DEFINING ENERGY LITERACY: A METHODOLOGICAL REVIEW

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Abstract

This paper reviews key definitions, frameworks, and approaches used to measure energy literacy, with a focus on its relevance for households and modern energy concepts. While early work by DeWaters and Powers (2011) provided a foundation for standardized tools like the Energy Literacy Questionnaire (ELQ), more recent studies have expanded these efforts into different cultural and educational settings. The review identifies several measurement challenges, including the complexity of energy literacy as a multidimensional concept and the need for culturally and statistically appropriate instruments. It also points out gaps in research on the general population and the growing importance of new energy practices. The paper concludes that energy literacy remains a developing research area and would benefit from more consistent measurement tools and greater attention to cultural and contextual differences.

Key words: energy literacy, review, measures, energy transformation

JEL Codes: O13, P18

Introduction

Energy literacy is an increasingly important concept in the global transition to renewable energy. As energy systems become more complex and decentralized, households are expected to play a greater role in managing their energy consumption to achieve higher savings and flexibility. Understanding and measuring energy literacy is crucial for designing effective policies that support these changes in consumer behaviour. However, considering its multidimensional nature, defining and assessing energy literacy presents significant methodological challenges. This paper aims to synthesize recent research on energy literacy, focusing on conceptual definitions, measurement methodologies, and implications for policy and future research.

1 Defining Energy Literacy

Energy literacy can change household consumption by either reducing it or adjusting it to the needs and possibilities of the energy system. Increasing energy literacy can help consumers become more active participants in the market and make more efficient energy-related decisions. Assisting consumers to understand more about their energy use could benefit both them and the environment by saving energy costs and reducing greenhouse gas emissions (Martins et al., 2020).

There is yet to be a consensus on the definition of energy literacy, and today, multiple definitions exist in scientific literature. One widely referenced definition is by DeWaters & Powers (2011), who view energy literacy as having basic energy-related knowledge about how energy is used in everyday life while also being aware of the environmental issues connected with energy production and consumption and the importance of energy-saving behaviours. This definition considers three dimensions of energy literacy: knowledge, attitude, and behaviour. Brounen et al. (2013) further emphasize that energy literacy involves the ability to assess the long-term impacts of energy efficiency investments, highlighting the importance of consumer awareness in energy-related decision-making. Kalmi et al. (2017) focus on a higher level of energy literacy, incorporating the specifics of individual energy consumption and understanding energy price formation. They also consider a higher level of consumer engagement by referencing the willingness of consumers to adjust their behaviour to save energy while seeking energy-related information. Blasch et al. (2021) also expand the definition by integrating energy literacy into financial literacy, calling it energy-related financial literacy.

While the financial aspect plays a significant role, it is not the only factor determining one's level of energy literacy. Energy literacy is a complex term that needs to be viewed from multiple angles. As mentioned in the first definition, the current theoretical framework (Martins et al., 2020) introduces three dimensions of energy literacy: knowledge (cognitive), attitude (affective), and behaviour (behavioral). The cognitive dimension relates to the consumer's knowledge, skills, and overall understanding of energy and finance. The affective dimension focuses on the individual's views and ideologies influencing energy-related decisions. These are mainly influenced by awareness of the environmental impacts and consequences of energy production and use. Lastly, the behavioural dimension assesses individual awareness of the effects of daily actions related to energy use. This dimension is crucial when discussing energy savings and the patterns in consumer behaviour that lead to responsible energy consumption (Martins et al., 2020). These three dimensions are the main concepts used in

energy literacy, but there are other ways to divide it. For example, van den Broek (2019) focuses on household energy literacy and introduces four types of household energy literacy. The first is device energy literacy, which reflects the customer's awareness of the relative energy use of household appliances. The second is action energy literacy, which, like the behavioural dimension, concerns consumers' actions to save energy in their households, such as efficiency investments or better management. The third type is financial energy literacy, which allows consumers to judge the financial impacts of their energy use and savings. Lastly, multifaceted energy literacy incorporates the previous three types while also considering broader general knowledge, energy values, and attitudes, making it the most complex type of energy literacy.

Across various definitions and views, common characteristics of an energy-literate person can be identified, according to DeWaters & Powers (2013). These include a basic understanding of everyday energy use, the impacts of energy production and consumption on the environment and society, knowledge of the consequences of individual and collective energy-related decisions, awareness of the need for energy savings, and the willingness to make decisions based on this knowledge. It is apparent from the multiple scientific sources that energy literacy is a broad term that can refer to varying degrees of knowledge.

