SUBJECTIVE PERCEPTION OF DIFFERENT WAYS OF ENERGY PRODUCTION AND RELATED ECONOMIC ASPECTS

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Abstract

Energy production and use are monitored worldwide, mainly due to rising energy prices. An interesting aspect is a possibility for households to co-create the energy supply, and thus they can at least partially cover their consumption. Various producers operate in the electricity market, both traditional producers and producers who produce electricity from renewable sources. Electricity is a particular good characterized by highly price inelastic and predictable demand. Electricity is tradable, but this trade is limited by network and transmission. On top of it, electricity is currently not storable, although it is considered that this will be possible within ten years. The paper aims to determine how consumers perceive different ways of electricity production. The paper focuses on the economic aspects of energy production. The professional community defines the environmental burden and its amount based on precise criteria (e.g., emission measurement). In contrast, households are affected by many factors (media presentations, lay talks), resulting in a difference between subjective perception and objective evaluation.

Key words: energy, electricity generation, renewable energy sources

JEL Code: L94, Q41

Introduction

Many twenty-first-century people take energy for granted. This view is incorrect. For instance, in the first half of 2022, the Czech Republic depended on gas supplies from abroad. Most experts point out that the functioning of developed economies and their growth depends on a sufficient disposable amount of energy sources. An essential kind of energy is electric energy. The importance of electric energy is still growing. Therefore, it is required to pay attention to the realm of electric power issues which is one of the immense political topics. To illustrate this, we name Act 367/2021 Coll., (On Measures for the Transition of the Czech Republic to Low-Carbon Energy and on the Amendment of Act No. 165/2012 Coll., on Subsidized Energy

Sources, 2021)[1]. Various political parties and institutions are trying to formulate opinions and solve questions about production, distribution, and electric energy consumption. One of the points on the political programme that is being neglected is the research of consumers' preferences on production, distribution, and consumption of electric energy and the factors that influence these preferences.

Today we cannot assume that consumer is concerned only with the price of electric energy. Consumers were informed about harming the planet and the negative environmental consequences of human activity. Based on that, it is possible to assume that exists a group of consumers who are worried about the planet's future. Therefore, this group prefers green energy or energy produced in the most ecological way possible.

Complete and accurate information should a probable campaign provide consumers with knowledge for decisions linked to the source[2]. This decision agrees with their preferences and is in line with their perceptions. A preferred energy source should be used to produce a higher proportion of energy, which is reflected in countries` strategies. The lack of information and knowledge hinders creating such a suitable energy strategy that is in line with the preferences of citizens in particular economies. The paper's main objective is to sketch why and how the research of preferences in the energy sector is important. The fact that investigation of preferences is important is supported by a body of literature that offers a more or less complex view of consumers' preferences.

Citizens lack information, e.g., on types of energy production, its advantages and disadvantages, possibilities of modern technologies, and so forth. This lack of information causes misunderstanding among citizens and consumers' knowledge that renewable sources can supply the energy demand fully. Also, citizens assume this production has only a positive side, but there are downturns to that production. The government does not yet provide sufficient information, especially concerning the small modular reactors burning nuclear waste. These facts and other circumstances are substantial for elections in a given country. Research of consumers` preferences allows finding factors for citizens (consumers) that are important for them and including this information in a possible campaign aimed at citizens. The paper's main

[1] Overview of political measures to be found at webpage of Ministry of Industry and Trade: https://www.mpo.cz/en/guidepost/for-the-media/press-releases/laws-under-the-responsibility-of-the-ministry-of-industry-and-trade-to-be-amended-with-the-upcoming-new-year--265481/

[2] There is a fundamental division of energy production for non- and renewable in electric energy production. This division is insufficient itself. For instance, producing electric energy based on nuclear sources is a complex issue. There are various kinds of nuclear reactors regarding safety or nuclear fuel. Modern nuclear reactors of the new generation have high protection and burn already spent nuclear fuel. Similarly, the production of electric energy using other sources (sun or wind) has advantages and disadvantages.

objective is to highlight the importance of research in finding preferences and factors that influence these preferences. For example, the influence of prices is included in the paper to illustrate the factor and other related economic aspects. These aspects are partially examined by using secondary data from Eurostat and partly from other studies. Previous surveys are used for selected European countries. The selection was based on two criteria: (1) population (approx. ten mil., except for France) and (2) nuclear energy use, where France is considered for a token (77% of the total energy produced is of nuclear type). The method used is a comparison and overview of the literature.

