Energy Knowledges

Elizabeth Shove, Centre for the Study of Environmental Change, Lancaster University

Synopsis

This paper examines practical and theoretical issues arising from the fact that experts and consumers have different ways of conceptualising and measuring energy consumption.

Abstract

James Thurber's grandmother "lived the latter years of her life in the horrible suspicion that electricity was dripping invisibly all over the house" (Thurber 1963, p168). The idea that electricity might leak from empty light sockets is both bizarre and at the same time strangely plausible. Delivered in a variety of forms, gas, electricity, oil, coal, wood etc.; energy permits countless services and is embodied in almost everything we find around us. Both everywhere, and nowhere, it remains a mysterious if not magical feature of everyday life. So the image of leaking light sockets is appealing not just because it is a quaintly ridiculous idea conjured up by a confused old lady but because it precisely articulates lingering uncertainty about the intangible qualities of this most pervasive resource. Taking the invisibility of energy as a point of departure, this paper explores the different kinds of knowledge we have of energy use. Although the technologies of domestic energy measurement are familiar enough, we know what a meter looks like and we all get energy bills, it still requires an act of faith to believe in the "reality" of energy consumption. Those who have learned the official languages of energy efficiency have access to richer vocabularies of revealing terminology and can talk more confidently in terms of kilowatts, U values and the rest. But how do these different knowledges relate, and how do different ways of knowing energy influence perceptions of the possibilities and problems of energy conservation? In exploring these issues, the paper re-examines theories of energy and knowledge implicit in energy policy and energy related research.

1. Introduction

The routine invisibility of domestic energy consumption presents special problems for energy conservation. To start with, it is impossible to know that you have made energy savings without first finding some way of identifying and quantifying energy consumption. There are different ways of going about this task and, as might be expected, professional and expert languages of energy measurement differ from those adopted by householders and energy consumers. To some extent this simply represents the range of questions asked about energy performance. For instance, energy modellers need to develop ways of measuring the thermal performance of a wall in order to calculate the likely benefits of new forms of insulation. Meanwhile, householders' interests in measurement typically revolve around size of their fuel bill. Despite these differences of interest, there is a sense in which these two languages of energy conservation, one of U values, the other of money, merely reveal different dimensions of energy performance. In other words they seem to represent alternative ways of describing the same thing. Going further, it is possible to argue that one language is "better", or more comprehensive than another. For example, professional conventions of measurement appear to give experts access to more complex, more accurate, representations of what is really going on than the comparatively limited vocabularies of householders and consumers. Although few would expect householders to be able to reel off the U values of their walls roof and floor, there seem to be good reasons for extending consumers' understandings of energy consumption. Equipped with more refined methods for measuring, comparing and evaluating energy consumption, they will be able to make more informed decisions. Or at least that is the theory.

In short, the conventional view is that energy use can be revealed in different ways and that alternative measuring technologies and methodologies uncover different aspects of energy performance. In addition, it is commonly accepted that more and better knowledge allows consumers greater control over this elusive commodity. Hence the idea that the future of conservation depends, in part, on modifying the interface between lay and professional languages of energy use and of giving consumers a "better" idea of what is going on.

The rest of this deliberately speculative paper takes issue with some of these propositions. The first part mixes ideas from the philosophy of science together with examples first from passive solar research for the UK's Energy Technology Support Unit, and then from a study of the cavity wall insulation industry for the UK's Building Research Energy Conservation Support Unit. This exercise suggests that methods of measuring energy actually help to constitute their subject. In other words, languages of measurement are not innocent or neutral mediators of reality but are themselves "theory laden". As a result, what counts as energy for the professional energy analyst or computer modeller is not what counts as energy for the consumer, or the insulation salesman.