Andolfi et al. (2024) propose a three-level energy literacy model: low, moderate, and high. The lowest level involves only energy-saving behaviour, meaning individuals are aware of activities to maximize savings and can compare energy device consumption, demonstrating device energy literacy. The second level adds energy-efficient investments requiring knowledge of energy-saving appliances and technologies involving greater financial understanding. The highest level covers the first two and adds flexibility provision. Individuals at this level understand new energy concepts, such as flexible tariffs, peak and off-peak rates, and demand response programs, and adjust their consumption patterns accordingly. Several studies have shown that the level of energy literacy is quite low worldwide, and there is significant potential for greater energy savings and efficiency among consumers. However, measuring and comparing energy literacy between countries is difficult because there is no standard assessment scale, and each study evaluates energy literacy differently (Andolfi et al., 2024).

2 Measuring energy literacy

Energy literacy is important for helping consumers make informed energy decisions (Martins et al., 2020). Multiple studies support this claim, such as Lee et al. (2015), finding that energy

literacy leads to better decision-making regarding energy, and Gołebiowska (2020), noting that it will be a key to future sustainable development.

Despite this, some studies offer a more pessimistic view of the impact of energy literacy, arguing that increased energy knowledge alone may not always lead to action. Some authors claim that energy literacy does not necessarily result in more efficient energy consumption (Santillán et al., 2023). This view is supported by Andolfi et al. (2024), who note a publication bias, where studies with insignificant or contrary results are not published. Many studies, including Andolfi et al. (2024), use student samples and the questionnaire by DeWaters and Powers (2013). It is specifically designed to assess energy literacy among students. DeWaters and Powers (2013) established the discipline's conceptual foundations by developing criteria for what defines an energy-literate individual. They introduced the Instrument Development Framework (IDF) - a key innovation that structured energy literacy as a multidimensional concept, integrating cognitive, affective, and behavioural components into a unified approach (DeWaters et al., 2013).

Their framework was specifically designed for middle and high school students and aimed to link energy literacy traits to measurable learning outcomes. It laid the groundwork for future tools such as the Energy Literacy Questionnaire (ELQ), which assesses knowledge, values, attitudes, and behaviours. The IDF includes eight general characteristics and 33 measurable benchmarks in the cognitive domain, three characteristics and 11 in the affective domain, and five characteristics and eight in the behavioural domain, further divided into predispositions to behave and behaviours (DeWaters et al., 2013).

The ELQ was developed through a structured approach that included reviewing existing literature, consulting with subject matter experts, and testing the instrument with student groups to refine its content and clarity. It includes multiple-choice questions to assess cognitive knowledge and Likert-scale items to evaluate affective and behavioural aspects. The final instrument demonstrated strong internal reliability (Cronbach's alpha between 0.75 and 0.83) and was validated across different age groups and adult populations. The ELQ was empirically applied by DeWaters and Powers (2011) in a study involving over 3,700 students in New York State. Results indicated low cognitive scores, high affective engagement, and moderate behavioural scores. Notably, affective factors such as students' attitudes, beliefs and values were more strongly correlated with behavioural outcomes than cognitive knowledge, suggesting that effective education should focus on content knowledge and impacting values and motivation.

For example, this finding has also been observed by Gołębiowska (2020), who surveyed 1,000 Polish adults using the CAWI method. The study focused on practical knowledge about

electricity prices, awareness of climate change, and attitudes toward saving energy. While most respondents scored poorly on knowledge questions, many, especially women, showed concern for the environment. The study emphasized the role of social norms (descriptive, injunctive and personal norms) in shaping beliefs and awareness about energy and climate, an area less explored in the earlier work of DeWaters and Powers. These three types of norms refer to what people actually do, what they believe should be done, and what individuals feel personally responsible for.

Cerović et al. (2024) studied economics students in Croatia using a questionnaire adapted to local cultural and educational settings. The students scored low on knowledge (33% on average), but their reported behaviors and attitudes were more positive. A key finding from this study was the mismatch between how much students thought they knew and their actual test results.

In Indonesia, Suryana et al. (2020) used a revised version of the ELQ to test high school students and analyzed the results using the Rasch model. This method, which comes from item response theory, allows researchers to place both students and questions on the same difficulty scale, showing which items are hardest and which students are more capable. Their results showed that students generally cared about energy issues but had weaker understanding and inconsistent behaviors. The use of the Rasch model was a key difference from the classical analysis used by DeWaters and Powers, offering more detailed insight into how students respond to different types of questions.

3 Previous studies measuring energy literacy

Apart from these publications, measuring energy literacy remains a relatively underexplored topic in scientific literature. The table below summarizes key characteristics of the studies mentioned in this document that relate to measuring energy literacy, including their target groups, methods, analytical tools, and notable contributions.

Most of these studies targeted students as their primary participants at the secondary or university level. The works by DeWaters and colleagues focused on middle and high school students in the United States and led to the development and validation of the Energy Literacy Questionnaire (ELQ), which has since been adapted in other contexts. The Croatian and Indonesian studies also involved high school and university students, applying modified versions of the ELQ to better fit their local curricula and cultural settings. The Polish study was

the exception, targeting the general adult population through a nationally representative online panel using computer-assisted web interviewing (CAWI).

