed whether electric lights should burn on an everyday basis or be reserved for special occasions, innovators and system builders were already imagining and planning electricity supply on a larger scale.The first centralized power stations for regional energy provision were tested in the 1880s. Regional power stations followed around 1900.This infrastructural development "heralded the era of regional electric supply systems, which linked cities, towns, countryside, and remote industrial sites," writes Thomas Hughes, who also famously showed that this development took place in country-specific ways.[57]

34 Country-specific structural differences thereby not only co-produced country-specific sociotechnical systems, but also sociotechnical imaginaries. In Germany for instance, the establishment of rural electric power supply in Germany was not only driven by a vision of modernity and progress,

53 As Beate Binder suggests, light displays were better suited to stirring public excitement and inspired less critical cost-benefit analyses than other technological novelties, e.g. the electric motor. Beate Binder, *Elektrifizierung als Vision: zur Symbolgeschichte einer Technik im Alltag* (Tübingen: Tübinger Vereinigung für Volkskunde, 1999), 108.

54 In the course of the 20th C. early installations of arc light towers disappeared and were replaced by less blinding public illuminations. See Nye, "The transformation of American urban space..." (cf. note 52) and Binder, *Elektrifizierung als Vision* (cf. note 53).

55 Alain Beltran, Patrice A. Carré, *La fée et la servante: la société française face à l'électricité, XIXe-XXe siècle* (Paris: Belin, 1991), 69. Furthermore, Charles Bazerman shows how Thomas A. Edison successfully promoted the electrification via public displays of the beloved incandescent light bulb on various occasions (cf. note 40).

56 Binder, *Elektrifizierung als Vision*, 57-58, (cf. note 53).

57 Thomas P. Hughes, *Networks of Power. Electrification in Western Society, 1880–1930* (Baltimore, ML: Johns Hopkins University Press, 1983), 363.

but also by a "social utopia" of countrywide social integration, the ideal of garden cities and tamed urbanization and the reconciliation of city and countryside.[58] The provision of lighting played a crucial role in this imaginary.

35 In France, electrification took place in a more decentralized manner and was linked even more closely to demand for lighting. In the absence of important industrial electricity consumers, electric lighting was the key argument for infrastructural development. Yet, this limited utilization of electricity also hampered the development of electrical power in France.[59] As French experts deplored when looking at Germany, *la France* eclipsed Germany in terms of lighting luxury, but did not aim at "practical applications" like her neighboring country.[60]

36 In the course of the 20th C. such enactments of imagined communities of light and electrical energy continued to develop in country-specific ways and also became increasingly nationalist. As Alain Beltran argues country comparisons are "not only a historical exercise," but were also undertaken by contemporary system builders. "Especially before 1914, Berlin served Parisian representatives as a constant reference point when they considered the growth in electricity use in the City of Light."[61] As electric infrastructures expanded, the city competition developed into a national comparison and competition.[62] In the climate of increasing nationalism prior to World War I, electrification and light were increasingly enacted in the form of national imaginaries of modernity and progress.[63]

37 With electrification still in full swing, the two world wars had a great impact on both the provision of electric energy and the experience of light. The war-time economies required more energy and led national governments to engage in the establishment of power stations and electricity infrastructures. Yet, these advances did *not* coincide with more lighting. On the contrary, blackouts were imposed to save energy and hide from the enemy.[64] Thus, the wars ended the symbiosis of energy transitions and advancements in lighting. As energy provision became a national task and a prerequisite for industrial development, the relevance of lighting as a driver of energy transitions decreased. The changing relation between light and energy is particularly obvious in post-war France.

The co-production of French radiance and French light lovers after World War II

38 In the second half of the 20th C., *le rayonnement de la France* (the radiance of France) was no longer associated with beams of light, but with atoms. As Hecht outlines, this notion of "radiance" differed from aestheticized baroque politics, enlightenment urban renewal and displays of *savoir vivre* shifting toward realist expert

58 Binder, *Elektrifizierung als Vision*, 234-50 and 277 (cf. note 53).

59 Especially outside Paris, electricity consumption in France was „very week" at the beginning of the 20th century. Pierre Lanthier, "L'évolution des techniques et des entreprises: le cas de l'électricité en France," *in* Hubert Kiesewetter and Michael Hau (eds.), *Chemins vers l'an 2000. Les processus de transformation scientifique et technique en Allemagne et en France au XXe siècle* (Bern: Lang, 2000), 222.

60 Alain Beltran cites Bos et Laffargue: "La lumière elle-même n'est pas toujours très belle et dans beaucoup d'endroits, par exemple à Francfort, les ingénieurs n'ont pas même cherché à éviter pour l'éclairage public, dans les lampes à arc, les ombres provenant des charbons" and they conclude "L'Allemand vise à l'utilisation pratique avant tout ; peu lui importe le luxe. Chez nous c'est malheureusement le contraire." Alain Beltran, "L'électrification de deux capitales: Paris - Berlin 1878-1939," *in* Yves Cohen (ed.), *Frankreich Und Deutschland : Forschung, Technologie Und Industrielle Entwicklung Im 19. Und 20. Jahrhundert* (München: Beck, 1990), 285.

61 My translation. *Ibid*., 281. The same was true for the German perspective.

62 Beltran observes that "passée la Première Guerre mondiale, la comparaison des électrifications urbaines a pris un autre sens car dans change pays on raisonnait à une nouvelle échelle : généralement régionale dans le cas allemand et plutôt nationale dans le cas français." *Ibid*., 287.

63 Binder, *Elektrifizierung als Vision* (cf. note 53) and Alain Beltran, Patrice A. Carré, *La fée et la servante* (cf. note 55).

64 Binder, *Elektrifizierung als Vision*, 336 (cf. note 53); David E. Nye, *When the Lights Went Out: A History of Blackouts in America* (Cambridge, MA: MIT Press, 2010); Karin Hirdina, Janis Augsburger (eds.), *Schönes gefährliches Licht. Studien zu einem kulturellen Phänomen* (Stuttgart: *Ibidem*, 2000).

Figure 5: Extraordinary festive illuminations on Place Bellecour in Lyon, Photo F. Schulte-Römer 2011.

technopolitics.[65] Nevertheless, light remained closely connected to energy. Nuclear power provided comparatively cheap energy for illuminating public spaces and buildings, making it easier for light planners to act upon an imagined French fear of darkness/love of light (in Germany, a similar imaginary would have cost twice as much).[66]

39 In addition to low electricity rates, the French national energy company EDF, which was a key player in the French nuclear program, also actively contributed to the illumination of France. EDF maintained the streetlights of Paris until 2011.[67] In Lyon, the third-largest city in France, EDF contributed to the regeneration of the "black" industrial city into a "City of Light" in the 1990s, supported Lyon's pionneering role in urban light planning and became a sponsor of the city's renowned *Fête des Lumières* (fig. 5).[68]

Yet what French lighting designers have termed 40
urbanism lumière is not only a Lyonnais speciality, but part of a unique French discourse and urban light planning.[69] This French light urbanism challenges allegedly universal technoscientific standards for outdoor lighting that are essentially made for *road* lighting and car traffic.[70] These standards developed in the 1960s as the result of a professionalization and institutionalization of public lighting.

65 It referred not only to nuclear power but was also "synonymous with the grandeur of France" referring "back to glorious days past, invoking Louis XIV, Napoleon, and the heyday of French imperialism." Hecht, "Technology, politics, and national identity in France," 260 (cf. note 4).

66 For instance, until 2003/2004 the City of Lyon benefited from low night-time electricity rates of €0.0757 per kWh whereas in Germany, energy prices for municipalities ranged around €0.15 per kWh. Schulte-Römer, "Innovating in Public," 136 (cf. note 1).

67 See: www.lemonde.fr/economie/article/2011/01/14/veolia-et-edf-en-passe-de-pe..., last access 2018-03-20

68 Schulte-Römer, "Innovating in Public" (cf. note 1), 128.

69 Roger Narboni, "From Light Urbanism to Nocturnal Urbanism," Light & Engineering, vol. 24, n° 4, 2016; Gonzalez, "Comment l'illumination nocturne..." (cf. note 50), or Schulte-Römer, "Innovating in Public," 113 (cf. note 1).

70 Sophie Mosser, "Eclairage urbain: enjeux et instruments d'action" (Ph.D diss, Université Paris 8, 2003), 34; Samuel Challéat and Dany Lapostolle (translated by Oliver Waine), "Getting Night Lighting Right. Taking Account of Nocturnal Urban Uses for Better-Lit Cities," Metropolitics, 2 November 2018 (URL: https://www.metropolitiques.eu/Getting-Night-Lighting-Right.html); Jean-Michel Deleuil and Jean-Yves Toussaint, "De la sécurité à la publicité, l'art d'éclairer la ville," *Les Annales de la Recherche Urbaine*, n° 87, 2000.

41 The first national lighting engineering societies in Europe and North America had been founded during the first decades of the 20th C. They became platforms for technoscientific exchange on adequate and "good" lighting and disseminated technical standards.[71]

42 Yet the science-based standardization of light outputs and light levels was still not universal. Lighting professionals and national associations developed country-specific ways of lighting. The creation of the European standard for road lighting (EN 13201) is a telling example in this regard. Today, the light-technical parts of the standard are the same in all EU member states, whereas the classification of streets, which defines their respective lighting requirements, was not harmonized and is provided by national standardization agencies like AFNOR in France (NF EN 13201-1). As a result, very similar streets in France, Germany or the UK might fall in different lighting categories with different light levels.

43 National differences in lighting standards and French *light urbanism* can both be considered as a French expert approach to lighting, which is also reflected in French lighting institutions. As Bernard Barraqué argues, the French professional society *Association Française de l'Éclairage* (AFE) was, from its inception, more interdisciplinary and had a greater sense of aesthetics and lighting design, while other illuminating engineering societies in Europe were more technically oriented.[72]

44 To conclude, electrification can be regarded as a prerequisite for imagining light preferences on a national scale. In the 20th C., the co-production of light and electric energy led to an expansion of light provision not only within cities but also beyond urban agglomerations. The provision of lighting was thereby institutionalized in the form of national standards, professional associations as well as expert imaginaries, which remained, so it seems, widely unchallenged. As experts took over, urban users of public light were less and less engaged in the art and task of lighting. As the marvelling masses of the late 19th C. fell silent and learned to take light for granted in the 20th C., the creative and future-making task of imagining illuminated communities was increasingly left to lighting professionals. In 1984, half of the French citizens who were interogated in a representative survey could not tell whether their municipal lighting experts did a good job or not.[73] While experts turned lighting into a science, citizens progressively cared less. This picture also resonates with Michel Callon's diagnosis of the French nuclear program and "delegative democracy":

> Nuclear power created an undifferentiated public, composed of individuals who were rendered ignorant and entirely deprived of a capacity to participate in decision-making. This public [...] became entrenched in French society.[74]

45 Thus, the emergence of national electricity infrastructures together with national expert associations and national lighting practices made it possible and plausible for lighting experts to imagine a French preference for well-lit public spaces and a French "fear of darkness." As long as this expert imaginary remained unchallenged, *la France* was illuminated accordingly. However, in the 21st C. this situation has changed as the following section shows.

Contesting expert imaginaries of light and energy

46 Today it seems that established expert assumptions and practices are being challenged by a

71 The professionalization and standardization had already started with the candle standard in the 19th C., when the economies of gaslight called for new measuring techniques. Otter, The Victorian Eye (cf. note 45).

72 Bernard Barraqué, "L'éclairagisme entre art et science. Jean Dourgnon (1901 – 1985)," *in* Fabienne Cardot (ed.), *L'Électricité et ses consommateurs* (Paris: Association pour l'histoire de l'électricité en France, 1987).

73 Sophie Mosser, Jean-Pierre Devars, "Quel droit de cité pour l'éclairage urbain?," *Les Annales de la Recherche Urbaine*, n° 87, 2000, 65.

74 Michel Callon's preface to Gabrielle Hecht, *The Radiance of France* (Cambridge, MA: MIT Press, 2009), xx.

number of local and global developments.[75] At a global level, climate change and the advent of LED technology has profoundly changed the ways in which lighting is envisioned and produced. The LED revolution in lighting has disrupted the primarily nationally organized European lighting markets and produced abstract imaginaries of smart and human-centric lighting. International climate change mitigation policies target lighting as an important area of energy consumption, forcing or incentivizing light users to rethink their demands.[76] Meanwhile, electricity costs for French cities and communities have risen considerably as the EU has harmonized its energy markets, giving municipalities even more reason to question their lighting practices.[77]

47 But the imagined community of French light lovers is also contested from below. Citizens care about energy-efficient outdoor lighting. In 2012, a public opinion poll showed that almost half of the French population views high light levels as problematic since they consume more energy. More remarkably, the responses suggest that the alleged French love of light is clouded by an emerging concern about the negative ecological effects of artificial light at night (ALAN).[78] This fairly new concern is also reflected in a public discourse on light pollution, which does not match the idea of a "delegative democracy."

48 Since the 1990s, French citizens have began to mobilize against artificial light at night and promote the preservation of dark skies.[79] Led

Figure 6: ANPCEN awards French cities and villages that take action to reduce light pollution. Source URL: https://www.parcs-naturels-regionaux.fr/article/lancement-de-ledition-2017-du-label-villes-et-villages-etoiles, last access 2019-05-12

by ANPCEN, the National Association for the Protection of the Nocturnal Sky and Environment, these initiatives culminated in a national law against light pollution.[80] While the national scope of the French dark-sky activism appears like an adequate response to the national sociotechnical system of light and energy, it has not developed a national counter-narrative to the imaginary of a French light-loving people. Instead, the national organization ANPCEN mediates and operates on different local and international scales and actively promotes the vision and enactment of *local and regional imaginaries of darkness*. These new French communities of

75 As Ute Hasenöhrl points out such contestations have regularly occurred in times of transition. Hasenöhrl Ute, "Lighting conflicts from a historical perspective" *in* Josiane Meier, Ute Hasenöhrl, Katharina Krause and Merle Pottharst (eds.), *Urban Lighting, Light Pollution and Society* (New York: Routledge, 2015).

76 For a more detailed description of the interplay between the LED revolution and climate change mitigation policies see Schulte-Römer, "Innovating in Public" (cf. note 1).

77 Anne-Marie Ducroux, "L'ANPCEN. Une voix toujours pionnière," *L'Astronomie*, vol. 129, n° 85, 2015.

78 TNS Sofres, "Les Français et les nuisances lumineuses," September 2012, 17-18. URL: https://www.tns-sofres.com/sites/default/files/2013.02.01-lumiere.pdf

79 In France, this discourse and the positive revaluation of darkness was initiated by astronomers and gained increasing public attention in the 1990s and led to the creation of the Association Nationale pour la Protection du Ciel Nocturne (ANPCN), which changed its name to ANPCEN in 2006 in order to include the concern for "l'environment nocturne" ("E") besides the protection of night skies ("Ciel"). Challéat Samuel, Lapostolle Dany, Bénos Rémy, "Consider the Darkness. From an Environmental and Sociotechnical Controversy to Innovation in Urban Lighting," *Articulo - Journal of Urban Research* [Online], n° 11, 2015, 4-5 and 9. URL: http://journals.openedition.org/articulo/3064 2015 (accessed 2019-05-02)

80 In 2013, the French government passed an environmental law which includes measures against light pollution that were even tightened up in December 2018. See: https://www.ecologique-solidaire.gouv.fr/pollution-lumineuse, last access 2019-02-28.

darkness are not only imagined by experts, but actually enacted by people, e.g. in a national competition for "Star Cities and Villages"—*Villes et Villages étoilés* (fig. 6).

49 Against this background, the initial provocative statement by a Lyon lighting designer regarding the "French fear of darkness" seems like an expression of a historical configuration. The imaginary of a French nation of light lovers resonates with both a baroque French tradition of luxurious urban light spectacles and illuminated buildings and boulevards, and a national nuclear energy system that guaranteed not only energy safety but also low night-time energy fees. Today there are signs that this *nationwide* imaginary is losing its performative power and is being replaced by new and emerging imaginaries of local dark-sky communities on the one hand and global smart LED-lit cities on the other.

CONCLUSION AND OUTLOOK: ENACTING IMAGINED COMMUNITIES OF LIGHT IN THE 21ST C.

50 This article took expert assumptions about collective light preferences as a starting point for an inquiry into the emergence of imagined communities of light and energy, as I call them. Looking back at European lighting history and France in particular, I argued that material energy and lighting infrastructures co-produced expert imaginaries of lighting demands. Although these imaginaries did not necessarily reflect actual preferences for light or darkness, they nevertheless shaped the ways the world was lit at night. They also became more powerful in the course of industrialization. As lighting became a professional task, experts' sociotechnical imaginaries became more consequential. Meanwhile, the comprehension and interpretation of preferences for light and darkness increasingly developed into a domain of professional experience and scientific inquiry. Mikkel Bille critically observes that today "a 'scientification' of lighting is taking place, in which the user is a physically responding *body* more than a social *person*."[81]

51 Yet the focus on sociotechnical imaginaries also reveals that engineers and scientists operate and develop their ideas in specific sociopolitical contexts. The scientification of lighting did not produce universal demands and norms, but national styles and standards. Moreover, we find that lighting professionals cultivate assumptions about collective preferences that cannot be explained by their photometric experiments and do not necessarily stand up to empirical social-scientific analyses and public opinion polls.[82] Instead, the historical overview suggests that expert imaginaries of light are co-produced by energy politics and infrastructures and develop performative power as long as they go unchallenged.

52 The historical perspective also reveals that imaginaries can change in scale. The upscaling from urban to nationwide imaginaries of light reflected and resonated with the changing scale of energy provision: While in preindustrial times, the high cost of candles and oil lamps made it difficult to imagine the illumination of single streets, the innovators and reformers of the 19th C. imagined and implemented gas and lighting infrastructures on an urban scale. It was only in the 20th C. that electric illumination became imaginable on a national scale. Meanwhile, public lighting had become taken for granted and professionalized, so that the question of individual or collective light preferences and appropriate light levels was no longer a matter of public concern, but inscribed in national lighting standards, debated by national professional communities and

81 Bille, *Homely Atmospheres and Lighting Technologies in Denmark*, 17 (cf. note 3).

82 There is an increasing body of social-scientific ethnographic research on the variety and ambivalence of light preferences in practice as I have outlined in a forthcoming review essay on Mikkel Bille's and Tim Edensor's recent monographs. Nona Schulte-Römer, "Research in the Dark. Explorations into the Societal Effects of Light and Darkness," *Nature and Culture*, forthcoming. Other examples include the LSE project Configuring lights (configuringlight.org) and the French research collective RENOIR (URL: renoir.hypotheses.org, accessed 2019-03-08).

supported by national energy supply systems. In this sense, the imaginary of a light-loving French people can be understood as a coproduct of cheap French nuclear energy, a French discourse on national standards and light urbanism and a "delegative" French democracy.[83] In the 21st C., this nationwide imagined community of light and energy is being challenged. French energy has become more expensive and less national. The norms and imaginaries of national professional networks are increasingly challenged by global environmental concerns, by European policies and, remarkably for the alleged "delegative democracy," by civic light pollution protests and initiatives for a darker France.

53 Thus, the focus on expert imaginaries is also politically relevant. The historical evidence presented here shows that lighting preferences do not have to be scientifically proven to have real consequences.[84] Like self-fulfilling prophecies, expert imaginaries have the potential to shape the actual distribution of light and darkness. They thereby reflect and stabilize political economies in highly performative and hence powerful ways. The imagined nationwide preference for light in the 20th C. went hand in hand with national markets for lighting products and services. As such, recent participatory approaches that aim to engage citizens in urban light planning and an increasing body of social-scientific research on the cultural diversity of lighting practices and preferences can offer valuable impulses for rethinking and reimagining communities of light and energy in the 21st C. These reflections are timely and much needed as a response to smart and global LED lighting imaginaries that lack local grounding.

83 Michel Callon in Hecht, *The Radiance of France* (cf. note 73).

84 Sociologists might refer to the Thomas theorem: "If men define situations as real, they are real in their consequences." Dorothy Swaine and William Isaac Thomas quoted in: Robert K. Merton, "The Thomas Theorem and the Matthew Effect," *Social Forces*, vol. 74, n° 2, 1995, 401.

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JEHRHE

Journal of Energy History
Revue d'histoire de l'énergie

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POST DATE
12/12/2019
ISSUE NUMBER
JEHRHE #2
SECTION
Special issue
THEME OF THE SPECIAL ISSUE
Light(s) and darkness(es): Shifting historical relations
KEYWORDS
Labour, Coal, Electricity, Politics, Light
DOI
in progress

TO CITE THIS ARTICLE
Trish Kahle, "Bargaining Electric Power: Miners, Blackouts, and the Politics of Illumination in the United States, 1965-1979", *Journal of Energy History/Revue d'Histoire de l'Énergie* [Online], n°2, published 12 décembre 2019, consulted XXX, URL: http://energyhistory.eu/node/145.

Bargaining Electric Power: Miners, Blackouts, and the Politics of Illumination in the United States, 1965-1979

Abstract

This article examines how the perils conjured by blackouts in American cities after 1965 became interpreted as a key point of political and bargaining leverage for the nation's coal miners. The anxieties provoked by these blackouts –sexual deviance, urban unrest, spoiled food, lost productivity, and Cold War incursions– pointed to a broader crisis of American political and social life driven by the massive social changes which had taken place since the end of the Second World War. As the United States entered the 1970s, a long-range energy crisis appeared not only to secure the future of the once-imperiled coal industry in the United States, but also allowed miners to recast their union as a bedrock of national security rather than as one of the main sources of the nation's labor unrest. Evoking the threat of coerced darkness in the modern American home which had been designed for bright illumination, they also pointed to the figurative darkness of the coal mining workscape, described by one miner as "beating the devil at a game of hell": the constant threat of black lung, disablement, and death. A form of collective bargaining leverage thus opened up a broader debate: how, given the deadly work of coal extraction, could energy be produced in a democratic society that guaranteed the right to life, liberty, property, and, increasingly, light? Did "one man" have to "die every day" to keep the nation's lights on? This paper argues that miners used the framework of lights and darknesses to contend that mines must be made safe and energy democratized in order to stabilize the energy regime in crisis. In so doing, they framed a new politics of illumination which allowed them to navigate a new terrain of collective action.

Plan of the article

ISSN 2649-3055

INTRODUCTION

1 In the early months of 1966, the coal industry was still reeling from the fallout of a large regional blackout that had "plunged" 30 million people and 80,000 square miles across the Northeast in "darkness and peril." The coalfields had not lost power in the blackout, and fuel shortages had played no role in the event. Still, the editors of the industry journal *Coal* recognized the utilities were coal's largest market, and that the future of the two industries were tightly bound together. They castigated those "who designed, built, operated and observed" the nation's power system and had "failed...to foresee disaster after disaster." The blackout was a "dark disgrace" which they compared directly to the "senseless tragedy of the assassination" of President John F. Kennedy. "Unbelievably," *Coal* observed, the blackouts had resulted from a system operating as intended –"it was a predictable yet unforeseen sequence of events" in a system increasingly organized around large-scale interconnection.[1] Their dismay and anxieties were emblematic of a society that across the early 20th C. had invested heavily in electric power to foster social, economic, and political stability.[2] The absolute necessity of reliable illumination reached from the coalfields to urban police forces that began to develop illumination-based security strategies in response to unrest in many of the nation's cities between 1964 and 1968. It exposed the way illumination bound together an emerging set of rights and obligations imagined to govern electricity production and use. These relationships of illumination gave political meaning and moral inflection to currents of electric power.

2 The majority of this illumination, with some regional variation in hydro-rich, coal-poor areas of the country, was coal-fired (fig. 1). The centrality of the utility market to the coal industry was well understood by coal miners, who imagined the relationships of illumination running along power lines –"coal by wire."[3] These relationships were equally important in supporting

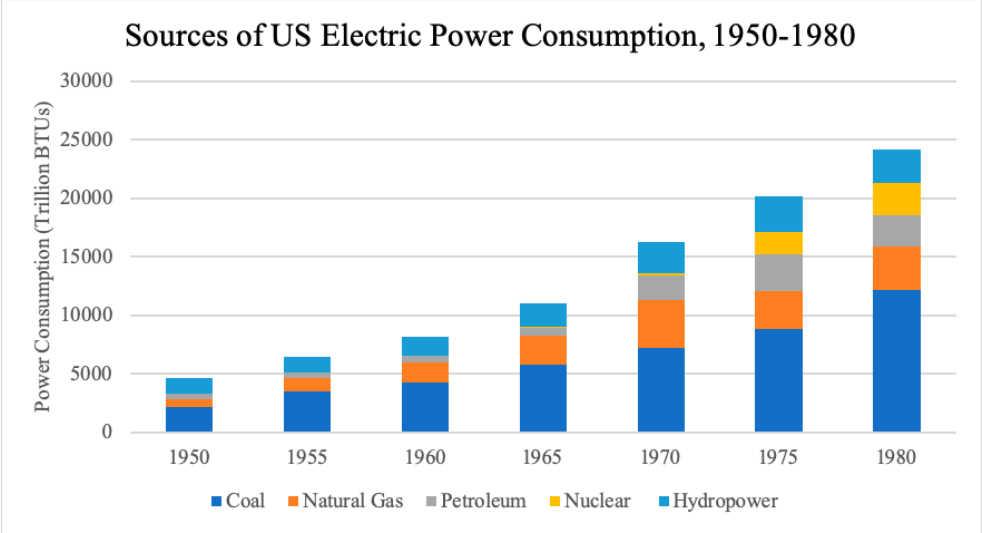

Figure 1: Primary Sources of US Electric Power Consumption, 1950-1980. Adapted from Energy Information Administration, "Electric Power Sector Energy Consumption," Monthly Energy Review, January 2019. Accessed January 29, 2019.

1 "Dark Disgrace!," *Coal*, Jan.-Feb. 1966. United Mine Workers of America Journal Records [UMWJR] 13/6; Charles Perrow, *Normal Accidents: Living with High Risk Technologies* (Princeton, NJ: Princeton University Press, 1999); Richard F. Hirsh, *Technology and Transformation in the American Electric Utility Industry* (New York: Cambridge University Press, 2003); Julie A. Cohn, *The Grid: Biography of an American Technology* (Cambridge, MA: MIT Press, 2017), 121-179.

2 For depictions of the outcome of these investments, see David E. Nye, *When the Lights Went Out: A History of Blackouts in America* (Cambridge, MA: MIT Press, 2010); Hirsh, Technology and Transformation; Cohn, The Grid. See for example, "A Mass Market for Electric Heat," *United Mine Workers Journal*, July 1, 1963; "Well-Balanced," *United Mine Workers Journal*, January 15, 1967.

3 See for example, "A Mass Market for Electric Heat," *United Mine Workers Journal*, July 1, 1963; "Well-Balanced,"

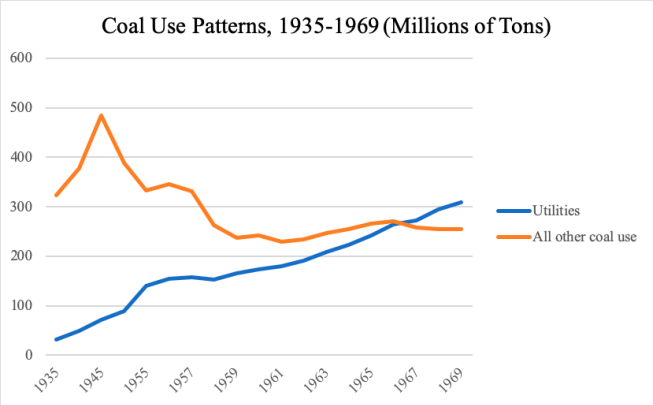

Figure 2: Coal Use Patterns, 1935-1969. Source: Charles River Associates, The Economic Impact of Public Policy on the Appalachian Coal Industry and the Regional Economy (Cambridge, MA: N.p., 1973), 11-12, 183. Bureau of Mines, Minerals Yearbook, 1969 (Washington, DC: US Government Printing Office, 1971).

the stability of electric power as the grid, but they only became apparent in moments of crisis, moments when suddenly, the lights threatened to go out, or when a system of energy production, operating as intended, produced disaster.[4]

3 Disaster was easy to come by in the nation's underground mines, which continued to claim their dubious distinction as the nation's most dangerous workplace. Underground miners suffered disabling injuries at nearly five times the national average, even as they produced the majority of the nation's coal and constituted the majority of its mining workforce.[5] While underground mining had always been dangerous, the rapid mid-century expansion of coal-fired electricity provided a new context for danger as coal powered suburban affluence and consumers' growing expectations (fig. 2).[6] These dangers were geographically concentrated too. Between 70 and 75 % of all coal mined in the United States during the late 1960s came from the Appalachian region, and the majority of Appalachian coal came from less than twenty counties, most of them in West Virginia.[7] In early 1969, union miners struck to force passage of the West Virginia House Bill 1040 –a series of amendments to the state's workers' compensation system colloquially referred to as the West Virginia black lung law. They found that the energy currents which tied them to the nation's cities formed a new source of political power which miners could exercise outside of both the voting booth and the collective bargaining table. The successful passage of the West Virginia black lung law, and the landmark Federal Coal Mine Health and Safety Act in December the same year instructed a new generation of miners how to bargain with electric power. This new practice of politics suggested the nation as a whole was culpable for the dangers of underground mining. Miners' organizing efforts exposed American energy politics as balanced between darkness and light –actual and metaphorical. The slippages that could occur between electric illumination and bargaining power, between blackouts and mine tunnels provided considerable fluidity in the way these changing relationships of energy could be understood and manipulated. While lighting needs represented only one of the many ways the average consumer might use coal-fired electricity, it was by far the most visible. Illumination often substituted as a catch-all for a wider group of energy-use practices.

United Mine Workers Journal, January 15, 1967.

4 Peter-Paul Verbeek, *What Things Do: Philosophical Reflections on Technology, Agency, and Design* (University Park: Pennsylvania State University Press, 2004); Stephen Graham and Nigel Thrift, "Out of Order: Understanding Repair and Maintenance," *Theory, Culture, and Society*, vol. 24, n° 3, 2007; Stephen Graham (ed.), *Disrupted Cities: When Infrastructure Fails* (New York: Routledge, 2010).

5 The majority of coal would come from underground mines through 1971. From 1971-74, underground and surface mining contributed similar tonnage, and after 1974, surface mining decisively overtook underground production. Energy Information Administration, "Coal Production, 1949-2017," *Annual Coal Report* (November 2018). Underground miners continue to outnumber surface miners, even after decisive shifts in the geography and intensity of production. Bureau of Labor Statistics, "Distribution of Employment for Coal Mining Industries," 2010; Safety Roundup, Pennsylvania Bituminous Council, Holmes Safety Association, September 1969.

6 Lizabeth Cohen, *A Consumers' Republic: The Politics of Mass Consumption in Postwar America* (New York: Vintage, 2003).

7 Robert C. Milici and Désirée E. Polyak, "Bituminous Coal Production in the Appalachian Basin: Past, Present, and Future," *in Coal and Petroleum Resources in the Appalachian Basin: Distribution*, Geologic Framework, and Geochemical Character, Leslie F. Ruppert and Robert T. Ryder, (eds.) (N.p.: US Department of the Interior, US Geological Survey, 2014), 4-6.

4 Tracing energy politics through illumination highlights the paradoxical set of relationships that governed coal production and use in the second half of the 20th C. Moreover, it offers an expanded conceptualization of the relationship between energy and democratic politics that has been a central concern of the energy humanities. The very growth in electricity consumption that visually removed coal from everyday life increased systematic and relational dependence on it. In the second half of the 20th C., the nation's political, social, economic, and ecological bonds were premised on and reflective of energetic connections which were often obscured through spatial concentrations of the burdens of production and the benefits of consumption. Efforts to bargain with electric power sought to make these obscured dependencies once again visible.[8]

5 Miners came to understand illumination as a relationship that bound energy workers and consumers together. Not simply meant as a synonym for light, illumination in this context evoked governance: the balancing of light and darkness in a democratic society. The politics of illumination that shaped regulatory legislation, the aspirations of energy consumers, and the demands and expectations of coal miners, offers a new domestic perspective on the energy crisis that incorporates the politics of production as well as consumption.[9] In the long 1970s, an energy shortage became a crisis, which called into question not just the composition of the American energy portfolio, but the future of democracy itself. Coalfield politics can help us understand why.

LIFEBLOOD OF THE MODERN NATION

6 Despite the hyperbolic responses contained in the pages of *Coal*, no major blackouts occurred in the three years following the 1965 failure. Yet the anxieties that had shaped the industry response to the event reflected an ongoing transformation of American energy use. For the first time in 1965 –the same year as the blackout– the amount of coal used for electricity surpassed the amount of coal used for all other purposes, combined. As access to electricity became an assumed feature of Americans' everyday lives, the meaning of coal mining became bound up with the provision of fuel for electric power. This transformation bound the iconic industrial workplace to a transforming economic landscape increasingly dotted with offices and shopping centers that depended on reliable illumination and ventilation, and to the larger suburban homes designed for an electrified lifestyle.[10] The more omnipresent electricity –especially illumination– became, the more the dependent on coal everyday life became.[11] As the Federal Power Commission observed in 1971, dependable electric power was the basis for "industry and commerce." Without

8 The concept of sacrifice zones has been widely applied in environmental studies and contemporary writing on ecological economics. Naomi Klein, *This Changes Everything: Capitalism Versus the Climate* (New York, Simon & Schuster, 2014), 165-177; Steve Lerner, *Sacrifice Zones: The Front Lines of Toxic Chemical Exposure in the United States* (Cambridge, MA: MIT Press, 2012). Also see Jason Moore's concept of "cheaps" and primitive accumulation in *Capitalism in the Web of Life: Ecology and the Accumulation of Capital* (New York: Verso, 2015).

9 For consumption and diplomacy focused narratives of the energy crisis, see Meg Jacobs, *Panic at the Pump: The Energy Crisis and the Transformation of American Politics in the 1970s* (New York: Hill & Wang, 2017); Daniel Yergin, *The Prize: The Epic Quest for Oil, Money, and Power* (New York: Free Press, 2009). Where the production side of the crisis has been made visible, it has focused on supply, which powerfully illuminated the transformation of political economy in this period but has ultimately left labor politics somewhat absent. See Robert D. Lifset (ed.), *American Energy Policy in the 1970s* (Norman: University of Oklahoma Press, 2014), 123-256.

10 Michelle Murphy, *Sick Building Syndrome and the Problem of Uncertainty: Environmental Politics, Technoscience, and Women Workers* (Durham, NC: Duke University Press, 2006); Marsha E. Ackermann, *Cool Comfort: America's Romance with Air-Conditioning* (Washington, DC: Smithsonian Institution Press, 2002); Jeanne Kisacky, *Rise of the Modern Hospital: An Architectural History of Health and Healing, 1870-1940* (Pittsburgh: University of Pittsburgh Press, 2017), 338-347; Russell Lopez, *Building American Public Health: Urban Planning, Architecture, and the Quest for Better Health in the United States* (New York: Palgrave MacMillan, 2012).

11 Gail Cooper, *Air-Conditioning America: Engineers and the Controlled Environment, 1900-1960* (Baltimore, MD: Johns Hopkins University Press, 2002); Ruth Schwartz Cohen, *More Work for Mother: The Ironies of Household Technology from the Open Hearth to the Microwave* (New York: Basic Books, 1985); David E. Nye, *Consuming Power: A Social History of American Energies* (Cambridge: MIT Press, 1998).

stable currents of electricity that emerged from this basic relationship between energy producers and consumers, "food spoilage" would occur, and "measurable effects on the economic health and residential well-being of the community" would follow. Coal-fired electricity was the "lifeblood of a modern nation." Americans had to recognize that "the nation's and their well being as individuals," were "at risk" from power loss and fuel shortages.[12] Illumination in the postwar United States was no luxury, but rather a crucial matter of personal and national security. But the security risk posed by coal shortages in the postwar period differed substantially from earlier understandings of coal's importance to national defense as a fuel for transportation.[13] Energy access was required for an "American" standard of living. Illumination, in part, powered the high-energy capitalism around which the United States centered its Cold War ideology.[14]

7 Moreover, the darkened urban landscape could not be well surveilled, and it was perceived as particularly vulnerable to fragmentation and insurgency.[15] In the United States, the anxieties of urban darkness were amplified by the process of white flight which further racialized urban space.[16] Moreover, security strategies that deployed electric lighting emerged amid a wave of urban uprisings and the growing militancy of the antiwar and student movements. Raymond M. Momboisse, Deputy Attorney General of California and a member of the President's Commission on Law Enforcement, expressed the stakes of illumination in his writings on riot prevention and industrial security. He drew a distinction between the orderly illumination of electric lighting and the unruly relationship between light and darkness conjured by images of "a city torn, bleeding and in flames...a wild mob on the rampage."[17] For industrial sites fearful of sabotage, he offered illumination as a crucial form of security. "Protective lighting," he wrote, provided a powerful "psychological deterrent," that was "inexpensive to maintain." The scale of protection could be adjusted by altering "the intensity or quantity of light and location of luminaires." In a society still adjusting to the new centrality of electric illumination to ordering daily life, Momboisse spent pages detailing different types of lighting, how the different light sources could be powered, and their attendant vulnerabilities.[18] More banal, but apiece of expanded use of illumination as an everyday form of security, utilities like Pennsylvania Power & Light advertised light as an investment in safety. Outdoor electric lighting could provide "Dusk-to-Dawn Safety, Security, Convenience." For "only $4.20 a month," one could purchase "safer" parking lots, working conditions, and outdoor recreation while the lights "discourage[d] prowlers, vandals, and pesky animals."[19] Illumination offered an expanded, widely accessible form of control –over insecurities, paranoia, structural vulnerabilities– in a society many felt to be on the verge disorder.[20]

12 Federal Power Commission, *The 1970 National Power Survey: Part I* (Washington, DC: US Government Printing Office, 1971), I-1-4 through I-1-5.

13 Peter Shulman, *Coal and Empire: The Birth of Energy Security in Industrial America* (Baltimore: Johns Hopkins University Press, 2015).

14 Kate A. Baldwin, *The Racial Imagination of the Cold War Kitchen: From Sokol'niki Park to Chicago's South Side* (Hanover, NH: Dartmouth College Press, 2015); Cohen, The Consumers' Republic.

15 Simone Browne, *Dark Matters: On the Surveillance of Blackness* (Durham, NC: Duke University Press, 2015); Robert Shaw, "Pushed to the Margins of the City: The Urban Night as a Timespace of Protest at Nuit Debout, Paris," *Political Geography*, vol. 59, 2017; Cynthia Enloe, *Maneuvers: The International Politics of Militarizing Women's Lives* (Berkeley: University of California Press, 2000).

16 Thomas Sugrue, *The Origins of the Urban Crisis: Race and Inequality in Postwar Detroit* (Princeton, NJ: Princeton University Press, 1996); Kevin Kruse, *White Flight: Atlanta and the Making of Modern Conservatism* (Princeton, NJ: Princeton University Press, 2005).

17 Raymond M. Momboisse, "Riot Prevention and Survival," *Chicago Kent-Law Review*, vol. 45, n°2, 1968.

18 Raymond M. Momboisse, *Industrial Security for Strikes, Riots and Disasters* (Springfield, IL: Charles C. Thomas, 1968), 97-111.

19 Pennsylvania Power & Light, newspaper advertisement proofs, September 1970. Pennsylvania Power & Light Co. Records, 46/2. Accession N° 1962, Hagley Library, Wilmington, Delaware.

20 On the chaos in US society in the late 1960s, see Charles DeBenedetti, *An American Ordeal: The Antiwar Movement of the Vietnam Era* (Syracuse, NY: Syracuse University Press, 1990); on violence particularly, see Jeremy Varon, *Bringing the War Home* (Berkeley: University of California Press, 2004).

8 The assumption that light was cheap, however, obscured the costs of coal-fired electricity which were being offloaded much earlier in the production process, and which were overwhelmingly borne by the nation's coal miners. Although not the site of urban uprisings, massive antiwar protests, or a large student movement, the coalfields which provided the majority of this illumination also percolated with their own form of unrest. Following a November 1968 explosion at the Consol No. 9 mine near Farmington, West Virginia, miners forced the nation to confront the dark reality of the coal mining workplace. Electric lighting, in this narrative, was darkness displaced, and experienced unequally.

9 Although coal mines were often depicted as dark tunnels, by the mid-1960s, mining proceeded with the help of substantial electric lighting. Underground, just as in the nation's cities, blackouts portended instability. For the miners working the evening of November 20, 1968, sudden darkness was a sign that something had gone terribly wrong. Of the ninety-nine men who had traveled underground, only seventy-eight would return alive.

10 George Wilson was part of a crew operating a continuous miner when the power went out. "I taken, I expect, two or three steps when this thing came in on us," he recalled. "Just like that through the air and there was flying debris, rock dust, coal dust, and everything so intense you couldn't see...it just felt like my eyeballs was cut up from this flying debris." Lewis Lake recalled "mining coal as usual and all at once the power went off and I hollered at Shorty, 'What's wrong with the power?'... and then I knew it was something I had never seen in the mines before." Alex Kovarisch had been dealing with power issues all night –a DC breaker was out at the slope bottom– but was above ground when "the ground trembled, then the lights dimmed and came back on." Notably, many miners were quick to point out that there might have been many causes for the blackout. Not all would have resulted in the death of nearly the entire shift. The loss of power suggested something was amiss. Only by placing the blackout in a broader cultural understandings of darkness and its perils did it take on the quality of an omen, as it did when miners recounted the moment they realized how much danger they were actually in. Darkness as the absence of light and the looming figurative darkness of impending disaster mixed together in the miners' statements to the West Virginia Bureau of Mines. Lawrence Riggs, for example, recalled a coworker describing the scene at the Llewelyn mine portal as "dark, smoke, or dust."[21] The hellish scene was later described by Ben A. Franklin of the *New York Times*:

> The first blast had burst up 600 feet through the portals and ventilation shafts, blowing the internal works of the mine to atoms... At the top, the main shaft became the muzzle of a mammoth subterranean cannon... For days, a boiling plume of poisonous black smoke alternatively belched from the shaft and then unaccountably reversed its flow and inhaled, bursting forth again with renewed detonations below.[22]

11 The *West Virginian Times* further evoked themes of darkness and sacrifice by provocatively referring to the blast's aftermath as an "underground holocaust," which continued to burn, even after attempts to seal the mine.[23] The preventable blast was not the first such disaster in the nation's mines, nor would it be the last. However, because of the complete transformation in coal use patterns, the disaster took on a new political meaning reflective of the changed energetic relationship between the nation's coal miners and its electricity consumers.[24] To be sure, state and union official attempts to shield Consol from blame in the wake of the disaster stood in a longer tradition of coal companies not being

21 West Virginia Department of Mines, *Official Hearing: Coal Mine Explosion, Consol No. 9 Mine*, November 20, 1968. Accessed online.

22 Ben A. Franklin, "The Scandal of Death and Injury in the Mines: Nobody Knows What the Cost of a Century of Neglect Has Been," *New York Times*, March 30, 1969.

23 "78 Miners Entombed in Farmington No. 9 after Blasts Rip Workings," *West Virginian Times*, November 21, 1968.

24 On the capacity of disasters to help cast political problems in new light, see Scott Gabriel Knowles, "Learning from Disaster?: The History of Technology and the Future of Disaster Research," *Technology and Culture* vol. 55, n° 4, 2014.

held accountable for accidents. But now implicated in a wider range of energy use by increasingly affluent domestic consumers, these efforts also appeared to naturalize the asymmetrical human costs of electricity production. J. Cordell Moore, the Secretary of the Interior, stated that "we don't understand why these things happen, but they do happen." Tony Boyle, president of the United Mine Workers, defended Consol as "one of the better companies as far as cooperation and safety are concerned."[25] Miners interpreted these statements as collusion among the companies, union, and the state to make disaster a natural feature of the mining workplace. Miners felt they were being asked to bear a disproportionate burden of the nation's energy costs –costs which could be measured in lives lost, bodies maimed, and lungs scarred.[26] Even if the utilities tried to mask these costs with their public relations cartoon Reddy Kilowatt –a friendly figure with electric currents for limbs and a lightbulb nose–, the debts to the nation's miners were still being incurred.[27]

12 The methane explosion at the Consol No. 9 had sparked the unrest. However, it was the failure of either the state or federal government to offer worker compensation to victims of black lung –the debilitating disease caused by inhaling coal dust– that ultimately became the central point of contention. While union president Boyle seemed to sit on his hands, miners held mass meetings and formed the Black Lung Association.[28] Following a "marathon" six-hour hearing on black lung compensation by the West Virginia legislature, members of the Black Lung Association threatened to close down fields if a law was not passed. Hundreds carried placards reading "No Law, No Work."[29] On February 18, 1969, 282 miners from the East Gulf Mine in southern West Virginia walked off the job. Within a week that number had increased to 12 000 miners, mostly in the state's southern counties where some of the richest bituminous coal in the world was mined. Two thousand marched on the state capitol in Charleston. As the strike gathered momentum, it spread into the northern sections of the state, and to the neighboring states of Pennsylvania and Kentucky.[30] Soon, 40 000 miners had together idled every coal mine in the state. Federal judge John Field said he had "no authority to order striking coal miners back to work."[31]

13 With utility stockpiles threatened mid-winter, the Senate Subcommittee on Labor demanded an explanation from Tony Boyle, head of the United Mine Workers. But Boyle, who had come of age in coal's industrial era, had clearly failed to grasp the growing impact a widespread strike might have in a high-energy society that increasingly

25 For a close study of the Consol disaster, see Bonnie E. Stewart, *No. 9: The 1968 Farmington Disaster* (Morgantown: West Virginia University Press, 2012). Comments of government, union, and company officials, including Moore's and Boyle's comments above, were compiled by dissident miners in "Coal Mine Safety: 9 Comments," from "The Hurricane Creek Massacre," January 26, 1971. Miners for Democracy Records [MFDR], 46/15.

