JEH RHE

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

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POST DATE
04/12/2018
ISSUE NUMBER
JEHRHE #1
SECTION
Special issue
THEME OF THE SPECIAL ISSUE
For a history of energy
KEYWORDS
Transition, Production, Consumption, Environment, Regime
DOI
in progress

TO CITE THIS ARTICLE
Geneviève Massard-Guilbaud, "From the history of sources and sectors to the history of systems and transitions: how the history of energy has been written in France and beyond", *Journal of Energy History/ Revue d'Histoire de l'Énergie* [Online], n°1, published 04 December 2018, URL: http://energyhistory.eu/node/88.

From the history of sources and sectors to the history of systems and transitions: how the history of energy has been written in France and beyond*

Abstract
This historiographical essay shows how historians have dealt with energy since the beginning of the 20th c. and until today. During the two first third of the 20th c., only a handful of authors have tried to give an overview of humans made use of the energy existing all around them over centuries. Historians of the last decades of the 20th centuries were interested in specific energy *sources* as well as in energy *sectors*. More recently, tendency has come back to considering energy as a whole, studying energetic *systems* and the *transitions* between them. There has been so far no consensus on the nature and the stakes involved in the past transitions.

Plan of the article

* An expanded French version of this article will appear in Mathis Charles-François, Massard-Guilbaud Geneviève (dir.), *Systèmes et transitions énergétiques. Les hommes et l'énergie du Moyen Âge à nos jours*, Histoire environnementale 3 (Paris: Éditions de la Sorbonne, 2019). I would like to thank the Editions de la Sorbonne for authorizing this translation.

ISSN 2649-3055

1 The IPCC[1] (which is not a neutral institution, and whose history should be written one day, although for now its research remains the most reliable available) has long considered it *extremely likely* that the anthropogenic portion is the greatest cause of global warming.[2] While fossil energies, which represent 80% of the energy we put into use,[3] are not solely responsible for the entire anthropogenic portion, they are by far the major cause.[4] As a result, it is no longer possible today to write the history of energy as we (or our predecessors) did 15 years ago, by speaking of "king carbon" or "the electricity fairy," as though we were unaware of how we have all mobilized and continue to mobilize energy that now has an impact on our planet's climate[5]; as though we were unaware that the climate upheaval underway has already led and will continue to lead—if we persist in proceeding on the same course—to a considerable degradation of the conditions of life on Earth, with the most fragile humans being the ones most brutally affected. It is no longer time to quibble over the share of a particular activity's responsibility in the emission of greenhouse gases, or to continue studying energy as the driver of an economy that must proceed along the same path, as though nothing were wrong. The time has come for historians to study the relations that societies have maintained with the energy available around them, which is to say how these societies have reflected on this energy (or not), how they mobilized it (or not), and how we have come to the energy system we have today, one that we must urgently leave behind.

2 Historians, who generally share this point of view, do not agree on how to go about writing this history, or on how it unfolded. It is therefore important for me to specify a few of my convictions on this subject. The first is that in order to understand the relations that our societies have maintained and continue to maintain with the energy dispensed to us by the sun, it is vital to consider things in as long a term as possible. During the course of this *temps long*, the forms for mobilizing energy have changed, and there have been transitions between different energy systems. By transition I mean the change, more or less extended in time, from one *energy system* to another (not from one energy to another, and even less from carbon-based energy to "clean" energy).[6] Just as demographic transitions shifted our Western societies from one demographic system to another, and continue to do so in other parts of the world, energy transitions have on many occasions shifted them from a system with one set of energies to a system with another. Yet unlike demographic transitions, which shifted our societies—according to different processes depending on the location—from a particular demographic system (high birth and death rates) to another particular system (low birth and death rates), energy transitions lead

1 Intergovernmental Panel on Climate Change

2 "The effects [of Anthropogenic greenhouse gas emissions, together with those of other anthropogenic drivers] have been detected throughout the climate system and are extremely likely to have been the dominant cause of the observed warming since the mid-20th c.." IPCC (Intergovernmental Panel on Climate Change), *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (Geneva: IPCC, 2014), 4. For more details, see the IPCC's "Summary for policymakers" (Group I), which notably mentions: "Human influence has been detected in warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in snow and ice, in global mean sea level rise, and in changes in some climate extremes." http://ar5-syr.ipcc.ch/topic_summary.php accessed 30 August 2017.

3 Enerdata, "Global Energy Trends - 2017 report", https://www.enerdata.net/publications/reports-presentations/global-ener..., 2017, accessed 12 July 2017. Historical data on energy that was reconstructed and gathered by historians is included in Etemad Bouda *et al*. (dir.), *World Energy Production, Production mondiale d'énergie, 1900-1985* (Genève: Droz, 1991).

4 IPCC, *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (Geneva: IPCC, 2014), 3.

5 Contrary to what the usual terminology may lead one to believe, we never produce energy, we simply mobilize it. We could also say retrieve.

6 A reflection on the use of this term can be found in Di Manno Sylvain, "La transition énergétique, entre histoire politique et politique de l'histoire", *Communication, école thématique d'automne 2014 de l'IFRIS : La transition comme question politique et objet de recherche pour les SHS* (Florence: 26/09 2014), https://dimannosylvain.wordpress.com/communications/la-transition-energ..., accessed 8 May 2018.

from dissimilar initial systems[7] to final systems that are not necessarily similar either.[8] They also proceed at varying speeds, and use methods that are different depending on each case. The concept of energy transition consequently does not at all have the same meaning today in Europe as it does in Africa, where certain populations still do not have access to electricity.[9] As a result, there is not *an* energy transition, but so many transitions, in time and space, from one energy system to another.

3 These transitions have not involved the substitution or simple addition of one or more energy sources to those already in use, but rather a gradual replacement of one *energy system* by another. The notion of energy system—used (in German) by Rolph Peter Sieferle, and later in French by Jean-Claude Debeir, Jean-Paul Deléage, and Daniel Heméry in works I will discuss in greater detail in the third part of this essay[10]—brings to mind the term "technical system" proposed by Bertrand Gille, which refers to the series of relations that connect the available techniques with the correlated social system at a particular point in time.[11] It can be usefully transposed to the domain of energy, as each energy system includes a series of elements relating to the economic, social, political, geopolitical, and cultural conditions of the time, as well as and perhaps especially to the choices made by humans—choice of primary energy sources put into use, choice of converters—with little room remaining for fatality. As it happens, the substitution of one system for another has rarely meant the disappearance of earlier energy sources. Often a new hierarchy of energy sources emerged, with some intensifying and other seeing their role reduced, but without disappearing altogether.

4 While the role of energy is crucial to the economy, the latter should not be the exclusive focus of our attention. The questions that arise regarding transitions are therefore not just "what sources of energy were used before and after the transition?", or "how efficient were the previous and new systems?", but also "who decided on these changes—if a decision was made—and to what ends?", "who possessed (the energy sources, the converters, the power to impose them on others)?", "how did the new forms spread?", "who benefited (or suffered) from these changes?", "what changes did they make to social organization?", etc. Transitions have never been linear or identical, and have sometimes included abandoned and even sabotaged experimentations, and have sometimes taken the form of cycles. Nothing was "scripted," as different choices could generally have been made. In fact, they were not called "transitions," as this term has apparently been used in connection with energy only recently. People spoke instead of energies of "substitution," "replacement," or "alternatives," or used paraphrase.

5 Focusing on these questions hardly entails, in my opinion, digging through observations of past transitions for formulas to reproduce for the present, as is believed by those who expect historians to provide "ready to use" models for managing the future—wars are never won with the weapons of the preceding war. What matters is to understand how and why the past choices were made, choices that have brought us to where we are today, in a system that we must

7 See for example, in the former European energy system, the importance of peat or coal for certain regions, sources that elsewhere played a small role, or no role at all.

8 For example, countries that today have "modern" energy systems comparable in many respects, such as Norway and Sweden, have very different energy mixes.

9 Pokam Kamden Moïse Williams, "Le thermique et l'hydraulique dans la production d'électricité au Cameroun (1931-2013) : enjeux de substitution et de combinaison", *in* Mathis, Massard-Guilbaud (dir.), *Systèmes et transitions énergétiques* (cf. note *).

10 Sieferle Rolf Peter, *Der unterirdische Wald, Energiekrise und industrielle Revolution* (München: Beck, 1982). English translation: *The Subterranean Forest: Energy Systems and the Industrial Revolution* (Cambridge: White Horse Press, 2001). Debeir Jean-Claude, Deléage Jean-Paul, Hémery Daniel, *Les servitudes de la puissance. Une histoire de l'énergie* (Paris: Flammarion, 1986). New revised edition in 2013 under the title *Une histoire de l'énergie*. English translation, *In the Servitude of Power: Energy and Civilization through the Ages* (London: Palgrave MacMillan, 1991).

11 Gille Bertrand (dir.), *Histoire des techniques. Technique et civilisations, technique et sciences* (Paris: Gallimard, 1978). See also Idem, "La notion de 'système technique' (essai d'épistémologie technique)", *Technique et Culture*, vol. 1, 1979.

abandon if we do not want to leave future generations an increasingly unmanageable legacy. It is precisely because these past choices weigh on the present and the future that we believe it is crucial to define them. This task falls to historians, who are the best equipped to carry it out. The work has just begun, and as we shall see, there is no consensus today among historians on how we entered our current energy system, or on the value of studying it, for some believe that the research has already been conducted, while others believe that transitions do not and have never existed.

6 Writing the history of energy is hardly something new, and this historiographical essay aims to show the forms this writing has taken over the last century. The objective is not to praise or stigmatize a particular approach to the subject, but rather to evaluate what we have at our disposal, to understand the nature of the views taken until present, and to better identify the direction in which we must now move.

7 I will first discuss the initial research conducted in the history of energy, which was written during the 19th c. and the first two thirds of the 20th, and then the considerable quantity of published research over the past three decades leading up to the present. During this last period, historians have generally focused on a particular energy source or sector. This is why I will also present them in this way. The scope of this historiography is such that it is impossible to include in this second part works outside the French bibliography, aside from exceptions justified by the particular interest of a specific work. This choice naturally raises problems, for there is no subject more global than energy, and as the historiography advances through both national and international exchange, it is difficult to isolate individual works from those that respond to and complement one another. It is easily comprehensible why I had to make choices, given that the library created by the Forest History Society—to cite just one example—alone includes 45,000 references, a collection that, for the most part, naturally involves the energy uses of wood.[12] This panorama will essentially be historical in nature. This is not out of ignorance of the aspects that other disciplines (physics as well as philosophy, economics, ecology, etc.) have explored within the history of energy, but once again out of necessity.

Finally, in the third part I will show that other ways of conceiving and writing the history of energy gradually emerged, along with the types of questions they raise. Contrary to the preceding section, this part will make room for foreign research, as well as research from other disciplines. We will see that the writing of the history of energy has tended to become more comprehensive, and recently the most stimulating ideas have not come from France, or always from historians. 8

HISTORIANS AND ENERGY, INITIAL RESEARCH

Beginning in the 18th c. and throughout the 19th c., economists such as Adam Smith, David Ricardo, Thomas Malthus and later Karl Marx, W. Stanley Jevons and others took a close interest in the *longue durée* of energy questions. I will not linger on this research, although we will see that the historians of energy about whom I will speak in the third part of this text were all interested in the perspective of classical, neoclassical, or Marxist economists. In *Les Économistes et la fin des énergies fossiles (1865-1931)* [Economists and the End of Fossil Energies],[13] the historian of economic ideas Antoine Missemer analysed how the perspective of economists evolved, notably that of Jevons, who in 1865 published his famous *The Coal Question.*[14] With regard to historians, numerous scholars in the 19th c. studied 9

12 The bibliography created by the FHS is available at http://prestohost26.inmagic.com/Presto/home/home.aspx The figure of 45,000 references refers only to written documents, and does not include images or audio archives. FHS management itself recognizes that despite its size, the collection is hardly exhaustive for publications in languages other than English.

13 Paris, Classiques Garnier, 2017.

14 Jevons William S., *The Coal Question, An Inquiry concerning the Progress of our Nation and the Probable exhaustion of our Coal Mines* (London: Macmillan, 1865).

the general problem of energy; while they did not do so in the same way as economists, they as least explored the history of wood and coal, whose massive use was disrupting the economy at the time.[15]

10 During the first decades of the 20th c., historians set to work on the history of animal power, hydraulics, firewood, and coal, producing works that still serve as references today. A few examples in very different genres are the books or articles of Richard Lefebvre des Noëttes, John Nef, and Marc Bloch.[16] Their interpretations have not always stood up against later studies, although this is entirely normal for pioneering research. For instance, Nef's argument that the exhaustion of forest resources caused the spread of coal use in England was reconsidered during the 1950s by G. Hammersley and Michael W. Flinn,and more recently by Robert C. Allen and others,[17] while Bloch's chronology on the industrial use of water mills was reconsidered by archaeologists specializing in Antiquity.[18]

11 The interwar period also produced an important text in *Technics and Civilization* by Lewis Mumford, a philosopher and historian of sciences who is today considered one of the precursors of the theory of degrowth.[19] The American academic was not, strictly speaking, offering a history of energy, but rather a history of technics in which the different phases that he identified were determined by the nature of the energy used. Emphasizing how energy was the basis of all human activity, Mumford recommended using it economically, and limiting the use of mechanical energy, subsistence crops, and raw material extraction. His reflections on transitions, which concern us today, remain worthy of interest.

12 In this digression beyond strictly historical confines, I would also like to mention the original thought of the geographer Jean Brunhes. In his *Géographie Humaine* [Human Geography], originally published in 1910 and with many subsequent editions, Brunhes classified extractive industries in the category of "acts of destructive

15 We will cite the famous *La Vie souterraine. Les mines et les mineurs*, by Louis Simonin (Paris: Hachette et cie., 1867), republished in 1993 by Champ Vallon, and in 2012 by General Books. For Great Britain, see Holland John, *The History and Description of Fossil Fuel, the Collieries, and Coal Trade of Great Britain* (London: Whittaker, 1835). There are numerous references of this type in the footnotes of Benoit Paul, Verna Catherine, *Le charbon de terre en Europe occidentale avant l'usage industriel du coke* (Turnhout: Brepols, 1999).

