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ARTICLE

Speaking for the 'world power economy': electricity, energo-materialist economics, and the World Energy Council (1924–78)[†]

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Abstract

The emergence of a field of global energy policy is usually traced back to the events around the 1973–74 oil embargo. This article provides a prehistory to this by tracing the genealogy of the 'global energy economy'. This genealogy is reconstructed through the lens of the World Power Conference (WPC, today the World Energy Council, WEC), a non-governmental international organization founded by a British electro-technical engineer in 1924. In a comparison with the engineering of 'natural forces' in the nineteenth-century steam economy, I argue that electricity, and particularly large electrical systems, not only changed the meaning of power and institutionalized a regular documentation of the 'power economy', but enabled and concentrated ownership of the 'forces of nature' as a productive factor. This more comprehensive view of the role of electricity in the economy gave rise to an energo-materialist economics among the electro-technical engineers, technicians, and planners whom the WPC assembled. The WPC imagined itself as the centre of calculation of this 'global energy economy', initiating international standardization and complementing the statistics of international organizations such as the League of Nations and the United Nations. As the integration of all 'energies' in one statistical model required conversion factors across very different technical processes, it took the urgency of the oil crisis for the WEC to compile a global energy balance, thus statistically 'representing' the state of the 'global energy economy'.

Keywords: economic thought; energy history; engineering organizations; international non-governmental organizations; technocratic internationalism

Introduction

The emergence of a field of global energy policy is usually traced back to the events around the 1973–74 oil embargo.[1] Referring to the US, Timothy Mitchell argues that 'the problem of energy as an interconnected and vulnerable system' emerged at that time.[2] With oil anchoring the dollar's value, and with US oil companies controlling the flow of oil over the globe, US energy policies were inherently international. However, there was an international space of power and energy that predates the 1970s. I argue that 'energy' did not suddenly appear as an interconnected system, nor

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[2]Timothy Mitchell, *Carbon democracy: political power in the age of oil*, London: Verso, 2011, p. 176.

was it a question of mere appearance. The very concept of power, which preceded 'energy' in the field of engineering, economics, and politics, was the result of actual interconnection in technological, statistical, and organizational ways. Tracing those interconnections back in history enables us to embed the history of the oil crisis into a longer history of resource politics, technocratic internationalism, and material economics.

Through the lens of the World Power Conference (WPC, today the World Energy Council, WEC), a non-governmental international organization founded in 1924, this article seeks to understand the emergence of a sphere of trade in technology and energy resources, an arena of scientific exchange in engineering and economics, as well as a field of policy-making, which emerged over the nineteenth and twentieth centuries.[3] This sphere was called 'world power economy' at the time of the WPC's foundation. Today, we would refer to it rather as 'global energy economy'. While energy history has developed into a lively research field over the last years, it has used 'energy' mainly to denote a group of resources. Little attention has been paid to the history of the specific order of knowledge that the concept itself entails.[4] Moreover, 'energy' is often understood as a clear-cut physical concept, which has been exhaustively studied by historians of science. However, the concept of energy in physics is not the same as the concept of energy in engineering or economics. There are measures of heating value, but there is no quantity of technically produced and economically utilized *energy* in the nineteenth century. The 'epistemic things' of physics and engineering are contained in entirely different experimental systems.[5]

The WPC became the international body of this field of technically produced and economically utilized energy. Created by a British electro-technical engineer after the First World War, it grew out of the rising electricity industry, but, from the beginning, its objectives transcended any single industry, encompassing all sources, uses, and aspects – educational, technical, and economic – of power. Like other international conferences, the WPC gathered an interested public around a specific problem 'that faced the whole world': the technical and economic organization of the power economy.[6] For some, the power economy was more than a part of the world economy: it constituted its basis and the taproot of its growing productivity.[7] Focusing on material basis and technological progress, rather than on capital and markets, the engineers, officers, and entrepreneurs assembled in the WPC never lost faith in the 'knowability' of the global economic sphere.[8]

This article traces the emergence of the 'global energy economy' from the nineteenth to the twentieth century. I begin by explaining the peculiarity of power engineers and their view of the world. In contrast to older fields of engineering, electro-technical engineering took place in a particularly international industry. While engineers had long harnessed 'natural forces', power engineering for the first time controlled and commodified them within a single technological system. The WPC was founded by electro-technical engineers, and drew on a shared assertion among themselves, that 'power' (understood as more than electricity) constituted a fourth, and central, factor of production. This later translated into the organization's attempt to measure and formalize this 'power economy' through its own surveys, national statistics, and the data produced

[3]The organization changed its name to the World Energy Conference in 1968, before becoming the World Energy Council in 1989. The abbreviation WPC is used for references to the body before 1968, WEC thereafter.

[4]Michel Foucault, *The order of things: an archaeology of the human sciences*, London: Routledge, 2002. Notable exceptions are Anson Rabinbach, *The human motor: energy, fatigue, and the origins of modernity*, New York: Basic Books, 1990; Thomas Turnbull, 'From paradox to policy: the problem of energy resource conservation in Britain and America, 1865–1981', PhD thesis, University of Oxford, 2017; Cara New Daggett, *The birth of energy: fossil fuels, thermodynamics, and the politics of work*, Durham, NC: Duke University Press, 2019.

[5]Hans-Jörg Rheinberger, *Toward a history of epistemic things: synthesizing proteins in the test tube*, Stanford, CA: Stanford University Press, 1997.

[6]Akira Iriye, *Global community: the role of international organizations in the making of the contemporary world*, Berkeley, CA: University of California Press, 2004, p. 23.

[7]Daniel Dunlop, 'World unity and world problems', *World Survey*, 1, 1, 1935, p. 4.

[8]In contrast to the neoliberals, who emerged at the same time, see Quinn Slobodian, *Globalists: the end of empire and the birth of neoliberalism*, Cambridge, MA: Harvard University Press, 2018.

by power systems. After the Second World War, the WPC and some of its members assumed formal advisory roles in international organizations. While the UN set up a statistical infrastructure and began to publish data on resources, it also decided to measure 'national economies' in terms of their gross domestic product (GDP), not in material terms. Material economics, in which energy was not just a commodity but an agent of economic change, declined over the 1960s. Within what was by then the WEC, discussions shifted towards energy systems, the substitutability of energy commodities and the efficiency of the system. I conclude this article with the WEC's role in the wake of the 1973–74 oil crisis.

Engineering 'natural forces'

The peculiar position of power engineers at the beginning of the twentieth century becomes clearer when seen within a longer tradition of engineering the 'natural forces'. Over the nineteenth century, research on energy in physics and engineering gradually decoupled. The science of energy, formulated in the first half of the nineteenth century, has its roots in commercial and engineering contexts.[9] By the early twentieth century, however, the concept of energy had turned into a formalized principle of theoretical physics, expressed without any reference to economic or technical perspectives.[10] In the technical, economic, and engineering contexts, 'energy' was used only in a vague, general sense, or not used at all. Solid, liquid, and gaseous fuels, heat and heating value, pressure, work, and mechanical effect were all meaningful, formalized concepts in these fields, whereas energy was not. In their practical work, it was never 'energy' – a pinned-down 'quantitative permanence' in *all* change[11] – that was at stake, but specific relations between fuel and heating value, or heat and mechanical effect. Engineers and entrepreneurs did not just apply the physical principles of energy, but tackled entirely different questions: what is the value of a fuel? How can one construct a profitable power system? What is the relation between energy and prosperity? Their concept of energy was embedded in a different set of social, technical, and economic relations.

Engineering – the art of building canals, digging mines, and constructing machines – rose to a state-building profession over the eighteenth and nineteenth centuries. In the late eighteenth and early nineteenth centuries, the field comprised civil (construction, canals, and railroads), mining (mines and steel plants), and mechanical (machine-building and maintenance) engineering. Civil and mining engineering were under the control of the state in countries where engineers were part of the state bureaucracy (such as France and Germany). In Great Britain and the US, state involvement was limited to military engineering, and broadened only with geological surveys.[12] Mechanical engineering was closer to private industry. It remained outside national engineering schools until the late nineteenth century, when states were already heavily invested in steam power through their navies, railroads, and industries.[13]

In the eighteenth century, steam engineering constituted only a small subfield of mechanical engineering, and was restricted to variations of the Newcomen engine, which was mainly applied

[9]Thomas S. Kuhn, 'Energy conservation as an example of simultaneous discovery', in Marshall Clagett, ed., *Critical problems in the history of science*, Madison, WI: University of Wisconsin Press, 1959, pp. 321–56; Herbert Breger, *Die Natur als arbeitende Maschine: zur Entstehung des Energiebegriffs in der Physik, 1840–1850*, Frankfurt: Campus Verlag, 1982; Crosbie Smith, *The science of energy: a cultural history of energy physics in Victorian Britain*, Chicago, IL: University of Chicago Press, 1998.