26 Chauncey Starr, "Social Benefit Versus Technological Risk: What is Our Society Willing to Pay for Safety?" *Science*, vol. 165, n° 3899, 1969; Mary Douglas and Aaron Wildavsky, *Risk and Culture: An Essay on the Selection of Technological and Environmental Danger* (Berkeley: University of California Press, 1983). On the naturalization of disaster, see Ted Steinberg, *Acts of God: The Unnatural History of Natural Disaster in America* (New York: Oxford University Press, 2006); Sara B. Pritchard, "An Envirotechnical Disaster: Nature, Technology, and Politics at Fukushima," *Environmental History*, vol. 17, n° 2, 2012; Knowles, "Learning from Disaster."

27 Bob Johnson notes the importance of Reddy Kilowatt in stripping energetic servitude of its racialized and gendered meanings. Bob Johnson, "Energy Slaves: Carbon Technologies, Climate Change, and the Stratified History of the Fossil Economy," *American Quarterly*, vol. 68, n° 4, 2016. For a range of Reddy Kilowatt promotional and billing materials from across the United States (and a limited global sample) see editions of Reddy News, c. 1969-1972, *Pennsylvania Power & Light Records*, 50/19-21 and 51/1.

28 The BLA also drew on a deeper tradition of health and safety organizing and regional welfare campaigns, but was a distinct organization. Alan Derickson, *Black Lung: Anatomy of a Public Health Disaster* (Ithaca, NY: Cornell University Press, 1998); Barbara Ellen Smith, *Digging Our Own Graves: Coal Miners and the Struggle over Black Lung Disease* (Philadelphia: Temple University Press, 1997).

29 Ben A. Franklin, "West Virginia Miners Demand Black Lung Compensation Law," *New York Times*, February 12, 1969.

30 Reuters, "12,000 Coal Miners Join Wildcat Strike," *New York Times*, February 26, 1969.

31 UPI, "Federal Court Says It Lacks Power to Halt Mine Strike," *New York Times*, March 2, 1969.

looked to coal-fired electricity both to underwrite consumptive citizenship and as a form of security.[32] As the statewide walkout continued to spread, he dismissed the strike as ineffective. Congress, he argued, would hardly pass legislation "because I have shut down every coal mine in the United States and have a *little blackout here and there*."[33] Urban observers, including the *New York Times* editors, disagreed. The power of the black lung strike, they argued, derived from the fact that the "Black Lungers" had "a claim on the conscience of a nation in which coal remains a vital fuel."[34] This claim coursed through the nation's power lines.

14 By February 25, public opinion on the strike had shifted from earlier calls for "sober thought and study," to agreement that action could not wait. "It is time for the miners to stop losing," the *New York Times* editorial board concluded. "Their record of defeat is written in blood."[35] On March 12, West Virginia Governor Arch Moore finally signed House Bill 1040, a landmark black lung bill that contained enough provisions for compensation to be accepted by the striking miners. The dramatic three-week strike finally drew to a close, with tens of thousands of miners returning to work the next day.[36] The strike appears not to have disrupted electric service, but it drew stockpiles down significantly and tinged the future with uncertainty. The lowered stockpiles amplified the impact of much smaller strikes later that year.[37] The power of the miners' new energetic relationship with the nation's energy consumers would not soon be forgotten.

DARK DISPARITIES

15 Anxieties about the nation's energy supply continued as the crisis in the eastern coalfields, which still supplied the majority of the nation's coal, deepened. Boyle's inability to pivot with the changing political economy of coal dovetailed with his own corruption and autocratic tendencies. In response to an early reform campaign in 1969, he ordered the murder of his opponent, Jock Yablonski, who was shot dead in his home along with his wife and their daughter.[38] The nascent reform movement coalesced in the aftermath of the Yablonski murders into an organization called the Miners for Democracy. From its earliest days, the Miners for Democracy contended with the new energy relationships that defined the mining workplace and placed them at the center of its campaign messaging and organizing strategy. The reformers drew a direct connection between illumination and their demand for a new union election. Warning that "the coalfields are rife with rumors of a nationwide strike," the Miners for Democracy's lawyers warned that "America's lights may go out this fall unless these men are given this fundamental right to be represented by men of their choosing."[39]

16 Beyond union politics, however, the Miners for Democracy sought to forge a new place for the coal miner in broader public life. These efforts were buttressed by the fact that although experts predicted that electricity use would continue to double each decade, the disparity between the growth in electricity consumption and wavering production across the domestic

32 For more on energy and consumptive citizenship, see Cohen, *A Consumer's Republic*.

33 W.A. Boyle, *Testimony before the Senate Subcommittee on Labor*, February 27, 1969. Reproduced in *The Fight for Coal Mine Health and Safety: A Documented History*, Ken Hechler (ed.) (Charleston, WV: Pictorial Histories Publishing Company, 2011), 119-120, emphasis added.

34 New York Times editorial board, "The Black Lungers," *New York Times*, February 3, 1969.

35 New York Times editorial board, "Coal Miners' Revolt," *New York Times*, February 25, 1969. PQHN.

36 AP, "'Black Lung' Bill Is Signed by West Virginia Governor," *New York Times*, March 12, 1969.

37 Michael K. Drapkin, "Coal Strikes Seen Being Settled Soon; Impact Expected to Be Felt for Months," *New York Times*, March 4, 1969; "Coal Strike Hits 12 Mines; Impact Seen within Days," *Wall Street Journal*, August 19, 1969.

38 For an overview of the Yablonski murders, see Brit Hume, *Death and the Mines: Rebellion and Murder in the United Mine Workers* (New York: Grossman, 1971).

39 Statement of Kenneth J. and Joseph A. (Chip) Yablonski, March 6, 1970. John Herling Papers, Walter P. Reuther Library for Labor and Urban Affairs, Detroit, Michigan, Box 11, Folder 18. The Yablonski brothers were the surviving sons of Jock Yablonski as well as the reform movement's lawyers.

fuels sectors persisted.[40] Coal miners contended they were the front-line troops defending the nation's energy security against the threat of fuel shortages, and they urged their members to take a broader view of energy politics beyond the mining workplace.[41]

17 To inculcate this broader view among rank-and-file members, the Miners for Democracy used interviews, editorials, and informational articles to cast old coalfield relationships of power in a new way –as operating along the electric grids which increasingly tied the seemingly remote coalfields to the nation's growing suburbs and urban centers. Although the Miners For Democracy had been organized to confront corruption within the union leadership, one of its first publications addressed electricity shortages on its front page instead. The leading headline asked "Will America's Lights Go Out?" The accompanying article spanned two full pages because "the answer is more complex than the question."[42] Electricity shortages –which seemed sure to cause widespread brownouts across the summer and potentially darken at least a dozen of the nation's largest cities– were a complex phenomenon. The cause of the shortages seemed to boil down to a breakdown of technocratic administration –a failure miners would have viscerally understood.[43]

18 Blackouts, as David Nye has noted, signaled profound systemic instability in a society that was increasingly accustomed to social relationships operating through complex technological systems.[44] The blackouts and brownouts powerfully exposed the underlying weaknesses of the technological systems which bound seemingly disparate areas of American society together. They also uncovered the social-energetic inequalities such systems sought to mediate through illumination. Wrote the Federal Power Commission, "like the human body," energy in modern America was "a complex system that can cease to function effectively if...its basic metabolism goes awry."[45] Built into this metabolic energy system that turned coal into illumination, however, was that energy production involved more than chemical reactions. The basic metabolic function, Senator Fred Harris (D-OK) noted, was that the nation was "burning up people to make electricity."[46]

19 While the darkness that accompanied power shortages and failures portended threats to national security and commerce, darkness in the mines was emblematic of growth, a prerequisite for light. The problem of darkness, then, was differentiated spatially, and by the type of work one did. In the cities, the points of consumption, literal darkness loomed as a threat to the nation's social fabric. In the coalfields, darkness was a condition of the mine's location within a broader system of energy flows, the point of articulation between human labor and the natural world. The fight for black lung legislation had demonstrated the darkness of the workplace was carried forward in miners' lungs even after they returned to the surface.[47] Dr. I.E. Buff, a physician-organizer who supported the miners' black lung fight, went so far as to carry the blackened lungs –removed postmortem– to rallies with him. He would then crumble the dried tissue in front of the miners in attendance.[48] Culturally woven into the mine face through religious metaphor and the folklore traditions of the fantastic, darkness extended through the miles of underground tunnels, experienced

40 Federal Power Commission, I-3-3.

41 Arnold Miller, transcribed in *Proceedings of the Forty-Sixth Consecutive Constitutional Convention of the United Mine Workers of America* (N.p.: UMWA, 1973), 7-12.

42 "Will America's Lights Go Out?" *Miner's Voice*, June 1970. Miners for Democracy Records (hereafter MFDR; Walter P. Reuther Library for Labor and Urban Affairs, Detroit, Michigan. Box 23, Folder 6.

43 Richard Hirsh, *Technology and Transformation*.

44 David E. Nye, *When the Lights Went Out; Astrid Kander, Paolo Malamina, and Paul Warde, Power to the People: Energy in Europe over the Last Five Centuries* (Princeton, NJ: Princeton University Press, 2014); Thomas Hughes, *Networks of Power: Electrification in Western Society 1880-1930* (Baltimore: Johns Hopkins University Press, 1983).

45 Federal Power Commission, I-1-4.

46 Fred Harris, "Burning Up People to Make Electricity," *The Atlantic*, July 1974.

47 This articulation of the social and natural in the workplace draws on Thomas Andrews, *Killing for Coal: America's Deadliest Labor War* (Cambridge, MA: Harvard University Press, 2008).

48 Depicted in Barbara Kopple, *Harlan Country, USA* (New York: Criterion, [1976] 2006). Also see Derickson, *Black Lung*.

as the looming threat of death.[49] Working underground, one miner described, was to constantly dodge peril "like beating the devil at a game of hell."[50] Michael Guillerman, who first entered the mines in this period, also described the dark tunnels in fantastical terms. They were a place where he "could envision every sort of monster lurking in the darkness, ready to pounce."[51] These experiences of darkness became a commonplace way of understanding the externalities of energy politics. It came at a cost, paid in miners' blood for the "cheap" energy they extracted.[52] This system of energy consumption promised a perverse kind of prosperity: the promise of growth and security for the nation gambled against the highly localized dangers of the mining workplace.

20 The spatial disparities in the meaning of darkness, however, did not consign miners to fatalism. The Miners for Democracy, both in their campaign for the 1972 union elections and in their first years in the union's international offices, used it to mobilize. In his first state of the union address, delivered just weeks into the 1973 Organization of Arab Petroleum Exporting Countries oil embargo Arnold Miller –a disabled miner, leaders of the West Virginia black lung strike, and Miners For Democracy campaigner who had surged to the United Mine Workers presidency– rejected the idea that "deaths in the mines" were "the work of fate." Instead, he declared that "coal miners *have* seen the light of day."[53]

BARGAINING POWER

21 If the Miners for Democracy were to truly leverage the politics of illumination and darkness to extract concessions not just from the companies, but from the nation, they had to generalize negotiation beyond the bargaining table. While a combination of law and precedent had created a relatively standard formula for contract negotiation, covering wages, benefits, and working conditions, contesting the risks of the nation's energy system necessarily moved their organizing efforts onto a wider political terrain. Bargaining electric power relied on broader public anxieties about power shortages as well as the broader set of rights and obligations that had emerged as part of the rights revolution of the 20th C.[54]

22 The centrality of coal to the nation's electric power supply played increased strategic importance in preparing for contract negotiations. The United Mine Workers' primary contract was with the Bituminous Coal Operators Association (BCOA). Negotiated among by the union with a subset of coal industry leadership, the contract applied to all unionized bituminous coal mines in the United States and some portions of Canada and governed the overwhelming majority of Appalachian coal production which was densely unionized. As the United Mine Workers prepared to begin bargaining the 1974 contract –the first to be negotiated under reform leadership– vice-president Mike Trbovich gave a featured interview on the subject to the *United Mine Workers Journal*. Politicians increasingly looked to coal, the most domestically abundant fossil fuel in the United States, to meet the nation's growing energy demands. According to Trbovich, who had been recently elected as part of the Miners For Democracy upsurge, the United States was mining "600 million tons and within five or ten years the production has to go to a billion tons of coal."[55] But the public increasingly demanded "energy in sufficient supply, from reliable sources, without environmental damage,

49 Brent Walter Cline, "Buried Bodies, Buried Treasure: Coal Mines and the Ghosts of Appalachia," *South Carolina Review*, vol. 47, n° 2, 2015.

50 M.W. Minarcin, "Man Who Has Been There Tells about Being Trapped in Mine," *Independent* (Ashland, WV), July 24, 1972.

51 Michael Guillerman, *Face Boss: The Memoir of a Western Kentucky Coal Miner* (Knoxville: University of Tennessee Press, 2009), 155.

52 Transcript, "The Cherokee Shaft: The Story of Mines and Men," ABC Broadcast, 8:30-9:30 PM, May 22, 1971. MFDR 63/1.

53 Arnold Miller, transcribed in *Proceedings of the Forty-Sixth Consecutive Constitutional Convention of the United Mine Workers of America* (N.p.: UMWA, 1973), 10-12.

54 Mark Tushnet, *The Rights Revolution in the Twentieth Century: New Essays in American Constitutional History* (Washington, DC: American Historical Association, 2009).

55 Interview with Mike Trbovich on energy, the '74 contract, organizing with the UMW Journal editorial staff. March 15, 1973. United Mine Workers Journal Records, Eberly Special Collections, Penn State University, 4/7.

without peril from radiation, without offshore drilling, without surface mining, and...cheap."[56] These public expectations for the nation's energy future reflected both growing public environmental consciousness as well as the success of miners and Appalachian communities in forcing an ongoing reckoning with the externalities of energy production, particularly in regard to surface mining.[57] Along with the centrality of coal to American electricity production, miners believed that the growing public expectation of safe and clean energy gave them a new point of leverage over the operators in collective bargaining. If the Bituminous Coal Operators Association wouldn't negotiate a fair contract, they would certainly take an economic hit from lost production. More importantly, though, they could suffer politically among a public which already viewed the energy sector with growing distrust.[58] Miners' activism in this period focused on perils to health and safety. It made visible form of workplace danger and coal pollution that many Americans would never otherwise see.

23 Even as the growth of artificial illumination in American life entered into the highly regulated framework of collective bargaining, coalfield energy politics were more likely to take place in a more "unauthorized" fashion: the wildcat strike. The number of unauthorized work stoppages had begun to increase in 1969, beginning with the West Virginia black lung strike, and continued into the 1970s as miners sought to "light the way to democracy," by pushing the boundaries of institutionally accepted workplace activity in defense of their bodies.[59] The safety walkouts were largely successful. They garnered not only public support, but also the support of judges who found in favor of miners who had walked of the job in defense of their lives. These successes further demonstrated the potential of miners to leverage their position in the nation's regime of electricity production to shift practices at the level of the firm, a firm which often would not be directly engaged in the production of light itself.[60]

Coal-fired electricity, often symbolized in public 24
discourse and everyday life as electric lighting, had offered miners a new mechanism for intervening in energy governance as crisis loomed.[61] As the 1970s progressed, it became clear that the nation had a long-range energy problem – one that was not simply defined by oil shocks.[62] In June 1971, President Nixon defined the problem more widely: pointing to brownouts, looming fuel shortages and increasing fuel prices. Shortages and price increases had coincided with a "growing awareness of the environmental consequences of energy production," and "a growing concern for the health and safety of the men who mine the nation's coal."[63] The nation's energy system stood on a knife's edge between a transforming international geopolitical economy that threatened restricted access to foreign oil and growing domestic concern about the geological viability of fossil-fueled high-energy capitalism and its attendant social costs. Coal had its share of problem: high sulfur content,

56 Quoted in "Higher Electric Bills Tied to Strip Abolition," *Charleston Gazette*, July 12, 1972. MFDR 32/3.

57 Samuel P. Hays, *Beauty, Health, and Permanence: Environmental Politics in the United States, 1955-1985* (New York: Cambridge University Press, 1989); Chad Montrie, *To Save the Land and People: A History of Opposition to Surface Mining in Appalachia* (Chapel Hill: University of North Carolina Press, 2003).

58 Samuel P. Hays, *Beauty, Health, and Permanence: Environmental Politics in the United States, 1955-1985* (New York: Cambridge University Press, 1989); Chad Montrie, *To Save the Land and People: A History of Opposition to Surface Mining in Appalachia* (Chapel Hill: University of North Carolina Press, 2003).

59 "Light the Way to Democracy," campaign broadside, 1969. MFDR, Box 81, Folder 8.

60 See safety strike case records in MFDR, 58/23-31, as well as Boxes 59 and 60. For a summary see, Robert C. Stephens, "The Right to Strike over Safety Issues," *Chi-Kent Law Review*, vol. 51, n° 200, 1974.

61 For a contemporary statement on the "special interest" of the Federal government in coal labor politics, see Richard Nixon, statement about a labor dispute in the coal mining industry, October 8, 1971. American Presidency Project (hereafter APP; University of California Santa Barbara), Node 241018.

62 Robert D. Lifset, "A New Interpretation of the Energy Crisis of the 1970s," *Historical Social Research*, vol. 39, n° 4, 2014.

63 Richard Nixon, special message to the Congress on energy resources, June 4, 1971. APP, Node 240214.

workplace safety, environmental degradation. But it remained the fuel over which the United States, which sat on the biggest coal reserves in the world, had the greatest direct control.[64] Bargaining electric power, formally and informally, could cut both ways –potentially expanding the demands miners might make on a nation which depended on them, while also opening themselves up to potential curtailment of their labor rights if energy shortages demanded. The new relationship between coal miners and electricity consumers had been articulated amid concerns over lighting. But these energetic ties extended well beyond the problem of illumination. In the fall of 1973, the Organization of Arab Petroleum Exporting Countries announced an embargo intended to sanction the United States for its support of Israel in the October War and increase their global economic leverage, the energy regime that shaped the politics of light and darkness would be put to the test on a new terrain: in the coalfields in a war over gasoline.[65]

ENERGY WILDCATS

25 In February 1974, 300 miners walked off the job in McDowell County, West Virginia. The strike spread quickly, and by February 24, most of the coal-rich county was participating in an unauthorized work stoppage because "THE MINERS ARE IN A DESPERATE POSITION DUE TO THE FACT THEY CANNOT GET GAS TO GET TO WORK." Even stations that did have gas had made the energy inaccessible, they said, by "JACKING THE PRICE ON EACH GALLON."[66] At the walkout's peak, around 30,000 miners would idle more than 200 mines across the state of West Virginia – mostly in the rich bituminous belt in the state's south which produced 15 percent of the nation's coal.[67] (fig. 3) As the strike spread, the Governor of neighboring Kentucky worried that the strikes would cross state lines.[68]

Across the 1970s, wildcat strikes were fairly com- 26
monplace in the United States, if controversial for violating the established legal framework for labor relations. Most wildcats, however, took place over workplace issues –unfair firings, discrimination in work assignments, unsafe working conditions. The largest and most politically controversial wildcat in recent memory had taken place just three years before, as postal workers across the United States struck to secure full collective bargaining rights. Still, that strike was directly targeted against an employer. That empoyer just happened to be the federal government.[69] The miners' strike was different because the companies were in no position to grant the miners' demands. The political strike sought to withhold one fuel to increase access to another: petroleum. Miners hoped to use this action to force action by a government agency, the Federal Energy Office, with which they had no direct avenue for negotiation. While collective bargaining had broader public support, as a well-understood aspect of industrial citizenship, and centered on the idea of "fairness" and good faith negotiation, the wildcat strike was much more volatile, its mean fraught with wider political tensions, particularly when the public imagined they may feel a direct impact as a result.[70]

64 US Energy Information Administration, International Energy Statistics, 2009. Accessed online.

65 Yergin, *The Prize*, 595-634.

66 Danny Deskins to Arnold Miller, February 24, 1974. United Mine Workers President's Office Records, Eberly Library, Penn State University [UMWPO], 203/16.

67 Unauthorized Work Stoppage Reports, February 26, March 8, 14, and 15, 1974. UMWPO 203/17; UMW Research Department Memorandum, "COAL-PRODUCING COUNTIES PRIMARILY AFFECTED BY GAS SHORTAGE," March 2, 1974. UMWPO, 203/16.

68 AP, "Perkins Warns Kentucky Coal Miners are on Verge of Strike," *Richmond Register* (KY), February 27, 1974. UMWPO 203/15.

69 On the impact of wildcat strikes in the 1970s, see Aaron Brenner, Robert Brenner, and Cal Winslow, (eds.), *Rebel Rank and File: Labor Militancy and Revolt from Below during the Long 1970s* (New York: Verso, 2010). Labor relations in the United States are narrowly construed through the collective bargaining process, and federal law curbs many of the most effective forms of collective action that workers engage in regularly in other countries. Additionally, by the 1970s, employers had begun to secure "no strike" clauses in their contracts with unions that provided strong disincentive to workers and unions who could be subjected to substantial legal action for wildcat strikes. Nelson Lichtenstein, *State of the Union: A Century of American Labor* (Princeton, NJ: Princeton University Press, 2013).

70 Lichtenstein, State of the Union.

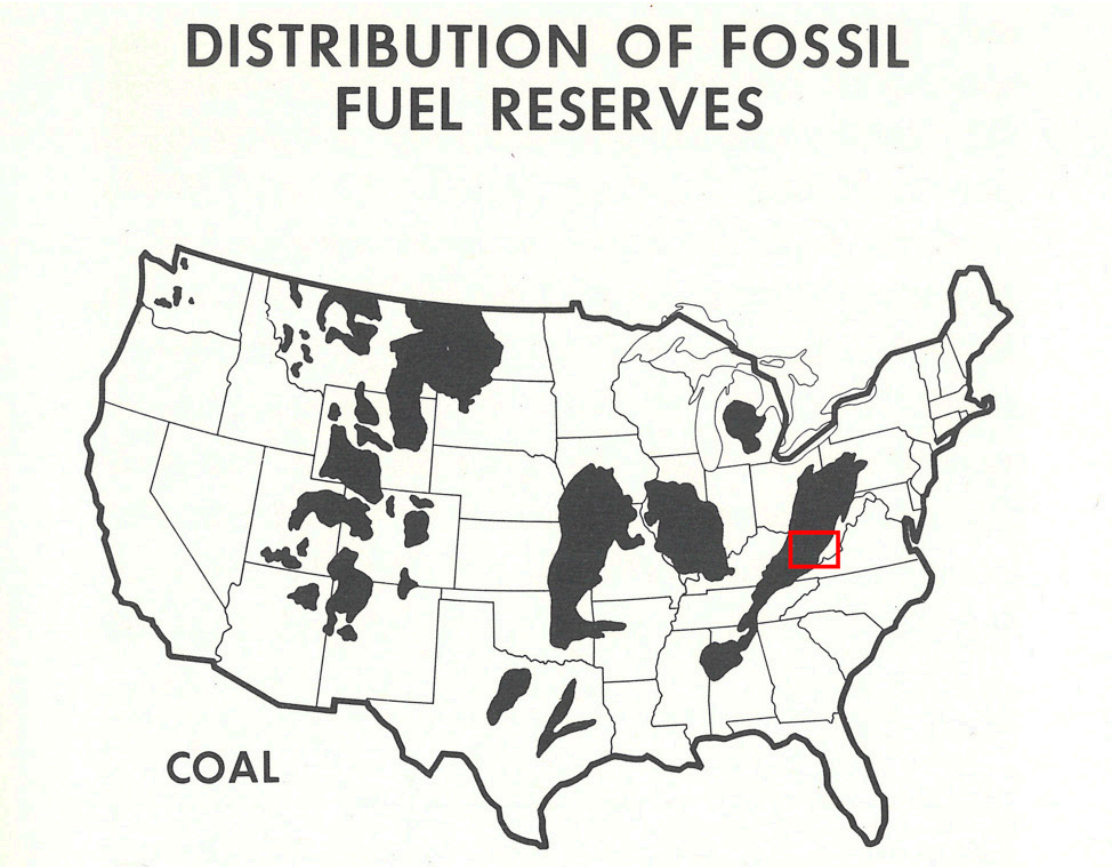

Figure 3: Distribution of Fossil Fuel Reserves: Coal. US Federal Power Commission, National Power Survey: A Report (Washington, DC: Government Printing Office, 1964), 55. The red square in the central Appalachian coalfield, added by author, marks the area in which the gasoline wildcats were concentrated.

27 The "gasoline wildcats" lasted more than three weeks as the oil embargo reached its zenith. In West Virginia, gasoline shortages had been exacerbated because the Federal Energy Office was using old consumption data to determine rationing levels. While many Americans experienced gas rationing, West Virginians experienced them disproportionately.[71] Further underscoring the way miners had interpreted their central role in the production of electricity a source of political power, the United Mine Workers invoked the idea of "energy fairness" and claimed that the strike was not only for miners, but for all the residents of West Virginia who felt they had been given a smaller energy ration than deserved. The growth of the strike quickly resulted in West Virginia Governor Arch Moore reversing a rule that had prevented anyone with more than a quarter of a tank from purchasing gasoline, but the strike continued.[72] Filling station owners, who felt they had no leverage to force the companies or the state to truck in additional supplies, supported the miners.[73] At the height of a nationwide energy crisis, the public would seemingly have had the most reason to lash out at the miners for striking for potentially intensifying fuel shortages. Still, many callers to West Virginia radio programs like the Don Lucas Show supported the strike. Even those who did not support the strike accepted the miner's central claim. Miners had a right to energy because they were engaged in energy production more broadly. Prioritizing gasoline access for miners to

71 UMW Research Department Memorandum, "West Virginia Gas Shortage," March 2, 1974. UMWPO, 203/16.

72 Arnold Miller, WLOG Announcement, aired once on March 7th and three times on March 8th, 1974. UMWPO, 203/15.

73 UMW Research Department Memorandum, "West Virginia Gas Shortage," March 3, 1974. United Mine Workers President's Office Records, 203/16.

secure other flows of energy seemed a reasonable approach to restabilizing a nation in panic. The strike's opponents instead suggested these claims should be brought to the bargaining table later that year when the new national contract was negotiated under the purview of the law.[74] The contention was not whether energy should be subject to bargaining, but under what conditions.

28 In the end, the miners were successful. Although an injunction issued by circuit judge H. E. Widener ordered the miners back to work, claiming they had unfairly targeted "the flow of bituminous coal in interstate commerce...as a source of energy," West Virginia governor Arch Moore lifted statewide restrictions on gasoline use for miners, and the Federal Energy Office promised 18 million gallons of increased gasoline supplies for the state in March.[75] Like the black lung and safety strikes in previous years, which had challenged the boundaries between workplace and politics structured by the postwar system of industrial relations, the gasoline strike made clear that energy served as a key bridge by which miners could negotiate with more power –literal and figurative– in an era that dominated by declension narratives of labor's power due to the ascendance of neoliberalism and globalization.

CONCLUSION : THE LONG SHADOWS OF COAL-FIRED POWER

29 Despite the fact that the massive expansion of electricity consumption had offered miners new forms of political leverage from their workplace in the long 1970s, the energy relationships represented through illumination along which this power flowed bore the mark of the original paradox. Darkness –and instability– could not be eliminated in an illumination-intensive, fossil-fueled energy system, only relocated. The energy regime produced many externalities –disemboweled Appalachian hillsides, the black lung epidemic, the constant threat of maiming or death. Alleviating the figurative darkness of looming death in the mines appeared to threaten the nation's ability to cheaply illuminate the nation's urban centers and growing suburban landscape –a belief only underscored as coal mining productivity plunged in the wake of the passage of the 1969 Federal Coal Mine Health and Safety Act.[76] More than a crisis of supply, the energy crisis was a political and industrial crisis that cut to the heart of the promise of prosperity in an age when affluence could be measured in kilowatt hours. The whole regime of energy production and consumption then, was built on this fundamental instability, which was overlooked in the rush to blame the Arabs, the regulatory state, or even the energy companies for the crisis.

30 Precisely because this tension was unstable, however, it also shifted the balance and contours of the energy relationships which defined American life. Examining the social relationships of energy, and the way that illumination necessarily cast shadows fundamentally challenges the way scholars of environmental degradation and energy production have conceptualized externalities. Typically considered as the costs of production that are charged up on the environment, this understanding leaves out the way that externalities, in certain social configurations, could actually be deployed as new forms of workplace or political power. Tying the externalities of coal to the illuminations omnipresent in American life allowed miners to make claims on the energy system more broadly, to connect places that might otherwise have seemed worlds apart. Thus, the very system that inscribed darkness –in the mine labyrinth, in and upon the bodies of the miners themselves– also allowed for miners to imagine beyond the confines of darkness, a future of energy fairness –even if ultimately, that aspiration has gone unrealized.

74 Don Lucas Show transcripts, March 11-13 1974, United Mine Workers President's Office Records, 203/15.

75 Memorandum Opinion, Armco Steel Corporation *et al.* v. United Mine Workers of America *et al.*, March 12, 1974. UMWPO, 203/16; UPI, "10,000 Miners End West Virginia Strike, 15,000 Still Idle," *New York Times*, March 15, 1974. UMWA Statement, March 13, 1974. UMWPO, 203/15.

76 General Accounting Office, "US Coal Development –Promises, Uncertainties: Report to the Congress" (Washington, DC: US General Accounting Office, 1977).

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JEHRHE

Journal of Energy History
Revue d'histoire de l'énergie

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POST DATE
15/05/2019
ISSUE NUMBER
JEHRHE #2
SECTION
Special issue
THEME OF THE SPECIAL ISSUE
Light(s) and darkness(es): Shifting historical relations
KEYWORDS
Light, Pollution, Town, Industry, Environment
DOI
in progress

TO CITE THIS ARTICLE
Nick Dunn, "Dark Futures: the loss of night in the contemporary city?", *Journal of Energy History/Revue d'Histoire de l'Énergie* [Online], n°2, published 15 mai 2019, consulted XXX, URL: http://energyhistory.eu/node/108.

Dark Futures: the loss of night in the contemporary city?

Abstract
The artificial but widely held binary conceptions of day versus night find themselves condensed in cities where strategies to recalibrate the nocturnal urban landscape are abundant. This transformation requires considerable energies and technologies to facilitate illumination. The night-time city remains poorly understood, requiring new inquiries to examine the tensions and coexistences of light and darkness. This article examines the city of Manchester, United Kingdom, its pioneering history of industrialisation, and subsequent phases of regeneration and gentrification to explore its contemporary urban landscape. It draws on extensive autoethnography of experiences in the city to consider the potential of different lights and darknesses for how we might think more holistically with regard illumination, and the reciprocity between our senses and the urban environment.

Plan of the article

ISSN 2649-3055

INTRODUCTION
RECONSIDERING DARKNESS AND LIGHT

1 *Threaded down along the river, a rich vein of* memento mori *for the city. The fuzz of distant light bobbles along the water's surface. The Irk, like the night, has a history of uneven tempo, once renowned for its speed then later akin to a large slug such was its apparent inertia. Onward and across Angel Meadows, a subplot for the district, solemnly resists further development of the next instalment of Manchester's rejuvenation program. The turf here quietly bridling with the mass grave of industrial past, the interned some of whom were overturned as poverty led to the digging up of cemetery soil for sale as fertilizer for nearby farmers. Looming ahead the globular spaceship of the Co-operative headquarters nestles into the urban warp and weft around it. Rochdale Road, a discreet fissure between pallid gentrification and bodged cosmetic surgery of renewal, strikes ahead, forging away from the city centre: an echo chamber of recurrent hopes and scuffed dreams. Tonight is cold in the lungs, the air turning them to brittle chambers that with each inhalation feel as though they might shatter. Crisp footsteps and the plumes of hydrated air accompany my perambulations. Dull metal-grey mini-submarines, discharged of gas for their hysteria, litter the doorway of an old mill. The laughing and jostling shadow forms having long moved onto another urban cove. The ramparts of the city's innards pulp here, yielding to exigencies of conflicting needs and desires.*

2 *Colourful illuminations of the music venue's façade count out the pulse. Disconnected from the audio inputs of the city or the music venue itself when open, the ultimate silent disco. But the city is not still nor without noise. The cacophony of drinkers, clubbers and taxis may be gone but the hum of distant traffic is still legible. Closer by a feline-eyed shadow leaps onto the wall of the Smithfield Gardens housing estate. Once another compost heap for humanity, the dispossessed deported to the outer suburbs, its replacement of orange-red maisonettes work on their own internal logic. Tib Street, the menagerie of birds and animals displayed along this bone of the city gone too. Dispensed between the stubbed side streets and poured onto Oldham Street. This road used to witness the parading of people in their Sunday best, consuming the stores' windows and eyeing up each other. Strict moral codes, ladies on one side, gentlemen on the other. Tonight though, the only attention coming my way is from a drained, rattling can, its energy-drink contents seemingly not giving up the ghost just yet.*

3 The opening section of this article is an extract from a description of a night-time walk I took in early 2014. Over the last five years I have spent many hundreds, if not thousands, of hours walking through various cities at night, interested in how my physical and psychological relationships with the built environment change amongst different lights and darknesses. Clearly, this set of experiences has led to a very particular and personal view. However, this is to be considered as a contribution toward what has been recently argued as an urgent need for both a plurality and diversity of perspectives regarding darknesses[1], how different experiences of place and time may contribute to our understanding of them[2], and the effects of light pollution.[3] From a historical perspective, the coexistence between light and darkness has been thoughtfully examined by Ekirch[4], whilst the different relationships of various communities, groups and movements and their cultural entanglements with darkness has been comprehensively discussed by Palmer.[5] Accompanying these accounts have been inquiries into the nature of darkness and its conceptual framing as being in opposition to light.

1 Ben Gallan, Chris Gibson, "New dawn or new dusk? Beyond the binary of day and night", *Environment and Planning A*, vol. 43, n° 11, 2011. Robert Shaw, "Night as Fragmenting Frontier: Understanding the Night that Remains in an era of 24/7", *Geography Compass*, vol. 9, n° 12, 2015. Available at: http://dx.doi.org/10.1111/gec3.12250

2 Nick Dunn, *Dark Matters: A Manifesto for the Nocturnal City* (Winchester: Zero, 2016).

3 Matthew Gandy, "Negative Luminescence", *Annals of the American Association of Geographers*, vol. 107, n° 5, 2017. Available at: https://doi.org/10.1080/246944 52.2017.1308767

4 Roger A. Ekirch, *At Day's Close: A History of Nighttime* (London: Weidenfeld & Nicolson, 2005).

5 Bryan D. Palmer, *Cultures of Darkness: Night Travels in the Histories of Transgression* (New York: Monthly Review Press, 2000).

This apparent antithetical relationship has led to darkness being bound up in powerful metaphorical relationships and moral implications. As Dunnett explicates, "the idea of light, both in a practical and symbolic sense, has come to be associated with modernisation and the so-called 'Enlightenment project' in various different ways… Here we can also see how the metaphor of light has taken on a moralising tone, seen as an all-encompassing force for good, banishing the ignorance of darkness in modern society".[6] However, this binary narrative has not gone unchallenged and the significant diversity in light and shadow has been the subject of different investigations that suggest a counter-history of the importance of dark places.[7]

4 In specific reference to night-time lighting, Schivelbusch observes that perceptions of it throughout history have consistently merged the literal and symbolic[8], whilst Schlör points directly to the dominance of light over darkness in considering the urban night, "[o]ur image of night in the big cities is oddly enough determined by what the historians of lighting say about *light*. Only with artificial light, they tell us, do the contours of the nocturnal city emerge: the city is characterized by light".[9] Yet the importance of penumbra and shadow in the Western arts and imagination across numerous artistic and literary traditions has enabled the multiple variations of light and dark to be reconsidered.[10] It has also been demonstrated by Sharpe that the spatiality and physicality of urban darkness amidst the burgeoning development of artificial lighting technologies directly influenced numerous artistic interpretations of the urban night.[11] Perhaps unsurprisingly, many of these accounts are dominated by male figures or collectives given the purview of the relationship between women and the night-time which was maintained throughout history and to various extents remains, depending on cultural differences, religious beliefs, and other social factors. The diversity of darknesses and experiences of them is notable despite a common tendency to think of the modern night as a consistent space and time, as Williams reminds us, "[n]ight spaces are neither uniform nor homogenous. Rather they are constituted by social struggles about what should and should not happen in certain places during the dark of night".[12] In the contemporary context, there has been important shifts in the accessibility and safety for a wider spectrum of different ages, genders, races and sexual orientations through movements and organisations such as *Reclaim the Night*[13] and *Take Back the Night*.[14] This has led to a more inclusive and tolerant attitude toward different communities and groups, signalling the major progresses that occurred during the 20th C. from widely demonised and prohibited activities, through necessary covert and codified behaviour, to more equal rights and less discrimination in the present day. It is important to recognise, however, that this is an ongoing process far from complete. Such developments have been paralleled by a history of the different forms of experience and places that LGBTQ+ communities have accessed, created, and sustained to provide, wherever possible, an enjoyable, vibrant and safe urban night.[15] Walking, especially at night, may be understood

6 Oliver Dunnett, "Contested landscapes: the moral geographies of light pollution in Britain", *Cultural Geographies*, vol. 22, n° 4, 2015, 622.

7 Marion Dowd, Robert Hensey (eds.), *The Archaeology of Darkness* (Oxford: Oxbow, 2016). Nancy Gonlin, April Nowell (eds.), *Archaeology of the Night: Life After Dark in the Ancient World* (Boulder, CO: University Press of Colorado, 2018). Roy Sorensen, *Seeing Dark Things: The Philosophy of Shadows* (Oxford: Oxford University Press, 2008).

8 Wolfgang Schivelbusch, *Disenchanted Night: The Industrialization of Light in the Nineteenth Century* (Berkeley, CA: University of California Press, 1988).

9 Joachim Schlör, *Nights in the Big City Trans. Pierre Gottfried Imhof and Dafydd Rees Roberts* (London: Reaktion Books, 1998), 57.

10 Peter Davidson, *The Last of the Light: About Twilight* (London: Reaktion, 2015).

11 William Chapman Sharpe, *New York Nocturne: The City After Dark in Literature, Painting, and Photography, 1850-1950* (Princeton, NJ: Princeton University Press, 2008).

12 Robert Williams, "Nightspaces: Darkness, Deterritorialisation, and Social Control", *Space and Culture*, vol. 11, n° 4, 2008, 514. Available at: https://doi.org/10.1177/1206331208320 117.

13 Reclaim the Night, http://www.reclaimthenight.co.uk.

14 Take Back the Night, https://takebackthenight.org.

15 Dave Haslam, *Life After Dark: A History of British Nightclubs and Music Venues* (London: Simon & Schuster, 2015).

to have multiple interpretations attached to it, since it is typically constructed through cultural, economic, political, and/or social interrelationships. For the purpose of this article, I will focus on how it enables architecture and spatial boundaries to be sensed differently in direct reference to the quality and quantity of illumination available, energy manifest in the urban landscape.

5 Architecture is typically understood as the material, sometimes literally concrete, facts of the built environment. Its presence and function reflect the values of the society that produced it. However, no matter how stable our buildings may appear they are constantly changing, inside and outside, through the effects of weather, occupation, ageing, and, of course, lighting and darkness. With regard the latter, light-pollution scientists amongst others have demonstrated that lighting is not about 'pure' numbers and it is evident that the reflective quality of surfaces, including those in the built environment[16], and weather conditions can have a significant impact on the quantity and quality of light and, by extension, darkness.[17] The context for this exploration is the city of Manchester, and the adjacent city of Salford, for several reasons. First and foremost, they have a considerable history relating to lights and darknesses, Manchester not least in relation to its pioneering role in the industrialisation of cities. Secondly, the subsequent phases of regeneration and gentrification that the former has undergone have produced a contemporary urban landscape of considerable diversity in terms of illumination. Thirdly, Manchester announced in 2014 that it would commence the replacement of its city-wide 56,000 lamps with LED lights thus changing the appearance of its lights and darkness for the foreseeable future.[18] Finally, as my home city and its neighbour, and the ones with which I am most familiar, I have been able to conduct my autoethnographic and experimental fieldwork frequently and in a practical manner. This fourth aspect has proved particularly important. Given the social construction of time and work, it would have been difficult to repeatedly travel significant distances on a very frequent basis in order to examine different conditions and situations for their lights and darknesses. My fieldwork has necessarily been conducted using mobile methods and often in an ad-hoc manner, so it could integrate within my life both fully yet also be as improvisational as possible.

ENERGY HISTORY AND URBAN ILLUMINATION IN THE FIRST INDUSTRIAL CITY

6 In order that we can appreciate the contemporary situation, we will first trace out some of the key developments in the city's history with regard its complex relationships between light and darkness. The transformation from a market town to an increasingly congested and expanding centre is recorded by Wheeler who notes in this rapidly changing landscape new forms of experience were produced such as the passage between St. Ann's Square and the Market Place that "was appropriately designated as the Dark Entry".[19] As the crucible for the Industrial Revolution, Manchester has been widely recognised as the world's first industrial city growing as it did from a market town with a population of less than 10,000 at the beginning of the 18th C. to a population of 89,000 by the end of the century. The boom in population continued in the 19th C., doubling between 1801 and the 1820s, only to double again before 1851, amassing a total population of 400,000 people. This was phenomenal growth by any standard, transforming Manchester into Britain's second city.

16 Cătălin D. Gălăţanu, "Study of Facades with Diffuse Asymmetrical Reflectance to Reduce Light Pollution", *Energy Procedia*, vol. 112, March 2017. Available at: https://doi.org/10.1016/j.egypro.2017.03.1100.

17 Pierantonio Cinzano, Fabio Falchi, "The propagation of light pollution in the atmosphere", *Monthly Notices of the Royal Astronomical Society*, vol. 427, n° 4, 2012. Available at: https://doi.org/10.1111/j.1365-2966.2012.21884.x.

18 Manchester City Council, Street Lighting LED Retrofit Programme, Executive Report, 12th February 2014. Available at: http://www.manchester.gov.uk/meetings/meeting/2042/executive/attachment/16500.

19 Joseph Wheeler, *Manchester. Its Political, Social and Commercial History, Ancient and Modern* (Manchester: Simms and Dinham, 1836), 256.

Perhaps unsurprisingly, such population growth brought with it extremely poor and dense living conditions for many of the city's inhabitants. A crucial driver to this population explosion was the opportunities for work. Unlike agricultural workers whose days were dictated by the availability of daylight and therefore limited in the dark winter months or very bad weather, factory workers could work every hour due to the use of artificial lighting and the technological advancements in mill machinery. In 1798, George and Adam Murray completed the first phase of their steam-powered urban cotton mill in Ancoats, the first suburb to integrate housing and industry.[20] When completed in 1806, the complex housed two separate cotton spinning mills, two warehouses, preparation and office ranges, all arranged around a central quadrangle. The importance of the Murrays' Mills development was evident with visitors travelling from the rest of the UK, Europe and the US to witness the huge complex, housing powered machinery and illuminated by gas.

