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Making sources of energy: the case of coal (1900–1936)

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Recent contributions to a sociological analysis of energy and society focus mostly on its political, economic and technological organization. Yet contrary to other parts of nature, little social scientific attention has been paid to how politics, economics and technology have come to produce and stabilize the concept of energy in the first place and how different natural materials were transformed into "sources of energy." Drawing from insights of the sociology of comparison, quantification and commensuration, "energy" in this paper is conceived as a "statistical object," around which a public discourse develops in which comparisons between resources are drawn. Since the beginning of the twentieth century, this discourse has been more and more stabilized by the regular, public production and ever tighter net of elements of comparison, the creation of a highly abstract, potentially quantified point of comparison, and the definition of various criteria tying the compared entities together with more general models and narratives. This theoretical framework is put into practice by an explorative analysis of coal classification in the first quarter of the twentieth century. In this empirical analysis, three fields are identified where coals were "made the same": engineering, economics and resource statistics. It is shown that the "calorific value" plays an important role for classification in all three fields and, furthermore, constitutes a measure that links coal to other fuels.

Keywords: energy systems; sociology of quantification; sociology of science; energy concept; social energetics; science and technology studies

Introduction

In 1924, in the midst of internationalist spirit, Daniel Nicol Dunlop sets up an organization in order "to consider the utilization of the forces of nature." He envisions it to provide "the wide platform required for a study of all aspects of the program under consideration" and to regularly hold conferences "of practical men, scientists, engineers, manufacturers, financiers and politicians" (The World Power Conference 1924, vii). It is the gist of this paper that the *concept of energy* arises precisely from the *practice of comparing* the "utilization of the forces of nature" – as Dunlop so aptly put it. With a foggy memory of the physical concept of energy in our minds, this might well sound absurd. Yet, the concept of energy in physics (far from being stable[1]) does not coincide with the "object" targeted by political, economic or technological means. It is this latter notion of energy that is at the heart of this paper.

This article holds that this notion of energy has its roots in the beginning of the twentieth century, when engineers, scientists and economists call for a "rational organization of

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the power economy" (The World Power Conference 1938, 13), which would change the way states "see" their territorial resources. Alongside the changes in political institutions, markets and technology described by Timothy Mitchell (2009, 2011), a "statistical object" of energy is gradually constructed and stabilized. Today, "energy" can be observed, compared over time, and targeted by measures and regulations. Historically, however, it evolved as a specific point of view that brings different resources into a common system and is co-produced by politics, economy and technology.

Unlike other parts of nature, little social scientific attention has been paid to how politics, economics and technology have come to produce and stabilize the concept of energy in the first place. There is a curious research gap between, on the one hand, studies on the emergence of the concept within science, mainly focusing on the time from 1830 to 1880 (Kuhn 1959; Breger 1982; Smith 1989; Smith and Wise 1989). And, on the other hand, recent contributions to a sociological analysis of "energy," which center on its political, economic and technological organization and favor studies of risky technologies, major crisis or bold transitions.

The concept of "sociotechnical imaginaries," for instance, stresses the importance of "collectively imagined forms of social life and social order reflected in the design and fulfillment of nation-specific scientific and/or technological projects" (Jasanoff and Kim 2009, 120), and has been fruitfully applied to several nation-specific "energy systems" (Jasanoff and Kim 2009; Jasanoff and Kim 2013; Tidwell and Smith 2015). Another, equally important, reference is Bruno Latour's Actor-Network-Theory (ANT), which figures prominently in Timothy Mitchell's "Carbon Democracy," where Mitchell explores the simultaneous rise of fuels and democratic institutions (Mitchell 2009, 2011). A recent special issue of Anthropological Quarterly approaches the subject from a different angle and tries to broaden Michel Foucault's concept of "biopower" by bringing energy in Boyer (2011, 2014) and Szeman (2014). "[E]nergopower is a genealogy of modern power that rethinks political power through the twin analytics of electricity and fuel" (Boyer 2014, 325). Here, the lack of a historical approach is particularly surprising considering the fact that Michel Foucault's works on "biopolitics" serve as a vital point of reference within the literature, though without mentioning that Foucault presented an interpretation of the emergence of "life" as a biological object (Foucault 2002) before coining the concept of "biopolitics" (Foucault 2008; Foucault 2007). No comparable groundwork has been done so far for the case of energy.