16 Lefebvre des Noëttes Richard, *La Force motrice animale à travers les âges* (Nancy: Berger Levrault, 1924). Nef John U., *The Rise of the British Coal Industry* (London: Routledge, 1932). [for Great Britain, the work of reference is now *History of the British Coal Industry: Hatcher John, Vol. 1 : Before 1700: Towards the Age of Coal* (Oxford: Oxford University Press, 1993). Flinn Michael W., *Vol. 2 : 1700-1830: The Industrial Revolution* (Oxford: Clarendon Press, 1984). Hall Alan, Church Roy A., Kaneksky John, *Vol. 3 : 1830-1913: Victorian Pre-Eminence* (Oxford: Clarendon Press, 1986). Supple Barry, *Vol. 4: 1914-1946: The Political Economy of Decline* (Oxford: Oxford University Press, 1987).] Bloch Marc, "Avènement et conquête du moulin à eau", *Annales d'histoire économique et sociale*, vol. 7, 1935. See also, in the same issue, regarding human and animal energy: Bloch Marc, "Les 'inventions' médiévales". The thesis by M. Rouff also bears mentioning, *Les Mines de charbon en France au XVIIIe siècle, 1744-1791, étude d'histoire économique et sociale* (Paris: F. Rieder et Cie, 1922). Dion Roger, "Usines et forêts. Conséquences de l'ancien emploi du bois comme combustible pour les forêts", *Revue des Eaux et Forêts*, vol. 76, 1938.

17 Hammersley George, "The Crown Woods and their Exploitation in the 16th and 17th c.", Historical Research, vol. 30/82, 1957. Flinn Michael W., "Timber and the advance of technology: A Reconsideration", *Annals of Science*, vol. 15/2, 1959. Warde Paul, "Fear of Wood Shortage and the Reality of the Woodland in Europe, c. 1450-1850", *History Workshop Journal*, vol. 62, 2006. Allen Robert C., *The British Industrial Revolution in Global Perspective* (Cambridge: Cambridge University Press, 2009). Idem, "Was there a timber crisis in early modern Europe?", *in* Simonetta Cavaciocchi (ed.), *Economia e Energia, Secc. XIII-XVIII, Atta de la "Trentaquattresima Settimana di Studi", 15-19 aprile 2002, Istituto Internazionale di storia economica "E Datini"* (Prato: Le Monnier, 2003).

18 Amouretti Marie-Claire, Le *pain et l'huile dans la Grèce antique, Évolution des techniques agraires d'Hésiode à Théophraste, Annales littéraires de l'Université de Besançon, Centre de Recherches d'histoire ancienne 67* (Paris: Les Belles Lettres, 1986). Wikander Örjan, *Handbook of Ancient Water Technology* (Leyden: Brill, 2000). Brun Jean-Pierre, "Les moulins hydrauliques en Italie romaine" et Leveau Philippe, "Les moulins de Barbegal. 1986-2006", *in* Jean-Pierre Brun, Jean-Louis Fiches (dir.), *Énergie hydraulique et machines élévatrices d'eau dans l'Antiquité* (Naples: Centre J. Bérard, 2007).

19 Mumford Lewis, *Technics and Civilization* (London: Routledge and Kegan, 1934). French translation: *Technique et civilisation* (Paris: Le Seuil, 1950). New edition with a new translation: Marseille: Parenthèses, 2016.

occupation."[20] The passage he devoted to the use of coal and petroleum was original to say the least—coming at a time when the climate didn't pose a problem for anyone—and prompted reflection on what we are doing when we use fossil resources.[21]

13 In 1961, the Italian economic historian Carlo Maria Cipolla published, in the "Débats et Combats" [Debates and Battles] section of *Annales ESC,* an article entitled "Sources d'énergie et histoire de l'humanité" ["Energy Sources and the History of Humanity"].[22] It was only an outline, but it offered a correct presentation of the problem.

14 Six years later, in the first volume of *Civilisation matérielle et capitalisme* [*The Structures of Everyday Life: Civilization and Capitalism, 15th-18th c.,* Vol. 1], Fernand Braudel devoted a large part of the fifth chapter to the history of energy during the centuries of the Ancien Régime.[23] While the work generally drew praise when it was published, it was also criticized, notably for the reliability of the quantitative data used.[24] While subsequent research once again clarified certain points, this chapter has the merit of being one of the first to attempt an overview of the energy question on a practically global scale—and not solely a picture of a particular source of energy, often in a single country, as most of his predecessors had done, or as many of his successors still do.[25] Nearly ten years before Gille proposed the notion of technical systems, thereby emphasizing the links between techniques and society, Braudel was drawing the economic and social conclusions of how all types of energy had been mobilized by humans up to that point. These conclusions were limited in number, and can be summarized as follows: the small quantities of energy put into use during the centuries of the Ancien Régime, coupled with this energy's lack of flexibility, prevented the development of machinism until the late 18th c., and with it economic growth. We will see that this theory was revived and developed both 20 years later as well as today, although it is now the subject of criticism.

STUDIES BY ENERGY SOURCE AND SECTOR

15 Research began to increase during the 1980s. Various aspects of the economic, political, and intellectual context most certainly explain this historiographical shift: oil crises, coal crisis, appearance of the history of companies... The French historiography of the time took the form of studies focusing on primary energy sources or sectors. The panorama that I will present here will therefore be classified in this way. It is with regret that I had to neglect the energy source of food, a very important aspect of the energy question, one that for a long time was approached in terms of subsistence capacity rather than in strictly energy terms. The birth of agriculture, a new human know-how that enabled the recovery—much more efficiently than gathering—of the energy produced by photosynthesis, was undeniably a major energy transition. The

20 Brunhes took inspiration from the German geography of Raubwirtschaft (economy of rapine or devastation). On this subject see Massard-Guilbaud Geneviève, "Historiens et géographes français et relation de l'homme au milieu, de Vidal de la Blache aux programmes de recherche interdisciplinaires de la fin du XXe siècle", *in* Robert Chenorkian, Samuel Robert (dir.), *Les Interactions hommes-milieux. Questions et pratiques de la recherche en environnement* (Versailles: éditions Quæ, 2014).

21 Brunhes Jean, *Géographie Humaine* (Paris: PUF, 1942), 215 et seq.

22 Cipolla Carlo M., "Sources d'énergie et histoire de l'humanité", *Annales. Économies, sociétés, civilisations*, vol. 3, 1961.

23 Braudel Fernand, *Civilisation matérielle, économie et capitalisme, XVe-XVIIIe siècles* (Paris: Armand Colin, 1967), 251-283.

24 Morineau Michel, "Un grand dessein : Civilisation matérielle, économie et capitalisme, XVe-XVIIIe siècles, de Fernand Braudel", *Revue d'Histoire Moderne & Contemporaine*, vol. 28/4, 1981.

25 One of the first, but not the first. With no pretention of being exhaustive, we will cite among earlier works the synoptic viewpoint of Wilhelm Schultz-Bodmer's (1797-1860) Menschenkraft, Tierkraft, Windenkraft, Dampfkraft, concerning Prussia, France, and England, which was mentioned by Morineau in his critique of Civilisation matérielle (cf. note 24), and the conference given by R.-J. Forbes, Professor at the University of Amsterdam, at the Palais de la Découverte in June 1956, published under the title *La Technique et l'énergie au cours des siècles, Les Conférences du Palais de la découverte 42* (Paris: Université de Paris), in which the author attempted a synoptic panorama from Antiquity to the mid-12th c.

capacity to produce food in quantity was also one of the important aspects of the transition that took place starting in the late 18th c. Taking food production into account would nevertheless have led me to consider the entire history of agriculture and land use, which was quite simply impossible given the space available here.

16 I will now mention, once and for all, an invaluable collection that has played a role across all sections of this article, for it involves diverse sources of energy: the proceedings of the study week held in Prato in 2002, published under the title *Economia e Energia, Sec. XIII-XVIII* [Economy and Energy, 13th-18th c.].[26] This volume of over a thousand pages brings together a remarkable series of contributions regarding all aspects of the history of energy from the Middle Ages to the 18th c.

Wood, water, and wind

17 The energy uses of wood in France under the previous economic system have been the subject of many conferences and books in France, generally published by researchers from the Groupe d'histoire des forêts françaises [Group for the History of French Forests]. The research of Denis Woronoff and the works he edited evoke the relation between wood and the steel industry,[27] while the book that Jérôme Buridant drew from his thesis explores the impact that another wood-hungry industry, glassmaking, had on forests.[28] The geographer Jean-Paul Métailié edited the proceedings of a conference on the relations between protoindustry and forests.[29] The handbook *Le Bois, source d'énergie* [Wood, A Source of Energy], edited by Andrée Corvol,[30] pertains more to domestic heating, as does Jean Boissière's thesis.[31] On heating there is also the fine recent book by Stéphane Castelluccio, *L'éclairage, le chauffage et l'eau* [Lighting, Heating, and Water], which notably examines—with regard to what interests us here—oil lamps, tallow candles, candles, and various other fuels used for heating.[32] Serge Benoit has shown the importance of the role played by traditional energy sources, wood and water, in industrialization *à la française*.[33]

18 Very recent research has come from other countries regarding wood and the key question of a possible "wood crisis" during the 18th c., and its role in the Industrial Revolution. This initially took place in Germany with the work of Joachim Radkau, a senior environmental historian, whose book *Holz, Wie ein Naturstoff Geschichte schreibt* [Wood: A History] is especially

26 Cavaciocchi Simonetta (ed.), *Economia e Energia, Secc. XIII-XVIII, Atta de la "Trentaquattresima Settimana di Studi", 15-19 aprile 2002, Istituto Internazionale di storia economica "E Datini"* (Prato: Le Monnier, 2003). The work includes articles in four languages (Italian, French, English, and German).

27 Woronoff Denis, *L'industrie sidérurgique en France pendant la Révolution et l'Empire* (Paris: Éditions de l'EHESS, 1984). Woronoff Denis (dir.), *Révolutions et espaces forestiers*, (Paris: L'Harmattan, 1989). Woronoff Denis (dir.), *Forges et forêts: recherches sur la consommation proto-industrielle de bois* (Paris: Éditions de l'EHESS, 1990).

28 Buridant Jérôme, *Espaces forestiers et industrie verrière XVIIe-XIXe siècle* (Paris: l'Harmattan, 2005). Buridant Jérôme, "Le premier choc énergétique. La crise forestière dans le nord du bassin parisien (début 18e-début 19e siècle)" (HDR (research-director thesis), Université Paris 4, 2008). See also Palaude Stéphane, "Verreries noires d'Avesnois-Thiérache, XIXe-XXe siècles" (Ph.D. diss., Université de Lille 3, 2009). On Colbert's forest reform, see the Ph.D. diss. publication of Devèze Michel, *Une admirable réforme administrative. La grande réformation des forêts sous Colbert (1661-1683)* (Nancy: impr. G. Thomas, 1962). A synthetic work on the history of forests: Chalvet Martine, *Une histoire de la forêt* (Paris: Le Seuil, 2011).

29 Métailié Jean-Pierre (dir.), *Protoindustries et histoire des forêts : actes du colloque tenu à la Maison de la forêt, Loubières, Ariège, les 10-13 octobre 1990* (Toulouse: GDR ISARD 881 - CNRS, 1992).

30 Corvol Andrée (dir.), "Le Bois, source d'énergie : naguère et aujourd'hui". *Journée d'Études de l'IHMC, janvier 1999 - Environnement, Forêt et Société, XVIe-XXe siècle. La Ville, troisième partie, IHMC-CNR, Cahier d'Études n° 10* (Paris: École normale supérieure, 2000).

31 Boissière Jean, "Populations et économies du bois dans la France moderne : contribution à l'étude des milieux forestiers entre Paris et le Morvan au dernier siècle de l'Ancien régime (vers 1685-vers 1790)" (Ph.D. diss., Université Paris 1, 1993).

32 Castelluccio Stéphane, *L'éclairage, le chauffage et l'eau aux XVIIe et XVIIIe siècles* (Montreuil: Éditions Gourcuff Gredingo, 2016).

33 Benoit Serge, "La modernité de la tradition: les énergies renouvelables classiques : l'eau et le bois dans la voie française de l'industrialisation, c.1750-c.1880" (Ph.D. diss., Université d'Evry-Val d'Essonne, 2006).

remarkable,[34] along with Rolf P. Sieferle, whose work I will discuss below.[35] It later emerged in Great Britain with the economic historians Tony Wrigley, Robert C. Allen, and Paul Warde, whose role in changing the historiography I will also discuss below.[36]

19 In an indication of its vitality, the history of water (in all its uses, not just as a source of energy) has been the sole object of study of the International Water History Association since 1999, while "non-specialized" societies of environmental history have also devoted numerous conference sessions to the subject.[37] Since 2009, the history of water has been the subject of both the journal *Water History,* as well as the academic social network (H-Water).[38] This substantial institutionalization of the research field reflects the considerable attention given to the subject by researchers.[39]

20 Most publications exploring watermills are naturally the work of archaeologists or historians of Antiquity and the Middle Ages. The former challenged the idea that watermills only spread during the Middle Ages despite dating back to Roman Antiquity,[40] while medievalists published broadly on the question of hydraulic energy and its role in medieval social organization, changing our perspective of the latter.[41] For instance, in a series of articles that were later reworked in his *Le Temps des laboureurs* [The Time of Labourers], Mathieu Arnoux defended a new reading of the links between the spread of mills, the development of seigniorial structures, and

34 Radkau Joachim, Holz, *Wie ein Naturstoff Geschichte schreibt* (München: Oekom Verlag, 2007). English translation *Wood: A History* (Cambridge: Polity Press, 2012).