7 Parallel to this development in the adjacent town of Salford, the first gas street lighting in world illuminated part of Chapel Street and the Philips and Lee Factory. This deployment of lighting technology was to transform the world as it was then known since it transferred and reframed the 'working day' to a non-stop, continually functioning place where the previous relationship between labour and time were shattered. Through his discussion of *Arkwright's Cotton Mills by Night* painted by Joseph Wright of Derby circa 1782, Jonathan Crary makes clear that it is not simply the unusual sight of a large brick building within a countryside setting that makes the image so strange. In addition, he identifies, "most unsettling, however, is the elaboration of a nocturnal scene in which the light of a full moon illuminating a cloud-filled sky coexists with the pin-points of windows lit by gas lamps in cotton mills".[21] For it is here that the artificial lighting of the factories announces its victory over the long-held light-dark cycle and circadian rhythms that had previously connected time and work. Pivotal to this endless labour was of course the need for constant energy production to power its machinery. The use of coal was essential to this process with all the attendant environmental and health hazards that contributed to significant commentators of the period such as the historian Thomas Carlyle decrying the condition of England and using "Sooty Manchester" which was "every whit as wonderful, as fearful, unimaginable, as the oldest Salem or Prophetic City"[22] as testament. Meanwhile, the squalid and dark landscapes that the industrialised city created provided fertile ground for numerous writers including Benjamin Disraeli, Elizabeth Gaskell and Charles Dickens, the latter creating 'Coketown' in *Hard Times*[23] as the very epitome of human misery within soot-covered brick buildings.

GLOOMY LANDSCAPES AND AN ARCHITECTURE OF DARKNESS

8 There is an interesting point to be made here about the impact of energy production upon the light and darkness of its surrounding context. The soot produced by the coal burning furnaces to power the machinery around them was airborne and quickly built up on the surfaces of the buildings across the city. As Alexis de Tocqueville when visiting Manchester in 1835 reported, "[a] sort of black smoke covers the city. The sun seen through it is a disc without rays. Under this half-daylight 300,000 human beings are ceaselessly at work. A thousand noises disturb this dark, damp labyrinth, but they are not at all the ordinary sounds one hears in great cities".[24] Within his account of his seven-day trip to the city, de Tocqueville relates the extremes of the Manchester experience and the paradox that lay at the heart of its industrial success.

20 Mike Williams, "The Mills of Ancoats", *Manchester Region History Review*, n° 7, 1993.

21 Jonathan Crary, *24/7: Late Capitalism and the Ends of Sleep* (London: Verso, 2013), 61-62.

22 Thomas Carlyle, *Past and Present* (London: n.d, 1843), 247.

23 Charles Dickens, *Hard Times* (London: Chapman & Hall, Ltd., 1905 [Reprint]).

24 Alexis de Tocqueville, *Journeys to England and Ireland* Ed. Jacob Peter Mayer. Trans. George Lawrence and K. P. Mayer (London: Faber and Faber, 1958 [Reprint]), 108.

This reminds us that in addition to the numerous forms in which the development of lighting technologies transformed people's perception of the world in spatialized ways through cultural, social, and political dimensions, not least with regard labour[25], the process of industrialisation also resulted in direct and significant shifts in the natural light of such contexts. Between 1842 and 1844, Manchester was to have another visitor in the form of Friedrich Engels who drew upon his time living in the city for his book, *The Condition of the Working Class in England*. Two local young women, Mary and Lizzy Burns accompanied Engels to enable him to gain access to wander the slums and ensure his safety. Engels' depiction of the "Hell upon Earth" amidst the coal-powered industry is vivid and haunting,"[s]uch is the Old Town of Manchester, and on re-reading my description, I am forced to admit that instead of being exaggerated, it is far from black enough to convey a true impression of the filth, ruin, and uninhabitableness, the defiance of all considerations of cleanliness, ventilation, and health which characterise the construction of this single district, containing at least twenty to thirty thousand inhabitants".[26]

9 The experiences of light and darkness in Manchester during this period were evidently grim. Indeed, the traces of the squalid, dirty and dangerous character of some of its inner-city areas lives on through the surviving nomenclature of Dark Lane and Temperance Street in the district of Ardwick, themselves still witness to a variety of illicit encounters and activity. The nascent industrialisation accelerated an energy production and artificially lit landscape that was subsequently much replicated and extended around the world. Whilst the conditions for working class people reached a nadir in Manchester for the time, its role as a blueprint for the modern city proved more the dominant pattern of development than an exception as the drivers of industrial capitalism swept around the world during the remainder of the 19th C. and early 20th C.[27] The blackened architecture in Manchester would remain for many years, material deposits that would serve to recall the city's dark history as its grandest buildings were coated with soot. Although furnished with some spectacular Victorian architecture, the coal fires and smoke from the nearby industry embalmed many of the city's landmarks black prior to the Clean Air Act of 1956 which reduced pollution. Having laid claim as the first industrial city in the world, in the first half of the 20thC Manchester could arguably also have been the dirtiest as its buildings and streets were filthy and dark. Rather than being "matter out of place",[28] the blanket of soot produced a city of light and darkness that was dramatic, unified and uncanny. There is an interesting point to be made here concerning the nature of this gloom. Darkness is typically associated with, and often perceived as a central feature of, night. Throughout this period, however, Manchester's sooty textures were capable of absorbing light during the day, a phenomenon that rendered the city to be much darker than without this layer of material deposit, and further exacerbate the sense of gloom in the crepuscular hours. The landscape that resulted was highly affective, creating a very particular urban sublime that reflected the city's industrial legacy. The implementation of the Clean Air Act of 1956 quickly removed the smog in the city and its architecture was largely returned to its original state, either by cleaning or the soot being washed off by the rain, although a couple of examples of Manchester's 'architecture of darkness' still remain to the present day. By this term I am referring to a two-fold aspect of the city's architectural landscape. Firstly, two blackened buildings from the industrial era stand as architectural testaments to Manchester's atmospherically darkened past, namely the interior courtyards of Alfred Waterhouse's Town

25 Wolfgang Schivelbusch, *Disenchanted Night: The Industrialization of Light in the Nineteenth Century* (Berkeley, CA: University of California Press, 1988).

26 Friedrich Engels, *The Condition of the Working-Class in England Trans. Florence Kelley Wischnewetsky* (London: 1892), 53.

27 Harold L. Platt, *Shock Cities: The Environmental Transformation and Reform of Manchester and Chicago* (Chicago, IL: The University of Chicago Press, 2005).

28 Mary Douglas, *Purity and Danger: An Analysis of the Concepts of Pollution and Taboo* (London: Ark Paperbacks, 1966).

Hall (1867-1877) and 22 Lever Street by Smith Woodhouse & Willoughby (1875). Secondly, the darkened built environment also provided a specific context for Manchester's subsequent architecture to be designed for, a striking example of the latter being Casson & Condor's District Bank Headquarters (1969) which Casson likened to a 'lump of coal' since the building's cladding was "deliberately specified as dark to absorb the soot that still clung to the city's buildings".[29]

PATCHWORK INFRASTRUCTURES, BLACKOUTS AND POST-WAR RECONSTRUCTION

10 Whereas contemporary uses for public lighting are diverse and numerous, the principal reasons for its deployment were to provide greater safety for people moving around after dark and as illumination for the flow of traffic. The association of darkness with fear and crime is longstanding, as is the notion that light prevents criminal activity. As Otter notes, Manchester was no exception to the need for safety and protection from the supposed ills of the night and the first public gas lamp in the city was established outside the police station in 1807.[30] The police also operated the gasworks between 1817 and 1843 until it was passed into municipal ownership. Whilst concerns for public safety were paramount, the debate regarding both the quality and quantity of lighting in the city throughout the 19thC and early part of the 20thC were resonant with contemporary perspectives on it. For example, *The Electrician* stated, "to light a whole city with a huge electrical sun is a great scientific achievement; but it is not the sort of light anybody wants".[31] Given the time of writing was firmly within the heyday of electrification, this statement is all the more remarkable since it was published by the foremost electrical engineering and scientific journal of the period which typically sought to promote applications and innovations concerning electricity. More specifically, in the report *Recent Developments in the Street Lighting for Manchester* it is apparent that the city was perceived by its authors, Pearce and Ratcliff, as being underserved in terms of its illumination and that the contest between different forms of energy for control of the street lighting had resulted in a patchwork of provision, "to the size of the city, it will not be disputed that the amount of street lighting, totalling only 114 lamps (inclusive of 42 lamps in the Gorton district), is ridiculously small. This state of affairs has been outside the control of the Electricity Department for the simple reason that up to a very recent date the Gas Committee of the Corporation has been the street-lighting authority for the city of Manchester".[32] This situation was to end on 2nd October 1912, when the City Council placed the control of the street lighting under the authority of a Street Lighting Committee, comprised of five members of the Gas Committee, five members of the Electricity Committee and five members appointed by the Nomination Committee, the latter not being members of either of the former two committees.

11 Although this enabled a better provision of street lighting to develop, the efforts of the Street Lighting Committee, like many other organisations and authorities, were curtailed by the advent of the Second World War. Manchester was targeted for its importance as both an inland port and industrial city whilst neighbouring Trafford Park was a powerhouse for the production of munitions and armaments. Like so many cities and towns across Europe, Manchester operated blackout following the Lighting Restriction Order made under Defence Regulation No 24 and effective from 1st September 1939. The official notice reprinted in the *Daily Telegraph* stated, "[t]he effect of the order is that every night from sunset to sunrise all lights inside the buildings must be obscured and lights outside buildings must be extinguished, subject to certain exceptions in the case of external lighting where it is essential for the conduct of work of vital national

29 Richard Brook, *Manchester Modern* (Manchester: The Modernist Society, 2017).

30 Chris Otter, "Let There Be Light: Illuminating Modern Britain", *History Today*, vol. 58, n° 10, 2008, 20.

31 The Electrician, 7th May 1881 (London: James Gray), 325.

32 S. L. Pearce, H. A. Ratcliff, "Recent Developments in the Street Lighting of Manchester", *Journal of the Institution of Electrical Engineers*, vol. 50, n° 219, 1913, 598.

importance. Such lights must be adequately shaded".[33] Air raids struck the city from August 1940, though the most significant damage took place on the nights of the 22nd and 23rd December 1940. It is estimated that almost 2,000 incendiaries were dropped on the city over these two nights following flares to enable the pilots to target their high explosives as accurately as possible. The stark transitions between darkness and sudden explosive light, silence and thundering noise can only have been terrifying. The *Daily Despatch* and *Evening Chronicle* estimated that the fire was the largest in England since the Great Fire of London in 1666 as the city centre lay "winged with red lightning and impetuous rage".[34] Compared to other cities, Manchester was not razed as comprehensively to the ground as it could have been, but the damage caused by the Second World War coupled with the need for considerable urban blight and poor living conditions had to be addressed. This led to extensive proposals for the city, not least the 1945 *City of Manchester Plan* by Rowland Nicholas.[35] However, as with many comprehensive planning proposals during the period of post-war reconstruction, the vision was not delivered fully for a number of complex reasons. The emphasis on rebuilding war-damaged and run-down areas of the city resulted in some fine examples of modernist-inspired architecture during the 1960s although the most significant building in the city centre, Wilson & Womersley's Arndale Centre constructed between 1972 and 1980, as Hartwell has observed was only memorable for its sheer size and inward-looking design.[36] Development across the 1970s, 1980s and early 1990s was largely piecemeal and arguably without a coherent and clear direction, a situation considerably worsened by a major economic recession. Indeed, as Parkinson-Bailey notes:

> although a number of sites in the city had been earmarked in the 1980s for potential development, most of them remained as derelict brownfield sites or car parks, and the nearest these schemes came to realisation was the artist's vision painted on the hoardings which surrounded the site.[37]

RECENT DEVELOPMENT AND THE DESIRE FOR INCREASED URBAN LIGHTING

12 The most recent phase of major redevelopment in Manchester followed the 1996 IRA bomb. The largest bomb detonated in the UK since the Second World War, it caused huge damage to the city centre precipitating the mass regeneration that has continued to the present day. In 2002, Manchester hosted XVII Commonwealth Games which was widely regarded a success. These two events emboldened the city to either demolish or re-develop large sections of the city centre, producing an entertainment and retail landscape that whilst contemporary perhaps is less unique than before. Most notable in these parts of the city centre is the high degree of illumination coherent with many city centres to provide a legible and safe landscape which needs to be reconsidered.[38]

13 In *Planning the Night-time City*, Roberts and Eldridge examine some of the challenges for planners and town/city centre managers as we move toward the 24-hour city in the early twenty-first century.[39] An explicit and recurring theme in their synthesis is that the night-time is framed, developed and performed in a different manner to the quotidian activities of the day. Historical accounts have shown how the night has long been associated with pleasure, transgression and freedom. This can take many forms

33 "Black-out regulations came into force at sunset last night", *Daily Telegraph*, 2 September 1939.

34 "Our Blitz: Red Sky over Manchester", *Daily Dispatch and Evening Chronicle* (Manchester: Kemsley Newspapers), 5 January 1941, 19.

35 Rowland Nicholas, *City of Manchester Plan* (Norwich: Jarrold & Sons Ltd., 1945).

36 Clare Hartwell, *Manchester* (London: Penguin, 2001).

37 John J. Parkinson-Bailey, *Manchester: An Architectural History* (Manchester: Manchester University Press, 2000), 233.

38 ARUP, *Cities Alive: Rethinking the Shades of Night* (London: Arup, 2015).

39 Marion Roberts, Adam Eldridge, *Planning the Night-time City* (Oxon: Routledge, 2009). Wolfgang Schivelbusch, *Disenchanted Night: The Industrialization of Light in the Nineteenth Century* (Berkeley, CA: University of California Press, 1988).

but may often be a type of pleasure seeking. The expectation of pleasure is a counterpoint and acts directly in opposition to day-time activities which are generally understood as relating to everyday worlds of labour, business and finance. But we also know that everyday activities such as convenience shopping or attending the gym have gradually expanded into the early morning or late into the evening. Notions of work and workplace have changed and eating out more commonplace, shifts which typically conceal the respective conditions of labour and economic status of those supporting such activities and services. For the night and timeframe of darkness is also an assemblage of uneven economic, political and social geographies since it belies a working population that reflects, to varying degrees, their ethnicity, immigration status, race and limited and/or precarious labour opportunities, as determined by their context.

14 As cities such as Manchester utilise techniques of illumination to extend their commercial offer in terms of both space and time, it raises questions about the experiences available in our urban landscapes and whether it is possible to find different lights and darknesses beyond the formally sanctioned, and typically commercially driven, festivals that occur. Further, as Manchester rolls out its comprehensive replacement of 56,000 lamps with new LED lights, it is clear that the process with its significant environmental and economic benefits will also change the character of many parts of the city for the foreseeable future as illustrated in figure 1.

15 Having been used in a number of major streetlight replacement projects around the globe, including Copenhagen, Los Angeles, New York and Shanghai, LED street lighting is evidently a popular choice for cities wanting to reduce their lighting energy costs though their impact has positive and negative effects as Bramley has reported.[40] This ongoing entanglement between

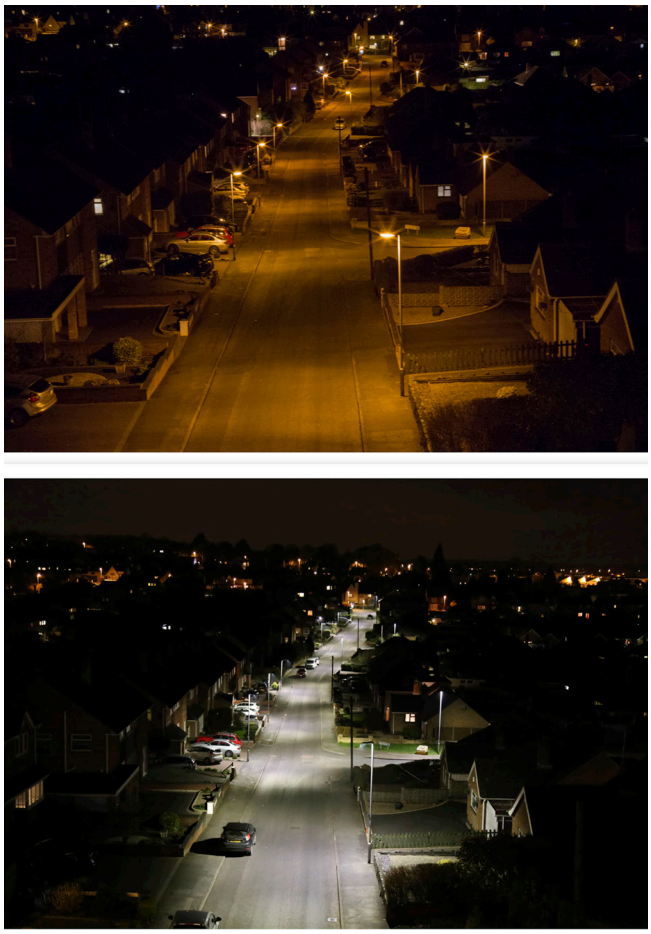

Figure 1: Comparison of traditional sodium lighting with LED lighting in typical British suburban street. © Image courtesy of Philips Lighting.

different lights and darknesses and the sources that produce them in urban environments continues. Despite the supposed benefits to efficiency in lighting technologies, Kyba, Hänel, and Hölker note that energy usage for outdoor lighting and artificial night-time brightness continues to increase annually.[41] A recent article by Petrusich stated that "new LED streetlights are almost universally described as unpleasant",[42] yet there are emerging responses to this view as Blander argues in the quest for letting 'night be night' where lighting designers are now seeking to develop a "holistic view of outdoor illumination, examining diverse sources and gradations

40 Ellie Violet Bramley, "Urban light pollution: why we're all living with permanent 'mini jetlag'", *The Guardian*, 23 October 2014. Available at: https://www.theguardian.com/cities/ 2014/oct/23/-sp-urban-light-pollution-permanent-mini-jetlag-health-unnatural-bed.

41 Christopher Kyba, Andreas Hänel, Franz Hölker, "Redefining efficiency for outdoor lighting", *Energy & Environmental Science*, n° 7, 2014.

42 Amanda Petrusich, "Fear of the light: why we need darkness", *The Guardian*, 23 August 2016. Available at: https://www.theguardian.com/environment/2016/aug/23/why-we-need-darknes....

of light, and advocating more thoughtfully conceived lighting systems that work with, rather than in opposition to, night-time darkness".[43] This rethinking is timely and significant, running counter as it does to the way in which urban lighting has been developed to date. Indeed, as Bille and Sørensen observe, "we generally continue to pursue quantity at the expense of quality of illumination when technological development is offering so many new opportunities".[44] These values of light, clarity, cleanliness and coherence are Western in their origin yet have been transferred across the global experience of culture more broadly.

16 In Britain, the current opportunities for a plurality and significant diversity of urban lighting are at present highly constrained by regulations imposed on street lighting which must conform to *British Standard 5489 1:2013 Code of practice for the design of road lighting: Lighting of roads and public amenity areas*.[45] Regulatory frameworks and codes of practice such as this are common in many countries and suggest how little we understand of different lights and darknesses. It is therefore my intention to record the urban landscape of Manchester with its different lights and darknesses before they are lost. This loss is not absolute but direct experience of the current variety of darknesses is likely to be obstructed, or at least hindered, by the profusion of LED street lighting. It is important to emphasise here that the comprehensive installation of 'new' lighting across the city, as with many strategies to establish total and uniform environments, is unlikely to produce a coherent landscape at night. This is because the planned power of completeness is illusory since the lighting technology is built over, and responds to, a longer history of partial infrastructures and contextual characteristics that shape its effects.[46] As such, difference will still persist or reassert itself across the city, albeit in ways potentially unforeseen and unintended. In order to capture some of the different atmospheres and ambiances of darknesses in Manchester at present, I use the following section of the article to present a combination of my autoethnographic fieldwork (in *italics*) interspersed with images to assist the reader's understanding of how the quality and quantity of lighting in these places mediate experiences of the built environment.

WALKING IN THE CITY AFTER DARK

17 *Strangeways here we come. But first: the cathedral. Gothic Perpendicular upgraded from parish church and hewn from the stone of nearby Collyhurst. Here, the subtle interplay between the sodium street light, the directional wash of coloured light up the cathedral's tower and the white light of its clock augment its brooding presence. Beneath my feet, the nearby Victorian Arches – the prize in the urban explorer's eyes – tricky to access these days, encumbered by the river, the infrastructure and the resolute locking down of (no) entry points. Feel that? The gravitational field has been breached once again as the centripetal force of the inner ring road is crossed. Back against the Manchester Arena, the city's mouth gapes open at this point. Drawn out along Great Ducie Street and behold: the epic asterisk plan of brick. Her Majesty's Prison Manchester will always be Strangeways to me, in the same way that for some Manchester Airport will always be Ringway, the rebranding and replaced signage never able to fully scrub the mind's palimpsest as ghost letters cling to their former sanctuary, the typescript stencilled in dirt. The streets either side of the prison are phantom escalators, feet unable to resist the upward heave of the compound's heft. A lone figure now set against a huge brick wall, multiple eyes of the surveillance cameras blankly looking back at me but unable to return any expression. My shadow grows and shrinks against the brick canvas in*

43 Akiva Blander, "Can Designers Combat Light Pollution by Embracing Darkness?", *Metropolis*, 2 May 2018. Available at: http://www.metropolismag.com/cities/lighting-designers-fighting-back-be….

44 Mikkel Bille, Tim Flohr Sørensen, "An Anthropology of Luminosity: The Agency of Light", *Journal of Material Culture*, vol. 12, n° 3, 2007, 271.

45 British Standards Institute, BS5489 1:2013 Code of practice for the design of road lighting: Lighting of roads and public amenity areas, 2013. Available at: https://www.standardsuk.com /products/BS-5489-1-2013.

46 David E. Nye, *When the Lights Went Out: A History of Blackouts in America* (Cambridge, MA: The MIT Press, 2010).

Figure 2: Manchester Cathedral and its Perpendicular Gothic shadows. ©Nick Dunn.

Figure 3: Strangeways in Salford, the panopticon of light. ©Nick Dunn.

rhyme with the streetlights. The atmosphere here within the admixture of sodium glow foregrounded by the piercing beams of security lights, the urban environment is quiet, contemplative, almost subterranean.

18 *I am now compressed in the wonderful push-pull of Library Walk. Perhaps the most dynamic open space in the city but not for much longer. Its nights are numbered, soon to become an impasse as the place is shielded from public feet and fettered with shiny, bulbous science-fiction adornments. This thing called progress lacerates the enchanting and favours the money. Derelict ideology requires the demolition of the cherished and savoured, all built on the shifting sands of finance. Booth Street cautions the legs past the police headquarters – nothing to see here officers. Then a dogleg across Deansgate and down towards the discordance of the Museum of Science and Industry and the excavated sets for the television show* Coronation Street. *Castlefield bowls out too soon to stack after stack of apartment blocks and incongruous fluorescence. Industrial heritage and its ruins crisscross around here, infrastructural behemoths of former success now speechless, corroding and beautiful as they run above sodium lamps. The origins of the city lie here, Mancunium, civic stones, the very bones of former settlements desecrated for the progress of the canal and railway, now reconstructed as heritage motifs for public acknowledgement. Eerie and vulnerable, the massiveness of the area and its artefacts is pliable and yields to the feet easily as archways and pillar frame new views and oddments of the past.*

Moving across the city now, the background slish 19
of traffic on the Mancunian Way overhead as I emerge from the subway, ears prickled by the smashing of glass somewhere behind. This is Manchester, on a cool and dry night in late May where the opacity of the city's infrastructure loses its gravity and melds toward the neon and sodium morse code above. Indecipherable messages, these ghost texts to unknown gods and spirits hang in the air like stolen thoughts from another time – the lost future that got delayed, tied down in the bondage of bureaucracy, boredom and blame. But now the shouting is all over. Instead, this award-winning concrete serpent remains frozen against asphalt forever, undulating between buildings and woven across the landscape. My left foot skids on the masticated remains of a club flyer chewed by rain and indifference. And yet this crepuscular beast, somehow always in the twilight due to the amount of sodium lighting around to, comes alive as the beams of motor cars traverse above and underneath it; a dizzying and dynamic shadow-play stirring the creature's geometry into motion as vehicles suddenly appear and recede with their white headlights and trails of red rear lights.

The pylon filigree makes poor company for its sil- 20
ver-birch brethren in the dim, clouded moonlight

Figure 4: Beetham Tower looms large behind the staircase of fluorescent light. ©Nick Dunn.

Figure 5: Castlefield and its sodium-tinged Victorian infrastructures. ©Nick Dunn.

Figure 6: Mancunian Way, the highway to a future that never arrived. ©Nick Dunn.

as the molten ebony of the Mersey River smears past below. Tonight, I am walking along the city's edge as I navigate an arc, less precise than the orbital motorway in the distance. Pushing up the riverbank, past the flood line of winter swelling, and across the bridge toward the scanty woods. A tent in the trees seems to be losing its tautness against the weather. Somewhere in the undergrowth, a small fox stirs and then skits across the path away from the crunch of boots and human scent. The cold, wintry air brings with it an ocular sharpening as the edges of flora and the longer grasses suddenly lean into view, the murky assemblage instantly composed like decoupage. Onward towards Wythenshawe, that bastion of Garden City displacement where the pitch shifter of the landscape alters from deadened calm and occasional rustling to an altogether more eerie quiet. Emerging from the jaundiced concrete flyover that arcs a man-made swathe and announces the end of nature, the orange glow of street lighting increases in as it punctuates the way forward, suburban homes lining the perspective on either side. A car sheens its way around the corner, lights off then headlights all ablaze as its exit velocity from the estate increases exponentially into the murk beyond. Satellite lives flicker lonely blues and greens behind glass portals and the distant smeared sounds of cars over the rooftops brum and fade away. Several turns later and the edge of Wythenshawe Park cascades away either side of me. The sentry of trees are filtered through and the vast carpet of the park rolls out, a luxurious deep-pile affair, feet sinking into the soft surface, bedecked with curvaceous mirrors where the land lies low and is saturated. The puddles stare back, reflecting the clouds overhead and a damp and dishevelled silhouette. The ground offers poor resistance to leather and rubber rhythms of my footwear, instead pulling each footstep further into the quagmire and pooling rainwater with each depression. Underneath the motorway, down a charcoal grey lane, a sodium lamp signals the residence for someone. Retracing my steps, the walk home leads to the ultimate denouement as I discover the immediate effects of the city's street light replacement programme on my own street, now a jumbled composition of directional, white LED lamps and the gradual oranges of sodium lighting.

Figure 7: Living with infrastructure on the outskirts of the city. ©Nick Dunn.

Figure 8: Shedding light on domestic matters. The newly installed and uneven illumination of a suburban street. ©Nick Dunn.

UNDERSTANDING THE DIVERSITY AND COEXISTENCES OF DARKNESS

21 What I intend to become evident through these textual and visual depictions is the rich potential of the night for our senses as a place for speculation and experience.[47] Walking through Manchester at night, the city slowly but perceptibly shifts in its composition of different lights and darknesses, reflecting the history of its lighting energy landscape. Perhaps unsurprisingly, historical accounts of lighting have focused on the routine circumstances of the urban night.[48] Though more recent studies have redressed this by providing investigations into unique, temporary and performative illuminations,[49] there may be an important overlap between these two areas of inquiry. That we can go and enjoy our nocturnal urban landscape improvisionally without recourse to consumerism suggests that by engaging with the 'every night' we might find ourselves open to new forms of experience and place.[50] Although there is an increasing amount of research across various disciplines related to the notion of the reciprocity and nuances between light and darkness being essential to each, there are also historical clues to how we might learn to embrace this. The Japanese novelist Jun'ichirō Tanizaki in his seminal 1933 meditation on his country's culture, *In Praise of Shadows*, highlighted the importance of this coexistence when he observed, "[i]f light is scarce then light is scarce; we will immerse ourselves in the darkness and there discover its own particular beauty".[51]

22 Writing about gloom and the urban landscape, Tim Edensor provides a robust argument for embracing it, "[r]ather than being lamented, the re-emergence of urban darkness, although not

47 Photophilos, *Hints for Increasing the splendour of illumination; securing the pleasure of the spectator, and the convenience of the householder, with some remarks for the prevention of tumult and disorder. Particularly adapted to the illuminations expected to take place on the proclamation for peace with the French republic* (London, 1801).

48 Chris Otter, *The Victorian Eye: A Political History of Light and Vision in Britain, 1800-1910* (Chicago, IL: University of Chicago Press, 2008). Joachim Schlör, *Nights in the Big City Trans. Pierre Gottfried Imhof and Dafydd Rees Roberts* (London: Reaktion Books, 1998).

49 Alice Barnaby, *Light Touches: Cultural Practices of Illumination, London 1800-1900* (Abingdon: Routledge, 2015). Tim Edensor, "Illuminated atmospheres: anticipating and reproducing the flow of affective experience in Blackpool", *Environment and Planning D: Society and Space*, vol. 30, n° 6, 2012. Tim Edensor, Mikkel Bille, "'Always like never before': learning from the lumitopia of Tivoli Gardens", *Social & Cultural Geography*, 2017. Available at: https://doi.org/10.1080/14649365.2017.1404120.

50 Nick Dunn, *Dark Matters: A Manifesto for the Nocturnal City* (Winchester: Zero, 2016). Tim Edensor, *From Light to Dark: Daylight, Illumination, and Gloom* (Minneapolis, MN: University of Minnesota Press, 2017).

51 Jun'ichirō Tanizaki, *In Praise of Shadows Trans. Thomas J. Harper and Edwards G. Seidensticker* (London: Vintage, 2001[1933]), 48.

akin to the medieval and early-modern gloom that pervaded city space, might be conceived as an enriching and a re-enchantment of the temporal and spatial experience of the city at night".[52] This relational understanding between lights and darknesses is crucial to how we might conceive of better ways to illuminate and engage with our cities at night. As our cities, not least Manchester, seek to evolve into 24-hour places reducing further the different types of atmospheres, lights and darknesses seems contrary to the increased diversity of their populations, cultures, social meanings and values. Understanding that darkness is "situated, partial and relational"[53] is essential to recognising what may be lost in our cities since it contributes significantly to "affective atmospheres"[54] of the urban. At a period in human history when so much of our activity is uploaded, categorised, tagged and compressed into moments, I contend that to sense a wider and deeper world directly through first hand encounter becomes more important than ever. Moving, quite literally, out of the glare and stare of our commoditized and structured days and into alternative modalities within the shadows of our cities may be one of the few truly sublime and beautiful practices available to us.

23 This is not simply a matter of replacing existing urban lighting with more energy efficient forms of it, but rather a vital and important need to examine its health implications since the distribution and intensity of urban lighting results in a detrimental and serious disruption to the circadian clocks of numerous species including human beings.[55] Furthermore, important in this context is the need to better understand the value of different lights and darknesses[56]; their qualities and effects so that we may further appreciate the array and nuances of lighting available to us as a means of situating us in our place, whether Manchester or elsewhere.[57] The methods presented here are part of a foray into examining and experimenting with the reciprocity between our senses and the built environment when the latter is experienced outside of the daytime hours. It is a nascent body of multi- and inter-disciplinary work. Yet it is also important to remember that our senses are culturally conditioned, alongside our view of darkness, being as they are bound up in specific historical, geographical and social circumstances and interrelationships. To conclude, I suggest that by building different knowledges and understandings of the complex relationships between light and darkness, their distinct qualities and their coexistences, we can also reveal the diverse meanings and experiences that not only contribute to the history of energy as manifest in illuminating our urban landscapes but also its future.

52 Tim Edensor, "The Gloomy City: Rethinking the Relationship between Light and Dark", *Urban Studies*, vol. 52, n° 3, 2015, 436.

53 Nina Morris, "Night walking: Darkness and sensory perception in a night-time landscape installation", *Cultural Geographies*, vol. 18, n° 3, 2011, 316.

54 Ben Anderson, "Affective atmospheres", *Emotion, Space and Society*, vol. 2, n° 2, 2009. Available at: https://doi.org/10.1016/j.emospa.2009.08.005.

55 Steve M. Pawson, Martin K.-F. Bader, "LED lighting increases the ecological impact of light pollution irrespective of color temperature", *Ecological Applications*, vol. 24, n° 7, 2014. Available at: https://doi.org/10.1890/14-0468.1.

56 Taylor Stone, "The Value of Darkness: A Moral Framework for Urban Nighttime Lighting", *Science and Engineering Ethics*, vol. 24, n°2, 2018. Available at: https://doi.org/10.1007/s11948-017-9924-0.

57 Robert Shaw, "Streetlighting in England and Wales: New technologies and uncertainty in the assemblage of streetlighting infrastructure", *Environment and Planning A*, vol. 46, n° 9, 2014.

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JEHRHE

Journal of Energy History
Revue d'histoire de l'énergie

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POST DATE
31/07/2019
ISSUE NUMBER
JEHRHE #2
SECTION
Special issue
THEME OF THE SPECIAL ISSUE
Light(s) and darkness(es): Shifting historical relations
KEYWORDS
Climate, Coal, Light
DOI
in progress

TO CITE THIS ARTICLE
Sara B. Pritchard, "Epilogue. Field Notes from the End of the World: Light, Darkness, Energy, and Endscape in Polar Night", *Journal of Energy History/Revue d'Histoire de l'Énergie* [Online], n°2, published 31 juillet 2019, consulted XXX, URL: http://energyhistory.eu/node/140.

Epilogue. Field Notes from the End of the World: Light, Darkness, Energy, and Endscape in Polar Night

Abstract
This personal essay describes light(s) and darkness(es) in Longyearbyen, Svalbard (Norway) during polar night in January 2019. Drawing on autoethnographic methods, I also seek to describe how I experienced the remarkable lightscapes and darkscapes of the far north during winter. I suggest how the history of energy in Longyearbyen has both shaped and been shaped by the "extreme" light/dark cycle of the high Arctic. In the process, I develop the concept of "endscape" to characterize vestiges of a landscape that has been, and will continue to be, transformed by global climate change, and will eventually disappear. This recent experience illustrates the potential of experiential, reflexive ways of contending with light/dark. It also draws attention to tensions in the academic study of light/dark and the history of energy, and how they play out in practice, in the context of a conference held in a remote location that requires scholars to contribute to the continued extraction of fossil fuels –something that most would otherwise decry. I suggest that Longyearbyen is a useful case study for other endscapes in the early 21st C.

Acknowledgments
I thank Stéphanie Le Gallic, Sarah Pickman, and Léonard Laborie for thoughtful comments on previous versions of this article. Conversations with Simone Dennis, Pamila Gupta, Catie Newell, and Michaela Thompson also influenced this essay. I thank the conference organizers of "Darkness 2019," as well as its participants for fascinating and productive conversations. This research is supported by the National Science Foundation's Program in Science, Technology, and Society (Grant No. 1555767).

Figure 1: Map showing Norway (in red) and Svalbard (the archipelago colored red within the circle). This view particularly shows the latter's proximity to the North Pole. Source: Wikipedia, "Svalbard."

1 January 2019. I've just experienced almost six consecutive "days" of polar night –a twenty-four-hour period without sunlight– in Longyearbyen, Norway. A small town on the archipelago known as Svalbard (fig. 1), Longyearbyen is located at the 78th parallel –2,000 kilometers almost due north of Oslo and just 1,050 kilometers from the North Pole. In 1906, American John Munro Longyear and his Arctic Coal Company established a coal mine near what became the new "town of Longyear" (Longyearbyen). One mine is operational today, but Longyearbyen is now mostly a tourist destination, hub for scientific research (especially related to global climate change), and outpost of Norwegian sovereignty in an increasingly altered and contested Arctic.

2 The six days I spent without seeing the sun is, however, a small fraction of polar night at this latitude. The sun remains below the horizon from October 26 until February 15, what is called the "dark period" (*mørketiden*). "Real" polar night –when the sun is at least 6 degrees below the horizon, so that no twilight illuminates the sky– extends from November 11 to January 30.[1] Although I loved my time in Longyearbyen (fig. 2), I could not imagine being a year-round resident.[2]

3 I had ventured to Longyearbyen in the depths of winter to participate in Island Dynamics' conference on –wait for it– "Darkness."[3] For the past few years, I have been studying the history of light pollution and scientific research about this issue.[4] What better place to think about artificial light at night than Longyearbyen –the northernmost town in the world– during real polar night.[5] I traveled some 8,000 kilometers to present work in progress, meet scholars from diverse fields studying darkness, and experience light and dark in a dramatic landscape of both.

4 I also went to Longyearbyen for personal reasons. My father, a retired Arctic sea ice modeler, spent time in the polar north studying sea ice during the era of the Cold War and fossil fuels. Many scientists in the next generation of sea ice modelers now do so under the rubric of climate

1 Spitsbergen-Svalbard, "Midnight sun and polar night," https://www.spitsbergen-svalbard.com/spitsbergen-information/midnight-s... (accessed 15 May 2019)

2 A hotel desk clerk told one conference participant that they thought winter and darkness were easier to adapt to than continuous light in summer. The clerk also shared that suicide rates are higher in summer. Their argument was that now "people" are used to working in artificially lit interior spaces, so it is therefore "easier" to adapt to winter conditions than to try to block out light during 24-hour days. This comment was especially interesting to me, given my work on artificial light at night. I wonder if people reliant on candle or whale oil (both past and present) would come to the same conclusions or if this is culturally, historically, and economically contingent.

3 "Darkness 2019," *Island Dynamics Conference*, Longyearbyen, Svalbard, 13-17 January 2019, https://darkness-conference2019.wordpress.com/ (accessed 15 May 2019)

4 Sara B. Pritchard, "The Trouble with Darkness: NASA's Suomi Satellite Images of Earth at Night," *Environmental History*, vol. 22, n° 2, 2017; Sara B. Pritchard, "On (Not) Seeing Artificial Light at Night: Light Pollution or Lighting Poverty?," *Discard Studies: Social Studies of Waste, Pollution, & Externalities*, June 12, 2017, https://discard-studies.com/2017/06/12/on-not-seeing-artificial-light-at... (accessed 20 May 2019)

5 As Sophia Roosth writes, "The church, like most other things in Longyearbyen, boasts being 'northernmost': northernmost commercial airport, northernmost newspaper, northernmost sushi restaurant." See Sophia Roosth "Virus, Coal, and Seed: Subcutaneous Life in the Polar North," *LA Review of Books*, December 21, 2016, https://lareviewofbooks.org/article/virus-coal-seed-subcutaneous-life-p... (accessed 7 June 2019)

Figure 2: Topographic map of Svalbard. Longyearbyen is marked with a white star; it is located almost in the middle of Spitsbergen. Credit: Oona Räisänen. Permission is granted to copy this document under the terms of the GNU Free Documentation License. Source: Wikipedia, "Svalbard."

change.[6] Most of my father's fieldwork took place in big tents on the ice over several weeks. He also went out on icebreakers –rugged ships departing from Longyearbyen or Tromsø that can bust through polar ice or, in his case, lodge themselves in Arctic ice for extended periods of time.[7] Most of my father's time "on the ice" was during the shoulder season when pack ice had built up and was close to seasonal highs, but didn't entail the additional challenge of doing fieldwork in the dark of polar night. We never talked much about the research he did or landscapes he saw, but for a variety of reasons, I wanted to see where my father had worked on and off over several decades. It is somewhat ironic, then, that I was in Longyearbyen during the prolonged period of darkness that is polar "night." However, as we know from everyday language, seeing is both literal and metaphorical.

I must admit that I was also drawn to Svalbard out of some sense of what I had started calling apocalyptic tourism[8]: the opportunity to see

6 Certainly, the era of fossil fuels is not over in the Arctic or elsewhere. In fact, the melting Arctic has afforded new industries and possibilities, including those in the oil and gas industry.

7 Late-20th C. Arctic sea ice modeling fieldwork is indebted to ships and practices developed during polar exploration in the late 19th and early 20th C., especially Nansen's "drift" over the Arctic Ocean between 1893 and 1896 in the polar ship "Fram." For an accessible overview of this ship and its history, see the Fram Museum's website, https://frammuseum.no/polar_history/vessels/the_polar_ship_fram/ (accessed 20 May 2019)

8 Not surprisingly, there is scholarship on "apocalyptic" and "post-apocalyptic tourism." Two useful starting points include Roger Norum and Mary Mostafanezhad, "A Chronopolitics of Tourism," *Geoforum*, vol. 77, December 2016; Mary Mostafanezhad and Roger Norum, "The Anthropocentric Imaginary: Political Ecologies of Tourism in a Geological Epoch," *Journal of Sustainable Tourism*, vol. 27, n° 4, 2019.

6

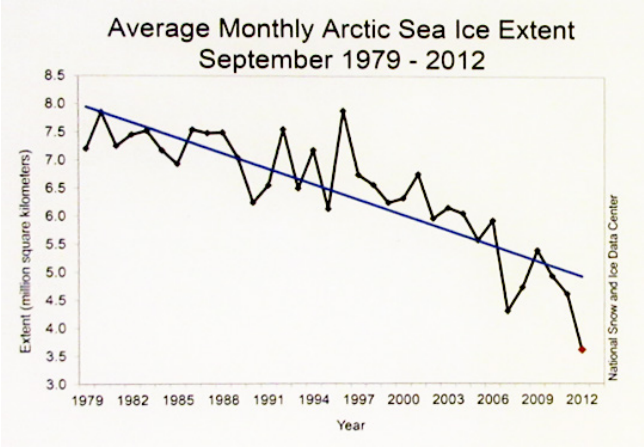

Figure 3: Graph of "Average Monthly Arctic Sea Ice Extent, September 1979–2012" on display at the Fram Museum in Oslo, Norway. Photo by the author.

some of the polar north before global climate change changes it further (fig. 3). The graph in Figure 3 has circulated in various media since 2012, but the descending line of Arctic sea ice averages feels more poignant and personal to me because these data map almost exactly onto my father's career in the Arctic. Then I saw the graph again when I visited the Fram Museum in Oslo the day before I headed north to Svalbard for the conference. With graph in recent memory and feet on the ground in Longyearbyen, I began thinking about my trip –admittedly pessimistically– as traveling to the end of the world to see the end of the world.[9] If the last living individual of a species is what Dolly Jørgensen calls an "endling," I went to Longyearbyen, in part, to see an *endscape* –vestiges of a landscape (as people have known it for most of human history) that has been, and will continue to be, transformed by global warming, and will eventually disappear.[10] Increasingly, "eventually" is, in fact, soon, if not now. In other words, this January, I was a dark tourist in both senses of the term.[11]

In this essay, I use my recent trip to Longyearbyen to reflect upon light, darkness, energy, and their entanglement in the endscape of the high Arctic during polar night.[12] I do so as a historian and scholar, but also as a privileged person navigating the hopes and fears of climate change in the early 21st C., as dire warnings mount and timelines for action shrink. I've also been pushed to

9 The phrase, "it is easier to imagine an end to the world than an end to capitalism" (and versions thereof), has been attributed to Fredric Jameson. On the metaphor of "the end of the world" within the environmental humanities, see Anna Lowenhaupt Tsing, *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruin* (Princeton, NJ: Princeton University Press, 2015); Stephen J. Pyne, "The End of the World," *Environmental History*, vol. 12, n° 3, 2007.

10 Dolly Jørgensen, "Endling, the Power of the Last in an Extinction-Prone World," *Environmental Philosophy*, vol. 14, n° 1, 2017. On "northscape," see Dolly Jørgensen and Sverker Sörlin, (eds.), *Northscapes: History, Technology, and the Making of Northern Environments* (Vancouver: UBC Press, 2013).

11 For several overviews of dark tourism, see John Lennon and Malcolm Foley, *Dark Tourism: The Attraction of Death and Disaster* (London: Continuum, 2000); Philip Stone, "Dark Tourism Scholarship: A Critical Review," *International Journal of Culture, Tourism and Hospitality Research*, vol. 7, n° 3, 2013; Glenn Hooper and John J. Lennon, *Dark Tourism: Practice and Interpretation* (New York: Routledge, 2016); Philip R. Stone, Rudi Hartmann, Tony Seaton, Richard Sharpley, and Leanne White, (eds.), *The Palgrave Handbook of Dark Tourism Studies* (London: Palgrave Macmillan, 2018). On forms of dark tourism in polar north specifically, see Harvey Lemelin, Jackie Dawson, Emma J. Stewart, Pat Maher, and Michael Lueck, "Last-Chance Tourism: The Boom, Doom, and Gloom of Visiting Vanishing Destinations," *Current Issues in Tourism*, vol. 13, n° 5, 2010; Dieter K. Müller, Linda Lundmark, Raynald H. Lemelin, (eds.), *New Issues in Polar Tourism: Communities, Environments, Politics* (Dordrecht: Springer Netherlands, 2013). On the related "last chance tourism," see Lemelin, *et al.*, "Last-Chance Tourism"; Harvey Lemelin, Jackie Dawson, and Emma J. Stewart, *Last Chance Tourism: Adapting Tourism Opportunities in a Changing World* (New York: Routledge, 2012). For one example of climate-change tourism (also last-chance tourism), see Carol Farbotko, "'The Global Warming Clock Is Ticking So See These Places while You Can': Voyeuristic Tourism and Model Environmental Citizens on Tuvalu's Disappearing Islands," *Singapore Journal of Tropical Geography*, vol. 31, n° 2, 2010. For a non-academic discussion of species-loss tourism, see Douglas Adams and Mark Carwardine, *Last Chance to See* (New York: Ballantine Books, 1992). Although there appears to be a growing literature on climate-change tourism, my preliminary assessment indicates much of this work focuses on how the tourism industry should change in an era of climate change and fossil-fuel reduction. Much less work tackles the problem of tourism actually created or even increased by climate change, along the lines of what Lemelin et al. and Farbotko discuss. As climate crisis intensifies in coming years, I wonder if privileged tourists (like those of us at the "Darkness" conference) will actually expand the market for this particular kind of dark tourism.