Although some of the contributions pursue a historic approach, and all of them refer to an object called "energy," none of them asks where this relatively clear domain of energy comes from. In other words, how was energy made into an object targeted by political measures, economic decisions, technological innovations – and social science research alike? Sometime between the nineteenth century and today, different phenomena have come to be seen as "energies," flow-like entities that are liable to a set of natural (and, later, economic) laws, which allow for them to be measured, channeled and harnessed. As diverse parts of nature as coal, water or oil were subsumed under the notion of energy and were thus made comparable and controllable.

This paper presents both an empirical and an analytical argument, whose limits should be outlined in the beginning. It is historical in the sense that it zooms into a particular context at the beginning of the twentieth century, when resource classification was hotly debated and the first global resource statistics were published. Apart from this specific historical situation, my paper seeks to make a more general theoretical, and more specifically genealogical argument that refers to all sorts of "sources of energy." Within the scope of this paper, however, the analysis is confined to the classification of coal in the period from 1900 to 1936. The debates on coal classification are interspersed with references to other "sources of energy" and can thus be understood as a first empirical exploration of my broader assumptions, but further research will yet have to show whether similar processes can be found in the classification of other resources as well.

The structure of the paper is as follows: First, I argue for understanding energy as a specific point of view under which resources are compared. This shift of perspective toward a "statistical object" of energy opens up another perspective on the "materiality" of resources. Drawing from insights of the sociology of comparison and commensuration, I outline more precisely what I mean by the "practice of comparing resources." The theoretical framework is then applied to a concrete case: the debates on coal classification that took place on the early World Power Conferences. After a short introduction of the World Power Conference and the specificity of the case of coal, I identify three different fields that shape the debate on coal classification: engineering, economics and resources statistics. It is shown that the "calorific value" plays an important role for classification in all three fields and, furthermore, constitutes a measure that links coal to other fuels.

Energy as a point of view

In 1910, Ernst Cassirer disenchants the concept of energy by noting that it "signifies nothing but an intellectual point of view, from which all these phenomena can be measured, and thus brought into one system inspite of all sensuous diversity" (Cassirer 1953, 192).[2] A similar view has been raised before by Ernst Mach,[3] though in a less idealistic manner. Although I am not concerned here with the concept of energy in physics, there is one thing we can learn from historians and philosophers of science: energy can be understood more adequately as *the emergence and stabilization of a new point of view*, rather than the *discovery of a new object*.

Just like in physics, there is no way to talk politically about energy without bringing up numbers. What is apparent, but nonetheless rarely mentioned, is that the understanding of energy conveyed by economic or political measures does not coincide with what counts as energy in physics, but carves out a very specific part of it. This is not to say that the physical concept of energy is closer to a "true" description of nature, but rather that the instruments of measurement, apparatuses, theories and models stabilizing energy as an object in physics differ radically from those fixing energy in political and economic discourses. So, in what way can energy be understood as a newly emerging point of view?

Energy as a "statistical object"

Today, the political and economic understanding of energy boils down to what is measured as Total Primary Energy Supply (TPES). This highly aggregated figure stands for the total amount of energy found in nature, that is, the input before any potential losses due to transformations from one type of energy into another. Measures like the TPES are conventional, which means that our understanding of energy is as well. There is no way to directly measure the overall energy input; indeed, it is computed the other way round. Starting from the output – the actual amount of energy produced – the input is calculated by taking the mean efficiency losses into account. Those numbers on energy "are both contingent and non-arbitrary" (Esposito 2007, 69f), calculated from "raw data" according to more or less transparent guidelines and methods.

Calculating the global TPES is highly demanding and requires the standardization of technology, methods and data on many levels. The TPES is conventional in the sense that the units of measurement and the method of data aggregation have been agreed upon, and the units are constructed in a way that allows for them to be converted into others (Mirowski 1989, 114; Kula 2014). The contribution of different "sources of energy" to overall energy input are made comparable by conversion into a common metric, nowadays usually Tera Watt hours (TWh) or Million tons of oil equivalent (Mtoe).

And yet, those charts and numbers are anchored in real bulks of coal, real drops of oil, real water pressure against the dam wall. Conceiving of energy as a "statistical object"[4] also allows for another perspective on materiality, as it understands natural materials to be *tamed* in a contingent, temporarily fixed, non-arbitrary way – as "energies." In this process, "materials" are dissolved and created at the same time (Law 2010).