The notion that what counts as energy is - for most practical purposes - determined by how it is known and experienced is not especially contentious. It is a notion which rings true even, or perhaps especially, when we remind ourselves of the range of energy discourses which make up contemporary debate. Just think, for instance of the forms of energy analysis undertaken by the international policy community, or by building scientists, building designers, utilities, or environmental pressure groups. These investigations encompass a really wide spectrum of aggregation, from individuals through to nation states, and a correspondingly varied set of time frames, from minutes and seconds through to years and decades. And in each case, records of energy consumption may be viewed as records of a static or a dynamic feature, as an end result or a moment in an iterative process of feed-back and review. As the bewildering array of units, indices, ratings, and labels reminds us, measures of energy can be, and often are, cast in the very different languages of economics, thermal performance, and environmental impact. Although we recognise all this, it is still hard to swallow the theoretical and policy implications of the view that energy is most usefully understood as a form of knowledge or to conclude that different methods of measurement generate different types of knowledge and hence construct what are, in effect, different forms of energy. Perhaps that is going too far. Yet it is an idea worth pursuing. At the very least, it promises to bring a new perspective to bear on our understanding of the interface between experts' and consumers' knowledges.

Framed in this way, the challenge is to understand how experts' energy discourses relate to each other, and how they connect, if at all with consumers' conceptualisations of consumption and conservation. The last two sections of the paper review recent developments at precisely those points at which lay and professional languages of energy use intersect. Re-examination of the introduction of new metering technologies and of energy labelling from this point of view suggests that such initiatives, which involve tampering with consumers' knowledge and conceptualisation of energy, effectively modify the meaning of energy itself. There are two ways of interpreting this conclusion. At one level it makes little practical difference. After all, who cares how people conceptualise energy as long as they use less of it. At another level, the argument that different methods of measurement actively constitute their subject (and do not simply provide more or less effective ways of showing what is really going on), implies quite a radical theoretical re-orientation for those seeking to reduce energy demand by changing (or improving) peoples' knowledge. Strategies designed to "get the message across", across, that is, from experts to others, revolve around the notion that however difficult it might be in practice, such transfer is conceptually straightforward. Although not involving quite the same transfer of expertise, initiatives to enhance understanding of energy use by means of feed-back have the similar ambition of improving *knowledge about energy* consumption. But by looking at *energy as knowledge*, we begin to problematise these ideas. Such a switch of perspective also forces us to think much harder about conceptualisations of energy within different domains.

2. Identifying Energies

But first let us explore the idea that energy is effectively constituted by the languages and measuring devices through which it is known. Consider, for example, the ways in which energy is conceptualised by two very different constituencies: solar energy analysts; and door-to-door insulation salesmen. Both face the challenge of identifying and making sense of something which is invisible.

2.1 Capturing the Sunshine

The ability to produce a building which can be shown to make good use of passive solar energy requires considerable methodological ingenuity. Although we all "know" that solar energy is there, we cannot simply refer to a sun meter, nor check the files for last year's solar bill. If they are to make claims about the merits of passive solar design, researchers have to devise methods for comparing or simulating comparison of buildings which are equivalent in all respects other than the way they capture and use solar energy. This is a demanding exercise, as illustrated by the CEC project PASSYS: "from 1986 to 1993, the CEC conducted a large concerted research action in the field of energy in buildings" involving 60 researchers from 28 institutes and 10 European countries, all striving to "develop advanced tools for a better understanding and more confidence in the solar and thermal performances of buildings and building components, especially passive solar components" (Wouters and Vandaele 1993). But how can even these researchers pin down the sunshine, and how can they isolate and quantify its benefits?

Facing a similar problem, researchers working on the UK's Energy Technology Support Unit Passive Solar House Design Study, went to considerable lengths to compare, by means of computer simulation, the energy characteristics of (a) a reference house, (b) an upgraded reference - which was the reference house with added insulation and (c) a passive solar version of (b), but with a different distribution of north and south facing glazing, a conservatory, or sun space, and so on. By means of careful and sequential subtraction, computer analysts were able to tease apart the relative contribution of incidental gains (from people, appliances etc.), "auxiliary" heating (from boilers and heating systems), and what was left - in other words, solar gain. Further refinement allowed them to distinguish between solar gain in general and "useful solar gain", by which they meant that which reduced the demands made of the auxiliary heating system.