12 Although I could spill much ink about light pollution in Longyearbyen, I will address these concerns elsewhere.

wrestle with my own complicity in this process, including my trip to the end of the world.[13]

IN THE (LIGHT/DARK) FIELD

7 Most conference participants flew into Longyearbyen on the afternoon of Sunday, 13 January. I, like most participants with whom I spoke, initially struggled to adjust to the landscape of light/dark –or the lightscape and darkscape– of the high Arctic during our first hours there. In retrospect, the Svalbard airport felt normal and familiar enough –other than its small size and the taxidermy polar bear posed on top of the lone baggage carousel. Many of us were soon grumbling, however, about the dim hotel lobby and even darker rooms. Dark paint, wallboard, flooring, carpeting, and cabinetry didn't help. Even the chair in my small room was forest green. Many of us wanted to turn on more lights in our rooms, but there weren't any. Sparse contemporary furniture in classic Scandinavian neutrals –take your pick among light grey, dark grey, beige, and taupe (woo hoo!)– didn't appreciably brighten common spaces. Was this characteristic Scandinavian *hygge*? Sure, it was cozy, but some of us, especially those over age 40, just wanted to see.

8 The following Saturday, on my trans-Atlantic flight home, I reread that month's issue of *Scandinavian Traveler*, the in-flight magazine of Scandinavian Airlines. This time I paused –full stop– at a full-page ad touting "WarmDim" lighting. The phrase perfectly encapsulated the lightscape –or rather, darkscape– of most interior spaces I had just experienced. Ambient lighting was minimal and subdued. Task lighting strategically illuminated the hotel reception, bar, chairs, sofas, and bed. Many were single, clear, warm yellow bulbs hung low, nearly at eye level. In fact, I observed two conference attendees whack their heads –hard, I might add– on lights as they got up from chairs and couches. Clearly, they did not expect the lights to be there.[14]

9 The exception to the darkscape of interior spaces was the bathroom. Here, ample recessed LED lights, also in warm yellow, brightened the small room like Las Vegas. Early in the conference, I confessed to another participant that I was strangely drawn to the bathroom –retreating to its intense lightscape and feeling like a lizard, desperate to soak up the bright light (and radiant floor heating). Perhaps I was unconsciously trying to reset my biological clock.[15] On that plane ride home, I realized that I had simply flipped by the "WarmDim" ad on the flight out because it had no meaning to me then. Now it did.[16]

10 In contrast to restrained interior lighting, street lighting, restaurant and hotel signs, Christmas lights strung across the pedestrian corridor of "downtown" Longyearbyen, front porch lights, and interior illumination coming through unobstructed windows all brightened the supposed darkness of polar night that had attracted so many of us to the conference and place.[17] As we walked to dinner downtown each evening (not that morning and nighttime walks looked any different), I couldn't help but notice the linear rows of street

13 IPCC, "Summary for Policymakers of IPCC Special Report on Global Warming of 1.5°C Approved by Governments," October 2018, https://www.ipcc.ch/2018/10/08/summary-for-policymakers-of-ipcc-special... (accessed 15 May 2019)

14 One person was an American; I don't recall the national identity of the other individual. I wonder if Scandinavians (or those who spend a lot of time in Scandinavia in winter) are less apt to do so because they have been socialized to these geographies of light and lighting technologies in interior spaces.

15 In "The End of the World," Pyne writes of Antarctic winters that "There is no way to reset one's biological clock" (650).

16 Danish "hygge" is now well known thanks to Meik Wiking's popular book, *The Little Book of Hygge: Danish Secrets to Happy Living* (New York: William Morrow, 2017). Nona Schulte-Römer discusses aspects of hygge in her contribution to this issue. Although I had spent time in Norway and Sweden before this trip, I had never been to Scandinavia during winter, which is probably why "WarmDim" lighting was so novel to me. By day four in Longyearbyen, I had also developed an additional hypothesis about the reason for interior darkscapes: dark(er) walls, floors, and furniture better absorb (ample) natural light during periods of "midnight sun." Interior environments in the far north may be designed more around summer conditions.

17 Admittedly, many of us at the conference confessed to one another that the dog sled excursion was a huge draw. It didn't disappoint.

lamps along the few streets in town that stopped at the pitch black of what I knew, from online maps, to be water's edge. From our hotel on the hill slightly above town, Longyearbyen's layout almost looked like an airport runway at night – except it looked the same whether it was "day" or "night." More significantly, though, it wasn't that dark in town. It was easy navigating in polar night, thanks to all the artificial lighting.

11 Given my work with light-pollution scientists over the past four years, I found this lightscape of polar night both fascinating and disturbing. Furthermore, I observed first-hand how snow and ice reflected artificial light. They covered streets, sidewalks, and yards, making it almost impossible to see where one began and the other ended. On the third day of the conference, a gentle snowfall intensified existing reflectivity, further brightening the outdoors. I noticed a number of us looking out the window that afternoon. Perhaps it was jetlag and conference fatigue by that point, but it seemed as if our eyes had been drawn to the subtle but perceptibly different lightscape beyond the walls of the conference hotel. The cascade of fluffy snowflakes slowly descending through the air brought a new level of light to the polar "darkness" that was, in actuality, not that dark. Natural winter conditions in the high Arctic thus amplify any "artificial" light.[18] Such magnification is even more dramatic during polar night, given that it is supposed to be dark for almost four consecutive months, and life forms have evolved in such environments. Put in the context of geologic time and evolutionary history, the transformation of the light/dark cycle in Longyearbyen since the early 20th C. is especially dramatic and significant.[19]

12 These patterns were what surprised me most about my limited time in Longyearbyen. Interior spaces were much darker than I had anticipated and was used to, while the exterior environment was much brighter than I had expected.

13 As I wrestled with tensions between my expectations and actual experiences –darkscapes inside, lightscapes outside– I began thinking about light and dark in Svalbard in the past, and what it would have been like to visit, live, or work there in previous decades, if not centuries. What would it have been like to work by candle or whale oil, particularly during polar night? Moreover, how much energy did it take to survive in this extreme environment of cold temperatures, severe wind chill, and a third of the year without any sunlight? The Svalbard Museum in Longyearbyen displayed life-sized models of tiny cabins (shacks, really) in which early explorers and hunters lived. In most of these displays, a single lamp rested on a small table. Even with these displays right in front of me, it was hard to imagine these places –cabins, Svalbard– as lived experiences.[20] But what was most difficult for me to envision was the experience of light/dark in times past –a product, no doubt, of my multiple forms of privilege.[21]

18 There are a number of papers that discuss the importance of reflectants –clouds, particulates, aerosols, snow, ice, even specific kinds of rocks– to shaping local manifestations of artificial light at night (ALAN). For snow specifically, see Andreas Jechow and Franz Hölker, "Snowglow– The Amplification of Skyglow by Snow and Clouds Can Exceed Full Moon Illuminance in Suburban Areas," *Journal of Imaging*, vol. 5, n° 8, 2019. These findings suggest how ALAN is, in fact, an envirotechnical phenomenon. I plan to explore both ALAN and scientific research about ALAN as envirotechnical phenomena in future publications.

19 Edmund Russell, *Evolutionary History: Uniting History and Biology to Understand Life on Earth* (New York: Cambridge University Press, 2011).

20 Christiane Ritter's hut can be toured virtually online. See "Ritter Hut," https://www.spitsbergen-svalbard.com/photos-panoramas-videos-and-webcam... (accessed 11 July 2019)

21 As I wrote and revised this essay, I became more aware of the multiple forms of privilege I have in relationship to artificial light (at night) and light/dark cycles. For one, artificial light is now infrastructure in most of the developed world. Yet, for the homeless, "squatters," and lower class people in the global North, electricity, including electric lighting, is not guaranteed. Some individuals and families are forced to choose, for instance, between food or medicine and electricity. My experience with artificial light and light/dark cycles is also conditioned by the fact that I grew up and live in the continental United States with temperate light/dark regimes. "Natural" light/dark cycles in Alaska, for instance, are closer to those in Svalbard. However, experiences with light/dark in the far north are far from monolithic

Our hotel rooms may have felt dark when compared to norms in industrialized countries in temperate or tropical regions during the early 21st C. Yet they were brightly lit when compared the possibilities afforded by candle, not to mention regions of the world with lighting poverty. Knowing the importance of the moon to contemporary light-pollution research, I wondered if lunar light during the full moon, especially given reflection on snow and ice, had been a valuable light source in the high Arctic. Did the full moon extend precious energy supplies, even if it was only for a few days each lunar cycle?[22]

Indeed, on a tour of former coal mine 3 (now a tourist destination for groups like ours), our guide as well as several conference presenters, shared that few permanent settlements had been located on Svalbard before the early 20th C. For at least four centuries, whalers and hunters had mined rich Arctic natures, oriented primarily to sea and shore. Someone at the conference mentioned that several Russian orthodox monasteries had been built in Svalbard, even farther north than Longyearbyen. With the exception of the monks, I assume few people purposefully stayed through winter.[23] Moreover, until recently, Arctic sea ice froze solid around the archipelago during the full length of winter, making it nearly impossible to escape the entirety of polar night, if one did not leave in time. The darkscape of polar winter, both actual experience and unintentional possibility, must have been daunting for those from temperate and tropical regions unaccustomed to these kinds of light/dark cycles. 14

That began to change with polar exploration. Some expeditions accidently overwintered. Others planned to do so in order to conduct research and take advantage of time in the field, rather than losing considerable time in transit between North American and European metropoles and polar regions.[24] Still, most explorers were transitory figures who intended to stay only for the duration of their expedition. They departed once resources were sampled, 15

culturally and historically. For instance, indigenous communities in the low and high Arctic developed strategies to live with light/dark cycles there. At times, white settlers and polar explorers learned from, relied on, and benefited from this knowledge; at other times, they critiqued and even condemned indigenous norms. It is also important to note that there were (and are) not indigenous populations in Svalbard –unlike, say, northern Canada or Alaska. Imposition of industrialized light/dark cycles or expectations about "proper" lighting were not, therefore, part of Svalbard's early history, unlike many northern places where settler colonialism occurred. Nonetheless, framing polar light/dark regimes as "extreme" normalizes and naturalizes conditions in temperate and/or tropical regions, thereby Other-ing the poles. My critique of "extreme" framing is influenced by conversations with Sarah Pickman, including her co-authored conference presentation: Sarah Pickman and Tess Lanzarotta, "Darkness Falls: Arctic Darkness and the Meanings of Normative Time," presentation at "Darkness 2019," Island Dynamics Conference, Longyearbyen, Svalbard, 13-17 January 2019. Despite my hesitation to use the term, for an overview of "extreme environments" in the field of environmental history, see the Introduction to the interdisciplinary forum on the topic, Steve Pyne, "Extreme Environments," *Environmental History*, vol. 15, n° 3, 2010; for a number of examples, see the accompanying essays. On the deep ocean, see Helen Rozwadowski, *Fathoming the Ocean: The Discovery and Exploration of the Deep Sea* (Cambridge, MA: Harvard University Press, 2005). On space, see Valerie A. Olson, *Into the Extreme: U.S. Environmental Systems and Politics Beyond Earth* (Minneapolis: University of Minnesota Press, 2018); Lisa Ruth Rand, "Falling Cosmos: Nuclear Reentry and the Environmental History of Earth Orbit," *Environmental History*, vol. 24, n° 1, 2019.

22 On hybrid systems of lighting that combined lunar and artificial light, see Stéphanie Le Gallic and Sara B. Pritchard, "Light(s) and Darkness(es): Looking Back, Looking Forward," *Journal of Energy History / Revue d'histoire de l'énergie*, vol. 2, July 2019, consulted 01/07/2019, URL : energyhistory.eu/en/node/137

23 Again, Svalbard's history is therefore distinct from places where white settler colonialism took place.

24 On polar regions as a unit of analysis, see Adrian Howkins, *The Polar Regions: An Environmental History* (Malden, MA: Polity Press, 2016). Much could be said here about "heroic" white, male science-exploration, which was implicated in and constitutive of (settler) colonialism. For one overview of science and masculinity, see Erika Lorraine Milam and Robert A. Nye (eds.), "Scientific Masculinities," *Osiris*, vol. 30, n° 1, 2015. In this respect, one might contrast the era of polar exploration in Svalbard with the era of the coal mine. However, the mine guide also shared that many (male) miners came from the mainland, worked for several years for high wages, and then returned to Norway. In this sense, many miners were transient, like earlier explorers. It is only more recently, especially with the decline of the coal industry and rise of science and tourism, that more families have established permanent homes in Longyearbyen.

data collected, and fieldwork completed, although many were serial polar explorer-scientists.[25] During the 1930s, Christiane Ritter, an Austrian painter, accompanied her naturalist husband to Svalbard and was the first woman to overwinter there. Apparently, one winter was plenty. In 1938, she published a book about her experience as "a woman in the polar night."[26]

16 The ability to overwinter and more easily experience the darkscape of polar night in Svalbard also changed with the discovery of coal and Munro's founding of the mine in 1906. Between then and the late 20th C., Longyearbyen was a classic company town. However, I suspect that the landscape –and specifically the darkscape– of the high Arctic heightened the town's dependency on the mine beyond standard arguments about a corporate near-monopoly on employment, ownership of housing and stores, and so on. Coal motivated year-round settlement. To maximize profits, mines needed to operate through winter –meaning, the dark season. Yet year-round living then required still more coal –for not only heat but also artificial light during the "days" of polar night. Coal thus altered Longyearbyen's energy budget. As Stephen J. Pyne explains, "The energy budget [of the poles] is always negative; none during the dark season, reflected away during the light."[27] Mining and using coal harnessed huge sums of energy in order to transcend these strict local constraints, making overwintering both feasible and easier.[28] Longyearbyen, by its very existence, suggests the fundamental link between artificial light and energy. However, by dramatizing this connection in an "extraordinary" landscape where it is dark for almost one-third of the year, it reminds us of these seemingly banal links elsewhere –indeed, everywhere.[29]

17 Coal was vital to Longyearbyen's founding and past, but it is not relegated to history. In the early 21st C., the town still relies on fossil fuel and specifically the coal from its surrounding mountains. Our coal mine tour guide explained that only mine 7 remains open and operational. The rest, like mine 3, have been decommissioned. Twenty-five percent of the coal extracted from mine 7 is used by the town to produce electricity –for light, heat, and other uses. The remaining seventy-five percent is shipped to the town's docks, transported, and sold (in island lingo) "on the mainland" (Norway). As we headed to and from the Svalbard airport, we passed the municipal electricity plant, as well as the harbor. Despite extensive artificial lighting around each large industrial facility, which would have made light-pollution scientists shudder, it was still hard to see the docks, ships, or coal.

18 Furthermore, fossil fuels, whether from Longyearbyen's own mine or elsewhere, undergird many other artifacts and systems in the town, connecting this "remote" place to almost anywhere in the world and thereby making it far less remote than high latitudes and sheer distances imply. Unlike polar explorers a century or more ago, many local residents expect the same goods, services, and conveniences that those on the mainland enjoy. Another guide explained that three supply flights land in Longyearbyen every week, even in winter. They replenish the grocery store, tiny medical facility, and numerous tourist shops, as well as connect locals with family and friends on the mainland and beyond –for those who still use snail mail. The flights mean that residents can count on packages being delivered three days per

25 These practices illustrate the idea of "centers of calculation." The classic work here is Bruno Latour, *Science in Action: How to Follow Scientists and Engineers Through Society* (Cambridge, MA: Harvard University Press, 1987).

26 Christiane Ritter, *A Woman in the Polar Night* (New York: Dutton, 1954).

27 Pyne, "The End of the World," 649.

28 My thinking here is influenced by Robert Marks's concept of the "biological old regime." See Robert Marks, *The Origins of the Modern World: A Global and Ecological Narrative From the Fifteenth to the Twenty-First Century* (New York: Rowman & Littlefield Publishers, 2002).

29 On extraordinary as simply extra-ordinary, see Gabrielle Hecht, "Nuclear nomads: A look at the subcontracted heros," *Bulletin of the Atomic Scientists*, January 9, 2012, https://thebulletin.org/2012/01/nuclear-nomads-a-look-at-the-subcontrac... (accessed 20 May 2019). At the same time, links between light and energy "everywhere" evade central questions about access, distribution, and (political) power, as well as some of the particularities of certain forms of energy and their affordances.

week. Locals may need to wait an extra day for, say, an Amazon package to arrive, but air travel, powered by fossil fuels, has annihilated time and space in the polar north, as elsewhere.[30] Moreover, unlike sea-based transit before the mid-1970s when the new, modernized airport became fully operational, travel is no longer seasonal, but year-round.[31] Longyearbyen may have some unusual characteristics, but fossil fuels enable the town to exist and then connect it with seemingly distant locales, thereby making it less distinct.

19 Everyone in Longyearbyen, whether residents or tourists, is therefore complicit in carbon-based energy regimes and climate change in multiple ways. Furthermore, there is not really a way to opt out, although one resident has tried to do so. On the bus, our mine guide shared that one Longyearbyen resident was extremely proud of his new Tesla. Apparently, though, he forgot where the town's electricity actually comes from: coal.

20 Trying to pursue alternative energy in a landscape and livelihood defined and dominated by coal is admirable. Yet, as our mine guide noted, many alternative energy sources are not really feasible in the high Arctic. Solar panels would yield huge sums of electricity during endless summer days –"the land of the midnight sun." However, the same panels would be useless during winter –"the land of the midday moon." To get through the long, dark season, enormous batteries would somehow have to store four months of energy –and without cold temperatures reducing storage capacity or efficiency.[32] Instead, some countries with rugged coastlines have turned to wind power. Wind in northern latitudes, including Norway, can be fierce. Svalbard is no exception. Our coal-mine guide asked us to consider, though, what it would be like to maintain and repair turbines during polar night.[33] I know that I wouldn't volunteer for the job.

21 As conference participants, we could reduce our considerable carbon footprints by turning down thermostats, turning off lights, reusing hotel towels, and so forth, but refusing fossil fuels entirely once in Longyearbyen, particularly in the depths of winter, would carry some serious consequences. January temperatures average −13 to −20° C (8.6 to −4.0° F), not including wind chill. The surrounding sea does moderate Svalbard's winters. However, winds can increase dramatically when cold polar air meets milder oceanic air from the south.[34]

22 Almost all food is imported. One greenhouse grows lettuce and other salad greens year-round, which the poshier local restaurants tout. We could see the greenhouse bathed in red light, 24/7, downhill from the conference hotel. I have to admit it was novel, but I wondered about the comparative carbon footprint of importing salad by plane versus growing it during winter via coal-fueled electricity. I suspect that light-pollution scientists would vote for imported lettuce. Two conference dinners did offer more locally sourced food: Svalbard reindeer and whale. (In case you are wondering, the former was delicious; the latter was not.)

23 We also received repeated stern warnings from the conference organizers: "for your own safety,

30 I thank Sarah Pickman for sharing this story about supply flights from the town tour she took during the conference. A classic study of the annihilation of space and time, drawing on Karl Marx, is Wolfgang Schivelbusch, *The Railway Journey: The Industrialization of Time and Space in the Nineteenth Century* (Berkeley: University of California Press, 1986).

31 For a basic history of the Svalbard airport, see https://en.wikipedia.org/wiki/Svalbard_Airport,_Longyear (accessed 11 July 2019). Of course, bad weather can cause air travel delays, but most flights still arrive and depart in winter.

32 The special challenges facing batteries in the polar north illustrate the premise of envirotech. For work that has applied an envirotechnical lens to batteries, see James Morton Turner, "Following the Pb: An Envirotechnical Approach to Lead-Acid Batteries in the United States," *Environmental History*, vol. 20, n° 1, 2015. Alternatively, if Svalbard could connect to some sort of European-wide grid, it would be able to produce extensive electricity in summer, then tap reserves drawn from elsewhere during the winter. I thank Stéphanie Le Gallic for suggesting this point.

33 For one work on maintenance and repair in the history of technology and science studies, see Andrew L. Russell and Lee Vinsel, "After Innovation, Turn to Maintenance," *Technology and Culture*, vol. 59, n° 1, 2018.

34 For an overview on Svalbard's weather and climate, see https://en.wikipedia.org/wiki/Climate_of_Svalbard (accessed 11 July 2019)

Figure 4: Gun storage locker and warning at the entrance of the supermarket in Longyearbyen. Photo by the author.

you should not go out for walks outside the inhabited areas if you are not accompanied by someone who can carry (and fire) a rifle."[35] Reminders of polar bears were everywhere (fig. 4). Furthermore, during the first conference dinner, some of us learned that Svalbard's polar bears do not leave the islands and head out onto the ice in winter. Even better, the archipelago's polar bear population (3,000) actually outnumbers its permanent human population (2,200). Does the town's extensive artificial lighting, powered by coal, attempt to segregate its large mammals –human and otherwise?

24 Current practices to conserve energy further show how dependent Longyearbyen is on coal. Many of us had hoped to visit the town's Polar Expedition Museum. Like many conference attendees, I hadn't planned ahead and failed to realize that the museum was normally closed in January. The museum did state it would open for special groups if at least 15 people committed to visiting. Our academic (read: nerdy) conference would have had no problem meeting this minimum. One participant actually contacted museum staff on Thursday, the day before we left, to see if they would be willing to open Friday morning before most of us flew out that afternoon. They apologized, but said they need three days' notice in order to warm up the building for visitors.[36] In the heart of Longyearbyen's dark season, it took that long for the building to heat up. The environment of the far north therefore requires modifications to customary architectural practices.[37] Although many of us were disappointed to miss the museum, we joked that we would have been perfectly happy touring it in our down parkas, ski pants, and wool hats. After all, most of us had spent a half-day outside on dog sleds in single-digit temperatures earlier that Thursday, but it was, alas, too late.

The museum's policy suggests how power failures 25
are serious business in the high Arctic. Blackouts matter for heat, but they also matter for light, foremost during the dark season of polar night.[38] David E. Nye has noted that unexpected blackouts in the global North sometimes foster unexpected conviviality and community.[39] Planned brownouts in the global South can enable systems to continue operating; functioning thus depends on periodic dysfunction. Consequently, families and neighbors organize aspects of their lives around the temporary availability of electricity or water. But, unlike their peers in the developed world, many live with the expectation that energy will not always be available.[40] Based

35 For the "practical information" the conference organizers shared with participants, see https://darkness-conference2019.wordpress.com/practical-information/ (accessed 11 July 2019)

36 I thank Michaela Thompson for sharing this story.

37 On envirotech and architecture, see Sophie Hochhäusl, "The Environment Is Social, Is Political: About Core Houses and Envirotechnical Regimes," *in* "Field Notes: Architecture and the Environment," (ed.) Sophie Hochhäusl and Torsten Lange, *Architectural Histories*, vol. 6, n° 1 (special issue), 2018., http://doi.org/10.5334/ah.259

38 The field of disability studies offers considerable insights here in terms of the presumed ableism of light and sight. Blind and visually impaired people would have fewer challenges during blackouts, although other aspects of a blackout in the far north during winter would probably still present serious issues.

39 David E. Nye, *When the Lights Went Out: A History of Blackouts in America* (Cambridge, MA: MIT Press, 2010).

40 Brownouts are not, however, exclusive to the so-called developing world, thereby challenging such a tidy dichotomy and generalization. For instance, in May 2019, the huge

on my brief time in Longyearbyen, I wouldn't want to be there during a power failure, most of all in winter. Considering this exceptional possibility reinforces, then, the town's everyday reliance on coal.

26 As conference participants and tourists, we were complicit in coal extraction, fossil-fuel dependency, and the environmental consequences of Longyearbyen's energy regime far beyond the coal dust on our hands and faces from the mine tour. The carbon footprint of the coal industry here, as in other places, is overt and direct. It is easy to blame miners and corporate headquarters. As tourists, our substantial carbon footprints were mediated and obscured by many technologies and intermediate steps –from the computers we used to write our conference papers to the airplanes that brought us from Australia, North America, South Africa, and Europe. During the mine tour, I watched new friends and colleagues don miners' coveralls (*lompen*, fig. 5) and crawl awkwardly through the most generously sized tunnels (90 cm high) for a dozen meters, behinds wagging in the air. That mining "experience" was nothing like the real thing, though: sometimes 30-centimeter-wide tunnels requiring miners to inch along on bellies, limited lighting, and a full day of hard labor underground, not to mention the constant threat of mine collapse.

27 I was both amused and uncomfortable as we played in what had been miners' hazardous workscape.[41] It was surreal seeing scholarly concepts brought to life before my very eyes

Figure 5: A miner's work suit (lompen) hanging near the entrance to mine 3. Note the reflective bars on the suit to facilitate seeing fellow miners in the depths (and darkness) of the mine. Photo by the author.

(fig. 6). To her credit, our mine guide did not entirely change risky histories of work into mere play. She told us how many miners had died since the first mine's founding in 1906; I am embarrassed to say that I no longer remember how many men have been lost. However, when I then asked her about miners' rates of injury and disease, she couldn't answer my question. My uneasiness, belied by the smile in this photograph during the mine tour, grew.

28 The final displays at the Svalbard Museum narrate these recent changes in Longyearbyen, including shifting manifestations of coal from an exclusive landscape of labor to, increasingly, one of leisure. Since the 1990s, scientific research and tourism have expanded, diminishing the power of the coal company in town. Thirty thousand tourists now visit Svalbard each year –a significant number, given Longyearbyen's permanent population. Summer visitors play in the midnight sun. Winter tourists hope to see the northern lights and explore the darkscape of

California utility, Pacific Gas and Energy (PG&E), announced that it would require occasional brownouts during the summer of 2019 to reduce wildfire risks after a catastrophic fire season the previous year. For one story, see "PG&E Plan to Cut Power on Windy Days Could Leave Millions in the Dark," *Mercury News*, 14 May 2019, https://www.mercurynews.com/2019/05/14/california-may-go-dark-this-summ... (accessed 1 July 2019)

41 Richard White, "'Are you an environmentalist or do you work for a living?' Work and Nature," *in Uncommon Ground: Rethinking the Human Place in Nature*, (ed.) William Cronon (New York: Norton, 1996); Thomas G. Andrews, *Killing for Coal: America's Deadliest Labor War* (Cambridge, MA: Harvard University Press, 2008); Thomas G. Andrews, "'Made by Toile'? Tourism, Landscape, and Labor in Colorado, 1858-1917," *Journal of American History*, vol. 92, n° 3, 2005.

Figure 6: The author in the "tool room" of former mine 3, now a tourist destination. This room includes many of the different kinds of tools Longyearbyen miners have used over the past century. All tour attendees were given hard hats with headlamps before we descended into the mine. Later, some attendees donned lompen. Photo by the author.

polar night beyond town by dog sled or snowmobile,[42] although the skyglow of Longyearbyen reaches far beyond town borders.[43] The striking light/dark cycle of the high Arctic –when these "cycles" are in fact mutually exclusive seasons, each lasting for months at a time– is therefore central to both summer and winter tourism. While some tourist economies suffer during the off-season –for instance, ski resorts seeking to recruit summer hikers and mountain bikers– the attraction of Longyearbyen is less seasonal and more stable. The town profits from light and dark tourism at their limits.

Yet coal still undergirds and enables the tourist 29
industry, even if this reliance is largely hidden.[44] Tourism is not necessarily a more sustainable industry or future for Svalbard. To the contrary, if tourism continues to expand, it may actually increase coal consumption in a region already more vulnerable to the effects of climate change. This is especially true if Svalbard attracts tourists who come not to "rough it" in tents with rustic services, but to expect reliable energy and amenities of the global North: comfortable hotels with flush toilets, hot showers, crisp white sheets, and wifi; alcohol imported from the mainland (and, more likely, far beyond); fruit salad at lavish breakfast buffets; and so forth. Our "Darkness" conference? Guilty as charged.

Of course, ironies abound. Growing tourism to a 30
remote location in the high Arctic worsens climate change that polar scientists at the University Centre in Svalbard (and elsewhere) study just a few hundred meters from shore. Given predictions of sea-level rise, will the University Centre need to move to higher ground in coming years? Even in the dimness of polar night, I could see new hotels and apartment buildings under construction. Meanwhile, old buildings are starting to heave out of the permafrost. Others are beginning to rot. Both processes threaten the town's cultural heritage. Even relatively new homes have become undermined, and new construction therefore rises from steel –rather than traditional wood– beams.[45]

Environmental and geologic destabilization asso- 31
ciated with global climate change suggests how time is nonlinear, differentially distributed and

42 Many conference participants downloaded a northern lights app on their phones. At one restaurant, a large, high-quality LED screen constantly streamed the "night" sky so tourists could get real-time updates on the quality of the northern lights. Notably, imaging technologies amplify the green hue of the northern lights, making them greener (and supposedly "better") than what appears to the naked eye.

43 On the dogsled excursion, Longyearbyen's skyglow was readily visible on much of the "return" portion of the loop course. Other artificial lights were present –from the headlamps all sled drivers were required to wear, to the headlights on snowmobiles on tracks farther up the hillsides. Nonetheless, being in the hinterlands of Longyearbyen under moonlight and stars –with snow and clouds reflecting both natural and artificial light– was a remarkable experience that is (still) hard to describe.

44 White, "'Are you an environmentalist?'."

45 I thank Catie Newell for sharing some of these stories from her town van tour. See also Thomas Nilsen, "Thawing Permafrost Makes Big Trouble for World's Northernmost Town," *Barents Observer*, 9 October 2018, https://thebarentsobserver.com/en/arctic/2018/10/thawing-permafrost-tro... (accessed 1 July 2019); Christine Karijord, "Climate Change Threatens Svalbard House," *High North News*, 25 October 2018, https://www.highnorthnews.com/en/climate-change-threatens-svalbard-hous... (accessed 1 July 2019)

experienced. Time is speeding up in the polar north. In 2016, "meltwater seeped into the entrance tunnel of the Global Seed Vault," on the hillside above Longyearbyen. Even in polar night, we could see the outline of the building because it was marked with lights and an illuminated Christmas tree. As one journalist wrote, "the breach made the world wonder: Will the Doomsday Vault last until doomsday?"[46] This timeframe is even more astonishing because the Global Seed Vault opened in early 2008, just eight years earlier. The built environment of Longyearbyen, constructed according to old codes and norms, is becoming rapidly obsolete as the pace of global warming quickens at the poles. Climate change is challenging and undermining existing envirotechnical systems, including –if not especially– those in the far north.[47] Even in the darkness of real polar night, I could sense the ways that Longyearbyen is an endscape, even as I, and other conference participants, contributed to its very making.

LIVED EXPERIENCES AND ENDSCAPES

32 Three months later, in April 2019, I ran into a fellow "Darkness" participant at another academic conference. (This time our carbon footprints were, thankfully, much smaller.) At an evening reception, we smiled and shook our heads at one another, still struggling to process our time in Longyearbyen. Both of us had written up field notes during and after our stay, but we agreed that they didn't adequately capture our experience there. I've been humbled by my inability to articulate what it was like.

33 Time and distance have helped –somewhat– although it is increasingly difficult to recall all the subtle sensory experiences of being in those remarkable lightscapes and darkscapes. Spending time, however limited, in Longyearbyen drove home the potential of experiential, reflexive ways of contending with light/dark.[48] Stéphanie and I co-wrote the Introduction to this special issue during the fall and early winter of 2018. A few weeks later, I was in Svalbard. Once there, some of the central themes of this issue –dynamic definitions of light and dark, porous borders, relationality, and multiplicity, among others[49]– became more tangible, even visceral, to me as I experienced light/darkness in all of its complexity. In the process, many of these themes shifted from more abstract, scholarly concerns to felt, lived experiences –a pattern I've found elsewhere in my fieldwork with light-pollution scientists. At the same time, with this special issue in mind and confronted with the actual, physical experience of being in Longyearbyen, I began thinking about this place as a landscape of energy.[50] I also began reflecting on the inseparability of these processes and histories.

Svalbard's "extreme" environment –specifically 34
its weather and polar light/dark cycle– has shaped the history of energy in Longyearbyen. In turn, artificial lighting, fueled by locally mined coal, not only contributes to climate change in a region already vulnerable to faster rates of environmental transformation, but also significantly alters the stunning darkscape of polar night.[51] Such changes in light-dark cycles in many parts of the world are, arguably, unprecedented in planetary history.[52] Trends elsewhere –patterns that are simultaneously local and global– are thus magnified at the poles. Longyearbyen may therefore be a generative case study for other endscapes in the early 21st C.[53]

46 Bridget Alex, "Artic [sic] Meltdown: We're Already Feeling the Consequences of Thawing Permafrost," *Discover Magazine*, 3 January 2019, http://discovermagazine.com/2018/jun/something-stirs (accessed 1 July 2019)

47 For one overview to envirotechnical systems, see Sara B. Pritchard, *Confluence: The Nature of Technology and the Remaking of the Rhône* (Cambridge, MA: Harvard University Press, 2011), especially the Introduction.

48 Adrian Howkins, "'Have You Been There?' Some Thoughts on (Not) Visiting Antarctica," *Environmental History*, vol. 15, n° 3, 2010.

49 Le Gallic and Pritchard, "Light(s) and Darkness(es)."

50 Christopher F. Jones, "A Landscape of Energy Abundance: Anthracite Coal Canals and the Roots of American Fossil Fuel Dependence, 1820-1860," *Environmental History*, vol. 15, n° 3, 2010.

51 As light-pollution scientists and activists are quick to point out, "natural darkness" is usually not that dark, due to celestial phenomena such as the moon, stars, Milky Way, airglow, and zodiacal light.

52 Sibylle Schroer, "STARS4ALL: Citizen Science to Save European Nightscapes," presentation at *Artificial Light at Night Conference*, Snowbird, Utah, 12-14 November 2018.

53 Many have been in the news –from Bangladesh and island nations like the Maldives to Venice, New Orleans, and New York City.

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OUT OF THE BOX

Interpellation

- **A call to historicize wind and site studies,**
  Rémi Gandoin
- **A Response to "A call to historicize wind and site studies",**
  Matthias Heymann

ISSN 2649-3055

JEH RHE

Journal of Energy History
Revue d'histoire de l'énergie

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POST DATE
08/04/2019
ISSUE NUMBER
JEHRHE #2
SECTION
Out of box
KEYWORDS
Eolian, Power, Knowledge, Environment, Renewable
DOI
in progress

TO CITE THIS ARTICLE
Rémi Gandoin, "A call to historicize wind and site studies", *Journal of Energy History/Revue d'Histoire de l'Énergie* [Online], n°2, published 08 avril 2019, consulted XXX, URL: http://energyhistory.eu/node/115.

A call to historicize wind and site studies

Abstract
Cet article appelle les historiens à inclure les études sur le vent et les sites dans leurs investigations relatives à l'énergie éolienne. Il fournit un certain nombre d'éléments intrinsèques et extrinsèques sur ces études qui pourraient faire l'objet de recherches plus poussées dans un contexte académique. Du design des turbines éoliennes à la perception par le public des renouvelables, ces sujets importent à l'heure où l'on tente de rendre nos sociétés plus adaptées aux énergies non-fossiles, intermittentes mais illimitées. La vaste majorité des documents mentionnés ici sont accessibles en ligne, notamment sur le site web de l'auteur: aeolians.net.

JEHRHE a invité Matthias Heymann, historien spécialiste de l'énergie éolienne, à commenter ce texte.

Acknowledgments
It appeared after a pleasant discussion with the editors that my considerations were relevant to the Journal of Energy History. I would like to thank them for reviewing this article and giving me the opportunity to publish it. In addition, I would also like to thank Matthias Heymann for his inspiring work and his comment on the present "interpellation".

Plan of the article

ISSN 2649-3055

Katsushika Hokusai (1760–1849), Ejiri in Suruga Province, circa 1830 for the first publication (here circa 1930). Wikimedia Commons.

CONTEXT

1 I have been working as an engineer in the wind industry for about ten years, first with onshore wind and for the last seven years almost only with offshore wind projects. My specialty is the study of wind, waves and other site conditions, in relation with the design of wind farms (the design of foundations and substructures, turbine layouts, the analysis of expected and achieved production-, wind- and metocean measurements). It is referred to commonly as "wind and site assessment studies", or in short "wind and site studies", but other denominations exist.[1]

2 For the past three years, I have been collecting documents and testimonies from the last decades, aiming at sketching the contours and boundaries of my field of expertise. I am gathering very concrete and detailed studies from the past, highlighting their context within the wider history of wind energy on a website: aeolians.net. This approach provides a factual basis for identifying the boundaries of my discipline, which interfaces with several other fields of engineering and science (meteorology, turbine design, project development and spatial planning, marine industry, energy policy, etc).

3 From a wider perspective, this project allows me to think about my work in its societal and epistemological context. That is in concise terms: to understand what there is to know, what needs to be known and what for, how it can be known and how this relates to the daily life in the office. Besides being relevant for providing some technical insight into a small subset of the energy industry, drawing up a genealogy of wind & site studies helps explore the relationship between technology and the study of nature.

1 Are also common: "wind resource and layout", "wind resource assessment", "metocean studies" (for offshore work), "site conditions" (in design standards). The term "wind & site" is used by Vestas Wind Systems and is, in my personal opinion, a well-suited expression.

INTRODUCTION

4 Wind & site studies are, in short, studies of the general and site-specific properties of the wind that are relevant for wind turbine and wind farm design. The work consists in characterizing these conditions by means of in-situ and remote sensing measurements (when relevant), carrying out subsequent analysis work (expected production, derivation of design parameters), and other affiliated tasks (turbine data analysis for instance). As such they form a relatively well-defined field of wind energy engineering, relatively young (it started after the second world war, together with the first modern turbine prototypes, but emerged commercially only in the late 1970s). The present article provides an insight into some aspects of wind and site studies that could be relevant to historical studies of wind energy.

5 Before looking into these aspects, it is important to mention that there exists already a great deal of publications (books, articles, dissertations, but also websites) dealing with the history of wind energy and wind turbine design in particular. To name a few key contributors: Heymann, Karnøe and Nielsen in Denmark, Gipe and Righter in the US, Rogier in France. These publications focus on wind turbine design or the wind energy market in general, and wind & site studies are not generally treated in detail. While acknowledging that all disciplines involved in wind energy form in reality a continuum of activities and that separations between them may sound artificial, the present article puts wind & site studies at the centre of the analysis and derives therefrom its relationships to other fields. By doing so, it neither challenges the existing literature, nor proposes alternative narratives on the wind energy history; on the contrary it proposes a vision of wind energy history, seen from a wind & site studies perspective, that is consistent with the existing works.

6 The article is structured as follows: first, through specific examples, it suggests that the relatively large corpus of wind and site studies (spanning the 20th century), could complement historical studies of wind turbine technology. In essence, the present article argues that the study of wind quantity and quality has been, to some extent, necessary to develop nowadays turbine technology and to support its global development, planning, and integration into the energy mix. Secondly, this article focuses on wind energy meteorology as a field of science. Since the late 1970s, the field of wind and site studies consists of both commercial and project-specific consultancy work, but it also includes applied and fundamental research in atmospheric sciences and fluid dynamics. This research work is typically carried out not in national meteorological institutes and atmospheric science laboratories, but instead in separate wind energy meteorology institutions. This article proposes to investigate whether/how the scientific knowledge created by the wind energy meteorology research is transferred to the wider atmospheric science research world, and suggests that studying the interplay between the wind energy industry, wind energy meteorology research, national weather institutes and the rest of academia could help understand the interplay between engineering and science, as well as the differences between engineering and scientific knowledge production. Lastly, this article proposes to explore how wind and site studies, as well as other pre- and post-construction surveys (for instance in offshore wind: soil, met ocean, preventive archaeology, fishing, fauna and flora impact surveys) provide to a wider audience a new set of information that can change its perspective on a territory, from a “natural” to an “energy resource” perspective. Examples are taken from the North Sea and Denmark and may be relevant for environmental historians.

WIND AND SITE STUDIES, DESCRIPTION AND TEXT CORPUS

7 Wind turbines are immersed in the atmospheric boundary layer, a fluid which differs in many aspects from the controlled experimental setup of aerodynamic studies, and from modelling results. Therefore, it was and still is, a necessity for the turbine designer and/or operator to consider the general and site-specific wind conditions to ensure technical and financial reliability

of a project. The study of these wind characteristics is referred to, since the late 1970s, as: "wind and site studies".[2] It is a field of engineering which aims at answering the following questions:

- *How much wind is there?* This involves accurate and precise measurement of wind speed and direction, as well as other atmospheric variables (temperature, pressure, humidity).
- *How much does the wind vary spatially and temporally?* Derivation of the wind climate at a site (statistical distribution of the wind speeds and directions, turbulence), or in a given area.
- *How much energy will the turbines produce, how to place them in an optimal way?* Energy production calculations, layout of wind farms.
- *How are these wind conditions affecting turbine design?* In particular for the first small and large prototypes, but also for the turbines nowadays (including offshore conditions), understanding the structure of wind (and waves) is a key to success.
- *How to optimize the design of a park?* This is especially true for offshore wind parks, where the study of wind, wake effects, waves and soil plays a large role in the reduction of the costs. Onshore, the study of the spatial variation of the wind resource, turbulence or other wind features helps optimize the production.
- *How to bridge the gap between expected and actual production?* A great deal of analysis is carried out in order to re-analyse production data, explain differences between expected and actual production, and carry out updated uncertainty estimates of the long-term and short-term production.

8 The field has evolved together with wind turbine design, and there exists a corpus of technical reports on wind & site studies at all the stages of the history of wind energy:

- Before the first world war, only sparse and individual studies of wind turbine efficiency in open air are available.[3]
- During and after the second world war and up to the late 1960s, a large number of surveys can be found beside the numerous reports of Johannes Juul[4] and Edward Golding[5] for instance. The main contributions identified so far are listed below:
  * Works by Palmer Putnam[6] and Percy Thomas[7] in the US: the former describes in detail a number of wind & site studies during 1940-1945, as well as the reasons for making such studies (with contributions from Theodore Von Karman and Sverre Petterssen).
  * Coordination effort as part of the OEEC Working Party n°1: in the proceedings[8] published in 1954, 19 papers (out of 45) fall under the topics "Wind Regimes and Studies, Selection of Wind Power Sites, and Wind Measurements and Measuring Instruments".
  * UNESCO and UN[9] conferences: in the latter, 14 papers (out of 40) fall under "Studies of Wind Behaviour and Investigation of Suitable Sites for Wind-Driven Plants".
  * Wind and site studies carried out as part of national and international research programs, see for instance the case of

2 See also "Context" in this article.

3 See for instance Vladimir Rafailovich Sektorov, "The Present State and Planning and Erection of Large Experimental Wind Power Stations", *NASA Technical Translation* (report NASA TT F-15, 512), April 1974 [1933].

4 See the very early and complete Johannes Juul, "Investigation of the possibilities of utilisation of wind power", *Elektroteknikeren*, Vol. 45, October 1949.

5 Edward W. Golding, *The Generation of Electricity by Wind Power* (London: E. & F.N. Spon, 1976 [1955]), covers wind and site studies in 10 out of 19 chapters.

6 Palmer Cosslett Putnam, *Putnam's Power from the Wind* (New-York: Van Nostrand Reinhold, 1982).

7 Percy Holbrook Thomas, "Harnessing the Wind for Electric Power", *in United Nations Scientific Conference on the Conservation and Utilization of Resources*. 17 August – 6 September, Lake Success, New-York. Volume III Fuel and Energy resources (Lake Success: United Nations Dept. of Economic Affairs, 1950-53)

8 Organisation for European Economic Co-operation, Committee for productivity and applied research. Working party n° 1 (Wind Power), *Technical Papers Presented to the Wind Power Working Party* (London: H.M. Stationary Office, 1956).

