For a history of energy and material symbioses

Jean-Baptiste Fressoz
Centre de recherches historiques CNRS-EHESS

In recent years, many books on the history of energy have been published. We can be pleased with this renewed interest, but we can also regret that these works have been placed under the banner of "transition". With the climate emergency, this word has acquired such prestige, such centrality, that historians have come to use it to describe all sorts of processes, including those that were, strictly speaking, energy additions[1].

The industrial revolution is thus presented as a "transition" from wood to coal, as the passage from an "organic economy" to a "mineral economy". A recent and important book states that oil and electricity in the twentieth century were "energy transitions" - whereas electricity increased the consumption of coal and oil did not reduce it[2]. The "phasist" vision of the material world is so deeply rooted that some historians oppose a 19th century of coal to a 20th century of oil - and draw from it hazardous conclusions about the history and nature of power[3]. Nor has the prodigious sluggishness of the current "energy transition" cancelled out the presumptions about those that are supposed to have taken place in the past[4].

The problem with these works is not so much their empirical basis as what they choose to study. By focusing on the dynamics of transitions and certain emblematic technologies such as

---

1 Bruce Podobnik, *Global Energy Shifts. Fostering Sustainability in a Turbulent Age* (Philadelphia: Temple University Press, 2005); Roger Fouquet, *Heat, Power and Light, Revolutions in Energy Services* (Chetelnham: Edward Elgard, 2008); Richard Rhodes, *Energy a Human History* (New York: Simon & Schuster, 2018); Arnulf Grubler, "Energy transitions research: Insights and Cautionary Tales", *Energy Policy*, vol. 50, 2012, 8-16; Charlie Wilson and Arnulf Grubler, "Lessons From the History of Technological Change for Clean Energy Scenarios and Policies," *Natural Resources Forum*, vol. 35, 2011, 165-184; Jean-Claude Debeir, Jean-Paul Deléage, Daniel Hémery, *Une histoire de l'énergie,* Paris, Flammarion, 2013; Yves Bouvier and Leonard Laborie, Europe in Transitions. Energie, mobilité, communication, XVIIIe-XXIe siècles, Paris, Nouveau Monde éditions, 2016; Geneviève Massard-Guilbaud and Charles-François Mathis, *Sous le soleil. Systèmes et transitions énergétiques du moyen âge à nos jours*, Paris, Presses de la Sorbonne, 2019. A counterpoint: Jean-Baptiste Fressoz, "Pour une histoire désorientée de l'énergie", *Entropia*, vol. 15, 2013.

2 Astrid Kander, Paolo Malamina, Paul Warde, *Power to the people. Energy in Europe Over the Last Five Centuries*, Princeton, Princeton University Press, 2013, p. 251.

3 Tim Mitchell, *Carbon Democracy. Political Power in the Age of Oil*, London, Verso, 2011.

4 Vaclav Smil, *Energy Transitions. History, Requirements, Prospects*, Santa Barbara, Praeger, 2010.

steam engine and combustion engine, history directs the lessons we infer from the past[5]. This article sheds a new light on the history of energy by using a different perspective : not that of dynamics, nor even that of persistence, but by considering the symbiotic relationships that exist between different sources of energies[6].

Industrial Symbioses.

Let us begin with the canonical example of the so called industrial revolution. Since the 1980s, energy historians have resurrected this notion by reinterpreting it as the secular transition from an "organic economy" (the expression goes back to Werner Sombart) based on wood, hydraulics, muscles (animal's and humans') to a "mineral economy" or "fossil capitalism" based on coal, the "underground forest" that allowed Europe to escape the "photosynthetic constraint"[7].

This interpretation is based on energy calculations that tend to underestimate the role of so-called "traditional energies » and that accentuate the revolution produced by coal[8]. Behind the appearance of objectivity of curves tracing the growing use of energy from the 16th to the 19th centuries, lie questionable choices about what is included in the calculation. For example, according to the data collected by Paul Warde -which is in the background of Anthony Wrigley's or Vaclav Smil's analyses of the industrial revolution- wood would no longer play any role in the British energy mix in the middle of the 19th century[9].