In this example, solar energy finally makes its appearance through, and only because of, a forest of methodological conventions. For the purposes of these studies, solar energy is the product of a series of debates and agreements about measurement, distribution, addition and subtraction. To get this far, researchers have to take for granted further layers of technical and methodological procedure: for instance, they have to build on theories of thermal performance, on accepted ratings of different materials, on models of how materials interact to influence total building performance, on the relationship between indoor and outdoor climate, and so on. Although such conventions are pretty well established there are nonetheless important and revealing areas of uncertainty and points of difference. For example, in the UK, architects and quantity surveyors do not share the same conventions of measurement. When it comes to quantifying area, surveyors seek to account for the whole structure, not just the "usable" space within a room. Calculations of energy performance, and indeed estimates of solar energy therefore differ if based on architects' or surveyors' descriptions of the building.

In this subtractive approach, estimates of solar energy depend on estimates of incidental gains: in other words on estimates of the nature and character of average activity within an average household (Bartholomew 1994). Despite their central role in the representation of solar energy, calculations of average activity are fraught with uncertainty.

Technical researchers can of course reach agreement about measurement conventions and procedures for quantify average activity but even this is not enough. As the authors of the ETSU overview report observe, there is still "no single method for determining good passive solar design ...each of the separate analyses used in this overview has limitations", (Boss, Orbalsi and Sutcliffe 1993, p35). In other words further negotiations are required about how to interpret separate strands of analysis and about how to add these together to estimate useful solar gain.

The point is not to criticise this study or others like it, only to underline the levels of methodological convention and the range of expertise required to drag solar energy out into the open. It is only by working their way through a rather specific sequence of organising abstractions that researchers can "see" what is happening. Moreover, they can only "see" through methodological spectacles of their own making. In this respect, solar energy research, along with "such discourses as economics, medicine, grammar, the science of living beings give rise to certain organisations of concepts, certain regroupings of objects, certain types of enunciation, which form, according to their degree of coherence, rigour and stability, themes or theories.... " (Foucault 1972, p44). It is tempting to pursue these parallels further but rather than getting deeper into the discourse of solar energy research let us now turn to the more mundane subject of cavity wall insulation.

2.2 Selling Insulation

Imagine an October evening in the leafy suburbs. An insulation installer stands on the door-step of No 27 Arctic Avenue, Chillsville. With an address like that it could be his lucky night. Lucky, that is for selling energy efficiency. Installing cavity wall insulation represents the single most effective energy saving measure a householder can take (EEO 1991) so there is no doubt our man is selling efficiency. Or is he? His boss would say he is really selling mineral wool. But who would buy a pile of mineral wool without some very good reason? In which case its not the wool itself which is at stake but the promise of the benefits it will bring. And to sell such ideas and promises, as our installer knows only too well, he has to sell himself, confidence, not mineral fibre, being his real stock in trade.

The door opens and the pitch begins. One option is to talk about the U values of walls, floor and roof. Another is to broach discussion of incidental gains, auxiliary heating and solar utilisation factors. Taking a seemingly easier route the installer can conjure up equally fantastical images of pound notes vanishing through the fabric of the house. Or he might sell his wares as a "cure" for condensation. As if condensation were an illness and the salesman a doctor offering patent remedies to those for whom all other prescriptions have failed. Then again he might draw on a new repertoire of catastrophe: rain forests slashed, ozone holes appearing, global warming getting out of hand. By offering to sell insulation the installer then provides householders with a way of doing something to "help the ozone problem" (the veracity of such environmental reference is of little significance) and which is in the national, perhaps even global, interest. Once seated in the living room he might make use of other more homely images, perhaps pointing to the humble tea cosy to help make his case. As these examples suggest, sales pitches tap into images and latent understandings of what energy is all about. They also highlight what energy and energy efficiency really means to individual householders.