1 Review of literature

According to (Kaenzig et al., 2013), successful product design and marketing strategies can give electricity providers a competitive advantage while contributing to energy policy goals. However, a thorough understanding of consumer preferences is essential. (Vassileva, et al., 2012), who analyzed the trends in household consumption and the parameters that affect them, and the characteristics of the feedback provided, also focus on the nature of consumer preferences in energy consumption. Preferences reflect socioeconomic factors of households, which could help understand how it affects households' behavior. The findings of (Vassileva, et al., 2012) show that the most preferred feedback is web-based. Their research also indicates that monthly income is one of the most influential factors determining electricity consumption, although only in high- and low-income groups. Apart from those mentioned, there are other socioeconomic factors in the study by (Ek & Söderholm, 2010) and (Sardiana, 2007).

Analysis of Swedish households (Ek & Söderholm, 2010) and their willingness to save electricity was a fundamental analysis because it reflects household behavior, both for economic and normative motivation. The results showed that costs, approach to the environment, and social interactions are essential determinants influencing household behavior. The same research direction is also evident in (Sardiana, 2007), who examined the determinants of household energy savings. Their results showed that preferences in this area affect consumer income and family size. In addition, the results suggest that electricity spending and the respondent's age are negatively linked to the number of energy-saving measures the consumer is willing to take. Finally, other variables, such as environmental information feedback and awareness of energy issues, are the characteristics of an energy-saving consumer.

Consumers´ impetus for changing the energy supplier could be determined by studying their preferences of consumers. It is a different problem in essence. A crucial question is if the consumer is linked to the supplier and the source that this supplier uses for energy production.

Some results in that respect (Ek & Söderholm, 2008a) show that the main impetus of the household, the consumer is the economic benefit. The benefit is motivation, mainly if electricity is used for heating. On top of benefit motivation, the study points out the importance of knowing the total cost. Consumers have only a limited ability to process cost information which could lead to inaccurate behaviour by households. Insufficient comprehensibility of energy information was examined (Ellegård & Palm, 2011) in energy consumption for the housing sector. As argued, improving this comprehensibility is essential for developing policies contributing to energy efficiency.

The problem of comprehensibility emphasizes that energy efficiency advice is often so general that households have difficulty coping with it (Ellegård & Palm, 2011). Therefore, they tried to suggest a way to effectively determine the energy consumption of different appliances during the day. (Gyberg & Palm, 2009) also have some difficulty presenting energy information and understanding to consumers. (Gyberg & Palm, 2009) analyzed the discourse on which the idea of efficiency is based, according to various actors who seek to influence the energy behavior of households. They state that information intended for households often contains a strong idea that individuals must take responsibility for their own decisions and that the energy system will become more sustainable through consumer decisions. Their findings show that a strong belief in science and technology leads to the definition of a problem.

2 Description of perception of electricity sources production

Production and supply in Czechia are demonstrated in Tab. 1. Following data, the use of non-renewable sources such as solid fossil fuels is decreasing from 2009 to 2020. Renewables and biofuels are increasing from 2009 to 2020. The use of nuclear sources in energy production has been relatively constant over the years (National Action Plan for the Development of the Nuclear Energy Sector in the Czech Republic, 2015). France uses more non-renewables compared with Greece or Sweden. There are similarities in the supply of renewable between France and Sweden and the other two countries, Czechia and Greece Tab. 2.

