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Low temperature district heating concept in the smart energy system: challenges and benefits

Conceptul de termoficare la temperatură scăzută în sistemul energetic inteligent: provocări și beneficii

Viederyte-Ziliene Rasa[1], Labanauskaite Daiva[2], Andziulis Arunas[3]

[1] Department of Economics, Faculty of Social Sciences and Humanities, Klaipeda University, S. Neries st. 5, Klaipeda, Lithuania
[2] Department of Economics, Faculty of Social Sciences and Humanities, Klaipeda University, S. Neries st. 5, Klaipeda, Lithuania
[3] Department of Informatics and Statistics, Faculty of Marine Engineering and Natural Sciences, Klaipeda University, Bijunų st. 17, Klaipeda, Lithuania
[4] Corresponding author's e-mail: rasa.ziliene@ku.lt

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Abstract. In modernizing energy systems, European countries are focusing on a smart energy system, and one of the goals of which is the rational use of energy resources and the reduction of negative environmental impact. The concept of the low temperature district heating in the smart energy system is one of opportunities to decrease loses and waste of energy and to implement a systemic approach to the energy use. A roll-out could begin selectively, based on experimental project activities in the near future, new construction will be used to develop the business infrastructure necessary for later, more widespread deployment. The aim of the research is to summarize challenges and benefits in the implementing of the low temperature district heating concept in the smart energy system. The object of the research: challenges and benefits in the implementing of the low temperature district heating concept. The objectives: to systemise the smart energy approach in sustainable future; to analyse the concept of the low temperature district heating in a smart energy system; to characterise risks and opportunities of the low temperature district heating concept. There were used these scientific methods: induction, systemic analysis, comparative analysis and synthesis of partial scientific knowledge. Analysis of various scientific articles and studies shows energy conservation, increased use of renewable energies, smart grids to promote renewable energy utilization, cleaner technologies, multigeneration, and efficient storage of energy carriers are necessary conditions for the transition to smart energy systems for a sustainable future. The low temperature district heating concept is associated with some forms of risk, but the dissemination of experience and on modern digital technologies based management can help to achieve ecological benefits although reduced CO2 emissions, minimize heat loses and waste of energy, to reduce costs of energy production and to improve the image of heating companies.

Key words: *smart energy, energy resources, renewable energy*

1. Introduction

The district heating is an important part of the energy system, and this importance is still growing. In the EU, district heating accounts for 13% of total heating sales, however in particular areas, the market is more established and has a longer history [23]. District heating is the fastest opportunity to modernize the heating system. The development of district heating can significantly contribute to the solution of the complex heating system problem, strengthening innovation and efficiency. The level of development of district heating differs in various EU countries. According to the investigation of E. Wheatcroft et al. (2020), In Denmark, Sweden, Finland, Estonia, Latvia, Lithuania, and Poland, district heating contributes to more than 50% of the total energy consumption. In terms of absolute numbers, Germany and Poland have the largest EU district heating markets. The four categories that the authors propose to divide the European district energy landscape into are consolidation nations, refurbishment countries, expansion countries, and new developing countries [23].

Concentrated efforts are orientated to implement existing alternative solutions to decarbonize the heating sector, to turn to the smart energy systems of the circular economy. Currently about 7% of heating in Europe is done by electric heating, which requires about 175 TWh per year [17], however, in the context of energy sustainability, this is not the most effective solution, a detailed review of energy efficiency improvements available in all energy using sectors. Different organisations are working on the new energy efficiency programs for the next years. According to the "Roadmap 2050" (2010), "smart" technologies and systems will be key enablers to proactively manage power flows and minimize increases in network capacity required. The concept of the low temperature district heating in the smart energy system is one of opportunities to decrease loses and waste of energy and to implement a systemic approach to the energy use. A roll-out could begin selectively, based on experimental project activities in the near term in new construction to build up the commercial infrastructure required for wider application later on.

