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FORECAST OF SUSTAINABLE ENERGY DEVELOPMENT IN SLOVENIA

PREDVIDEVANJE RAZVOJA TRAJNOSTNE ENERGETIKE V SLOVENIJI

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Keywords: Delphi survey, technology forecasting, sustainable development, energy policy, Slovenia

Abstract

The development of the energy industry is strongly correlated with technology forecasting, which can provide core information for the planning of future energy policy. Energy policy must adhere to the global development paradigm in accordance with energy demand, population growth, global trends, environmental, and legislative restrictions, as well as the specific aspects of specific geographical areas. Reliable data on future trends are crucial for setting up an effective energy policy; therefore, results from a Delphi survey are essential for policy design. This paper presents the most significant findings gathered in the Delphi survey regarding future sustainable energy development in Slovenia. The results have revealed that achieving an increase in energy efficiency and a decrease in final energy consumption is much more important than maintaining low energy prices. The study has also forecast that the prices of all energy sources, including fossil fuels and wood biomass, will increase by 2020 and again by 2030. Delphi also forecast that Slovenia will transition to sustainable energy industry by 2046. The investments favoured by energy experts are small and micro hydro-electric power plants as well as cogeneration units.

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Povzetek

Razvoj v energetiki je močno odvisen od tehnoloških predvidevanj, ki lahko predstavljajo osnovni vir informacij pri načrtovanju prihodnje energetske politike. Energetska politika se mora navezovati na globalno razvojno paradigmo ob upoštevanju energetskih potreb, demografskih sprememb, globalnih trendov, okoljskih in zakonskih omejitev ter posebnosti posameznih geografskih področij. Za pripravo učinkovite energetske politike potrebujemo zanesljive podatke, ki jih Delphi raziskava z naborom različnih strokovnjakov s področja energetike nedvomno zagotavlja. V prispevku so predstavljene najpomembnejše ugotovitve pridobljene v slovenski Delphi raziskavi o prihodnjem razvoju trajnostne energetske politike v Sloveniji. Rezultati raziskave so pokazali, da je doseganje višje energetske učinkovitosti in zmanjševanje rabe končne energije veliko bolj pomembno od ohranjanja nizkih cen energije. Raziskava je prav tako potrdila predvidevanja, da se bodo cene vseh energentov, vključno s fosilnimi gorivi in lesno biomaso do leta 2020 povečale, še nadaljnje povečevanje cen energentov pa je mogoče pričakovati tudi do leta 2030. Po predvidevanjih Delphi raziskave bo Slovenija prešla v trajnostno energetiko okoli leta 2046. Po mnenju energetskih strokovnjakov so najprimernejše investicije v male- in mikro-hidroelektrarne ter v kogeneracijske enote/v enote za soproizvodnjo toplote in elektrike.

1 INTRODUCTION

While it is true that the future is unpredictable, some future events can be forecast to some extent to prepare for the future (with limitations) and attempt to shape it, *[1].* In the case of energy policy, the future will be shaped with the goal of minimizing the use of natural resources, particularly conventional energy sources (CES), to raise energy efficiency, to transition to renewable energy sources (RES) and to ensure a secure energy supply.

With technological forecasts, high-quality data on future energy industry development can be obtained that provides a solid foundation for effective and coordinated energy development planning. If forecasts are carried out systematically, professionally and periodically, the shaping of energy policy measures is more effective, can achieve greater positive effects, and be more consistent with the overall development paradigm, *[2].* Technology foresight, which emerged as a proven instrument of technology policy during the 1950s, has nowadays become one of the essential tools for the creation of technological development throughout the world, *[3].* In the mid-20th century, people realized that energy and energy sources are scarce. Focusing on technology forecasting in the energy sector the effect of the oil shock in 1973, followed by the first oil crisis in 1979 cannot be ignored. At that time, the Western world, in particular, was faced for the first time with insufficient and insecure oil supplies. The development of the energy industry and energy policy at that time, therefore, demanded the development of new energy models and energy-related technology forecasts in order to foresee the possible future and to prepare energy policies and action measures for it according to a variety of scenarios.

Forecasting future energy development has recently become even more crucial, since the price of energy sources is increasing, constituting a significant share of total costs in the energy industry, *[4]*, as well as in transport and logistics and some other energy-intensive industries. The effective planning of future energy development and forecasting development trends also

enables us to consider the probability and assessment of different scenarios. The IEA, *[5]*, states that future energy development and planning is a core competency for policy decision makers.