[10]Max Planck, *Die Einheit des physikalischen Weltbildes: Vortrag gehalten am 9. Dezember 1908 in der naturwissenschaftlichen Fakultät des Stundentenkorps der Universität Leiden*, Leipzig: S. Hirzel, 1909, pp. 8, 19; Daan Wegener, 'De-anthropomorphizing energy and energy conservation: the case of Max Planck and Ernst Mach', *Studies in History and Philosophy of Science*, 41, 2, 2010, pp. 146–59.

[11]Alfred North Whitehead, *Science and the modern world*, New York: Free Press, 1997, p. 100.

[12]Ben Marsden and Crosbie Smith, *Engineering empires: a cultural history of technology in nineteenth-century Britain*, Basingstoke: Palgrave Macmillan, 2005, p. 35.

[13]Peter Lundgreen, 'Engineering education in Europe and the USA, 1750–1930: the rise to dominance of school culture and the engineering professions', *Annals of Science*, 47, 1, 1990.

in mining. James Watt was desperate to find engineers who could handle his improved steam engine, complaining that he had 'not only to form my own Engines but also my own Engineers'.[14] When he began marketing his steam engine in 1775, he offered construction and maintenance for the engines, as well as training for engineers. A couple of years later, he published a little manual entitled *Points necessary to be known by a steam engineer*.[15] Between 1775 and 1825, over a hundred Watt engines were sold abroad, most of them to manufacturing industries, setting off indigenous production of steam engines in some countries.[16] As steam engines became more generally applied over the first half of the nineteenth century, regional or national associations of mechanical engineers formed towards the middle of the nineteenth century, developing standardizations and codes of conduct for the use of engines.[17]

Steam power became the first machine-produced 'force of nature', generating a reliable, measurable economic effect, and penetrating production and transport. By 1781, Watt's steam engine was able to transform the up-and-down movement of the pistons into rotary motion, making it more widely applicable in industry. Sadi Carnot, the first theoretician of the steam engine, heralded it as the 'universal drive' (*moteur universel*). More powerful than animals, and independent of space, unlike windmills and water wheels, the steam engine would ultimately replace them.[18] By the second half of the nineteenth century, not only industries, but also navies, shipping companies, and railroads ran on steam power. Steamships, railroads, and the telegraph, the first commercial invention of the electrical age, radically changed the experience of space and time. Transforming travel and communication, they enabled a control of far-away territories, integrated markets, and led to new forms of organization.[19] In the nineteenth century, international administrative unions emerged, such as the International Telegraph Union, the Universal Postal Union, and the International Electrotechnical Congress, to negotiate standards for these network technologies.[20] Owing to their high capital costs, the construction of railroads, telegraphic lines, and electrical systems were closely interwoven with the development of international financing and new forms of corporations.[21]

While Welsh steam coal and the Watt engine circulated widely, steam itself was locally produced and consumed. Engines, measurement devices, engineering drawings, calculations, valves, and other parts of engines were also widely traded. This made steam engineering into an undertaking referring everywhere to similar technical objects. Steam is homogeneous; by the mid nineteenth century, its defining characteristics – pressure and temperature – could be precisely determined and (re-)created under given technical conditions. The properties could

[14]Cited in Marsden and Smith, *Engineering empires*, p. 52.

[15]*Ibid*., p. 57.

[16]Jennifer Tann and M. J. Breckin, 'The international diffusion of the Watt engine, 1775–1825', *Economic History Review*, 31, 4, 1978, pp. 543–5; Charles P. Kindleberger, 'Technological diffusion: European experience to 1850', *Journal of Evolutionary Economics*, 5, 3, 1995, pp. 229–42.

[17]The Institution of Mechanical Engineers was founded in 1847, the Verein deutscher Ingenieure (open to all fields and ranks of engineering) in 1856, and the American Society for Mechanical Engineers only in 1880.

[18]Sadi Carnot, *Refléxions sur la puissance motrice du feu et sur les machines*, Paris: Bachelier, 1824, p. 2. See also Andreas Malm, 'The origins of fossil capital: from water to steam in the British cotton industry', *Historical Materialism*, 21, 1, pp. 15–68.

[19]Dwayne R. Winseck and Robert M. Pike, *Communication and empire: media, markets, and globalization, 1860–1930*, Durham, NC: Duke University Press, 2007; Simone M. Müller and Heidi J. S. Tworek, '"The telegraph and the bank": on the interdependence of global communications and capitalism, 1866–1914', *Journal of Global History*, 10, 2, 2015, pp. 259–83.

[20]Douglas Howland, 'An alternative mode of international order: the International Administrative Union in the nineteenth century', *Review of International Studies*, 41, 2015, pp. 161–83.

[21]William J. Hausmann, Peter Hertner, and Mira Wilkins, *Global electrification, multinational enterprise and international finance in the history of light and power, 1878–2007*, Cambridge: Cambridge University Press, 2008; Thomas P. Hughes, 'The electrification of America: the system builders', *Technology and Culture*, 20, 1, 1979, pp. 124–61; Jeremiah D. Lambert, *The power brokers: the struggle to shape and control the electric power industry*, Cambridge, MA: MIT Press, 2015, pp. 1–49.

be related to the mechanical effect yielded, and chemists tried to relate them to the composition of the fuel, too.[22] Within the scope of fuel, steam, and mechanical effect, the physical and economic potential – 'energy' – could be reliably realized. With the emergence of large electrical systems between 1880 and 1920, the scope of this potential broadened considerably.

Electro-technical engineering became institutionalized in schools, universities, and engineering associations in the 1880s. Before the First World War, electrical development meant central stations in urban areas, and self-generation of electricity in industries for lighting and a few electrical motors. Around 1900, the principles of central station management – the relation between capacity, tariff, and load – were codified in talks, articles, and textbooks for electrical engineers.[23] During the war, states took control of the power supply, urged industries to connect to the grid, and thus centralized and diversified load.[24] In the interwar years, the regional or national interconnected system was seen as the most adequate, as it integrated diverse power sources and consumers in such a way that they would complement each other.[25] Through interconnection, the overall system could become profitable even though single sources or consumers were not. This was a powerful scheme of electrical development, influencing projects around the world, such as the GOELRO plan in the Soviet Union, the Tennessee Valley Authority, and the Bonneville Power Administration.[26]

Load management lay at the centre of electrical development. As power systems had to balance supply and demand in every moment, they were constructed with a view to the availability of power sources, the capacity of machinery, and the load demand of consumers. To maintain a working and profitable system, the load had to be carefully observed and managed. Load curves circulated in international conferences, and engineers soon developed a sense of typical load curves for certain types of cities, regions, industries, or households. Through load management, power systems recorded the growing part of economic and everyday life that involved the use of electricity. In other words, they acted as an *Aufschreibesystem* (registration system) for the power economy.[27] As electricity penetrated more and more areas of life, its consumption could even act as an indicator of productivity and prosperity.[28] In the power economy, the economic and physical

[22]Samuel Parr, 'The classification of coal', *University of Illinois Bulletin*, 25, 48, 1928, pp. 6–7.

[23]Charles H. Merz and William McLellan, 'Power station design', *Journal of the Institution of Electrical Engineers*, 33, 167, 1904, pp. 696–742; Georg Klingenberg, *Der Bau großer Elektrizitätskraftwerke. Band I: Richtlinien für den Bau großer Elektrizitätswerke*, Berlin: Julius Springer, 1913; Samuell Insull, *Central station electric service: its commercial development and economic significance as set forth in the public addresses (1897–1914) of Samuell Insull*, Chicago, IL: privately printed, 1915. See, for the connection of these three, Thomas Hughes, *Networks of power: electrification in Western society, 1880–1930*, Baltimore, MD: Johns Hopkins University Press, p. 228.