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The object of the research: challenges and benefits in the implementing of the low temperature district heating concept.

The objectives:

• to systemise the smart energy approach in sustainable future;

• to analyse the concept of the low temperature district heating in a smart energy system;

• to characterise risks and opportunities of the low temperature district heating concept;

• to figure out which benefits of the low temperature district heating concept are implemented in the behaviour of the population of the Baltic Sea Region in the context of the transition to smart energy.

Scientific approaches such as induction, comparative analysis, and synthesis of partial information, as well as quantitative research (a questionnaire survey), were employed in the study. Data processing techniques were also used in the empirical research.

2. Materials and methods

The future energy system should be based on the concept of the renewable energy, free of fossil fuels and should not cause CO2 emission into the atmosphere. D. Skaarup Østergaard (2018) commented it as an ambitious, but necessary goal, as fossil fuels are a limited resource, and continuous CO2 emissions will cause climate change that will endanger our way of life. In view of the limited oil resources, the direction of the development of the country's heat supply in the context of energy conservation takes on special relevance in the energy sector as well [2].

The challenge for the developers of innovative energy projects is not only to minimize losses of energy, to avoid the pollution of the atmosphere, but how to transform the energy system in the cost saving way. District heating can be an example for a potential successful transition of the energy system on a way to a sustainable functioning smart energy system. Geothermal heat, solar thermal heat, excess heat from industry, and heat sources from power production based on biomass or trash can all be effectively used in district heating and would otherwise go unused [19].

2.1. Smart energy approach in sustainable future of smart cities

Smart city concept is immensely popular model of the city development nowadays. The Smart Cites share the two common features as follow [14]:

• the widespread and development of Information and communication Technology (ICT) infrastructures of Internet, data sharing, e-government, public services, innovation and entrepreneurship, and social cohesion;

• green policies for a smart growth with environmental protection policies, and traffic congestion.

A smart energy system can be analysed as a part of priorities in a green policy of the sustainable development. Smart energy systems are investigated and assessed as a tool to solve major global energy and environment related issues. H. Lund et. al. (2014) has defined a smart energy system - is a strategy in which intelligent electrical, thermal, and gas grids are connected and coordinated to find synergies between them and arrive at the best possible solution for both the sector in question and the entire energy system.

A smart energy system is described by different scientists and experts as a prerequisite for sustainable growth and sustainable future. Energy conservation, increased use of renewable energies, smart grids to support renewable energy utilization, cleaner technologies, multigeneration, and efficient storage of energy carriers and chemicals [6] are the key prerequisites for the transition to smart energy systems for a sustainable future. These systems include cutting-edge infrastructures and technology that produce new kinds of flexibility, particularly during the energy system's conversion phase [11].

Main expectations from the smart energy systems are summarized by I. Dincer et. al. (2017) and characterized as:

• energetically sound - a system could not only conserve the quantity, but also the quality of its energy content.

• energetically secure - end users can obtain a dependable, useful, safe, and efficient energy supply with the help of smart energy systems, which finally leads to energy security.

• environmentally benign - more effective systems, lower emissions, and a cleaner environment for future generations all result from less waste and loss.

• economically feasible - smart energy systems provide reliable, economical, and useful end-use options as well as considerable economic advantages.

• commercially viable - the ability to compete effectively and to be profitable.

• socially acceptable - since these systems may satiate social requirements and harmonize available options, they are anticipated to be socially acceptable.

• integrable - integration is a final operation that combines energy sources and systems in a synergetic way to improve efficiency, cost effectiveness, resource consumption, and the environment.

• reliable - smart energy systems should be dependable, which includes using reliable and conveniently accessible/available resources, dependable energy processing/ conversion technologies, and dependable end-user service.

Smart energy systems help to implement a responsible approach to the use of energy resources increasing their economic and technological efficiency. Energy efficiency improvements are significant in a process to reduce greenhouse gases emissions. The implementation of priorities and targets of a “Roadmap 2050” (2010) depends to a large extent on the success of the implementation of a smart energy system.