One of the tools for such forecasts is the Delphi method which is nowadays widely applied as a valuable future-oriented intuitive foresight tool for the qualitative and quantitative assessment of probable future development, *[3]*, but is rather complicated and very time-consuming.

The intuitive Delphi method is based on trust in the knowledge, expertise and ability of the participating experts to make projections for the future, *[6]*. All identified experts must be extremely well-informed about specific research issues and must have extensive knowledge and information related to relevant energy issues. Because inaccuracies may occur if only one expert makes a forecast, Delphi includes a small number of experts ranging from 10 to 15 top experts on the specific discipline, *[6]*. The number of leading energy experts is severely limited due to the highly specialized research topic. The identification of appropriate and credible experts is crucial, *[1]*, and can be an extremely challenging and time-consuming part of the Delphi survey, *[7, 8]*.

With the Delphi method, we can access and study highly specialized data provided by the participating top experts to form technology forecasts. Delphi methodology has already been widely used for energy-related forecasts such as designing and modelling future energy development in India, *[9]*, to forecasting maritime oil freight flows, *[10]*, or studying future energy industry planning in Spain, *[11].* Delphi methodology is highly appropriate for predicting future energy sector development; however, it can be used in a range of approaches, as can be seen in a) the study by Makkonen et al., *[12]*, focussing on the effects of different measures for European electricity markets or b) in the study by Hussler et al., *[13]*, focussing on whether diversity of opinions might lead to greater robustness and whether different groups of people (experts vs laypersons) rely on divergent rationalities in composing reliable panels of technological forecasting in the nuclear sector. Wehnert et al., *[14]*, surveyed the energy future of the EU, where researchers performed a) a Delphi survey to analyse the opinions of the involved experts, and b) developed three scenarios with different aspirations for sustainable development. Another study, by Di Zio and Maretti, *[15]*, used the Delphi method to determine the energy sources that are most acceptable or most preferred by the public, political systems and the market. They also studied the weight that these dynamics of acceptability have on global energy movements.

The purpose of this Delphi survey is to forecast detailed future energy development, especially on the Slovenian market with some implications on the EU and the world as well, by 2030 with guidelines and directions for its development by 2050. The aim of the research is to interview relevant Slovenian top energy experts and to integrate their opinion on energy issues to make a technology forecast for different energy-related sectors, to assess the transition time to the sustainable energy industry, to assess the fulfilment of set of renewable energy objectives and sustainability of the Slovenian electricity mix, to forecast energy demand and trends related on energy prices and to set the scale of priority measures for the development of more sustainable energy technology.

2 METHODOLOGY

The Delphi study was conducted in separate content-distributed sections. Due to the large amounts of collected data, this paper only presents the core results of future energy development trends.

The survey was carried out in several stages. First, potential energy experts evaluated as eligible to participate in the study were identified. The selection key included their professional experience; job title, description and field of employment (e.g. government, private company, etc.); education; participation in energy projects and publications in the field of energy in professional and scientific journals. We managed to identify and draw up a credible base of 56 top energy experts in Slovenia from a variety of fields, constituting the core for a Delphi study. These experts were personally contacted, informed about the topic and procedure of the Delphi survey and invited to participate in it. Thirty-four of the contacted experts were willing to cooperate. From the participants, 61% or 20 questionnaires were obtained on time, representing a survey sample.

The Delphi survey was conducted from January 2012 to August 2012. Among the participating experts, 80% of them were men, and 20% were women. The employment period of the experts in the energy sector was above 10 years in 75% of the respondents and more than 15 years in 50% of them, which means that the participating experts are long-time contributors to the energy sector. The structure of cooperating experts is presented in Figure 1.