The empirical literature also shows the distinction between renewable and non-renewable resources. This section focuses on determining which factors affect electricity generation consumer preferences. Based on existing research, we are trying to make an overview of some factors that motivate consumers to prioritize renewable and non-renewable energy sources. In general, both renewable and non-renewable energy sources are associated with positive and negative arguments in their favour. As reported (Heras-Saizarbitoria et al.,

2018), for example, photovoltaic solar energy as a renewable energy source is not only connected with positives such as profitable in the long term, clean and inexhaustible source of energy, reduces energy dependency and safe. However, there are apparent negatives such as expensive energy proposals, the inability to replace other sources, the technology has not reached maturity, and the electricity tariff being more expensive.

Tab. 1: Energy supply by product only non-renewables in four countries (Thousand tonnes of oil equivalent)

Time	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Czechia	219	225	216	250	277	304	305	346	359	368
Greece	28	14	21	20	89	60	0	28	41	9
France	1 559	1 609	1 647	1 692	1 674	1 744	1 695	1 709	1 741	1 632
Sweden	504	531	572	592	623	785	824	772	819	989

Source: Eurostat (2022), author´s calculation.

Tab. 2: Energy supply by product only renewables in four countries (Thousand tonnes of oil equivalent)

Time	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Czechia	3 498	3 757	4 131	4 269	4 385	4 434	4 540	4 567	4 913	5 123
Greece	2 199	2 507	2 676	2 506	2 840	2 704	2 915	3 141	3 172	3 350
France	19 161	22 582	25 243	23 424	24 273	26 232	25 868	27 873	28 408	28 603
Sweden	17 625	19 794	18 382	18 540	20 480	19 814	21 104	20 212	21 422	23 210

Source: Eurostat (2022), author´s calculation.

While, for example, nuclear energy is linked with the advantage of low production costs, it is reliable and associated with zero carbon emissions. However, disadvantages may include the production of toxic nuclear waste and the risk of nuclear accidents. The advantages and disadvantages of particular methods of electricity generation may or may not be reflected in consumer preferences. That is why the paper illuminates the situation in the Czech Republic partially and summarises some most important factors to consumers: firstly, mentioned in the literature review mainly the Swedish perspective, secondly is the French perspective on the nuclear source of energy, and thirdly is Greek arguments for and against renewable sources.

2.1 Non-renewable resources – the case of the French survey

France is an excellent example of studying attitudes and subjective behavior patterns concerning nuclear energy that is considered non-renewable (Gilli et al., 2021). In the report, people answered questions on the argument against using nuclear power plants. The first two reasons were: the risk of accident and the production of radioactive waste. Followed by other

two reasons: the vulnerability of nuclear facilities that changed position (from the fourth till 2012, to the third onwards) for the reason of "lack of transparency in the nuclear industry". The transparency must have improved by 2012. Interestingly, respondents did not select the rest of the reasons (emissions and competition with investments in renewable energies). People preferred to select others instead.

This country has reasons to use nuclear facilities, but there are reasons against it. Consumers do not know that there is already a new generation of nuclear reactors that use the spent fuel and fear the threat of generating new nuclear waste. It means that some consumers use outdated information. It supports the idea of researching the proportion of informed consumers and providing them with updated and correct information.

2.2 Renewable resources – the case of the Greek survey

The respondents' high level of awareness (72%) about environmental issues related to fossil fuel consumption is found in a survey of the Greek energy sector (Kaldellis et al., 2012). On average, 18% of respondents are not interested in (Ibid.) engaging in developing the use of renewable energy sources. There was the slightest interest in wind energy of the three forms of renewable sources analyzed: wind power plants, small hydroelectric installations, and photovoltaic systems. On average, 4% of respondents would not want to be involved in renewable energy sources, even if it would be financially advantageous. Using all financial benefits, only 10% of respondents would like to participate on average; the most significant interest was evident in photovoltaic installation. On average, 5% of respondents would not be interested in using renewable energy sources because they heard it was financially disadvantageous, especially concerning small hydropower plants. The largest share of respondents, 62%, would need more detailed financial data; again, it was the most preferred answer for small hydropower plants. A survey's overall result is that the economic complexity of the investment can be one of the factors influencing consumer preferences (Kaldellis et al., 2012).