Some of the approaches to understand the organization of "energy" outlined above invoke this "materiality" of resources in their explanations. Drawing from ANT, Timothy Mitchell tries to combine the materiality of coal and oil with the political and economic structures that evolved to channel and harness it. "The carbon itself must be transformed (…). The transformations involve establishing connections and building alliances – connections and alliances that do not respect any divide between material and ideal, economic and political, natural and social" (Mitchell 2011, 7). In "Carbon Democracy" (2011), the different material features of coal and oil are highlighted, but seen as relatively stable over time – the crucial point of difference being the scope of trade the materiality allows for: local or regional in the case of coal, global in the case of oil (Mitchell 2011, 37). The distance over which coal and oil are sold is certainly dependent on transport technology, but also on market and production prices, for which knowledge on resources is crucial. Resource knowledge encompasses both the knowledge about available or prospective resources and the knowledge on their composition. Only known coal resources make a difference for political planning or economic investments, and this presupposes both a classification of *coals* and of *resources*. Thus, classification is one way of making resources "materially" different. The classification systems themselves vary according to technology (that allows for analyzing resources), geological or chemical knowledge, statistical requirements, political regulations, and the commercial value and use of the resource.

Resources are not only stripped statistically from their former material being and made comparable under one abstract, common point of comparison. Statistics also produce new materialities by fixing the ways in which things are allowed to differ meaningfully (Espeland and Stevens 1998, 324). A case in point here is the difficult inclusion of non-scarce resources ("renewables") into a framework like the TPES, which ignores the conversion efficiency and thus systematically overstates the contribution of fuels, a problem noticed as early as 1930.[5] Hence, to study "energy" as a specific point of view under which resources are compared shifts research toward the *changing* and *contested materialities* that evolve through classification and statistical compilation.

Comparison, classification and commensuration

It is striking that in the empirical example described below, the term energy is rarely used. In what way, then, can we think of this case as exemplifying the emergence of an "energetic" point of view? I want to argue that making natural materials into "sources of energy" involves two intertwined processes of standardization: *First*, the natural material is transformed into a certain type of resource by establishing defining features of this resource that also allow for sub-classifications (like types of coals, etc.), and *second*, those resources are made into "sources of energy" by establishing a meaningful, conventional unit of measurement that puts them in a unique relation to other "energies." It is important to note that those steps are distinguished *analytically*, and are not necessarily *empirically* following one after another. Quite the contrary, in the case of coal classification mentioned below, standardization within a resource (i.e. the development of coal classification schemes for scientific or economic purposes) is partly prompted by non-satisfying comparison with other resources. Measures like the fuel ratio, the heating or calorific value come up first as a quantified point of comparison between different types of coals. At the same time, though, they already allow for potential comparison to other fuels.

Thus, my argument draws from sociological work on comparisons and commensuration (Espeland and Stevens 1998; Espeland and Stevens 2008; Heintz 2010, 2016; Heintz and Werron 2011). The distinction is important, because resource comparisons do not necessarily involve "the transformation of different qualities into a common metric" (Espeland and Stevens 1998). Fuels have long been sorted into solid, liquid and gaseous fuels. This demarcation is both relatively clear and meaningful, as it coincides with existing markets, distinct careers and professions (mining or petroleum engineers), as well as the most relevant features of the resource, for instance, its homogeneity or transportability. Resource classification systems were and remain until today manifold: non-quantified classification schemes coexist with highly aggregated measures, some can be "converted," and others do not, depending on their purpose. What they, however, do have in common is their *standardized* form of knowledge. While not every comparison needs a common metric, every commensuration implies a comparison; and both require standardization.

Quantification and commensuration have often been said to be particularly able to straddle social and cultural distances (Latour 1986; Porter 1995, ix; Espeland and Stevens 1998, 324; Heintz 2016, 174f). Heintz and Werron (2011) go beyond this focus on numbers, models and statistics, and explicitly link the "establishment of a public discourse of comparisons" to globalization dynamics. In the same paper, they suggest an explanation for the stabilization of comparisons and point to the mutual reinforcement of three processes: (1) the regular production of elements of comparison, such as events or statuses, (2) the process of making things the same, that is, establishing a point of comparison (cf. MacKenzie 2009), and (3) the definition of criteria, which embed the elements in a larger context of comparison and allow for a meaningful interpretation of the relation between elements (Heintz and Werron 2011, 365). Quantified and non-quantified comparisons can then be interpreted temporally as different stages of one discourse of comparison that develops toward more abstract (cf. Kula 2014) or public (cf. Porter 1994, 389) points of comparison, or they can be juxtaposed as different ways of comparing within the same public discourse.