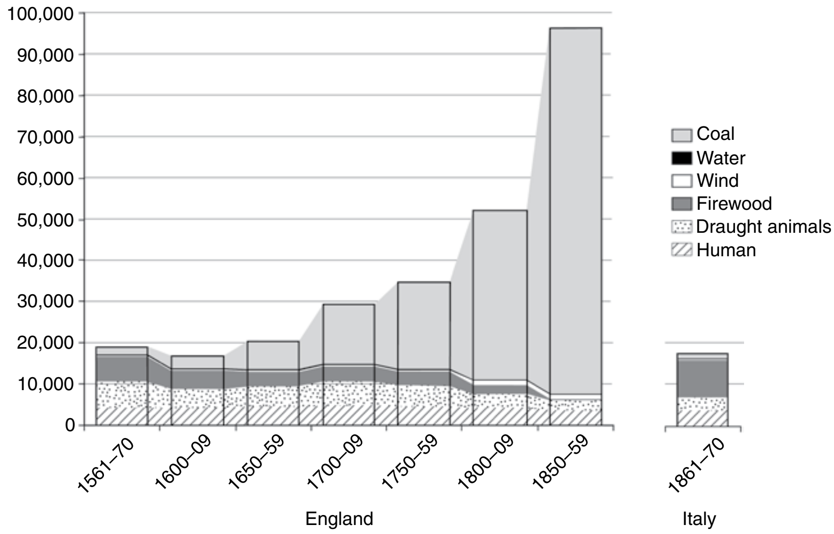
5 Some of the authors quickly mention in passing the fact that the energies add up more than they substitute, while maintaining an ultra-transitionalist perspective to their accounts. This is because these articles have an essentially motivational function and their optimistic message, which is much appreciated by the countless reports on the transition, should not be spoiled. A striking example: Benjamin Sovacool, "How long will it take? Conceptualizing the temporal dynamics of energy transitions," *Energy Research & Social Science*, vol. 13, 2016, p. 202–215.

6 The study of persistence is extremely important and it is this work that informs this article. For charcoal iron industry Richard H. Schallenberg, "Evolution, adaptation and survival: the very slow death of the American charcoal iron industry", *Annals of Science*, vol. 32, No. 4, pp. 341-358; on hydraulics Louis C. Hunter, *History of Industrial Power in the United States, 1750-1930*, Vol. I, *Waterpower in the Century of Steam*, Charlottesville, University Press of Virginia, 1979 and Serge Benoît, *D'eau et de feu : forges et énergie hydraulique, XVIIIe-XXe siècle. Une histoire singulière de l'industrialisation française*, Rennes, Presses Universitaires de Rennes, 2020. On animal power: J. A. Tarr, *The Horse in the City. Living Machines in the Nineteenth Century*, Baltimore, The John Hopkins University Press, 2007; François Jarrige and Mohamed Kasdi, "Moteurs animés des filatures", in François Jarrige and Alexis Vrignon, *Face à la puissance. Une histoire des énergies alternatives à l'âge industriel*, Paris, La Découverte, 2020. On technological persistence in general, see David Edgerton's powerful book, *What's New? A Global History of Technology in the 20th Century*, Le Seuil, 2012.

7 Rudolf Sieferle, *The Subterranean Forest: Energy Systems and the Industrial Revolution*,Cambridge, The White Horse Press, 2001; Anthony Wrigley, *Energy and the English industrial revolution,* Cambridge, Cambridge University Press, 2010.

8 There are several reasons for this: (1) the approach focuses on energy production and not on the energy services actually rendered, (2) due to lack of data, it is difficult to properly measure certain organic energies (3) the parameters chosen for the efficiency of converters (water mill vs. steam engine for example) increase the impact of coal. On this point see Jean-Baptiste Fressoz, "Pour une histoire matérielle de a lumière" in F. Jarrige and A. Vrignon, *Face à la puissance* op. cit.

9 Paul Warde, *Energy Consumption In England and Wales*, Consiglio Nazionale delle Ricerche Istituto di Studi sulle Società del Mediterraneo, 2007, p. 69 and appendix 2. Anthony Wrigley, *Energy and the Industrial Revolution*, op. cit, p. 37; Vaclav Smil, *Energy transition...*, op. cit, p. 79.