[24]Jonathan Coopersmith, 'When worlds collide: government and electrification, 1892–1939', *Business and Economic History On-Line*, 1, 2004, pp. 1–31; Hausmann, Hertner, and Wilkins, *Global electrification*, pp. 125–89; Julie Cohn, Matthew Evenden, and Marc Landry, 'Waterpowers: the Second World War and the mobilization of hydro-electricity in Canada, the United States and Germany', *Journal of Global History*, 15, 1, 2020, pp.

[25]WPC, *Transactions of the World Power Conference, sectional meeting, volume 2, section C: the economic relation between electrical energy produced hydraulically and electrical energy produced thermally*, Basel: Birkäuser & Cie, 1927; Thomas Hughes, 'The culture of regional systems', in *Networks of power*, pp. 363–403.

[26]Heiko Haumann, *Beginn der Planwirtschaft: Elektrifizierung, Wirtschaftsplanung und gesellschaftliche Entwicklung Sowjetrusslands 1917–1921*, Düsseldorf: Bertelsmann, 1974; Alex G. Cummins, 'The road to NEP, the State Commission for the Electrification of Russia (GOELRO): a study in technology, mobilization, and economic planning', PhD thesis, University of Michigan, 1988; Jonathan Coopersmith, *The electrification of Russia, 1880–1926*, Ithaca, NY: Cornell University Press, 1992; David Ekbladh, '"Mr. TVA": grass-roots development, David Lilienthal, and the rise and fall of the Tennessee Valley Authority as a symbol for U.S. overseas development, 1933–1973', *Diplomatic History*, 26, 3, 2002, pp. 335–74; Lambert, *Power brokers*, pp. 1–49.

[27]Friedrich Kittler, 'Aufschreibesysteme 1800/1900 – Vorwort', *Zeitschrift für Medienwissenschaften*, 6, 1, 2011, pp. 117–26.

[28]Hugh Quigley, 'Electricity as an index of industrial production and employment', in World Power Conference (henceforth WPC), ed., *The transactions of the Second World Power Conference, volume 16: world problems of power economics*, Berlin: VDI Verlag, 1930, pp. 95–127; Maria Fal'kner-Smit, 'The motor power outfit of labour and its economic efficiency', in *ibid.*, pp. 60–71.

potential was no longer limited to the input and output of a machine, but could be sent through a system, and applied for various purposes.

A book on electricity for the general public published in 1893 predicted:

> It is certain that electricity will gain a general validity comparable to gold, because a certain quantity of electricity is the same in America and in Australia. Here, the universal character of electricity manifests itself. Due to the simplicity that electricity as a product of trade will gain, it is particularly suitable to large-scale production, and it is certain that there will one day be large corporations that will take over production and distribution of electricity for significant areas, even for entire countries.[29]

With electricity, for the first time, a physio-economic effect could be owned, sold, and invested in. Steam was not traded in the steam economy; coal was. Steam was simply a 'working substance', serving as a medium between the combustion of fuel and the movement of machinery.[30] During this process, its property title did not change. As Hugh Quigley summarized in *Electrical power and national progress*, 'Coal has still only a potential value.' A certain weight of coal generated a relatively certain mechanical effect. In contrast to electricity, which penetrates the entire economy, coal's 'function begins and ends with combustion'.[31] With electricity, consumers could purchase the economic effect directly as power per time, making them independent from the quality and type of fuel. Electricity as a commodity 'represented an absolute in itself, incapable of modification or dilution'.[32]

The rise of large-scale power systems enabled the ownership and concentration of the 'forces of nature' as a productive factor. This is not to say that central stations, utilities, and grids were necessarily private. In fact, public development of electricity was cherished more broadly in the interwar years. However, this property did account for the specific perspective of the electricity industry, holding an interest in coal and other fuels, water power, and all kinds of applications for electricity. The power industry's interests covered all its potential suppliers and consumers, which, owing to the modality and flexibility of electricity, meant almost the whole of economic life.

Technocratic internationalism and the foundation of the World Power Conference

By the turn of the twentieth century, state power had become dependent on industrial production and network technologies, and thus on engineers. State-funded research in fields of strategic importance, such as fuels and synthetic materials, was common. Electrification on the communal and regional level had brought electro-technical engineers into contact with political administrations, if not into positions of public service. Engineers entered conventional politics during the First World War in different positions: a number of countries introduced technical attachés in their diplomatic corps, and assigned engineers to allocate scarce resources, or to secure electricity supply.[33]

In 1921, Stanislav Špaček, a Czech civil engineer, began lobbying for the creation of a World Engineering Federation (WEF), an organization seeking to institutionalize political influence of engineers on an international level. In the twentieth century, van Meer argues, most engineers 'no longer equated expertise with public service; instead, they viewed their professional interests to be

[29]Arthur Wilke, *Die Elektrizität, ihre Erzeugung und ihre Anwendung in Industrie und Gewerbe*, Berlin: Springer, 1893, p. 633 (my translation).

[30]Marsden and Smith, *Engineering empires*, p. 44.

[31]Hugh Quigley, *Electrical power and national progress*, London: G. Allen & Unwin, 1925, p. 31.

[32]Quigley, 'Electricity', p. 96.

[33]Daniel J. Kevles, 'Into hostile political camps: the reorganization of international science in World War I', *Isis*, 62, 1, 1971, p. 51; Markus Krajewski, 'Systemökonomie', in *Restlosigkeit: Weltprojekte um 1900*, Frankfurt am Main: Fischer, pp. 287–336; Thomas Hughes, 'War and acquired characteristics', in *Networks of power*, pp. 285–323.

closely aligned with those of the industries that provided them with careers in management and research'.[34] In her view, there were two conflicting ideas of internationalism at this time. On the one hand, there was a 'technocratic internationalism' that sought to 'reform diplomacy or international relations'. On the other hand, there was a more narrow 'engineering internationalism', which was 'committed to forging international ties for the purpose of building professional solidarity or for sharing engineering knowledge with foreign colleagues'.[35] Van Meer borrows 'engineering internationalism' from Bruce Sinclair's history of the American Society of Mechanical Engineers, where he states that 'Calvin W. Rice [was] also widely known abroad for his efforts on behalf of engineering internationalism.' Rice was engaged in the foundation of the WEF, the project of engineering internationalism to which Sinclair presumably refers.[36] Curiously, van Meer then chooses to associate the WEF with 'technocratic internationalism', a term coined by Johan Schot and Vincent Lagendijk.

In 1924, Daniel N. Dunlop, a British electro-technical engineer, assembled the first World Power Conference. The term 'power' leaned towards electricity and revealed the WPC's roots in the electro-technical industry. However, the version in other languages was equally telling. In Romance and Slavic languages, the term was translated as 'energy'. In German, it became *Kraft*, which was highly reminiscent of natural philosophy. Both concepts were less associated with electricity and conveyed a more universal meaning.[37] The association with electricity was one reason why the organization was renamed the World Energy Conference in 1968.[38]

The conference grew out of a techno-internationalist spirit that opposed national politics with a materialist conception of the global economy based on energy. Johan Schot and Vincent Lagendijk hold that the interwar technocratic internationalism combined 'the myth of networks, an assumed harmony between nation-states, and a preference for a working method which separates technical issues from politics'.[39] The WPC's engineers promoted a specific version of technocratic internationalism, which associated the network with an organic economy, harmony between nations that had insight into the energetic principles of economic development, and a technocratic method based on the rational development of power.

Before summoning all 'practical men, scientists, engineers, manufacturers, financiers and politicians' to the first WPC in London in 1924, Dunlop had been involved in the foundation of the British Electrical and Allied Manufacturers' Association in 1911. Given the international entanglements of the industry, the WPC could draw on a network of electro-technical engineers and entrepreneurs, thereby aiming to safeguard the international exchange on which their technologies and business models depended. Throughout the 1920s and 1930s, members of the WPC national committees attended both the World Power Conferences and the World Engineering Congresses. Over time, however, the WPC developed into a functioning body with a central office, national committees, a mission, and a constitution, whereas the WEF remained a loosely organized network, and a project with an uncertain future.[40]

The decline of the WEF and the rise of the WPC have been related to a change in the self-conception of engineers, but I want to suggest a slightly different reading. The equation of diplomacy with public service, and of engineering solidarity with business interest, falls short of how

[34]Elisabeth van Meer, 'The transatlantic pursuit of a world engineering federation: for the profession, the nation, and international peace, 1918–48', *Technology and Culture*, 53, 1, 2012, pp. 137–8.