9 UNESCO, *Arid Zone Research. Wind and Solar Energy. Proceedings of the New Delhi Symposium* (Paris: 1956).

France,[10] the UK,[11] as well as studies of the global wind resource commissioned by the UNESCO.[12]

- From 1973 onwards, all conferences led and organized by the American research program include numerous papers on wind and site studies.[13]
- From 1978, the first commercial/consultancy reports were produced in the US.[14]

9 With only a couple of exceptions, this text corpus is available at https://aeolians.net/library.

INCLUDING WIND AND SITE STUDIES IN THE HISTORY OF WIND ENERGY

10 Works about the history of wind energy mainly report, rightly so, about the development of wind turbines. They highlight the pros and cons of the different concepts and narrate the parallel developments, in the 1970s, of the grass-root movements in Denmark and the large national R&D programs (USA, Germany). See for instance the work of Matthias Heymann[15] or by Preben Mægaard, Anna Krenz and Wolfgang Palz:[16] both references provide a detailed description of these two design traditions, that is: the successful 3-bladed upwind Danish turbine concept from Johannes Juul (1887-1969), and the now-abandoned 2-bladed downwind concept inspired by Ülrich Hütter (1910-1990). However, in these works, the study of site conditions (wind characteristics, siting of the turbines) is not reported in detail, nor identified as a separate field. Wind conditions are either shortly described together with other design constraints or presented in the context of a turbine mechanical failure.[17] In other works, site conditions are reported by practitioners in the form of anecdotes.[18]

11 It seems however that rare were the wind and site studies isolated from wind turbine design studies or renewable energy programs. Thereby, the text corpus above-mentioned is in itself rather well structured, making it already possible for the practitioner to build up a genealogy of wind and site studies. The examples listed below, together with a short argumentation, aim at making the wind and renewable energy systems' historians' community aware of these studies, as they could complement existing works and/or shed a new light on some possibly yet unexplored research topics. The first example focuses on the works by post-war wind energy pioneers, the second one focuses on the US wind turbine research program in the 1970s-1980s. Finally, when focusing on the period starting in the early 1980s, considerations on the role of wind & site studies for the development of the wind industry are provided.

Post-war pioneers

12 Taking as examples Juul and Golding, both published many wind and site studies results. Golding especially has worked mainly on these topics.[19]

10 United Nations, *Proceedings of the United Nations Conference on new sources of energy: solar energy, wind power and geothermal energy*, Rome, 21-31 August 1961 (New-York: United Nations, 1963).

11 Rémi Gandoin, "Ailleret, Serra, and the Wind Resource of France: 1946-1953", 09/03/2018. Url: https://aeolians.net/2018/03/09/ailleret-serra-wind-resource-france/ (accessed 12/03/2019).

12 Energy Research Agency, *Reports on Wind Power published by ERA, 1949 to 1968*, Volume 1: *Wind Measurements and Characteristics. 1975*. ADD vol 2, etc.

13 World Meteorological Organisation, *Technical Note n°4. Energy from the Wind. Assessment of Suitable Winds and Sites* (Geneva: WMO, 1954).

14 Rémi Gandoin, "Workshops and conferences, 1973-1980", 15/12/2017. Url: https://aeolians.net/2017/12/15/workshops-and-conferences-1973-1980/ (accessed 12/03/2019).

15 Matthias Heymann, "Signs of Hubris: The Shaping of Wind Technology Styles in Germany, Denmark, and the United States, 1940-1990", *Technology and Culture*, Vol. 39, n°4, oct. 1998, 641-670.

16 Preben Maegaard, Anna Krenz, Wolfgang Palz, *Wind Power for the World: The Rise of Modern Wind Energy* (Singapore: Pan Stanford publ., 2013).

17 *Id*. Chapter 5 or Matthias Heymann, "Signs of Hubris: The Shaping of Wind Technology Styles in Germany, Denmark, and the United States, 1940-1990", 647 (cf. note 15) as well as Trevor J. Price, "Edward Golding's Influence on Wind Power", *Wind Engineering*, vol. 29, n° 6, 2005, 513-530.

18 See for instance Matt G. Hopkins, *The Makings of a Champion or, Wind Innovation for Sale: The Wind Industry in the U.S. 1980-2010* (Cambridge MA: Academic-Industry Research Network, 2013) or Peter Asmus, *Reaping the Wind: How Mechanical Wizards, Visionaries, and Profiteers Helped Shape Our Energy Future* (Washington: Island Press, 2001).

19 Edward William Golding, *The Generation of Electricity by Wind Power* (London: E. & F.N. Spon, 1976 [1955]).

He worked for instance on how to accurately measure wind speed distributions, assess the speed-up above hills and compute estimates of energy production using the turbine technology available at the time (that is, mainly from Palmer Putnam and Johannes Juul). He also worked on characterizing atmospheric turbulence and its effect on the turbine power performance. The work carried out by himself and his colleagues from the Energy Research Agency included advanced anemometry and extensive field study and data analysis.[20]

13 Johannes Juul, in Denmark, provided as early as 1949 some experimental results about wind conditions across Denmark, as well as their influence on turbine production.[21] In the OEEC Technical Report n° 38,[22] he includes experimental evidence of the different turbulence conditions onshore and offshore, and their effect on the turbine performance. Juul has also taken advantage of the OEEC Working Group Party to improve his testing procedures, for instance by using an anemometer developed as part of the French wind survey. He used his knowledge of the wind speed distribution and the turbine site, together with test results, to design optimal turbines in terms of rated power, rotational speed and rotor diameter. Anecdotally, he explained[23] how the Smith-Putnam turbine (famous for being the first MW-size turbine) was in effect not optimally designed:

> At 16 m/s wind, it developed 1500 kW and at 12 m/s about 700 kW. The plant, however turned out a disappointment. It soon appeared that powerful winds occurred with the same frequency at Grandpa Knob as at Zealand in Denmark and with the great tip velocity the plant did not supply any current till at about 9 m/s wind and with but a low usable energy, at that. Had the mill been constructed so as to rotate at barely half its speed, it might have supplied more than twice the amount of energy and it would not, then, have been necessary to dimension gears and generator for more than 600 kW. Actually, the plan corresponded in size to a 600-kW plant when adjusted to our wind conditions which correspond to those prevailing in U.S.A.

14 The unfortunate over-estimation of the mean wind speed at Grandpa Knob by Putnam and his team involved common challenges of wind & site studies: characterization of the vertical wind profile, spatial variation of the wind resource, lack of confidence in pre-existing nearby measurements, and an instrument calibration error[24]. Although not at the root of the Smith-Putnam turbine problematic design, the lack of knowledge of the impact of wind conditions on the turbine production and loading may have played a role in the fate of the project. As Palmer Putnam writes:[25]

> It was not until the summer 1945, [...] that it was learned that the "anomaly" at Mount Washington had been caused by the application of an arbitrary correction to the anemometer records *(ed: used for the long-term correcting the on-site measurements)*. The correction had been applied by one of the observers without notification to the users of the published data. It is quite likely that we have this observer to thank for the Smith-Putnam Wind-Turbine experiment. If it had been known at the end of 1940 (ed: when they conducted on-site measurements) that not only was there no anomaly, but also little wind

20 Rémi Gandoin, "Golding and ERA (1949-1965)", 27/11/2018. Url: https://aeolians.net/2018/11/27/golding-and-era-1949-1965/ (accessed 12/03/2019)

21 Johannes Juul, "Investigation of the possibilities of utilisation of wind power" (cf note 4). See also Rémi Gandoin, "Wind works, Johannes Juul (1949-1962)", 05/03/2019. Url: https://aeolians.net/2019/03/05/wind-works-johannes-juul-1949-1962/ (accessed 12/03/2019)

22 Johannes Juul, "Results Obtained with the Experimental Windmill of Sydøstsjællands Elektricitats Aktieselskab-Seas", *Technical Paper* n° 38 in (OEEC, 1956).

23 Johannes Juul, "Results Obtained with the Experimental Windmill of Sydøstsjællands Elektricitats Aktieselskab-Seas", *Technical Paper* n° 38 in (OEEC, 1956).

24 Rémi Gandoin, "'Wind is not wind': Palmer C. Putnam wind studies (1939-1945)", 22/11/2018. Url: https://aeolians.net/2018/11/22/wind-is-not-wind-palmer-c-putnam-wind-s... (accessed 12/03/2019)

25 Putnam Palmer Cosslet, *Putnam's Power from the Wind* (cf. note 6).

> at those elevations below which we did not fear ice, it is likely that the experiment would have been abandoned out of hand.

15 And according to Sverre Pettersen:[26] *"The meteorology, the wind regimes, icing storms, and damaging gusts became my domain. This turned out to be the least explored area and it soon became the crux of the project"*.

16 These few examples are provided in order to highlight that wind and site studies were an inherent part of the work in wind energy and turbine design in the post-war period, and that both Johannes Juul and Edward Golding - two of the "pioneers" - contributed significantly to this field. As also reported by Palmer Putnam, being able to quantify the wind conditions before and after the construction of the prototype was key to taking the right and cost-effective decisions. Juul discussed much of his trials and retrospective adjustments to his turbines in his papers, using observations of both wind and turbine structural conditions. Unlike Ulrich Hütter, Johannes Juul did not develop a detailed modelling of the wind/turbine interaction, but instead and with great talent quantified accurately and precisely the influence of wind conditions on the prototype. As this has proved to be a very good way to engineer wind turbines, it may therefore be relevant and interesting to consider wind & site studies of the wind energy pioneers in historical research work. Some very interesting research work[27] has compared the trajectories of Johannes Juul and Palmer Putnam, in a very detailed manner. Could some considerations about the wind & site aspects of their works maybe help understand better the similarities and differences between the two approaches? The contribution of Ulrich Hütter to the study of the wind conditions and their impact on turbine design could also be further developed, and/or advertised.[28]

The NASA wind turbine program

17 From 1973 to the late 1980s, NASA developed a number of large (MW size) turbine prototypes, with the aim of making them industrial successes. The rationale that led NASA to choosing a 2-bladed MW-size turbine can be traced in conference proceedings, as early as 1974.[29] A General Electric (GE) parametric study[30] commissioned by NASA-Lewis,[31] and finalized in 1976, is the seminal study which recommended building MW-size machines. This recommendation was based on a parametric optimization model which concluded that small turbines are more than four times more costly than bigger turbines, for the same mean wind speed at a given site. Later, in the late 1970s and the mid 1980s, the large weight of the components caused issues to the MOD program and it was discontinued. The details of this calculation are provided in Vol. 2 Section 4 of the GE report from 1976[32] where the cost model is described in Section 4.3.1 of *Id*. as containing an optimization module of the rotor itself. It seems to have used rated power, rotor speed and rated rotor speed as independent variables, while the rotor diameter was only set thereafter as a dependent variable. This may have strongly biased the results against small rated powers: turbines with small rated power were assigned rated wind speed smaller than the large turbines and provided with larger (costlier) rotors compared to the previous practice[33]. As highlighted by the Juul' remark above about the non-optimal rated power of the Grandpa Knob turbine, care should be taken in designing

26 Rémi Gandoin, "'Wind is not wind': Palmer C. Putnam wind studies (1939-1945)" (cf. note 24).

27 Kristian Hvidtfelt Nielsen, "Technological Trajectories in the Making: Two Case Studies from the Contemporary History of Wind Power", *Centaurus*, vol. 52, 2010, 175-205.

28 Rémi Gandoin, "Ulrich Hütter's contributions (1942-1979)", 29/11/2018. Url: https://aeolians.net/2018/11/29/ulrich-hutters-contributions-1942-1979/ (accessed 12/03/2019)

29 Olle Ljungström (ed.), *Advanced Wind Energy Systems. Workshop proceedings. Stockholm, August 29-30, 1974* (Stockholm: Styrelsen för Teknisk Utveckling, 1976), 7-25 where the MOD-0 100kW prototype was announced.

30 General Electric Company, *Design Study of Wind Turbines 50kW to 3000kW for Electric Utility Application*. Volumes 1-3. September 1976.

31 And summarized in Frank R. Eldridge (ed.), *Proceedings of the second Workshop on Wind Energy Conversion Systems. Washington, 1975* (Washington: Government Printing Office, 1976).

32 General Electric Company, *Design Study of Wind Turbines 50kW to 3000kW for Electric Utility Application* (cf. note 28).

33 *Id*., Figure 4-5.

wind turbines, not only considering their average aerodynamic performance, but instead the total energy output. The optimization routine of the GE study seems to differs from these principles, and thereby may have favoured large turbines (technically complex), which proved to be detrimental to the MOD program. This episode of wind energy is discussed in detail in wind energy historical works.[34] As mentioned above, the NASA turbine prototypes suffered from a number of issues, some being related to the wind conditions:[35]

> *The following paragraphs quote a leading American wind engineer. He summarizes the technological experience from the first 10 years of wind technology development (Stoddard, 1986).The biggest lesson that we engineers have learned in California: the engineering problems are much more difficult than we originally thought (p. 84). This has largely boiled down to two areas of technical uncertainty: the aerodynamic loads and the dynamic motions. We were guilty of 'steady flow' aerospace-type thinking, and largely did not appreciate the range and difficulty of the wind environment (p. 85). Design risk is generally in the wind turbine industry because we still can't adequately predict rotor aerodynamic loading and rotor dynamic motions. Low speed Danish-type turbines have reduced this risk by: 1) limiting exposure to aerodynamic loads, 2) letting inertial (weight) forces overshadow the aerodynamic loads, 3) and preventing dynamic motions (p. 89).*

18 While a form of hubris can certainly be found in the ambitious MW-size MOD turbines program,[36] the technical conference proceedings and reports above-mentioned may help understand in greater detail how the GE parametric study possibly penalised small wind turbines by using an inappropriate set of optimisation criteria which did not consider past empirical results,[37] and how the knowledge of wind conditions (in particular turbulence) played a role in the design process. It is also interesting to note the evolution of the Danish wind energy meteorology research community during the 1970s compared with the one in the US: while the American research was already booming from 1973, a research program started in Denmark in 1976 only. However, within four years (1977-1981) it achieved more than the other programs: rapidly a number of key tools and methods were developed, which placed Denmark as leader in wind energy research, in particular within wind & site studies. This could be further examined and investigated using a similar approach to that of Heymann, that is by highlighting some Danish cultural specificities, and by complementing the argumentation with some insight into wind and site studies. One could for instance, while acknowledging the importance of the Danish grass-root movement which supported the early growth of the industry and by focusing on wind & site studies:

- Study how Danish researchers used the heritage of Juul's empirical results, together with the existing boundary layer meteorology research knowledge at RISØ, to bring up the engineering knowledge to a scientific level, and thereafter produce new and advanced knowledge.
- Reflect on the importance of linking and scoping wind & site studies for advancing wind turbine design, and compare the strategies developed in Denmark, Germany, Spain and the US[38] for instance.
- Consider the singular case of the French Wind Energy program, which developed very thorough and decent wind and site studies, as well as field turbine testing and aerodynamic studies, without success, thereby showing

34 See Matthias Heymann, "Signs of Hubris: The Shaping of Wind Technology Styles in Germany, Denmark, and the United States, 1940-1990" (cf. note 15).

35 Peter Karnøe, "Technological innovation and industrial organization in the Danish wind industry", *Entrepreneurship & Regional Development: An International Journal*, vol. 2, 1990, 105-124.

36 Matthias Heymann, "Signs of Hubris: The Shaping of Wind Technology Styles in Germany, Denmark, and the United States, 1940-1990" (cf. note 15).

37 These in turn, inspired directly the first Danish turbine makers, see Maegaard, Krenz, and Palz, *Wind Power for the World: The Rise of Modern Wind Energy* (cf. note 16).

38 In the US the national renewable energy lab (NREL) was founded very late (1991), about 10 years after its counterparts and main challengers in Europe.

an example where there may be non-optimal approaches to wind and site studies. In this way it resembles the first US program during the first world war.

Contributions to the modern wind industry

19 One needs to acknowledge that the contribution of wind & site studies to the early development of wind energy, in the post-war period, was probably minor compared to the other turbine design drivers. Although not anecdotal, their role was (in the case of Juul and Hütter for instance) limited to the characterisation of the wind turbine prototype response to the turbulent wind field, and to the high-level assessment of suitable wind turbine installation sites.

20 However, with the development of the modern wind industry, in particular in California in the 1980s, the need for specialist knowledge and independent consultancy services regarding wind & site studies increased suddenly.[39] It is only then that this field of engineering really emerged as a separate professional discipline. Although a relatively young profession, it would then be natural to study these actors and their role in the development of the wind energy industry. Typically, the services consisted (and still do so) in technical due diligence and risk assessment, optimisation of the wind farm project (choice of turbine, layout, installation and maintenance costs), follow-up and reanalysis of the performance (production, structural loads, turbine warranty contracts), sometimes research and development (data acquisition, calculation tools and methods), and also contribution to international standards. For instance, research topics could be:

- Study the market driving forces that led to the creation of these consultancy services (for example the need for the lender to assess the financial viability of the project) and assess whether it led to some particular need for consultancy services in different countries, and how that compared with other industries (for example oil and gas, but also solar power).
- Explore the evolution (if any) of the commercial and research wind & site studies and their impact on the wind industry (wind turbine design for instance), again in different countries or regions.
- Study the evolution of the different actors within wind & site studies (commercial companies, research centres providing also consultancy services, small consultancies, etc.), their relations to each other and to the other actors of wind energy (including institutional actors like energy agencies).

WIND ENERGY METEOROLOGY

Problematics

21 The emergence of wind & site studies has led to great developments in atmospheric sciences research, in particular within boundary layer meteorology, as briefly mentioned in the previous Section. Note that these activities are in their vast majority non-commercial and classify as public research work, in a very similar manner to other fields of atmospheric/marine science. The large amount of measurement datasets, the need for precise and accurate modelling, has driven the development of detailed meteorological studies that are of interest for the practitioner, for instance: wind profile modelling (how much is the wind changing with height), atmospheric turbulence (relevant especially for slender components like blades), or weather forecasting. A good example of such synergies is the meteorology department of RISØ in Denmark (now part of DTU Wind Energy) which initially worked on pollutant dispersion[40] in the 1960-70s and shifted focus towards wind energy in the late 1970's after the refurbishment of Juul's Gedser turbine.[41] These early research studies cover similar topics as in Juul's papers. Both microscale effects (turbulence) and large-scale patterns (wind maps over Denmark) have been studied in parallel. Similar developments took place in the Netherlands (ECN) and Germany. Furthermore, thanks to the large-scale

39 Rémi Gandoin, "Palm Springs-Whitewater, 1980" (cf. note 14).

40 RISØ was home for a demonstration nuclear reactor.

41 The longest-lasting wind turbine prototype experiment (1957-1967) that had been carried out prior to wind energy renewal in 1973.

development of wind energy, a great number of measurement data and model validations have been carried out by engineers and consultants in the past decades.

22 It seems unclear though, how this research work[42] has "fed back" into the major body of atmospheric science research. For instance, Copenhagen University has its own meteorology department, with little (if any) overlap with DTU Wind Energy; this seems to be the case in other countries. It is worth noting that a non-negligible part of the DTU Wind Energy publications deals with the most fundamental aspects of meteorology (for instance: atmospheric turbulence, wind profiles, mesoscale phenomena, measurement techniques), therefore they do not only cover wind energy-related applications. This raises the following questions:

- *How to characterise wind energy meteorology today, and historically?* Whether it defines itself as a subset of boundary layer meteorology,[43] or as an "applied science",[44] thorough and independent historical work seems to be missing. Also, the importance and role of wind energy meteorology research to wind turbine design and the wind turbine market could be investigated from a historical perspective.
- *How has wind energy meteorology contributed to other fields of science?* Provided that the field has been active globally for at least 40 years, and has benefited from relatively continuous funding (in Europe), how did this new knowledge disseminate in other fields of science, including boundary layer meteorology, but others as well?

23 Answering these questions may be relevant for both practitioners within wind energy meteorology and its interfacing fields, as well as the general public.

Relevance for practitioners

24 Practitioners may find a way to describe and map the actors of their field, understand what goals they pursue, what sort of organisations are present within their and others' field, what mechanisms bind them together, or in contrast take them apart. It may help identify, differentiate and eventually reconcile scientific and engineering aspects of the work. For instance, climate scientists have in recent years benefited from much research work on these problematics, including decision making under model uncertainty.[45] While the field of wind energy meteorology has a smaller impact on natural science and the global political debate than climate science, it is an active field of research with an ever-growing number of undergraduate, graduate students and researchers.[46] Therefore, it can be challenging for both industry and academic members to understand what the significant scientific and technological achievements are, where they are occurring and how to make use of them. Having a clearer definition of the field, as well as an understanding of its historical developments (not only of scientific and technical advances, but also of the evolutions of the field itself), could help connect the dots.

25 A recent example of a long multi-disciplinary project which had a large impact on the industry is the elaboration of the newest edition of the IEC 61400-12 standards[47] which prescribe how wind turbine performance should be measured. The topic is crucial to project financing, as it provides a way for the turbine owners to check and compare the power output of a turbine compared with the specifications from the

42 See for instance a summary in Alfredo Peña et al., "Ten Years of Boundary-Layer and Wind-Power Meteorology at Høvsøre, Denmark", *Boundary-Layer Meteorology*, vol. 158, jan. 2016, 1-26.

43 See Stefan Emeis, *Wind Energy Meteorology, Atmospheric Physics for Wind Power Generation*, (Springer-Verlag Berlin Heidelberg, 2013).

44 See Erik Lundtang Petersen *et al.*, "Wind Power Meteorology" *Risø National Laboratory*. Risø-I, N° 1206(EN), 1997.

45 See for instance Matthias Heymann, Gabriele Gramelsberger, and Martin Mahony, *Cultures of Prediction in Atmospheric and Climate Science* (London; New-York: Routledge, Taylor & Francis Group, 2017).

46 Elias Sanz-Casado, "Renewable energy research 1995–2009: a case study of wind power research in EU, Spain, Germany and Denmark", *Scientometrics*, vol. 95, 2013, 197-224.

47 See https://webstore.iec.ch/publication/26603 (accessed 2019-03-12)

turbine contract. Eventually, the owner can be entitled to financial compensations from the manufacturer if the turbine does not pass the test. The former edition of the standards (2005) was 90-pages long, however the newest edition is 558-pages long. This six-fold increase denotes the increased complexity of the testing methodology, which includes a new measurement device (LiDAR) and a new analysis method (Rotor-Equivalent Wind Speed, RWES). This wealth of new procedures provides many advantages but also some challenges.[48] Wind energy meteorology has been at the heart of the elaboration of the scientific and technical basis for these new standards, it could therefore be interesting, retrospectively, to understand what the whole process consisted of, what goals were pursued by the participants (academia, manufacturers of turbines and measurement equipment, consultants), how the standards have been and are actually used, and what lessons can be learned for the next editions. Tools and methods applied elsewhere in the history of technology could help provide this overview, starting by working on the history of wind energy meteorology.

Relevance for the history of technology and innovation

26 Wind energy meteorology is composed of relatively small and atypical organisations, in the sense that research laboratories are a mix of university departments (f.ex. DTU-Wind Energy, TU-Delft, Texas Tech), state technology institutes (f.ex. ForWind, Fraunhofer IWES), national labs (f.ex. NREL, CENER, CRES), commercial research institutes (f.ex. ORE Catapult), consultancy companies (f.ex. DNV-GL, Wood Group, UL) and manufacturers (f.ex. turbines, measurement equipment). Innovation takes place in all these places, and there are many links between the agents themselves, across organisations. Since modern wind energy is a relatively young industry (40-years old), it could be interesting to understand whether, compared to other industries, the specific structure of wind energy meteorology has been influenced by the general historical context of the last 40 years, whether it has peculiar aspects or, on the contrary, generic aspects that apply to other fields. As mentioned earlier in this article, wind & site studies have been carried out at first from a wind-turbine design perspective, focusing therefore primarily on the turbine manufacturers. Considering wind energy meteorology in a historical study of wind energy could for instance question under what technical and financial conditions the large-scale development of wind energy has occurred.

- From a national policy planner perspective: how has the wind resource been established, on what basis, with what confidence level and for what result?
- From the project owner and turbine manufacturers perspective: how has the knowledge produced within wind energy meteorology been applied to de-risk projects and increase profitability?
- How have these parties benefited from wind energy meteorology, and has the above-mentioned "open"[49] structure of this organisation played a role?
- From a wider perspective, and considering that the wind energy meteorology has drawn a lot from meteorology (and in particular boundary layer meteorology),[50] can one map these "loans" historically, understand how this transfer happened and for what purpose? How has knowledge been exchanged and at what levels?
- Given the large progress in wind energy meteorology, for instance in the very fine characterisation of the wind profile or the atmospheric turbulence, has some knowledge from this field been transferred "back" to meteorology, or another field of science? An interesting

48 Not listed here, the curious reader can refer to https://aws-dewi.ul.com/knowledge-center/webinars/how-iec-standard-powe...

49 As opposed to "rational" of "natural" see Richard W. Scott, *Organizations: Rational, Natural, and Open Systems* (Upper Saddle River: Prentice Hall, 2003 [5th Edition]).

50 Turbulence spectrum characterisation (Jagadish Chandran Kaimal, John Corry Wyngaard, Yukata Izumi, Owen Reid Coté, "Spectral characteristics of surface-layer turbulence", *Quaterly Journal of the Royal Meteorological Society*, vol. 98, n° 417, july 1972, 563-589), pollutant dispersion models, the Weather Research and Forecasting model (WRF), reanalysis, etc.

technology from that perspective is the LiDAR, which has become a very common way to measure wind speed with great accuracy and precision in wind energy. The technology was used in meteorology 40 years ago but was heavy and expensive to use. Advances in telecommunications (fibre optics) in the late 1990s led to fast development of cheap, robust, accurate, precise and reliable LiDARs that suit the need of the wind energy industry. How has meteorology gained from this development? Is the use of LiDARs in meteorology influenced by its success in wind energy?

27 These are particular examples of the kind of questions that the study of wind energy meteorology history could trigger.

SOCIETAL ASPECTS OF SITE STUDIES

Problematics

28 Wind Energy, together with other means of renewable electricity production, are often discussed in public debates. It is often the case that discussions on wind projects relate to problematics that extend far outside the wind turbine technology itself, for instance: spatial planning and land/sea use, local employment and industry as well as carbon emissions and climate change, therefore wind energy often takes a disproportionate part in the discussion compared with other sectors relevant for climate policies (transport, housing, agriculture, etc). In other words, the spatial and societal "footprint" of wind energy is, relatively to the size of the industry, rather large.

29 Despite some opposition, a lot of work is being carried out and a great number of projects has been commissioned, each of them based on a number of site studies (not only wind, but also environmental and sometimes historical/geographical). Therefore, through the lenses of wind and site studies, it could be interesting to review how a large renewable infrastructure project (for instance an offshore wind farm) impacts societies and understand how this impact resembles or differs from other infrastructure projects. There exists already a great number of studies on the social acceptance of wind energy and its impact on territorial planning; it would be interesting to know how much wind & site studies have been considered in these, as they could lead to interesting discussions (possibly related to environmental history), for instance:

- *How do site studies change the way a territory is understood and perceived?* Together with other environmental studies (birds, mammals, benthic, archaeology, soil and metocean studies), a sum of engineering knowledge is created for every wind farm project. Does this change the way the territory is perceived and understood? If we are to meet the objectives of climate policies, a large share of the energy production needs to be moved from fossil fuels power plants to renewables. However, in practice, locally, issues arise often regarding land- and sea- use and property value for instance. Regarding large offshore wind projects, delays and issues are met when having to obtain consent from sometime several dozens of authorities.[51] Are there "wind & site specific" issues related to this project compared with other infrastructure projects?
- *How to characterise knowledge created by engineering wind & site studies*? As opposed to research studies, engineering studies aim at supporting technically a given, site-specific wind farm project. To do so, they use a number of data, tools and methods which may or may not have been produced by wind energy meteorology and oceanography sciences. Typically, the work consists in analysing measured data, running a number of models (wind, waves) and validating them, and finally drawing conclusions as to the site suitability of the expected energy production and the design of foundations. In the process, some information is created, which to some extent can be referred to as engineering knowledge, in the sense that it may well be considered as true and valid by other studies/actors, as well as become part of engineering standards, but not become scientific knowledge. How is such knowledge created, what does it consist

51 See an example of consenting document for the Dogger Bank offshore wind area in the UK: http://www.oceanologyinternational.com/__novadocuments/49180?v=63531001...

of? What does it take for it to become trustworthy by third parties,[52] and is uncertainty (measurement, model) dealt with?[53]

30 These two problematics are further developed below.

Perception of a territory as a renewable energy resource

31 If we are to meet the objectives of the climate policies, a large share of the energy production needs to be moved from fossil fuels power plants to renewables. Transmission system operators are preparing for this shift[54] and it is unlikely for other countries than the already-existing nuclear energy leaders to develop nuclear programs (an alternative low-carbon energy production method). In this perspective, the large-scale development of renewable electricity production needs to continue, thereby increasing the presence of renewable power plants on land and at sea. It could be interesting to interrogate how the general public sees the renewable energy potential of a given region or local area. For instance, some local opposition movements to wind energy have coined the term "*industrial wind energy*" projects,[55] while wind energy advocates refer to *locally* sourced energy.[56] What is at play in this narrative? How is the current, fossil-based energy production perceived? Is it possibly a type of acceptable industry for some, and a non-local product for others? "Forces of the Nature" are still nowadays a source of admiration for the natural environment, however their modern, physics-based equivalent (thermal or kinetic energy for instance) may not be seen in all countries, places and cultures in the same way. These issues seem well-suited to being studied historically.

32 For the specific case of wind and site studies, how has the general public been aware of the "windy" places on a local, regional, and global scale? Many have a general and high-level knowledge about fossil fuel resources and their global distribution, but what about renewable energy? How does an improved knowledge of renewable energy sources favour or hinder the development of renewable energy technology? Examples could be taken from Denmark and France: Denmark has a modest size, but is rather uniformly windy, whereas France is in some places windier than Denmark but in some places much less windy. What is the role of the real and perceived variability (in time and space) of the wind resource in the elaboration of renewable energy policies and the engagement of the public? For instance, it may be easier for a country to plan the exploitation of a renewable resource when this resource is uniformly spread over the territory, as this makes it easier for the population to reach consensus on how much wind there is to exploit.[57] This question is also relevant from a historical perspective: how has the picture of a territory as a renewable energy resource emerged and changed, historically? One could imagine that before the industrial age and the electrification of Europe, this perception was different. Similarly to the concept of landscape, the concept of "energyscape" and how it relates to forces of nature and the territory we live in, is likely to be different nowadays from what it was 50 years, or 200 years ago.

33 Furthermore, comparisons could be made, for the specific case of offshore wind, between the spatial planning approaches of different countries: in what way have people in these places, throughout history, perceived the marine territory as (energy) resource? How has this perspective changed with the evolution of technology and science?[58] In old maritime nations like

52 Typically, certification bodies, who provide a certificate that the design of the park is sound, as well as third-party advisors who provide financiers with some level of certainty about the return of the project. In particular for offshore wind where investments are in the order of billions of euros, the quality of wind & site studies has a big impact on these financial transactions and technical risk assessment.

53 Links could be made with the work of Wendy Parker on climate models' uncertainty and decision making, https://www.dur.ac.uk/philosophy/staff/?id=11577.

54 See https://tyndp.entsoe.eu/tyndp2018/.

55 In France: "l'éolien industriel".

56 The validity of the expression, when it comes to electricity, is questionable.

57 In the case of Denmark, intuitively: enough.

58 For a similar, yet non-historical approach, see for instance Vanesa Castán Broto and Lucy Baker, "Spatial Adventures in Energy Studies: Emerging Geographies of Energy Production and Use", *Energy Research & Social Science*, vol. 36, 2018.

England, Denmark or the Netherlands, what was known about the wind and the sea prior to offshore wind, and what role has this played in the development of this new technology?[59] What about other nations that do not have a strong maritime tradition? The singular case of offshore wind may help understand the link between production of knowledge about a given territory (what is known about it from natural sciences, and humanities) and advances in technology: while it is trivial to say that the English or Dutch maritime tradition helped foster offshore wind from the very first days, it may be relevant to analyse these topics from a historical perspective, building up on past technological developments that have had the same, or different, characteristics.

Characterising engineering knowledge

34 During the development, construction and operation phases of a large renewable energy infrastructure project, a number of studies are carried out, and thereby some knowledge is produced. For instance, it is usual for an offshore wind farm project to carry out the following studies:

- Wind and metocean measurement campaigns, modelling and analysis,
- Spatial planning studies (f.ex: fisheries, shipping),
- Environmental impact assessment (f.ex: benthic and non-benthic, mammals),
- Geophysical and geotechnical measurement campaigns and analysis,
- Archaeology and heritage (both for offshore and onshore works)

35 These studies are not scientific and do not aim at being such. However, while their content is not necessarily "scientifically right", it is not wrong either; a number of quality checks and certification processes are carried out to make sure the results are sound and provide a good basis for technical, financial and political decisions.

36 For instance, for the particular case of the wind and site studies, an accurate and precise depiction of the wind and waves is demanded by certification bodies for the design of foundations and substructures. Conservatism and safety margins are eventually added to some design loads (extreme loads), as well during detailed design of the steel structures, to account for the unforeseen fabrication defects, but a great deal of effort is spent on deriving the best and most correct site conditions in the first place. As the work involves a number of comparisons between models, measurements and theoretical results from the standards and the scientific literature, a great deal of engineering knowledge is produced. It is produced under a different knowledge regime than if it were science, and can therefore hardly be compared with it, yet such studies are made for every project, using different models and measurements, and span a much wider and more detailed range of environmental conditions than most scientific studies (which typically focus on much narrower datasets - for valid reasons). How to characterise this knowledge, as it is not scientifically true, nor engineeringly wrong? One obvious limit to knowledge-sharing is confidentiality of some studies, but there are a number of studies publicly available, and it may be interesting to study how these are being considered. In itself, the rationale for keeping some wind and site information confidential could be further explored as well: could there be better approaches?

37 Compiling the results from the studies above-mentioned equates to compiling site specific knowledge about the site, in many aspects. Does this come on top of pre-existing knowledge, or complement it? Does it sometimes infirm the pre-existing knowledge? Once the project is realised, how is this knowledge transferred to the general public, or scientists? Parallels could be drawn with the archaeological exploration of Doggerland thanks to seismic surveys from oil and gas companies,[60] where these large industry projects had an unforeseen beneficial impact

59 Anecdotally, the very interesting Günter Dietrich, *Wind Conditions over the Seas around Britain during the Period 1900-1949* (Hamburg: German Hydrographic Institute, 1952) is available on aeolians.net.

60 See Vincent L. Gaffney, Fitch Simon, Smith David, *Europe's Lost World: The Rediscovery of Doggerland* (York: Council for British Archaeology, 2009).

on the way we think of the long-term history (by making it possible to describe the geography of now-submerged settlements of the Mesolithic).

CONCLUSION

38 To conclude, this article provides a number of intrinsic and extrinsic elements of wind and site studies, that could be investigated further in an academic context. From wind turbine design to the public perception of renewables, these topics may be relevant to the ongoing work aiming at making our societies more fit to non-fossil, intermittent but unlimited, power generation. The vast majority of the documents in the reference list are either available on the respective publishers' websites, or at aeolians.net.

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JEH RHE

Journal of Energy History
Revue d'histoire de l'énergie

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POST DATE
08/04/2019
ISSUE NUMBER
JEHRHE #2
SECTION
Out of box
DOI
in progress

TO CITE THIS ARTICLE
Matthias Heymann, "Réponse à 'A call to historicize wind and site studies'", *Journal of Energy History/Revue d'Histoire de l'Énergie* [Online], n°2, published 08 avril 2019, consulted 4 janvier 2020, URL: http://energyhistory.eu/node/115.

A RESPONSE TO "A CALL TO HISTORICIZE WIND AND SITE STUDIES"

Wind and site studies have not been treated in much detail in historical work about wind energy technology and wind power use. I appreciate the authors' observations and arguments and the questions he raises. The author is not a historian, but an engineer. We had a useful and productive exchange, after I wrote a review and allowed the editors to reveal my identity. The exchange was productive and very agreeable. Both of us – historian and engineer – learned from it. I thank the author for his openness and interest in historical work. Historians of science and technology have ample and not always fruitful experience with engineers. Some engineers seek to challenge historians' accounts for their critical narratives and the lack of appropriate detail and appreciation of engineering accomplishments. This exchange was clearly different. The broader message to make is that conversations across disciplinary boundaries are necessary and profitable. Fruitful they can be, if the dialogue is on both sides not understood as an opportunity of teaching (or convincing) the other, but of exploring and learning from each other. Asking questions, like the author has amply done in his article, is not the worst for a start. 1

As the author is an engineer, it is not surprising, and for the scope of this journal fully acceptable, that he does not provide a full account of the state of wind power historiography. Many historical publications on the history of wind power have become available in recent years; and many of the examples the author mentions have been covered to some extent in this literature.[1] Still, the author has a valuable point to make. His emphasis on wind and site studies is a valid argument. This domain had skipped my and other historians' attention for at least two reasons. 2

First, historical actors partly neglected wind and site studies in their investigations, or did not pay much attention to it. During the 19th century, for example, American turbines emerged in the American Midwest, because farmers needed power for pumping water. Their design originated from practical experimentation rather than any engagement in wind and site studies. In the early 20th century, Saxony (a hilly region in 3

1 A first wave of major publications comes from the 1990s: Karnøe 1991; Heymann 2018 (1995); Gipe 1995; Righter 1996; Heymann 1996; Heymann 1998; Verbong 1998. A second wave focusing on various aspects of innovation and policy in recent wind power developments started in the 2000s: e.g. Ibenholt 2002; Kamp 2002; Garud and Karnøe 2003; Neukirch 2010; Nielsen 2010; Nielsen, Heymann 2012; Heymann 2015; Chlebna 2017.

ISSN 2649-3055

central East Germany) became a center for the production of American turbines in Europe, most of which were exported to other places. Saxony, however, was a place not known for windy coasts (which are several hundred kilometers away), but for a productive and innovative metal industry adopting this technology. Wind and site studies were not an issue for this industry. In the 1930s, a controversial pioneer such as German engineer Hermann Honnef planned to construct huge towers for wind power use in the middle of large cities. In this case, solid wind and site studies also lacked. Siting followed political interests rather than scientific results or technical reasons.

4 Second, partly, on the other hand, wind and site studies and their roles are only little visible in the historical sources, even though pioneers such as Johannes Juul and Ulrich Hütter paid attention to it. The author shows that a range of wind power pioneers in the 20th century indeed engaged in wind and site studies. Most importantly, however, the author clarifies the significant role of wind and site studies not only for optimizing energy production through appropriate siting but for optimizing turbine design. Turbine design, a delicate and demanding engineering task, has caught a lot of attention in historical accounts with focus on different design approaches, learning experiences, etc. Wind and site studies, however, remained neglected as an important piece in the puzzle of building reliable turbines. Turbine structure and generator dimensions requires wind and site studies. Wind conditions also cause atmospheric turbulence, which defines fatigue loads at the blade roots and needs to be accounted for appropriately. The case of Putnam's experimental turbine in the USA during the 1940s shows the importance of these points.

5 On the other hand, historical precursors to wind and site studies still appear marginal compared to the explosive expansion of wind technology since the 1970s, in which wind and site studies slowly became a crucial and increasingly professionalized element. Initially, during the 1970s and 80s, wind studies mainly served for pushing the narrative that abundant wind power resources were available and represented a competitive energy source compared to large fossil power plants. It served for siting decisions rather than turbine design. Most governmental wind power programs, launched after the first oil price crisis in 1973, focused on very large wind turbines (hugely transcending power ratings of historical turbines). Not wind and turbine design studies, but the politics of energy pushed the focus on large turbines, notably the competition against much larger conventional power plants. In Germany, it was the government's decision (not an engineering decision) that the largest experimental turbine in its research program, built in the early 1980s, had to reach a height of 100 m (called GROWIAN project). Wind and site studies, though an emerging discipline, hardly affected the misguided and ill-fated GROWIAN.

6 Only more recently, wind and site studies have become a crucial element for turbine design and the optimization and prediction of wind power yields. It would be interesting to investigate more in detail how this special domain of wind technology developed and expanded. When did wind turbine builders start to develop in-house expertise in wind and siting? At which point in the history of wind turbine innovation did it receive attention? Who were the drivers of this discipline? What disciplinary background prevailed? The author suggests that wind and site studies have become a specialized discipline pursued and developed within wind turbine companies. How did this development play out for different wind turbine developers? What expertise did wind and siting departments develop? Which trajectories of institutionalization and professionalization did wind and site studies take? Are there significant national differences? These are historical questions about the differentiation of knowledge production in the history of wind technology.

7 The author raises many further questions. He experiences, it appears, the emergence of wind and site studies as a new research domain also as a challenge. Differentiation constructs boundaries and creates distances. It raises questions

of professional identity and about the relation to other knowledge domains. Is he a meteorologist or an engineer (or both)? Is the knowledge he and his colleagues produce relatable, even usable in other domains? Historical research can help to find answers and deepen the understanding of this knowledge domain. Engineers, like the author, who sense these open questions and seek broader understanding, help historians, on the other hand, to ask new questions and develop new historical narratives.

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Journal of Energy History
Revue d'histoire de l'énergie

ENERGY SOURCES

ISSN 2649-3055

JEH RHE

Journal of Energy History
Revue d'histoire de l'énergie

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POST DATE
03/06/2019
ISSUE NUMBER
JEHRHE #2
SECTION
Energy sources
KEYWORDS
Oil, Heritage, Gas, Dam
DOI
in progress

TO CITE THIS ARTICLE
Finn Harald Sandberg, "Condeeps. The Dinosaurs of the North Sea", *Journal of Energy History/Revue d'Histoire de l'Énergie* [Online], n°2, published 03 juin 2019, consulted XXX, URL: http://energyhistory.eu/node/136.

Condeeps. The Dinosaurs of the North Sea

Abstract
When oil was found in water depths larger than 150 meters in the North Sea in the 1970s, a new and revolutionary concept was needed to be able to support deck structures for production of petroleum. Norwegian entrepreneurs introduced a new design based on their experience with large structures of concrete. The design, named Condeep, was developed. For a period of 25 years this design became the dominant support structure for platforms placed in water depths up to 300 meters. By early 1990s new technology had been developed and deeper waters were being challenged. The Condeeps could no longer withstand the competition and the industry had no longer use for the giant structures. However, the world needs a symbol or monument over a very special period that may come to an end sooner than we know. One such platform may be well suited for a UNESCO world heritage – the Draugen platform in the Norwegian Sea. This article introduces the reasoning behind such a suggestion.

Plan of the article
→ Concrete platforms for the North Sea
→ Designing Condeeps
→ Preserving one of the dinosaurs of the North Sea: why and how

ISSN 2649-3055

1 When Norway became an oil producing country towards the end of the 1960s, only a few people expected that a Norwegian entrepreneur company could become one of the largest subcontractors to the upcoming exploration of the North Sea – using concrete as a material in exceptional and giant structures.

2 Realizing what a great influence the oil industry has had for the development of economic and social life in Norway there have been several ideas how to preserve at least one of these structures for the future – when the fossil fuel era comes to an end. One platform - in my mind - Draugen, could be a strong candidate for becoming an international monument and possibly gain status as a UNESCO world heritage status. Having spent more than 30 years in the Norwegian oil industry I have seen most of the technical progress that has been taking place. The most important structures are the huge Condeeps (abbreviated from Concrete Platform for Deep Waters). The time of the fossil fuels may be obsolete within this century, the petroleum industry has been the basis for the development of modern Norway and the concrete structures are unique pieces of design and construction.

CONCRETE PLATFORMS FOR THE NORTH SEA

3 The first traces of a material that can have some resemblance to concrete dates back 20 000 years. It was however the Romans, a little more than 2000 years ago, who really developed the knowledge and competence of how to create huge buildings based on using ashes from volcanoes as an important ingredient. The volcano ashes used in concrete were called pozzolans after the city Pozzuoli, close to Naples and Vesuvius, where the material was first collected.[1] Two hundred years ago, an industrial product named Portland cement was introduced overtaking the market from the natural pozzolans.[2]

1 Ruth Whitehouse, John Wilkins, *The Making of Civilization. History Discovered Through Archaeology* (New York: Alfred A. Knopf, 1986).

2 Frederick Measham Lea, *The Chemistry of Cement and Concrete* 3rd ed. (London: Arnold, 1970).

Figure 1: The Zakarias dam (completed 1969). Photography by Vidar Iversen [CC BY-SA 3.0].

4 In Norway concrete has been used as the main material in dams built for producing electricity. Until the mid-1950s concrete was the dominating material and many companies were involved in the big projects in the Norwegian mountains (fig. 1).