The survey (Kaldellis et al., 2013) showed that a positive view of alternative sources of energy production prevails due to the severe negative impacts of the thermal power plant (in Megalopolis) on the environment. In the case of small hydroelectric installations, photovoltaic systems, and wind energy, this was the opinion of about 83% of respondents. However, in the case of wind energy, for example, 21% of respondents said that wind turbines annoy them visually or are not aesthetically correct. Respondents also held a similar opinion regarding photovoltaic panels (22%). Interesting findings are evident when using small hydroelectric

installations. The survey shows that "clean" electricity appears to be positive because the water supply in the region's rivers is controlled (62%), and it can contribute to the development of the area through entertainment facilities and aquaculture (13%). Still, some respondents also think it negatively affects fauna and flora (14%). In addition, only 9% of respondents said that small hydroelectric installations are visually or not aesthetically correct. Based on (Kaldellis et al., 2013), factors influencing consumer behaviour include landscape impacts and other side effects related to a given method of energy production.

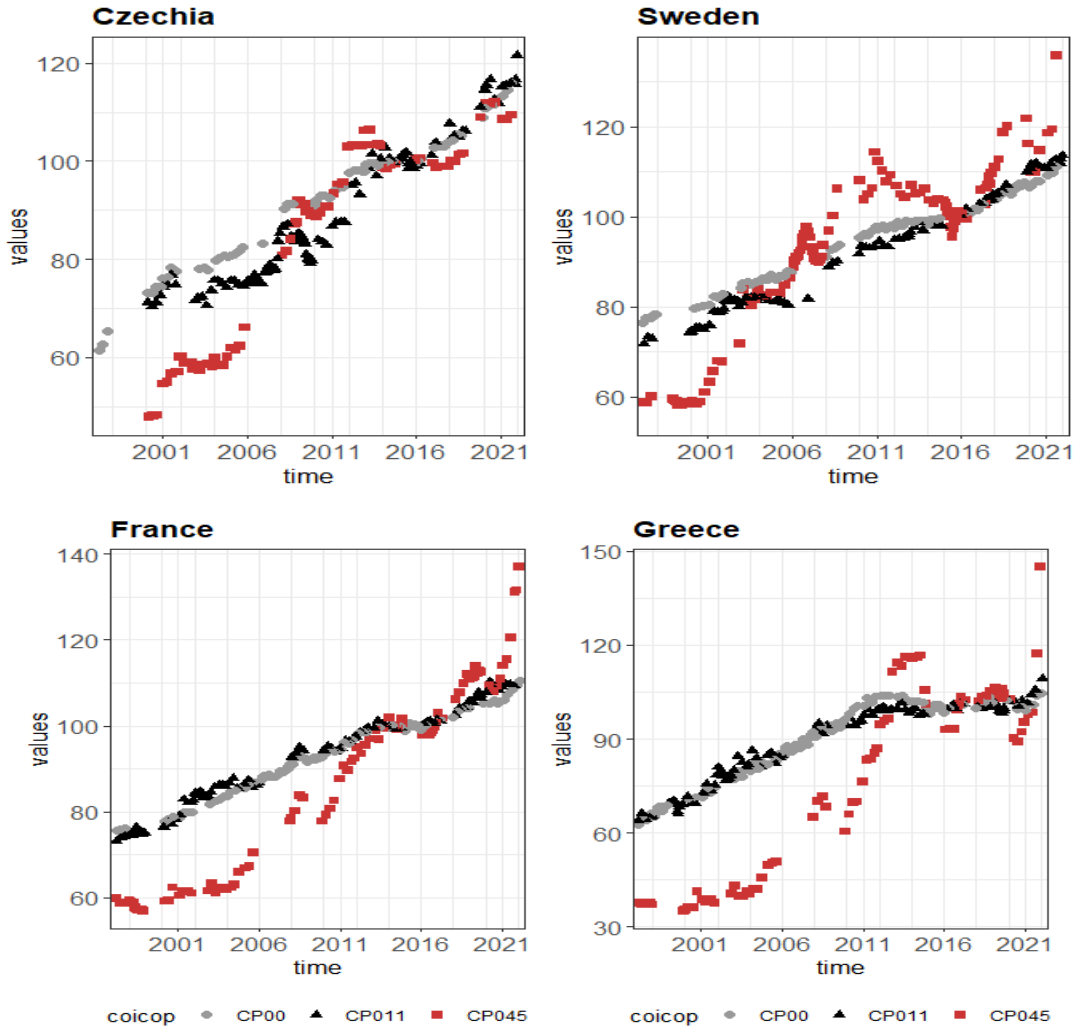
3 Prices of electricity production as related economic aspects