Table 1 shows that previous research relied primarily on essential statistical tools like descriptive statistics and correlation analysis to examine the relationships between what people know, how they feel, and how they act about energy. The reliability of the constructs was checked with Cronbach's alpha. DeWaters et al. (2013) used factor analysis to look more closely at the structure of the questionnaire. They found that the knowledge questions (cognitive domain) were unidimensional, meaning they all focused on measuring the same central idea - energy knowledge. In contrast, the attitude and behaviour questions (affective and behavioural domains) were multidimensional, reflecting several different but related ideas, such as personal values, concern for the environment, motivation, and habits. In the Indonesian context, the Rasch model was used by Suryana et al. (2020). This helped compare how difficult each question was and how well each student performed, all on the same scale.

Tab. 1: Overview of articles focusing on measuring energy literacy

Study	Target Group	Methodology	Analytical Tools	Key Focus	Notable Feature
DeWaters & Powers (2011)	Middle & high school students (NY)	Survey using ELQ	Descriptive stats, correlation (Spearman)	Empirical assessment of energy literacy	Large sample (3708); affect-behavior link
DeWaters et al. (2013)	Students, teachers, adults	Questionnaire design and pilot testing	Reliability testing (Cronbach's alpha), factor analysis	Development and validation of ELQ	Strong psychometric design
Gołębiowska (2020)	Polish adults (national sample)	Online survey	Descriptive stats, correlation (Spearman)	Energy literacy and social norms	Included climate awareness and pricing knowledge
Cerović et al. (2024)	Croatian economics students	Custom questionnaire	Descriptive stats, Reliability testing (Cronbach's alpha), factor analysis	Knowledge-perception gap	Emphasis on subjective vs objective knowledge
Suryana et al. (2020)	Indonesian high school students	Modified ELQ with interviews	Rasch model	Comparing student ability to item difficulty on a shared scale	Rasch analysis; teacher interviews

Source: Own elaboration based on the cited studies

4 Methodological challenges

Several methodological challenges emerge from this body of research. First, self-reported data often overestimate actual understanding, requiring instruments that can capture objective knowledge accurately. Second, affective and behavioural dimensions frequently exhibit multidimensionality, requiring careful item construction and factor analysis. Third, cultural adaptation is crucial: Indonesian and Croatian studies adapted the ELQ to local contexts to improve validity. Specifically, the Indonesian and Croatian studies adapted the original ELQ to align with national curricula, local terminology, and student contexts. Without such adjustments, instruments risk being misunderstood or measuring concepts that are irrelevant to the local setting. This applies equally to measuring energy literacy in the general population, where cultural, linguistic, and contextual factors can significantly affect how questions are interpreted and answered.

Items selection and rightness of the adaptability of the questionnaire to a specific context can also influence results. The Indonesian study by Suryana et al. (2020) used the Rasch model to evaluate how well each question matched student ability levels. This method provides insights into which items were too easy or too difficult and whether the scale functioned consistently across respondents. Such models are useful but introduce more complexity into the research process.

Another important consideration is the choice of statistical methods. While most studies rely on descriptive statistics and correlation analysis (e.g., Spearman's rho), more advanced studies include reliability testing (such as Cronbach's alpha) and factor analysis to examine the internal structure of the questionnaire. These tools help validate whether items within each dimension truly measure what they intend to. Finally, sampling strategies can be biased if not carefully designed. Many studies have focused primarily on students, particularly in secondary schools or universities. While this is useful for educational interventions, it leaves gaps in understanding energy literacy among broader, more diverse populations such as households, working adults, or older age groups. Sampling methods should be tailored to the population of interest, especially when investigating how energy literacy connects with real-world decisions about energy use, investment, or technology adoption.

5 Implications for studying energy literacy in the Czech context

Energy literacy in the context of the Czech Republic remains an unexplored topic. A recent study by Buchtele et al. (2023) examined the level of energy literacy among Czech citizens,

focusing on the influence of socio-demographic factors and how energy literacy shapes perceptions. However, this research has limitations, as it primarily addresses the cognitive dimension of energy literacy, namely knowledge about the energy mix and balance in the Czech Republic, without exploring the behavioural or affective dimensions. This literature review can serve as a foundation for developing a comprehensive tool to measure energy literacy in the Czech Republic. The design of such a questionnaire should reflect all three key dimensions - cognitive, affective, and behavioural, while also considering the characteristics of the target population and regional specifics. Since existing studies have mainly focused on measuring energy literacy among students, there is a clear need to develop a tool tailored to the general public. Insights from studies that specifically examine household energy literacy, such as the one by van den Broek (2019), can be combined with concepts from student-focused research to introduce new approaches. Furthermore, with the rise of new technologies and energy-related concepts such as demand-side flexibility, smart meters, and household renewable energy systems, there is an opportunity to update existing measurement frameworks to reflect these developments more accurately.