Targets of a smart energy system are concentrated on [6]:

• better efficiency: efficiencies could be increased by cutting back on waste and losses.

• better resources use: this target strives to lessen reliance on resources that aren't readily and affordably available locally.

• better cost effectiveness: smart energy systems offer higher cost effectiveness by minimizing losses and waste, producing numerous products from the same energy source, and using dependable, accessible, abundant resources.

• better environment: the worldwide CO2 emissions from the energy sector and industry must be reduced to 30–70% of 2000 levels before 2050 in order to meet this wise goal.

• better energy security - one of the main goals of smart energy systems is to reduce reliance on energy import/export and deliver dependability, flexibility, availability, and cost.

• better design and analysis: smart energy systems are made to boost productivity and the quantity of desired products while reducing losses and waste.

A smart city development may be an ideal chance for creating and testing of a smart energy system, where the low temperature district heating would be a significant element to achieve goals of economic and technological efficiency.

2.2. The concept of the low temperature district heating in a smart energy system

District heating can contribute significantly to a more efficient use of energy, but old infrastructure and technologies can be a reason for the absence of the progress in the framework of sustainability. D. Schmidt (2018) has determined, that district heating pipes (type of pipes, insulation materials/conditions), district heating operation (heating load, temperature level, bypass operation, and other factors such as leakages), and geometrical condition (network dimension, length, and ground conditions/properties) all contribute to the district heating network's heat loss.

The use of lower temperature heat medium in district heating networks, according to Rhys Jones et al. (2019), has the following advantages:

• improved heat load distribution due to the ease with which lower temperatures can be controlled;

• reduced distribution pipe heat losses of up to 75% when compared to high-temperature district heat networks;

• using low-temperature heating sources such waste heat, solar thermal collectors, and heat pumps;

• a smaller margin for system design;

• less risk of high-pressure explosion and scorching;

• a longer lifespan for the piping infrastructure as a result of less pipe damage from temperature stress.

H. Averfalk et. al. (2018) mentioned that from a system perspective, low temperature operation has the following synergistic supply benefits: increased access to geothermal heat, increased use of industrial waste heat, increased use of heat from cooling processes, improved efficiency of solar thermal collectors, increased use of ambient heat sources by heat pumps, increased efficacy of flue gas condensation, and increased electrification.

Low temperature district heating is expected by experts as one of the factors facilitating the shift to an eco-friendly, low-carbon civilization. The switch to the new generation system is a paradigm shift that aims to improve citizen quality of life while also maximizing resource and material consumption, reducing environmental effect, and increasing socioeconomic benefit [12]. To improve both efficiency and economic performances of district heating, the fourth district heating generation, also called “low temperature district heating” was first proposed in 2014 [7]. Through a holistic strategy to increase communications between heat generation, distribution, and consumption, more system efficiency improvement can be found [12].

Four basic criteria in particular were noted [7, 18, 8, 3]:

• the capability of supplying thermal energy at low temperatures to both new and existing structures,

• the capability of decreasing heat losses throughout the network,

• the integration of low enthalpy heat plants while retaining the present supply circumstances; and

• to participate in smart energy systems and thereby help the transition to a 100% renewable energy supply system that integrates several energy sectors.

When providing district heating to low energy buildings or buildings in scarce locations, the low temperature district heating idea was initially introduced to ensure district heating was more cost-effective than local heat generation. The network supply temperature is lowered from 80°C to 55°C to prevent network heat loss (Li et al., 2016). The system temperatures that each type of district heating technology employs can be used to classify the technology [19]. Modern systems are frequently based on lower temperatures, which enable higher efficiency in both heat production and heat distribution. But in a world without fossil fuels, with less garbage to burn and a greater need for biofuels for alternate purposes, the use of urban heat sources will be crucial [23]. D. Skaarup Østergaard (2018) mentioned that the future district heating system should therefore be based on temperatures that are lower than the current district heating temperatures of roughly 80-85 °C and 40-45 °C for supply and return in order to enable an affordable transition to a new sustainable energy system.