Loosely following this model of explanation, I conceive of "energy" as a public discourse in which specific comparisons between resources are drawn. Since the nineteenth century, this discourse has been more and more stabilized by the regular, public production and ever tighter net of elements of comparison, the creation of a highly abstract, potentially quantified point of comparison, and the definition of various criteria tying the compared entities together with more general economic or ecological models and narratives. This approach could face the pitfall of smoothing history: Looking back from a world where the TPES already exists, any standardization and quantification efforts might appear as mere steps toward increasing aggregation, quantification and abstraction. What becomes stabilized though is not a specific quantified model, but the comparison of resources under a specific (energy) perspective. This comparison is always entrenched in different practical fields and thus generates a myriad of coexisting classification systems and types of commensurations (cf. Levin and Espeland 2002). Though this is not a simple story of abstraction, it might very well be one of increasing *institutionalization of the observation* of energy. In many ways, and in many fields, the regular and systematic comparison within and across resources has been established: through scientific journals, emerging scientific disciplines (energy economics, for instance), research institutes, political administrations or market reports.

In the following, I want to explore this argument by means of a historical case study on coal classification. Here, I want to show that an emerging "energetic" point of view becomes visible in the first quarter of the twentieth century through a new way of comparing different coals, as well as coals and other resources. The archives of the World Power Conference provide a unique source of data to study those changes in the discourse.

Energy as a practice of comparison – the world power conference

The World Power Conference, renamed World Energy Conference in 1968 and World Energy Council in 1992, is the first international, non-governmental organization to explicitly cut across several resources. Encouraging and celebrating cross-energy observations, the World Power Conference is a symptom of the sweeping need for comparisons across resources that become apparent in economics, politics and science by the end of the nineteenth and beginning of the twentieth century. From locally diverse and resource-specific contexts, various means of making resources "the same" arise – classification systems, technologies and methods of fuel analysis, as well as new units of measurement.

The World Power Conference is unique not only in its coverage of all "sources of energy," but also because it defies standard definitions of international organizations. It is neither a governmental nor a non-governmental organization; and it distances itself both from being a standardizing body like the International Electrotechnical Commission, as well as from organizations based on one single profession, like the World Engineering Federation whose set-up had been proposed in 1930 (The World Power Conference 1930, 23; cf. Wright, Shin, and Trentmann 2013, 17). It was called the "Technical League of Nations" by Paul von Hindenburg in 1930, pointing out that "nothing is indeed better calculated to league together the nations of the earth than a mutual endeavor of this kind to further the common weal" (cited in Wright, Shin, and Trentmann 2013, 10). From this technological girdle around the world, it would have been only one step toward a standardizing body for fuel and power technology. Though the World Power Conference never acted like it, numerous resolutions for standardizations have been raised on its conferences and have been brought before the International Executive Council (IEC) in the years before World War II. The IEC would usually just discuss the issue and then forward it to the respective international body. In 1932, following an avalanche of resolutions set off on the conferences in London and Berlin, Franz zur Nedden felt the need to "record once more that the World Power Conference does not itself undertake to act as a standardising body, but merely as a clearing house for information and suggestions regarding standardisation" (The World Power Conference 1932, Annex F). Refraining from any international standardization was very much in line with the WPC's self-understanding at that time. "Instead of an international body with powers of control, it championed cooperation and knowledge exchange" (Wright, Shin, and Trentmann 2013, 17).

Like other international bodies of that time, the World Power Conference is structured in "National Committees" that are expected to represent a country's "power economy" and would usually include power, mining and petroleum companies or umbrella organizations, national engineering associations, research institutions, as well as part of the political administration or ministries. As the name already implies, its main object was the organization of conferences for the exchange of knowledge on different topics related to the use and organization of power and fuels. While the first World Power Conference in London centered around resources and the panels were structured along country lines, the following conferences dealt more concretely with specific "sources of energy." In the following, I want to illustrate my argument by having a look at the debates on the classification of coal taking place on the first World Power Conference in 1924, the Fuel Conference of the World Power Conference in 1928, and the second World Power Conference in 1930. Furthermore, the debates on standardizing issues and statistics are continued in the annual meetings of the IEC of the World Power Conference, whose minutes could be accessed and analyzed for the meetings from 1930 through 1936, with the exception of 1931.[6]