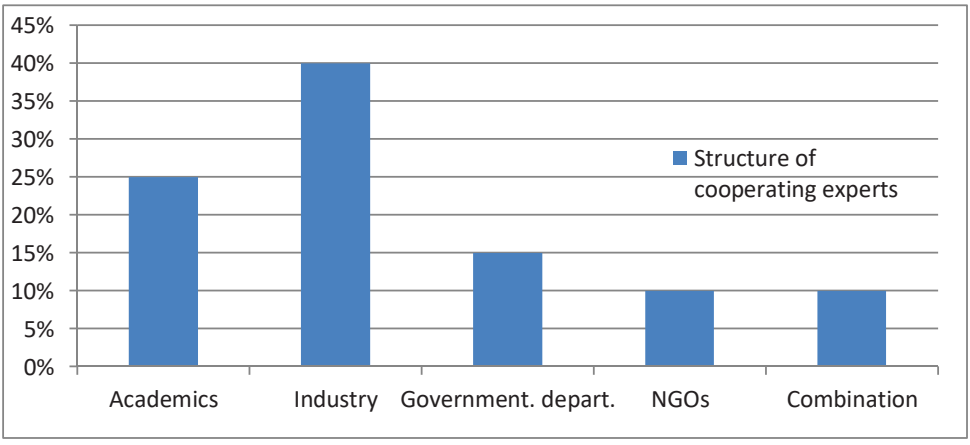

Figure 1: *Structure of cooperating top energy experts*

Almost two-thirds of the participating experts worked in industry or as academics; others were from governmental departments, NGOs, or a combination of these. Similar classifications of different stakeholders were also in studies by Soner Celiktas and Kocar, *[16]*, Czaplicka-Kolarz et al., *[3]*, and Makkonen et al., *[12]*, etc.

In the Delphi survey, a structured questionnaire was used to examine four lots of energy-related content. The survey was conducted through: “assessment of the importance of sustainable energy development”; “assessment of the accuracy of the study of the factors of sustainable energy development”; “assessment of the accuracy of the developed energy model” and the

most essential part of the research – "a forecast of future sustainable energy development in Slovenia, the EU and the world". Due to the large amounts of obtained data, data analysis was performed in separate lots. This paper presents the essential part of the study for Slovenia – the forecast of future energy development in Slovenia. The remaining parts of the research were or will be published separately.

The acquired quantitative data were analysed using descriptive statistics and a comparative analysis of the various demographic groups of experts (stakeholders). The acquired qualitative data were analysed first with data sampling and then statistically processed.

3 RESULTS AND DISCUSSION

3.1 The outline of the studied results

In this paper, the core results of the Delphi survey are presented in partly separated lots. The first lot (I) presents an assessment of the achievability of the European Union energy-climate objectives, known also as the 20/20/20 objectives targeting to achieve 20 % of renewables in final energy consumption (25% as a specific national target for Slovenia), reducing greenhouse gas (GHG) emissions by 20% and increasing energy efficiency by 20%, all by 2020, as well as an assessment of the impact of the new Slovenian thermal power plant on achieving these legally binding international targets. In the second lot (II), the time frame for the transition from conventional energy to sustainable energy was forecast. Furthermore, in the third lot (III), the direction of energy development was foreseen in accordance with the assessed sustainability of different energy sources in Slovenia. This also studied in a survey about public opinion on energy policy, *[2]*, and results were presented to the participating top energy experts. Differences of the general public (lay-public) and expert judgements are also mentioned and discussed. Furthermore, in the fourth lot (IV), future trends in energy demand in Slovenia were explored and compared with the EU and the world energy demand. These results allow especially Slovenian energy policy decision makers to forecast crucial changes that can be expected in the 21st century.

3.2 Achievability of SLOVENIAN energy policy objectives

The structure of the findings on the achievability of the set objectives in the energy sector is further divided as follows: Experts forecast the probability of achieving the three different goals – the Kyoto protocol (1a), 20/20/20 objectives in general (1b) and a 25% share of renewables in final energy consumption in Slovenia by 2020 (1c).

The participating experts also discussed achieving the Kyoto protocol targets for Slovenia. The crucial issue is that various incompatible and incomplete databases do not allow unequivocally confirming or refuting whether Slovenia will/have fulfilled current Kyoto targets or not. Even during the period of research implementation, differences between the experts on the probability of achieving the Kyoto protocol goals were considerable; however, less than half (41%) believe that targets were achieved (1a). (1b) The experts have also estimated that the chance of achieving the 20/20/20 objectives in Slovenia is 0.387 and (1c) the chance of achieving a 25% share of RES in final energy consumption in Slovenia by 2020 is 0.431.

Since the new block (no. 6) of Šoštanj thermal power plant (TPPŠ) is the largest energy industry project in Slovenia in decades, its impact on achieving the above-mentioned goals (1a, 1b and 1c) was studied as well. The probability of achieving different energy-climate related goals as well as the effects of TPPŠ on the set goals are presented in Table 1.