In the scope of perceptions, there are environmental issues of energy production and costs and price of energy as expressed by the Harmonized Index of Consumer Prices (HICP) index. Prices are presented in Fig. 1. and counterparts to prices are amounts (Tab 1 and 2).

In the scope of the energy issues, the complex view is crucial for individual economies' development. These are both economic indicators and other facts, such as sustainable development. The development of energy prices is always a significant variable in individual economies because energy represents an essential input in producing and distributing other goods. Graph 1 shows the development of prices in the Czech Republic, Sweden, France, and Greece in the years 2001-2021. In Greece, price liberalization in the electricity market began in 2007, causing prices to rise. Tariffs have not increased much since liberalization, but the wholesale price has risen sharply. The mismatch between the wholesale price and the retail tariff, combined with growing demand and limited supply, could lead to this price increase. In 2008, Greece found itself in a deep economic recession. In addition, in 2012, the impending energy crisis hit Greece due to high fixed electricity costs, bad debts, and poor regulation. In 2021, the prices were affected by a heat wave, below-average production of wind power plants, high coal prices, and a slowdown in the economy due to a pandemic.

Sweden and Norway created the Nord Pool wholesale market after the deregulation in 1996. In many European countries, the liberalization of energy markets has increased taxes and electricity charges. In Sweden, for example, fees more than doubled between 1996 and 2006. From 2008–2015, electricity prices in Sweden were affected by three key factors: an increase in electricity production from renewable sources, additional electricity supplies from hydropower plants, especially during 2015, and a decline in electricity demand. Subsequently, in 2016-2019, changes in revenue cap regulation and the introduction of incentive programs for the security of supply and efficient use played a role. In Sweden and France, in 2021, electricity prices were affected by, for example, rising coal prices and water shortages.

Fig. 1: Illustration of HICP (index 2015) changes in three items over two decades



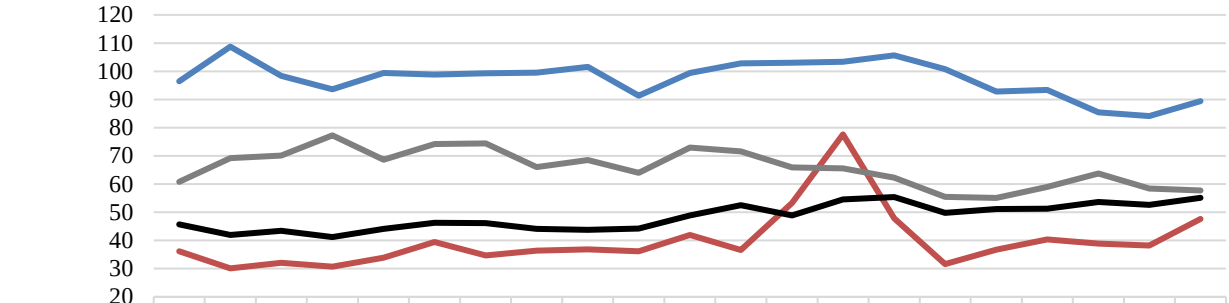
Source: Eurostat (2022), author´s calculation. Note: CP045 - Electricity, gas, and other fuels, CP011 - Food, CP00 -All-items HICP