35 Sieferle, *Der unterirdische Wald* (cf. note 10).

36 Wrigley E. Anthony, "The Supply of Raw Materials in the Industrial Revolution", *The Economic History Review, New Series*, vol. 15/1, 1962. Idem, *Continuity, Chance and Change. The character of the industrial revolution in England* (Cambridge: Cambridge University Press, 1988). Idem, *Energy and the English Industrial Revolution in England* (Cambridge: Cambridge University Press, 2010). Allen Robert C., *The British Industrial Revolution* (cf. note 17). Warde Paul, "Fear of Wood Shortage" (cf. note 17). Idem, *Energy Consumption in England & Wales, 1560-2000* (Naples: CNR, 2007). Idem, "Early Modern 'Resource Crisis': the Wood Shortage Debates in Europe", *in* A. T. Brown, Andy Burn, Rob Doherty (eds.), *Crisis in Economic and Social History* (Woodbridge: Boydell & Brewer, 2015, 137–160).

37 *European Society for Environmental History* http://eseh.org; *American Society for Environmental History* https://aseh.net; *la Sociedad Latinoamericana y Caribeña de Historia Ambiental* https://solcha.uniandes.edu.co/index/

38 https://link.springer.com/journal/12685, https://networks.h-net.org/h-water *H-Net* also includes the *H-Energy network*: https://networks.h-net.org/h-energy

39 We will cite only a single "international" title: *A History of Water: Vol. 1.* Tvedt Terje, Jakobsson Eva (ed.), *Water Control and River Biographies; vol. 2.* Coopey Richard, Tvedt Terje (ed.), *The Political Economy of Water; Vol. 3*. Tvedt Terje, Oestigaard Terje (ed.), *The Political Economy of Water* (London: I. B. Tauris, 2006).

40 Amouretti Marie-Claire, *Le pain et l'huile* (cf. note 18). Wikander Örjan, *Handbook of Ancient Water Technology* (cf. note 18). Leveau Philippe, "Les moulins de Barbegal" (cf. note 18). Viollet Pierre-Louis, *Histoire de l'énergie hydraulique: Moulins, pompes, roues et turbines de l'Antiquité au XX^e siècle* (Paris: Presses de l'école nationale des Ponts et Chaussées, 2006). Brun Jean-Pierre, Fiches Jean-Louis (dir.), *Énergie hydraulique* (cf. note 18). A strictly technical work: Bonnin Jacques, *L'eau dans l'Antiquité : l'hydraulique avant notre ère* (Paris: Eyrolles, 1984).

41 Chauvin Benoît, "Réalités et évolution de l'économie cistercienne dans les duché et comté de Bourgogne au Moyen-Age. Essai de synthèse", *in* Flaran 3. *L'économie cistercienne, géographie, mutations du Moyen Age aux Temps Modernes, [Actes des] Troisièmes journées internationales d'histoire, Abbaye de Flaran, 16-18 septembre 1981* (Auch: Comité départemental du tourisme du Gers, 1983). Lohrmann Dietrich, "Le moulin à eau dans l'économie de la Neustrie, VII^e-XIX^e siècles", *in* Hartmut Atsma (dir.), *Les pays du Nord de la Loire de 650 à 850, Beihefte der Francia 16, vol. 1* (Ostfildern - Sigmaringen: Jan Thorbecke Verlag, 1989). Crouzet-Pavan Élisabeth, Maire-Vigueur Jean-Claude (ed.), *Water Control in Western Europe 12th-16th c., 11th International Economic History Congress* (Milano: Université Bocconi, 1994). Benoit Paul, Berthier Karine, "L'innovation dans l'exploitation de l'énergie hydraulique d'après le cas des monastères cisterciens de Bourgogne, Champagne et Franche-Comté", *Actes des congrès de la Société d'archéologie médiévale*, vol. 6/1, 1998, 58-66. Rivals Claude, *Le Moulin et le meunier. Mille ans de meunerie en France et en Europe Vol. 1 : Une technique et un métier, Vol. 2 : Une symbolique sociale* (Portet-sur-Garonne: Empreinte, 2000). Mousnier Mireille (dir.), *Moulins et meuniers dans les campagnes européennes (IX^e-XVIII^e siècle), Actes des XXI^e Journées internationales d'histoire de l'Abbaye de Flaran, 3-5 septembre 1999* (Toulouse: Presses Universitaires du Mirail, 2002). Durand Aline, *Jeux d'eau. Moulins, meuniers et machines hydrauliques, XI-XX^e siècles. Études offertes à Georges Comet, Cahiers d'histoire des techniques 7* (Aix-en-Provence: Publications de l'Université de Provence, 2008). We also note the existence of the doctoral thesis by Philippe Robert, "L'Énergie au Moyen-Âge" (Ph.D. diss., Université Paris 4, 1980), for which I have been unable to locate a copy.

the constitution of a regulated hydraulic market, inviting us to rethink the role of peasants in their implementation and operation.[42]

21 Modern historians often devoted their research on water to river management (deepening, straightening, diking up) and the conflicts these works led to, rather than energy production.[43] Some works, such as *Archives, objets et images des constructions de l'eau du Moyen Âge à l'ère industrielle* [Archives, Objects, and Images of Water from the Middle Ages to the Industrial Era], explore both aspects.[44] The role played by mills in the Industrial Revolution, studied by Serge Benoit in his previously cited thesis, was challenged in 1984 by Louis Bergeron, who wrote very cogently in a ground-breaking article: "The history of watermills puts historians on the path of re-examining the general interpretation of French industrialization during the 18th and 19th c. in light of the energy choices made by entrepreneurs."[45]

22 Floating, a mode of transport that played a major role because water power could transport the highly important fuel (and raw material) of wood over long distances, was also the subject of research.[46] Modern historians of course have tended to focus on hydroelectric dams, which I will discuss further in the paragraph devoted to electricity.

23 Most likely because the wind energy that powered them was intermittent, windmills never had more than a relatively secondary economic role, and have garnered less research attention than watermills.[47] The work by Claude Rivals, *Le Moulin à vent et le meunier dans la société française traditionnelle* [The Windmill and the Miller in Traditional French Society], also bears mentioning.[48] While wind-driven boats played an essential role in both commerce and European endeavours for overseas extension, and also maintained their primacy in maritime transport until the late 19th c., wind energy does not seem to have interested historians of sailing ships either, despite greatly lowering operating costs (unlike draft animals, sailing ships did not eat). Jean Rougé, the historian of Mediterranean

42 Arnoux Mathieu, *Le Temps des laboureurs. Travail, ordre social et croissance en Europe, XIe-XIVe siècle* (Paris: Albin Michel, 2012).

43 Fournier Patrick, Lavaud Sandrine (dir.), *Eaux et conflits dans l'Europe médiévale et moderne actes des XXXIIes Journées internationales d'histoire de l'abbaye de Flaran, 8 et 9 octobre 2010, Flaran 32* (Toulouse: Presses universitaires du Mirail, 2012). Ballut Christèle, Fournier Patrick (dir.), *Au fil de l'eau ressources, risques et gestion du néolithique à nos jours* (Clermont-Ferrand: Presses universitaires Blaise-Pascal, 2013). Serna Virginie, Gallicé Alain (dir.), *La rivière aménagée entre héritages et modernité formes, techniques et mise en oeuvre actes du colloque international, Muséum des sciences naturelles d'Orléans, 15-16 octobre 2004, Aesturia cultures et développement durable 7* (Cordemais: Estuarium, 2005).

44 Hilaire-Pérez Liliane, Massounie Dominique, Serna Virginie (dir.), *Archives, objets et images des constructions de l'eau du Moyen Âge à l'ère industrielle, Cahiers d'histoire et de philosophie des sciences n° 51* (Lyon: ENS Éditions, 2002).

45 Bergeron Louis, "'Le cœur de la vallée, c'est son moulin…' Les moteurs hydrauliques et leurs applications industrielles en France (XVIIIe-XXe siècle)", *Terrain - anthropologie & sciences humaines*, vol. 2, 1984, http://journals.openedition.org/terrain/2796.

46 Guillot-Chêne Gérard, *Le Flottage en Morvan, du bois pour Paris* (Paris: Garnier, 1979). Martinet Jean-Claude, *Clamecy et ses flotteurs de la monarchie de juillet à l'insurrection des "Marianne", 1830-1851* (Précy-sous-Thil: Ed. de l'Armançon, 1995). Boissière Jean, *Populations et économies du bois* (cf. note 31). Kleine Roland, *Le flottage du bois sur la Sarre aux XVIIIe et XIXe siècles* (Sarrebourg: Société d'Histoire et d'Archéologie de Lorraine, 2003).

47 Things have proceeded differently elsewhere. See for example Kealey Edward Joseph, *Harvesting the Air: Windmill Pioneers in twelfth-century England* (Berkeley: University of California Press, 1987). Hills Richard L., *Power from Wind, a History of Windmill Technology* (Cambridge: Cambridge University Press, 1994); Lohrmann Dietrich, "Von der östlichen zur westlichen Windmühle", *Archiv für Kulturgeschichte*, vol. 77/1, 1995; Righter Robert W., *Wind Energy in America: A History* (Norman: University of Oklahoma Press, 1996). Lucas Adam, *Wind, water, work ancient and medieval milling technology, Technology and Change in History 8* (Leiden Boston: Brill, 2006). See also chapters 3 and 4 of Cottrell William F., *Energy & Society (Revised): The Relation Between Energy, Social Change, and Economic Development* (New York: AuthorHouse, 2009).

48 Rivals Claude, *Le Moulin à vent et le meunier dans la société française traditionnelle* (Boulogne-Billancourt: Berger Levrault, 1995). See also Philippe Robert, "Les premiers moulins à vent", *Annales de Normandie*, vol. 32/2, 1982. Leguay Jean-Pierre, *L'air & le vent au Moyen Âge* (Rennes: Presses universitaires de Rennes, 2011).

commerce during the Roman Empire, nevertheless took some interest in the subject.[49]

Fossil energies

24 The various kinds of fossil energies have not prompted as many studies in proportion to their genuine importance in history. First, with regard to peat, whose use had a particularly important impact on the environment, and which the early modernist Paul Allard believes played a very uneven role in Europe depending on the region—but one that is more important than generally believed (for its many uses and not just as a fuel)—was the subject of a conference held by the Groupe d'histoire des zones humides [Wetlands History Group], published by the journal *Aestuaria*.[50] Its collected articles concern France as well as Scotland, Ireland, Holland, and Flanders. Jérôme Buridant explores forest crises and peat use side by side, calling the fuel an "energy of transition." Aside from this collective work, there are numerous local monographs on peat bogs, but no work of synthesis.[51]

25 The historian of technology Paul Benoit made a major contribution to our understanding of mines, coalmines in particular.[52] The most interesting work for our subject is the one he edited with Catherine Verna on coal before the industrial use of coke.[53] This work brings together contributions from different European countries, and covers the period from the Middle Ages to the 18th c.. It notably informs us that the Romans, whose country did not have mineral coal, nevertheless used it where it was available in their empire.[54] While coal use is not attested in Europe during the High Middle Ages, it was vigorously rekindled during the 13th c. in Belgium and England, with increasingly deep mines that required the raising of considerable capital and the creation of large companies. Its use and consumption expanded during the 16th and 17th c.. Outside of England, where it was used for heating and caused considerable health and environmental damage, as William Cavert has shown in a recent book,[55] coal was used essentially by industry, and the properties specific to the different types of carbon were well known. The social and environmental impact of its use was, like that of peat, considerable. During the 18th c., French production increased seven- or eightfold, and industrial uses became even more diversified. However, as pointed out by the many works on the Industrial Revolution, it was only during the second half of the 19th c. that it took on a major role in France. The leading branch of industrialization, textiles, initially developed thanks to animal[56], human, or hydraulic power, with the latter playing an important role for a

49 Rougé Jean, *Recherches sur l'organisation du commerce maritime en Méditerranée sous l'empire romain* (Paris: SEVPEN, 1966), 47-81. See also Cucari Attilio, *Les Grands voiliers du Moyen âge à nos jours* (Paris – Bruxelles: Elsevier Séquoia, 1978). Masson Philippe, *Histoire de la marine* (Paris: C. Lavauzelle, 1981, 2 vol.). is in the tradition of "battle-history." Charliat Pierre-Jacques, *Le temps des grands voiliers, Histoire Universelle des explorations 3* (Paris: Nouvelle librairie de France : F. Sant'Andrea, 1955) does not take an interest in wind power, despite being prefaced by Lucien Febvre.

50 Derex Jean-Michel, Grégoire Fabrice (dir.), *Histoire économique et sociale de la tourbe et des tourbières, actes du deuxième colloque international du groupe d'histoire des zones humides (GHZH), naturAgora, Laon, 18, 19, 20 octobre 2007, Aestuaria Histoire et terres humides* (Cordemais: Estuarium, 2009).

51 The work cited in the preceding footnote includes numerous references for peat bogs. See also http://pole-tourbieresdoc.org/dyn/portal/index.seam?page=home&fonds=2 (accessed 1 August 2018).

52 Benoit Paul, Braunstein Philippe (dir.), *Mines, carrières et métallurgie dans la France médiévale, actes du colloque de Paris, 19, 20, 21 juin 1980* (Paris: Éditions du CNRS, 1983). Benoit Paul, Fluck Pierre (dir.), *Les techniques minières de l'Antiquité au XVIIIe siècle actes du colloque international sur les ressources minières et l'histoire de leur exploitation de l'Antiquité à la fin du XVIIIe siècle réuni dans le cadre du 113e Congrès national des sociétés savantes* (Strasbourg, 5-9 avril 1988), *Actes des congrès nationaux des sociétés savantes Comité des travaux historiques et scientifiques 113* (Paris: Éditions du CTHS, 1992).

53 Benoit Paul, Verna Catherine, *Le charbon de terre en Europe occidentale avant l'usage industriel du coke, Proceedings of the 20th International congress of history of sciences* (Turnhout: Brepols, 1999).

54 On this subject see also Dearne Martin J., Branigan Keith, "The Use of Coal in Roman Britain", The Antiquaries Journal, vol. 75, 1995, 71–105.

55 Cavert William M., *The Smoke of London: Energy and Environment in the Early Modern City* (Cambridge: Cambridge University Press, 2016).

56 Little attention has been granted to animal energy. On this topic, see however Roche Daniel, *La culture équestre de l'Occident, XVIe-XIXe siècles. L'ombre du cheval, Tome 1, Le cheval moteur, essai sur l'utilité équestre* (Paris: Fayard, 2008).

long time thanks to the substitution of turbines, whose energy efficiency was greatly superior to waterwheels.