In addition, fifth generation district heating is being discussed, which integrates heating and cooling, enables demand side response and related thermal energy storage, and widens the integration of waste/surplus heat sources [4]. The fourth generation district heating with a supply temperature below 70°C enables lower heat losses, integration of renewable heat (solar, geothermal, wastes, and biomass sources), and compatibility with cooling networks and smart energy systems. Fourth or fifth generation district heating technology is used for low temperature heat recovery, with the fifth generation representing lower distribution temperatures than the fourth [23]. The same authors contend that because technology change is now young and in its infancy, there is opportunity because waste heat sources are widespread and frequently found adjacent to urban regions with high heat demand. These factors increase the resilience of the energy system as a whole [23].

Modernization of the district heating system requires significant investments: between 2016 and 2050, it is predicted that 27 trillion USD must be invested in renewable energy in order to achieve the goals of the 2016 Paris Agreement [23]. Achieving sustainable change in the energy system requires a systemic approach to energy system reforms, continuity on the political level and governmental support.

2.3. Challenges to realize the smart low temperature district heating concept

According to the nearly zero energy requirements specified by the European energy performance directive, new buildings will have decreased heating requirements. Buildings undergoing major renovations should be renovated to meet minimum energy performance standards, which means that in the near future there will be a rise in the number of passive and highly efficient buildings, resulting in very diverse loads on the district heating demand side [22]. The challenges and opportunities of low temperature district heating system are discussed in various studies.

Different authors describe main challenges in the transition towards lower temperatures in existing district heating networks:

• The district heating business may decide to lower the supply temperature, but as the return temperature is a function of client installations and needs, it is not directly under the company's control [19]. However, there is an issue with high return temperature and the low temperature differential between the supply and the return temperature in the network when the switch to low temperature district heating is being made [16]. This presents a general issue because several tests in existing building areas show that, while supply temperatures can often be reduced quite a bit without causing problems for the comfort of customers, there is no guarantee that the return temperature will also be reduced equally. A smaller temperature difference between supply and return would result in an increased mass flow that might not be sustainable with the current pipe dimensions [19].

• H. Li et. al. (2016) argue that traditionally, the The district heating system is designed with a large safety margin based on experience, which is reflected in both the oversized equipment and the high network supply temperature. This type of system design is more dependable and can withstand situations where individual components fail or when many users are simultaneously using the tap water, for example. Low temperature district heating tends to reduce system design margin in comparison to traditional systems in order to reduce heat losses and investment costs; distribution network and building installation designs should be more precise and should reflect the best knowledge currently available gathered from cutting-edge demonstration projects and model-based design and optimization practices [10, 12].

• The legionella risk can be identified in the low temperature energy system. The use of systems without domestic hot water storage and pipes with modest volumes from the heat exchanger to the taps could enable the safe use of domestic hot water at supply temperatures in the range of 50 oC in the case of low temperature domestic hot water supply. By doing so, the risk of legionella growth could be reduced without the need of higher temperatures [21].

• The planning of renewable heat generation technologies and capacities should be coordinated with building energy conservation plans because renewable energy will likely make up a significant portion of the total energy supply in the future and because it is capital demanding by nature. Demand Side Management and significant building refurbishment can meet customers' heating demand with less installed capacity, saving money and improving partial load operation [10, 12].

The use and implementation of low temperature district heating networks offers various benefits. Global benefits are ecological benefits, related to the environmentally friendly concept of energy system. Low temperature district heating systems have better opportunities for utilization of waste heat and for the use of renewable heat sources [16]. An additional advantage of this is a lower dependency on foreign fuel supplies [21].

Benefits for district heating networks are mostly based on technological and economic advantages [21, 3, 8, 18]:

• Lower heat losses in the district heating networks make low temperature district heating advantageous for utility companies.

