

Martins, Ana Isabel; Madaleno, Mara; Dias, Marta Ferreira

Article

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Energy Reports

Provided in Cooperation with:

Elsevier

Suggested Citation: Martins, Ana Isabel; Madaleno, Mara; Dias, Marta Ferreira (2020) : Energy literacy: What is out there to know?, Energy Reports, ISSN 2352-4847, Elsevier, Amsterdam, Vol. 6, Iss. 1, pp. 454-459,
<https://doi.org/10.1016/j.egyr.2019.09.007>

This Version is available at:

<https://hdl.handle.net/10419/243772>

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ICEER2019 — 6th International Conference on Energy and Environment Research: “Energy and environment: challenges towards circular economy”, SCience and Engineering Institute, 2019, 22–25 July 2019, Aveiro, Portugal

Energy literacy: What is out there to know?

Ana Martins^{a,*}, Mara Madaleno^{a,b}, Marta Ferreira Dias^{a,b}

^a DEGEIT — Department of Economics, Management, Industrial Engineering and Tourism, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal

^b GOVCOPP — Research Unit on Governance, Competitiveness and Public Policies, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal

Received 29 July 2019; accepted 7 September 2019

Available online 23 September 2019

Abstract

Viewed as an essential tool, which sensitizes citizens to create sustainable energy consumption habits, energy literacy has attained a growing interest among researchers and policy makers in recent years. Energy literacy encompasses not only the cognitive domain, but also the affective and behavioral characteristics, enabling citizens to make appropriate decisions regarding energy. Considering its relevance, several studies have been carried out on this topic. In this paper, we seek to gather the main contributions of the existing literature on the subject, in order to concentrate and organize them. Most of the existent research seeks to assess the levels of literacy of the population, in the three dimensions – knowledge, affectivity and behavior –, to perceive the relationships between them, and which factors influence literacy levels. Recently another concept has emerged that relates energy literacy to financial literacy. Conciliating these two views, we present a proposal for a more comprehensive assessment of energy literacy levels, which includes the evaluation of financial and energy knowledge, without neglecting the evaluation of attitudes and behavior. This study will provide useful pointers to researchers and policy makers.

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Peer-review under responsibility of the scientific committee of the 6th International Conference on Energy and Environment Research, ICEER 2019.

Keywords: Attitude; Behavior; Decision making; Energy literacy; Knowledge

1. Introduction

Nowadays, energy is an essential good. It is constantly produced and used, which requires a careful management of its sources and consumption, only achieved through the bet on knowledge. Only by understanding what energy is, which are its sources and production processes, ways of use and conservation strategies, it is possible to make informed decisions about the best use of energy. However, knowledge alone does not determine a more conscious use of energy. It is necessary that people be able to translate this knowledge into concrete actions.

* Corresponding author.

E-mail address: anapmartins@ua.pt (A. Martins).

<https://doi.org/10.1016/j.egy.2019.09.007>

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In recent years, various definitions of energy literacy have been presented and a number of studies have been carried out, which the main objective was to assess the levels of energy knowledge, sensitivity to the need to adopt energy-saving behaviors and citizens' energy decisions, or by assessing financial and investment knowledge applied to energy issues. In this paper, we seek to gather the main contributions of existing literature on energy literacy, and based on them, construct a concept of energy literacy that allows to encompass the various dimensions and sub-dimensions suggested in the literature. Our goal is also to provide suggestions for future research and to provide researchers and policy makers with relevant material to their studies and policies.

Then, in point 2, we present the various definitions of energy literacy, showing the need to create a common and comprehensive concept that adds the two main currents of the literature. In point 3, we present a brief explanation of the various dimensions and sub-dimensions that integrate the concept of energy literacy, and in point 4 we explore the relationship between them. Finally, in point 5, we have gathered the main factors that influence the levels of energy literacy, identified in the literature, in point 6, we summarize the main conclusions, and in point 7, we present some suggestions for future research.

2. Energy literacy: the definition

In the last decade, energy literacy has attracted increasing interest among researchers. However, until now, no consensus has been reached on a common definition of energy literacy. DeWaters and Powers [1] define energy literacy as the domain of basic energy-related knowledge, coupled with an understanding of the impacts of energy production and consumption on the environment, how energy is used in everyday life and the adoption of energy-saving behaviors. This definition adds three different dimensions: knowledge, attitude and behavior.