[35]*Ibid*., p. 121.

[36]Bruce Sinclair, *A centennial history of the American Society of Mechanical Engineers, 1880–1980*, Toronto: University of Toronto Press, 1980, p. 15.

[37]For an early discussion on naming, see 'Zweite Weltkraftkonferenz Berlin 1930', *Polytechnisches Journal*, 345, 7, 1930, p. 124.

[38]WEC records, London (henceforth WECL), WPC, Meeting of the International Executive Council, 1967, p. 11.

[39]Johan Schot and Vincent Lagendijk, 'Technocratic internationalism in the interwar years: building Europe on motorways and electricity networks', *Journal of Modern European History*, 6, 2, 2008, pp. 197–8.

[40]WECL, WPC, Meeting of the International Executive Council, 1930, pp. 23–4.

electro-technical engineers imagined their contribution to interwar international collaboration. It is true that, unlike civil engineers such as Špaček, electro-technical engineers, who were the largest single group in the WPC, had so far mainly been employed by private corporations. However, the actual composition of national committees varied widely, covered many different national engineering traditions, and included other industries, government agencies, and ministries. What is more, the 1920s were precisely the time when electro-technical development itself seemed to point towards more collective forms of organization.

In his foreword to the proceedings of the first WPC, Dunlop opposed a world of prejudice and competition with a world of 'practical men' cooperating in a rational way. While he did not rule out that politicians could act rationally, too, this international space of cooperation was clearly epitomized by the work of scientists, engineers, and businessmen:

> A vision of the nations of the world after the great war revealed the need for a conference of practical men, scientists, engineers, manufacturers, financiers and politicians, to consider the utilisation of the forces of nature, in the light of a new internationalism, and to attempt to discover a means by which the nations of the world might be preserved from the constant actions and reactions of past history, and might all advance together.[41]

Dunlop went on to cite Rudyard Kipling's 'The sons of Martha' (1907), a poem dedicated to assiduous and virtuous engineers. Political competition between states had used 'even the winds and the seas ... for purposes of destruction', so an 'international morality' was needed to make sure that the 'forces of nature' were harnessed for the benefit of all.[42] Emphatic references to the engineering profession and a certain type of engineer – neutral, rational, visionary, diligent, and 'always ahead of his time'[43] – were strong within the WPC. As their knowledge on how to put nature to work was universal, and as it was their duty to keep it working, engineers were the bearers of competent international morality.

This moralized image of the engineer was connected to a vision of economic interdependence and development. Franz zur Nedden, a delegate of the German national committee to the International Electrotechnical Commission (IEC) and president of the Verein deutscher Ingenieure, put the WPC's mission into a broader perspective by pointing out that 'engineers and humanity at large seem to wake up gradually to a new and higher form of consciousness, viz., that we are all forming not only communities held together by some static laws, but rather a dynamic organism of collective life of which all individuals and groups are living parts, depending in their existence on each other'.[44] This echoed Dunlop's claim that 'The progress of even the most advanced nations is clearly seen to be limited by the conditions of the whole.'[45] The WPC spoke for the 'global energy economy' precisely in this sense of the 'whole' of which all industries and nations form a part. It routinely referred to itself as 'the power industry of the world, as represented in the World Power Conference'.[46] The WPC engineers saw themselves as responsible not to a nation, but to an economy, global and material, which was the foundation of all existence. The development of any single national power economy could and should serve the whole. This implied not only the permission, but the responsibility to develop one's own and other countries, and to put a country's resources at the disposal of the world economy.

As an alleged servant of this global sphere, the WPC stressed its neutrality. It welcomed all 'nations of the world' to form 'national committees' and join the organization.[47] After the initial

[41]WPC, *The transactions of the first World Power Conference*, London: Lund, Humphries, 1925, p. vii.
[42]*Ibid*., p. viii.
[43]Marsden and Smith, *Engineering empires*, p. 2.
[44]WECL, WPC, Meeting of the International Executive Council, 1933, p. 52.
[45]WPC, *First World Power Conference*, p. vii.
[46]WECL, WPC, Meeting of the International Executive Council, 1932, p. 43.
[47]WPC, *First World Power Conference*, p. ix.

conference in 1924, a central office was set up in London to act as 'nothing more than a clearing house for the interchange of information on all matters relating to the development of power resources'.[48] As with other international organizations, the national committees inscribed a national structure into a non-governmental, technical organization.[49] Implying the idea of a world economy made up from a number of smaller entities, these committees were intended in principle to be representative of their 'national power economy': that is, they were to cover the relevant industries and agencies existing in that country. The actual composition of national committees varied widely. Those of socialist countries often included not a single non-public actor, while other national committees showed little government involvement. National committees chose the delegates whom they wished to send to the International Executive Council, the WPC's central organ, which met once a year. At that meeting, a chairman and vice-chairmen were elected, while the president was appointed by the national committee organizing the year's conference.[50]

The WPC was funded solely by the national committees. In the beginning, there were no fixed fees but voluntary contributions, which differed vastly. As Wright, Shin, and Trentmann wrote, 'Geopolitical power was reflected in the WPC through financial influence.'[51] Great Britain, the US, and France were by far the major donors. In the first wave of institutionalization and professionalization during the 1930s, a discussion on a more stable basis of funding was opened, and fees 'based on a quota', such as population size, were discussed. However, population size would disadvantage poor but densely populated countries, and, with no comparable data on economic power, another basis seemed hard to find.[52] Central office suggested membership fees, with a view to economic power, but without a transparent procedure. Calculation of fees was rationalized only with a wave of applications from newly independent states in the 1950s and 1960s.

The WPC claimed to be neutral in a second sense that distinguished it from earlier non-governmental technical organizations, in that it sought to go beyond any single industry or technology. At the time of its foundation, there were already two international organizations in the field of electro-technical engineering, the IEC, a permanent body that had developed from the earlier International Electrotechnical Congresses in 1906, and the International Council on Large Electric Systems (CIGRE). They were both associated with a certain technology or industry. In contrast, the WPC promised to include all sources and forms of power in its programme. Over the 1920s and 1930s, there were fierce discussions within the organization about the right balance between technical details of single technologies, and about the more general question of the 'power economy'. Worried that the WPC might be torn apart by the highly specific technical questions discussed at the conferences in the 1920s, Nedden argued for strengthening the second facet of the WEC's neutrality: 'It should . . . be the common aim of engineers, businessmen and statesmen, to co-operate for the best possible combination of all sources and forms of power and power supply rather than expanding in a one-sided fashion the application of any one technical solution for which from any reason any individual group may have predilection.'[53]

In the interwar years, the economic became the common, and allegedly neutral, perspective. The WPC did not represent a given business interest. Instead, it employed a comparative perspective that was already practised in investment decisions, the regulation of industries, and the construction and interconnection of power systems. Decades before departments of energy and the rise of the energy company, this perspective was not clearly located in a certain industry,

[48]*Electrical world* (1925), cited in Rebecca Wright, Hiroki Shin, and Frank Trentmann, *From World Power Conference to World Energy Council: 90 years of world energy cooperation, 1923–2013*, London: World Energy Council, 2013, p. 16.

[49]Tim Büthe, 'Engineering uncontestedness? The origins and institutional development of the International Electrotechnical Commission (IEC)', *Business and Politics*, 12, 3, 2010, pp. 1–62.

[50]Wright, Shin, and Trentmann, *From World Power Conference*, p. 16.

[51]*Ibid*.

[52]WECL, WPC, Meeting of the International Executive Council, 1933, p. 18.

[53]*Ibid*., p. 52.

corporation, or agency.[54] The WPC put an emphasis on questions of accounting, administration, and regulation, which concerned all kind of industries involved in the exploitation, processing, transport, or generation of the 'forces of nature'. It assembled a public that was interested in these questions, and addressed it by public forms of communication, such as surveys, statistics, models, and indicators.[55]

In a specific sense, the experience of large power systems made it easy to believe that technology would reconcile economic interests and the public good. The two principles of electric system development – economies of scale and diversity of load – suggested a trend towards large, centralized systems, in which different loads would mutually enable each other. The well-managed power system harmonized individual economic activities with the stability and efficiency of the overall system. For 'philosophers' of power, such as Walther Rathenau, Gleb M. Krzhizhanovskii, David Lilienthal, and Hugh Quigley, large power systems served as a model to organize and overcome the contradictions of modern society.