• District heating networks can use plastic piping, which can be more cost effective than conventional district heating metal based pipes.

• Using low temperature heat enables the district heating system to incorporate additional heat sources including solar thermal collectors, deep geothermal wells, and low temperature waste heat. The low temperature of the utilised heat, when produced by cutting-edge CHP plants like combined-cycle plants, can increase power production and, consequently, boost energy sales revenues. While offering consumers district heating without increasing the capacity of heat production at the central production unit, adopting environmentally friendly energy solutions benefits the company's reputation. [13].

Customer benefit in various ways [21]:

• Using district heating guarantees a safe supply.

• Customers do not need to be concerned about heating system maintenance, fuel availability, or optimal performance.

• Due to the great overall system performance that low temperature district heating may accomplish, fewer resources would be consumed, resulting in cheaper fuel expenditures. Additionally, this would improve price stability and might even make heating extremely affordable.

With properly functioning real-time monitoring, control, and decision-support tools, the low temperature district heating supply of the future will become "smarter," increasing system efficiency, lowering capital expenditures, and maintaining consumer comfort [19]. Digitalisation based management concepts in the district heating system can be a tool for the shift of the traditional energy system to modern, fourth or fifth generation district energy systems and will accelerate change, allowing to provide sustainable energy at competitive prices.

2.4. Benefits of the low temperature district heating concept are implemented in the behaviour of the population of the Baltic Sea Region in the context of the transition to smart energy: methodology of the research

A quantitative survey has been conducted in the nations of the Baltic Sea Region to examine how customers' behavior orientation toward the core components of smart energy concept is expressed. Multiple choice and Likert scale items were included in the survey. Eight EU-member nations from the Baltic Sea region are included in the study: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, and Sweden. The survey's participants were chosen using the snowball sampling method [14]. The sample size of the research has been calculated using Paniotto’s formula [9]:

$$n = 1/(\Delta 2 + 1/N) \qquad (1)$$

where Δ is the error allowed. The error of the sample of the research is 0.05.

According to the calculations using this formula, the sample size of 400 respondents has been chosen. The survey has been carried out in 2021 April. The survey questionary has been filled by 440 respondents. The research data were organized and processed using Microsoft Excel software.

2.5. Benefits of the low temperature district heating concept are implemented in the behaviour of the population of the Baltic Sea Region in the context of the transition to smart energy: methodology of the research

The research involved 440 respondents. 238 females and 202 males participated in the survey. The biggest part of the respondents – 198 people – belongs to the group within 30 - 50 years. The inclusion of respondents in the representation of the countries of the Baltic Sea Region was carried out in accordance with the principle of proportionality according to the share of the population in the total general population of the region (Table 1).

Table 1.

Demographic factors of the research respondents.

Demographic factors	**Frequency (N)**	**Percentage (%)**
Gender		
Female	238	54,1
Male	202	45,9
Rather not to say	0	0,00
Age		
29 below	162	36,81
30-59	198	45,01
Above 60	80	18,18
Country		
Denmark	23	5,30
Estonia	5	0,96
Finland	15	3,37
Germany	234	53,49
Latvia	7	1,45
Lithuania	10	2,17
Poland	110	25,06
Sweden	36	8,19

Source: compiled by the authors.

Responding to the question of how to understand the concept of smart energy, what characteristics most express the essence of the concept of smart energy, the opinions of the respondents were distributed as follows (Fig. 1).