Interviews with some 24 insulation installers (Shove 1991) confirm the view that "it is talk that sells the product", and that in most cases it is the promise of comfort which is the real attraction. Not the science of energy efficiency, not payback period alone, nor the size of the fuel bill, but comfort. That is what counts. So how is comfort represented? For individual householders it is translated into all sorts of proxy measures: how near the window can you put the settee? how long is it before you need to put on more than a dressing gown? Such are the terms of domestic energy discourse.

Of course comfort comes at a cost and, in the domestic context, economics remains an important measuring device for energy, as for much else. What energy means is money as well as comfort. But in the hands of our installer, economics is a slippery subject. Having built up a perception of the worth of cavity wall insulation - through reference to comfort, the environment, the tea cosy etc. - installers then cash in on the apparent bargain represented by the proposed deal and on the anticipated savings which lie ahead. In setting a rate for their services, they make judgements about what they think the customer can pay and about what the customer will count as a "bargain". Pay back periods (important in both domestic and in professional languages of energy efficiency) bob up and down in the ensuing process of bluff and double bluff as customer and installer work their way through a ritual game of tag: customers know that cavity wall insulation will save them money but they don't mention this for fear that overt recognition of significant savings might encourage the installer to quote a higher initial cost. Meanwhile the salesman knows that this is what the customer thinks and maintains the illusion of his own ignorance. The actual costs of labour, materials and office overheads provide little more than a distant baseline though the "rose bush factor" (that is the installers' estimate of the likely fussyness of the customer, and hence the risk of complaint and hassle, as indicated by the condition of the front garden) can be of real significance. In this rugged world of real life economics, everyone knows that rose bushes, sharp suits and confident sales techniques complicate the calculation of pay back periods. Yet the specification of future savings has an important part to play in the door-to-door representation of the otherwise abstract notion of energy conservation.

As these examples suggest, insulation installers and their customers make energy visible in a variety of different ways. They do not rely on computer simulations but depend, instead, on an array of images, judgements and acts of faith. By these means, customers come to believe in energy, trust the installer and accept the promise that insulation will lead to greater comfort and lower fuel bills.

2.3 Measuring conventions

The two instances described above, one relating to solar energy, the other to insulation, suggest that measurements of energy are matters of convention. Unearthing the social and cultural history of the British Thermal Unit, the Kilowatt hour or the U value would have similar effect, also showing that measuring devices and conventions themselves depend on certain theories about the social and physical world.

This suggests that householders and solar energy experts do not merely see different aspects of the same thing: that is, "energy". Here, as elsewhere, it is not quite right to argue that "The layman sees exactly what the physicist sees"... but "cannot interpret it in the same way because he has not learned so much" (Hanson 1981, p263). Instead, it seems that layman and physicist, energy expert and energy consumer, see different things because different "theories and interpretations are "there" in the seeing from the outset". As Hanson puts it, "There is a sense, then, in which seeing is a "theory-laden" undertaking (Hanson 1981, p270).

Developing this line of argument, it is important to distinguish between the different discourses of energy alluded to earlier for each brings with it a different conceptualisation of its subject. Again much of this is familiar. We know, for instance, that the presentation of "energy" in terms of money, or the preservation of finite resources, or the reduction of CO_2 emissions leads observers to make different recommendations and inspires different sorts of policy actions. The table below is illustrative of the variety of knowledges at play. In each cell, methodologies of quantification and representation have the role of constructing what counts as energy.

