Some key aspects at stake in the social construction of energy

by Nicola Labanca

I am a physicist who has been dealing with energy questions for about thirty years. I started in the 1990s working on elementary particle accelerators and continued over the following decades with research on energy policies at Milano Politecnico and, recently, for the European Commission.

While training as a physicist, my teachers never focused on explaining how the principles of energy physics were put into practice and how theoretical constructs were applied in specific socio-technical settings. The chasm between the application of energy conservation and degradation principles to study steam engines and the application of these same principles to, say, study human metabolism or to organize energy supply and demand within societies was never bridged by adequate understanding. I believe that the notion of the social construction of energy is still quite exotic within most technical universities and research organizations focused on energy science and technology.

I began to read the literature on the history and philosophy of science, prompted by my struggles to understand the practical implementation of energy concepts and principles and by my disappointment with how they had been introduced to me as unquestionable givens. My translation of Illich's Social Construction of Energy for *Conspiratio* (this issue) is the result of this ongoing effort to develop a different perspective on energy research and policy. It is with a sense of liberation that I now better grasp the interaction between societies and laboratories in the construction of energy regimes.

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The main insight I gained from this investigation is that a social construction can be, in appearance and fact, a very solid and concrete thing. A social construction does not imply that the resulting artifacts, techniques, and organizational arrangements are imaginary or fragile. Rather, to recognize that much of the energy systems we live with are made and not given is to recognize that they and their associated outcomes are neither necessary nor unavoidable. This simple fact implies that there are always alternatives to the constraints generated by how energy concepts are operationalized within societies. For example, it is taken for granted that energy resources are scarce, that societies are dependent on such resources, and that energy policies should be designed to help societies optimize this inevitable dependence. This logic, while not necessary, drives much of the push to expand the "green economy."

As strange as it may seem, there are still societies where people still live without energy and its organizing constraints. The point of recognizing the social construction of energy is to see that the more we stick to this concept by organizing our lives around associated energy conservation and degradation principles, the more these theoretical ideas are made real and the more difficult it becomes to escape the constraints they generate. To state my thesis clearly: I think that the energy principles used to organize contemporary societies are not natural, and further, that their application contines to transmogrify people and the universe into motors that need to consume limited energy resources.

What I attempt here is to add some elements to the analyses and insights already provided by Illich by discussing the social dynamics occurring around energy at three distinct but interacting levels:

1) The level of technical definitions and procedures established by experts including scientists, engineers,

energy analysts, etc. to operationalize energy principles when analyzing socioeconomic systems and devising intervention policies.
2) The level of social interactions between energy technologies, experts, and societies at large.
3) The level of culture where certain metaphors circulate across societies and disciplines to forge the spectacles through which we look at the world.

Before doing that, I must emphasize that the social dynamics I would like to discuss have nothing to do with questioning the energy laws as established and verified by scientists and technicians within their laboratories. Rather, my effort is to understand how energy concepts are employed to organize human activities outside laboratories and how they shape and have been shaped by interactions between laboratories and everyday life.

Another consideration that needs acknowledgment is that, despite the fundamental role it plays for science and society, nobody seems to know what energy is, including Nobel Prize-winning physicists. For example, Richard Feynman admitted that we "have no knowledge of what energy is," that energy "does not tell us the mechanism or the reasons for the various formulas," and that "we do not have a picture that energy comes in little blobs of a definite amount."[1] Similarly, Percy Williams Bridgman noted that "the energy concept has no meaning apart from a corresponding process."[2]

Though energy laws hold rigorously within laboratories, energy is not a thing of which we can have direct experience. Energy is only evident in specific transformation processes. This is a crucial point to keep in mind when en-

1 Feynman, R.,1964. *The Feynman Lectures on Physics.* Volume I, 4-1

2 Bridgman, P.W., 1961. *The Nature of Thermodynamics.* Oxford University Press.

ergy concepts are employed to design policies and intervene in societies. For example, when policymakers tell us about the need for more energy, we must remember that what they mean is that we need more of a particular transformation process, whether through gas turbines, solar panels, or wind farms. Energy cannot be considered as an entity or a substance that underlies specific manifestations of it. Rather, there are specific transformation processes—a cheetah running, a plane flying, a turbine spinning—to which energy is imputed and computed. I will address some aspects of how this is done when discussing how energy is used to describe and intervene in socio-ecological systems.