The case of coal

Coal makes for an interesting case to study the specificity of this newly emerging "energetic" point of view. It has been used intensively since the middle of the nineteenth century (Kander, Malanima, and Warde 2013, 131ff), and consumption peaked somewhere between 1900 and 1940 (Kander, Malanima, and Warde 2013, 257). The first local classification schemes emerge in mining and along trade routes (Parr 1928, 5) long before any international standardization efforts. For various reasons though, coal has proved rather hard to classify. Compared to liquid and gaseous fuels, solid fuels are not homogeneous – a difference advocates of coal classification are well aware of (Parr 1928, 5; Wheeler 1928). The composition of coal varies not only across regions, but also across seams within a certain mineral deposit. Serious debate about international standardization begins not until the first quarter of the twentieth century, in a moment when coal is by far the largest "source of energy," but water power ("primary electricity") and oil are already becoming more and more relevant. Wright, Shin, and Trentmann (2013, 15) point out that contemporaries were well aware of the "swing of power away from the old coal-producing countries." With worried looks toward oil and water power, coal classification is approached for the first time from another angle, indicating the rise of a new "energetic" point of view.

Claims for a new system of coal classification are raised prominently in three different fields. The two fields most actively engaged in coal classification are mining engineering (by mining engineers, geologists and chemists) and economics (mining companies or companies processing coal). Referring to the messy system applied to British coals, one of the pioneers of coal classification, Samuel W. Parr, complains that:

> [t]he terms used for designating different coals were not chemical, but almost wholly derived from physical properties and industrial uses (…). In recent years Seyler [a British coal analyst - D.R.] has rescued the English coals from a terminology almost meaningless, at least to the foreigner, and inaugurated a scientific method based on chemical values. (Parr 1928, 6)

Yet, classification is hardly just a matter of scientific, but also of economic understanding between buyer and seller: "[C]orrect classification," states Fieldner on the Fuel Conference in 1928, "would prove a great aid to a better understanding between seller and buyer, and would result in directing each class of coal into the use for which it is most valuable" (Fieldner 1928, 230).

A third field might come as a surprise: global coal statistics. Starting from the report on "The Coal Resources of the World" presented by the International Geological Congress in

Toronto in 1913, several attempts to publish world coal statistics[7] follow, and all of them are faced with the challenge to bring national data based on diverse classification schemes into a common system.

Coal classification is not merely a problem of knowledge and agreement, but also of the availability of technology that would allow for a detailed analysis of coal. The chemical composition of coal is already well-known in the beginning of the twentieth century. Coal could theoretically be exactly determined, if it were not for an important practical reason: The “ultimate analysis” of coals is a demanding task; it requires a chemist and a proper laboratory. Also, for many purposes, it is not efficient as it produces information unnecessary for a practical classification of coal. In contrast, “proximate analyses” of coals can be conducted by simple, widely used apparatuses like calorimeters, but lack in precision. Hence, the problem of coal classification in the three fields is shaped by the available technology and methods used for analyzing coal, the information it produces and the classification it allows for, as well as the purpose of the classification system.

My point here is that while those three approaches do not conflate, they all try to attain a universal classification of coals by centering around and longing for a determination of the “calorific value” of coal. The calorific value signifies the value of coal in its most common technical utilization: the production of steam (for motive power electricity, etc.). While it was clear “that this only touched the fringe of the question [of coal classification]” (The World Power Conference 1928, 243), it remained nonetheless the primary point of comparison. In engineering, fixing the calorific value of coal promises a simple relation between each bulk of coal and its performance; economically, the calorific value comes closest to being an indicator of the price (at least when sold as unprocessed steam coal); in statistics, the calorific value would make a conversion from one type of coal into another possible. Thus, the point of comparison is the same, while the degree of quantification and institutionalization are still radically different. What is more, classifying coal according to its calorific value also establishes a link to other fuels.

“Coalification” or the engineering classification

Engineers tapped geological and chemical knowledge in order to come up with a scientific classification of coals that would also prove useful in the practical handling of a fuel. More specifically, they tried to find a feature of coal that would allow for coal to be sorted into a meaningful rank. In the US, since 1877, coal had been ranked from anthracite to bituminous coal according to the “fuel ratio,” that is, the ratio of fixed carbon to volatile matter which had been shown “to have a constant relation to the evaporative power of the fuels tested” (Parr 1928, 7). However, this classification had never been a world-wide one, as it had been applied almost solely to American coals, and both determining properties vary substantially as a function of other constituents of coal. As a result, new ways of bringing coal into a meaningful, exact order were explored. Clarence A. Seyler, next to Parr one of the two most important developers of a universal coal classification system, brought up this question on the Fuel Conference in London in 1928. Commenting on the papers, he hold that they:

> raised many interesting questions, among them the meaning of the term ‘the rank’ of a coal. In a general way we knew that this meant the degree of alteration of the original plant material; but how was this to be measured?