In reality, the perspective put forth by the WPC was not neutral, but productivist. Referring to the nineteenth century, Anson Rabinbach has used the term 'productivism' to denote a 'metaphysic in which the concept of energy, united with matter, was the basis of all reality and the source of all productive power'. This 'totalizing framework … subordinated all social activities to production, raising the human project of labour to a universal attribute of nature'.[56] In some sense, the interconnected power systems penetrating the economy turned the 'metaphysics' of productivism into physics. The productiveness of 'natural forces' in industry could now be measured and documented. The new, twentieth-century version of productivism was less preoccupied with single motors than with systems of production. Formalized through electrification, productivist ideology developed into a material economics that was widely shared among engineers, and almost uncontested in both capitalist and socialist countries until well into the second half of the century.

Energo-materialist economics and the calculability of the 'world power economy'

In the literature on economic statistics and the making of economic knowledge, there is a tendency to view money and the rise of price-based accounting as the taproot of the distinction between the complex reality – economic life – and its representation in a single economic model. 'It was no longer possible', writes Timothy Mitchell with regard to diversified production at the turn of the century, 'to consider material relations to be expressed by one dominant commodity, such as wheat, so economists narrowed the study of wealth to this contentless act of exchange.'[57] In research on economic statistics, abstract quantification is often associated with the calculation of monetary value, and is opposed to the calculation of physical units, such as raw material balances.[58] However, unlike economists, engineers and geographers identified a commodity equalling money in its transformative and universal character: energy. Up to the mid 1950s, there were several attempts to 'formalize' descriptions of an economy on the basis of energy. Some version of this 'energo-materialist' approach developed in Great Britain, the US, and Germany in the early

[54] Bruce C. Netschert, 'The energy company: a monopoly trend in the energy markets', *Bulletin of the Atomic Scientists*, 27, 8, 1971, pp. 13–17.

[55] Theodore M. Porter, *Trust in numbers: the pursuit of objectivity in science and public life*, Princeton, NJ: Princeton University Press, 1995.

[56] Rabinbach, *Human motor*, p. 4.

[57] Timothy Mitchell, *Rule of experts: Egypt, techno-politics, modernity*, Berkeley, CA: University of California Press, 2002, p. 94.

[58] Daniel Speich Chassé, 'Die "Dritte Welt" als Theorieeffekt', *Geschichte und Gesellschaft*, 41, 4, 2015, pp. 580–612; Adam Tooze, *Statistics and the German state, 1900–1945: the making of modern economic knowledge*, Cambridge: Cambridge University Press, 2001.

twentieth century, but nowhere did it assume a political influence comparable to the science of 'energetics' in the Soviet Union.[59]

Indeed, Dunlop himself had hoped to set up a World *Economic* Conference instead of a World *Power* Conference. For him, the 'world economy' was an emphatic expression and a humanist project, which was to be pursued against all national politics. However, such a project appeared to be a forlorn hope in the years after the First World War: 'I could see clearly that it was impossible to bring together politicians, and as all the important economic decisions are in the hands of politicians, it was hopeless to found an international economic body as a first step. But it was possible to bring together human beings in the field of technical questions.'[60] Hence, he set out to do what came closest to his original idea, by creating an organization that would study the natural foundation of all things economic. Questions of power transcended national problems, just as energy spilled over national boundaries.[61] Initially, the WPC published a journal called the *World Survey*, which Dunlop held particularly dear, and which was suspended after his death in 1935. It featured a statistical section on data concerning the 'power economy', and focused on general economic questions, ranging from questions of integration in the world economy, and the value of economic statistics, to monetary policy.

Participants of the conferences noted a British interest, but still agreed on a general perspective on the economy. An American magazine surmised that the British initiative had to do with the loss of power of the coal-using countries, who 'must be alert or they will soon lose their present industrial hegemony'.[62] The Russians were even more suspicious. For Gleb M. Krzhizhanovskii, head of the Soviet electrification and planning commission, the WPC was a tool of the capitalist electro-technical industry, which, accelerated by wartime industry, was desperately searching for new markets.[63] Commenting on the London conference, he reflected that 'In the near future the centre of gravity of struggle will shift from military to economic conflicts.'[64] Not for a moment did Krzhizhanovskii fall for the peaceable nature of the 'technocratic internationalism' championed by the British host, who pictured all nations advancing together by making use of the 'marvellous resources of nature'.[65] International struggle had not come to a halt, but now 'expresses itself in the struggle for energetic resources'.[66] The British geographer Halford Mackinder had formulated a similar geopolitical vision twenty years earlier, arguing that 'a closed political system' would lead to imperial competition, in terms not of territorial expansion, but of a more efficient use of power.[67]

Despite these suspicions, the WPC assembled an international audience sharing the conviction that power had become a fourth factor of production, and that rational planning could make the most efficient use of resources, labour, and mechanical power. The Soviet Union's embrace of the WPC's perspective was particularly telling. To Krzhizhanovskii, the rise of planned forms of economic organization was evidence of a general economic development, and as such deserved attention. He saw this as truth in a wrong form: that is, rational organization separated from the

[59]Daniela Russ, 'Arming labour with energy, Soviet economic planning from GOELRO to energetics (1921–1928)', *Historical Materialism* (forthcoming).

[60]Wright, Shin, and Trentmann, *From World Power Conference*, p. 12.

[61]*Ibid.*, p. 11.

[62]'Science and world unity', *Living Age*, 332, 4178, 1924, p. 196.

[63]Gleb M. Krzhizhanovskii, 'Perspektivy elektrifikacii (Perspectives of electrification)', *Planovoe Khozyaystvo (Planned Economy)*, 2, 1925, p. 13 (my translation); Gleb M. Krzhizhanovskii, 'Zadachi energeticheskogo khosyaystva (Tasks of the energetic economy)', *Planovoe Khosyaystvo*, 6, 1928, p. 14 (my translation).

[64]Krzhizhanovskii, 'Perspektivy elektrifikacii', p. 12.

[65]World Power Conference, *First World Power Conference*, p. viii.

[66]Gleb M. Krzhizhanovskii, 'K peresmotru plana GOELRO (On the revision of the GOELRO plan)', *Planovoe Khozyaystvo*, 7, 1925, p. 11.

[67]Halford Mackinder, 'The geographical pivot of history', *Geographical Journal*, 23, 4, 1904, p. 422. I thank Thomas Turnbull for pointing me to Mackinder's work.

struggle to realize a socialist order.[68] In his view, the truth of a single energy economy lurked behind national peculiarities and could be made visible through statistics. While the Soviet Union's economic state looked poor from the standpoint of energetic indices, rational development of electrification would allow it to catch up.[69]

The WPC envisioned itself as a centre of calculation, which surveyed the 'world power economy', and collected, standardized, published, and disseminated data on it.[70] The idea to share and collect knowledge was prevalent in Dunlop's plans from the beginning. From the 1930s, the WPC published a *Statistical yearbook* (today called the *Survey of energy resources*). The first conferences manifested the need for common terms and units. In the six years from 1924 to 1930, the WPC organized two major and four sectional conferences. In some sense, these meetings generated confusion and misunderstandings, which the organization then sought to overcome in its concrete statistical and lobbying activities for international standardization. Every one of these conferences swept a wave of resolutions towards the International Executive Council, which was still working without much internal differentiation or formal rules of decision-making. Most of the resolutions were aimed at the exchange of information via statistics or bibliographies, and the international standardization of fuels, testing methods, units, and measures.[71] It took the Executive Council until the mid 1930s to work off the resolutions that had accrued over the 1920s.

This construction of a statistical representation of the 'power economy' required the harmonization of industries with a very different degree of international standardization, with names and measures serving different functions.[72] The available data on reserves, production, trade, and consumption, as well as their comparability, varied widely across different sources of power. Coal industries had mainly developed locally, and over a longer period of time. The names for different types of coal mirrored their visible and palpable properties, and coal was usually traded by weight or size, not by a numerical scale of quality or performance.[73] With regard to reserves, the coal industry could draw on a century of geological surveys, whereas petroleum reserves were technically more difficult to survey, and water reserves were hard to calculate mathematically. In contrast, with its dependence on foreign capital and new forms of transnational corporations, the electricity industry had been engaged in standardization of terms and units for four decades.