Brounen et al. [2] present a narrower definition and more related to the economic notion of cost–benefit. According to these authors, energy literacy is related to the trade-off between the highest initial investment needed to acquire more efficient equipment and the monetary and energy savings resulting from this choice in the long-term. Kalmi et al. [3] also use a similar but somewhat more comprehensive definition. In addition to the trade-off reported by Brounen et al. [2], Kalmi et al. [3] refer to the awareness of the individual energy consumption, the understanding of the process that involves the formation of the final energy price, the willingness to adopt energy-saving behaviors, and the need for information and willingness to access information related to energy.

Other authors, such as Blasch et al. [4] focus on a concept that they call energy-related financial literacy. This concept encompasses, not only knowledge related to the energy needed to make informed decisions, but also the skills needed to process this information, such as the ability to perform financial calculations.

Last but not least, the U.S. Department of Energy [5] provides a broader view, stating that energy literacy encompasses not only the understanding of the nature and role of energy in the world and in everyday life, but also the ability to apply this understanding to answer questions and solve problems.

Considering the definitions presented, we take as reference the definition provided by the U. S. Department of Energy [5] on this paper. Given its scope, it allows incorporating the various definitions presented, including the three dimensions of energy literacy proposed by DeWaters and Powers [1], but also the ability to perform suggested financial calculations suggested by Blasch et al. [4].

3. Energy literacy dimensions

In the literature, the discussion on energy literacy began by focusing on knowledge [6], but researchers soon realized that it is a more comprehensive concept. Despite the importance of knowledge, the access to it, by itself, does not determine a more effective behavior change. Energy literacy emerges in the more recent literature, as a broad concept encompassing three dimensions: knowledge, attitude, and behavior (see Fig. 1) [1,7,8]. According to DeWaters et al. [7]:

- The knowledge — is the understanding of basic scientific concepts, rules and theories, energy transfer and transformation processes, the influence of energy flows and the role that energy plays in ecosystems;
- The attitude — assesses the understanding of common energy supply and shut down situations, the processes of production and use of energy and the consequent environmental impacts, the influence of energy issues on human life, and convictions and ideologies of each person, based on the energy knowledge, which are inherent in the decision-making process;

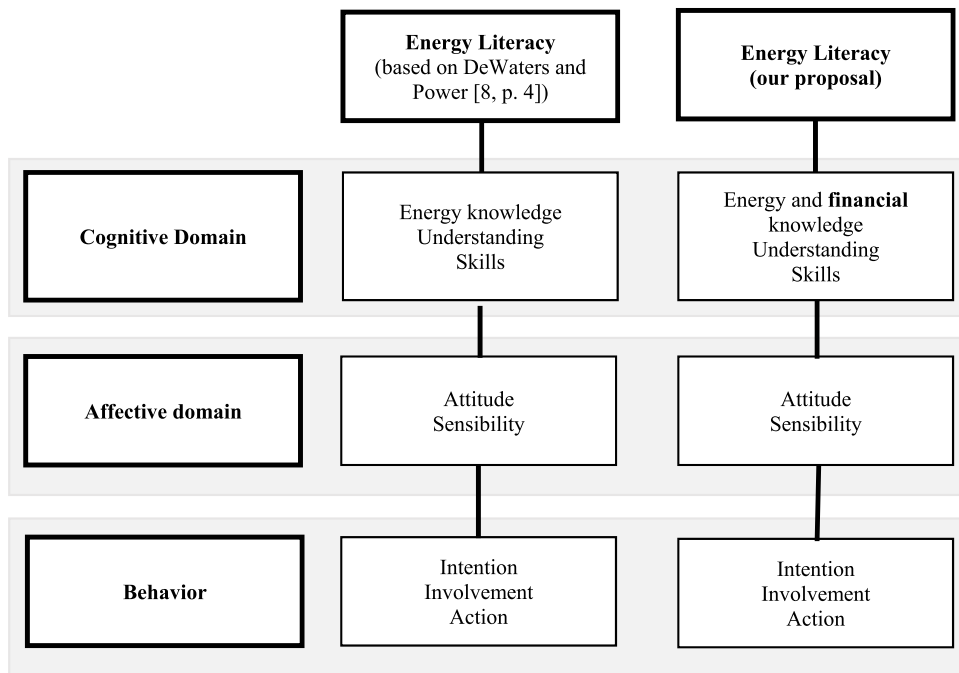


Fig. 1. Energy literacy dimensions and sub-dimensions.
Source: Adapted from DeWaters et al. [8, p. 4].