Energy consumed in megajoules in Wrigley, *Energy in the Industrial Revolution*, p. 95

Yet English coal mines consumed huge quantities of wood: beams, props, poles and planks to support the roof of the galleries. In all, 4.5 million tons in the early 20th Century[10]. In the twentieth Century, Britain used more wood to extract its coal than it burnt in the mid-18th century. Despite efforts to economise timber consumption, especially during the two world wars, wood consumption by mines remained proportional to coal extraction (at about 2-4% of the coal extracted) till the 1950s[11]. This example bears witness to a general phenomenon: much more than a transition from wood to coal or from organic to mineral matter, industrialization was above all a symbiotic relationship between the three kingdoms.

This relationship was obvious to all the foresters of the time: one of them laughed at the "superficial judgments" of those who « believe that thanks to the use of iron, steel and coal, wood is a product that is increasingly abandoned[12]". Throughout the 19th century, the use of firewood held up well against coal. At the beginning of the 20th century, the foresters Zon and Sparhawk estimated that in North America as in Europe, nearly half of the wood was felled to be burned or charred - in other continents the proportion would be as high as 80%[13]. In the United States, the production of steel with charcoal continued to grow until the 1890s and declined between the wars only[14]. France burned 20 million m3 of wood in 1876 and still 17 million in 1908[15]. The decrease of firewood in the nineteenth century concerned mainly the cities. It was compensated by the rise of the coal but

---

10 "Supplies of pit timber", Department of Agriculture, *Bulletin of foreign agriculture intelligence,* vol. 5, no. 1, Ottawa, p. 57. According to Paul Warde, 3.6 million cubic metres corresponds to the high range of the peak of firewood in the middle of the 18th century in England and Wales, see Warde, op. cit. p. 38.

11 Jean-Pierre Coulon, *Les bois de mine*, Paris, Presses universitaires de France, 1940

12 A. Mélard, *Insuffisance du bois d'oeuvre dans le monde*, Paris, Imprimerie Nationale, 1900, p. 3.

13 Dudley Stamp, "The Forest of Europe: Present and Future", *Empire Forestry Journal* , 1928, Vol. 7, No. 2, pp. 185-202.

14 Schallenberg, art. cit.

15 See *Statistique forestière,* Paris, Imprimerie nationale, 1878, p. 108 and Lucien Daubrée, *Statistique et Atlas des forêts de France,* Paris, Imprimerie nationale, 1912, vol. 2, p. 334.

also by that of the charcoal. In Paris the consumption of charcoal per inhabitant actually increased until the last quarter of the 19th century[16].

At that time, the chemical industry took over: the forests that supplied Paris were now exploited on site thanks to the wood pyrolysis industry, which was established in the late 1880s. Modern methods of carbonization (the Lambiotte retort) made it possible to obtain better yields and therefore more charcoal, and above all to recover gases from which high value-added chemical products were obtained. The end of timber floating on the Yonne river in the 1920s was not a sign of the decline an organic economy energy but rather of its transformation by industrial chemistry[17].

Even if the consumption of fuelwood decreased during the nineteenth century in some countries or some industries, this decrease is more than compensated by the increase in the consumption of timber. British consumption of timber increased sixfold between 1830 and 1930 and threefold per-capita[18]. Of all the European countries, Great Britain, the champion of coal, also imported the most wood: 12 million m3 at the end of the 19th century, i.e. two and a half times the timber production of French forests. Thanks to the progress of transport, it was able to obtain increasing quantities of wood at a decreasing price (-35% in the last quarter of the 19th century). Other European countries with more forests also followed this trend: Belgium saw its imports multiplied by 6 between 1860 and 1900 and Germany, despite its high-yielding lowland softwood forests, doubled its imports between 1888 and 1898. France, which had mainly coppice forests for firewood, was obliged at the end of the 19th century to import 3 million m3 of timber, i.e. half its national production[19].