In line with its self-understanding as an organization spanning many different industries, the WPC refrained from setting international standards itself, apart from the definitions, measures, and units used in its own *Statistical yearbook*. It also, as early as the 1930s, sought contact with the IEC, the International Association for Testing Materials (IATM, today the ASTM), as well as the International Standard Association (ISA, today the ISO). Franz zur Nedden was particularly active in lobbying for standardization, and he was in personal contact with all three organizations. In 1932, he drafted a memorandum that would clarify the WPC's role in international standardization and would thus draw a line between the standardizing bodies and the WPC:

> whereas the power industry of the world, as represented in the World Power Conference, is very deeply interested in seeing standardisation carried through in the most efficient manner … be it resolved, [t]hat … the World Power Conference does not itself undertake

[68]Gleb M. Krzhizhanovskii, 'K teorii i praktike planovogo khozyaytva (On the theory and practice of the planning economy)', *Planovoe Khozyaystvo*, 3, 1925, p. 14.

[69]Krzhizhanovskii, 'K peresmotru plana GOELRO', p. 10.

[70]Bruno Latour, *Science in action: how to follow scientists and engineers through society*, Cambridge, MA: Harvard University Press, 1987, pp. 215–57.

[71]WECL, WPC, Meeting of the International Executive Council, 1930, pp. 15–16.

[72]Witold Kula, *Measures and men*, Princeton, NJ: Princeton University Press, 2014.

[73]Clarence A. Seyler, 'Is classification or nomenclature of coal possible or desirable?', *Journal of the Society of Chemical Industry*, 51, 25, 1932, pp. 531–2; O. Mohr, 'Die Analyse als Grundlage für die Kohlenbewertung und den Kohlenhandel', *Angewandte Chemie*, 21, 40, 1908, pp. 2089–94.

to act as a standardising body, but merely as a clearing house for information and suggestions regarding standardisation.[74]

In practice, this meant that the WPC would approve and bundle the conference resolutions and forward them to the respective body for international standardization. This was more difficult than it appeared to be, as the division of labour between the IEC, the IATM, and the ISA was not yet clear, and some of the WPC's resolutions targeted fields that had so far not been part of the work of any of these organizations. The WPC brought together the ISA and the IEC on some matters, including an international definition of the upper and lower heating value.[75] In 1936, it published a *Survey of the present organisation of standardisation, national and international*, which went beyond standardization in the field of power. The WPC can be seen as mediating between international organizations and national governments, without, however, always keeping the neutrality of a mediator. Through it, certain industries were able to pit national and international actors against each other, either keeping governments from engaging in international standardization, or pushing them to do so.[76] It also approached international bodies to request that they refrain from acting without considering certain 'competent' – mostly British or US – views on the matter.[77] In a survey for the UN in the late 1940s, the WPC still named the IEC and the ISA as its most important cooperation partners.[78]

In his work on gross national product, Daniel Speich Chassé argues that economic knowledge mediated the perception of global differences, and generated the distinction of a 'first', 'second', and 'third world'.[79] While the concept of a world power economy reflected an energo-materialist economics, and resulted from another kind of formalization, it too produced ranks and paths of development. Precisely because of the imagination of a common economic path determined by the use of energy, differences and inequalities within the organization could be justified. After the Second World War, the WPC picked up the distinction between 'developed' and 'developing' (or 'undeveloped') countries, and began to frame energy more explicitly as a resource of the 'world economy'.

Economic reconstruction and energy development politics

After the Second World War, the WPC struggled to regain its pre-war standing and remain the international platform on power – or, as it was now more often called, energy – problems. It became a formal part of the emerging space of international organizations, and some of its members assumed advisory positions in the institutions involved in economic reconstruction. The organization grew quickly, as it came to include many newly independent countries. This led to a profound organizational restructuring in the 1960s. Membership eligibility was formalized, fees became transparent, the organization of conferences and meetings was standardized, and the constitution was amended. Last but not least, the organization was renamed World Energy Conference in 1968. Whereas energo-materialist economics was in decline, a shared interest in 'energy systems analysis' emerged in East and West, and oil crises furnished the WEC with a world political mission.

The WPC became formally affiliated with the UN in 1947, when it was granted category-B consultative status to the UN Economic and Social Council (ECOSOC) in 1947. This status was given to those organizations that were of particular interest to the global public, and to certain

[74]WECL, WPC, Meeting of the Meeting of the International Executive Council, 1932, p. 43.

[75]WECL, WPC, Meeting of the Meeting of the International Executive Council, 1934, pp. 24, 56–7.

[76]WECL, WPC, Meeting of the Meeting of the International Executive Council, 1932, p. 19.

[77]WECL, WPC, Meeting of the Meeting of the International Executive Council, 1933, p. 19.

[78]United Nations Archive, New York (henceforth UN ARMS), Charles H. Gray to Lyman C. White, Information supplied for the Handbook of Non-Governmental Organisations, 18 January 1949, S-0441-0048-0005.

[79]Speich Chassé, 'Die "Dritte Welt" als Theorieeffekt', pp. 580–612.

parts of ECOSOC's activities.[80] It also meant some UN leverage over membership, as non-governmental organizations could lose their consultative status in case of non-compliance with UN resolutions.

UNESCO was more specifically interested in engineering matters. It cherished engineering as a bridge between pure and applied science for development, and planned 'to create an institutional structure for international collaboration in the field of engineering'.[81] In this context, it also reached out to the World Engineering Conference (formerly the WEF) and the WPC. A UNESCO officer attended the International Technical Congress, organized by the WEF, and identified it as 'the kind of international organisation that UNESCO will have to depend on for help and support to translate its aims into concrete actions'.[82] The WPC gained consultancy status to UNESCO one year after the WEF, in 1949, and became a part of the Union of International Engineering organizations (UATI) in 1953.[83] However, contrary to UNESCO's intentions, the UATI remained a weak coordinating body between international engineering organizations.

The WPC wanted to remain the uncontested international platform where 'energy problems' were discussed, and the broad scope of both the WEF and UATI jeopardized this unique position.[84] The main worry was that the WEF and the new network of national engineering associations would, perhaps unintentionally, encroach upon the WPC's field of activities. The programme of the WEF's conferences was much broader and dealt with questions of industry as a whole. 'Now, no industry could exist without constant connection with, and absolute dependence upon, energy problems', a French delegate pointed out, and 'one could then ask to what degree the Congress would be successful in avoiding … energy problems which were the proper field of activity of the World Power Conference'.[85] The WPC continued to put forward 'energy problems' as a distinct perspective.

After the idea of setting up an International Petroleum Council, alongside the World Bank and the International Monetary Fund, had failed, world production and consumption of strategic resources remained unregulated on an international level.[86] However, some institutions organized parts of a market, such as the European Coal and Steel Community (ECSC) from 1951, or the Organization of Petroleum-Exporting Countries (OPEC) from 1960.[87] The WPC served as a platform for delegates of various international and national institutions involved in energy statistics, planning, and development. Its consultative relation to ECOSOC entailed not only the exchange of statistics and other material, but also the invitation of UN officers to give papers at conferences. In turn, as national experts in the field of energy, members of the WPC's national committees figured prominently in these new institutions. Walker Cisler, a member of the US national committee, was a key adviser to the Marshall Plan. Harold Hartley was president of the WPC, and at the same time chairman of the Commission of Energy set up by the Organisation for European Economic Cooperation (OEEC). Ion D. Stancescu, former president of the Romanian national committee, came to serve as a special technical adviser to the energy sector at ECOSOC's

[80] Andreas von Weiss, 'Die Non-Governmentalen Organizations und die Vereinten Nationen', *Zeitschrift für Politik*, 27, 4, 1980, p. 398.

[81] Casper Andersen, 'Internationalism and engineering in UNESCO during the end game of empire, 1943–68', *Technology and Culture*, 58, 3, 2017, p. 650.

[82] S. N. Gupta, cited in *ibid*., p. 661.

[83] WECL, WPC, Meeting of the International Executive Council, 1953, p. 13. The status changed from direct consultatory status to consultatory status via the UATI, a body designed to channel technical and engineering advice to UNESCO. See also Andersen, 'Internationalism and engineering', pp. 650–77.