Table 1: *Evaluation of achievement of different international goals relating to the energy industry in Slovenia (n = 20)*

Goal	Probability of achieving it (interval from 0 to 1)	Effect of TPPŠ on achieving goals* (interval from -1 to 1)	Probability of achieving it without TPPŠ (interval from 0 to 1)
(1a) Kyoto protocol	0.413	-0.10	0.513
(1b) 20/20/20 objectives	0.387	-0.15	0.537
(1c) 25% of renewables in final energy consumption by 2020 in Slovenia	0.431	-0.05	0.481

* -1 means highly negative impact, and 1 means highly positive impact on achieving the goals

As presented, it will be very difficult to achieve the 20/20/20 objectives in general (probability 0.387); however, the probability of achieving them would be much higher if TPPŠ were not constructed (the probability of achieving these objectives without the reconstruction of TPPŠ would rise to 0.537). Experts have also evaluated that out of all the studied objectives, a 25% share of renewables in final energy consumption in Slovenia by 2020 is the most promising (probability 0.431). RES share at the end of 2014 was 21.9%. (Eurostat, 2016). Due to this high share, the authors evaluate that the probability of Slovenia achieving a 25% share of RES by 2020 is even higher than as assessed by energy experts; however, this share is no longer increasing as fast and as constantly as it was before 2013.

Energy experts have also assessed which target integrated in the 20/20/20 goals is the most difficult to achieve for Slovenia and for the EU in general. Lowering GHG emissions was assessed as the most difficult target to achieve in Slovenia (10 out of 20 experts), followed by achieving increased energy efficiency (EE) (6 out of 20 experts). However, this forecast did not consider reduced feed-in tariffs due to the termination of feed-in tariffs for solar photovoltaics.

On the EU level, in general, the situation is slightly different. For the EU, the most difficult goal to achieve is increasing EE and lowering energy consumption (8 out of 20 experts), followed by increasing the RES share to 20% by 2020 (6 out of 20 experts). Lowering GHG emissions was evaluated as the goal that the EU is most probably going to achieve because only four experts expressed doubt about meeting this target. This is quite realistic, since the EU GHG emissions trend has been declining significantly in recent years, partially due to improved energy efficiency in buildings but partially also due to the economic crisis and the consequently lower level of economic activity between 2009 and 2015, *[17].*

3.3 Assessment of transition to sustainable energy industry – Slovenia, EU and the world

Furthermore, experts were asked to assess the anticipated time of transition to a sustainably oriented energy industry (lot II). Such an industry was defined in the questionnaire as the end of increasing energy demand, a continually decreasing share of fossil fuels and at least a 30% share of renewables in the national energy mix. Denmark was presented as the best practice case since it has more than halved fossil fuel consumption since 1972, kept the same level of final energy use despite an increase in population and heated areas and plans to have a 30% RES share by 2020.[1] The gathered data were analysed, and the results are presented in Figure 2, separately for Slovenia and compared to the EU and the world. To present the period of this forecast, the Delphi survey implementation time point is also presented.

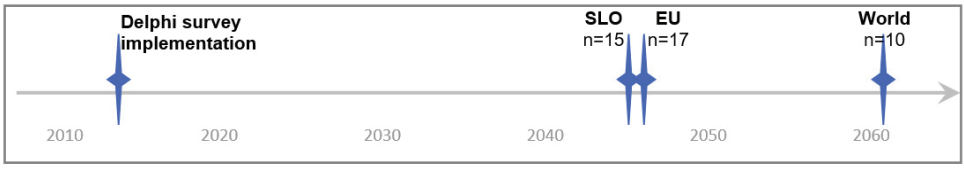

Figure 2: *Evaluated period of forecast transition to sustainably oriented energy industry (Slovenia, EU, and the world)*

Average values are presented in Figure 2. Experts beliefs for achieving sustainable energy industry in Slovenia differed significantly, with a group of very optimistic experts (evaluating the period of transition between 2025 and 2030) and one that was less optimistic about it (four experts). On the global level, two of them evaluated that global energy industry will never be sustainably oriented. However, the average grades indicate that Slovenia will transition to a sustainably oriented energy industry in 2045, the EU one year after Slovenia, which makes sense according to current energy statistics and trends and the world approximately 15 years later (in the year 2061). It is clear that the transition to a sustainable energy sector in Slovenia as an EU Member State as well as in the EU in general will be faster than the global transition, since the EU and Slovenia have almost no oil reserves and are, therefore, more interested in independent and locally available energy supply. They are also already significantly investing to achieve this goal, have a common energy policy promoting the use of RES and EE. In another Delphi, survey the results were even more optimistic as Poland's experts forecast that the country will produce at least 30 % of its energy from its local renewables as early as in 2023, *[3].* This is however debatable, since the share of renewables in Poland's primary energy production is approximately 15%, *[18].*