26 While the Jeanneney Plan (1960) had just announced the start of the French coal industry's rollback in France, and at the very moment that a general strike of miners (March-April 1963) forced Georges Pompidou's government to yield, a conference under the direction of Louis Trénard was held in Lille on the subject of coal mines and miners, which would be published under the title *Charbon et Sciences Humaines* [Coal and the Humanities].[57] With regard to energy, the conference essentially focused on the role of coal in the Industrial Revolution. In the Spring of 1963, *Le Mouvement social* devoted a very substantial special issue to miners[58]: it included three research articles, with two on the historical sources for mining, along with a record and a dozen or so reviews, including a review of Pierre Guillaume's *La Compagnie des mines de la Loire, 1846-1854* [The Loire Mining Company, 1846-1854].[59] Rolande Trempé contributed a bibliography, while foreign researchers provided reviews of the state of research in their respective regions. The bulk of studies on coal were still to come, but a generation of young historians had clearly seized upon the subject.

27 Beginning in the 1970s, a number of orientations can schematically be distinguished in the history of coal and coalmines.[60] The first is an economic history primarily interested in the appearance of the industrial branch and its evolution, the companies that comprise it, industrial strategies, and products and markets. In addition to Pierre Guillaume's previously cited thesis, this group of research also includes Marcel Gillet's thesis on the coalfields of the Nord and Pas-de-Calais departments between 1815 and 1914,[61] Reed G. Geiger's study on the Compagnie d'Anzin,[62] Jean-Michel Gaillard's study of the mining company and city of la Grand-Combe, and Nadège Sougy's book on La Machine.[63] The coal market has more recently been the subject of two theses, one covering the years 1945-1958, and the other the First World War.[64]

28 A second orientation is in line with the history of the labour movement, and later that of the miners themselves. It was initially personified by Rolande Trempé, who devoted her doctoral thesis to miners and the formation of their "political class conscience."[65] In her *Les Trois batailles du Charbon* [The Three Battles of Coal], published 20 years after her thesis, Trempé returned to

57 Trénard Louis (dir.), *Charbon et sciences humaines actes du colloque, actes du colloque organisé par la Faculté des lettres de l'Université de Lille en mai 1963, Industrie et artisanat 2* (Paris - La Haye: Mouton and co., 1966).

58 Le Mouvement Social, n°43: *La Mine et les mineurs*, 1963.

59 The review does not indicate the nature of the text analysed. It was most likely P. Guillaume's doctoral thesis, which would be published in 1966 under the same title (Guillaume Pierre, *La Compagnie des mines de la Loire (1846-1854). Essai sur l'apparition de la grande industrie capitaliste en France, Publications de la Faculté des Lettres de Clermont-Ferrand, 2ème série n° 24* (Paris: PUF, 1966)).

60 These orientations did not succeed one another chronologically, and are of course not hermetic.

61 Thesis published under the title of *Les Charbonnages du Nord de la France au XIXe siècle, Industrie et artisanat 8* (Paris - La Haye: Mouton, 1973). Marcel Gillet had already explored the economy of coalmines in a book he published with J. Bouvier and F. Furet: Bouvier Jean, Furet François, Gillet Marcel, *Le mouvement du profit en France au XIXe siècle matériaux et études, Industrie et artisanat 1* (Paris: Éditions de l'EHESS, 1965), 23-163. See also Gillet Marcel, *Histoire sociale du Nord et de l'Europe du Nord-Ouest, Recherches sur les XIXe et XXe siècles* (Lille: Presses Universitaires de Lille, 1984), a collection of articles whose entire first section is about coal mines.

62 Geiger Reed G., *The Anzin Coal Company 1800-1833: Big Business in the early Stages of the French Industrial Revolution* (Newark: University of Delaware press, 1971). Also see Mastin Jean-Luc, "Concentration dans l'industrie minière et construction de l'espace régional : le cas du Nord-Pas-de-Calais de 1850 à 1914", *Revue du Nord*, vol. 387/4, 2010.

63 Gaillard Jean-Michel, "Un exemple français de 'ville-usine' la Grand-Combe, Gard et sa 'compagnie des mines', 1836-1921" (Ph.D. diss., Université de Paris-Nanterre, 1974). Sougy Nadège, *Les charbons de la Nièvre la houillère de La Machine, ses produits et ses marchés, 1838-1914* (Grenoble: Presses universitaires de Grenoble, 2008).

64 Perron Régine, *Le marché du charbon, un enjeu entre l'Europe et les États-Unis de 1945 à 1958, Publications de la Sorbonne. Série internationale 51* (Paris: Publications de la Sorbonne, 1996). Chancerel Pierre, "Le marché du charbon en France pendant la Première Guerre mondiale (1914-1921)" (Ph.D. diss., Université Paris X - Nanterre, 2012).

65 Trempé Rolande, *Les mineurs de Carmaux, 1848-1914* (Paris: Éditions ouvrières, 1971).

miners by studying their role in coal crises from the Front Populaire to the Liberation.[66] During the same period, the American labour historian Donald Reid also devoted a study to the miners of Decazeville, which had the distinctive feature of stretching from the end of the Ancien Régime to the Fifth Republic, while the Terre Humaine collection published the account of the miner Augustin Viseux.[67] This vein also includes theses on unionism, the labour movement among miners, and the miners of the Cévennes,[68] as well as Jean-Louis Tornatore's thesis on the peasant mines and miners of the Briançonnais.[69] More recently, Diana Cooper-Richet has returned to the subject of her early research with a work on the *longue durée* entitled *Le Peuple de la nuit. Mines et mineurs en France (xix^e^-xxi^e^ siècle)* [The People of the Night: Mines and Miners in France (19^th^-21^st^ c.)].[70] The series of works published on the occasion of the centenary of the Courrières catastrophe[71] could also be classified in this group, as could the interesting work by Marion Fontaine on the Liévin catastrophe (1974) and the "elimination" of the figure of the miner.[72]

A third category of publications, generally more recent and focusing on longer periods, has presented the temporary nature of coal extraction, and revisits the history of coal mines by emphasizing new aspects: relation to the land, the myth of the Gueules noires [Black faces], the end of coal-producing activity, and strategies of reconversion.[73] The research emerging from studies of plans, international relations, and the ECSC (European Coal and Steel Community) also bear mentioning.[74]

29

66 The battle for coal was also explored in Desbois Évelyne, Jeanneau Yves, Mattéi Bruno, *La Foi des charbonniers les mineurs dans la bataille du charbon 1945-1947, Ethnologie de la France 5* (Paris: Éditions de la Maison des sciences de l'Homme, 1986).

67 Reid Donald, *The Miners of Decazeville a genealogy of deindustrialization* (Cambridge Mass.: Harvard University Press, 1985). Viseux Augustin, *Mineur de fond fosses de Lens, soixante ans de combat et de solidarité, Terre humaine* (Paris: Plon, 1991).

68 Cooper-Richet Diana, "La fédération nationale des mineurs, contribution à l'histoire du syndicalisme français avant 1914" (Ph.D. diss., Université Paris 4 Sorbonne, 1976). Michel Joël, "Le Mouvement ouvrier chez les mineurs d'Europe occidentale (Grande-Bretagne, Belgique, France, Allemagne)" (Ph.D. diss., Université Lumière - Lyon 2, 1987). Sugier Fabrice, "La Classe ouvrière et le mouvement ouvrier dans les mines de charbon du Bassin du Gard : 1914-1922" (Ph.D. diss., Université Paris 8, 1990).

69 Tornatore Jean-Louis, "Le charbon et ses hommes : Tensions, coordination et compromis dans le réseau sociotechnique de l'exploitation du charbon des Alpes briançonnaises, XVIII^e^ - XX^e^ siècles" (Ph.D. diss., Université de Metz, 2000).

70 Cooper-Richet Diana, *Le peuple de la nuit. Mines et mineurs en France (XIX^e^ - XX^e^)* (Paris: Perrin, 2002).

71 Conus Marie-France *et al.*, *10 mars 1906, Compagnie de Courrières, enquête sur la plus grande catastrophe minière d'Europe, Mémoires de Gaillette 9* (Lewarde: Centre historique minier du Nord-Pas-de-Calais, 2006). Varaschin Denis, Laloux Ludovic (dir.), *10 mars 1906, Courrières, aux risques de l'histoire* (Vincennes: Groupe de recherche sur l'histoire de l'énergie, 2006).

72 Fontaine Marion, *Fin d'un monde ouvrier. Liévin, 1974* (Paris: Éditions de l'EHESS, 2014).

73 Leboutte René, *Vie et mort des bassins industriels en Europe, 1750-2000* (Paris: l'Harmattan, 2000). Rabier Jean-Claude (dir.), *La remonte. Le bassin minier du Nord-Pas-de-Calais entre passé et avenir* (Villeneuve d'Ascq: Presses universitaires du Septentrion, 20002). Varaschin Denis, *Travailler à la mine, une veine inépuisée* (Arras: Artois Presses Université, 2003). Daumalin Xavier *et al.*, "Le bassin minier des Bouches-du-Rhône", *Industries en Provence, dynamiques d'hier et d'aujourd'hui*, n°11, 2003. Daumalin Xavier *et al.*, *Gueules noires de Provence. Le bassin minier des Bouches-du-Rhône (1744-2003)* (Marseille: Jeanne Lafitte, 2005). Autran Jacques, Lochard Thierry, Monteau Raymond, *L'exploitation dans le bassin minier de Provence, quartiers, puits et galeries* (Aix-en-Provence: CNRS – Travaux de l'Observatoire Hommes-Milieux du Bassin minier de Provence, 2014). Daumalin Xavier, Daviet Sylvie, Mioche Philippe (dir.), *Territoires européens du charbon : des origines aux reconversions* (Aix-en-Provence: Publications de l'Université de Provence, 2016). Eck Jean-François, Friedemann Peter, Lauschke Karl (dir.), *La reconversion des bassins charbonniers. Une comparaison interrégionale entre la Ruhr et le Nord-Pas-de-Calais, Revue du Nord, Hors-Série 21* (Lille: Université Charles de Gaulle - Lille 3, 2006). Eck Jean-François, Terrier Didier (dir.), *Aux marges de la mine. Représentations, stratégies, comportements autour du charbon en Nord-Pas-de-Calais, XVIII^e^-XX^e^ siècles* (Valenciennes: Presses Universitaires de Valenciennes, 2007). Martin-Amouroux Jean-Marie, *Charbon, les métamorphoses d'une industrie* (Paris: Technip, 2008). Godard Michel, "Enjeux et impacts de l'exploitation minière du bassin houiller de Ronchamp" (Ph.D. diss., Université de technologie de Belfort-Montbéliard & Université de Franche-Comté, 2012). Aprile Sylvie *et al.* (dir.), *Les Houillères entre l'État, le marché et la société les territoires de la résilience XVIII^e^ - XXI^e^ siècles* (Villeneuve d'Ascq: Presses Universitaires du Septentrion, 2015).

74 Thuillier Jean-Paul, "Les Charbonnages de France et le Plan Marshall", *in* René Girault, Maurice Lévy-Leboyer (dir.), *Le Plan Marshall et le relèvement économique de l'Europe*

30 A final research category renews the history of mines through its focus on the health and environmental impact of the extractive industry. This category includes Paul-André Rosental's research on silicosis,[75] as well as the works recently edited by the historian Judith Rainhorn and the law expert Hervé Pujol.[76] In the same vein, two theses show the considerable damage and conflicts caused by coalmining in the France-Belgium and France-Saarland cross-border coalfields.[77]

31 While in the case of hydraulic power historians generally evoke the "improvements" made to a river to capture energy, the traditional converter for the power of flowing water (the mill), and finally the miller as well as his work and position in society as a whole, the same is not true of coal: its historiography always separates what falls under mineral extraction (coal mining companies, manpower, along with health, social, and environmental impact) from the conversion phase of the potential energy contained in the mineral, which is connected to the history of industrial technology. From the standpoint of the history of energy that I espouse, the implementation of this potential coal energy should also be added to this historiography of coalmining. For the 19th c., this essentially involves the history of the steam engine (stationary and mobile), the boiler, and coal gas. I will not provide an exhaustive list of the existing works on these subjects, however I will simply note the existence of major research works, such as those by Jacques Payen on the steam engine,[78] and Jean-Pierre Williot, Lenart R. Berlanstein, and Jean-Baptiste Fressoz on gas lighting.[79] The

(s.l.: Comité pour l'histoire économique de la France / IGPDE, 1993). Thuillier Jean-Paul, "De Monnet à Massé. Enjeux politiques et objectifs économiques dans le cadre des quatre premiers plans (1946-1965)", in Henry Rousso (dir.), *De Monnet à Massé. Enjeux politiques et objectifs économiques dans le cadre des quatre premiers plans (1946-1965)* (Paris: Éditions du CNRS, 1986). Lucas Nigel J. D., *Energy in France : Planning, Politics and Policy* (London: Europa Publications for the David Memorial Institute of International Studies, 1979). Carbonnel Mauve, "La politique charbonnière de la CECA 1952-2002", *in* Xavier Daumalin, Sylvie Daviet, Philippe Mioche (dir.), *Territoires européens du charbon* (cf. note 73). Berger Françoise, "La CECA et la question de l'énergie", *in* Alain Beltran *et al.* (dir.), *État et énergie XIXe-XXe siècle* (Paris: Comité pour l'histoire économique et financière de la France, IGPDE, 2009).

75 Rosental Paul-André (dir.), *Silicosis, A World History* (Baltimore: John Hopkins University Press, 2017). Rosental Paul-André, Devinck Jean-Claude, "Statistique et mort industrielle. La fabrication du nombre de victimes de la silicose dans les houillères en France de 1946 à nos jours", *Vingtième Siècle, Revue d'histoire*, vol. 95/3, 2007. Idem, "La silicose comme maladie professionnelle transnationale", *Revue française des Affaires Sociales*, vol. 2-3, 2008. Rosental Paul-André, Devinck Jean-Claude, "'Une maladie sociale avec des aspects médicaux' : la difficile reconnaissance de la silicose comme maladie professionnelle dans la France du premier XXe siècle", *Revue d'histoire moderne et contemporaine*, vol. 56/1, 2009. Idem, "De la silicose et des ambiguïtés de la notion de 'maladie professionnelle'", *Revue d'histoire moderne et contemporaine*, vol. 56/1, 2009.