What all this lumber become? With national variations, the most demanding sector is construction (about half the demand), followed by paper production (one fifth), transport, and then packaging (barrels and crates)[20]. Other massive uses have fallen into oblivion: at the beginning of the 20th century most of London's main roads were covered with wood paving stones (a slippery material but appreciated for its smoothness) as were a fifth of Parisian roadways[21].

The emblematic techniques of the "industrial revolution" are based on wood. In the 1890s, the maintenance of the American railroad network required 73 million ties per year, or 14 million m3 of logs - the production of 20 million hectares of forest. One tenth of the forest production of the United States was devoted to train tracks[22]. At the same time the consumption of iron for rails

---

16 Charcoal consumption in Paris rose from 100,000 m3 in 1800 to 500,000 m3 in 1880. Becquerel, "Mémoire sur les forêts et leur influence climatérique", *Mémoire de l'Académie des sciences*, vol. 35, 1866, pp. 508-5010 and Imbart de la Tour, *La crise agricole en France et à l'étranger*, law thesis, Paris, 1900, p. 103.

17 R. Braque, "Les industries de la carbonisation du bois en France", *L'Information Géographiqueographique,* 1949, vol. 13, no. 1, pp. 28-33.

18 W.E. Hiley, *The Economics of Forestry* (Oxford: Oxford University Press, 1930), p. 38.

19 Mélard, *op. cit*.

20 Egon Glesinger, *Le Bois en Europe*, Paris, Sirey, 1932.

21 It can be seen on *Bartholomew's road surface map of London & neighbourhood. See* https://vu.contentdm.oclc.org/digital/collection/krt/id/1618/rec/1 (accessed 21 October 2020). J. Beauverie, *Le Bois,* Paris, Gauthier-Villar, 1905, vol. 2, p. 1327. André Guillerme, *Bâtir la ville: révolutions industrielles dans les matériaux de construction,* Paris, Champs Vallon, 1995, pp. 220-222.

22 Tratman and Fernow, "Consumption of ties by the railroads of the United States of America," *General Railway Review*, 1891, vol. 14, p. 44-49.

was 1.5 million tons per year, a weight roughly equivalent to the above-mentioned sleepers[23]. The « iron horse » was in fact a « wooden horse ». In addition, locomotive manufacturers preferred to use "luxury" steel from the wood industry (at least for the boilers and axles), which was less brittle than coke steel.

Construction is also based on a combination of wood and coal: the firing of bricks is an energy sink -the third largest industrial consumer of American coal- and the largest consumer of lumber[24]. More anecdotally, the famous Crystal Palace at the 1851 London World's Fair, a supposed symbol of material modernity (iron/glass) in the 19th century, used at least three times more wood than cast iron. One of the real innovations of this building -inspired by agricultural greenhouses- was the mechanical production of standardized wooden parts[25].

Some industrial innovations also had an essential role in the increase of wood production. Naturally, we think of the brute force technologies -the railways that opened new fronts to the forestry exploitation or the steam sawmills- but in this field the real revolution will take place later, after the second world war with the diffusion of small combustion engine (the chainsaw) and powerful diesel engines for forestry machinery : skidders, forwarders, wood chippers etc[26]. The great innovation of the 19th century, which indirectly increased the production of wood, was cellulose paper. At the beginning of the 20th century, in rich countries, paper was the third largest consumer of wood after energy and construction[27]. It is a combination of equal parts of wood and coal: each ton of paper requires about a ton and a half of each of these materials (in addition to chemical products)[28]. Its interest is to valorize the immense coniferous forests of Canada and Scandinavian countries, to use smaller wood and thus to allow faster forest rotations: through the paper industry coal thus increased the production of wood[29].

Carbon fallacy

« You could quite easily drive a car right across the north of England » wrote George Orwell in 1937 « and never once remember that hundreds of feet below the road you are on the miners are hacking at the coal ». « Yet » he added « in a sense it is the miners who are driving your car forward »[30]. In their rush to tell the epic story of oil and electricity, historians are also forgetting the coal which past the 1900s, fades into the background, presented sometimes as a "persistence of the old[31]", even though coal's greatest growth took place in the 2000s.

---

23 *Monthly Summary of Commerce and Finance of the United States* (Washington: Government Printing Office, July 1900), p. 258.