The geological “coalification” hypothesis was, albeit widespread, far from being uncontentious. It was generally accepted that every coal had underwent a geological process, but whether they were part of the *same* process, or whether bifurcations had let to differences in composition was still unclear (cf. Wheeler 1928, 203).

To answer those questions, the data basis on coal needed to be broadened, and while nineteenth century classification systems were limited to a regional or national scope, advocates of coal classification in the twentieth century strove for the global application and testing of their models.[8] Also, new methods of analyses were explored. The “graphic studies” of coal analyses, that is, the plotting of several coal properties within a chart and its graphical analysis, was itself an innovation and elucidated hitherto unknown relations between features (The World Power Conference 1928, 244; see, for example, Ralston 1915; Parr 1928).

Apart from plotting the coals, Parr uses another technology of abstraction to reach analytical values: he bases his calculation not on real coals, but on an artificial measure – unit coal. “Unit coal is the pure coal substance considered altogether apart from extraneous and adventitious material which by accident or through natural causes may have become associated with the combustible organic substance of coal” (Parr 1928, 11). Thus, the “unit coal” serves as a theoretically and statistically purified object. As analyses of real coals are notoriously messy, classification should be based on an artificial calorific value (“Unit B.t.u.”), which is represented by the indicated heat value as derived by the calorimeter, divided by the unit coal factor. For the calculation of the non-coal part in coals, Parr required only data on ash and sulfur. So, in theory, Parr’s classification allows for the global sorting of coals on the basis of a few determining factors. At that time, Parr’s system was not the only one introducing conventional, mathematical objects in the classification of coal.[9] Coals, in those systems, vary according to the degree to which they differ from a “perfect coal.” This “perfect coal” exists only as a formula, an abstract point of comparison that allows for assigning values to coals – a statistical “coalification.”

Though nineteenth century classifications based on the fuel ratio were never explicitly expected to be limited to American or British coals, they were neither expected to actually prove their universal application. Only around 1900 were classification systems expected to be based on the analysis of global coal deposits. In this process, new quantified, conventional entities are created, such as the “unit coal.” The primary point of comparison – the calorific value – is not entirely different, but efforts are made to transform it into a more abstract concept, that would enable the recalculation of existing data and the testing of classification system against each other.

Who pays for classification? The economic classification

In another paper presented at the Fuel Conference, R.V. Wheeler links the classification of coal explicitly to its economic value:

> The term coal is conveniently restricted in normal British usage to the black varieties of technical importance. Elsewhere, the term may be, and is, extended to include such fuels as lignites and brown coals, when the deposits are of such an extent and nature as to be of value commercially. (Wheeler 1928, 200)

The insight that what counts, and is studied, as a fuel is as much an economic as a geological question, is voiced time and again (cf. Parr 1928, 5).[10] Before coal is classified according to its features or the purposes it may serve, it needs to be, at least prospectively, commercially mineable. For a long time then, research on coal has been limited to the coals sold by colliery companies, and classification systems have been notoriously bad for low-rank coals that "had been brought into prominence by political considerations" (The World Power Conference 1928, 243). As a point of view that compares the utilization of nature, the concept of energy is in a fundamental way linked to the economic valuation of nature; this is the first point of comparison, the first common feature of resources. Of course, this economic threshold is dynamic and what counts as a resource varies, but it has to be overstepped in order for natural materials to become visible as resources.

Once this barrier is overcome though, more practical classification systems emerge on markets. For instance, coal has been locally and sporadically bought "under a guarantee with regard to heat value, ash content and moisture" (The World Power Conference 1928, 244). Where coal has been exported, recognized brands developed that were expected to have certain properties (The World Power Conference 1928, 255). As long as the useful heat remained the most important factor to the consumer, the information provided along with the coal could reasonably center on the features affecting the calorific value. The analyses those brands were based on did not even potentially allow for a world classification, but were limited to actual trade relations. Probably because coal was mostly consumed close to where it was mined (Mitchell 2011, 32), a global trade classification had not become necessary. But in the age of the rising significance of oil, "there is no doubt that colliery companies are very much behind in their methods (…); very few collieries can furnish reliable and authoritative analyses of the fuels they are offering" (The World Power Conference 1928, 257). When the issue of international commercial standardization was brought up on the Fuel Conference by the Swedish Consul-General E. G. Sahlins, it was met with serious criticism and numerous warnings of a dominance of the scientific side.