76 Pujol Hervé (dir.), *Tristes mines. Impacts environnementaux et sanitaires de l'industrie extractive* (Bordeaux: Les études hospitalières, 2014). Rainhorn Judith (dir.), *Santé et travail à la mine (XIXe-XXIe siècle)* (Villeneuve d'Ascq: Presses Universitaires du Septentrion, 2014). For the United States, see Andrews Thomas G., *Killing For Coal. America's Deadliest Labor War* (Boston: Harvard University Press, 2008). One of its chapters has been translated into French: "Militants des profondeurs de la terre. Luttes des mineurs du Colorado au tournant du XXe siècle", *Écologie & Politique*, vol. 50, 2015.

77 The Ph.D. diss. by Troch Kévin, "'Ne pas grever l'avenir au bénéfice du présent.' Une histoire environnementale de l'extraction du charbon, de la fin du XVIIIe siècle jusqu'à l'Entre-deux-guerres : un développement non soutenable. L'exemple du Couchant de Mons et du Valenciennois" (Université de Lille 3), defended in January 2018, explores the environmental aspect of coal extraction in Belgium and France from the 1870s to the 1950s. Jonas Kaesler's Ph.D. diss (dir. G. Massard-Guilbaud and Ch. Cornelißen), whose defence is scheduled for 2019, examines the cross-border conflicts sparked by the Lorraine coalfields from 1945 to the 1970s. See also Troch Kévin, "Une vulnérabilité délibérément acceptée par les pouvoirs publics ? Extraction du charbon et inondations dans la vallée de la Haine, 1880-1940", *Vertigo : la revue électronique en sciences de l'environnement*, vol. 16/3, 2016. Kaesler Jonas, "'Ein vordringlich europäisches Problem?' Industrielle Verschmutzung und die Entstehung saarländischer Umweltproteste im deutsch-französischen Grenzgebiet, 1957-1959", *in* Olivier Hanse, Annette Lensing, Birgit Metzger (dir.), *Mission écologie. Tensions entre conservatisme et progressisme dans une perspective franco-allemande // Auftrag Ökologie. Konservativ-progressive Ambivalenzen in deutsch-französischer Perspektive* (Bruxelles: Peter Lang, 2018).

78 Payen Jacques, *Technologie de l'énergie vapeur* (Paris: Éditions du CTHS, 1985). Idem, *Capital et machine à vapeur au XVIIIe siècle : les frères Périer et l'introduction en France de la machine à vapeur de Watt* (Paris: Mouton and co., 1969). Idem, *La machine locomotive en France : des origines au milieu du XIXe siècle* (Lyon: Presses Universitaires de Lyon - Éditions du CNRS, 1988).

79 Williot Jean-Pierre, *L'Industrie du gaz à Paris au XIXe siècle* (Paris: Rive-Droite, 2010). Berlanstein Lenard R., *Big business and Industrial Conflict in 19th c. France: A Social*

work co-edited by Serge Paquier and Jean-Pierre Williot, *L'industrie du gaz en Europe* [The Gas Industry in Europe], covers two centuries in various European countries, and includes both coal gas and natural gas.[80]

32 Most likely because its role in our societies, which albeit important did not truly become so until the second half of the 20th c., the historiography of petroleum was for a long time limited to the work of André Nouschi, who approached it from the perspective of the history of international relations.[81] It has developed recently, notably under the impetus given by Alain Beltran, who edited a number of works opening new perspectives on oil companies, oil routes, and oil and war.[82]

Electricity

33 Electricity, an energy whose industrial production still relies on the use of another energy source, has a prominent place in the historiography. The initial impetus came, in our country, from l'Association pour l'histoire de l'électricité en France [The Association for the History of Electricity in France]. This association, which was created in 1982 by EDF President Marcel Boiteux, EDF Inspector General Maurice Magnien, and the economic historian François Caron, was behind the monumental *Histoire générale de l'électricité en France* [General History of Electricity in France], published between 1991 and 1996.[83] Growing out of Boiteux's desire for the history of the company he presided over to be written, in the eyes of François Caron and the other historians engaged with him in the undertaking, Maurice Lévy-Leboyer and Henri Morsel,[84] this history was in fact an opportunity to work with the executives of a major nationalized company, in an effort to both retrace its history and to record their point of view regarding its construction.

34 This compendium, which mobilized dozens of authors, and whose volumes and chapters are fairly different in tone from one another, sought to cover electricity's scientific, technical, economic, industrial, social, and cultural aspects. It took its place within a tradition of a liberal history of companies, and prized innovation and technological progress. It contributed a great deal to our knowledge, but in my eyes poses a major epistemological problem.

35 Could the decision to allow three senior EDF executives to write 80% of the third volume actually produce anything but a *pro domo* appeal, defence and illustration of the company so dear to them? For instance, the authors took as certitudes ideas that had already been broadly debated and even outmoded at the time the volume was written, such as the unavoidable nature of the permanent rise in the consumption of electricity, and the indisputability of the choices made to provide it—or to prompt it. Ten years after Chernobyl, opposition to civilian nuclear programs was referred to as "fear of the year 2000," "psychological obstacles" that had

History of the Parisian Gas Company (Berkeley: University of California Press, 1991). On the risks of gas lighting, see chapter 5 in Jean-Baptiste Fressoz, *L'apocalypse joyeuse. Une histoire du risque technologique* (Paris: Seuil, 2012). On the imaginary of lighting, see also Schivelbusch Wolfgang, (trad. Weber Anne), *La nuit désenchantée: À propos de l'histoire de l'éclairage artificiel au XIXe siècle* (Paris: Gallimard, 1993).

80 Paquier Serge, Williot Jean-Pierre (dir.), *L'industrie du gaz en Europe au XIXe et XXe siècles. L'innovation entre marchés privés et collectivités publiques* (Bruxelles: Peter Lang, 2005).

81 Nouschi André, *Pétrole et relations internationales depuis 1945* (Paris: Armand Colin, 1999). Idem, *La France et le pétrole : de 1924 à nos jours* (Paris: Picard, 2001).

82 Beltran Alain (dir.), *A Comparative History of National Oil Companies* (Bruxelles: Peter Lang, 2010). Idem (dir.), *Le Pétrole et la Guerre / Oil and War* (Bruxelles: Peter Lang, 2011). Idem (dir.), *Les routes du pétrole. Oil routes* (Bruxelles: Peter Lang, 2016). See also Malti Hocine, *Histoire secrète du pétrole algérien* (Paris: La Découverte, 2010). Bouguen Jean-Marie, *Le Pétrole en France. Genèse et stratégies d'influence* (Paris: l'Harmattan, 2013).

83 *Histoire générale de l'électricité en France*, Volume 1: Caron François, Cardot Fabienne (dir.), introduction by Marcel Boiteux, *Espoirs et conquêtes (1881-1918)*; Volume 2: Lévy-Leboyer Maurice, Morsel Henri (dir.), *L'interconnexion et le marché (1919-1946)*; Volume 3: Morsel Henri (dir.), *Une oeuvre nationale : l'équipement, la croissance de la demande, le nucléaire (1946-1987)* (Paris: Fayard, 1991, 1994 and 1996).

84 F. Cardot represented EDF for the editing of the first volume.

to be "overcome."[85] As a result, instead of the history of electricity announced by the title, we have, at least with the third volume, something of a collection of accounts made by the actors. What is required to make it into history is to connect this source with others and to provide a critique of it, as historical method requires.

36 Beginning in 2001, when the great work was complete,[86] the association most probably no longer had a reason to exist. It gave way to a Comité d'histoire de l'électricité [Committee for the History of Electricity], which in 2013 added energy to its name. This committee, presided over by Alain Beltran and financed by the Fondation EDF, has published *Annales historiques de l'électricité* from 2003 to the present, and in 2011 launched the "Histoire de l'énergie" [History of Energy] collection with the publisher Peter Lang.

37 The historians who are committee members, along with their students (and a few others), have published such a large number of works that it is impossible to provide a summary here, or even a complete list. Their publications have explored all domains relating to electrical energy: companies, production (especially hydroelectric),[87] the national and international market,[88] transportation and distribution networks,[89] the role of state and public policy,[90] the organization of research,[91] and sometimes even the social and cultural history of electricity, as in the book *La Fée et la Servante. La société française face à l'électricité (XIX-XX^e siècle)* [The Fairy and the Servant: French Society in the Face of Electricity (19th-20th c.)], for which a broadly revised and expanded new edition was just published under the title *La Vie électrique. Histoire*

85 Volume 3, 776 (cf. note 83).

86 The association also published other works, such as Lamiral Georges, *Chronique de trente années d'équipement nucléaire à Électricité de France* (Paris: Association pour l'histoire de l'électricité en France, 1988), or the proceedings of its conferences, including Trédé-Boulmer Monique (dir.), *Électricité et électrification dans le monde 1880-1980, Actes du deuxième colloque international d'histoire de l'électricité, organisé par l'Association pour l'histoire de l'électricité en France* (Paris: Presses Universitaires de France, 1992), and Grelon André, Ramunni Girolamo, Badel Laurence (dir.), *La naissance de l'ingénieur-électricien. Origines et développement des formations nationales électrotechniques, Actes du troisième colloque international d'histoire de l'électricité* (Paris: PUF, 1997).

87 Varaschin Denis, "La Société lyonnaise des forces motrices du Rhône, 1892-1946. Du service public à la nationalisation" (Ph.D. diss., Université Pierre Mendès-France - Grenoble, 1996). Giandou Alexandre, "Histoire d'un partenaire régional de l'État : la Compagnie nationale du Rhône (1933-1974)" (Ph.D. diss., Université Lyon 2). Bertrand-Camitaud (Dalmasso) Anne, "Nationalisation et exploitation de la production hydroélectrique dans les Alpes de Savoie des années 1930 aux années 1970" (Ph.D. diss., Université Lyon 2, 1993). Varaschin Denis, *La Fée et la marmite : électricité et électrométallurgie dans les Alpes du Nord* (Paris: La Luiraz, 1996). Varaschin Denis, Tignes, la naissance d'un géant (Arras: Artois Presses Université, 2001). Gouy-Gilbert Cécile, Bertrand-Camitaud (Dalmasso) Anne, Jakob Michael (dir.), *Alpes électriques : paysages de la houille blanche* (Renage: Dire l'entreprise, 2011). Bouvier Yves, Varaschin Denis (dir.), *Le patrimoine industriel de l'électricité et de l'hydroélectricité, actes du colloque international de Divonne-les-Bains et de Genève (7 et 8 juin 2007)* (Chambéry: Université de Savoie, 2009). Varaschin Denis, *Les Entreprises du secteur de l'énergie sous l'Occupation* (Arras: Artois Presses Université, 2006). Bouneau Christophe, *The History of CIGRE (International Council on Large Electric Systems). A key player in the development of electric power systems since 1921* (Paris: Conformes, 2011). Varaschin Denis, *Mémoires de l'électricité* [DVD] (Paris: Éditions de la Maison des Sciences de l'Homme, 2007); Bouneau Christophe *et al.* (dir.), *Les Paysages de l'électricité : perspectives historiques et enjeux contemporains (XIX^e - XXI^e siècles)* (Bruxelles: Peter Lang, 2012). See also Frost Robert L., *Alternating Currents. Nationalized Power in France, 1946-1970*, (Ithaca - London: Cornell University Press: 1991). Barjot Dominique (dir.), *Annuaire statistique de l'économie française, vol. 2 : L'Énergie au XIX^e et XX^e siècles* (Paris: Presses de l'ENS, 1991).

88 Beltran Alain, Morsel Henri (ed.), *Electricity generation and supply : regulation, market, competition. International comparisons. Proceedings of the eleventh International Economic Congress (B15 Session)* (Milan: Università Bocconi, 1994); Beltran Alain, Couvreux Jean Paul (collab.), *Électricité de France, Cinquante ans d'histoire(s) à l'international* (Paris: Le Cherche-Midi, 1996).

89 Bouneau Christophe, Derdevet Michel, Percebois Jacques, *Les réseaux électriques au cœur de la civilisation industrielle* (Boulogne: Timée Éditions, 2007). Arzul Jean-Yves *et al.*, *Le système nerveux du réseau français de transport d'électricité : 1946 à 2006, 60 années de contrôle électrique, EDF R&D* (Paris: Tec & Doc-Lavoisier, 2012).

90 Picard Jean-François, Beltran Alain, Bungener Martine, *Histoire(s) de l'EDF. Comment se sont prises les décisions de 1946 à nos jours* (Paris: Dunod, 1985). Varaschin Denis, "États et électricité en Europe occidentale" (HDR (research-director thesis), Université Pierre Mendès-France - Grenoble, 1997).

91 Bouvier Yves *et al.* (dir.), *De l'atelier au laboratoire. Recherche et innovation dans l'industrie électrique. XIX^e-XX^e siècles* (Bruxelles: Peter Lang, 2011).

et imaginaire (XVIII-XX^e siècles) [Electric Life: History and Imaginary (18th-20th c.)].[92] Some of the publications by committee members also involve energy in general,[93] such as the seminar on the state and energy co-edited by Alain Beltran, Christophe Bouneau, Yves Bouvier, Denis Varaschin, and Jean-Pierre Williot.[94] Aside from two exceptions relating to the energy policy of the state, the contributions in this group all focus on one specific energy sector.