5 A few years after oil was found in the Norwegian part of the North Sea, Norwegian Contractors (NC) was formed in 1973 as a Joint Venture of three large contractors and their idea was to utilize their joint experience, competence and resources and take advantage of the country's special topography with deep fjords and plenty of raw material to produce structures specialized for this new industry.[3]

6 The first ideas using concrete for oil extraction were launched in 1970 by two of the co-founding companies – and a concrete floatable platform support was introduced (picture) shortly after.

7 A total of 17 giant structures were built in Norway by Norwegian Contractors (and the founding companies) during a period of 25 years. Most of them were Condeeps based on the principle of standing securely on the sea bed only by the force of its own weight – a so called gravity-based structure (GBS).

3 Øyvind Steen, *På dypt vann. Norwegian Contractors 1973 – 1993* (Oslo: Norwegian Contractors, 1993), 16.

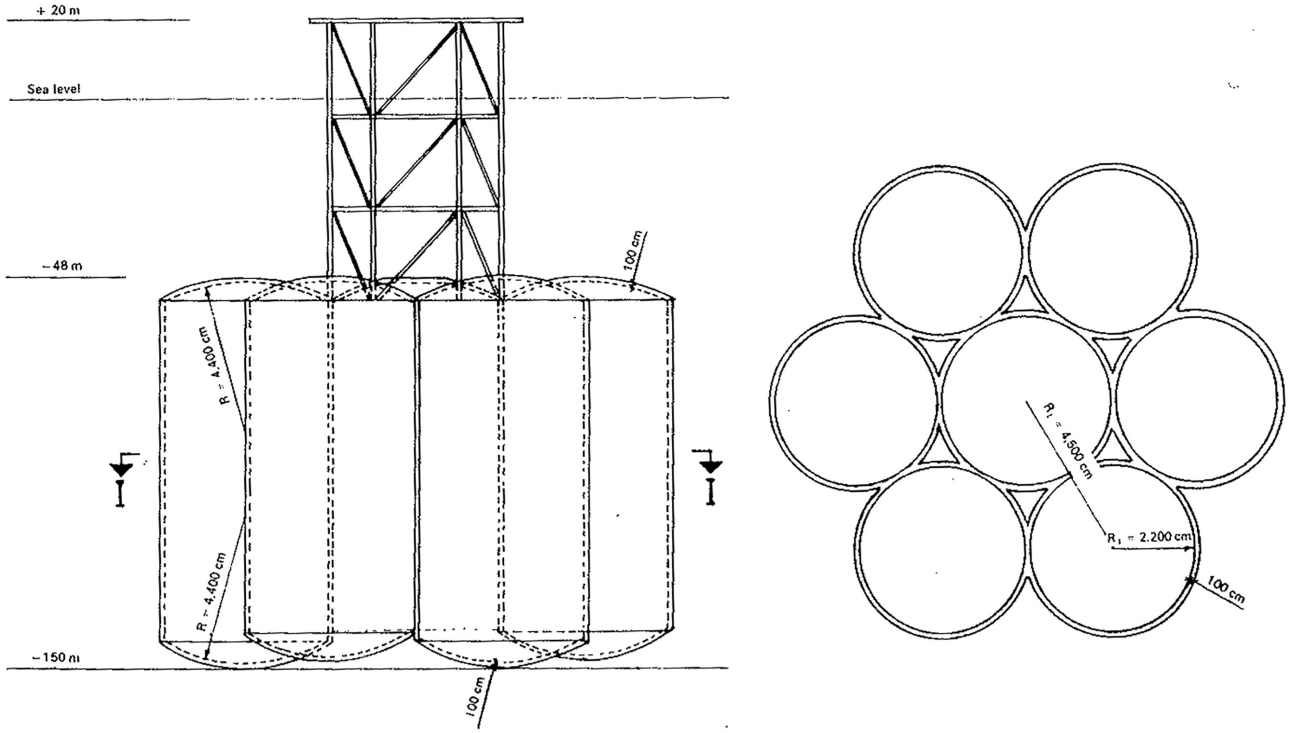

Figure 2: Høyer-Ellefsen's first suggestion for a concrete platform structure (1970) – an early Condeep experiment. Source: Øyvind Steen, *På dypt vann. Norwegian Contractors 1973 – 1993* (Oslo: Norwegian Contractors, 1993), 7.

Year installed	Field/Unit	Original Operator	Platform design	Water depth m	Concrete vol. cubic mtr.	Offshore Location
1973	Ekofisk	Phillips	Caisson, Jarlan Wall	71	80 000	Norway
1975	Beryl A	Mobil	GBS, 3 shafts	118	52 000	UK
1975	Brent B	Shell	GBS, 3 shafts	140	64 000	UK
1975	Frigg CDP 1	Total	Caisson, Jarlan Wall	104	60 000	UK
1976	Brent D	Shell	GBS, 3 shafts	140	68 000	UK
1977	Frigg TCP 2	Total	GBS, 3 shafts	104	50 000	Norway
1977	Statfjord A	Mobil	GBS, 3 shafts	145	87 000	Norway
1981	Statfjord B	Mobil	GBS, 4 shafts	145	140 000	Norway
1984	Statfjord C	Mobil	GBS, 4 shafts	145	130 000	Norway
1986	Gullfaks A	Statoil	GBS, 4 shafts	135	125 000	Norway
1987	Gullfaks B	Statoil	GBS, 3 shafts	141	101 000	Norway
1988	Oseberg A	Norsk Hydro	GBS, 4 shafts	109	116 000	Norway
1989	Gullfaks C	Statoil	GBS, 4 shafts, skirt piles	216	244 000	Norway
1993	Sleipner A	Statoil	GBS, 4 shafts	82	77 000	Norway
1993	Draugen	Shell	GBS monotower, skirt piles	251	85 000	Norway
1995	Troll A	Shell	GBS, 4 shafts, skirt piles	303	245 000	Norway
1995	Heidrun	Conoco	TLP	350	63 000	Norway
1995	Troll B	Norsk Hydro	Semi submersible	325	43 000	Norway

Figure 3: Table listing the 17 concrete platforms produced in Norway by Norwegian Contractors between 1973 and 1995. Source: Steen, *På dypt vann. Norwegian Contractors 1973 – 1993* (Oslo : Norwegian Contractors, 1993).

Figure 4: The remains of the concrete platforms left on Frigg field in the North Sea. © Total E&P Norge / Norwegian Petroleum Museum.

8 Of the listed structures Ekofisk, the Brents and the Friggs have already been decommissioned – but the concrete structures are left in the fields with the deck structures removed (fig. 4).[4]

9 The Norwegian Petroleum Museum (NPM) cooperates with The Norwegian Oil and Gas Archives (NOAGA) in documenting many of the large developments on the Norwegian Continental Shelf. So far five large Industrial Heritage Projects have been completed (Ekofisk, Frigg, Statfjord, Valhall and Draugen).

10 In addition, NOAGA has received the complete archives from Norwegian Contractors for the period between 1973 and 1995 when the company was in existence. Altogether there is 16 shelf meters of interesting material to be found. All films and photos from the building, transport and installations of the concrete platforms have been made available for the NPM. Many of these are made publicly available at the site https://digitaltmuseum.no. – more than 3000 pictures can be found using only Norwegian Contractors as search criterion.

DESIGNING CONDEEPS

11 From the list above one finds that the Condeeps came in many different shapes both in height and number of legs. Most of them were never meant to be removed, but some are designed for being towed back to the coast to be destructed. The above mentioned Draugen is one of these.

12 There were several reasons for starting to build concrete platforms in the North Sea. In the early 1970s, several huge discoveries of oil on the British and Norwegian continental shelf, Beryl, Brent, Ninian and Statfjord were made, to name the largest. At that time, there were no marine structures such as “jackets” (large steel framework structures fig. 5) or floaters suitable for building production facilities of 120m - 150m

4 Adam Vaughan, “Shell begins huge task of decommissioning Brent oil rigs”, *The Guardian*, 06/02/2017. Url : https://www.theguardian.com/business/2017/feb/06/shell-decommissioning-... (accessed 17/05/2019)

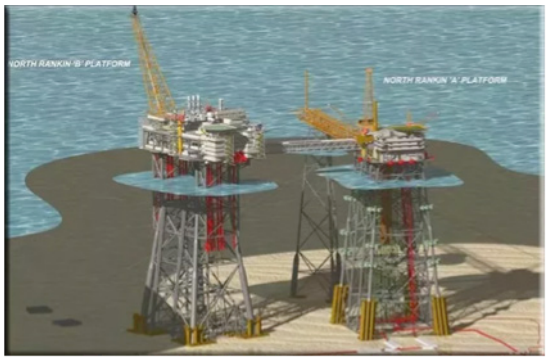

Figure 5: An example of a steel jacket – supporting structure for oil producing facility in the North Sea. Source: Puput Aryanto Risanto, *Introduction to Offshore Oil and Gas Surface Facilities* (2015). URL: https://www.slideshare.net/PuputAryanto/introduction-to-offshore-oil-and-gas-surface-facilities.

water depth in the North Sea. In addition, there was no infrastructure in the form of pipelines for exporting oil and gas from the platforms.

13 In the 1960s the Gulf of Mexico was the reference point for offshore oil and gas production. However, there were several conditions that were different in the North Sea. One of these differences was that the production rate was consistently higher from the North Sea areas. This required systems for the UK and the Norwegian sectors with more equipment and considerably increased weight. Steel platforms at that time had to have the deck installed offshore after the support structure was placed on the seabed. Cranes with lifting capacity of 10,000 - 12,000 tons, as we know it today, did not exist then. It was therefore a huge task to transport modules of 800-1000 tons offshore, lift them into place and connect the modules that could weigh a total of 20,000-30,000 tons. Typically, in the Gulf of Mexico, lifts of 500 to 5000 tons were covered. Second, weather conditions which were constantly much worse in the North Sea, even though the Mexican Gulf had its challenges during the hurricane season. Third and last, the generally larger distance to shore resulted in increased demands for logistics arrangements and space for equipment storage on board. The development of offshore platforms in the Gulf of Mexico had started with facilities near shore and pipeline installation became an integral part of field developments. The platforms were connected to the nearest pipeline as one moved further from the coast. In the North Sea, the most promising areas were situated far from the coastline both in the UK and in Norway and there were no pipelines available.

The basic conditions and the marine environment are more demanding in the North Sea. Piling equipment designed for installation of steel platforms in the Gulf of Mexico, was inadequate for the seabed in the northern North Sea with hard sand and clay layers formed by the glaciers during the ice age. Without pipelines for export, oil storage and offshore loading to tankers were necessary to uphold a consistent production under adverse weather conditions. There were thus many challenges and opportunities that the industry faced when developing large oil fields in the North Sea. Norwegian industry, and Norwegian entrepreneurs, were active and inventive in promoting ideas and developing suggestions for new concepts. Høyer-Ellefsen and Akergruppen (two of the companies forming Norwegian Contractors in 1973) were involved in a collaboration that proved to be very successful resulting in the Condeep platform design. The biggest challenge was with the oil companies that had to choose solutions and methods that neither supplier nor customer had full scale experience with. 14

The reasons for the operating companies Mobil and Shell in 1973 to develop the Beryl and Brent oilfields on the UK shelf, using concrete platforms were to avoid the expensive and time-consuming work of installing piles to secure the steel jacket. In addition, the platform had sufficient buoyancy to carry the deck with the necessary facilities for processing the petroleum from an inshore construction site. Thus, the deck could be equipped and coupled up in a controlled environment and the finishing offshore was substantially simplified. And last but not least, when the platform was set on the seabed it no longer needed buoyancy and the cavity in the concrete platform would serve as oil storage (fig. 6). 15

The first three Condeeps were delivered to Mobil and Shell in 1975 for the British continental shelf. 16

Figure 6: Troll A, the last Condeep. Photography Øyvind Hagen / Equinor.

It also meant the start of an industrial adventure for Norwegian suppliers. The concrete substructures were built in Norway and the deep fjords on the west coast were suitable for mating with the deck and tow. This gave Norwegian shipyards a natural advantage for building top sides. The effects of this scheme were huge. Engineering companies, technology development, subcontractors, consultants and research institutions were engaged because the business was conducted in Norway. If Mobil and Shell had focused on steel platforms for Beryl and Brent, construction work would not have ended in Norway and Norwegian industry would not have had the same development opportunities. When Mobil found the Statfjord field in 1974, they were building the Beryl platform and they chose the same solution for the Statfjord development.

17 The Ekofisk tank was the first of the giant concrete structures to be placed on the seabed of the Norwegian Continental shelf. It was not a Condeep, but it made it possible to establish a company and a construction yard for future oil related activities. The two Norwegian entrepreneur companies Ingeniør F. Selmer A/S and A/S Høyer-Ellefsen were contracted by the French company C.G. Doris in May 1971 to build an 'oil container of concrete' that could hold one million barrels of crude oil.[5] Two years and one month later the structure now known as the Ekofisk tank was towed to the oil field.[6] Within that time span the companies also had to develop a site that should be the breeding ground for the Norwegian concrete dinosaurs for more than 20 years.

The next month (July 13, 1973) the first con- 18
tract for the new concept of an oil platform (Condeep) made of concrete was signed.[7] It was Mobil North Sea Limited who wanted to use this type of platform for their Beryl field development. Two weeks later Shell ordered a similar platform for their Brent field development also in the UK sector of the North Sea. The Beryl and Brent platforms were built in Stavanger and have been operating on the British side of the border. Brent B was abandoned in 2016 and the decommissioning started early in 2017. The Beryl platform is still operating.

5 Steen, *På dypt vann* (cf. note 3).
6 *Ibid.*
7 *Ibid.*

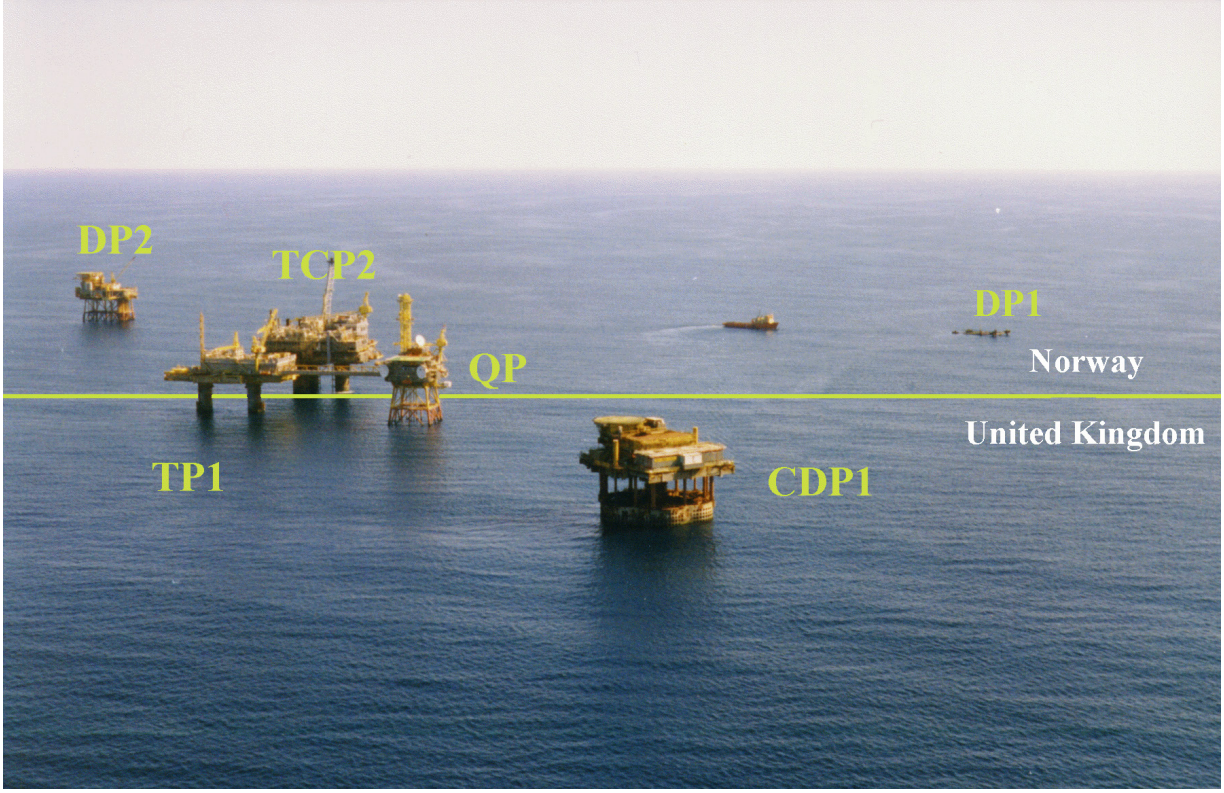

Figure 7: The Frigg field in the North Sea – the border between UK and Norway is indicated with a green line. © Total E&P Norge / Norwegian Petroleum Museum.

19 The next field to be using concrete platforms was the French operated Frigg field where the gas reservoir stretched out to both sides of the British/Norwegian border. The treatment platform TP1 was designed by Sea Tank Company in Paris and was built in Scotland, The Manifold Compression Platform MCP-01, designed by Doris Engineering was built in Sweden. This platform was decommissioned in 2006. Two Frigg platforms were the only concrete platforms to be built in Åndalsnes and only one was of the Condeep-design, The Treatment Compression Platform 2 - TCP2. The TP1 and the TCP2 were physically connected with a bridge crossing the Norwegian UK border (fig. 7).

20 The three platforms for the Statfjord field, all Condeeps, have been operating in one of the world's largest offshore oil fields since 1979. On October 12th, 1983 they produced a record volume of 870 000 barrels of oil. Based on the present oil price of 50 - 60 USD per barrel, that means roughly 2 million dollars per hour!

21 The Gullfaks A was the first platform to be 100% Norwegian owned and operated.[8] The Gullfaks offshore field was owned jointly by the three Norwegian oil companies that existed at that time. Statoil was the operator with Norsk Hydro and Saga as partners. The field has used three Condeep platforms for the development and the Gullfaks C was the first platform to be fitted with concrete skirts (to penetrate the sea bottom to create a stable foundation), and it is also the heaviest structure to be moved by man (1,5 million metric tons).

22 The Sleipner A platform was the only platform to collapse during construction. On a beautiful August morning in 1991 the concrete structure sank during a submergence test In the Gandsfjord close to Stavanger. One of the internal cells could not withstand the pressure from being submerged lower than the depth at the destination in the North Sea and water poured

8 Harald Tønnesen, Gunleiv Hadland, *Oil and Gas Fields in Norway. Industrial Heritage Plan* (Stavanger: Norwegian Petroleum Museum, 2011).

Figure 8: The Heidrun platform. Photography by Harald Pettersen / Equinor.

Figure 9: The Norne, a Floating Production, Storage and Offloading (FPSO) unit, shaped as a ship. Photography by Kenneth Engelsvold / Equinor.

in. On the way down to the bottom of the fjord the structure imploded creating a soundwave that was registered as a small earthquake at a geological center in Bergen, several kilometers away.[9]

23 The Draugen was built with only one leg – a monotower design. The platform and its designer Olav Olsen were in 1995 awarded the Gustave Magnel Golden medal for a structure in prestressed concrete.[10] The platform was the first to produce oil north of the 62nd latitude and the only platform north of this borderline to be standing directly on the sea bottom. The other platforms are floating structures either semi-submersible structures (fig. 8) or ships (fig. 9).

24 The Troll A – the tallest structure to be moved by mankind 472 meters from the lowest point

9 "Havariet av SLEIPNER A GBS, August 1991", Presentation at the Petroleum Safety Authority Norway conference (PTIL) 2007.

10 The letter from AIG-Stiching declaring the winner was sent September 7th 1994 – the ceremony was held in 1995. See : https://draugen.industriminne.no/en/2018/05/14/medal-award-for-draugen-...

Figure 10: The Troll A platform ready for tow out to the field. Source: https://i.redd.it/8w98q0tha0a01.jpg.

on the concrete skirts to the top of flare boom It was also the last of the giants to be built for the North Sea (fig. 10).

25 When it was placed on the sea bottom at a depth of more than 300 meters in 1995 it meant the end of an era. Similar structures have been used for the oil industry in other parts of the world such as east of Canada (Hibernia and Hebron) and offshore the Pacific coast of Russia (Sakhalin). The Condeeps are fantastic structures that not only were meant to support the oil factories, but also to offer temporary storage for the black gold.

PRESERVING ONE OF THE DINOSAURS OF THE NORTH SEA: WHY AND HOW

26 In his book *Leviathan* (1979), Alfred Hauge used the words "Condeep Cathedral" and "petrodome" to describe the shape of these giant structures and one can sense some resemblance with cathedrals. Hauge's fascination with these structures was also present in an essay from 1980: "So beautiful it is with the tall slender shafts as they are called; resembling huge lighthouses. I will not be surprised if such structures will inspire architects to create new ideas for example churches ..."[11]

27 Even the interior of the Troll A platform lends itself to giving an impression of a large church. Picture to the left is from a concert given in 2006 by the song artist Katie Melua at the bottom of the Troll A platform (the deepest concert ever held).[12] But not only inside – the top of the platform Draugen as it can be seen above the water does seem to copy the Stavanger Cathedral from the 12th century – both internally and externally.

28 Should we preserve one of the dinosaurs for eternity? – It is technically possible but extremely expensive! Indications that have been discussed among experts, range between 1 to 3 billion American dollars, only for 'picking it up' offshore, transporting and placing it close to shore. What it will cost to prepare it and

11 Alfred Hauge, *Leviathan* (Oslo: Gyldendal Norsk Forlag, 1979).
12 Trailer here: https://www.youtube.com/watch?v=o5W-rk7GRiS4 (accessed 29 May 2019)

Figure 11a: Sagrada Familia (Barcelona, Spain). Source: Atlas Obscura.

Figure 11b: Sletringen Lighthouse (Norway). Photography by Odd Einar Helmersen Helge Høifødt [Public domain].Atlas Obscura.

Figure 11c: The Nidaros Cathedral (Trondheim, Norway). Photography by Photo: Zairon [CC BY-SA 3.0].

Figure 11d: Troll A. Norwegian Contractors / Norwegian Petroleum Museum.

Figure 11e: Katie Melua at concert in the Troll A platform. Photography by Kjell Alsvik.

Figures 12: *T*he Stavanger Cathedral and The Draugen platform. Photographies by Helge Høifødt [Public domain], and A/S Norske Shell / Norwegian Petroleum Museum.

presenting it as an industrial heritage has not been evaluated. But as a monument of the era that brought Norway immense wealth in money and technological competence it should be an idea to follow up at least.

29 The importance of these structures for the development of deep-sea oil producing technology and the growth of Norway's and other oil producing nations' position today cannot however be underestimated. It is therefore relevant to ask if one of these giant structures should be preserved for future generations and be used as an arena to explain to the general public all the technical aspects of deep-sea natural exploitation.

30 UNESCO World Heritage Sites is a program under the auspices of UNESCO for the preservation of a variety of natural and cultural sites on Earth. The places, such as a forest, a mountain, a lake, a desert, a monument, a building, a complex, or a city, are selected because of their cultural importance or for the natural history of humanity. UNESCO's World Heritage List is the most widely used environmental treaty in the world. The program was launched on November 16, 1972, when UNESCO adopted a Convention for the Protection of Cultural and Natural Heritage. 1092 places were listed on March 2019, 845 of which are cultural heritage sites, 209 natural heritage sites and 38 a mixture of the two categories.[13]

31 Industrial cultural monuments are part of the cultural heritage sites but represent only about 5% of these. Requirements for world heritage status are:

- Outstanding universal value. An area or object has outstanding universal value if it represents in the global context the best example within a cultural or natural subject of a particular format.
- Integrity. All world heritage objects or areas must contain all elements necessary to express the prominent universal values. The area's integrity is also dependent on the delimitation capturing all necessary elements.
- Authenticity. The object or the environment's degree of origin or authenticity is an expression of authenticity.
- Protection and management. World Heritage Sites should be subject to long-term formal or contractual protection against measures or threats that may adversely affect the universal values.
- The areas must be *clearly defined* and where necessary be surrounded by a buffer zone with its own provisions ensuring that qualities within the world heritage area are not adversely affected.
- The management of the area will follow a reversal plan that ensures coordinated follow-up of measures that are best for the area.
- Human activity within world heritage sites must be ecologically and culturally sustainable.
- Local support. A world heritage nomination will not be approved without it being anchored in the community.

32 Why an oil platform? Through more than fifty years of activity on the Norwegian continental shelf (NCS), the petroleum industry has grown to become Norway's most important industry. The exploration and production of oil and gas has been the most important reason for the global development of modern society for more than 150 years.

33 In Norway the industry directly and indirectly employs around 300 000 people, while a high tax rate and the state's direct ownership contribute to the bulk of the value creation on NCS. Many of the contracts for building modules and production units for the Norwegian Continental Shelf have been and still are being placed all around the globe. Of the gross domestic product in Norway in 2014, the state calculated that it amounted to NOK 958.9 billion. That is about one third of the 3 167 billion that are created in Norway for a year. It includes both oil and gas production, investments on platforms and ships, as well as all those working on petroleum.

13 UNESCO World Heritage. Url: https://whc.unesco.org/en/list/ (accessed 02/04/2019)

34 In April 2001, the Directorate for Cultural Heritage of Norway expressed in a letter to the Norwegian Petroleum Museum the following: "The Directorate [..] will like the oil museum to draw up a systematic overview of large physical oil installations that may be preserved - on the spot, at museums or elsewhere." So far the phrase «large structures» has meant equipment limited by size and weight up to 10 meters and/or 100 tons. An oil platform is of a completely different magnitude. But on the other hand – no suggestions have ever been officially introduced – maybe it's about time!

35 Why Draugen? The most unique feature from the Norwegian oil industry is the use of concrete platforms – Concrete Deepwater Structures, Condeep. The Draugen is a concrete platform and has also achieved an international award for its design – The Golden Medal Gustav Magnel 1989 - 1994. Concrete technology that has been developed is also applicable to other geographic areas. Draugen was the first platform north of 62th latitude – an important limit politically. Indeed, the Norwegian oil industry's expansion towards the north has contributed to the most polarized conflict line in Norwegian oil policy. At the end of the 1970s, the battle was about whether to open the areas north of 62nd latitude for oil drilling. From the 1970s, the opposition was primarily between fisheries and conservation interests on the one hand and industrial interests and a desire for local business development on the other.

36 Draugen is one of the fields that has the highest utilization rate on the Norwegian continental shelf (about 70%) - which is world-wide super league. The Draugen will probably shut down production from the main reservoir within 10 years. The unique monotower structure was also designed to be physically removed from the seabed in one piece. Basically, all installations on the field shall be removed when production ends.

37 Save Draugen! There is no project launched to save the platform for eternity. The Draugen field is still producing at a daily rate of about 20 000 barrels a day. The planning for abandonment has not officially started - yet. When I (as a private person) have introduced the idea to different persons and authorities, they have all shaken their heads and called it crazy and impossible. However, after having presented my case, the skepticism has often turned into curiosity and sometimes excitement. It all started during an informal dinner meeting with representatives of the Directorate for Cultural Heritage of Norway. I started to investigate what were the rules and regulations for the UNESCO-list, and I discovered that it could be possible if one could get enough attention. I made a PowerPoint presentation and showed it to friends and historians. They were all very skeptical of the project, but since I am an engineer by profession, I explained the technology behind the idea (not thinking about the money) and they were convinced by the project... One person said after having seen and heard my enthusiastic dream: It may be a dream – but the idea is crazy enough to actually be possible!

38 That has since been my guideline and I will spend my first year in retirement following my dream! The seeds have been planted, but it still is a long way to go. The cost will be enormous and many technical problems will have to be solved – but 60 years ago nobody believed there was any oil at all in Norwegian waters...

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REVIEWS

ISSN 2649-3055

JEH RHE

Journal of Energy History
Revue d'histoire de l'énergie

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POST DATE
29/04/2019
ISSUE NUMBER
JEHRHE #2
SECTION
Reviews
KEYWORDS
Coal, Transition, Sustainability, Industry, Environment
DOI
in progress

TO CITE THIS ARTICLE
Wout Saelens, "The Path to Sustained Growth: England's Transition from an Organic Economy to an Industrial Revolution (Edward Anthony Wrigley, 2016)", *Journal of Energy History/Revue d'Histoire de l'Énergie* [Online], n°2, published 29 April 2019, consulted XXX, URL: energyhistory.eu/en/node/125.

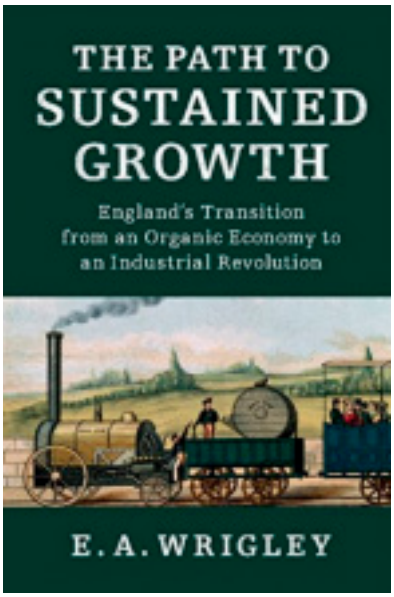
The Path to Sustained Growth: England's Transition from an Organic Economy to an Industrial Revolution (Edward Anthony Wrigley, 2016)

Bibliographic reference
Edward Anthony Wrigley, *The Path to Sustained Growth: England's Transition from an Organic Economy to an Industrial Revolution* (Cambridge, Cambridge University Press, 2016).

Abstract
The Path to Sustained Growth is Edward Anthony Wrigley's latest and hitherto most comprehensive book on his highly influential notion of the early modern energy revolution as a precondition for the English industrial revolution. In an erudite and compelling way he has further expanded his idea of organic and mineral economies. While this has become one of the key elements in (neoclassical) economic history, now is perhaps the time to move beyond the classical economists towards a more integrated energy history, in which energy is framed in its social, economic, political, and cultural meanings, contexts, and realities.

Plan of the article
→ A pioneer in the economic history of energy
→ *The path to sustained growth*: in search for explanations of the industrial revolution
→ Moving beyond the classical economists?
→ Energy, economy and society: towards an integrated history of energy?

ISSN 2649-3055



A PIONEER IN THE ECONOMIC HISTORY OF ENERGY

1 The great merit of Edward Anthony Wrigley is that he has put energy on the agenda of economic history. As one of Britain's leading economic historians, Wrigley has written a wealth of publications on a wide range of topics such as energy transitions, historical demographics, agricultural change, and urbanisation – all of which were employed to explain the industrial revolution.[1] Indeed, Wrigley has fruitfully dedicated most of his academic career to seeking for the long-term explanations of the English industrial revolution. One of his most known and influential theses is the role of new energy forms in producing modern economic growth. Since 1962, when he published his first article on the supply of raw materials in the industrial revolution, Wrigley has worked out an innovative model on the relation between energy and economy.[2] By pointing at the importance of England's early embrace of coal, he has put greater emphasis on one of the earlier "revolutions" that preceded industrialisation. Due to its land-saving effects, coal allowed the agricultural output of food and raw materials to grow, while its physical characteristics also supplied a vastly greater amount of energy required to meet large-scale consumer and industrial demand. Through energy, Wrigley found a way to integrate the complex historical dynamics between demographic changes, agricultural productivity, urban growth, changing occupational structures, changes in transport facilities, and technological changes into the grand narrative on the English "industrial revolution".

2 In this respect, Wrigley's most recent book *The Path to Sustained Growth: England's Transition from an Organic Economy to an Industrial Revolution* is a continuation of his series of volumes on the topic. The central argument remains the same: the exploitation of fossil fuels as a new energy source was essential for "organic economies" to transform into an industrialised "mineral economy". The organic economy is defined as an energy-scarce economy relying on *flows* of energy generated by photosynthesis, a process by which solar energy is captured and stored by plants. This traditional energy system predominantly remained an agrarian regime where farmers fetched whatever they needed from the land: food and fodder for human and animal muscle power, complemented by water and wind power; and wood as building material and fuel for their fires. A mineral or industrial economy, on the other hand, is characterised by high levels of energy consumption, primarily drawn from pre-existing *stocks* of fossilised energy – "the product of plant photosynthesis accumulated over geological ages" – which are used to break the photosynthetic constraint

1 A selection from his bibliography: Edward Anthony Wrigley, *Industrial Growth and Population Change: A Regional Study of the Coalfield Areas of North-West Europe in the Later Nineteenth Century* (Cambridge: Cambridge University Press, 1961); *Id.*, *People, Cities and Wealth: The Transformation of Traditional Society* (Oxford: Blackwell, 1987); *Id.*, *Continuity, Chance and Change: The Character of the Industrial Revolution in England* (Cambridge: Cambridge University Press, 1988); *Id.*, *Poverty, Progress, and Population* (Cambridge: Cambridge University Press, 2004); *Id.*, "The Transition to an Advanced Organic Economy: Half a Millennium of English Agriculture", *The Economic History Review*, vol. 59, n° 3, 2006; *Id.*, *Energy and the English Industrial Revolution* (Cambridge: Cambridge University Press, 2010); *Id.*, "Urban Growth in Early Modern England: Food, Fuel and Transport", *Past and Present*, vol. 225, 2014.

2 Edward Anthony Wrigley, "The Supply of Raw Materials in the Industrial Revolution", *The Economic History Review*, vol. 15, n° 1, 1962.

on growth in organic economies.[3] The industrial revolution can thus essentially be viewed as an energy revolution, a significant breakpoint in the material circumstances of mankind after the mastery of fire and the Neolithic agricultural revolution as earlier transformations of energy supply.[4] Eventually, this transition paved the way for modern economic growth, of which the essence consists in its sustained character. In the words of Sieferle, who is quoted by Wrigley, "[t]he history of energy is the secret history of industrialisation".[5]

3 While scholars like Alfred Crosby and Vaclav Smil have more focused on the "big history" of energy, Wrigley pioneered in writing energy's economic history.[6] Although it probably was the Italian historian Carlo M. Cipolla who wrote the first real economic history of energy through its relationship with population growth,[7] Wrigley has fundamentally shaped this entire field. A first wave of publications appeared during the 1970s and 1980s. In the wake of the oil crisis scholars such as Jan-Willem de Zeeuw, Paul Bairoch, Brinley Thomas, and Jean-Claude Debeir, Jean-Paul Deléage and Daniel Hémery – to name but a few – searched for the historical meanings of energy in processes of economic development.[8]

But it is only since very recently that energy is being taken seriously in (economic) history again. Some of the most elegant examples of this renewed scholarly interest in energy history are the book series directed by Paolo Malanima providing a great amount of data on energy consumption in various European countries,[9] the synthesis *Power to the People* written by Astrid Kander, Paul Warde and Paolo Malanima on the historical entwinement between energy consumption and economic development,[10] and the collection of case studies looking for a typology of (hybrid) energy transitions in the past within their economic, political and social frameworks in *L'Europe en transitions* edited by Yves Bouvier and Léonard Laborie.[11] The scope of energy historians has not been limited to Europe, as is apparent in the work of Christopher F. Jones and Ruth Wells Sandwell for instance who investigated the energy history of America and Canada, respectively.[12] In global history as well, energy has become a potential factor in explaining divergent paths of regional development, particularly so in Kenneth Pomeranz" concept of "ghost acreage", by which he not only refers to the European colonies in the New World but also to the domestic coalfields in Britain, both alleviating pressures on the land.[13] While adding different accents in each of their narratives, all

3 Edward Anthony Wrigley, *The Path to Sustained Growth: England's Transition from an Organic Economy to an Industrial Revolution* (Cambridge: Cambridge University Press, 2016), 18.

4 See *Ibid*., chapter 1 ("Organic economies").

5 Rolf Peter Sieferle, *The Subterranean Forest: Energy Systems and the Industrial Revolution* (Cambridge: The White Horse Press, 2001), 137.

6 Alfred W. Crosby, *Children of the Sun: A History of Humanity's Unappeasable Appetite for Energy* (New York: W.W. Norton, 2006); Vaclav Smil, *Energy in World History* (Boulder: Westview Press, 1994); Vaclav Smil, *Energy and Civilization. A History* (Cambridge: MIT Press, 2017).

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12 Christopher F. Jones, *Routes of Power, Routes of Power: Energy and Modern America* (Cambridge: Harvard University Press, 2014); Ruth Wells Sandwell (ed.), *Powering up Canada: A History of Power, Fuel, and Energy from 1600* (Montreal: McGill-Queen's University Press, 2016).

13 Kenneth Pomeranz, *The Great Divergence: China, Europe, and the Making of the Modern World Economy* (Princeton: Princeton University Press, 2000).

these historians have stressed the importance of energy transitions in history.[14]

THE PATH TO SUSTAINED GROWTH: IN SEARCH FOR EXPLANATIONS OF THE INDUSTRIAL REVOLUTION

4 At the beginning of his introduction Wrigley states that the object of his book is "to describe the transformation in the capacity to produce goods and services which took place in England over a period of three centuries between the reigns of Elizabeth I and Victoria, and which is conventionally termed the industrial revolution".[15] A largely agrarian society, England was still on the economic periphery of Europe at the beginning of the sixteenth century. By the eighteenth and nineteenth centuries, however, it had turned into the leading power of the global economy. In search for explanations for this remarkable transformation, Wrigley has found a solution in the energy basis which an economy relies on. In order to escape the trap of energy scarcity and organic stagnation, he claims, societies had to gain access to a different source of energy. Mining coal was the solution. Exploiting a stock of fossil fuels that provided abundant and cheap energy enabled the English economy to attain a scale of production that was otherwise beyond reach.[16]

5 Much of Wrigley's resource-intensive view is constructed on the notion of positive and negative feedback. In organic economies negative feedback was common. Population growth was kept in check by the natural limits on agricultural productivity. Cultivation of marginal land or intensification of existing land would eventually experience diminishing marginal returns (involution), thus inhibiting further growth and reducing living standards. The increasing importance of England's underground ghost acres from the sixteenth to nineteenth centuries gradually alleviated these pressures on land, turning negative feedback into positive feedback. Coal not only allowed to break the energy constraints on economic and demographic growth, it also provided a drastic expansion of the limited supply of land by substituting fields and forests by the stores of minerals lying beneath them. In other words, if an industrial revolution was to take place, England first had to transform from an energy-scarce to an energy-rich society.

6 This "energy revolution" binds all the chapters of the book together. But other topics that interacted with the changing balance between traditional and new energy sources are grasped by Wrigley as well. In chapters 3 to 6 he tackles the interplay between energy consumption, urban growth, agricultural productivity, changing occupational structures, and demographic changes.[17] A first fundamental process was the urbanisation of early modern England. The intense nature of this process stimulated the production of both an agricultural and energy surplus that needed to meet ever growing urban requirements of food and fuels. Next, the expansion of the secondary and tertiary sectors amplified the incentive for farmers to produce for an urban market even further. Not only resulted this into a rise in the total consumption of energy, the per capita energy consumption increased as well. Wrigley explains this mostly through the rise of the Western European marriage system, which, by increasing the number of nuclear families, probably increased the demand for home heating. Most of the per capita increase in energy consumption, however, was due to rising demand for heat-intensive manufacture like metallurgy, glassmaking, and dyeing, which, in its turn, benefited from growing consumer demand for such products of urban "comfort" as a result of a rise in the real income per head. In chapter 7, Wrigley describes the role of transport improvements in making

14 A recent overview in Alain Beltran, "Introduction: Energy in History, the History of Energy", *Journal of Energy History/Revue d'Histoire de l'Énergie*, vol. 1, 2018.

15 Edward Anthony Wrigley, 1 (cf. note 3).

16 See also Robert C. Allen, *The British Industrial Revolution in Global Perspective* (Cambridge: Cambridge University Press, 2009) who emphasised the combination of high wages and cheap energy in Britain's process of cost-effective industrial mechanisation.

17 Edward Anthony Wrigley, chapters 3 to 6 ("Energy consumption", "Urban growth and agricultural productivity", "Changing occupational structure and consumer demand", and "Demography and the economy") (cf. note 3).

coal cheaply and abundantly accessible to a wide market area.[18] All of these processes were symptomatic to an advancing organic economy that, with the invention and steady improvement of the steam engine, eventually turned into a mineral economy at the beginning of the nineteenth century, when the English industrial revolution finally reached its completion and the way to sustained growth was paved.[19]

MOVING BEYOND THE CLASSICAL ECONOMISTS?

7 It is evident from the entirety of Wrigley's work on the industrial revolution that energy mattered, if not only, then primarily. Wrigley has certainly not neglected various other historical processes in the build-up to the industrial revolution, as I mentioned above, but his binary model of organic and mineral economies is fundamental in his understanding of the genesis of a modern self-sustaining economy. Most of the economic historiography on energy is firmly rooted in a Malthusian and Ricardian terminology, which could be deemed as an "ecological model of economic development", as Ricard G. Wilkinson has attempted to reconstruct.[20] Coal is then perceived as an exogenous factor that helps explaining why England, anchored in its energy endowments, was able to overcome the limits to both production and reproduction. The turn to fossil fuels thus formed the answer to Ricardian land scarcity and Malthusian checks on population growth in a pre-industrial context, enabling the country to establish a Smithian economy of growth.

8 Wrigley has closely read the writings of the classical economists, to whom he devotes an entire chapter in his book.[21] In economic history Adam Smith, David Ricardo and Thomas Malthus obviously continue to have a tremendous influence. While highly original, Wrigley's narrative, however, follows the classical economists rather blindly at times. Part of his thesis might therefore appear to be somewhat self-explanatory; as soon as coal replaced traditional forms of energy, modern economic growth was the logical outcome. But was it? There is a long history between England's energy revolution in the sixteenth and seventeenth centuries and its industrial revolution in the eighteenth and nineteenth centuries. As said, Wrigley has convincingly pointed at the importance of the long-term effects of an early transition to coal, but the way how he ties both revolutions to one another is not always as convincing. For Wrigley, the industrial revolution in the long run – "between the reigns of Elizabeth I and Victoria" – *was* the energy revolution to coal.[22] But was this coal revolution so inextricably linked to a process of industrialisation, if until far into the nineteenth century most coal was consumed by households?[23] Surely coal, whether consumed for industrial or domestic purposes, afforded land-saving effects. But when the industry definitively liberated itself from natural constraints at the beginning of the nineteenth century, households had already done so two or three centuries earlier. Perhaps we need in the future to devote more attention to the role of the household economy in "learning to heat a house with coal", rather than focusing on the industrial benefits and applications of new energy sources.[24]

ENERGY, ECONOMY AND SOCIETY: TOWARDS AN INTEGRATED HISTORY OF ENERGY?

9 Wrigley's celebratory narrative on England's energy transition and his rather uncritical reading of the classical economists runs the risk of rectifying a somewhat a-historical view on the "normal state of affairs" of poverty and stagnation in economic history. Wrigley sees in coal a necessary condition for the industrial revolution to happen. The rare blessing – or "geographical

18 Edward Anthony Wrigley, chapter 7 ("Transport") (cf. note 3).
19 *Ibid*., chapters 8 and 9 ("England in 1831" and "The completion of the industrial revolution").
20 Richard G. Wilkinson, *Poverty and Progress: An Ecological Model of Economic Development* (New York: Praeger, 1973).
21 Edward Anthony Wrigley, chapter 2 ("The classical economists") (cf. note 3).
22 *Ibid*., 1.
23 William M. Cavert, "Industrial Coal Consumption in Early Modern London", *Urban History*, vol. 44, n° 3, 2017.
24 Robert C. Allen, 90 (cf. note 16).

accident", as Pomeranz has called it[25] – that England found in its accessibility to an abundance of coal explains how it escaped the "logical constraints of an organic economy".[26] Chance lied in between continuity and change. The lack of a transition to coal is then the reason why an economy like the Dutch, which in the early modern period was most comparable to the English economy, failed to capitalise on all the features it had of becoming a prosperous and modernised society. Less so in *The Path to Sustained Growth* but rather bluntly in his earlier work, Wrigley refutes the connection between industrial capitalism – as a social-economic system – and the rise of fossil fuels, by depicting it as "casual rather than causal".[27]

10 Energy, as an exogenous factor, can never be an autonomous explanation in itself. Wrigley interprets coal mostly as an independent explanatory factor in trying to understand the industrial revolution. But the question why modern economic growth could be achieved by eighteenth- and nineteenth-century England is inextricably linked to the reverse question: why coal? Most economic historians of energy would reply that coal was the obvious answer to pre-industrial scarcity. But this is an insufficient answer. How could a fuel already known and used since the Middle Ages and long considered inferior because of its foul smell and smoke only be popularised from the sixteenth to nineteenth centuries?