When researching energy literacy among the broader public in a country like the Czech Republic, it is essential to account for the diversity of the population. Different households may have varying levels of access to new technologies, as well as different capacities to engage with them. This means that the required level of energy literacy and the skillsets may differ significantly across household types and should be reflected in both the questionnaire design and sampling strategy.

In terms of methodology, future research should prioritize the use of validated instruments and apply appropriate statistical tools for analyzing energy literacy across its three dimensions. For example, calculating reliability coefficients (e.g., Cronbach's alpha) for each construct is essential to ensure internal consistency. Conducting exploratory or confirmatory factor analysis can help verify whether the survey items group together meaningfully, especially in newly adapted instruments.

Ultimately, developing a comprehensive energy literacy questionnaire for the Czech Republic requires both content adaptation to the local context and methodological quality to ensure that the tool is valid, reliable and comparable to international research.

Conclusion

Energy literacy is increasingly recognized as an important factor in enabling individuals and households to actively participate in the energy transition. This review has shown that energy literacy is best understood as a multidimensional construct that includes cognitive, affective, and behavioural elements. Although tools like the Energy Literacy Questionnaire (ELQ) offer a strong foundation for measurement, differences in cultural context, population groups, and emerging technologies require adaptations to existing frameworks. For countries like the Czech Republic, future research should focus on developing validated, culturally appropriate tools that reflect current energy realities and extend beyond the student population. Carefully chosen statistical methods and thoughtful sampling will be essential to ensure reliability, validity, and usefulness for policy and education.

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References

Andolfi, L., Akkouch, R., & Pavić, I. (2023). From awareness to action: Energy literacy and household energy use, *18th IAEE European conference. The Global Energy Transition Toward Decarbonization*, Milan, Italy.

Blasch, J., Boogen, N., Daminato, C., & Filippini, M. (2018). *Empower the consumer! Energy-related financial literacy and its socioeconomic determinants* (18/289). Centre for Energy Policy and Economics (CEPE), Zurich, Switzerland.

Buchtele, R., Cudlínová, E., Lapka, M., Sagapova, N., Krásnická, M., Vávra, J., & Líšková, Z. D. (2023). Energy literacy in Czechia and its influence on citizens' perception of energy consumption behaviour. *Economics and Environment*, *84*(1), 306-327.

Brounen, D., Kok, N., & Quigley, J. M. (2013). Energy literacy, awareness, and conservation behavior of residential households. *Energy Economics*, 38, 42–50.

Cerović, L., Malnar, A., & Sinčić, D. (2024). Energy Literacy of Economics Students in Rijeka: Knowledge, Attitudes, and Behavioral Approach. *Energies*, *17*(8), 1840.

DeWaters, J. E., & Powers, S. E. (2011). Energy literacy of secondary students in New York State (USA): A measure of knowledge, affect, and behavior. *Energy Policy*, 39(3), 1699-1710.

DeWaters, J., & Powers, S. (2013). Establishing measurement criteria for an energy literacy questionnaire. *The Journal of Environmental Education*, *44*(1), 38-55.

DeWaters, J., Qaqish, B., Graham, M., & Powers, S. (2013). Designing an energy literacy questionnaire for middle and high school youth. *The Journal of Environmental Education, 44*(1), 56–78.

Gołębiowska, B. (2020). Energy literacy in Poland. *Economics and Environment*, *73*(2), 23.

Kalmi, P., Trotta, G., & Kazukauskas, A. (2017). The role of energy literacy as a component of financial literacy: Survey-based evidence from Finland. In *15 IAEE European Energy Conference Conference*, Vienna, Austria.

Lee, L. S., Lee, Y. F., Altschuld, J. W., & Pan, Y. J. (2015). Energy literacy: Evaluating knowledge, affect, and behavior of students in Taiwan. *Energy Policy*, *76*, 98-106.

Martins, A., Madaleno, M., & Ferreira Dias, M. (2020). Energy literacy: What is out there to know? *Energy Reports*, *6*(Supplement 1), 454-459.

Santillán, O. S., & Cedano, K. G. (2023). Energy literacy: A systematic review of the scientific literature. *Energies, 16*(21), 7235.

Suryana, T. G. S., Setyadin, A. H., Samsudin, A., & Kaniawati, I. (2020). Assessing multidimensional energy literacy of high school students: An analysis of Rasch model. *Journal of Physics: Conference Series, 1467*, 012034.

van den Broek, K. L. (2019). Household energy literacy: A critical review and a conceptual typology. *Energy Research & Social Science*, *57*, 101256.

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