> That whatever may be done in this direction (…), such standardisation or classification, whether national or international, should not err to greatly on the technical side, but should be expressed in terms which are capable of comprehension by the reasonable efficient and interested commercial mind. (The World Power Conference 1928, 256f)

In a report presented by a delegate from the U.S. Bureau of Mines, A. C. Fieldner, this tension between scientific and commercial classification is explicitly addressed. To keep the price of commercial analyses low, classifications based on "proximate analyses," like the one introduced by Parr, were preferred:

> The Parr system appears to have most of the advantages of the ultimate analysis system, without requiring the tedious ultimate analysis determinations, for which many commercial laboratories are not equipped. Most coal laboratories are now able to do accurate calorimetric work and to make correct proximate analyses. (Fieldner 1928, 227)

Also, the amount of information provided by coal companies should be reflected in the price, that is, should be directly useful for the consumers, which would otherwise not be willing to pay additional money for analyzed coals. As coal companies wished to factor standardization efforts (i.e. the costs for analyzing the coal) into the price, more complex classification was rather demand driven and coincided with a the use of coal in other, not heat-producing fields. For most purposes, however, classification according to Parr's system based on the calorific value remained suitable.

It is important to notice that the type of classification coal companies were equipped for was not only an economic matter, but affected as well the quality and comparability of resource statistics, as coal companies provided the data on coal production. Thus, economic classification directly influenced the way coal could be classified statistically.

Omit the incomparable – the statistical classification

In 1913, the International Geological Congress in Toronto publishes the first comprehensive report of the world's coal resources, following the success of its survey on iron ore resources a couple of years earlier. On the first World Power Conference in 1924, Sir Richard Redmayne, who advocated the set-up of the Coal Conservation Committee and Fuel Research Board in Britain, gives the Toronto report a second look. As a person working in the field of coal, he summarizes perfectly satisfied that "coal holds the field, and must continue for many hundreds of years to hold the field, as the general source of energy" (Redmayne 1924, 436). Pitting coal against other resources, Redmayne worries little about the classification system of anthracite, bituminous and sub-bituminous coal applied by this survey. On a side note, however, he mentions that "the estimates of the Toronto Congress appear to have been made as if brown coal had not been included in respect of some of the countries," but then goes on by comforting himself that "the omissions will probably be more than fully balanced – certainly in so far as estimates by continents are concerned – by the resources of 'black' coal yet undiscovered" (Redmayne 1924, 422).

Statisticians of all centuries have sought shelter in the fact that wrong numbers might cancel each other out. The interesting point here is that the missing estimates for brown coal were by far not the accidental flaw Redmayne thought them to be. The seemingly wrong numbers of the Toronto report are more likely a consequence of different local coal classification systems at the beginning of the 20th century, which, again, are an expression of the composition of local deposits and their "commercial mineability" (see Wheeler 1928). The "Statistical Yearbook" is fairly explicit: "It is evident that in many countries statistics of brown coal and lignite (…) are not compiled. Foreign trade in these fuels (…) is nowhere of great importance" (The World Power Conference 1936, 16). Countries blessed with anthracite coal might simply not consider their brown coal or lignites as coals, that is, as a relevant fuel, in the first place.

The resource survey of the International Geological Congress remained a one-off project. Within the World Power Conference, however, Daniel N. Dunlop put forward the collection and publication of energy data straight from the beginning. Starting with the "The Power Resources of the World (potential and developed)" edited by Hugh Quigley in 1929, another one-off publication that brought together and discussed data from previous sources, the World Power Conference continued with a more ambitious publication project. The "Statistical Yearbook of the World Power Conference" was conceptualized as a regular survey including data on resources and production of all relevant "sources of energy." In 1931, a sub-committee was formed, which was to work out the details and oversee the whole progress. It reported regularly to the IEC, and major decisions on scope and funding of the survey were discussed there (The World Power Conference 1930, 14). The publication was expected to be of general public interest (The World Power Conference 1933, 34).

The standardizing power of this survey depended very much on the survey forms countries were expected to fill out. When the sub-committee started working, National Committees were encouraged to hand in "draft surveys," which could then serve as a basis for discussion. In reality though, the tables, and most of the "draft definitions for the terms and units employed (…) had been proposed by the American National