[84] Andersen, 'Internationalism and engineering', p. 664.

[85] WECL, WPC, Meeting of the International Executive Council, 1946, p. 16.

[86] Mitchell, *Carbon democracy*, pp. 117–18. The idea of bringing oil resources under international control was brought up again by the International Co-operative Alliance in a request to ECOSOC in 1949.

[87] John Gillingham, *Coal, steel, and the rebirth of Europe, 1945–1955: the Germans and French from Ruhr conflict to economic community*, Cambridge: Cambridge University Press, 2004; Giuliano Garavini, *The rise and fall of OPEC in the twentieth century*, Oxford: Oxford University Press, 2019.

Centre for Natural Resources, Energy and Transport, founded in the early 1970s. He constituted an important link between the WEC and ECOSOC throughout the 1970s and advocated for WEC membership in 'developing' countries.

Even though the WPC was quick to claim that questions of energy arguably affected every economic activity, it was much more difficult to pin down this 'economic effect'. With the foundation of the UN, however, the WPC became even less of an authority to actually compile the statistics for a global public interested in questions of energy, although it was a platform where the shortcomings of international statistics were assessed and discussed. At the Conference in 1951 in Vienna, state engineers (such as the socialist *glavenergetiki*), technical experts from private electric utilities, and delegates from national ministries discussed with officials from the OEEC, the UN Economic Commission for Europe (UNECE), the ECSC, and the UN Development Program about 'methods of compilation and use of statistics in the production and utilization of energy'.[88] The result was the same as had been stated by the WPC's survey on standardization twenty years earlier, in that national and regional comparability of data was satisfying, but international comparability remained a complete mess.

In 1969, Walker Cisler once more proposed setting up an 'energy information centre' within the WEC, where comparable data on 'national power economies' could be easily accessed from all around the world. The WEC approached the UN, the UNECE, Comecon, the OECD, and the European Economic Community to learn about the scope and time-lag of their statistics. The project was dropped after this survey of existing sources, as the endeavour was determined to be 'not economically viable'. Instead, the 'World Energy Conference [was] in a position to take account of the changing requirements [of information] and to make them known to those who have the means of providing the solution'.[89] The national committees could approach their governments and lobby for changes in the statistical methodology, or they could work on converting different units, but these were only superficial fixes. Regarding the UN, the WEC stressed 'that it should be most willing to discontinue the collection and publication … of data … should the United Nations be willing to collect and publish such statistics substantially on the same lines as [the WEC] has done'.[90] Having published energy statistics from the very beginning, the WEC never achieved the same authority and degree of comparability as the intergovernmental institutions set up after 1945 and during the oil crises.

In the wake of the Second World War, a new membership regime was negotiated, based on participation in the United Nations. Apart from full UN members and a couple of neutral states such as Switzerland, this allowed other countries 'upon their admission … to the [UN] Specialized Agencies' to become eligible for membership. This additional clause meant that countries that were not members of the UN but were members of any organization to which ECOSOC had granted the status of 'specialized agency' – such as the World Bank, UNESCO, or the International Labour Organization – could become WPC members. This enabled Austria, Italy, and many other countries that joined the UN only in the 1950s to regain their WPC membership in the late 1940s.

Owing to its focus on development, the WPC had always been a uniquely diverse nongovernmental, international organization. Compared to other international organizations in the field of technology, its official member base and formal rules were more inclusive. Not more than two of the four most important offices – the chairman and the three vice-chairmen of the

[88]WPC, *Fünfte Weltkraftkonferenz Wien, Band 4: Statistische Methoden in der Energiewirtschaft*, Vienna: Österreichisches Nationalkommittee der Weltkraftkonferenz, 1957.

[89]WECL, WEC, Meeting of the International Executive Council, 1972, pp. 37–8. The WEC introduced yet another version of this 'centre for calculation' in 1998, when it launched its Global Energy Information System (GEIS), an internet database accessible to its members. WEC members themselves acknowledge, however, that the most important sources for energy statistics are today the BP statistics, the US Energy Information Administration, and the International Energy Agency.

[90]UN ARMS, Charles H. Gray to Ansgar Rosenborg, special adviser in charge of economic development matters, 22 December 1953, S-0441-0048-0006.

International Executive Council – could be held by citizens of the same continent.[91] Organizational practice, however, favoured the larger industrial powers and the biggest donors. This inequality can be seen in the locations of the conferences (the first full conference in the Global South only took place in 1983, in Delhi), the persons attending and most vocal in meetings of the Executive Council, and the distribution of papers presented at conferences. With many of the newly independent states joining the WPC in the 1960s, countries that had traditionally dominated the organization sought to safeguard their position and the centrality of their voices at the conferences.

Rarely was the idea of a knowledgeable developed West, and an ignorant underdeveloped rest, made as explicit as in an internal discussion within the German national committee. When the restructuring of the organization was discussed in 1975, it was agreed that 'The contingent of conference papers has to be reduced considerably for small and mid-sized member countries. This will be easy to be agreed upon, as we do not expect substantial, interesting contributions from the plethora of developing countries.'[92] It was quite obvious who was expected to learn from whom.

In its attempt to rationalize organization in the 1960s and 1970s, the WEC benefited from the statistics issued by other bodies. In 1970, a formula for membership fees based on annual energy consumption was developed. In 1966, of the sixty-one countries, almost two-thirds paid the minimum fee, and only three (Great Britain, the USSR, and the US) the maximum amount.[93] Just as being a member of the UN meant that GDP was calculated, membership of the WEC came to presuppose quantitative knowledge on the 'national power economy'. This became possible in the 1960s, when statistical data on energy production and consumption were already gathered on a regular basis by national and international agencies, above all the UN, as stipulated by post-war organizations of economic recovery and Technical Assistance programmes.[94] The conference in Munich, in 1980, for the first time established the exact terms, measures, and units that each paper presented at the conference had to use, bringing a fifty-year-long practice of heteroglossia (and translation) to an end.[95]

Energo-materialist economics lingered on after the war, but slowly lost its plausibility and credibility. The Sectional World Power Conference in Belgrade in 1958 was still dedicated to 'Power as a factor of development of underdeveloped countries'. At that time, the UN had already institutionalized GDP as measure of economic performance and development, leaving the engineers, scientists, and planners at the conference with two different languages of development. Most of them associated monetary accounting with 'blind' development, and preferred indicators measuring material change. GDP covered up qualitative changes in industry, on which a theory of material change focused. These changes affected the relationship between economic growth and energy consumption, as energy-intensive industry did not necessarily produce the greatest value.[96] Changing patterns of economic reproduction and development were at the heart of energo-materialist economics. Two Czechoslovakian engineers proposed an indicator to capture these qualitative changes in a 'ratio of specific energy demand of additional production [to] the basic year production': that is, a positive number indicating whether the industry was becoming more energy-intensive in comparison to the base year.[97]

[91]Wright, Shin, and Trentmann, *From World Power Conference*, p. 16.

[92]WECL, German National Committee of the WEC, Meeting of the National Executive Council, 1975, p. 3.

[93]WECL, WEC, Meeting of the International Executive Council, 1966, p. 39.

[94]WECL, WEC, Meeting of the International Executive Council, 1972, p. 30.

[95]WEC, *Transactions of the 11th World Energy Conference*, London: World Energy Conference, 1980.

[96]R. Freiberger and F. Schulz, 'Some relations between industrial production and consumption of energy', in Yugoslavian National Committee of the World Power Conference, ed., *Transactions, World Power Conference XIth sectional meeting: power as a factor of development of underdeveloped countries, section A, economic aspects*, Belgrade: Jugoslovenski Nacionalni Komitet Svetske Konferencije za Energiju, 1958, p. 162.

[97]Freiberger and Schulz, 'Some relations', p. 138.

Under the influence of cybernetics and demand-side economics, the focus shifted from 'energy' as an agent of economic change to the analysis of energy as a function in an economic system. Energy balances, a statistical model proposed within the WPC as early as the 1920s, assumed a new meaning. They were no longer 'estimated', or aggregated sector by sector, to trace the channelling of energy into productive consumption, as in the Soviet Union, where fuel and power balances had been calculated since 1924. Discussions now centred on energy services, their conversion factors, and relative efficiencies. Energy balances figured prominently at the World Energy Conferences in Vienna in 1957, Moscow in 1968, and Bucharest in 1971. However, to establish clear-cut relations between 'energies' would require accounting for their performance in very different technical processes.