[1] However, one expert noted that Denmark's relatively sustainable energy situation was extremely expensive and causes high electricity prices

3.4 Sustainability of energy sources and Slovenian energy mix

(III) At this point, the sustainability of different energy sources used in Slovenia was addressed. Sustainability of energy sources was also studied in a survey about public opinion on energy policy [2]. Results presented in Figure 3 show substantial differences in evaluated sustainability of different energy sources. Hydro energy was assessed to be the most sustainable energy source on which Slovenia can rely. The authors believe that this is a realistic evaluation since Slovenia's energy industry is strongly related to hydro-energy and new possibilities for even broader exploitation of hydro energy are being investigated. Public support to hydro energy exploitation is also high, and technical analysis of it shows that it is very appropriate because unlike sun and wind energy that depend on weather conditions, climate, period of the year and are highly volatile, we can predict its availability and manage it to cover peak consumption. Wind and solar energy both got high evaluations in the environmental perspective but rather low in economic appropriateness, mainly due to previously mentioned deficiencies known especially to energy experts but also to the general public.

The second best average grade in all three perspectives on sustainability was assigned to biomass and biogas. Because over 55% of Slovenia is covered by forests, this evaluation also aims that biomass and biogas potential should be exploited to a greater extent and more efficiently in the future of Slovenian energy industry. As expected the lowest environmental grades were assigned to oil and coal, which were also assessed as economically quite appropriate, which was surprising due to controversial issues regarding TPPŠ and economic indicators that reveal TPPŠ is operating negatively already from the beginning and is going to be even more problematic for energy industry economics and sustainability in the future.

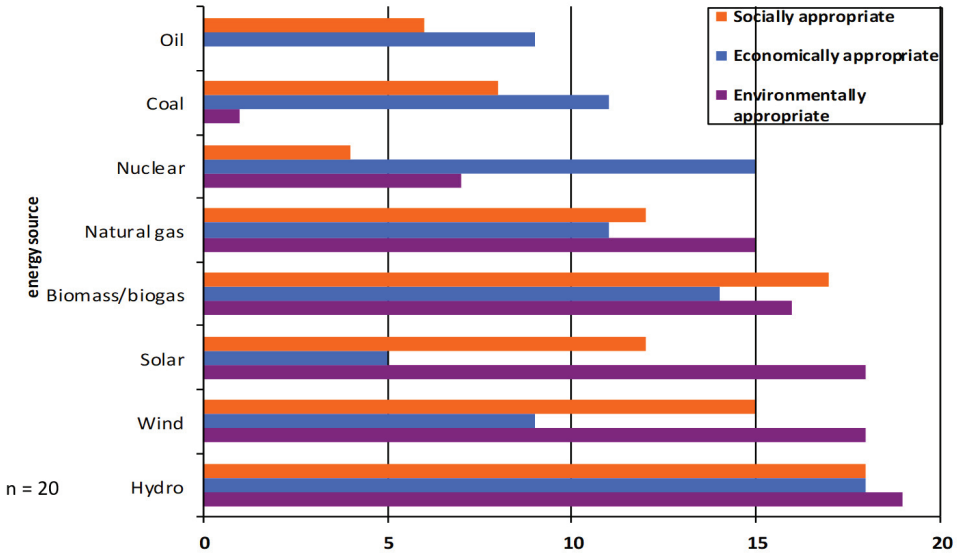

Figure 3: *Appropriateness of different energy sources in Slovenia from social, economic and environmental perspectives*

However, when assessing energy policy priorities, top energy experts and lay public both identified increased energy efficiency, decreased energy use and planning environmentally friendly energy industry as the top energy policy priorities therefore consensus was clear in this case. If we go one step further and consult Hussler's study, *[13],* in which the variety of judgments within and between experts and lay public was studied, the conclusion was apparently paradoxical: that non-expert judgment is less stable, but not necessarily less accurate, than that of the experts.

3.5 Forecast of energy demand and energy prices for Slovenia

(IV) Since global energy demand has been increasing in recent decades, experts were asked to forecast future energy demand in Slovenia, the EU and the world, along with future prices of different energy sources and electricity, as well as emission allowances. Forecasts were made separately for the time frames until 2020 and from 2020 to 2030.[2] Future energy demand in Slovenia, the EU and the world is further presented in Figure 4.