	Energy as money	Energy as thermal performance	Energy as environment, CO_2 emissions	Energy as service	Approach to revealing energy
Professionals, Utilities, Designers, Technical researchers, Policy Analysts, Economists	Languages of energy costs, represented in terms of nation states, sectors, properties, etc.	Languages of U values, Kwh, BTUs, etc. per unit of area, time, etc	Languages of CO_2 emissions associated with forms of energy use	Hard to grasp, even by utilities	Physics, experimentation quantification, computer simulation
Users, consumers	bills, meters, etc.	labels on houses or appliances	labels on houses or appliances	Experiences of comfort and convenience	Black box of process, energy as magic, belief and faith

Languages and methods of representing energy

In the next sections of the paper I want to reconsider the relationship between these languages and ways of "constructing" energy. Is each cell a bounded domain unto itself? Does each imply an exclusive paradigm (Kuhn, 1962)? Alternatively, are lay understandings of energy best seen as "low level" simplifications and translations of the "higher level" concepts shown above? This is a key question for those who seek to provide consumers with more and better knowledge whether by transferring expertise from the top half of the matrix to the bottom row or through developing new representations of energy, for example, by providing regular feed-back on energy use or by changing the role and function of the energy meter.

3. New Knowledges

In thinking about these issues it is useful to focus on two specific examples: the development of new metering and billing methodologies and the introduction of energy labelling.

3.1 Meters and bills

The gas or electricity meter and the energy bill stand at the interface between consumer and utility. As such they represent cross-over points between the knowledge systems of these two domains. However, meters and bills are not neutral “players” in the historical evolution of this interaction (Hughes 1983). As Madelaine Akrich suggests, “Each individual meter intervened as referee and manager of the relationship between supplier and consumer” (-Akrich 1992, p218). In the early days when meters did not exist, billing depended on such crude measures as multiplying the number of gas jets or light bulbs by a flat rate (Guy 1995) and energy was a uniform commodity. The introduction of different tariffs for day and night-time use marked an important symbolic shift in this arrangement. Such a move effectively created two quite distinct types of energy, namely a cheaper night-time time version and more expensive day-time variant. This re-definition in turn depended on a significant restructuring of the sociotechnical organisation of energy supply around the newly installed meter. For there to be two rates, and two types of energy, both utilities and consumers needed to know where they stood, hour by hour, with respect to energy use. The meter was thus both the occasion, and the precondition, for the re-definition of energy. Counting light bulbs simply would not do for although the behaviour of electrons was unchanged, energy had become more complex.

The idea that energy changes with the means by which it is known applies just as powerfully with respect to the introduction of “smart meters” or the re-design of energy bills.

The development of smart meters which have the capacity to switch selected appliances on and off at different times of day, whilst also recording consumption and feeding information back to the utility control station implies a further re-definition of energy for utilities and for their customers. As Simon Guy explains, such technologies take energy “beyond the meter” (Guy 1995, p29), moving both consumers and providers from a world of energy as recorded fuel consumption into a new realm of energy as knowledge, service and control. In purely practical terms, interaction between utilities and consumers depends on what each party thinks is being bought and sold. Do electricity companies simply sell electricity or do they see themselves as selling the means to make toasters, televisions and night store heaters work? The technology of metering makes a difference both to the perception of this relationship and to its substance. In these respects, the transition from light-bulb counting to smart metering represents much more than a technological advance for it also transforms associated understandings of energy services.

Less dramatically, the idea of showing customers how their energy consumption compares with that of their neighbours serves to re-define energy bills as a medium of social comparison or as key elements in a learning process, rather than or as well as a one-off record of past action. In creating a new kind of energy knowledge these bills do not simply provide “better” information about energy consumption (Egan, 1996). By changing the frame of reference and the context in which knowledge is situated and approached such schemes do something else. If we are to follow the argument summarised by Hanson, what’s changing here is not the quantity of knowledge but the conceptual organisation of energy. In other words, alternative display options have the unintended but important consequence of modifying what energy means to people. This may (or may not) have the effect of reducing fuel consumption. But in the context of this argument, the point is that rather than representing raw data in ways which are more and less readily interpreted, or which generate more and less “accurate” interpretations, such techniques revise the meaning of energy itself. In terms of the perspective we are exploring here, it is misleading to evaluate different ways of designing energy bills in terms of the extent to which they create a “better” understanding of what is really going on. Instead we should see each new representation as an addition to the range of ways in which energy can be conceptualised: as social discriminator, as commodity, as service, and so on.