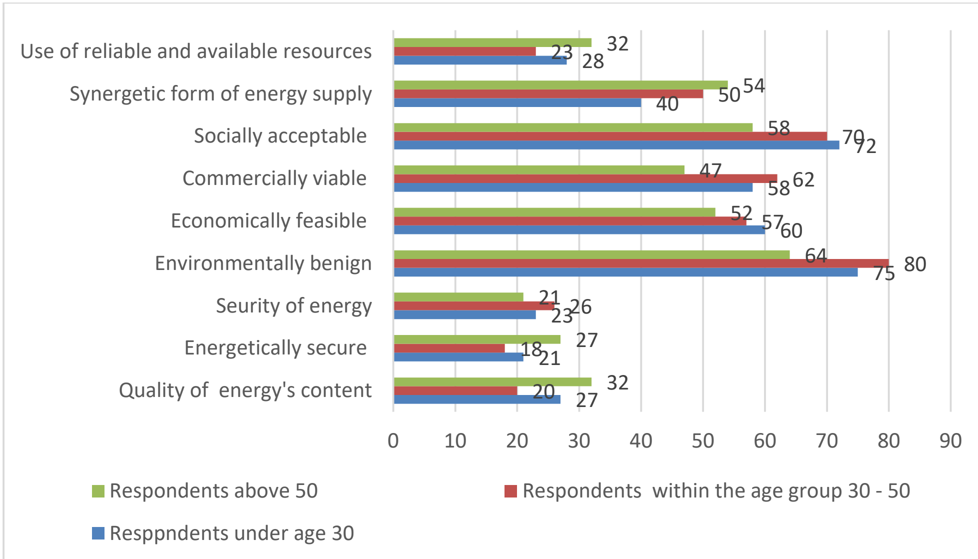

Figure 1. Distribution of respondents' opinions, highlighting the most important components of the smart energy concept (in percent)

It should be noted that there are no significant differences between respondents representing different age groups. Smart energy concept for respondents is mainly associated with social acceptance and environmental benign.

Table 2.

Respondents' acceptance of the key elements of low temperature district heating concept in the smart energy system.

Elements	Mean (total)	Standard deviation (total)	Mean							
			Denmark	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Sweden
1. Economic dimension	***3,81***	***0,94***	3,79	3,56	3,91	**4,02**	3,54	3,95	**4,05**	3,65
(E1.1) I consider my heating costs to be relatively high	**3,99**	1,08	4,1	4,25	3,64	4,28	3,67	4,33	3,90	3,76
(E1.2) I am interested in heating cost saving opportunities	3,83	0,88	3,59	3,25	4,14	3,85	3,67	4,11	4,38	3,65
(E1.3) I am ready to invest in energy-saving solutions	3,65	0,92	3,64	3,50	3,79	3,96	3,17	3,93	3,83	3,41
(E1.4) I agree that the smart energy concept will give me some economic benefits	3,77	0,86	3,82	3,25	4,07	4,01	3,67	3,44	4,08	3,79
2. Security dimension	***3,88***	***0,73***	3,69	3,88	3,77	**4,01**	3,53	**4,07**	**4,03**	3,87
(E2.1) Smart energy ensures energy security	3,66	0,69	4,11	3,72	3,28	4,01	2,71	3,48	3,82	4,16
(E2.2) Lower temperatures of heating are more readily controlled	3,90	0,63	3,45	3,82	4,12	4,04	3,88	4,16	4,08	3,68
(E2.3) Low temperature heating concept reduces risk of scalding and high-pressure explosion	3,61	0,82	3,04	3,74	4,06	3,82	3,38	3,84	3,58	3,42
(E2.4) I agree that low temperature heating increases piping infrastructure lifetime	**4,34**	0,79	4,16	4,25	4,32	4,16	4,12	4,82	4,64	4,24