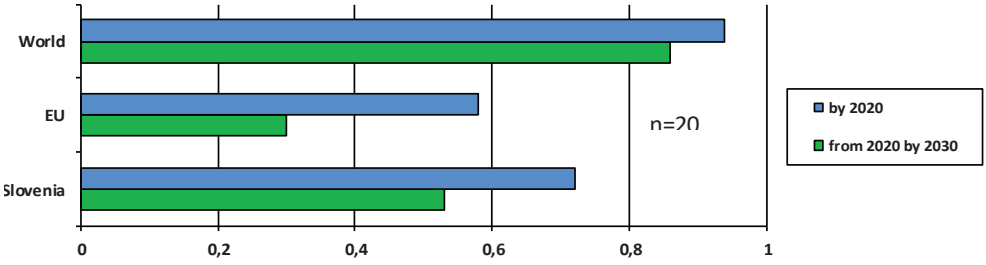

Figure 4: *Forecast of future energy demand in Slovenia, the EU and globally (interval from 0 to 1, where 0 means growth is not possible, and 1 means growth is very possible*

As presented in Figure 4, experts believe that energy demand will increase mostly on the global level by 2020 (95% of all experts believe that global energy demand will rise by 2020) as well as from 2020 to 2030. An increase in energy demand in Slovenia by 2020 will be slightly lower than globally but higher than in the EU and significantly lower from 2020 to 2030. Some experts believe that energy demand in Slovenia will remain constant in the period from 2020 to 2030. The slowest increase is forecast for the EU from 2020 to 2030. A slower increase in energy demand in the EU after 2020 was also projected in other studies, *[17].* The future economic situation will most probably also have severe impacts on future prices of energy sources and emission allowances, since it is highly dependent on energy demand as the prices of fossil fuels are mainly regulated by OPEC. If Slovenia is able to achieve the transition towards a more sustainable energy industry, energy price volatility could be significantly decreased.

In accordance with energy demand forecasts, energy experts also forecast increasing prices of energy sources and emission allowances in all the studied periods. It was evaluated that fossil

[2] In accordance with the time frame of 20/20/20 objectives and their discussed upgrade which is planned to be set by 2030.

fuel prices along with electricity prices will increase most rapidly by 2020. It can be expected that prices will also increase from 2020 to 2030 but less intensively than by 2020. Some energy experts have also forecast the increasing price of wood biomass, *[17]*. However, only the average values are presented in Figure 4. A more detailed data analysis has shown that these assumptions differ significantly from each other, since some experts have forecast strong growth and others a decrease in wood biomass prices. The wood biomass price is probably more difficult to forecast since studies dealing with future biomass prices are rare. However, Slovenia suffered severe freezing rain in February 2014 which damaged 42% (3.5 million cubic meters) of Slovenian woods, an amount equal to the annual timber removal. The trend of increasing prices of wooden biomass, seen from 2009, consequently changed and prices (especially wooden biomass for heating and energy use) were in 2014 much lower because the wooden biomass supply has rapidly increased, *[19]*. In addition, further wind breakage destroyed additional 1 million cubic meters of wood in 2016 and 2017.

4 CONCLUSION AND POSSIBLE IMPLICATIONS

The Delphi method proved to be a successful research method in studying the future technology development of a specific sector. It was conducted to shed light on an issue that is highly topical in Slovenia, the EU and the world: the forecast of future technological development of the energy sector and its influence on the transition to a sustainable energy industry.

The Delphi method revealed critical issues relating to the probability of achieving the 20/20/20 goals especially due to the negative effect of TPPŠ on Slovenian national energy statistics, increasing future energy demand by 2030, and the forecast increase in oil prices (despite the significant decrease in oil prices at the beginning of 2015), natural gas prices, wooden biomass prices, as well as emission allowance prices. The study revealed that experts believe that future energy policy must be radically transformed since top energy policy priorities were 1) the reduction of energy use, 2) an increase in EE, and 3) development of an environmentally friendly energy industry.

Since leading energy experts have forecast that the EU and Slovenia as a member state will transition to a sustainable energy industry by 2046, the top priorities will most likely be realized, at least to some extent. This is especially important for the EU and its Member States, such as Slovenia, since there are no significant oil reserves, but the energy sector is already heavily dependent on imported oil. As this dependency can lead to economic and socio-political risk, energy policies based on prudent and efficient energy use and energy production from local renewables are crucial for the long-term socio-political stability of the EU as well as rising standards of living on the local level.

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