38 During the 2000s, large dams were the subject of research seeking to show the decision-making behind them, the communication policy of the EDF, the reaction of communities affected by their construction, and the consequences of massive expropriations.[95] Even more recently, a new generation of studies have appeared that are more distant from the institutions concerned, critical of the policies pursued, and attentive to the environmental aspects of development.[96]

39 The French electronuclear sector has until now prompted only a limited amount of historical research, which is most probably due to the accessibility of sources.[97] The most interesting academic work, recently expanded and revised, is the one by the anthropologist Françoise Zonabend, in which she shows how we inhabit, think, and defend a peninsula dedicated to nuclear power.[98]Among historians, the most stimulating reflections on the subject have come from across the Atlantic, in the work of Gabrielle Hecht. The rich documentation assembled by this historian has enabled her to discuss the French nuclear exception with great cogency, as well as to examine the relations between the nuclear industry and national identity, engineers and politicians, and unions and local populations.[99] More recently, Hecht has published a second book focusing on the market, labour and workers connected to African uranium (the source of an energy that is supposed to embody out "national" energy independence).[100] The sociologist Yannick Barthe has analysed public policies with regard to nuclear waste,[101] Cyrille Foasso the debates that have

92 Beltran Alain and Carré Patrice, *La Fée et la Servante. La société française face à l'électricité (XIX-XX^e siècle), Paris, Belin, 1991. New edition under the title La Vie électrique. Histoire et imaginaire (XVIII-XXI^e siècles)* (Paris: Belin, 2016).

93 Beltran Alain, "La question de l'énergie en Europe occidentale", *Histoire, Économie et Sociétés*, vol. 18/2, 1999. Beltran Alain, "La question énergétique en France de 1960 à 1974 : dépendance, crise et rôle de l'État", *in* Éric Bussière (dir.), *Georges Pompidou face à la mutation économique de l'Occident : 1969-1974 : actes du colloque des 15 et 16 novembre 2001 au Conseil économique et social* (Paris: PUF, 2003). For a comparative viewpoint see Chick Martin, *Electricity and Energy policy in Britain, France and the United States since 1945* (Cheltenham: Elgar, 2007).

94 Beltran, *État et énergie XIX^e-XX^e siècle* (cf. note 74).

95 Bodon Virginie, *La modernité au village : Tignes, Savines, Ubaye. La submersion de communes rurales au nom de l'intérêt général, 1920-1970* (Grenoble: Presses universitaires de Grenoble, 2003). Blanc Nathalie, Bonin Sophie (dir.), *Grands barrages et habitants, Les risques sociaux du développement (Versailles - Paris: Quae Editions - Maisons des sciences de l'Homme, 2008). Nougarède Olivier, Naussac-en-Margeride : L'histoire économique et sociale d'une vallée noyée* (Ardon: INRA, Laboratoire d'économie et de sociologie rurales, 1980).

96 Pritchard Sara B., *Confluence. The Nature of Technology and the Remaking of the Rhône* (Cambridge (Mass.): Harvard University Press, 2011). Bernhardt Christoph, *Im Spiegel des Wassers. Eine transnationale Umweltgeschichte des Oberrheins (1800-2000)* (Köln: Böhlau Verlag, 2016).

97 See nevertheless chapters 8, 9, and 10 of a book that we will discuss later, Debeir, Deléage, Hémery, *Les servitudes de la puissance* (cf. note 10). Investigative journalists, along with pro- and anti-nuclear militants, have nevertheless published largely on the subject.

98 Zonabend Françoise, *La Presqu'île au nucléaire* (Paris: Odile Jacob - Le Seuil, 1989), republished under the title *La Presqu'île au nucléaire : Three Mile Island, Tchernobyl, Fukushima... et après ?* (Paris: Odile Jacob, 2014).

99 Hecht Gabrielle, *The Radiance of France, Nuclear Power and National Identity after World War II* (Cambridge (Mass.): MIT Press, 1998). French translation *Le Rayonnement de la France. Énergie nucléaire et identité nationale après la seconde guerre mondiale* (Paris: La Découverte, 2004).

100 Being Nuclear, *Africans and the global Uranium Trade* (Cambridge (Mass.): MIT Press, 2012). French translation *Uranium africain, une histoire globale* (Paris: Seuil, 2016). Two American journalists have discussed the role of engineers from the Mines school of mining engineers at the head of the CEA: Pringles Peter, Spigelman James, (trad. Vierne Béatrice), *Les barons de l'atome* (Paris: Seuil, 1982). For a diametrically opposed perspective, see Belot Robert, *L'atome et la France. Aux origines de la technoscience française* (Paris: Odile Jacob, 2015). See also Soutou Georges-Henri, "La logique d'un choix : le CEA et le problème des filières électro-nucléaires, 1953-1969", vol. 68, *Relations Internationales*, 1991. Soutou Georges-Henri, Beltran Alain (dir.), *Pierre Guillaumat. La passion des grands projets industriels* (Paris: Éditions Rive Droite, 1995).

101 Barthe Yannick, *Le pouvoir d'indécision. La mise en politique des déchets nucléaires* (Paris: Economica, 2006).

marked the community of engineers in this sector and the process of expertise and decision-making that have enabled assessments of this energy source's acceptability,[102] and Sezin Topçu how this strongly contested industry is governed.[103]

40 This group of research on electricity finally includes the annual issue of the *Annales de l'Électricité* [Annals of Electricity], which explores subjects as varied as social movements and electricity, electricity and the environment, the human body and electricity, public policy and solar energy, etc.

STUDIES OF ENERGY SYSTEMS AND TRANSITIONS

41 These sector-based studies were necessary. Others will come as well, if only because territorial anchoring is necessary for the writing of history, and works of synthesis require more targeted works in order to be written. However, as abundant and useful as these works may be, they cannot replace a reflection on the relations humans have had at different periods with the energy available around them, a history that I believe, as previously stated, takes the form of a study of systems and transitions. This history, which emerged slowly, is what I would like to speak about presently, by once again pointing out that it is impossible to be exhaustive in the space available here. My objective is therefore not to cite *all* of the works that discuss energy systems and the transitions between them. I have instead tried to show the terms in which the debate has been framed since the emergence of this type of study, using a few of the works I believe to be the most significant. I will begin by one of the rare French-language works, if not the only one, that can be included in this category of studies taking a global approach to the energy question, before discussing an essentially English-language historiography.

42 The first edition of a book entitled *Les Servitudes de la puissance. Une histoire de l'énergie* [In the Servitude of Power: Energy and Civilization through the Ages] appeared in 1986.[104] In their introduction, the authors Jean-Claude Debeir, Jean-Paul Deléage, and Daniel Hémery affirm: "Historians have not granted any attention to energy so far,"[105] "it does not exist in the social sciences as a specific object of knowledge."[106] The 2013 edition adds: "It is evoked only from the standpoint of economic growth."[107]

43 This statement may seem paradoxical in view of the preceding historiographical panorama, but the paradox is only apparent, with the remark regarding energy as a totally neglected subject being essentially justified. Let us consider, as an illustration of this assertion, the example of a collection of texts on contemporary economic history published by Michel Margairaz in 1992, six years after the publication of *Servitudes de la puissance*.[108] This well-conceived work brings together a few dozen of the best pieces by economic historians of modern France from the preceding decades. One looks in vain for energy, both in the twelve sections into which the texts are divided, or within the texts themselves. While energy is the necessary condition for all economic activity to be possible, modern economic historians were still ignoring it as recently as the last decades of the 20th c., or at least were not putting it at the heart of their reflections. They conceived of it only as a condition—of course a *sine qua non*—of what for most of them was central to their reflection: economic growth. The author of the anthology was not the cause, as he could not include what did not exist: his collection presents the areas of interest of economic historians as they stood at the time.

102 Foasso Cyrille, *Atomes Sous Surveillance: Une Histoire de la sûreté nucléaire en France* (Bruxelles: Peter Lang, 2012).
103 Topçu Sezin, *La France nucléaire. L'art de gouverner une technologie contestée* (Paris: Seuil, 2013).
104 Debeir, Deléage, Hémery, *Les servitudes de la puissance* (cf. note 10).
105 *Ibid*., 10 of the 1986 edition.
106 *Ibid*., 11 (1986, p. XII English translation).
107 *Ibid*., 9 (2013). This addition, which was entirely relevant in 1986, is not entirely in keeping with the present reality.
108 Margairaz Michel (dir.), *Histoire économique, XVIIIe-XXe siècles* (Paris: Larousse, 1992).

44 Of course many works on the Industrial Revolution had discussed coal at length, while the ones focusing on the 20th c. explored electricity and its networks, works that I mentioned earlier. Yet this historiography was missing a global view of the energy question as I defined it in my introduction: a vision of how societies reflected on (or didn't) and organized (or didn't) energy use; a global vision that also shows the consequences (not always desired) of how they mobilized, converted, divided, and spent it; a history that considers humans for what they are, living beings who are an integral part of nature, and subject to its balance and limits—in matters of energy as with everything else.

45 The authors of *Servitudes de la puissance* were thus correct on this point, for in 1986 energy essentially remained a neglected historical subject, although the reason they saw for this is not a convincing one for me:

46 Not least among these [the limits of history] is the proliferation of empirical research, ever more fragmented and obedient to the current dominant trend in research—the infinite accumulation of findings—with its refusal to look at the totality, to place the energy crisis in historical perspective. Such a perspective, however, is the only methodological choice that can provide a solid foundation for the analysis of society's relation to energy.[109]

47 Here we have the old reproach that historians of science direct toward historians "as such," who submerge themselves in empirical and monographic research, and prove unable to assemble generalities, or even worse *refuse* to do so. Yet while it is indeed necessary to "solidly base analysis of the relations societies maintain toward energy," it is also true that at least until a certain level of research, empirical studies (whatever their sources, which in the case of history includes archives that are written, oral, visual, archaeological, etc.) are the best way, if not the only way, of doing so. For a historian, the search for *totality,* however necessary it may be, is built through the synthesis of information contained in primary sources that are constructed, problematized, analysed, and cross-referenced. The rest of *Servitudes de la puissance* was in fact based on empirical research, without which the writing of this book would not have been possible. As a result, the question of energy's neglect is not framed in terms of a refusal to consider totality, but instead calls for a genuine reflection on the reasons why global studies of energy proved so rare for such a long time.

48 The fact that historians have been so slow in seizing upon the subject is another illustration, as though one were necessary, of the fact that they ask of the past only questions of their time (and in this case their future). But they manage to do so only in the best cases, and can be late in seizing upon key questions, or can simply not see them or even want to not see them—neglected subjects are nothing new in history, and various historians have shown how certain disturbing questions have taken a while to be raised. Neither the writing of intellectuals on both the right and the left—who for decades have laid the foundations for a critical reflection on the relation between humans and their environment—nor the environmentalist movement of the 1970s, nor anti-nuclear protests, nor "oil crises" have been enough to trigger a fundamental historical reflection on the relations our societies have with energy. It took the discovery of global warming and the role that human activity has played and continues to play in its arrival for it to emerge, and for us to begin to worry. The revelation that human activity is responsible for a change in climate served as an (still insufficient) incentive to explore a new aspect of history. This is why in the preceding sections I emphasized the existence of works that had already begun to reflect on the relation between society and energy, pioneering works that were "ahead of their time."

49 The German historian Rolph Peter Sieferle, whose contribution I will discuss below and who noted the importance of energy in the Industrial Revolution, also wondered why it was so slow in

109 Debeir, Deléage, Hémery, *In the Servitude of Power* (cf note 10), 15 (page XV of English translation).

coming to centre stage. He believed this blind spot goes back to classical economists, who understood questions of natural resources only as agricultural questions.[110] Marx placed the textile industry at the heart of his analysis. Yet this sector, which brought spectacular changes to work organization, was initially not based on the use of fossil energy (but on hydraulic and human power). Sieferle believes that this prevented Marx from assessing the problem.

50 To understand the slowness of historians in exploring the energy question, one must also explore how the vocabulary integrated the scientific meaning of the word "energy." For while the notion of energy as a "force that can create work" indeed appeared during the 19th c., with the formulation of the first laws of thermodynamics, it was not until 1932 that the *Dictionnaire de l'Académie française* [Dictionary of the Académie française] mentioned this meaning as a complement to its earlier one of "vigour of soul" or "vigour of speech." Even if, as indicated by *Le Robert*, the word began to be used in its scientific sense starting in 1868, or in a vaguer sense even as early as 1807, it took over a century for it to be adopted by l'Académie. The latter is certainly not known for its propensity to swiftly adopt novelty, but this slowness is surely also the reflection of society's difficulty (reticence?) in taking a global view of energy. The question calls for further exploration.

51 Whatever the reasons for this difficulty, it is necessary to give the authors of *Servitudes de la puissance* credit: theirs was the first French-language book to stress that the history of energy had not received necessary attention, and to propose an approach. Beyond the global outline it endeavoured to sketch out, some aspects of which can be debated, and the fact that the 2013 republication hardly took into account the evolution of the historiography since the 1980s, it drew attention to a number of important elements.

52 The first is that relations between human societies and nature are not limited to their economic and social aspects.[111] Human history cannot be written effectively without including biological aspects. Regardless of how it is formulated, this is the credo of environmental history[112]: as an integral part of nature, humans and the societies they form cannot be understood without their relation to the environment being taken into consideration.

53 Debeir, Deléage, and Hémery made another important remark directly connected to energy: the quantity of energy provided by the sun being infinitely superior to human needs,[113] the true question for them is not the existence of energy, but rather putting it into use, and therefore a question of converters. This remark has not lost any of its relevance.

54 A third essential point is the notion that the history of the relations between societies and the energy surrounding them takes place via the study of energy *systems*.[114] The authors' definition of an energy system included supply zones and techniques used for primary energy, methods for collection, extraction, transportation, and storage, types of converters, final forms of energy, competitive relations between various sectors, and finally forms of appropriation, which controlled the arrangement of energy converters and modes of energy.[115] This also leads to questions of free access to energy sources and

110 Sieferle, *Der unterirdische Wald* (cf. note 10). E. A. Wrigley also developed this point in the first part of *Energy and the English Industrial Revolution* (cf. note 36).

111 Debeir, Deléage, Hémery, *Les servitudes de la puissance* (cf. note 10), 17.

112 It was in an effort to support this idea that the author of this essay co-organised a conference with S. Mosley in Paris in 2008, partially published (under the same title): Massard-Guilbaud Geneviève, Mosley Stephen (ed.), *Common Ground. Integrating Social and Environmental in History* (Newcastle: Cambridge Scholars Publishing, 2011).

113 The authors refer on this subject to the article by Michel Bosquet (alias André Gorz), "Sources d'énergie et humanité", *Le Sauvage*, Spring 1980, 55-58.