In the Czech Republic, the start of the growth of electricity prices in 2002 is evident, together with the beginning of price regulation. Rising prices were mainly associated with an imbalance between energy supply and demand, a significant rise in energy prices, and a growing burden on the environment through emissions. In the following years, 2006 - 2009, the electricity market reflected weak competition, insufficient customer information, warm weather, and surplus production from wind power plants. In 2011, legislative interventions began manifesting themselves, such as the law taxing photovoltaic power plants. In 2021, among other things, there was a high demand for electricity and gas and a significant increase in emission allowances. The rise in electricity prices began two years after price liberalization, in 2005. Many factors affected the increase of prices in the period under examination, such as

the carbon price (since 2005), the global economic crisis (since 2008), geopolitical factors, and the nuclear disaster in Fukushima (in 2011).

As it was assumed, the development of prices in individual countries was caused by both global and specific factors. Moreover, HICP uses weights for each component or sub-index, which is different in each country (Fig. 2).

Fig. 2: HICP electricity, gas and other fuels weights in 2001 – 2021



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Czechia	96	109	98	94	99	99	99	99	102	91	99	103	103	103	106	101	93	93	85	84	89
Greece	36	30	32	31	34	39	35	36	37	36	42	37	53	78	48	32	37	40	39	38	48
France	46	42	43	41	44	46	46	44	44	44	49	52	49	55	55	50	51	51	54	53	55
Sweden	61	69	70	77	69	74	74	66	69	64	73	72	66	66	62	55	55	59	64	58	58

Source: Eurostat (2022), author´s presentation. Note: HICP all item weights are 1,000.

As evident from Fig. 2, the energy weights in the basket are the most important in the households of the Czech Republic. Greece households have the lowest importance apart from the years 2013 to 2014. It is due to the geographical location of Greece and lowers heating costs. The change in 2013 could be explained by short-run price rocketing. For the position of France in the figure, it applies the same reason of the geographical location.

As for the energy, information on weights in the basket are somewhat indicative, as the weights correspond to the consumption of an average household. Energy consumption is included in the production and distribution costs; therefore, it could be assumed that weights cannot present the importance of energy in economics. It relates to industrial consumption that is greater than the consumption of the household. Therefore, it would be ideal for searching in detail the share of industry, its structure in the particular country, its energy intensity, and the share of imported products. However, the importance of the impact of changes in energy prices on the average household in a particular country is disputable. It should be noted that the real impact of the energy price changes is examined by considering the country's average basket and

energy shares in the total consumption basket. It means that not only the direct expenditures on energy but also the expenditures included in the prices of food and other items.

Conclusion

Renewable energy sources are becoming increasingly popular in the last decades. Important questions for energy production are the consumers` preferences and the factors determining those preferences. As was mentioned in the introduction, it cannot be automatically assumed that consumers react only to the price of energy. The problem is the low awareness of the advantages and risks of the energy produced from different types of sources. Some problems with energy, specifically electric energy, are policy issues, i.e., one of the immense political topics. The risks of electric energy production from renewable sources in the Czech Republic are not discussed sufficiently yet. It creates the conclusion that many people are relatively uninformed about the risks. As it was sketched in the paper with the case of Swedish price development that is explained by the lack of water (for hydropower plants) as a consequence, renewable resources cannot be relied on for the time being. Some citizens are not informed about modern technologies, as mentioned in the introduction (e.g., small modular reactors that burn already burned nuclear fuel, i.e., waste). The overall conclusion and suggestion are to identify factors that citizens consider interesting. Based on factors presenting relevant information for the households who decide on their consumption and lifestyle.

This paper has tried to raise attention to consumers' preferences in the energy sector. Authors of quoted studies have already examined a few factors influencing the preferences. These prove that it is valid research questions for Czechia as well. The improvement in communication among consumers of electric energy, producers, and the rest of the institutions should be achieved by suggested research of preferences. The result of this research is input on communication strategy. Many studies emphasize the importance of providing understandable information to consumers. The key factors influencing consumer behavior in electric energy include the economic complexity of the investment, landscape impacts, and other side effects related to a given method of energy production, job creation, and technological progress that can be exported abroad.