Although positioned at the interface between customer and provider, metering and billing technologies do not simply filter knowledge from experts to households or from suppliers to buyers. As suggested above, modifications to the ways in which energy is known (whether by metering or billing), have implications for the conceptualisation of energy on both sides of the divide. When forms of representation and understanding change there is a sense in which utilities sell something subtly different and a parallel sense in which meanings of consumption are similarly modified.

3.2 Labels

Something of the same process can be seen with the development of energy labels. Labels for domestic appliances like fridges, washing machines, and dishwashers also occupy a key position at the interface of professional and consumer knowledge. In most if not all cases they form part of a deliberate effort to translate technical measures of energy consumption, capacity and sometimes performance into a consumer oriented language which can be understood, interpreted, and acted upon by the ordinary shopper. By means of a label, really elaborate chains of argument, measurement and assumption work their way on to the shop floor.

The guiding logic is the same above: better informed consumers are expected to make better choices, hence the importance of clear, accurate and informative summaries like bills and labels. There are, of course, obvious differences. The history of the energy bill parallels the commodification of energy supply. By comparison, labels are relatively recent inventions. In a sense they really are additions, temporarily attached to objects as they pass through critical moments in the narrative of specification, selection and acquisition. Once safely installed in the kitchen, the label can be peeled off. So what is the role of this transient sticker, and what is its relationship to the thing on which it is stuck? Again the conventional view is that labels provide information *about* energy consumption. And as with energy bills, the story is that they do so more and less effectively depending on their design, and on the ease with which they can be read and interpreted: “An important factor for consumers is the ability to interpret the information on the labels” (Boardman et. al. 1995, p21).

But this analysis short circuits critical elements of the labelling process. In many ways the effective introduction of labelling is much like the effective introduction of a whole new product. Demand has to be created from scratch and social conventions established. What did the first people to ever view an energy labelled fridge make of this new sign and the ideas embodied in it? More important, what is the process involved in converting such a one-off, isolated symbol, into a meaningful system of evaluation and comparison. After all a label on its own is not much good. Labels only have effect relative to one another and for there to be any effect at all, potential label readers have to learn the conventions of a whole new sign language. This is a matter of collective social process, not only of individual interpretation. In making sense of the development of labelling we would do well to refer back to “labelling theory”, as developed and used by sociologists such as Becker (1973) , or even Cohen (1972) and ask ourselves what is involved in the social construction of consumers as label readers?

Again different answers are possible. One is that the label makes visible previously obscure features, but features which were there all along, like energy use. Another is to suggest that making energy a consideration where it was not before involves changing the nature of the product by giving it a substantially new dimension. In other words, people do not only conceptualise a labelled-fridge as something which keeps food cool and which has other important fridge features such as silence and indefatigability (Schwartz Cowan, 1985), but they can, and in a sense have to, see it as something which has a further novel property relating to its use of energy.

Labelling strategies differ in terms of the units and scales adopted(from 1 to 10, 10 to 1, 1 to 100 etc.) but in all cases the first challenge is to create a context in which the chosen language carries some meaning. Whatever else, this suggests that labelling is an active and a dynamic process involving an implicit dialogue between labellers and readers. From this perspective, it makes little sense to talk baldly of the consumer “impact” of a label, or to measure the effect of labelling as if it were a one-way form of communication from expert to consumer.