Committee" (The World Power Conference 1932, 16). The sub-committee engaged mainly in simplification: in order for the forms to be suitable for a wide range of countries, a number of dimensions needed to be abolished. In the case of coal, the American type of classification into anthracite, bituminous and sub-bituminous coals was abandoned "owing to the lack of international agreement as to how these terms should be defined, and to the fact that the statistics generally available would not permit of the making of separate returns" (The World Power Conference 1932, Annex B). That is to say that in order to be comparable, a less complex classification scheme was applied. In spite of those adjustments, the publication of the first Yearbook had to be postponed several times, because National Committees had to deal with the differences between the form in which data were published by their national agencies and the form used by the World Power Conference (The World Power Conference 1934, 21). This time lag affected resource and production statistics differently, as numbers on annual production do quickly become obsolete while numbers on resources do not. Also, annual production and trade statistics required conversion factors, that would make the different processed types of coal (for instance, briquettes), comparable within a "coal equivalent." The calorific value of coal would in general be a suitable conversion factor, but globally comparable data on the heating value of different products was still not available. The practical way out was to invoke a legitimate conversion factor instead: "Where it was necessary to express lignite in terms of coal, conversion factors as used by the League of Nations would be employed" (The World Power Conference 1932, Annex B).

In the process of compiling statistics, no new classification schemes were developed. At the same time, their scope and comparability were understood to be dependent on further classification and standardization efforts. During the discussions in the IEC, it was oftentimes referred to the "explorative" character of the statistics.

Conclusion

Based on an analysis of the debates on coal classification in the first quarter of the twentieth century, this article aimed at exploring the various social forces at play in the making of "sources of energy." By doing so, it develops the argument that the concept of energy emerges with the practice of comparing resources at the beginning of the twentieth century. Triggered by the war economies, as well as the rise of oil and electricity, resources are observed in a new manner and energy evolves as a specific point of view on resources. Research institutions, political administrations and actors on markets draw more and more comparisons between different fuels and other resources, and this perspective becomes increasingly regularized and institutionalized in the form of reports or annual statistics, for which specific methods and measurement units are developed. Energy, as we understand it today, is a product of these comparative practices.

Notes

1. See for instance Mirowski (1989, chap. 2), Feynman (2011, chap. 4–1) and Smith (1989, 7).
2. It is not by accident that Ernst Cassirer is usually not mentioned in the row of famous physicists or philosophers studying the "discovery" of energy in nineteenth century physics. Cassirers work on "Substance and Function" (1953) is not only one of the most understudied of his works (Blumenberg 1996, 164), it also puts the emergence of energetics into a broader, general process of the mathematization of the sciences. His main argument is more about the relation between mathematization and the emergence of a new type of concepts in the natural science – "functions" instead of "substances," "relation-concepts" instead of "thing-

concepts” (Cassirer 1953, 9). He considered the energy concept to be a symptom of this general trend, a case in point of a “functional” term: “In energy, we grasp the real because it is the effective. (…) The object *is* what it appears to be: a sum of actual and possible ways of acting” (Cassirer 1953, 188).

3. Mach held that energy is less of a new fact to be discovered than a new way of making sense of existing facts (Breger 1982, 70; Mach 1872).
4. In a similar sense in which scholars of the sociology of quantification stress the emergence of categories through counting (Hacking 1982).
5. On the second World Power Conference in Berlin in 1930, E. Haidegger proposes the compilation of “Energy Balances,” an endeavor inspired by double entry accounting and national trade balances. In his calculation of the “energy balances” of Western European countries, he points out that the inclusion of hydro power makes for a special case: “When compiling energy balances, hydro power requires a special treatment. The contribution of hydro power to a country’s annually produced kWh can easily be determined by taking the mean degree of utilization, 25%, as a basis” (Haidegger 1930, 20).
6. The minutes for earlier EC meetings are lost and could not be accessed through archival research in the WPC’s headquarter in London.
7. Data on world coal production are published regularly in the League of Nation’s Statistical Yearbook since 1926, and for some countries even earlier in “The Mineral Industry of the British Empire and Foreign Countries” (1920). Although both production and resource statistics require a standardized classification system, resource statistics additionally face the problem of developing an international classification system of resources (proven, estimated, etc.) and a general lack of data in some world regions. Resource statistics, including coal, appear for the first time on a regular basis from 1936 onwards as Statistical Yearbook of the World Power Conference.
8. After presenting his new approach to coal classification, Parr (1928), for instance, gives over 10 pages of tables, with 4 pages dedicated to a recalculation of the rank of coals from a wide variety of countries.
9. The Gesellschaft für Wärmewirtschaft (Vienna) presents on the Fuel Conference a model that statistically determines the “pure coal substance” (*Reinkohle*) for Austrian coals (The World Power Conference 1928, 46–53).
10. This perspective is today reflected in a radical strand of resource economics holding that resources are infinite as literally anything can turn into a resource depending solely on its price (Fettweis 1979, 156f).

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