Papers conclusion is that researching consumers' preferences in producing electric energy is essential. Namely, consumers' selection is based on the reason for accurate information about the most suitable energy source. This research can identify what is critical for the consumer and if (s)he decides based on objective and updated information.

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References

Heras-Saizarbitoria, I., Cilleruelo, E. & Zamanillo, I. (2011). Public acceptance of renewables and the media: an analysis of the Spanish PV solar experience. *Renewable and Sustainable Energy Reviews*, 15, 4685 – 4696. doi: http://dx.doi.org/10.1016/j.rser.2011.07.083

Ek, K. & Söderholm, P. (2010). The devil is in the details: Household elektricity saving behavior and the role of information. *Energy Policy*, 38(3), 1578 – 1587. doi: http://dx.doi.org/10.1016/j.enpol.2009.11.041

Ek, K. & Söderholm, P. (2008). Norms and economic motivation in the Swedish green electricity market. *Ecological Economics*, 68(1-2), 169 – 182. doi: http://dx.doi.org/10.1016/j.ecolecon.2008.02.013

Ellegård, K. & Palm, J. (2011). Visualizing energy consumption activities as a tool for making everyday life more sustainable. *Applied Energy*, 88(5), 1920 – 1926. doi: http://dx.doi.org/10.1016/j.apenergy.2010.11.019

Gilli, L., Velez, R., & Bueso, P. (2021). IRSN-Barometer_2021 All The Charts (p. 150 p.). Institut de radioprotection et de sureté nucléaire. http://barometre.irsn.fr/wp-content/uploads/2021/06/IRSN-Barometer_2021-All-The-Charts.pdf

National Action Plan for the Development of the Nuclear Energy Sector in the Czech Republic, Ministry of Industry and Trade of the Czech Republic, Ministry of Finance of the Czech Republic (2015). https://www.mpo.cz/

On measures for the transition of the Czech Republic to low-carbon energy and on the amendment of Act No. 165/2012 Coll., on subsidized energy sources, Act 367/2021 Coll., Ministry of Industry and Trade, 2021 Amendment to the Energy Act (2021). https://www.mpo.cz/

R Core, T. (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing,. https://www.R-project.org/

Gyberg, P. & Palm, J. (2009). Influencing households' energy behaviour—how is this done and on what premises? *Energy Policy*, 37(7), 2807-2813. doi: http://dx.doi.org/10.1016/j.enpol.2009.03.043

Kaenzig, J., Heinzle, S. L. & Wüstenhagen, R. (2013). Whatever the customer wants, the customer gets? Exploring the gap between consumer preferences and default electricity products in Germany. *Energy Policy*, 53, 311–322. doi: http://dx.doi.org/10.1016/j.enpol.2012.10.061

Kaldellis, J. K., Kapsali, M. & Katsanou, Ev. (2012). Renewable energy applications in Greece — What is the public attitude? *Energy Policy*, 42, 37 – 48. doi: http://dx.doi.org/10.1016/j.enpol.2011.11.017

Kaldellis, J. K., Kapsali, M., Kaldelli, El. & Katsanou, Ev. (2013). Comparing recent views of public attitude on wind energy, photovoltaic and small hydro applications. Renewable Energy, 52, 197 – 208. doi: http://dx.doi.org/10.1016/j.renene.2012.10.045

Lahti, L., Huovari, J., Kainu, M. & Biecek, P. (2017). Retrieval and analysis of Eurostat open data with the eurostat package. *R Journal*, 9(1), 385-392. doi: 10.32614/RJ-2017-019

Sardianou, E. (2007). Estimating energy conservation patterns of Greek households. *Energy Policy*, 35(7), 3778 – 3791. doi: http://dx.doi.org/10.1016/j.enpol.2007.01.020

Vassileva, I., Odlare, M., Wallin, F. & Dahlquist, E. (2012). The impact of consumers' feedback preferences on domestic electricity consumption. *Applied Energy*, 93, 575 – 582. doi: http://dx.doi.org/10.1016/j.apenergy.2011.12.067

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