- The behavior — evaluates the personal awareness of the impact of day-to-day actions, the production and use of energy, the responsibility of each one as a citizen of the world, and the commitment to effective and truly committed actions in saving energy.

Considering the studies of Brounen et al. [2], Kalmi et al. [3] and Blasch et al. [4], we understand that the knowledge needed to make informed energy-related decisions, can not only include the knowledge about energy, but will have to include some basic financial concepts, that give to people the necessary skills to perform financial calculations. In this way, we propose an integrative approach (see Fig. 1), which adds knowledge in the areas of energy and finance, the capacities that this knowledge provides, the sensitivity to energy issues and the need to change energy consumption habits, the perception of the individual role of each citizen and behavior or decision-making.

4. Levels of energy literacy and the relationship between its dimensions and sub-dimensions

From the best of our knowledge on the subject, we find that there is none well-defined and common scale in the literature, which establishes a limit up to which the level of energy literacy is considered low, and from which it is considered reasonable or good. Despite this, various authors have sought to establish their own scales and cutoff values, taking into account the methods of data collection they used.

Studies conducted for the US, report low levels of energy literacy for US citizens [1,9,10]. Although the levels of knowledge are satisfactory, there is little concern with regard to energy conservation [1]. The results observed for Taiwan are more encouraging, revealing reasonable levels of energy literacy [11,12]. However, these results are achieved mainly by the acquisition of knowledge and this does not seem to be translated into concrete actions, given the discrepancy between attitude and behavior. In Denmark, despite the reasonable levels of knowledge that exist, most of the respondents report that they have not yet installed more efficient equipment or sought to use renewable energy sources [13]. New Zealand children also seem to dominate energy issues, even demonstrating a positive attitude towards energy savings. However, most of them do not show efforts on energy saving [14]. In Portugal, the university students seem to have also a weak commitment to energy conservation activities, spending more energy and showing less concern with conservation initiatives [15,16]. The same happens in Switzerland and Finland, where the levels of energy literacy registered are low, despite the satisfactory levels of financial literacy [3,4].

Analyzing energy literacy from the point of view of the consumer/decision-maker, some difficulties related to knowledge will emerge. Herrmann et al. [17] shows that people find it difficult to understand data on domestic energy consumption, and to establish the relationship between their consumption and daily actions and behaviors. According to Galesic and Garcia-Retamero [18], most people are not familiar with regarding and understanding complex graphs and find it difficult to extract useful information from them.

The problem of low levels of energy literacy seems to be related not so much to knowledge, although this is also very important and there is still space for improvements, but more with the behavior and the application of knowledge in everyday situations. Attari et al. [19] and Costanza et al. [20] reinforce this view, showing that consumers' concerns about energy are not strong enough to commit themselves, as much as would be desirable, in the monitoring of the energy they spend. Carlsson-Kanyama and Lindén [21] also reinforce that only being informed is not enough to promote a behavior change.

5. (Some) Factors that influence energy literacy

Another current strand of the existing literature also seeks to analyze the factors that influence the degree of energy literacy. One of the factors most widely analyzed by researchers is gender. While there are some studies that point out that women have more negative attitudes towards energy or have lower levels of energy-related financial literacy [4,22,23], other studies conclude that women have higher levels of energy literacy than men [24]. Very low and high ages and awareness with free-riding seem to have a negative influence on levels of energy literacy [23].

Encouragement and promotion of positive environmental attitudes in childhood seems to contribute significantly to instilling correct habits of energy consumption that last throughout life [25]. In truth, the role of schools and of the frequency of energy-related curricular units seems to be relevant [8,13,26,27]. Other factors such as the parents' educational level [28], the performance of evidence/games on energy [19,20], the advertising campaigns [29–31], and socioeconomic status [12] seem to have a positive influence on energy literacy levels.

Another issue that seems to affect the awareness on saving energy is the way in which energy is paid and by whom it is paid. When electricity is prepaid, consumers tend to consume more than those who pay the electricity bill after consumption has been made [32,33]. According to the identified literature results, if the participant is the person who pays the electricity bill, he is likely to show a higher level of energy literacy.