24 Henri Le Chatelier, Le Chauffage industriel, 1925, p. 454; "How much coal is burned in clay products plants," *The Black Diamond*, 1919, vol. 63, no. 1, p. 321.

25 *Report of the Commissioners for the exhibition of 1851,* London, Clowes*,* 1852*,* p. 69.

26 Paul Josephson, *Industrialized Nature, Brute Force Technology and the Transformation of the Natural World,* 2002, chapter 2.

27 Glesinger, op. cit. at 315.

28 Between the wars, the British paper industry burned 2.5 million tons of coal, slightly more than the textile industry. John R. Bradley, *Fuel and Power in the British Empire* (Washington: Government Printing Office, 1935), p. 52.

29 Hiley, op. cit. at 10.

30 George Orwell, *The Road to Wigan Pier,* 1937, New York, Harcourt, 1958, p. 34

31 *Power to the People* op. cit. p. 258.

If oil is added to coal rather than replacing it, it is because the two materials are only marginally in competition. On the contrary, the specialists of the 1930s insisted on their complementarity or even their "solidarity[32]". Above all, petroleum allowed new uses and, above all, the use of trucks and cars. However, the automobile, through its induced material consumption, consumed far more coal than oil. In 1934, the chief engineer of the *Anglo-Iranian Company* calculated that in Britain, the automobile industry, the construction of oil tankers, reservoirs and refineries required 13 Mt of steel between 1918 and 1934 which in turn required 53 Mt of coal. As Britain consumed only 21 Mt of oil in the same period, he concluded that each tonne of oil required 2.5 tonnes of coal[33]. Louis Pineau, the director of the *French Office of Liquid Fuels,* arrived at a similar result: the production of a car in France required about as much coal (7 tons) as it consumed petrol in its lifetime[34]. Conclusion: oil is "backing up coal". These calculations are low estimates, since it would be necessary to add the coal used for the adaptation of the road network to heavy traffic[35]or that necessary for the refining and the transport of oil[36].

In fact, Orwell had a point: before World War II, coal was an important fuel for cars. Indeed benzol extracted from coal improved the anti-knock qualities of gasoline and was used in small or great proportion according to prices. In the early days of the automobile in France, most vehicles were running not on petroleum gasoline, but on benzol. In 1911, a journalist explained "it was benzol that developed the automobile »[37]. During the First World War, the belligerent states obliged the coking plants and gasworks to recover benzol, which was also a component of explosives. The production increased strongly in the interwar period in connection with the prospect of a military conflict. In France, the government encouraged the use of a mixture of benzol and alcohol called le « carburant national". In the large coal-producing countries, benzol plays a significant role: in England, it represents a tenth of the petrol and even up to a quarter in Germany[38].

During the Cold War, oil played only a secondary role as an industrial energy source, the period corresponding rather to the apogee of coal, which was modernised under the leadership of dirigiste states: England saw its consumption peak in 1956, with coal accounting for 95% of its primary energy[39]; in France, the consumption peak was reached in 1962 with 75 million tonnes[40].

---

32 Robert Brunschwig, "Charbon et pétrole dans l'économie moderne", *Annales de l'Office national des combustibles liquides*, vol. 8, n°2, 1933, p. 266. Except in maritime transport where there is indeed a substitution thanks to the higher efficiency of diesel engines compared to steam engines.

33 Dalley, "oil as an ally of coal", in John R. Bradley, *Fuel and Power in the British Empire*, US department of Commerce, 1935.

34 Louis Pineau, "Le Pétrole", *Le Génie civil,* vol. 106, n°14, p. 338-340

35 Before 1960, cement was produced almost exclusively from coal. The explosion in cement production occurred at the same time as the automobile: world production rose from 2 Mt in 1880 to 235 Mt in 1956. Each tonne of cement required 300 kilos of coal. The proportion of cement used for roads varied from country to country: 10% in France, 25% in the USA in the 1950s. Yves Lacoste, "L'industrie du ciment", *Annales de Géographie*, 1957, n° 357, p. 411-435.