114 The authors claim to have introduced this concept of energy system, but it had already been used by Rolph Sieferle four years earlier in Der unterirdische Wald, for which see below.

115 Debeir, Deléage, Hémery, *Les servitudes de la puissance* (cf. note 10), 17.

the appropriation of surplus, both of which also deserve particular attention.

55 The German historian Rolph Peter Sieferle, who died prematurely in 2016, had proposed a new vision of energy questions four years before the appearance of *Servitudes de la puissance*.[116] His work *Der unterirdische Wald. Energiekrise und industrielle Revolution*[117] [The Subterranean Forest: Energy Systems and the Industrial Revolution], which was published in 1982, did not appear among the bibliographical references of *Servitudes de la puissance*. Probably because its original version was in German and its English translation came late, before finally being republished in paperback nearly thirty years after the first edition, the work was little-known for a long time, with the original ideas developed by Sieferle sometimes being attributed to others, who in reality only repeated or reinterpreted them.

56 *Der unterirdische Wald* is not, strictly speaking, a general history of energy. Consisting of five relatively independent sections, the book offers a series of avenues for reflection that are both pioneering and stimulating. The first section sketches out a panorama of successive energy systems since the Neolithic; two others discuss questions connected to German forests during the early modern period; and a final section explores perceptions of energy. I will summarize here only one or two arguments developed in the third section, which pertain to coal and the Industrial Revolution in Britain. Sieferle argued that the use of coal as a replacement for wood had enabled the export of British textiles by freeing up land (that no longer had to be reserved for forests). In other words, the use of fossil energy allowed Great Britain to gain space. The use of fossil energy also meant that the country could transition to the stage of both territorial expansion (use of natural resources outside its territory) and temporal expansion (use of fossil resources accumulated underground during the Palaeozoic era). In changing from direct solar energy (through photosynthesis) to fossil energy,[118] Sieferle believed that the British economy shattered earlier territorial limitations. This was undeniably a new and stimulating way of considering things.

57 In an article from 1962, the English historian Tony Wrigley, a pioneer of historical demographics along with Peter Laslett, formulated a general interpretation of the change that had taken place with the Industrial Revolution. He introduced the notions of an advanced organic economy to refer to the pre-Industrial Revolution economy, and the mineral economy for the one that succeeded it.[119] He returned to these notions in *Continuity, Chance and Change,* a work in which he analysed why he believed Malthus' theory was inaccurate (evoking in this case the energy transition rather than the demographic transition).[120] In 2010 Wrigley finally returned to the question in *Energy and the English Industrial Revolution*,[121] in which he organized his entire interpretation of the Industrial Revolution around the question of energy. While recognizing that it is always difficult in the social sciences to identify *the* determining factor in a change, he again argued that the transition from the old economy (and therefore, in his mind, the end of poverty and misery for many) would not have been possible without access to a form of energy that was not subject to the limitations of the annual cycle of sunshine and photosynthesis.

58 This analysis, which brings to mind Braudel's conclusion when he presented the former economic system as being essentially restrained by nature in its energy system, raised the question of the relation to energy, economic growth, and the well-being of populations, and subsequently that of knowing whether the former economy

116 Tony Wrigley had already introduced the notion of organic/mineral economies, and discussed questions of energy in articles that can also be considered as being the first on their subject. However, it was not until 1988 and 2010 that he synthesized his body of ideas in two works that we will discuss below.

117 Sieferle, *Der unterirdische Wald* (cf. note 10).

118 Fossil energy of course also comes from solar energy, but on an entirely different time scale!

119 Wrigley, "The Supply" (cf. note 36), 1-16.

120 Wrigley, *Continuity, Chance and Change* (cf. note 36).

121 Wrigley, *Energy and the English Industrial Revolution* (cf. note 36).

had not in its course come to a breaking point, one in which a change of energy system had become necessary, and massive use of fossil energy *inevitable*. While the question is clearly an important one during a time of inventing "low-carbon" economies, there is no consensus today on this subject among historians.

59 The American historian Robert C. Allen has sought to show why Great Britain during the Elizabethan period developed an economy that was at least partially based on coal. The existence of coal underground is not reason enough to undertake its use: Germany and China also had large reserves of coal, but only began to extract it much later.[122] The traditional explanation for the early use of coal in Britain was the lack of wood (Nef's timber crisis): Great Britain deforested its territory well before France or Germany, and therefore ran short of wood much sooner than other countries. A wood shortage should have led to a price rise, yet Allen shows that the rising price of wood was neither clear nor uniform. The price varied from one British region to another, and from one period to another. The respective prices of wood and coal were of course not the only criterion in play. The respective properties of these two sources of energy also came under consideration: coal was greatly superior for lime kilns and forges, while wood or charcoal were in principle favoured for other uses. The price of fuels was nevertheless a key argument, as in London wood had become exceptionally expensive compared to the coal imported from the north of the country by waterway.

59 According to Allen, coal gradually became a backstop technology, that is to say an energy source that could provide very large quantities of energy at a low price, with this price becoming the price of reference. Yet important transformations had to take place for this to be possible, and not just with industry and among artisans. During the 17th c., over half of the energy consumed was for domestic heating. Yet it was impossible to heat homes with coal without completely transforming how they were built. The use of coal required them to be equipped with a chimney (which was not the case before that period), a stone wall to support it, a firebox lined with metal that could accommodate a fire with sufficient draft, etc. The British capital, whose centre had partly been destroyed by the Great Fire of London in 1666, and which was experiencing growth that was not present in the country's other cities, consequently (re)built, and transitioned to coal more quickly than the others. Whether or not Allen's overall theory is correct, this is a simple but particularly clear example of the important role played by a converter, and how a change in fuel could lead to social change that can only unfold over a relatively long period of time (but fostered here by the catastrophe of 1666—catastrophes having the property of accelerating change.)[123]

60 The book *Power to the People,* by Astrid Kander, Paolo Malanima, and Paul Warde, three European historians who have greatly contributed to this field of research in their previous publications, appeared in 2014.[124] Aside from the possible

122 Allen, *The British Industrial Revolution in Global Perspective* (cf. note 17). See also by the same author "Backward into the Future. The Shift to Coal and its Implications for the next Energy Transition", *Energy Policy*, vol. 50, 2012.

123 Massard-Guilbaud Geneviève, "The urban catastrophe, challenge to the social, economic and cultural order of the city", *in* Geneviève Massard-Guilbaud, Dieter Schott, Harold L. Platt (eds.), *Cities and Catastrophes : Coping with Emergency in European History. Villes et catastrophes. Réactions face à l'urgence dans l'histoire européenne* (Frankfurt am Main: Peter Lang Verlag, 2002, 9–42).

124 Kander Astrid, Malanima Paolo, Warde Paul, *Power to the People: Energy in Europe over the Last Five Centuries* (Princeton: Princeton University Press, 2013). Previous publications by these authors (among others): Stern David I., Kander Astrid, "The role of Energy in the Industrial Revolution and Modern Economic Growth", *The Energy Journal*, vol. 33/3, 2012. Kander Astrid, Warde Paul, "Energy Availability from Livestock and Agricultural Productivity in Europe, 1815-1913: a New Comparison", *The Economic History Review, New Series*, vol. 64/1, 2011. Gales Ben *et al.*, "North versus South: Energy Transition and Energy Intensity in Europe over 200 years", *European Review of Economic History*, vol. 11/2, 2007. Malanima Paolo, *Le energie degli italiani. Due secoli di storia* (Milano: B. Mondadori, 2013). Idem, *Energy Consumption in Italy in the 19th and 20th Centuries* (Napoli: Issm-Cnr, 2006). Idem, *Energia e crescita nell'Europa preindustriale* (Roma: La Nuova Italia Scientifica, 1996). Warde, "Fear of Wood Shortage" (cf. note 17). Idem, *Energy Consumption in England & Wales* (cf. note 36). Idem, "Early Modern 'Resource Crisis' " (cf. note 36).

nod to John Lennon's cult song, the authors lay claim to the dual meaning of the word *power*, affirming that control over energy is indeed a source of power, an idea that enjoys consensus. They present their work as a history of the European economy seen through the question of energy. They briefly discuss the various theories that have succeeded one another to explain why the Industrial Revolution initially took place in England (arguments that are economic and energy-based but also institutional, cultural, etc.), but deem this debate to be partly artificial, as they do not see the disagreements as being fundamental. They nevertheless point out that one of the central arguments that emerged from this debate was the existence in Great Britain of an abundant and relatively affordable fuel. Firmly convinced of this fact, they aim for the first time to provide as reliable of figures as possible for European energy consumption (or at least for a part of Europe) over a *longue durée*. The data they have constructed shows the succession, since the late Middle Ages, of three phases of consumption: three centuries of stagnation in energy consumption (1500-1800) were followed by an explosion in consumption (1800-1970), interrupted by the two world wars, with the period between 1970-2008 (date at which their data breaks off) being one of stabilization. The authors' objective is clearly to also provide meaning for this curve, and to explore the relations between economic growth and energy consumption. The study of elements driving energy transitions and the respective efficiency of various systems are also among the book's objectives.

61 Kander, Malanima, and Warde conclude that Europe before the Industrial Revolution indeed suffered from energy restrictions of two kinds: the lack of productivity of its lands (compared for instance to certain parts of Asia), and the low energy efficiency of its converters. These restrictions were obstacles to economic growth. The use of fossil energies was both the condition and the determining factor of the growth it subsequently experienced. The prosperity of Great Britain and the Netherlands during the Ancien Régime was also apparently due to their early use of fossil resources (coal for the former, peat for the latter), as well as their intensive use of wind (for their merchant marines). The transition seemingly took place during the 19th c. with the development of large-scale coal use. The latter created the conditions for developing steam engine use (which they consider to be one of the most important inventions in the history of humanity), which was itself at the origin of modern growth. Low coal prices and high salaries combined to make Great Britain the origin of the revolution instead of elsewhere. The authors also insist on the fact that they believe the energy factor to be more important for economic growth than economist generally think. In order to show how this transition took place, they also set out the functioning of what they call development blocks (for example the steam-coal-steel block).

While emphasizing that concern over energy 62
was an age-old and recurring phenomenon in Europe,[125] and that projections on this subject have always proven inaccurate, the authors attempt, while offering many precautions, to evaluate the implications of their study for the future. These implications can be summarized thus: returning to an organic economy would be both expensive and an obstacle to economic growth and the well-being of populations; today there is no macro-innovation of the type that drove the transition toward coal; the future is based on better energy efficiency ("Negawatt is the best watt"), although the rebound effect should not be neglected; and technological innovations often develop in niches and networks. Kander, Malanima, and Warde's book therefore provides a mass of new numerical "data," whose

125 On this point, see for example Brüggemeier Franz-Josef, "Le dépérissement de la forêt. Construction et déconstruction d'un problème d'environnement", *in* Christoph Bernhardt, Geneviève Massard-Guilbaud (dir.), *Le Démon moderne / The Modern Demon. La pollution dans les sociétés urbaines et industrielles d'Europe. Pollution in Urban and Industrial Societies* (Clermont-Ferrand: Presses universitaires Blaise-Pascal, 2002). See also Jonsson Fredrik A., "Abundance and Scarcity in Geological Time 1784–1844", *in* Forrester Katrina, Smith Sophie (eds.), *Nature, Action and the Future: Political Thought and the Environment* (Cambridge: University of Cambridge Press, 2018).

construction will surely be the subject of criticism, although in terms of interpretation it is in keeping with the sketch drawn out at another time by Braudel, and later developed by Wrigley.

63 Other authors, such as Kenneth Pomeranz, have developed arguments that do not differ enough from the ones I've mentioned for me to present them here as well.[126] However, I would like to briefly mention the research conducted in environmental history, and notably the history of energy, through the study of flows and the social metabolism. This research initially emanated from the Institut für Soziale Ökologie Alpen-Adria-Universität Klagenfurt (Austria), a research centre founded and for a long time directed by the sociologist Marina Fischer-Kowalski, who developed this concept.[127] A good overview of this approach can be found in the chapter by Richard Unger that will appear in *Systèmes et transitions énergétiques* [Energy Systems and Transitions].[128] The method has, to a certain extent, been echoed in France by specialists of the urban environment, such as Sabine Barles.[129]

64 Some researchers either do not appear to share the notion that we must renounce fossil energy, speaking of transitions but without appearing convinced of their value, or believe that taking pains to study them denotes the "triumph of a cultural history of energy."[130] Others mention transitions only as a warning. For instance in the degrowth journal *Entropia*, Jean-Baptiste Fressoz considers the concept of transition a "dangerous lure with no historical referent," and any attempt to understand how they function a kind of "managerial ambition."[131] François Jarrige and Jean-Louis Tornatore wonder "whether the concept of 'ecological transition' is not in fact the final avatar and consummate form of denial [of climate change]."[132]

65 Researchers who use the concept of the "anthropocene," which they define as a new geological era marked by the fact that humans have become a geological agent,[133] base their theory on series of charts that present the radical changes that have taken place during the last two centuries (changes that are familiar to historians, whose research has helped construct these charts), although they do not discuss its causes, the ways in which the presented changes took place, or the actors who sought them or initiated them. For example Alfred W. Crosby, in his synthetic history of human energy use entitled *Children of the Sun,*[134] offers an elegant description of phenomena that he never actually explains. In their recent book *The Great*

126 Pomeranz Kenneth, *The Great Divergence: China, Europe, and the Making of the Modern World Economy* (Princeton: Princeton University Press, 2000). French translation *Une grande divergence. La Chine, l'Europe et la construction de l'économie mondiale* (Paris: Albin Michel, 2010).

127 See especially Krausmann Fridolin, Habert Helmut, "The Process of Industrialization from the Perspective of Energetic Metabolism. Socioeconomic Energy Flows in Austria. 1830-1995", *Ecological Economics*, vol. 41, 2002.

128 Mathis, Massard-Guilbaud, *Systèmes et transitions énergétiques* (cf. note *), chapter 9. Other references on the energy metabolism are included in this article.