11 Moving beyond the classical economists might help us in establishing future perspectives in the economic history of energy. Current challenges in society will urge energy historians to engage more with ecological issues in their broadest sense: the historical interaction between "energy", "economy", and "society". Scholars like Stephen Mosley and William M. Cavert pioneered in writing an environmental-economic history of energy, by scrutinising the feedback between processes of urbanisation, economic growth, and their environmental consequences.[28] The dialectic relation between "energy" (or, more broadly, "environment") and "economy" is further elaborated in the concept of urban metabolism, as initiated by Fridolin Krausmann and Sabine Barles for instance. They illustrate how urban economies were not only made by energy endowments but how they also co-produced their own ecological hinterlands.[29] A book like Timothy Mitchell's *Carbon Democracy* also shows how energy systems and their histories are closely intertwined with structures of political and economic power.[30]

12 "Society" is the last part of the ecological triad. A recent initiative on the material cultures of energy led by Frank Trentmann and Hiroki Shin for instance shows that homes, rather than industrial workshops or factories, have long been the sites in which energy regimes were produced and reproduced within the social and cultural practices of domestic life.[31] A ccording to David E. Nye the electrification of America was largely a social product made by ordinary consumer behaviour, eventually reaching "technological momentum"

25 Kenneth Pomeranz, 62 (cf. note 13).

26 Edward Anthony Wrigley, *Continuity, Chance and Change*, 115 (cf. note 1).

27 *Ibid*.

28 Stephen Mosley, *The Chimney of the World: A History of Smoke Pollution in Victorian and Edwardian Manchester* (London: Routledge, 2008); William M. Cavert, *The Smoke of London: Energy and Environment in the Early Modern City* (Cambridge: Cambridge University Press, 2016).

29 Fridolin Krausmann, "A City and its Hinterland: Vienna's Energy Metabolism 1800-2006", *in* Simron Jit Singh, Helmut Haberl, Marian Chertow, Michael Mirtl, and Martin Schmid (eds.), *Long Term Socio-Ecological Research: Studies in Society-Nature Interactions across Spatial and Temporal Scales* (Dordrecht: Springer, 2013); Sabine Barles, "The Main Characteristics of Urban Socio-Ecological Trajectories: Paris (France) from the 18th to the 20th Century", *Ecological Economics*, vol. 118, 2015.

30 Timothy Mitchell, *Carbon Democracy: Political Power in the Age of Oil* (London: Verso, 2011). See also: Andreas Malm, *Fossil Capital: The Rise of Steam Power and the Roots of Global Warming* (London: Verso, 2016).

31 See http://www.bbk.ac.uk/mce. See also: Ruth Schwartz Cowan, *More Work for Mother: The Ironies of Household Technology from the Open Hearth to the Microwave* (New York: Basic Books, 1983); Priscilla Brewer, *From Fireplace to Cookstove: Technology and the Domestic Ideal in America* (Syracuse: Syracuse University Press, 2000); Elizabeth Shove, *Comfort, Cleanliness and Convenience: The Social Organization of Normality* (Oxford-New York: Berg, 2003); Christopher F. Jones, "The carbon-consuming home: residential markets and energy transitions", *Enterprise & Society*, vol. 12, n° 4 (2011).

as soon as social pressures on this large-scale energy network grew high enough.[32] In a similar vein, Yves Bouvier very recently introduced in this journal the concept of "energy consumers" to emphasise the deeper societal roots of energy consumption and transitions.[33] Ultimately, according to Roger Fouquet, energy systems were subjected to the path-dependent effects of technologies, infrastructures, institutions, and behaviours.[34] Moving beyond the Ricardian-Malthusian idea of "external" constraints on the "internal" dynamic of social and economic development, all these new approaches of research have stressed the interconnectedness between economy, society, and energy.

13 In a way, Wrigley ends *The Path to Sustained Growth* on a similar note. It is no coincidence that he has already attracted the attention of environmental historians. In his coda, Wrigley nuances the success story of England's industrial revolution, by pointing out the potential dangers of resource exhaustion, pollution and global warming.[35] Even if it provided the opportunity to radically expand the productivity of the economy, in the longer term the energy basis of a mineral economy cannot be sustained. As I said at the beginning of this article, the great merit of Wrigley is that he has made energy central to the research agenda of economic historians. Wrigley's work provides many answers, but also raises numerous new questions. In the future, energy historians will depart from where Wrigley has ended.

32 David E. Nye, *Electrifying America: Social Meanings of a New Technology, 1880-1940* (Cambridge: The MIT Press, 1992); *Id.*, *Consuming Power: A Social History of American Energies* (Cambridge: The MIT Press, 2001).

33 Yves Bouvier, "Energy consumers, a boundary concept for the history of energy", *Journal of Energy History/Revue d'Histoire de l'Énergie*, vol. 1 (2018). See also the very recent special issue on this topic in The History of Retailing and Consumption: Ruth Wells Sandwell and Abigail Harrison Moore, "Off-grid empire: rural energy consumption in Britain and the British Empire, 1850-1960", *The History of Retailing and Consumption*, vol. 4, n° 1, 2018.

34 Roger Fouquet, "Path dependence in energy systems and economic development", *Nature Energy*, vol. 1 (2016).

35 Edward Anthony Wrigley, chapter 10 ("Review and reflection") (cf. note 3).

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Journal of Energy History
Revue d'histoire de l'énergie

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POST DATE
08/04/2019
ISSUE NUMBER
JEHRHE #2
SECTION
Reviews
KEYWORDS
Oil, Politics, Business, Dissent, Knowledge
DOI
in progress

TO CITE THIS ARTICLE
Clarence Hatton-Proulx, "Machineries of Oil: An Infrastructural History of BP in Iran (Katayoun Shafiee, 2018)", *Journal of Energy History/Revue d'Histoire de l'Énergie* [Online], n° 2, published 08 April 2019, consulted XXX, URL: energyhistory.eu/en/node/119.

Machineries of Oil: An Infrastructural History of BP in Iran (Katayoun Shafiee, 2018)

Bibliographic reference

Katayoun Shafiee, *Machineries of Oil: An Infrastructural History of BP in Iran* (Cambridge, MA: MIT Press, 2018).

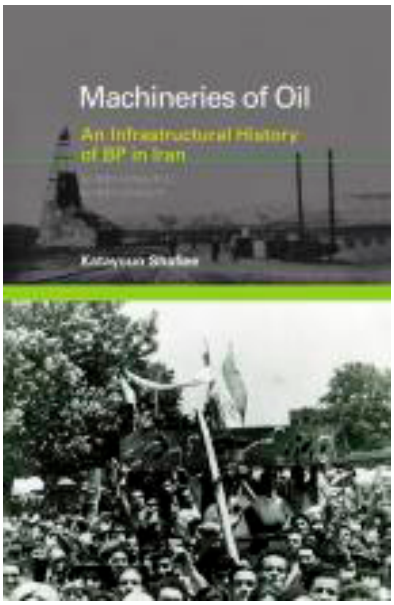
Abstract

L'ouvrage de Katayoun Shafiee se penche sur l'histoire de British Petroleum (BP) en Iran, de 1901 à 1954. Le livre montre comment la multinationale a développé toute une série de pratiques visant à déplacer les revendications politiques égalitaires des travailleurs du pétrole vers des calculs techno-économiques. Ces calculs sont parties prenantes de la constitution d'un vaste réseau d'alliés (des autres majors pétrolières aux gouvernements occidentaux). Ils participent ainsi de la transformation de la politique au Moyen-Orient, et de la formation du régime énergétique de notre monde.

Acknowledgments

The author would like to thank Marc Letremble for his kind comments.

Plan of the article



1 From time to time, in the academic world, a researcher strikes oil and opens a new field for exploration. Timothy Mitchell's book *Carbon Democracy: Political Power in the Age of Oil*[1] certainly belongs to this category. By showing energy's centrality in shaping political and economic forces, and how oil in particular helped create a world order dependent on an undemocratic Middle East, he has paved the way for many scholars interested in revisionist accounts of energy history. Among these, Katayoun Shafiee follows this path with her first monograph entitled *Machineries of Oil: An Infrastructural History of BP in Iran*[2] which examines the history of the Anglo-Persian Oil Company's[3] activities in Iran through a socio-technical lens, studying in detail the organizational practices that allowed the British company to keep a monopoly on the extraction of Iranian oil until its nationalization in 1951. These organizational practices and artefacts, such as mathematical formulas, concession terms, and international law, were used by AIOC to transform social and political claims, such as demands for higher wages or increased Iranian participation in the company, into technoeconomic calculations, argues Shafiee. Therefore, the book's main ambition is to delve into these machineries of oil through six different case studies, each forming one chapter, in order to show how Pandora's boxes get tranformed into black boxes.

2 Mitchell's influence over Shafiee's work is not fortuitous since the former supervised the latter's PhD thesis[4] at New York University's departments of History and Middle Eastern and Islamic Studies; since then, Shafiee has held positions at the National University of Singapore, at University College London and at the University of Warwick, where she is now assistant professor. In fact, following one of the key points made in *Carbon Democracy*, Shafiee opens her book by inviting us to see oil as more than just an economic resource, traditionally viewed in academic discourse through the rentier state[5] and the resource curse lens, since this narrow conception of oil ignores its materiality and how, "for oil to be transformed into profits, it must rely on a set of technical arrangements, human forces, political powers, distribution systems, forms of expertise, and coercive mechanisms."[6] However, seriously considering oil's materiality contrasts with most histories of oil and of AIOC, whose existence is usually explained solely by the Royal Navy's switch from coal to oil in 1912; additionally, these accounts treat states and transnational corporations as separate entities, seeing AIOC and the Iranian state as distinct. But these narratives are insufficient, according to Shafiee. Indeed, other motives can explain AIOC's foundation in 1908, one being a constraint on global oil supply to ensure high profits for transnational

1 Timothy Mitchell, *Carbon Democracy: Political Power in the Age of Oil* (London: Verso, 2011).

2 Katayoun Shafiee, *Machineries of Oil: An Infrastructural History of BP in Iran* (Cambridge, MA: MIT Press, 2018).

3 First known as Anglo-Persian Oil Company (APOC), then Anglo-Iranian Oil Company (AIOC), and today known as British Petroleum (BP). Following Shafiee, we will unilaterally use the acronym AIOC to refer to this firm throughout the text for simplification.

4 Katayoun Shafiee, *Cracking Petroleum with Politics: Anglo-Persian Oil and the Socio-Technical Transformation of Iran, 1901-1954* (New York, NY: New York University, 2010).

5 The author points out that the rentier state concept was first formulated in relation to Iranian economic history. See Hossen Mahdavy, "The Pattern and Problems of Economic Development in Rentier States: The Case of Iran," *in* Michael A. Cook (ed.), *Studies in the Economic History of the Middle East* (Oxford: Oxford University Press, 1970), 428-467.

6 Shafiee, *Machineries of Oil*, 8.

oil corporations, another being the undermining of Iranian[7] state sovereignty. Furthermore, the dividing line between private actors and states is often quite fuzzy, since they are deeply linked through complex energy networks and infrastructure and are therefore co-constructed.

3 To differentiate her work from the traditional historiography on Iran's oil industry, the author uses a sociotechnical analytical framework, stemming among others from Michel Callon's work and the actor-network theory (ANT)[8] widely used in the emerging research field of science and technology studies (STS). A sociotechnical approach is useful, in this particular instance, since it encompasses not only human but also non-human actors such as oil, organizational techniques or royalty calculations, to understand how these actors form a network to reach certain objectives and shut down political possibilities. Even if the sociotechnical framework usually goes hand in hand with ethnographical work, Shafiee applies it with great skill to an historical approach based on archival work conducted in Iran, in the United Kingdom and in the United States. The resulting book is built around six different sociotechnical artifacts involving AIOC and presented chronologically, from 1901 to 1954.

CONCESSIONS AND GEOLOGICAL REPORTS AS "POLITICAL WEAPONS"

4 In 1901, the Iranian government grants a 60-year concession to William Knox D'Arcy for wide access to its petroleum resources. This is not the first fossil-fuel related concession on Iranian territory, however, since access to coal was granted to the British Baron von Reuter in 1872. And, indeed, coal will remain the dominant fossil-fuel consumed globally over oil in relative and absolute terms until 1965 (see fig. 1 and fig. 2).[9]

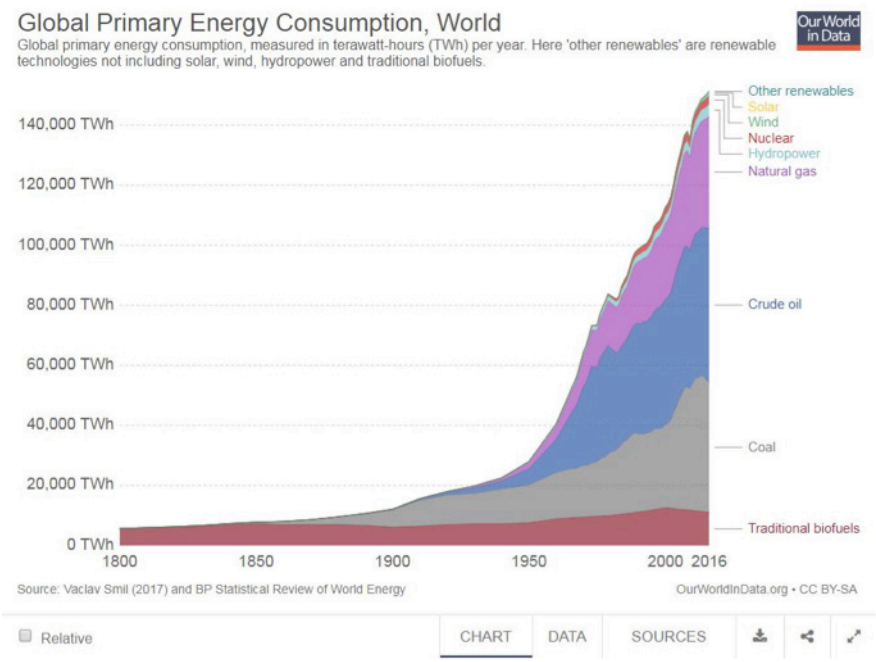


Figure 1: Global primary energy consumption in absolute terms since 1800. Free of copyright restrictions (Creative Commons)

7 Iran was known globally as Persia until 1935, but we will use the former for clarity.

8 See, for example: Michel Callon, "Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay," *in* John Law (ed.), *Power, Action and Belief: A New Sociology of Knowledge?* (London: Routledge, 1986), 196-223. Callon himself sat on her PhD dissertation committee.

9 Hannah Ritchie and Max Roser, "Energy Production & Changing Energy Sources." OurWorldInData.org (2018). Retrieved from: https://ourworldindata.org/energy-production-and-changing-energy-sources. Data from: Vaclav Smil, Energy Transitions: Global and National Perspectives (Santa Barbara, CA: Praeger, 2017). Charts are free of copyright restrictions (Creative Commons).

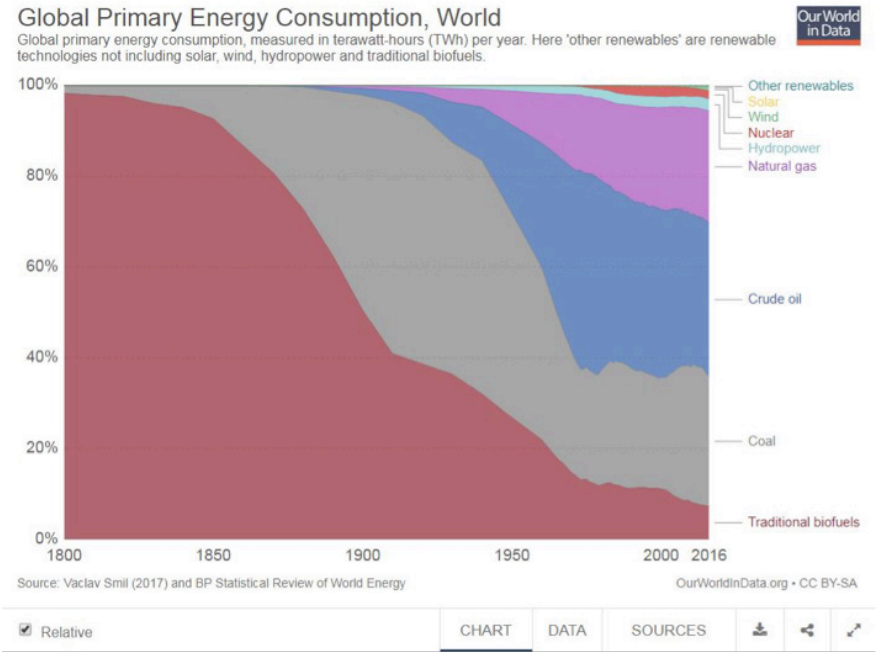


Figure 2: Global primary energy consumption in relative terms since 1800. Free of copyright restrictions (Creative Commons).

5 So, one may ask, why were D'Arcy and the British interested in Iranian oilfields when oil consumption was still very much in its infancy? Traditional accounts portray the adventures of transnational oil corporations in the Middle East as a race to discover and exploit new oilfields. But, following a point made in *Carbon Democracy*,[10] Shafiee instead shows how the concession's Article 6 prevented Russia from building a pipeline on Iranian territory, illustrating a persistent cartel strategy adopted by the oil majors throughout the 20th century consisting of curbing oil production to restrict competition and maintain high prices, thus ensuring high profit margins.

6 The concession did not clearly address the matter of property rights, which AIOC and the British government, majority shareholder from 1914 to save the firm from bankruptcy, used to their advantage. To address land and property claims made by local actors, such as the Bakhtiyari khans, AIOC chose to deal with them directly, in effect bypassing the central government's jurisdiction and weakening its reach, at least until Reza Pahlavi's accession to power through a British-sponsored coup in 1921, after which he eliminated these middle groups and allowed AIOC to repatriate all the Bakhtiyari's shares and dividends. Shafiee thus illustrates how the concession, a seemingly neutral legal text, was in effect a technology of power and control that "did the physical work of building the machinery in and through which more democratic forms of oil production and politics were shut down and other arrangements left open."[11]

7 Another interesting document examined by Shafiee is a geological report written by Hugo de Böckh in 1924 for AIOC.[12] He and others before him had pointed out how Iran's oil reserves were calculable and limited; for example, the Masjid Suleiman oilfield was estimated in 1929 to go dry by the 1950s. This information, however, was seen as highly sensitive by AIOC, which was keen to manufacture a sense of uncertainty around known reserves to reassure investors[13] and keep

10 "The main feature of Middle Eastern oil throughout the twentieth century was that there was always too much of it" (Timothy Mitchell, *Carbon Democracy: Political Power in the Age of Oil*, 43).

11 Shafiee, Machineries of Oil, 55 and 90 where she speaks of this concessions as "political weapons" (90).

12 Hugo de Böckh, *Preliminary Report on the Principal Results of My Journey to Persia*, 1-93. BP archives 70501, 1924.

13 William Fraser, deputy chairman of AIOC, indicates that estimates of oil reserves "should never be circulated to the Board or shareholders." Shafiee, *Machineries of Oil*, 75.

Figure 3: Iranian workers building a pipeline leading to the Abadan refinery, 1908. Retrieved from http://www.iichs.org/srcfiles/printmag.asp?id=180. Free of copyright restrictions (in the public domain).

the Iranian government from asking questions about royalties, production rates and concession terms. To achieve this, AIOC removed all geological conclusions, including maps, from de Böckh's report and recalled the 72 copies sent before these revisions: the second edition of the report delivered to the Iranian government is thus bare of technical details and made useless. Yet, this interesting point needs to be nuanced: Shafiee takes the calculations coming from AIOC at face value, while we must acknowledge that oil reserves are socially[14] and economically[15] constructed. Nevertheless, her wider argument stands. While AIOC was building technical expertise about oil reserves in Iran to serve its economic interests, the British company was at the same time constructing ignorance about the resource to the Iranian government. Oil production sites, she argues, served as laboratories where petroleum knowledge was formed *in situ*, since the particular type of oil found in Iran was peculiar due to its high viscosity, pressure and sulfur content. But "unknowability"[16] about oil was also produced in these laboratories, in effect black-boxing geological reserves, maps[17] and estimates whose knowability would have hurt AIOC's business interests. As ever, the technical and social worlds merge, forming a "seamless cloth."[18]

Despite these attempts to stifle debate, the 1901 concession, which was extremely favorable to AIOC, was the subject of growing discontent during the 1920s and the 1930s in Iran. The lack of local employment and both technical and accounting information made available to the government, the low production rates resulting from cartel practices, as well as the meager royalties, equivalent to 16% of AIOC's annual net profits, led to the concession's cancellation in 1932. The dispute opposing the oil firm and its majority shareholder — the British government — to the Iranian government was taken to the League of Nations and, as Shafiee

14 Gary Bowden, "The Social Construction of Validity in Estimates of US Crude Oil Reserves," *Social Studies of Science*, vol. 15, n°2, 1985.

15 Gordon C. Watkins, "Oil scarcity: What have the past three decades revealed?," *Energy Policy*, vol. 34, n°5, 2006.

16 This is the term the author uses. See: Shafiee, *Machineries of Oil*, 71.

17 Unfortunately, few maps and images in general are presented in the book.

18 Bruno Latour, *Politics of Nature: How to Bring the Sciences into Democracy* (Cambridge, MA: MIT Press, 2004), 12.

shows, transformed international law by introducing such concepts as national sovereignty over natural resources and, conversely, the right of governments to represent and defend private firms on the international scene. The long arm of petroleum and the centrality of energy systems thus shaped international laws and institutions, as the subsequent nationalization of Iran's oil industry in 1951 under Mohammad Mosaddegh would again demonstrate.

DIVIDING PROFITS, DIVIDING LABOR

9 Negotiating a new concession meant coming up with more generous royalties for Iran without frustrating AIOC shareholders, all the while limiting annual oil output despite calls from Tehran to step up production. Two mathematical formulas were concocted by AIOC's accountants to calculate royalties based on profits and production rates: however, both formulas led to royalties fixed at about 20% of AIOC profits. These gave the illusion of choice: an illusion since key variables, such as production volumes, remained identical in both formulas. As Shafiee underlines, "each proposed scheme corresponded to a particular arrangement, with the ultimate aim of narrowing the field of dispute by removing the possibility that the government would demand access to company accounts and an increase in production and profits."[19] Mathematical formulas transformed political claims, such as increasing oil output and royalties accordingly, into purely technical calculations. In the end, a new concession was adopted in 1933, addressing royalties but also demands for increased Iranian participation in the labor force, both in non-technical and technical roles. Article 16 (III) of this new concession stipulated that the share of non-Iranian AIOC employees had to be gradually reduced while the share of employed Iranian nationals had to increase concomitantly. However, well aware of the imminent threats facing its operations in the region, notably unionization and nationalization, the British oil major had to ensure social and labor division through a set of social technologies.

10 This division of labor on racial terms, a classic strategy used in a similar context by Aramco in Saudi Arabia,[20] resulted in high inequalities in pay as well as in working and living conditions between employees of the same firm. British nationals occupied most technical and managerial roles, while Iranians were left to more basic tasks, a differentiation ingrained in the 1901 concession's Article 12. Indian "coolies" were also crucial to AIOC's operations in Iran after the First World War, forming almost a quarter of its workforce in 1921. Many social technologies were employed by the company to ensure discipline amongst its workers, according to Shafiee. English proficiency was necessary to work in its higher divisions, and this imperative was used by the firm as a tool of distinction between different classes of workers in order to weaken Iranian participation in decision-making. Housing, for example near the Abadan oilfield, was highly discriminatory: Europeans inhabited bungalows in a dedicated section of town, while the locals lived in deprived shantytowns. "Never in the whole of my experience indeed in any other country which I have had the privilege of visiting, did I see so close together such extremes in Housing Accommodation"[21] remarked a British parliamentary delegate in 1946.

11 Without surprise, this led to multiple strikes, encouraged by the rise of the Iranian Communist Party that was to become known as the Tudeh in 1941. In May 1929, a strike in Abadan lasted six days, and had mixed results. On one hand, it did not have much success in disrupting regional and global oil flows, only managing a suspension of geological surveys for a few days. This relative failure can be explained by one of the crucial points made by Timothy Mitchell in *Carbon Democracy*: contrarily to a coal-centered energy system, in which workers have more leverage in labor disputes since they are more important to the extractive process and also because coal is more expensive to import from distant locations, an oil-centered energy system is synonym

19 Shafiee, *Machineries of Oil*, 107.

20 Robert Vitalis, *America's Kingdom: Mythmaking on the Saudi Oil Frontier* (Stanford, CA: Stanford University Press, 2006).

21 Cited in Shafiee, *Machineries of Oil*, 141.

Figure 4: Indian soldier guarding an AIOC refinery, 1941. Retrieved from http://media.iwm.org.uk/ciim5/293/637/large_000000.jpg. Free of copyright restrictions (in the public domain).

with more networked energy routes and thus less political clout for workers.[22] Yet, on the other hand, the strike led to improved working conditions for Iranian workers, partly thanks to increased pressure on AIOC coming from Reza Shah's administration.

12 The British firm was thus in an uncomfortable position: improving living standards for its employees was inescapable, although ceding ground would eventually lead to more power for labor movements supporting nationalization of the Iranian oil industry. This impasse is reflected in the company's forced efforts to form local technicians, setting up the Abadan Technical Institute in 1938 but ultimately promoting trade training over university training, the latter generating highly-educated workers suspected of being trouble-makers. AIOC, thanks to its experience in administering oil workers in the Middle East, even held a meeting in London with most oil majors operating in the region to share information on commendable administration practices, showing how transnational oil corporations collaborated not only on production and prices but also on industrial relations. Nevertheless, additional strikes in 1945 and 1946 guided by the Tudeh party and rising trade unions led to a new labor law introducing a 48-hour work week and establishing a National Ministry of Labor with local branches in oil-producing regions across the country.

NATIONALIZATION, BACKLASH, AND STRATEGIES OF "MASTERLY INACTIVITY"

The social technologies and administrative techniques employed by AIOC couldn't completely hide the fact that royalties paid to the Iranian government, despite the renegotiated concession in 1933, were still mediocre, as were the working and living conditions of the workers employed in the petroleum sector. Finally, in March 1951, after one more strike, the oil industry's nationalization was voted by the Majlis, the Iranian parliament: the 1933 concession was then cancelled, AIOC oil-related property expropriated and the British firm replaced by the new National Iranian Oil Company (NIOC). This drastic measure was instantaneously contested by the British government, arguing that it violated international law. Internationalizing this dispute by bringing it to the newly established International Court of Justice (ICJ) was a way for the United Kingdom to mobilize allies, mostly the United States, and for Iran to make the case for national sovereignty over oil in international legal terms. 13

To retaliate against nationalization, AIOC and the British government, working hand in hand, imposed multiple economic sanctions, freezing Iran's sterling balances in London, stopping Iran from converting sterling into dollars and suspending exports of commodities like steel and sugar. An oil boycott was also enforced: AIOC stopped paying royalties altogether, including advances and past dues, barred its British technicians from working on oil sites and prevented companies from loading oil at the Abadan refinery. American oil majors diligently followed suit, since global demand for oil was met by increased production, with major oilfields being put on stream in the Middle East such as Ghawar in 14

22 See Mitchell, *Carbon Democracy*, 13-42.

Saudi Arabia, discovered in 1948: in other words, there was no need to bring the oil coming from Iran's newly nationalized industry to markets immediately since doing so would have depreciated oil prices and contradicted the cartel's main tried and tested objective of maintaining high oil prices.

15 This alignment of British and American interests, both public and private, shows how oil has been central in shaping a Western world whose growth was and still is dependent on the undemocratic forms of politics brought about by oil in the Middle East. Nationalization was then simply unacceptable for the British and the Americans.[23] Multiple strategies of "masterly inactivity"[24] were devised to delay and block this new dangerous political path, not only for Iran but for other countries tempted by an anti-liberal measure in a post-Second World War context haunted by the specter of communism. As mentioned earlier, the first strategy was to internationalize the dispute by bringing it to the ICJ. In the end, the court concluded in July 1952 that it lacked jurisdiction to render a definitive verdict, in effect ruling in favor of Iran and of national sovereignty and setting an international legal precedent in the process. The second consisted in implicating the young International Bank for Reconstruction and Development (IBRD), now known as the World Bank, which offered to manage Iran's oil supply chain until a compromise was found, but Mossadegh refused, arguing that the IBRD "failed to grasp the dimensions of Iranian nationalism"[25] and that it mostly served British and American interests. The third, planned since 1951, resulted in Mossadegh's overthrow in August 1953 under Operation Ajax arranged by the CIA with MI6's assistance.

16 AIOC was reinstated as the British Petroleum Company in 1954, but was no more on its own to exploit Iran's oilfields, since a consortium arrangement allowed US majors, Shell and the Compagnie française des pétroles[26] to gain access to this market. The outcome left full rights to the oil majors over oil output and prices, Iran gaining a legal title to its oil and a 50-50 distribution of net production profits. Once again, for Shafiee, the transnational oil corporations came out as the real winners of this consortium arrangement: it helped them secure lasting control over Iranian oil supply and allowed them to circumvent political alternatives opened by workers and public opinion after a lengthy struggle. This closure proved crucial in the post-Second World War world order, centered around an oil-based energy system.

SOCIAL TECHNOLOGIES AND THE SHUTTERING OF POLITICAL ALTERNATIVES

17 By offering a detailed and erudite account of how a transnational oil corporation evolved in the first half of the 20th Century, Katayoun Shafiee's history of British Petroleum's ancestor from the 1901 concession to the consortium arrangement of 1954 is compelling under various angles. It clearly demonstrates how an oil-based energy system was deliberately constructed, highlighted by Winston Churchill's decision for the Royal Navy to turn to oil instead of coal in 1912; this reminds us how so-called energy transitions are complex, gradual,[27] and result from political and economic decisions.[28] Replacing coal, whose materiality enabled more democratic forms of politics, with oil allowed the West to neutralize egalitarian demands at home through control of the Middle East's enormous oil reserves. The insider look at the numerous cartel practices

23 To that effect, we must remember George Bush's words in 1992, at the first Earth Summit: "The American way of life is not up for negotiation." Cited in: "A greener Bush," *The Economist*, 13/02/2003. Retrieved from: https://www.economist.com/leaders/2003/02/13/a-greener-bush

24 Roger Louis, cited in: Shafiee, *Machineries of Oil*, 208.

25 Amy L. S. Staples, cited in: Shafiee, *Machineries of Oil*, 211.

26 Now known as Total.

27 Vaclav Smil, "Examining energy transitions: A dozen insights based on performance," *Energy Research & Social Science*, vol. 22, 2016.

28 Jean-Baptiste Fressoz, "Pour une histoire désorientée de l'énergie," *in* Daniel Thévenot (dir.), *25e journées scientifiques de l'environnement – L'économie verte en question* (Créteil : JSE, 2014). Retrieved from: https://hal.archives-ouvertes.fr/hal-00956441

adopted by the oil majors, from manipulating oil output and prices to cooperating on the management of labor dissent and unionization, is also extremely insightful. Another important side story in *Machineries of Oil* is the fading influence of the United Kingdom and its replacement by the United States as global superpower; also worth mentioning is how public and private interests, often portrayed as separate, merged, most famously to overthrow Mossadegh in 1953. This tragic event reminds us just how oil, and energy, are crucial. Finally, in what is Shafiee's main focus throughout the book, she shows how social technologies and organizational practices were mobilized by AIOC to discipline its workers and shut down political alternatives, such as nationalization and unionization. The 1901 and 1933 concessions, mathematical formulas to calculate royalties and output, housing, international law and the division of labor on racial terms were all employed by the British firm to transform political claims into technical calculations as to render its decisions as objective and scientific, black-boxing egalitarian demands in the process.

18 *Machineries of Oil* is a great read for scholars interested in Iranian and Middle Eastern history, but also in global history, since it offers great insight into the interactions between Western and Middle Eastern states throughout the first half of the 20th Century. Business historians will also find great material in the book, above all a precise account and description of the oil major's monopolistic practices. Historians of technology, however, might feel puzzled by the extremely elastic use of the concept of technology: for the author, "sanctions and a boycott, 50-50 profit-sharing, the APQ [*Aggregate Programmed Quantity*], the racial-technical organization of labor, and legal-economic metrology"[29] as well as concession terms[30] or housing[31] are all considered technologies. This wide use of the term, close to Foucault's,[32] is somewhat disconcerting and doesn't allow for clear analysis: what is and is not considered as technology by the author is not specified. Likewise, although the title promises an infrastructural history of AIOC, very little is said of pipelines,[33] not to mention roads, telecommunication networks, railways or shipping routes. Infrastructure, then, as technology, is used very liberally, which can disconcert the reader.

Despite these details, *Machineries of Oil* narrates a crucial episode in energy and global history, supported by great archives coupled with an interesting socio-technical analysis of past events inspired by the ANT. It links with great dexterity the materiality of oil, state formation, technical expertise, imperialism, and labor politics. As the oilfields in Khuzistan are about to be depleted, one wonders what will happen to this well-oiled machine when nothing will be left to fuel it. 19

29 Shafiee, *Machineries of Oil*, 236.

30 *Ibid*., 53.

31 *Ibid*., 122.

32 Michel Foucault, *Surveiller et punir: Naissance de la prison* (Paris : Gallimard, 1975). See also: Michael C. Behrent, "Foucault and Technology," *History and Technology*, vol. 29, n°1, 2013.

33 See for example: Christopher F. Jones, *Routes of Power: Energy and Modern America* (Cambridge, MA: MIT Press, 2016).

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JEH RHE

Journal of Energy History
Revue d'histoire de l'énergie

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POST DATE
15/04/2019
ISSUE NUMBER
JEHRHE #2
SECTION
Reviews
KEYWORDS
Oil, Business, Geopolitics, Sovereignty
DOI
in progress

TO CITE THIS ARTICLE
Radouan Andrea Mounecif, "Oil exploration, Diplomacy, and Security in the Early Cold War (Roberto Cantoni, 2017)", *Journal of Energy History/Revue d'Histoire de l'Énergie* [Online], n°2, published 15 April 2019, consulted XXX, URL: energyhistory.eu/en/node/121.

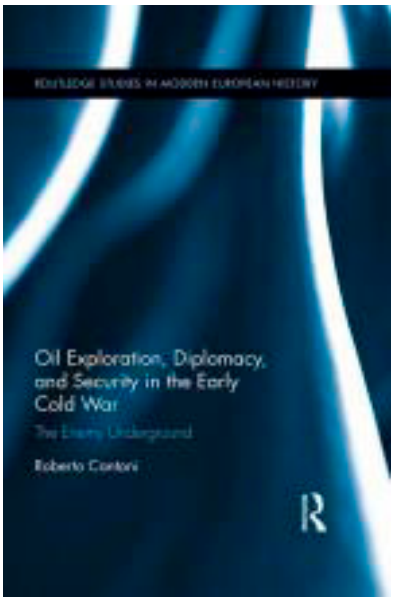
Oil exploration, Diplomacy, and Security in the Early Cold War (Roberto Cantoni, 2017)

Bibliographic reference
Roberto Cantoni, *Oil exploration, Diplomacy, and Security in the Early Cold War: The Enemy Underground* (New York: Routledge, 2017).

Abstract
Le livre de Roberto Cantoni, Oil exploration, Diplomacy, and Security in the Early Cold War: The Enemy Underground, présente une vision alternative du rôle stratégique des techniques d'exploration pétrolière durant la Guerre froide. Elargissant la littérature existante sur l'histoire de l'énergie, il analyse les relations entre technosciences et diplomacie et le rôle de la prospection pétrolière dans la sécurité nationale, contribuant ainsi à replacer la technique au centre de l'analyse géopolitique.

Plan of the article

ISSN 2649-3055



1 The main ambition of a history book is to enhance the reader's understanding of the present through the interpretation of past events. This is particularly true for the history of energy if we consider how this emerging discipline is committed to actively participating in the contemporary debate on energy transition. *Oil exploration, Diplomacy, and Security in the Early Cold War: The Enemy Underground* elucidates the strategic role of the technoscientific development of petroleum exploration industry in relation with international diplomacy and energy security, drawing a line of continuity between the early Cold War period and the present time. Roberto Cantoni's work combines a solid archival research, with an acute theorization of the role of technicians, technocrats and technical institutions in the definition of national, supranational and international energy security strategies between 1945 and 1962. Adopting a multidisciplinary approach and a multiscale perspective, the originality of this book lies in the transnational analysis of the technological development of petroleum industry confirming that "technology is not a tool of politics, but a mode of politics."[1] Differently from other scholars, Roberto Cantoni's work contributes to develop energy studies by focusing the analysis on the role of science and technology in the history of petroleum industry.

TECHNOSCIENTIFIC DEVELOPMENT AND NATIONAL SECURITY IN THE EARLY COLD WAR

2 Roberto Cantoni reconstructs the history of Italy and France's quest for energy self-sufficiency after World War II, presenting the role of oil prospection technology and geoscientific intelligence in the attempt to limit their dependence on Anglo-American oil supplies. The book shows how oil industry technoscientific development promoted by the Italian state-owned *Ente Nazionale Idrocarburi* (ENI), the French *Compagnie Française des Pétroles* (CFP) and the *Bureau de Recherche de Pétrole* (BRP) was a core element of France and Italy's national security strategies during the early Cold War. In particular, it shows how the acquisition of knowledge on geophysics and seismic methods has allowed these companies to find alternative sources of oil outside the producing regions controlled by the oil majors, setting the basis for an independent European energy sector. After tracing the historical evolution of France and Italy's national energy policies in the post-war period, the focus shifts towards a geopolitical perspective presenting the effects of the French and Italian oil commercialization strategies based on Algerian and Soviet oil on Cold War international dynamics. Contextualizing his analysis in the interconnecting framework of transnational history of science and technology and diplomacy of natural resources, Cantoni investigates the correlation between oil prospecting activities and national security, taking into consideration the involvement of technocrats and technical elites in diplomatic relation and policy making.[2]

3 In this book hydrocarbons do not lie at the center of the analysis because the access to oil resources is considered as the consequence of the possession of knowledge and the mastery

1 Gabrielle Hecht, *The Radiance of France: Nuclear Power and National Identity after World War II* (Cambridge: MIT Press, 2009 [1998]).

2 Roberto Cantoni, *Oil exploration, Diplomacy, and Security in the Early Cold War: the Enemy Underground* (New York: Routledge, 2017), 122.

of oil exploration, production and transportation technologies. As Cantoni explains, despite peak oil having been predicted for many years in various forms, fossil fuels have remained until today the main source of energy all over the world. This has been possible thanks to the development of new industrial processes that have made "the extraction of oil and gas from non-conventional reservoirs economically and technically viable."[3] In this sense, the development of oil prospecting technology and the collection of geophysical information of the underground were strategic tools for France and Italy at the end of World War II, contributing to strengthen their position in the international oil market ensuring their national security. Dispelling the myth of the lack of scientificness of oil exploration summed up by the old saying "oil is where you find it," the author demonstrates that oil discoveries "are not simply the result of individual exercises in data collection, but years of scientific and technological activities, industrial failures and success, and the high public and financial investment associated with them."[4]

4 Roberto Cantoni's hybrid theoretical framework is based on the operationalization of the concept of "transnationalism" in multiple dimensions. Considering their physical qualities, oil and gas are border-crossing resources, as oil transportations infrastructures also constitute transnational energy supplies networks. In the same sense, oil companies are transnational actors spreading their activities and structures all over the world. In this sense, the innovative argument proposed by the author rests on the transnational dimension of technoscientific knowledge in the field of geophysics and the crucial role played by technoscentists, and in the development of oil exploration and production in France and Italy. Underground prospecting activities represent the early stage of oil exploration, for this reason expertise in geophysical methods such as gravimetry, magnetic techniques and seismology, is a necessary pre-condition to limit the dependency on foreign companies.

3 *Ibid*.

4 *Ibid*., 3.

5 Shifting from a macro-historical to a micro-historical perspective, the author focuses on the process of professionalization of geophysicists in the oil sector, presenting their scientific background and their transnational mobility. Emphasis is placed on the "neglected role of oil exploration geosciences"[5] in contemporary literature on energy history.[6] This is particularly due to the perception of geophysics as a "conventional" and "uninteresting" technology, the scarcity of archival sources and the prominence of nuclear culture during the Cold War.[7] Defying this lack of interest, the book presents the strategic role played by geophysicists from the US-based prospecting companies working in the Sahara training European companies' technicians, and the role of technology in the systematic oil discoveries during the 1950s. Furthermore, the originality of his interpretation of the early 1960s "midstream shift,"[8] lies in the analysis of the correlation between the decline of geophysical activities and the sharpened focus on pipeline technology. In fact, the overproduction due to the abundance of Algerian and Soviet oil on the European market imposed a reduction of exploration activities and a focus on the acquisition of pipeline construction know-how so as to ensure national security and international market stability.

5 *Ibid*., 4.

6 According to the author geophysics have a limited place in contemporary literature: few works in history of technosciences and monograph studies of geophysical companies such as Compagnie Générale de Géophysique and Schlumberger have been published. Louis A. Allaud and Maurice H. Martin, *Schlumberger: The History of a Technique* (Hoboken: John Wiley & Sons 1972). Ken Auletta, *The Art of Corporate Success: The Story of Schlumberger* (New York: Penguin, 1985). Charles Carpenter Bates, Thomas Frohock Gaskell, Robert B. Rice, *Geophysics in the Affairs of Man: a Personalized History of Exploration Geophysics and its Allied Sciences of Seismology and Oceanography* (Oxford: Pergamon Press, 1982). Geoffrey C. Bowker, *Science on the Run: Information Management and Industrial Geophysics at Schlumberger, 1920-1940* (Cambridge: MIT Press, 1994). Compagnie générale de géophysique, *CGG: 1931-2006: 75 ans de passion* (Paris: Chêne, 2006).

7 Cantoni, *Oil Exploration*, 15.

8 *Ibid*., 168.

A TELESCOPICALLY STRUCTURED BOOK: FROM NATIONAL TO SUPRANATIONAL DIMENSION

6 *Oil exploration, Diplomacy, and Security in the Early Cold War: The Enemy Underground* is a book characterized by a geopolitically "telescopic"-structure.[9] The reader will be guided through the Cold War oil intrigues, shifting from national to supranational and transnational dimension. This multiscale analysis fosters the understanding of the strategic role of oil exploration technologies in the reconfiguration of oil industry that characterized the period between the end of the 1940s and the early 1960s.

7 In the first chapter, Cantoni traces the post-war reconstruction of Italian oil exploration industry and the early steps of the Italian national oil company ENI on the international scene. He overviews the Anglo-American strategy to take control of oil exploration in Italy and their attempt to re-establish the pre-war distribution of the Italian market thanks to the geophysical data in their possession. Cantoni analyses the foundation of ENI in the early 1950s highlighting the role of geoscientific knowledge whose acquisition granted the company greater independence in the development of oil exploration plans. The author praises the foresightedness of Enrico Mattei's long term strategy which encouraged the training of Italian technicians and the autonomization of the Italian national company through the transfer of foreign technology.

8 In the second chapter Cantoni discusses the reorganization of French oil industry in the aftermath of World War II and the implementation of the new oil policy based on the development of a national oil exploration *savoir-faire*. In particular he analyzes the evolution of CFP strategy in decentralizing the company's core business from Middle East to Africa, other than the establishment of research institutes and public agencies dedicated to hydrocarbons such as the *Bureau de Recherche de Pétrole (BRP)* or the *Institut Français du Pétrole (IFP)*. He questions the role of Pierre Guillaumat and the influence of the French technical elite in the implementation of a French national oil policy through the development of oil prospection in remote French colonial territories such as the Sahara.

9 After showing the key role of American companies in training French exploration geophysicists, the third chapter investigates Algerian oil diplomacy adopting a multilateral perspective. In this sense the author proposes an analysis of the Algerian decolonization process that goes beyond the classical literature characterized by a French-Algerian bilateral perspective. Cantoni shows how scientific and technological knowledge is at the heart of the secret war for hydrocarbons that involves France, foreign government officials, the intelligence service, and oil companies.[10] In this context, he analyzes oil discoveries in the Sahara, highlighting the importance of geophysical information in the definition of new strategies that combine French political and economic ambitions with foreign companies' interests. Roberto Cantoni argues that the need to accelerate exploration activities in the Sahara during the Algerian war of independence encouraged French authorities to adopt a "half-open-door policy," admitting American companies affiliates in the Sahara. He explains the key role of US technology and investments for the French development plans in the Sahara as well as the need to contrast the Algerian National Liberation Front 's (FLN) lobbying activities that were offering American companies the priority in oil concession in exchange for political and economic support for Algerian independence. Discussing ENI's secret agreements with the Algerian independentists, Cantoni questions the role of technical knowledge transfer for the emancipation of the newborn African state.