6. Conclusion

In an age when the effects of poor energy management and pollution are beginning to be felt with increasing intensity, it is urgent to make efforts to empower people and bring them to change their energy consumption habits. Considering the existing literature, we find that knowledge about energy issues and financial knowledge are the cornerstones of change. In this way, we suggested a more integrative approach to the concept of energy literacy, which encompasses financial and energy knowledge, the ability to perceive processes of energy transformation and financial calculations, sensitivity to energy and behavioral issues. Considering all these aspects, the assessment of energy literacy levels, will be, in our opinion, more complete and will give more precise indications of which of the dimensions need more intervention.

We also found that most of the results and conclusions from the literature reveal low levels of energy literacy, which are mainly explained by the lack of commitment to energy saving and by the concern with free riding. However, the frequency of workshops or classes about energy and the domain of skills on financial calculations seems to have a positive influence on energy literacy levels. Therefore, it seems necessary to invest in training and empowering consumers, in order to give them the necessary tools to make the best energy-related decisions. We also need to invest in the formation of children, because they will be the citizens of the future and as they do not yet have defined habits, they easier adopt the correct habits.

7. Suggestions for future research

For future research, we suggest the evaluation of energy literacy levels, using the approach proposed in this paper, the comparison of the levels of energy literacy between countries, and the realization of some experiences to evaluate the people energy behavior in a real context. Moreover, and provided that there are already studies relating financial with energy literacy [34] it is important to look at the relationship between financial and energy literacy accounting for both supply and demand, provided that there is evidence establishing low financial literacy as a

mechanism driving low investment in energy efficiency [34]. Future research should concentrate on new insights on: (i) the level of energy literacy, financial literacy, and energy awareness in households; (ii) the range of energy behaviors' and attitudes towards energy consumption; and (iii) the socio-demographic and dwelling factors affecting energy literate households by employing specific econometric models (like logit or panel data models). In addition, the relationship between financial literacy and energy literacy should be better analyzed. This implies the specific answer to the following questions: What is the intersection of energy and financial literacies in the community? In what ways do people draw upon their personal energy and financial literacies when making decisions about the use of energy? What are possible learning interventions that could influence, support, and impact decision-making and energy use behaviors? There are already some projects ongoing which consider these questions [3]. In accordance with Kalmi et al. [3] Finnish households have low levels of energy literacy and energy awareness, but possess good capabilities to manage their personal finances. Moreover, no correlation between energy literate and financial literate households has been found.

