Energy literacy

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# Consumer awareness of load shapes

Ulf J. J. Hahnel

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The growing proportion of renewable energy increases the need to align consumer consumption behaviours with fluctuating energy supply. A new study pairs objective smart meter electricity data with subjective survey data to offer important insights into whether consumers are aware of their own electricity use patterns and thus whether they are prepared for an increasingly dynamic energy system.

For most Western consumers the energy system is generally straightforward: electricity is constantly available at constant prices throughout the day. Yet even without the current energy crisis, it was already clear that this situation was likely to change. The need to greatly increase usage of renewable energy sources, such as wind and solar, increases fluctuation in energy production, and then this intermittent supply has to be matched with customer demand. While the flexibility of the renewable energy supply is limited due to its physical constraints, there is room for greater flexibility on the demand side.

So-called 'demand response programs' aim to increase this flexibility, for instance by providing financial incentives for energy consumption at off-peak times[1]. However, these new time-of-use pricing schemes add complexity for consumers, who need a detailed understanding of their individual electricity demand across the day in order to choose an optimal dynamic electricity tariff. But does the average consumer have this kind of accurate cognitive representation? In their recent article in *Nature Energy*, Chad Zanocco, Ram Rajagopal, Hilary Boudet and colleagues at Stanford University and Oregon State University set out to answer this question for a sample of Californian households[2].

Zanocco and colleagues call this concept of whether and how laypeople are aware of their electricity consumption patterns 'load shape awareness'. By pairing objective smart meter electricity consumption data with self-report questionnaire data, the researchers showed that around 50% of participants were able to detect their dominant load shape from a set of four different load shape types. Accuracy significantly dropped when participants were asked to identify their dominant load shape during the period in which there were shelter-in-place orders in response to the COVID-19 pandemic.

There is a growing body of research on the concept of energy literacy, which can be broadly defined as a layperson's knowledge and competences in the energy domain[3]. For instance, previous research has investigated public awareness of energy consumption of household devices or the potential of household energy actions to save energy[4,5]. These studies have primarily focused on temporally stable values (for example, the savings potential of reducing laundry temperature) or aggregated values (for example, the annual electricity consumption of typical household devices). Research on how laypeople cognitively represent their behaviour and the associated electricity consumption across time, however, is limited (for exceptions, see ref. [6]).

In light of the increasing uptake of renewables and the growth of demand response programs, this research gap represents a surprising omission. The study by Zanocco and colleagues is therefore a significant step forward for better understanding how well-prepared consumers are to make optimal decisions in an increasingly dynamic energy system.

One reason for the limited research on dynamic energy literacy is grounded in methodological challenges. Comparing individual dynamic load shape patterns with self-reported judgments of consumption requires the assessment and processing of household energy consumption data at high temporal resolution; this data also needs to be paired with self-reported data from surveys. Previous research has generally assessed each of these data sources — objective energy consumption and self-reported data — in isolation. Interdisciplinary approaches that integrate these two sources are still scarce. Recent interdisciplinary research has illustrated the value of combining objective and subjective data sources[7,8]. Zanocco and team's study provides another important contribution to this necessary methodological advancement.

Zanocco and colleagues find that load shape awareness significantly dropped when participants had to judge their consumption patterns during the COVID-19 pandemic. This tells us something about how load shape awareness is influenced by experience and indicates that laypersons have to recalibrate their load shape awareness in the face of key societal events that alter everyday practices.

The finding also highlights another gap in the field: consumer research often neglects contextual influences on cognition, affect, and behaviour. Yet in an applied field like energy research, such contextual embeddedness is crucial. Accounting for context will become even

more important in the realm of the current energy crisis. We can assume that rapidly increasing energy prices and potential energy shortages will affect how the European public perceives the energy system, including their mental models of stable and secure energy supply.

Zanocco and colleagues also found that women more accurately identified their dominant load shape than men. No other association between demographic variables and load shape awareness could be identified: variations in load shape awareness could not be explained by age, income, education, or previous experience with time-of-use pricing schemes. Future research should therefore aim to better understand the psychological factors that determine individual differences in load shape awareness, using larger and more representative samples to provide robust conclusions about the generalizability of findings.

Moreover, we need to examine the association between load shape awareness and other established energy literacy concepts such as device consumption and energy saving knowledge[4]. Thus, one might argue that load shape awareness is not only affected by people's awareness of when they consume electricity across the day, but also by their knowledge of the impact of device usage on electricity consumption. Future research could help to disentangle the different types of stable and dynamic energy literacy concepts.

Another burning question raised by the study is how load shape awareness impacts actual energy behaviour. Can we assume that consumers with higher load shape awareness make better energy tariff choices? Are 'aware' people more likely to shift their usage to off-peak times? Or do they engage in even more energy efficient behaviour generally? Answering these questions could be the starting point for behavioural research on the development of interventions to help citizens improve their load shape awareness and thus to adapt to increasing dynamics in the energy system.

These avenues for future research seem like the beginning of a long journey at a time when immediate action to reduce $CO_2$-emissions is needed. Perhaps then we should focus exclusively on behaviour and ignore the cognitive inspired research discussed here? I don't think so. We must better understand how laypeople cognitively represent energy behaviour and the energy system at large, in order to develop effective evidence-based interventions[9]. This implies theory-based and empirical knowledge about when, where, and why interventions work. We have to accumulate, exchange, integrate, and communicate this knowledge quickly. The article by Zanocco and colleagues may set the starting point for this research line. Let's begin unravelling the understanding of energy dynamics now — there's no time to waste.

**Ulf J. J. Hahnel** [1,2] ✉

[1]Faculty of Psychology, University of Basel, Basel, Switzerland.
[2]Swiss Center for Affective Sciences, University of Geneva, Geneva, Switzerland.
✉e-mail: ulf.hahnel@unibas.ch

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## Competing interests

The author declares no competing interests.