Energy negotiations at the technical level

Let us begin with the *technical level* of definitions and procedures established by experts, including scientists, engineers, and energy analysts dealing with energy. The first point to note of what is done at this level is that *it is impossible to quantify energy contents without referring to specific transformation processes.* Without an agreement on a useful accounting framework, it is impossible to discuss the quantification of energy. For instance, the phrase "the energy equivalent of a barrel of oil" is meaningless without specifying how it is used. This is clearly illustrated by Giampietro et al.,[3] who refer to the different ways in which a barrel of oil can be used. They point out that the same barrel of oil can have a different energy equivalent when: (a) burned as fuel in a tractor, (b) thrown against a locked door to break it, or (c) used as a weight to hold down a tent against the wind (p.177).

3 See Giampietro, M., Mayumi, K. (2008). Complex Systems Thinking and Renewable Energy Systems. In: Pimentel, D. (eds) *Biofuels, Solar and Wind as Renewable Energy Systems*. Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-8654-0_8 but also Patterson, M. G. (1996). *What is energy efficiency?: Concepts, indicators, and methodological issues., 24(5), 377–390.* doi:10.1016/0301-4215(96)00017-1

Accordingly, energy is not a thing. There can be many different processes that can be activated by using the same thing (a barrel of oil) and different energy amounts that can be associated with each of them (moving a tractor versus holding a tent against the wind). When quantitative estimates of energy are used to inform policy action, these abstractions serve the social construction of specific transformation processes (e.g., driving cars instead of cycling) in the name of efficiency, progress, and so on.

The second type of social construction generated at the technical level concerns the so-called *joint production dilemma*. This dilemma occurs when a given energy *input* generates multiple *outputs*. In such cases, there is in general no objective way to establish how this input must be apportioned among the different outputs. For example, a given amount of energy input is used by a sheep to simultaneously produce milk and wool.[4] Establishing the energy needed for a sheep to produce a bale of wool requires a social agreement among experts on how much of the total energy consumed by the sheep should be ascribed, for example, to milk and not wool production.

This case of joint production is not unusual, and the ways input quantities and costs are apportioned across different outputs are always arbitrary to some extent. Societies can use the same material inputs for a variety of different purposes just as people and animals use the energy they get from what they eat for a myriad of bodily functions. Whenever scientists, researchers, and policy analysts assess how energy inputs are linked to different outputs (e.g., factories using given energy inputs to produce a variety of outputs or households using the same gas inputs for cooking, space, and water heating) they are always required to establish agreements on how to allocate this apportionment.

4 Giampietro et al. provide the similar example of a camel to discuss the joint production dilemma (p. 177).

The third and last type of social construction of quantitative energy assessments is necessitated by the unavoidable arbitrariness entailed by the so-called *truncation problem*. Social agreements necessitated in this case concern the number of inputs and related energy amounts to be associated with the production of the *same* output. As again mentioned by Giampietro et al., the literature on the energetics of human labor provides a nice example. Consider the flow of energy embodied in one hour of labor. This can refer to any of the following: (i) the metabolic energy of the worker during the actual work only, including or excluding the resting metabolic rate; (ii) the metabolic energy of the worker, including non-working hours; (iii) the metabolic energy of the worker and his dependents; (iv) all embodied energy, including a share of commercial energy spent in the food system to provide an adequate food supply to the population; (v) a share of all the energy consumed in societal activities; or (vi) a share of the solar energy spent by the biosphere in providing environmental services needed for human survival (p. 178).

Accordingly, Giampietro et al., observe that due to the different assumptions that can be taken, "rigorous scientific assessments of the 'energy equivalent of 1 hour of labor' found in the literature vary from 0.2 MJ to more than 20 GJ, a range of the order of 100,000 times!" The quantification of an energy input required for a given process (or an energy output) depends heavily on the choice made when defining the boundary of that process.