36 Three quarters of the tankers were still *steamers* in 1929. See Jacques Schuman, *Le transport maritime des pétroles*, Paris, Pedone, 1936, p. 54. American refineries consumed 3 million tonnes of coal per year in the 1920s.

37 *Bulletin municipal officiel de la ville de Paris*, 5 December 1911, p. 4299

38 Charles Bihoreau, "Le benzol et son emploi comme carburant," *Annales de l'office nationale des carburants liquides*, 1927, pp. 281-308.

39 Warde, 2007, p. 69.

40 The extraction peaks took place before: 1913 in Great Britain, 1958 in France.

Electrification further reinforced the centrality of coal: thermal power stations were established directly in the coalfields, the largest of which could consume 4 million tons of coal per year[41]. The policy followed in the capitalist countries is not to favour oil but rather to manage its coexistence with coal in the most economical way: to the former, petrol, lubricants, plastics, i.e. more remunerative products; to the latter, electricity production, cement and the steel industry. Progress in refining has made it possible to reduce the share of heavy fractions intended for industry. The consumption of *industrial* heavy fuel did not take off in Europe until 1958 with the influx of cheap Middle Eastern oil and the truly massive spread of the automobile, which made oil competitive with coal for industrial uses[42].

Thus, contrary to Tim Mitchell's hypothesis, it was not a non-existent transition to oil that could tame the miners. In France, the great strike of 1947-1948 in the northern collieries was defeated thanks to repression, layoffs and above all thanks to American and German coal[43]. To break the strike, the French government imported up to one million tons of coal from the USA per month thanks to the Marshall Plan. This plan, sometimes presented as the Trojan horse of oil in Western Europe[44], contributed more to the modernization of mines. In France, after EDF, Charbonnage de France received the most money from the Marshall Plan[45].

Coal is at the heart of the United States' strategy in Europe[46]. It was under their aegis that the great "Coal for Europe" plan was launched. Its aim was to rebuild and integrate European industry with coal from the Ruhr, while at the same time providing outlets for their own coal mines. The Marshall Plan administration took a dim view of France's expansionist oil policy, which sought to strengthen its energy sovereignty. This plan - which was to become the Schuman Plan in 1950 and then the ECSC in 1954 - protected the French government from the communist miners of the North, since it was now possible to draw on German coal. Finally, the decline of coal in France after the 1962 Jeanneney Plan was much more spectacular in relative terms (due to the influx of cheap Middle Eastern oil) than in absolute terms: France still consumed between 40 and 50 million tonnes in the 1970s and 1980s, i.e. twice as much as it had a century earlier.

The wave of globalisation and the neo-liberal revolution of the 1980s were also perfectly suited to coal. In the US, the election of Reagan marked the beginning of a huge growth in coal use, which was launched by the oil crises and which led to the historic peak in US consumption of 1.2 billion tons per year in 2008. Much more than oil, it was the technological evolution of coal that transformed the political culture of miners. Mining in the US migrated from the anthracite mines of Pennsylvania to Wyoming, from working-class strongholds to the agricultural and Republican *Midwest.* Mining activity was entirely transformed: instead of extracting coal from the ground, huge

---

41 C. Prêcheur, "L'électricité en France en 1959 et 1960", L'information géographique, vol. 25, no. 3, 1961, pp. 109-120 and C. Chaline, "Tendances actuelles de la production de charbon en Grande-Bretagne", L'information géographique, vol. 26, n°4, 1962, p. 169-171.

42 Roger Brunet, "Oil in Great Britain", *L'Information géographique*, 1961, vol. 25, no. 2, pp. 69-77.

43 Marion Fontaine and Xavier Vigna, "La grève des mineurs de l'automne 1948 en France", Vingtième siècle, 2014, n°121, p. 21-34.

44 David Painter, "The Marshall Plan and oil", *Cold War History,* vol. 9, no. 2, 2009, pp. 159-175.h

45 Jean Chardonnet, "Le problème du charbon", *La revue économique*, 1951, vol. 3, pp. 315-325; *Rapport sur les aspects économiques du plan de modernisation des houillères,* Paris, Lahure, 1949, pp. 7-9.