Though seen as means of representing complicated scientific facts in simple terms, labels appear to have a social life of their own. Rather than simply jumping the divide between the top and bottom row of the matrix above, they seem to foster and at the same time depend upon the creation of new energy languages within the user/consumer domain. Again the effect may be beneficial, but again that is not the central point of this paper.
The key question, as with meters and bills, is whether these mediating devices translate energy knowledge from experts to consumers or improve consumer awareness in some other way (as is generally the intention), or whether they create new forms of energy knowledge within and between the constituencies involved. The examples discussed above suggest that the latter is a real possibility and that we should take this prospect seriously.

4. Energy knowledges

This discussion has circled, somewhat critically, around the proposition that experts have more knowledge of energy than ordinary consumers and that if consumers had more knowledge they would make better energy related choices. Such ideas depend on a fixed notion of energy and on a view that different measuring technologies reveal different aspects of what is essentially the same thing. The conventional view is that each type of knowledge offers a different window on a common underlying process. More than that, it is routinely assumed that some people know more about energy than others and that some methods of measurement provide a better representation than others of what is really going on. This is what justifies initiatives to "get the messages" of energy across to new audiences, and this is what justifies efforts to design or re-design bills and labels so that the messages they contain are interpreted easily and accurately.

In developing a subtly but significantly different perspective I've suggested that we should at least consider the idea that peoples' actions do not reflect different types of knowledge *about energy* but instead reflect alternative conceptualisations of *what energy is*. Accepting this notion, we then have to see languages of measurement not as alternative ways of mirroring what's really going on but as devices for constructing and creating knowledge within the bounds of a specific paradigm. Cast in these terms, the experiences of solar energy researchers and insulation installers relate to two quite different energy worlds. It is not that each sees different aspects of the same thing. Instead, each deals in a different way with what are, for all practical purposes, quite different issues.

The idea of viewing energy as the outcome of theoretical and methodological convention rather than as an unproblematically fixed entity has a number of positive advantages. Rather than leading us into a black hole of relativism, such an approach sensitises us to new questions and puts familiar issues in a different perspective. For example, it suggests that we need to look again at the theoretical sub-structure of policies designed to get messages of energy efficiency across from expert to lay audiences. If conventions and traditions have their own rules of description and their own methodologies there can be no simple process of translation from one to another. For the most part, initiatives to promote energy conservation have started from the realm of professional expertise. Other efforts to build bridges between domestic and expert knowledge have begun from the consumer side of the divide. Yet even these strategies assume that translation is both practicable and possible and that expert and domestic worlds need to be connected. But what if we view these worlds as essentially discrete domains each with their own languages, conventions and "theory laden" conceptualisations of energy. If we take this view, deliberate efforts at bridge building, from which ever side, are almost certainly doomed to failure for neither paradigm is permeable in the way that aspiring bridge builders imply.

Equally, energy paradigms are neither as exclusive nor as static as this image suggests: there are points of overlap and similarity between conventions, and methods of measurement and description do evolve. The point is not that linkages do not exist, but that we need to know more about existing conceptualisations of energy, about the ways in which they interconnect, and most important of all, about how ideas and theories change within each domain.

Such an approach also suggests that we should pay more attention to the methods of measurement through which energy is known. Having come to see bills and meters not as passive recording devices but as critical components in the manufacturing and development of knowledge we need to know more about their functioning in this respect. A detailed history of ideas about energy is long overdue not just because it would be interesting in its own right, but because it would help us to understand the relationship between knowledge and practice in the field of energy consumption. To give an extreme example, those who share the belief that energy leaks out of empty sockets if the wall switch is left on (Thurber 1962, p168) are likely to behave in ways which seem perplexing to those who have a different understanding of how electricity works. However extreme, such stories serve as really useful reminders of the rich and dynamic nature of energy knowledges, promoting us to ask about how such ideas come about, and how they develop. By asking questions such as these we begin to move away from the overly mechanical view that people simply need more and better knowledge about energy, and begin to open the way for a more sensitive analysis of how energy-related beliefs and practices really change in expert as well as in domestic settings.

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