Overall, the descriptions and assessments of natural systems in terms of reproduced functions, produced outputs, and/or consumed resource inputs require the establishment of social agreements and standards to retain some meaning and usefulness. The separation between inputs and outputs that these descriptions and assessments entail is completely artificial and generates attribution problems that are always at least partially arbitrary.

How many outputs might I be producing while driving home from work? These outputs might be represented by miles traveled per hour, relaxation (or stress) produced in my body while driving, words produced while speaking with someone through the car phone, and many other activities that might be imputed to myself and my car during the journey. The level of arbitrariness in the definition of the outputs is inevitably reflected in the attribution of a determined energy consumption level to each output.

The discussed artificial separation and dichotomy between inputs and outputs also legitimizes policy intervention focused on the substitution of energy and technological inputs, for example, when it comes to devising solutions to reduce the environmental impacts of human activities. Based on this assumed separation, the European Union has estimated the energy impacts of regulations and directives implemented to induce first the wholesale substitution of incandescent light bulbs by compact fluorescent lamps (CFLs)[5] and then the substitution of CFLs by light-emitting diodes (LEDs).[6] These regulations and directives have been designed based on assessment studies[7] where energy savings associated with these substitutions have been established 1) using estimates of the amount of energy saved by each CFL (or LED) installed to substitute for an incandescent light bulb (or a CFL) and 2) on the assumption that the set of outputs is constant across the different inputs. Unfortunately, changing the inputs also changed the outputs, leading to

5 See https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX-:32009R0244

6 See https://www.eceee.org/all-news/news/eu-commission-adopts-regulation-to-ban-fluorescent-lighting-by-september-2023/

7 See for example VITO, "Preparatory Studies for Eco-design Requirements of EuPs: Project Report Lot 19: Domestic lighting," 2009.

assessments that overestimated the actual energy savings.[8] Among other factors that may account for this discrepancy is the large-scale commercialization of energy-saving technologies, which caused new unexpected applications. For example, unlike incandescent bulbs, LEDs are being used to grow plants, illuminate billboards, purify water and air, etc.

Inputs and outputs are generally not independent. They co-evolve unexpectedly, in both good and bad ways. Whenever new technologies replace existing ones, they typically trigger unexpected changes in their field of applications that can defeat our attempts to foresee their energy impacts. Human activities must be reduced to a limited number of standardized operations when managed through the lens of scientific energy constructs. Although necessary to manage resource flows for populations at a large scale, seeing through this lens also blinds us to non-standard styles of life that do not depend on typical energy transformation processes.

Energy negotiations at the societal level

Illich's essay provides a series of relevant insights into the social interactions between technologies, experts, and society that I will not repeat here. What I would like to highlight is a key dynamic that seems to be at the root of these interactions, a point I've discussed in more detail elsewhere.[9] When central metaphors developed around energy are literalized, they overwhelm and blot out the underlying phenomenon being described or understood. Such literalization implies forgetting the distinction between the phenomena a metaphor

8 Schleich, J., Mills, B., Dütschke, E. (2014). *A brighter future? Quantifying the rebound effect in energy efficient lighting*. Energy Policy, Volume 72, Pages 35-42, ISSN 0301-4215

9 Labanca, N. (2017). *Ontological Fallacies Linked to Energy, Information and Related Technologies*. In: Labanca, N. (eds) *Complex Systems and Social Practices in Energy Transitions*. Green Energy and Technology. Springer, Cham. https://doi.org/10.1007/978-3-319-33753-1_8

attempts to bridge. For example, assume that when we say "Mr. Smith is a Lion" we constantly and completely identify the person of Mr. Smith with a lion, thereby engaging in a sort of tribal ritual. In these ritual transformations, the Lion becomes so magnified as to completely overshadow Mr. Smith's identity in the interactions we have with him, so much so that we lose the capacity to distinguish the context where Mr. Smith lives his everyday life from the context where the statement "Mr. Smith is a Lion" holds. This exaggerated example nevertheless shows how the literalization of metaphors developed around energy is transmogrifying ourselves and our environment. Nowadays, almost everybody thinks of coal as just an energy producer and of cars as merely energy consumers.