46 Darryl Holter, "Politique charbonnière et guerre froide 1945-1950", *Le mouvement social*, 1985, n°130, p. 33-53 and Régine Perron, Le marché du charbon, un enjeu entre l'Europe et les États-Unis de 1945 à 1958, Paris, Editions de la Sorbonne, 1996; Keisuke Mamehara, "Du plan Monnet au plan Béthancourt Comment ont évolué la politique charbonnière et la politique énergétique pendant les trente glorieuses", dissertation of the University of Paris IV, 2016.

machines remove the soil above it[47]. As a result, mining productivity in the United States tripled between 1980 and 1995. A worker in Wyoming's opencast mines extracts 20 tons of coal a day, compared with 1.5 tons in France's collieries in the 1950s[48]. Similarly, in Germany, it is not oil that is replacing coal, but lignite that is replacing anthracite. Coal has also fuelled China's economic boom, with consumption rising from 1.5 Gt to 4 Gt between 2000 and 2015. Each year China burns about as much coal as France has in its entire history. Coal is not an energy that is "less modern" than oil. It is just as much the energy of the "industrial revolution" as that of the internet, which is basically just another network of electrons.

Finally, it should be noted that while energy is the focus of attention, its history is by no means exceptional: over the last two centuries, the range of raw materials used has been constantly expanding and each of the materials is consumed in increasing quantities. Raw materials never become obsolete and substitution processes are largely offset by rebound effects or changes in use. Between 1900 and 2015, the total weight of raw materials consumed by the world economy increased by a factor of 12[49]. Since the Second World War, despite the proliferation of synthetic products (plastics, etc.), no major raw material has decreased, except for sheep's wool, which is declining in comparison with synthetic fibres, and this is not a particularly good news for the environment. Between 1960 and 2010, of the 69 main raw materials, only six saw their global consumption decline. And for five of them this decline is due to their toxicity and national bans[50]. Despite the environmental crisis, and despite the financial crisis of 2008, global material consumption is accelerating: it grew by 53% between 2002 and 2015. Between these two dates, 1000 Gt of material were extracted from the ground, i.e. one third of all that had been extracted since 1900.

Conclusion

In the 1980s, when a new wave of coal was sweeping the world, « energy transition » became the major preoccupation of energy historians. This paradox reflects the influence of energy forecasting, which has been very much in vogue since the 1970s. The transition discourse became ubiquitous in the milieu of futurologists who were thinking about the energy future of the United States after the oil shock of 1973. If this notion is not a good descriptor of the past, it is because it was simply not its initial goal[51]. And if it seduced historians, it is because it also gave a certain importance to their trade: by speaking the language of technocrats, entire sections of the historiography (economic history, the history of technology, the industrial revolution) suddenly seemed to acquire great relevance for thinking about the challenges of the future. With their knowledge of past « energy transitions », historians could become experts on the transition to come.

---

47 Jean-Pierre Anglier, "Le charbon, industrie nouvelle", *Revue d'ééconomie industrielle*, 1981, vol.16, p. 1-15; Jeff Goodell, *Big Coal: The Dirty Secret Behind America's Energy Future*, New York, Houghton Mifflin, 2006.

48 M. Kuby, Z. Xie, "The effect of restructuring on US Coal Mining labour productivity", *Energy*, 2001, vol. 26, no. 11, pp. 1015-1030.

49 Krausman et al. "From resource extraction to outflows 1900-2015," *Global environmental change,* 2018.

50 These are asbestos, mercury, beryllium, tellurium and thallium. See Christopher L. Magee Tessaleno C. Devezas, "A simple extension of dematerialization theory: Incorporation of technical progress and the rebound effect," Technological Forecasting & Social Change, vol. 117, 2017, p. 196-205.

51 On this point, see Jean-Baptiste Fressoz, « La 'transition énergétique',
de l'utopie atomique au déni climatique, USA, 1945-1980 » to be published.

The problem is that this notion did not at all take into account the cumulative and symbiotic nature of the energy and material past. Instead, it allowed us to imagine a decarbonized economy as the continuation or even the culmination of a majestic historical process that began two centuries ago. The problem with the "energy transition" is that it projects a past that does not exist onto a future that remains, at best, hypothetical.