129 Kim Eunhye, Barles Sabine, "The Energy Consumption of Paris and its Supply Areas from the 18th c. to the Present", *Regional Environmental Change*, vol. 12, 2012. Barles Sabine, "The Seine and Parisian Metabolism: Growth of Capital Dependencies in the 19th and 20th Centuries", *in* Stéphane Castonguay, Matthew Evenden (eds.), *Urban Waters: Rivers, Cities and the Production of Space in Europe and North America* (Pittsburgh: Pittsburgh University Press, 2012). Barles Sabine, "A Metabolic Approach to the City: 19th and 20th C. Paris", *in* Dieter Schott, Bill Luckin, Geneviève Massard-Guilbaud (eds.), *Resources of the City: Contributions to an Environmental History of Modern Europe* (Aldershot: Ashgate, 2005).

130 Bouvier Yves (dir.), *Les défis énergétiques du XXIe siècle. Transition, concurrence et efficacité* (Bruxelles: Peter Lang, 2012). Cultural history is nevertheless not my orientation, as my chair at l'EHESS is entitled "Environmental, economic, and social history of the modern world."

131 Fressoz Jean-Baptiste, "Pour une histoire désorientée de l'énergie", *Entropia, Revue d'étude théorique et politique de la décroissance*, vol. 15, 2013.

132 Jarrige François, Tornatore Jean-Louis, "Un ministère pour la transition", *Sciences critiques*, https://sciences-critiques.fr/un-ministere-pour-la-transition, 2017.

133 See the seminal article for the concept of the anthropocene: Crutzen Paul J., "Geology of Mankind", *Nature*, vol. 415/23, 2002. French translation "La géologie de l'Humanité", *Écologie et Politique*, vol. 34, 2007. A more developed version co-authored by Steffen Will, Crutzen Paul J., McNeill John R., "The Anthropocene: Are Humans Now Overwhelming the Great Forces of Nature?", *Ambio*, vol. 36/8, 2007.

134 Crosby Alfred W., *Children of the Sun. A History of Humanity's Unappeasable Appetite for Energy* (New York: W.W. Norton, 2006).

Acceleration,[135] John McNeill and Peter Engelke devote a 60-page chapter to energy, yet they also describe situations without ever saying how they were implemented, and evolutions without specifying what brought them about.

66 Marxist historians, who are critical of the concept of the anthropocene, which they believe obscures the responsibility of the capitalist bourgeoisie in a hypothetical *anthropos*, propose giving the former its due by replacing the term anthropocene with that of capitalocene. Let us note in passing that the term anthropocene raises many other (fully real) problems than the identity of the *anthropos* in question, notably knowing how and according to what time and spatial scales history is written, as well as the relation between the Earth and nature sciences on the one hand, and the Humanities and social sciences on the other. Developing this point is beyond the scope of my objective here, although not considering the anthropocene a useful framework for my reflection is an assumed choice.

67 Marxist historians therefore do not deny the existence of transitions, but endeavour to show how the most remarked of these transitions took place, namely the introduction of the mass use of coal. This is how *Capital Fossil* proceeds, a book published in 2016 and based on the doctoral thesis of Andreas Malm, a human ecology teacher at Lund University in Sweden.[136] The author directly opposes the conclusions of *Power to the People* and those he refers to as "Ricardo-Malthusians," with this term including Kander, Malanima, and Warde as well as Wrigley, Allen, and others such as Pomeranz. I will only discuss Malm's argument regarding the Industrial Revolution in Great Britain, the only one that is based on the study of original sources. Malm's demonstration aims to show that what led industrial actors in key sectors of the factory system to renounce hydraulic power in favour of coal was neither technological advances, nor the price of the different energies available or their converters, nor the need for economic growth, but rather the "logic of capital," especially the need for a large concentration of manpower, and the desire to control it more effectively and at lower cost, as well as to benefit from urban commercial infrastructure. While some of these "demonstrations" are in fact only theories, as the author recognizes himself a number of times,[137] the first part of this book provides a certain number of elements that deserve attention. The passages on industry's independence from firewood, the untapped capacities of hydraulic power, and the price of setting up steam power, for instance, could certainly fuel the current debate.[138] The conclusion Malm arrives at on the question of the Industrial Revolution is clearly diametrically opposed to that of the works I mentioned previously, and that can easily be sketched out as the following: the use of fossil energy was in no way necessary, but was simply the reflection of, or what made possible, the implementation of capitalist relations of production.[139]

68 This idea that the transition to fossil energy use was hardly inevitable or unequivocal as has been stated—an idea that has already been strongly emphasized by researchers who, without framing the problem in the same terms, were interested in wood or hydraulic power in recent decades (I am referring to the previously cited

135 McNeill John R., Engelke Peter, *The Great Acceleration. An Environmental History of the Anthropocene since 1945* (Cambridge (Mass.): The Belknap Press of Harvard University, 2014).

136 Malm Andreas, *Fossil Capital, The Rise of Steam Power and the Roots of Global Warming* (London: Verso, 2016), 38. *The book L'Anthropocène contre l'histoire* (Paris: La Fabrique, 2017), is not a translation of the aforementioned book, but a compilation of four articles.

137 Notably on page 264 of the English edition, where he writes, "But these are merely contours of a theory, waiting to be filled in."

138 If it is, for all that, possible to debate with an author who speaks with such a condescending tone of historians whose views he does not share!

139 It supplements in this sense the theories of Timothy Mitchell, who in his *Carbon Democracy. Political Power in the Age of Oil* (London: Verso, 2011), raised the strictly political aspects of energy systems by affirming that the transition from coal to oil was sought out in order to weaken miners' capacity to cause blockage, which was itself behind democratic advances. This is an appealing theory, but contradicted by many other works, and one that lacks support in my opinion.

works by Denis Woronoff and Serge Benoit)—is today reinforced by those who question the fact that the energy mix of the Ancien Régime, which experienced different transitions itself, was the cause of the economy's blockage. For instance, in an article published in the journal *Alternatives économiques,* Mathieu Arnoux stresses the fact that the renewable resources of the Ancien Régime were in fact the very ones that provided the margins of growth that made the Industrial Revolution possible.[140] Some authors, such as Grégory Clarks and David Jacks, go even further by affirming, contrary to Malm's theory, that coal did not play the role we have ascribed it under the Industrial Revolution, and that it only made negligible contributions to the profits in England earned during this period.[141]

CONCLUSION: WRITING THE HISTORY OF ENERGY DURING A TIME OF GLOBAL WARMING

69 I would like to conclude with a few brief remarks about the nature of the contributions and debate in the field of the history of energy.

70 The first is that the debate over the interpretation of transitions is not complete. To move forward, we need new contributions based on studies that are both territorialized *and* reflected on according to a global perspective.

71 The second is that to date, the debate surrounding the causes and processes of transitions focuses essentially on what Vaclav Smil has called "the Great Transition," which took place in the West during the 19th c. and led us (by stages, if truth be told) to our current energy system.[142] This is regrettable, for more perspectives on other transitions would contribute to a better understanding of the complex processes that we are seeking to grasp.

Finally, it is important to note that while French historians have contributed a great deal to research on various energy sectors, to date they have not made major contributions to the history of energy systems and transitions. Various signs nevertheless suggest that a shift is underway. 72

With regard to historians from the comité d'histoire de l'électricité [Committee for the History of Energy], a number of signs seem to indicate a desire to take a different approach to the history of energy: in 2013 the committee changed its name to the comité d'histoire de l'électricité *et de l'énergie*. Its journal transformed in 2018 into the *Journal of Energy History / Revue d'histoire de l'énergie,* whose first issue publishes this historiographical essay. Energy transitions were the subject of a conference in December 2017 under the leadership of these historians, a conference whose communications will serve as the material for a future issue of the same journal.[143] As indicated earlier, in 2011 this committee created a collection entitled "*Histoire de l'énergie*/History of Energy," which already includes ten titles. We can only offer praise for the creation of such a collection, although practically all of the works that make it up are devoted to the history of electricity. The Fondation EDF has also co-financed the doctoral allocation for Sophie 73

140 Arnoux Mathieu, "Les transitions énergétiques d'hier", *Alternatives Économiques*, no352, 2015.

141 Clarks Gregory, Jacks David, "Coal and the Industrial Revolution, 1700-1869", *European Review of Economic History*, vol. 11/1, 2007, 39–72.

142 In this text I could have discussed the contribution of Vaclav Smil, Professor Emeritus of Environmental Science and the author of many books on energy, its history and transitions. In my view his historical analyses do not always ascribe the appropriate role to the social aspects of the energy question. However, he has a remarkable capacity to explain the physical aspects to an audience whose initial education does not predispose it to understanding the question. See among others Smil Vaclav, *Energy in World History* (Boulder: Westview Press, 1994). Idem, *Energy and Civilization, a History* (Cambridge (Mass.): MIT Press, 2017). Idem, *Prime Movers of Globalization: The History and Impact of Diesel Engines and Gas Turbines* (Cambridge (Mass.): MIT Press, 2010). Idem, *Energy in Nature and Society. General Energetics of Complex Systems* (Cambridge (Mass.): MIT Press, 2007). Idem, *Energy Transitions. History, Requirements, Prospects* (Santa Barbara: Praeger, 2010). Idem, *Energy in China's Modernization* (New York: M.E. Sharpe, 1988).

143 https://calenda.org/404295 http://www.museoscienza.org/news/dettaglio.asp?idnotizia=1090 I did not attend this conference held in Italy, and therefore do not have anything to say in its regard.

Pehlivanian, who in 2014 defended a doctoral thesis on the history of solar energy in France.[144]

74 At l'Université Paris-Diderot, the LIED (Laboratoire interdisciplinaire des énergies de demain, UMR 8236) [Interdisciplinary Laboratory for the Energies of the Future] multidisciplinary research unit that was created in 2013 has placed research on "past, current, and future energy transitions" at the heart of its work. The Humanities and social sciences are represented within the unit in the same way as biology and physics, and one may believe that multidisciplinarity is not just a facade, because the research unit is directed by the historian Mathieu Arnoux. It is not common for a research centre to associate the natural and social sciences, and it is even less common for it to be directed by a researcher from the latter group.

75 At CIRED (Centre international de recherche sur l'environnement et le développement, UMR 8568) [International Research Centre for the Environment and Development], economists, historians, and sociologists have come together to offer master's students from both the social and environmental sciences multidisciplinary instruction on the history of past and current energy transitions.[145]

76 In September 2016 RUCHE (Réseau universitaire de chercheurs en histoire environnementale) [Network of University Researchers in Environmental History] organized a conference on the history of energy, which it had prepared by organizing a series of one-day workshops.[146] One of these was on transitions, and was entitled "Énergies renouvelables, énergies carbonées: transitions énergétiques à double sens" ["Renewable Energies, Carbon-Based Energies: Two-Way Energy Transitions], suggesting by its title alone that the history of transitions has nothing finalistic or linear about it. RUCHE also supported the conference held in March 2018 at l'Université de Bourgogne, organized by François Jarrige and Alexis Vrignon, on the history of renewable or alternative energies during the Industrial Age. During this conference, various interventions showed the abundance of cases in which the energy trajectory did not follow the model often presented as universal and inevitable,[147] in which traditional forms of energy use endured, or were readapted by new economic and social configurations. The publication of these communications will be of great interest.

77 Beyond the places and institutions that take a specific interest in the question of energy, we can see the emergence among some economic historians of an intention to rethink their knowledge in light of new environmental questions. This research is sometimes still in gestation, although that fact that it is rooted in a deep knowledge of a specific area makes it particularly interesting. One example is the ongoing research of Xavier Daumalin and Olivier Raveux on how the energy transition of the first half of the 19th c. took place for industry and the merchant marine in Marseilles. This transition is a good example of non-linearity, of a transition that did not include the addition of a previously unknown energy source, one marked instead by the adoption of a new converter (steam engine), and consequently by a new hierarchy within the existing energy mix. In Marseille, steam engines were slow to replace

144 Pehlivanian Sophie, "Histoire de l'énergie solaire en France : science, technologies et patrimoine d'une filière d'avenir" (Ph.D. diss., Université de Grenoble, 2014).

145 "Socio-histoire des transitions énergétiques, XVIII^{e}-XX^{e} siècles," seminar coordinated in 2016-2017 by G. Massard-Guilbaud, and in 2017-2018 by A. Nadaï. Additional details at https://www.ehess.fr G. Massard-Guilbaud has already devoted three years (2013-2016) to seminars on the history of both energy and energy transitions. In 2018-2019 she and R. Bécot will offer a seminar entitled "Qu'avons-nous fait du soleil ? Histoire environnementale de l'énergie et des nuisances industrielles."

146 "L'animal source d'énergie: enquêtes dans l'Europe d'avant la Révolution industrielle" (Université de Valenciennes et du Hainaut-Cambrésis), "Énergies renouvelables, énergies carbonées: transitions énergétiques à double sens" (EHESS), "Anticiper la pénurie énergétique" (Université Bordeaux-Montaigne), "Le moteur hydraulique" (Université Clermont-Auvergne).

147 This is notably the theory of the sociologist Gras Alain, *Le Choix du feu. Aux origines de la crise climatique* (Paris: Fayard, 2007).

78 watermills not because they were unknown or inefficient, but because those who made their living from hydraulic power represented a powerful social group, and delayed its adoption, and also because their use required adapting the entire production and merchant system in order to be profitable. When it occurred, the transition to steam was brutal, but it hardly put an end to hydraulic power, which still had a bright future ahead of it.[148]

79 In an article that appeared in the journal *L'Histoire,* Mathieu Arnoux justly stresses that interdisciplinary imagination and curiosity are indispensable to the historian of energy.[149] Thinking globally of an energy that involves all human activities without exception, and whose coherence as a concept is not easily grasped, is a genuine challenge. We should be delighted that a growing number of historians are tackling the subject.

148 On this subject see the conference given by Daumalin Xavier, "La transition énergétique au regard de l'histoire", *Cahiers des Fellows de l'IMéRA*, https://imera.hypotheses.org/510, 2017. See also Daumalin Xavier, Raveux Olivier, "La marine marchande marseillaise en transition énergétique. Origines et enjeux d'un choix socio-écosystémique", *Cahiers de la Méditerranée*, forthcoming [2018].

149 Mathieu Arnoux, "200 000 ans de transition énergétique," *L'Histoire*, n°408, 2015, 8-15.

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