10 Widening the scope of the analysis, in the fourth chapter Cantoni introduces the concept of "mid-stream shift." After the period characterized by the multiplication of oil discoveries and the oversupplying in oil market, the author explains the shift from prospection technologies

9 *Ibid*., 21

10 *Ibid*., 151.

(upstream sector) to transportation technologies (midstream sector) in the national security priorities. The "mid-stream shift" induced a drastic reduction of the oil companies' prospecting activities while national energy strategies converged towards the commercialization of crude oil and the construction of pipeline transportation facilities. Furthermore, the author shows that the decline of geophysical activities at the end of the 1950s is inversely proportional to the rate of innovation invested in prospecting methods. The extensive use of computers induced a remarkable acceleration in data processing, reducing the costs of geophysics activities.[11] Therefore, the rapid decline of geophysical prospection is strictly correlated to the beginning of the battle for European pipelines that opposed the French plans for the commercialization of Saharan resources and ENI's attempt to flood Western Europe with Soviet oil.

11 The analysis of the "pipelinization"[12] of Europe is the narrative element that allows the transition in the fifth chapter where the author focuses on the role of supranational institutions such as NATO and the EEC in an expanded geopolitical framework. Merging political, economic and military dimension, Cantoni analyzes NATO's opposition to Soviet oil exports in Europe and the role of the pipeline as a means of political struggle, adopting a transnational point of view.[13] Studying the international organization discourse Cantoni highlights the role of technological transfer in the relations between the Soviet Union and Western Europe in this delicate phase of the Cold War.

A TRANSNATIONAL ARCHIVAL RESEARCH

12 Cantoni's theorization is based on an extremely solid archival research that confirms the author's rigorous methodology in comparing historical sources coming from different public and private archives. This approach is an attempt to overcome the lack of primary sources that characterizes research in the field of energy, particularly in the history of geosciences and the history of technosciences. The underestimated role of geophysics in the history of oil exploration is certainly the consequence of the inaccessibility of historical archives from geophysical exploration companies and other contractor companies specialized in oil prospection. Commenting on his methodological approach, in the footnotes of the book's introduction Cantoni does not hide the difficulties he had to access the Compagnie Générale de Géophysique (CGG Veritas) documentation center[14] and the limited relevance of the sources kept by this institution, despite the role played by this actor in his narrative. For this reason, he found the main sources for his research both in public archival institutions and in oil companies' private archives. Roberto Cantoni explores diplomatic and ministerial archives in five different countries: France, Italy, the United Kingdom and the Unites States of America other than the NATO archives based in Brussels. Furthermore, Total and ENI corporate archives constitute an important part of his work, as well as records of institutions in charge of professional training in the oil sector, such as the *Institut Français du Pétrole* and the *Scuola Superiore di Studi sugli Idrocarburi*.

13 The use of a great variety of sources demonstrates the author's attempt to analyze a complex phenomenon through the multiplication of points of view. Adopting a multiscale approach, Cantoni's analysis embraces the study of the technical elites, the definition of industrial strategies and the geostrategic impact of technoscientifc development in the Cold War dynamics. The author integrates sources from different public and international bodies in order to compare the impact of France's and Italy's industrial development in the oil sector in the International Relations System and the oil market. In this sense, the most remarkable aspect of Roberto Cantoni's research is the decision to document the oil exploration development in wartime Algeria exploiting the sources kept by the

11 *Ibid.*, 173.
12 *Ibid.*, 23.
13 Andrew Barry, *Material Politics: Disputes Along the Pipeline* (Hoboken: John Wiley & Sons, 2013). Timothy Mitchell, *Carbon Democracy: Political Power in the Age of Oil* (London: Verso Books, 2011).

14 Cantoni, *Oil Exploration*, 8.

US National Archives and Record Administration and the Italian *Archivio Storico Diplomatico Del Ministero degli Affari Esteri*. The Algerian war of independence having been perceived by French authorities as a matter of domestic policy, the adoption of an outside view helps the author not only to overcome the restricted access to French public archives but also to contextualize this event in the Cold War dynamics. In the same sense, ENI plans to support the construction of Soviet pipelines in Europe to ensure Italian self-sufficiency appears well documented by British Foreign Office and Ministry of Power files. But only the comparison with sources kept in NATO archives makes it possible to appreciate the importance of this event in the broader pattern characterized by the East-West struggle for energy security.

14 But the core of Cantoni's research is characterized by the massive recourse to corporate records kept in Total and ENI Historical Archives that reflects the author's attempt to create a dialogical relation between individuals, firms and governments in oil exploration history. According to the author, oil companies are a fundamental part of the "strategic information collecting apparatus"[15] implemented by states to fulfil the surveillance imperative and to gather strategic information. For this reason, oil companies' archival sources are mainly used to trace the activities of Total and ENI and the strategic role of their decision makers during the Cold War period. Official correspondence and notes kept in CFP president Victor De Metz and ENI president Enrico Mattei's files, helps the author to define the existing connections between oil company executives, political and diplomatic agents. In this sense, Total historical archives have provided many unreleased sources such as geostrategic studies and economic reports kept by the *Centre de Documentation et de Synthèse* and the CFP Secretary General's archives. Cantoni's work shows how Oil companies' historical archives are essential sources for the analysis of the Cold War geopolitical framework and particularly the cooperation between transnational actors and governments in their quest for energy security. Considering the transnational dimension that characterizes technosciences, the study of the strategic role of geosciences in oil exploration industry adopting an historical perspective cannot bypass the cross analysis of existing public and private sources.

CONCLUSION

15 The year 1962 marks the end of Roberto Cantoni's analysis of the oil exploration and diplomacy during the Cold War. Characterized by the end of the Algerian War, Enrico Mattei's death, the NATO Large-Diameter Pipe Embargo against the Soviet Union and the Cuba Missile Crisis, this really hectic year has caused a sharp caesura, both in the history of the Cold War and in the evolution of the international energy sector. The narrative stops at that time but the general analysis provided by the author highlights the importance of recurring long-term themes in energy history and the continuity between the recent past and present days.[16] The current dependency on Russian gas has replaced the Cold War dependency on Soviet oil[17] but the intertwinedness and the interdependence of national foreign policies and energy companies' strategies is still relevant nowadays in the attempt to limit Europe's energy vulnerability.

16 This analysis of the relations between technosciences and diplomacy and the role of oil prospecting in national security opens a new transnational debate on oil exploration history, merging literature and archival sources from different national contexts. Cantoni's work is a synthesis of historical knowledge whose main outcome is a coherent attempt to unify different historiographical traditions. In doing so the author makes us aware of the risk of restraining the analysis of complex phenomena in energy history in a nation-based historiographical debate. Furthermore, Cantoni's argument highlights how the old-fashioned diplomatic history approach is not adapted to respond to the

15 *Ibid*., 13.

16 *Ibid*., 247.

17 *Ibid*.

ambitions of history of energy as a new field of research. Through the study of geosciences, the book replaces technology at the center of the narrative, reframing the role of technical elites in the development of oil industry. Examining the interplay of technicians, diplomats, entrepreneurs and intelligence agents, and the "permeability" of these categories[18] Cantoni proposes an original interpretation of the history of oil exploration during the early Cold War where a meticulous historical reconstruction meets a comprehensive analysis of the interaction between geoscience, strategic information and national diplomacy.

18 *Ibid*., 248.

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JEHRHE

Journal of Energy History
Revue d'histoire de l'énergie

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POST DATE
01/04/2019
ISSUE NUMBER
JEHRHE #2
SECTION
Reviews
KEYWORDS
Nuclear, Pollution, Knowledge, Dissent, Environment
DOI
in progress

TO CITE THIS ARTICLE
Roberto Cantoni, "Storia ambientale dell'energia nucleare. Gli anni della contestazione [Environmental History of Nuclear Energy. The era of contestation] (Andrea Candela, 2017)", *Journal of Energy History/Revue d'Histoire de l'Énergie* [Online], n°2, published 01 April 2019, consulted XXX, URL: energyhistory.eu/en/node/116.

Storia ambientale dell'energia nucleare. Gli anni della contestazione [Environmental History of Nuclear Energy. The era of contestation] (Andrea Candela, 2017)

Bibliographic reference

Andrea Candela, *Storia ambientale dell'energia nucleare. Gli anni della contestazione* [Environmental History of Nuclear Energy. The era of contestation] (Milano/Udine: Mimesis Edizioni, 2017)

Abstract

En utilisant les outils de l'histoire environnementale, Andrea Candela analyse les événements sociaux et scientifiques qui ont lieu en relation avec l'énergie nucléaire dans les années 1970, une époque caractérisée à la fois en Europe et aux Etats-Unis par la contestation des autorités et par le mûrissement de l'écologie scientifique. Candela centre son approche sur l'Italie pour mettre en lumière l'ensemble des questions géo-environnementales critiques soulevées par les applications de la technologie nucléaire.

Plan of the article

ISSN 2649-3055

1 As indicated by its title, Candela's work focuses mainly on environmental history: however, one would be mistaken if s/he thought the interest of the book stops at that. Candela's is also, to a considerable extent, a work that provides valuable elements to historians of science and technology. In fact, these two historical fields, while different in their analytical focuses, are often intertwined, as the case of the birth and development of radioecology clearly demonstrates. But *Storia ambientale dell'energia nucleare* can also be understood as a work relating to the history of mobilizations, given the significant attention that the author dedicates to anti-nuclear protest movements. Candela's book is therefore a work that, although it had to leave out for reasons of space extensive analysis of a debated topic in the nuclear realm, such as the management of radioactive waste, fills important gaps in different historical sub-disciplines. This is true, first, in relation to the historical period studied: the 1970s. Secondly, it is even truer as far as Italian historiography is concerned, where this gap is largely a consequence of the policies of declassification of the main archives of the Italian state. These are characterized by a certain inertia, which makes access to documents dating from after the early 1960s complex (as I myself was able to experience) even today. It is perhaps no coincidence that Candela opted to limit his archival sources to the Fondazione Luigi Micheletti in Brescia and the Istituto Nazionale per la Storia del Movimento di Liberazione in Italia in Milan, archives that are less extensive and more accessible than their big brothers in Rome. This limit on primary archival sources, however, is compensated by numerous references to non-archival primary literature, consisting mainly of literary and scientific essays from the period Candela analysed, but also of newspaper articles, bulletins and newsletters available on the web.

The book is divided into three, long chapters, 2
preceded by a methodological introduction and followed by a conclusion that sets a narrative terminus—which is also a political terminus in the history of Italian nuclear power—at the 1980s. The three chapters are ordered according to a scalar structure, which goes from the general to the particular and from the world scale to the national, Italian scale through the European scale, with some back-and-forths that, however, do not affect the reading. The Introduction to the book explains the methods of historical analysis that inspire the work: referring to Fernand Braudel's writings, Candela distinguishes between a long duration (thousands and millions of years—geological, geographical and cultural times), an average duration (decades or centuries—social and economic time), and a short duration (or "events": days, weeks, a year—diplomatic and political time). The concatenation of these three temporalities is particularly relevant to the case of nuclear energy. Here the geological times related to uraniferous formations interact with the "middle" times of the implementation of national energy plans, and with the short times of significant events such as the release of atomic bombs on Hiroshima and Nagasaki, the Chernobyl nuclear accident, or more simply the publication of a foundational document, or the organization of a particular conference.

EARLY STAGES OF GLOBAL ENVIRONMENTALISM

3 The first chapter introduces the 1970s historically, politically, and culturally: a decade in which the two oil crises of 1973 and 1979 intertwined

with the consolidation of the world's bipolar political structure, the questioning of the concepts of progress and technical-scientific development, and in some European countries the emergence of movements of political protest characterized by violent modalities of action. At the same time, however, a widespread passion for ecology was also consolidating, because of the spectre of atomic death caused by ever-growing arsenals. Ecology was not only intended as a space for creativity and problematization, but also of political confrontation. It is in this period that some founding texts of ecology and political ecology were published, by both scientists and thinkers. Candela dwells on the Earth Day in 1970 and on the UN conference on the human environment in 1972. He analyses the reception and criticism received from seminal publications of the time, such as *The Limits to Growth* (1972), authored by researchers at MIT, and Barry Commoner's *The Closing Circle*, which highlighted the potential ecosystem hazards arising from the use of nuclear power. Commoner, in particular, was to be taken up by the movements of the Italian left to push towards a democratization of the power of technology. That in turns would lead to the creation of various groups of scientists-activists.

4 The democratization of the management of technosciences is, still today, a fundamental theme of studies on science and technology, and in the 1990s led to a rediscovery from an academic point of view of the value of "lay expertise" (see below). The chapter closes with a reconstruction of the origins of radiobiology in the United States between the 1950s and 1960s: in particular, Candela dwells on a congress held at Colorado State University in 1961, whose proceedings he considers a fundamental turning point in the study of interactions between ecosystems and induced radiation. In the wake of the Colorado conference, radioprotection and radiobiology courses started to be devised at European universities. In Italy, it was not until 1970 that the first conference on health physics and radiation protection was organized.

THE INTERNATIONAL EVOLUTION AND DEVELOPMENT OF THE NUCLEAR OPTION

5 The book's second chapter deals more extensively with the international nuclear context, as well as with disputes over the technological designs of reactors, and with conflicts surrounding the development of the continent's nuclear power plants. The geographical focus of this chapter is Brussels, where in 1977 the EEC members gathered to discuss and plan various energy options in a foreseeable post-oil era. In fact, Candela shows, the discussion was somewhat fictitious, since the EEC member representatives considered the nuclear option as inevitable, even if there were critical differences on the modalities of expansion and the models of nuclear power plants to be adopted. In any case, the discussion took place behind closed doors, among members of the European political and technical elites. That, argues the Author, reflected the idea of Europe that had come to succeed after World War II, with the concept of a rigid institutional apparatus prevailing over that of a shared space, open to various dialoguing instances.

6 Unveiling the complexity of the decision-making situation at European level, Candela contrasts Euratom, an agency created exclusively for dealing with the civilian purposes of nuclear energy, with the 1957 report of the Three Wise Men, which instead saw the atom as a strategic element in anti-Soviet function. Euratom would be set up as a regulatory body, but any decision on fissile materials would be excluded from its scope, under pressure from the French Government, which wished to develop its nuclear arsenal. While Candela's reconstruction of the activities and critical moments of Euratom's initial history does not seem to add particularly innovative elements to the existing literature,[1]

1 Jaroslav V. Polach, EURATOM: Its Background, Issues and Economic Implications (Dobbs Ferry: Oceana Publications, 1964) ; Bertrand Goldschmidt, The Atomic Complex: A Worldwide Political History of Nuclear Energy (La Grange Park, 1982); Jonathan E. Helmreich, "The United States and the Formation of EURATOM," Diplomatic History, vol. 15, 1991, 387-410.

contrarily, his study of world uranium exploration activities in the 1960s and the analysis of various, more or less successful, European initiatives aimed at creating an adequate technological apparatus that could diminish Europe's dependence on US manufacturers, disclose novel and/or previously understudied aspects. As a result of various slowdowns, European countries—including France—were to eventually switch to reactors designed in the USA, while not completely giving up experimenting with new models (for example, France's fast-neutron reactors).

7 At this point in the book, a different story begins, more oriented to contestation and environmentalism in antinuclear function, and less to the decisions taken by technopolitical elites. With the anti-nuclear mobilization in the U.S., the institutional reorganization of the American nuclear regulatory institutional apparatus in the mid-1970s, the release of the film *The China Syndrome* and the almost contemporary Three Mile Island accident in 1979, the narrative moves back to North America, to then extend to the globe. Candela details the spread of anti-nuclear protest movements on all continents, and the contemporaneous—in fact, related—appearance on the nuclear agenda of the thorny issue of nuclear waste management. This issue, albeit belatedly, was to form the basis of the US Nuclear Waste Policy Act, a foundational document that became executive in 1982. Here again, regulation taking shape in the Western world's most technologically advanced nuclear power set the pace for other nuclear countries to start devising their own regulatory apparatus

NUCLEAR CONTROVERSY AT NATIONAL LEVEL: THE CASE OF ITALY

8 In the book's third and last empirical chapter, we shift from the global to the national scale. Here, it is the environmental history of Italian nuclear energy that takes centre stage. Considered by the Italian scientific, political and industrial elites as the only viable path towards greater energy autonomy and economic recovery, nuclear energy nevertheless started to be the subject of serious controversy in the wake of the 1968 protest movement. The antinuclear protest was to become an integral part of the demonstrations of the 1970s. It would be characterized by an increasing questioning of the neutrality of the Italian nuclear institutions (such as CNEN—National Committee for Nuclear Energy—and ENEL—National Electricity Agency), as well as by the emergence of figures of scientists-activists, not unlike what was happening in the same period in neighbouring France.[2] Candela argues that a further witness to the technocratic mode of managing the Italian nuclear sector was the absence of legislation involving public participation in major decisions on issues of public interest, such as those concerning the locations of power plants and storage sites for radioactive waste. While this situation was rather common in all European countries active in the implementation of nuclear plans, it was particularly critical in the Boot.

9 The Law no. 393 of 1975, establishing an emergency regime that restricted individual and collective freedoms in the event of disagreement with the nuclear plans decided by the central administrations, gave concrete expression to the technocratic conception according to which the management of the nuclear option developed in Italy. Here, I believe, the Author could have seized the opportunity to refer to, and reflect on works by Giorgio Agamben, one of the most influential contemporary theorists on emergency states.[3] In conjunction with this technocratic drift, an ever-increasing environmental awareness was also emerging and being institutionalized. In addition to protests concerning environmental and medical aspects, political protests ensued, since the places for the construction of new power stations were mostly in rural areas, which would not benefit in terms of jobs, and which depended on the surrounding areas for their livelihood. In this regard, Candela identifies an important criticality in the different positions

2 Sezin Topçu, *La France nucléaire. L'art de gouverner une technologie contestée* (Paris: Seuil, 2013).

3 Giorgio Agamben, State of exception (Chicago: University of Chicago Press, 2003). A further, older reference could have been to the German political theorist, Carl Schmitt.

taken by left-wing political parties on nuclear power, and the frequent differences between the central bodies of these parties (generally, more in favour of nuclear power) and their local sections (generally against).

10 Another of the book's innovative elements is the analysis—though perhaps described with an excessive amount of details and quotations from primary literature, which abound also in other sections of the book—of the institutional conflict of interest involving CNEN, to which the State Council entrusted the study of the reliability of seismic findings in view of the construction of the Montalto di Castro nuclear plant, overlooking the fact that the CNEN itself was engaged in the research and development of nuclear power. CNEN was therefore at the same time controller and controlled. As one would expect, CNEN's study, the *Charter of Sites likely to host nuclear plants* (Carta dei Siti suscettibili di insediamento di impianti nucleari), which appeared in 1979, was to provoke criticism from many sides for both its methodology and results: among the critics stood no less than the National Order of Geologists. In particular, Candela points out that the uncertainty about seismic hazard conditions was a consequence of the lack of a high-resolution geological map of Italy, and that that could have instead highlighted some geodynamic processes that remained hidden in the region of Lazio, where the plants was scheduled to be located.

11 Criticism of the Charter was not only formulated by official geologists but also by scientists-activists and ordinary citizens with knowledge of aspects of the local geology. This led Candela to reflect on the formation of lay expertise and its role in mobilizations. Such expertise was not only geology-, but also epidemiology-related: on its basis, technical committees were formed, even if the degree of institutionalization did not reach that of France. In its evocation of the concept of lay expertise lies probably one of the book's (minor) weaknesses: while Candela does mention the concept of lay expertise, he fails to mention the scholars, especially in the domain of the STS, who contributed most to the reflection on this topic. Works like those by Sheila Jasanoff, who spent over 20 years documenting avenues for co-production of knowledge in the US; Brian Wynne, who similarly worked on lay expertise in connection with the nuclear industry in the UK; or Steven Epstein, who pioneered the concept in epidemiology by working on knowledge co-production by AIDS-affected communities in the US, would have deserved larger credit.[4] The role of scientists-activists and of non-scientists in the production of knowledge on nuclear matters is mentioned again in the conclusions (p. 294), and rightly so, as we learn it was particularly important in the contestation. Nevertheless, one has the feeling that this item is left a bit hanging, and that the Author could have dedicated more space and deeper analysis to it.

12 The chapter closes with an analysis of the phases preceding the closure of the first Italian power plant, the Garigliano power plant, following two flooding events of the nearby river, the consequent contamination of the surrounding areas, and a series of scientific publications that testified to this contamination. In the conclusions, Candela reflects on a foundational event that occurred at the beginning of the new decade of the 1980s: namely, the National Conference on Nuclear Safety held in Venice. The conference, where very different positions on nuclear energy were confronted, and which saw the participation of both state agencies and anti-nuclear and ecologist associations was, according to the Author, a lost opportunity for dialogue and discussion, as the decision to increase the number of nuclear stations had already been taken before the conference. As a demonstration

4 Sheila Jasanoff, (ed.), *States of Knowledge: The Co-production of Science and the Social Order* (London; New York: Routledge, 2004); Brian Wynne, "May the Sheep Safely Graze? A Reflexive View of the Expert – Lay Knowledge Divide," *in* Scott Lash, Bronislaw Szerszynski, Brian Wynne (ed.) *Risk, Environment and Modernity: Towards a New Ecology* (London: SAGE, 1996), 44-83 ; *Id.*, "Misunderstood misunderstanding: social identities and public uptake of science," Public Understanding of Science, vol. 1, n°3, 1992, 281-304; Steven Epstein, "The Construction of Lay Expertise: AIDS Activism and the Forging of Credibility in the Reform of Clinical Trials," *Science, Technology, & Human Values*, vol. 20, n°4, 1995, 408-437.

of such intent, in the months following Venice the National Energy Plan involving the construction of additional power plants was approved. The change of course in Italy's nuclear history would only come with the Chernobyl accident.

CONCLUDING REMARKS

13 Overall, this well-written and instructive piece of work, while sometimes indulging in too much technical detail, discloses and analyses understudied aspects of nuclear energy. It sheds light on the recent environmental history of a country that, because of its current nuclear status as a have-not, is seldom associated with nuclear energy and the attendant complexities of its political, diplomatic, environmental, and social consequences. Perhaps a different organization of the structure of the book, in shorter chapters, would have benefited the agility of the text.

14 One may find the book wanting in terms of archival sources: while it dedicates much space to international matters, it accessed no sources from non-Italian archives. Possibly these sources might have contributed to making the history of the environmental aspects of Italy's nuclear energy more global, for example by investigating the links woven by anti-nuclear activists with their non-Italian counterparts. Informed readers may also wonder why, considering that the book's core relates to a topic characterized by a marked techno-scientific basis, the Author did not access the historical archives of Italy's ENEA (Agency for new technologies, energy and environment), which keeps the records of the country's former nuclear agencies. However, a criticism in this sense would be inappropriate, as those archives were under construction at the time the book was being written. Quite possibly these archives will help scholars of nuclear Italy access a vast amount of previously widely scattered materials that will further contribute to increase our knowledge on this topic.

15 Besides environmental historians and historians of science and technology, who are the most immediate audience for this book, *Storia ambientale dell'energia nucleare* is of interest to scholars of nuclear cultures and history, who will find here an analysis of nuclear energy as seen through a rather uncommon environment-centred perspective. Scholars of contemporary Italian history will also enjoy this book as a complement to the existing literature on Italy's nuclear domestic and foreign politics.[5] Finally, because of its focus on social movements, organizations, associations involved in the contestation of nuclear energy and in the production of expertise, Candela's work will also be of interest to social historians.

5 Leopoldo Nuti, *La sfida nucleare. La politica estera italiana e le armi atomiche 1945-1991* (Bologna: Il Mulino, 2007); Silvio Labbate, *Il governo dell'energia. L'Italia dal petrolio al nucleare (1945-1975)* (Firenze: Le Monnier-Mondadori, 2010).

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JEH RHE

Journal of Energy History
Revue d'histoire de l'énergie

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POST DATE
06/02/2020
ISSUE NUMBER
JEHRHE #2
SECTION
Reviews
KEYWORDS
Coal, Oil, Industry, Knowledge, Public policy
DOI
in progress

TO CITE THIS ARTICLE
Antonin Pottier, "Les économistes et la fin des énergies fossiles (Antoine Missemer, 2017)", *Journal of Energy History/Revue d'Histoire de l'Énergie* [Online], n°2, published 06 february 2020, consulted XXX, URL: http://energyhistory.eu/node/123

Les économistes et la fin des énergies fossiles (Antoine Missemer, 2017)

Bibliographic reference
Antoine Missemer, *Les économistes et la fin des énergies fossiles (1865-1931)* (Paris : Garnier, 2017).

Abstract
In *Les économistes et la fin des énergies fossiles*, Antoine Missemer explores the different ways by which economists have made fossil fuels an object of economic analysis, in the period that runs from *The Coal Question* by William Stanley Jevons to Harold Hotelling's 1931 paper. He is interested in the fear of resource exhaustion and its impact on industrial development, but also reports on the theories that pay attention to the economic activities of fossil fuels producers.

Plan of the article

ISSN 2649-3055

1 Written by a young scholar, *Les économistes et la fin des énergies fossiles*[1] is a rare piece in the history of economic thought that deals with economic theories related to energy and was awarded the 2017 Marcel Boiteux Prize for energy economics. Juan Martínez-Alier[2] brought to light a fascinating gallery of forerunners of Nicholas Georgescu-Roegen's bio-economics, often marginalised or forgotten thinkers. In his book, Antoine Missemer centres on more traditional figures of economic analysis and tells the story of resources economics from the vantage point of fossil fuels. He covers the period before Hotelling's 1931 paper[3], often considered as a starting point of this subfield of economics.

2 Before 1931, how had economists thought about fossil fuels? How was the limited amount of the resources taken into account in economic theories? What were the analytic consequences? How did economists perceive the possible exhaustion of fossil fuels? How can the changing stances and methods regarding fossil fuels be related to broader evolutions of economic analysis? Antoine Missemer seeks to engage with these questions in his research.

3 Missemer's book is very valuable because it covers ground to which few works have been devoted. From the point of view of economic analysis, Missemer makes us discover a little known yet rich period, when economic analysis evolves greatly after the seeds of marginalism had been sown. We therefore have the opportunity to see how a paradigm shift pervades applied studies and gradually modifies how their objects are handled. From the point of view of the history of energy, Missemer writes an important chapter on the scientific discourses on energy and the analytic tools that support them. Past reflections on fossil fuels exhaustion and its consequences for economic prosperity echo the concerns of our times. Missemer's account of the birth of economic arguments on fossil fuels connects directly to our current concerns about fossil fuel availability and the way we think about it.

4 To establish the corpus on which his work is based, Missemer finds texts, speeches, books or articles, mainly by economists, which discuss fossil fuels. Such a corpus constitutes what Missemer calls the economic discourse on fossil fuels. He identifies two trends in this discourse: a macroscopic point of view, which is concerned with the economic system as a whole, and especially the role of fossil fuels on industrial development, and a microscopic point of view, that pays attention to the economic behaviours and constraints of mine owners and operators.

5 He studies the economic concepts used to analyse fossil fuels, how they evolve through time and under the pressure of broader changes in economic theory. He opens out their analytic interrelations and the ways they are mobilised in arguments. If this internalist perspective is more prominent, it is combined with an externalist perspective that pays attention to the social context of the production of ideas.

1 Antoine Missemer, *Les économistes et la fin des énergies fossiles (1865-1931)* (Paris: Garnier, 2017).

2 Juan Martínez-Alier, *Ecological Economics: energy, environment, and society*, (Oxford: Basil Blackwell, 1987).

3 Harold Hotelling, "The Economics of Exhaustible Resources", *Journal of Political Economy*, vol. 39, n°2, 1931, 137–175.

THE COAL QUESTION AS AN AUTONOMISING WORK

6 The starting point is the *Coal Question* (1865)[4]. In it, William Stanley Jevons investigates the role of coal in the development of British industry, examines geological evaluations of coal deposits, in Britain and abroad, anticipates the increase of extraction costs that will impede British industry compared to its competitors, discusses the possible substitutes or the technical solutions to curb consumption, and finally proposes the repayment of national debt as a means of mitigating the adverse consequences for future generations of the complete use of cheap coal deposits. Jevons' book is situated in the context of the period. First, a long-term socio-economic context, that is the growing importance of coal for British industry. Jevons writes after a century of tremendous transformations of the British economy, which creates a break with the conditions experienced by Smith, Malthus or Ricardo, who hardly spoke about the role of coal. Second a short-term political context, the context of the 1860s with worries about the availability of high-quality coal and the possible subsequent end of British industrial supremacy. These worries were vocally expressed by an engineer and powerful British manufacturer, William Armstrong. With *The Coal Question*, Jevons thus enters a lively political debate and his contribution will reverberate throughout the next half-century.

7 Missemer starts with the *Coal Question* not only because it is the first work of importance that an economist has devoted to fossil fuels but more importantly because Missemer claims that, with it, Jevons detaches the economic discourse from others. Missemer points to a twofold autonomisation. First, from geologists' evaluations: whereas geologists took the exhaustion of coal deposits as a physical exhaustion, that is the end of the availability of coal, its disappearance as an existing object, Jevons denies the usefulness of this understanding of exhaustion and argues that the exhaustion should be considered economically. What is relevant is not the end of coal *per* se, but the end of coal at a given cost of extraction. The exhaustibility of coal does not raise a problem of mere availability, rather it is a problem of raising extraction costs. A second autonomisation, from engineers' perspectives, is provided by Jevons. To postpone the exhaustion of cheap coal deposits, engineers promote new techniques or devices that save coal. Jevons points to the fatal drawback of these methods to make coal use more efficient: the economies realised thanks to these new processes make final use of coal less costly and develop the demand for coal instead of reducing it: this is the famous rebound effect. Engineers' reasoning is useless if it is not embedded in proper economic thinking. According to Missemer, these two moves made by Jevons set apart an economic discourse. This autonomisation is important for the coherence of Missemer's project, as it defines the unity and structure of his object, its relative autonomy. If there is something like an economic discourse on fossil fuels, distinct from geological, engineering and political discourse, with its own rules, arguments and arenas, it is justified to study it independently from other fields.

DISCUSSION OF THE AUTONOMISATION THESIS

8 I will take issue with this autonomisation thesis. Instead of the breaks with the geologists and the engineers, I would rather notice the continuities. Certainly, Jevons makes the abstract argument that exhaustion is a matter of too high costs and not of physical availability. But when he comes to numbers, he relies on geologists' estimates of coal reserves, and these do not depend on cost. Furthermore, one of his main arguments is that the common measure of exhaustion (the ratio reserves on production) is not relevant when production is growing. He emphasises that its rate of growth has a stronger influence on the exhaustion date than the estimates of reserves, a simple argument that does not have a distinctive economic angle but has more in common with geologists' or engineers' contributions to the debate.

4 William Stanley Jevons, *The Coal Question* (London: Macmillan, 1865).

9 When writing the *Coal Question*, Jevons had no intention of taking a specifically economic stance. His essay is rather a contribution to an ongoing political debate, whose socio-economic context is aptly described by Missemer, a contribution which is embedded in the same knowledge used by other contributions, a knowledge about geology of coal reserves, trade, industry, energy uses, international competitions. What Jevons wrote can be considered today as an economic discourse on fossil fuels, but it was in continuity with discourses that we would assign, from the viewpoint of today, to other realms of knowledge.

10 Because Missemer is keen to highlight how Jevons broke with past works, he rightly dismisses the connection with Malthus' fear, yet he does not give a fair hearing to the resemblance between Jevons' depiction of the effects of the raising price of coal and the stationary state of Ricardo-Mill induced by increasing cost of land cultivation. This resemblance is not a coincidence. Jevons wrote his book partly to gain public stature and to be offered a position in academia. That Jevons wanted to be heard and recognised by his fellow citizens explains why he resorted to language close to Mill's *Principles*, the common language of the British elite at the time.[5] This stresses again that Jevons' book was addressed to a political audience that is not limited to that of economic analysis.

11 The innovations made by Jevons, like the rebound-effect, are real but the continuities outweigh the ruptures. The specific economic reasoning spotted by Missemer is so intertwined with different types of arguments that it is not convincing to consider the *Coal Question* as an act of autonomisation of economic analysis. *The Coal Question* is a passionate plea from a learned gentleman about a problem he sincerely fears. I view it more as a remarkable example of how economic analysis can be blended with other types of knowledge to yield an assessment of a policy problem.

12 The autonomisation thesis that sets apart an economic discourse legitimises Missemer's point of view, but it is also a product of his focus on economic arguments and economists. Unfortunately, what should be viewed as economic or as an economist is not defined nor thematised, even though the very notion of what an economist is evolves greatly across the period studied, as indicated by the name change from political economy to economics. It seems that Missemer relies on the contemporary conception of what is economic to select his material. To apply this category far back in time, however, when the boundaries between academic disciplines were not established as they are today, raises generic problems. For the analysis of Jevons' work, two risks are involved. First, drawing a sharp boundary between "economists" and those we do not recognise as such severs Jevons from his intellectual associates, because we hail him as a great economist and not them. At the time, however, he contributed to chemistry, spectroscopy, was an ex-gold assayer and was to become professor of logic and moral philosophy. Viewing him as an economist makes his contribution more special than it is. For example, what makes it especially economic, according to Missemer, is the distinction between physical and economic exhaustion. But this had already been made by Thomas Sopwith, an "engineer" and Williams Armstrong, the manufacturer, as Missemer recognised. Why not instead consider Sopwith as an economist? The separation between what today we call an engineer, a geologist, an economist, an industrialist, a moral philosopher or a natural scientist was less sharp than our current categories suggest. Addressing properly this issue would have broadened the scope of the book by making room for non-economic interventions in the debates about fossil fuels in Great-Britain.

AMERICAN CONSERVATIONISM

13 Fortunately, the detailed account of American conservationism avoids these pitfalls. Here the coherence comes naturally from the fact that a single social and intellectual movement is under the spotlight. The case of Gifford Pinchot,

5 Michael V. White, "A Biographical Puzzle: Why Did Jevons Write The Coal Question?", *Journal of the History of Economic Thought*, vol. 13, n°2, 1991, 222–242.

forester, civil servant and a leading figure of conservationism, who characterises it in the phrase "the greatest good for the greatest number for the longest time", an obvious extension of Bentham's, amply demonstrates that the separation of what is economic and what is not is highly debatable.

14 Missemer presents the context of the end of frontier at the end of 19th century. Conservationism sought to avoid the waste of resources and to develop the natural resources of the country in a rational, ordered manner, in a way that would benefit present and future generations. Fossil fuels were only one topic among others for conservationists and fear of exhaustion was not so influential on their thinking. Contrary to the British who were afraid of the end of their supremacy over other nations, conservationism was self-centred on America, as it seeks to hand natural resources and landscapes on to future generations.

15 Yet, bringing together American conservationism and the British fear of coal exhaustion reinforces the impression that the "economic discourse on fossil fuels" is a questionable object. We really have two different scenes, with different actors, different backgrounds, different temporalities. The arenas in which the texts were produced are separate and Missemer gives no hint that the two are effectively connected, that there had been some transfers of ideas, concepts or texts between the two. It even seems that the *Coal Question* was not known on the other side of the Atlantic, as I found no citation of Jevons in some major works that I checked. Instead of a single strand that develops across countries and evolves through time, we have at least two different strands, each coming from its own context. This does not make less relevant the comparison carried out by Missemer and the contrast he draws between the rather pessimistic British slant and the more optimistic and future-oriented American one, but it certainly puts into perspective the presentation of the *Coal Question* as the opening work of economic discourse on fossil fuels.

NATURE AS AN ASSET

16 Missemer's focus on economists is much more convincing in the rest of the book, which deals with two "microscopic" questions, the rent of mines and the intertemporal allocation of resources. Here, the level of technicality of the debates indicates a greater autonomy of the field, and there is certainly a strong overlap between those who venture into these arenas and the economists.

17 In a particularly successful chapter, Missemer focuses on the issue of rent. Starting from Ricardo's theory of land rent, he describes how a demand grows for an explanation of the rent of mines, as the notion of Ricardian rent is itself called into question with the advent of marginalism. This shows the link between the more specific issues of resource economics and general developments in economic analysis. A firm theoretical ground seems eventually to be found with the notion of compensation: mining rent would thus be a compensation for the reduction in underground value due to extraction. However, this consensual position is completely abandoned and, in a dramatic reversal, economists shift back to Ricardo's mining rent theory.

18 The fourth and last chapter details the conceptual changes that made Hotelling's 1931 article possible. It begins with what appears, at first sight, to be a detour, with the theory of capital, one of the places where economic theory evolves rapidly and separately from the repercussions of marginalism. The changes began with the Austrian school and Böhm-Bawerk, which saw capital as a production roundabout. Capital is then very different from raw materials and energy resources. Then comes the Fisherian approach to capital, which opposes it to income: income is a flow of payments, capital is a stock of wealth. Here, the characteristics of the production process no longer matter. Only the flow or stock nature of the payments is decisive in qualifying them as capital or income. From this point on, Missemer describes a fascinating process of extending the meaning of capital, by analogy, contiguity, contamination. With Alvin

Johnson, the notion of natural capital is forged: nature is seen as a stock of wealth. A forest, or a mine, for example, is a stock of wealth because it can be sold for money. They are elements of natural capital. Missemer sees this extension of capital to nature as a critical link in explaining the genesis of Hotelling's article.

19 Hotelling's article indeed deals with the exploitation of exhaustible resources and gives the conditions for its intertemporal equilibrium. But, Hotelling's view is designed to apply to all exhaustible assets, without supplementary specifications. The encompassing category of natural capital explains how a mine can be view as an instance of exhaustible assets.

20 Missemer notices the gaps between Jevons and Hotelling. Hotelling focuses on the micro-economic properties of a mine, in a very abstract way. The consequences of fossil fuels for economic development are out of his scope. The result is a much more optimistic view of the end of fossil fuels. This end is not in fact a problem since resources are assets like any other. This is a remarkable change from Jevons, partly due to the change in context, partly due to the change in perspective.

21 The contrast is also established at the level of the method each uses. Hotelling used sophisticated mathematical tools for the period (the calculus of variations) whereas Jevons' subject was literary. I would like to stress that Hotelling's article contrasts with Jevons' book not only because of its use of mathematics. They differ also in the way they argue and the audience they target. Hotelling took American conservationism as a trigger to investigate whether the restrictions of exploitation favoured by conservationists are warranted. Yet, when reading his article, it is difficult to shrug off the impression that this is only a pretext. Hotelling develops at great length the modelling and the different cases which lend themselves to his mathematical treatment but is far less interested in the conclusion he could draw and feed back into the debate that originally motivated his research. The debate about conservation has inspired Hotelling but he does not connect his work back to that debate. His paper frames questions in a way that only interests economists. So here, in the paper, we detect the harbinger of the autonomy of economics. It signals that economics can become a self-centred field, strongly detached from practical reality. So, if there is someone who detaches himself from the social context and is not much interested in the effect his writing could produce, it is certainly Harold Hotelling.

A RETROSPECTIVE OBJECT?

22 To close this review, I would like to make two comments that both originate in the use of current categories of economic knowledge in writing its history.

23 First, economics now has a category of exhaustible resources, *i.e.* resource that is non-reproducible, of finite stock and of unique use. Missemer looks at past works through these lenses. He often stresses whether past economists classified resources in a similar way to that which we deem relevant today, and especially whether they have identified the finiteness of the stock of so-called exhaustible resources. Yet, this category is not a matter of fact. Resource economists with a good knowledge of the oil industry, for example Adelman[6], have challenged whether finite stock is a truly distinguishing and meaningful feature.

24 The current classification is the very product of the theoretical work recounted by Missemer. Consider, for example, the distinction that Bruce, an American economist at the turn of the 20th century, made between solid mineral (like coal) and fluid (like oil and gas). That this distinction has not taken roots in economic analysis does not tell us something about the economic nature of exhaustible resources. After all, a provocative essay by Timothy Mitchell[7] precisely relies on this distinction, deemed irrelevant by economists. Economists have chosen to highlight some

6 E.g. Morris A. Adelman, "Modelling World Oil Supply", *The Energy Journal*, vol. 14, n°1, 1993, 1–32.

7 Timothy Mitchell, *Carbon Democracy : Political Power in the Age of Oil* (London: Verso, 2011).

characteristics and to downplay others and it would have been very interesting to report and discuss how they justified their choices. Because both the category of "exhaustible resources" and the classification of fossil fuels in it are mostly taken for granted, the opportunity has not been taken to reflect on the process of their construction, although there is the material to service such an exploration.

25 A similar observation can be made about the nature of the exhaustibility of resources. Any question on this subject is settled from the start by hailing Jevons as the great initiator of the economic discourse on fossil fuels. This narrative depicts his economic understanding of exhaustion as the bedrock on which others will build. There are nevertheless variations across authors as far as we can learn from what Missemer reports. For example, the way Hotelling's model introduced a finite stock of resources, known ex ante, points to a physical understanding of exhaustion. It would have been valuable if this aspect had been monitored more closely throughout the book.

26 Second, Missemer wants to go farther into the past than the moment often considered as the starting point of exhaustible resources economics. This is a very legitimate endeavour. However, its own starting point, Jevons' book, is the "act of birth of fossil fuel economics" only in retrospect. Jevons's book, if it influenced political debates in Britain, was not the onset of a tradition of studies or discourses on the subject of fossil fuels. Until the concerns of the 1960s-70s drew attention to it again, it remained largely ignored or was seen as a work that had no value outside the context in which it had been produced. For example, the *Palgrave dictionary of Political economy* of 1896 only mentions the book in connection with the repayment of national debt. And Keynes[8], in his bibliographical notice on Jevons, mocks its fear of exhaustion and disparages Jevons's solution to it. Nor did his book cross easily the Atlantic, as I have noted above.

27 This does not suggest that the current narrative should not be challenged. Hotelling's 1931 paper is intuitively perceived today as a starting point of exhaustible resources economics because the intense theoretical elaboration of the 1960s and 1970s "is essentially based on Hotelling's paper" as Arrow[9] said, and also because some influential papers,[10] presented it as such. But Hotelling's 1931 paper was rarely cited before that. Early landmark works[11] in the area (incidentally, not all made by economists in the current meaning) ignored Hotelling's paper. If Hotelling's article is seminal, it has taken more than thirty years for it to stimulate wider research. If we want to date the beginning of exhaustible resource economics, I believe that we should place it in the 1970s when it exists not only intellectually, in the links that can be made across books and articles, but when it also takes the form of a social group, with leaders, rituals, teaching, and its quest for founding fathers.

28 Taking fossil fuels as a common thread enables Missemer to provide an overview of economic analysis related to resources during three quarters of a century and to illustrate the important evolutions of the concepts in this period. Placing the material gathered under the umbrella of an "economic discourse on fossil fuels" does a disservice to his impressive work. If we put aside this narrative of a discourse that develops from a single point, we find an exciting story of the birth, evolution and death of several intellectual traditions devoted to questions relevant to fossil fuels' exploitation. Moreover, what strikes me the most in Missemer's depiction is how little fossil fuels are a definite object of economic analysis. In the eyes of the economists of the period, fossil fuels are not viewed as a coherent

8 John Maynard Keynes, "William Stanley Jevons 1835–1882: A Centenary Allocation on his Life and Work as Economist and Statistician", *Journal of the Royal Statistical Society*, vol. 99, n°3, 1936, 516–555.

9 Kenneth Arrow, "Hotelling", in John Eatwell, Murray Milgate et Peter Newman (eds.), *New Palgrave: a dictionary of Economics* (London: Macmillan, 1987), 67.

10 E.g. Robert M. Solow, "The Economics of Resources or the Resources of Economics", *American Economic Review*, vol. 64, n°2, 1974, 1–14.

11 Like the Paley report (1952) or Harold J. Barnett, Chandler Morse, *Scarcity and Growth: the Economics of Natural Resource Availability* (Baltimore: John Hopkins University Press for Resources for the Future, 1963).

object, they are either fragmented or lumped with other resources. For example, Jevons' book deals only with coal. American conservationism is concerned with natural resources in general (including forests). The theory of the rent of mines applies indiscriminately to fossil fuels and minerals. And Hotelling's contribution actually extends to any exhaustible "asset". Fossil fuels were not built as an analytic object of economics in the pre-Hotelling period.

The situation has not changed much in this regard. Theoretical research has dived into the micro-economic characteristics of the production of fossil fuels but has neglected their macroscopic impacts on the economy. What connects the two and what makes fossil fuels specific is their energy content. This fundamental aspect of fossil fuels, fossil fuels as an energy source, was present in Jevons but has been missed since.

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