The calculation of energy balances made the difference between the physical and economic-technological meaning of energy explicit. One of the most comprehensive studies of a national energy economy before the 1970s was *Energy uses and supplies, 1939, 1947, 1965*, an assessment of the US energy industry edited by Harold J. Barnett and published by the US Department of the Interior in 1950.[98] Foreshadowing Barnett's later argument in *Scarcity and growth* (1960), the study presented the energy sector as a modular system, where single parts could be replaced with others. However, a formally identical input of energy could perform very differently: 'Energy is a complex abstraction. Despite the attraction of B.t.u. [British thermal unit] conversion factors, B.t.u. are essentially measures of work and not of physical quantity, and the amount of work a fuel performs depends on the function to which it is put and the equipment in which it is used.'[99]

The report distinguished between 'sources of energy' (coal, petroleum, etc.), 'energy commodities' (fuel, electricity, etc.), and 'uses of energy' (railroads, manufacturing, households, etc.). Any given quantity of fuel would realize a very different share of its potential according to the use to which it was put: '1 B.t.u. of diesel oil performed as much work as 5 B.t.u. of fuel oil in 1947.'[100] As absurd as this might sound, it reflected the inequality of technically mediated energy. 'The only way to avoid such a dilemma', states Barnett, 'is to estimate fuel need only after identifying the function and type of the equipment used.'[101] In other words, the energy economy had to be approached from the demand side.

The Barnett report was cited at the Vienna conference as further evidence for the shortcomings of energy balances. Setting up a meaningful supply and demand table for energy was more complicated than just gathering data on production. It required a central survey of the entire field, a documentation, systematization, and analysis of the technologies used in the production and consumption of energy, their handling, and their specific efficiencies.[102] Only then could conversion factors be calculated that were specific to a certain national energy economy and thus represented the 'substitutions that actually take place'.[103] This was the view on energy balances conveyed in the pre-1970s conferences. Because such centralized, in-depth studies of national energy sectors were unlikely to happen in a globally concerted way, world balances were seen as misleading or not very meaningful. And yet, only a few years later, the WEC began to work on global energy balances.

[98]Harold J. Barnett and United States Bureau of Mines, *Energy uses and supplies, 1939, 1947, 1965*, Washington, DC: US Governmental Printing Office, 1950.

[99]*Ibid*., p. 8.

[100]*Ibid*., p. 4.

[101]*Ibid*., p. 8.

[102]WPC, *Fünfte Weltkraftkonferenz Wien*, p. 1107.

[103]WEC and International Union of Producers and Distributors of Electrical Energy, *Substitutions between forms of energy and how to deal with them statistically: a guide*, London: World Energy Conference, 1985, p. 15.

A world plan for energy

The beginning of global energy politics is usually located in the 1970s, when a surge in oil prices shocked consumers and policymakers around the world. The so-called oil crisis of the 1970s catapulted the 'problem of energy' onto the agenda of international organizations. The conflict with the petroleum-producing countries prompted the formulation of the OECD's International Energy Program, and the foundation of the International Energy Agency (IEA). The IEA was modelled after previous emergency sharing mechanisms, but went beyond them in allowing low petroleum reserves to be made up for by 'fuel switching capacity'.[104] This capacity meant any 'normal oil consumption' that through government agency 'may be replaced by other fuels in an emergency'.[105] Even though energy balances had always implied the substitutability of energies, they had mostly been discussed with regard to general conservation or efficiency measures. Now, they were to fulfil a more specific function: the formalization of 'oil substitution' on an international level.

Representing both petroleum-producing and petroleum-consuming countries, the WEC did not officially take sides in the conflict but resorted to its role as a clearing house for knowledge on energy. At the World Energy Conference in 1974, Gerald Ford criticized 'the pulverizing impact of energy price increases on every aspect of the world economy', and formulated a responsibility of every country to develop and 'not to misuse' its resources, to soothe the situation in the world market.[106] Shifting the responsibility to the oil-producing countries without mentioning the political dimension of the embargo, he was attacked not only by delegates of the OPEC countries.[107] In the WEC's International Executive Council, Ford's opening speech was interpreted as a mission 'to produce a world plan for energy'.[108] The WEC had already been in discussion with the OECD for some time, which 'had led to an understanding that they [the OECD] would deal with the problem and its solutions up to 1985, [while] the World Energy Conference had expressed its willingness to take on the task from that point until the year, say, 2020'.[109]

The calculation of energy balances assumed a new meaning in this context. The IEA and the WEC promoted them as a statistical innovation that would help countries to realize oil substitution. The WEC argued that 'Energy statistics, at present collected by governments, were inadequate to pinpoint areas where oil substitution could be realised.'[110] Therefore, the WEC set up its first permanent commission, the Conservation Commission, to compile a world energy balance. In the 1970s, various institutions – the IEA, the WEC, and the International Institute for Applied Systems Analysis – began to compile energy balances on an international level. To do so, however, conversion factors between different kinds of energy had to apply to all energy economies. As a compromise between a meaningless, abstract conversion factor and the detailed conversion factors of national energy balances, the WEC and the International Union of Producers and Distributors of Electrical Energy agreed to use the relation between fuel and electricity, as calculated in the operation of co-generating plants (1 Joule of electricity equalled 2.6 Joules of fuel).[111] At the level of the nation

[104]J. C. Woodliffe, 'A new dimension to international co-operation: the OECD International Energy Agreement', *International and Comparative Law Quarterly*, 24, 3, 1975, p. 528; Richard Scott and the IEA, *The history of the International Energy Agency, 1974–1994: IEA, the first 20 years*, Paris: OECD and IEA, 1994, p. 414; Thijs Van de Graaf and Dries Lesage, 'The International Energy Agency after 35 years: reform needs and institutional adaptability', *Review of International Organizations*, 4, 3, 2009, p. 301.

[105]IEA, 'The International Energy Program, signed on November 18, 1974', annex, article 2, https://treaties.un.org/doc/Publication/UNTS/Volume%201040/volume-1040-A-15664-English.pdf (consulted 24 January 2020).

[106]WEC, *Digest: transactions of the 9th World Energy Conference, September 23–27, 1974*, New York: US National Committee of the World Energy Conference, 1975, pp. 25–7.

[107]Wright, Shin, and Trentmann, *From World Power Conference*, p. 42.

[108]WELC, WEC, Meeting of the International Executive Council, 1975, annex 4.

[109]*Ibid*.

[110]WELC, WEC, Meeting of the International Executive Council, 1980, p. 9.

[111]WEC and International Union of Producers and Distributors of Electrical Energy, *Substitutions between forms of energy*.

or the world, the calculation of energy balances no longer required the actual measurement of economic effects in concrete power plants, but merely aggregated data on production and consumption.

Conclusion

While it is true that the 1970s saw a surge in the production of knowledge on energy and petroleum, and the institutionalization of 'energy politics' on an international level, this development has to be seen in a larger context.[112] By tracing back the relation between energy, technology, and economic value into the nineteenth century, I have tried to provide a prehistory to this. Based on the origins and history of the World Energy Council, I have argued that electric power systems were crucial for an international, technical, and commercial space of the production and consumption of the 'forces of nature' to emerge. In the form of electricity, 'energy' became a universal object and economic effect that could be possessed, seized, traded, and invested in. The WEC saw itself as a non-governmental international organization representing this world power industry. Its work was located precisely at the nexus between industries of very different financial, technical, and social organization, depending on each other. Rooted in the field of electro-technical engineering, the energo-materialist economics put forth by some of the WEC's members went beyond any narrow business interest. Instead, it opposed economics based on the flow of money with a material economics imbued with a productivist ideology. When growth became questionable in the 1960s and 1970s, engineers and energy economists turned to an ahistorical, less material conception of the energy economy, namely energy systems analysis. Instead of an immaterial economics, however, an inverse of energo-materialist economics could have served as a theory for today's world of declining energy returns.

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[112]Rüdiger Graf, *Oil and sovereignty: petro-knowledge and energy policy in the United States and western Europe in the 1970s*, New York: Berghahn Books.

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