A particularly interesting case of this literalization is represented by the ritual practices developed around the metaphor "labor is energy." This is an organizing metaphor for societies everywhere and fundamentally shapes the everyday lives of people —from daycare and schooling supposed to develop human capital to technologies that increase labor productivity. Given the role it plays within societies, it would be false to suppose that this metaphor is a mere figure of speech. Instead, it is validated by specific actions and thereby constitutively organizes social dynamics. For example, the "weekend" is a worldwide institution established for working people to conserve and recharge the energy they expend during the week. Similarly, wages and salaries are paid as a function of the time spent at work, which is considered a resource equivalent to the energy expended while working.[10] Thus, pervasive social patterns are diffused by literalizing the theoretical notions of energy conservation and degradation established by physicists and engineers in the laboratories.

It is then worth emphasizing that the metaphor "labor is energy" identifies two terms—one of which (energy)

10 Perulli, A. (1996). *Il tempo da oggetto a risorsa*. FrancoAngeli Editore.

refers to a concept and its related operational definition produced by science, while the other term (labor) refers to a series of embodied interactions with the physical world. In the process of literalization, the energy concept functions as a kind of black hole into which the myriad alternative ways of understanding and engaging with the world evaporate into the empty shell of a scientific concept. The scientific concept of energy creates a void of meaning because, as such, it has no meaning, and when applied to activities in daily life, has merely symbolic value. Therefore, the metaphor "labor is energy" is a catachresis.[11]

These arguments might be disputed on the grounds that energy is not a metaphor, but a real entity of which people can have direct and physical experience, such as when they receive an electric shock or when their body is warmed by solar radiation. The answer to this objection is that the direct experience of such transformation processes does not allow the inference of the existence of a universally conserved and continuously degraded entity that has been named "energy" by scientists and whose meaning is questioned by the scientists themselves.

Energy negotiations at the cultural level

The final dynamic concerns how social constructions occurring around energy act at the *cultural level* through the circulation of certain central metaphors across societies. Energy concepts have coalesced within societies around metaphors of motors and steam engines.[12] However, the validation of the literal interpretation of the energy metaphor does not exclusively come from activities organized around

11 See https://en.wikipedia.org/wiki/Catachresis

12 Rabinbach, A. (1990). *The Human Motor: Energy, Fatigue and the Origins of Modernity*. New York: Basics Book.

motors and steam engines. Philip Mirowski has shown that the societal validation of energy is most probably the result of mutual reinforcement and validation across different scientific fields: metaphors of motion in physics, metaphors of value in economics, and metaphors of the body in biology.[13] The ceaseless literal interpretation of the energy metaphor should therefore be seen as the result of the joint and mutually reinforcing constructions of invariants and conservation principles across the fields of physics, biology, and economics. Mirowski points out that the structures of explanation produced in these three different fields are homomorphic and might legitimize each other even in the face of possible disconfirming evidence produced in any particular field. The mutual reinforcement across these scientific fields started when the institution of money was disconnected from any specific commodity and became the representation of pure value; when the dual concepts of species (as entities that can be distinguished and separated from an external environment) and natural selection were established within the evolution theory of Darwin; and when energy conservation and degradation principles were established by physicists and engineers around the mid-nineteenth century. In my opinion, the idea of mutual reinforcement across explanatory structures in different sciences goes a long way to explaining how and why certain metaphors take a deep hold in a culture.

Energy conservation and degradation principles were invented together with fossil fuels and these principles still hold rigorously in the laboratory. Nevertheless, we are nowadays moving towards renewable sources, which are highly fluctuating and variable energy sources. The fossil-fueled economy is constituted through materials that can be stocked

13 Mirowski, P., 1989. More Heat than Light. Economics as Social Physics, Physics as Nature's Economics. Cambridge University Press.

and used when needed. In contrast, solar radiation is a flow that fluctuates unpredictably and in ways wholly beyond our control. Whenever we stock it within batteries or other materials through given energy transformations, we lose large amounts of usable energy. Therefore, we must rely as much as possible on information networks to employ or redirect renewable energy from the point of generation to end-use points without storing large quantities of it. This is a very general trend going on within societies, well beyond the narrow issue of transmitting energy. Through information theory and information networks, we are learning that local storage of energy sources, materials, competencies, and skills of any kind can be highly inefficient and has to be avoided.