References

- [1] DeWaters JE, Powers SE. Energy literacy of secondary students in New York State (USA): A measure of knowledge, affect, and behavior. *Energy Policy* 2011;39(3):1699–710.
- [2] Brounen D, Kok N, Quigley JM and. Energy literacy, awareness, and conservation behavior of residential households. *Energy Econ* 2013;38:42–50.
- [3] Kalmi P, Trotta G, Kazukauskas A. The role of energy literacy as a component of financial literacy: Survey-based evidence from Finland. In: IAEE conference in Vienna, 2017.
- [4] Blasch J, Boogen N, Daminato C, Filippini M. Empower the Consumer! Energy-Related financial literacy and its socioeconomic determinants, 18/289, 2018.
- [5] USDepartment of Energy. U.S. Department of Energy, Energy Literacy: Essential principles and fundamental concepts for Energy Education. 2017.
- [6] Gambio JS, Switzky HN. A national survey of environmental knowledge in high school students: Levels of knowledge and related variables. 1994.
- [7] DeWaters J, Qaqish B, Graham M, Powers S. Designing an energy literacy questionnaire for middle and high school youth. *J Environ Educ* 2013;44(1):56–78.
- [8] DeWaters JE, Powers SE, Graham M. Developing an energy literacy scale. In: 114th annu. ASEE conf. expo. Conf. Proc. p. Dassault Systemes; HP; Lockheed Martin; IBM; DuPont, 2007.
- [9] Bodzin A. Investigating urban eighth-grade students' knowledge of energy resources. *Int J Sci Educ* 2012;34(8):1255–75.
- [10] Murphy TP. The Minnesota Report Card on Environmental Literacy: a benchmark survey of adult environmental knowledge, attitude and behavior; 2002.
- [11] Chen SJ, Chou YC, Yen HY, Chao YL. Investigating and structural modeling energy literacy of high school students in Taiwan. *Energy Effic* 2015;8(4):791–808.
- [12] Lee L-S, Lee Y-F, Altschuld JW, Pan Y-J. Energy literacy: Evaluating knowledge, affect, and behavior of students in Taiwan. *Energy Policy* 2015;76:98–106.
- [13] Sovacool BK, Blyth PL. Energy and environmental attitudes in the green state of denmark: Implications for energy democracy, low carbon transitions, and energy literacy. *Environ Sci Policy* 2015;54:304–15.
- [14] Aguirre-Bielschowsky I, Lawson R, Stephenson J, Todd S. Energy literacy and agency of New Zealand children. *Environ Educ Res* 2017;23(6):832–54.
- [15] Cotton D, Shiel C, Paço A. Energy saving on campus: a comparison of students' attitudes and reported behaviours in the UK and Portugal. *J Clean Prod* 2016;129:586–95.
- [16] do Paço A, Alves H, Shiel C, Filho WL. Conserving behaviour: A replication of the ENVIROCON scale in four countries. *APCBEE Proc* 2013;5:44–9.
- [17] Herrmann MR, Brumby DP, Oreszczyn T. Watts your usage? A field study of householders' literacy for residential electricity data. *Energy Effic* 2017;1–17.
- [18] Galesic M, Garcia-Retamero R. Graph literacy: A cross-cultural comparison. *Med Decis Mak* 2011;31(3):444–57.
- [19] Attari SZ, DeKay ML, Davidson CI, De Bruin WB. Public perceptions of energy consumption and savings. *Proc Natl Acad Sci* 2010;107(37):16054–9.
- [20] Costanza E, Ramchurn SD, Jennings NR. Understanding domestic energy consumption through interactive visualisation: a field study. In: Proceedings of the 2012 ACM conference on ubiquitous computing; 2012. p. 216–25.
- [21] Carlsson-Kanyama A, Lindén A-L. Energy efficiency in residences—Challenges for women and men in the North. *Energy Policy* 2007;35(4):2163–72.
- [22] Dijkstra EM, Goedhart MJ. Development and validation of the ACSI: measuring students' science attitudes, pro-environmental behaviour, climate change attitudes and knowledge. *Environ Educ Res* 2012;18(6):733–49.
- [23] Kumar N. A model-based clustering approach for analyzing energy-related financial literacy and its determinants, CER-ETH—Center of Economic Research at ETH Zurich, 19/312, 2019.
- [24] Rätty R, Carlsson-Kanyama A. Energy consumption by gender in some European countries. *Energy Policy* 2010;38(1):646–9.

- [25] Ballantyne R, Connell S, Fien J. Students as catalysts of environmental change: a framework for researching intergenerational influence through environmental education. *Environ Educ Res* 2006;12(3–4):413–27.
- [26] Bodzin AM, Fu Q, Peffer TE, Kulo V. Developing energy literacy in US middle-level students using the geospatial curriculum approach. *Int J Sci Educ* 2013;35(9):1561–89.
- [27] Geller ES. Evaluating energy conservation programs: Is verbal report enough? *J Consum Res* 1981;8(3):331–5.
- [28] Yeh S-C, Huang J-Y, Yu H-C. Analysis of energy literacy and misconceptions of junior high students in taiwan. *Sustain* 2017;9(3).
- [29] Brewer RS, Lee GE, Johnson PM. The Kukui Cup: A Dorm energy competition focused on sustainable behavior change and energy literacy. In: 2011 44th Hawaii international conference on system sciences; 2011. p. 1–10.
- [30] van der Horst D, Harrison C, Staddon S, Wood G. Improving energy literacy through student-led fieldwork – at home. *J Geogr High Educ* 2015;40(1):67–76.
- [31] Staats HJ, Wit AP, Midden CYH. Communicating the greenhouse effect to the public: Evaluation of a mass media campaign from a social dilemma perspective. *J Environ Manage* 1996;46(2):189–203.
- [32] Brutscher P-B. Payment Matters?-An exploratory study into the pre-payment electricity metering, Faculty of Economics. 2011.
- [33] Dianshu F, Sovacool BK, Minh Vu K. The barriers to energy efficiency in China: Assessing household electricity savings and consumer behavior in liaoning province. *Energy Policy* 2010;38(2):1202–9.
- [34] Brent DA, Ward MB. Energy efficiency and financial literacy. *J Environ Econ Manage* 2018;90:181–216.