Just as metaphors of steam engines are thereby being superseded by metaphors of *information processors*, equilibrium physics is being englobed by far-from-equilibrium physics. Rather than species understood as entities distinct from their environment, bodies are thought of as *holobionts* composed of species in symbiotic interaction;[14] and, rather than the result of an equilibrium between demand and supply, economic value becomes the non-equilibrium outcome of agents that constantly change their actions and strategies in response to conditions that they themselves create.[15]

Energy, bodies, and economic value became entities that could be separated and abstracted from their environment when coal, oil, natural gas, and other carbon-based materials became resource stocks that could be extracted from the soil to fuel Western societies. Nowadays, these same societies are increasingly relying on information networks and

14 Simon, J.C., Marchesi, J.R., Mougel, C. et al. Host-microbiota interactions: from holobiont theory to analysis. Microbiome 7, 5 (2019). https://doi.org/10.1186/s40168-019-0619-4

15 Arthur, W.B. Foundations of complexity economics. Nat Rev Phys 3, 136–145 (2021). https://doi.org/10.1038/s42254-020-00273-3

fluctuating flows of solar radiation. As this happens, energy, bodies, and economic value are becoming relational entities that result from tight interactions with an everchanging environment and that can hardly be defined within delimited and fixed boundaries. The mutual reinforcement among metaphors and structures of explanations across the different disciplines of economics, biology, and physics appears to still hold despite the radical changes occurring in each field.

Conclusion

As already mentioned, this paper does not aim to question energy conservation and degradation principles or the fundamental role energy conversion processes play within societies. Contemporary societies are using huge amounts of natural energy resources to provide for their needs and wants. The situation seems to be destined to worsen, not least because of its impact on the climate and environment in general. Addressing this issue in energy terms is therefore inevitable and necessary. The point I am making is that approaches informed by technoscientific energy considerations should not claim exclusivity. Such views become detrimental when not complemented by alternative views that reflect the diversity of social practices, processes, and capacities of people to provide for themselves. Addressing the problem of resource conservation in terms of energy necessarily transforms a political question of how to live into a technical problem requiring an expert solution. It is therefore urgent to complement technocentric approaches with approaches where citizens are more actively engaged.

Rather than focusing on substituting cars and fuels with more "sustainable" technical input solutions, let's also consider and give more credit to the varieties of context-dependent approaches whereby people can reorganize their mobility practices in cities (e.g., by reimaging urban planning, changing mobility practices related to shopping, labor, leisure, etc). Rather than focusing on more efficient refrigeration technologies, let's also consider how food production, distribution, and consumption can be re-organized to improve the quality of what we eat while reducing associated energy impacts and dependency on refrigeration (e.g. through autonomous initiatives represented e.g. by solidarity purchasing groups, zero-Km food, etc). Rather than solely focusing on the construction of more energy-efficient buildings, let's also consider how increased comfort can be achieved by changing dress and living habits (e.g. by using jumpers/shorts indoors during winters/summers or by sharing living spaces). The technically created dichotomies between inputs and outputs can thereby be reduced and energy demand and supply reimagined.[16]

Energy invites us to think that whatever we do, we end up consuming differing amounts of the *same* natural resource input. By sticking to this view on a large scale, we socially construct a world in which humans everywhere behave in the same way. This is one of the main reasons why people end up consuming ever more amounts of energy resources and why policy measures devised to reduce energy consumption will be restrictive and unfair. In contrast, when we can change our way of life, we can identify a variety of ways to do things differently and in ways that increase our well-being while also reducing energy dependency.

16 Labanca N. et al. (2020). Transforming innovation for decarbonisation? Insights from combining complex systems and social practice perspectives. *Energy Research & Social Science*, 65, 2020, 101452, ISSN 2214-6296, https://doi.org/10.1016/j.erss.2020.101452.