Elements	Mean (total)	Standard deviation (total)	Mean							
			Denmark	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Sweden
3. Environmental dimension	***3,79***	***0,93***	3,86	3,94	3,93	3,87	3,42	3,67	3,98	3,70
(E3.1) It's important for me that lower temperatures of heating are minimizing losses and waste of energy and are specifically designed to cause as little damage to environment	3,88	0,99	3,77	4,50	3,86	3,86	3,50	3,78	4,21	3,56
(E3.2) It's important for me that lower temperatures of heating are minimizing global CO2 emissions from the energy sector	3,6	0,96	3,73	3,75	3,86	3,67	3,00	3,22	3,75	3,82
(E3.3) I agree that low temperatures heating is more efficient	3,38	0,93	3,68	3,00	3,50	3,86	3,17	3,00	3,65	3,21
(E3.4) It's important for me that low temperatures heating saves resources	**4,32**	0,83	4,27	4,50	4,50	4,07	4,00	4,67	4,31	4,21
4. Self-positioning in the transition to smart energy	***3,73***	***0,84***	3,74	3,78	3,88	3,89	3,75	3,59	3,67	3,55
(E4.1) I am willing to join smart energy system	**4,11**	0,74	4,32	4,12	4,08	4,26	3,98	3,84	4,06	4,22
(E4.2) My household infrastructure has energy-saving solutions in place	3,42	0,91	3,50	3,54	3,48	3,28	3,48	3,26	3,62	3,18
(E4.3) In choosing an energy supply company, it is important that the company practices green energy policies	3,27	1,02	3,26	3,25	3,14	3,71	3,17	3,44	3,19	3,03
(E4.4) I describe myself as responsible consumer of energy	3,38	0,84	3,52	3,54	3,82	3,64	3,31	3,06	3,13	3,06
(E4.5) I agree that smart energy system could not only conserve the quantity, but also the quality of its energy content	**4,46**	0,68	4,12	4,44	4,82	4,54	4,82	4,34	4,36	4,28
5. Attitude towards smart energy transformation	***3,53***	***1,12***	3,24	3,40	3,66	3,86	2,97	3,44	3,90	3,42
(E5.1) The depletion of the world and SDG, Green Deal strategies changed my attitude towards energy	3,09	1,18	2,86	2,95	2,48	3,29	3,12	3,41	3,37	3,27
(E5.2) The depletion of the world and SDG, Green Deal strategies encouraged me to prefer more responsible way of energy consumption	3,05	1,09	3,09	2,58	3,16	3,03	3,05	3,01	3,17	3,29
(E5.3) I support innovative solutions	3,94	1,15	3,98	3,82	4,31	3,72	3,84	4,32	3,79	3,74
(E5.4) I think a smart energy system can be easily integrated into an existing system	3,37	1,18	3,87	2,54	3,71	3,82	2,77	3,38	3,14	3,73
(E5.5) It's important for me that low temperatures heating contributes to a better future	**4,21**	0,85	4,27	4,62	4,42	4,27	3,83	3,95	4,06	4,25

Source: compiled by the authors.

Table 2 reveals respondents' acceptance of the key elements of the smart energy concept. The results are split into five sections: economic dimension, security dimension, environmental dimension, self-positioning in the transition to smart energy and attitude towards smart energy transformation. Looking at the first economic dimension, which includes four statements, as the respondents evaluate each statement in number from 1 to 5, the average meaning for the whole dimension, is 3.81 points. That means residents of the Baltic Sea Region agree with economic benefits and efficiency of a low temperature district heating concept in the smart energy system. As the standard deviation averagely fluctuates around 0.94, that means respondents had quite similar opinion, which did not vary far from the average meaning. The next, security dimension was evaluated with 3.88 points on average, what is the highest point of agreement comparing all dimensions. These results reveal that respondents quite strongly agree with the level of the low temperature energy security. The average standard deviation of 0.73 reveals that the answers of the respondents evaluating these statements were quite unanimous. The third dimension is environmental dimension. The average evaluation for the statements of this dimension is 3.79 points, the standard deviation, averagely fluctuating around 0.93, means that respondents had quite similar opinion with the little distribution of the choices. Analysing separately each dimension, economic dimension was highly evaluated by respondents from Poland and Germany. Security dimension gain the highest result from Poland, Lithuania and Germany. Environmental dimension had the strongest agreement from respondents from Poland, Finland and Estonia as well. The highest points in the self-positioning in the transition to smart energy and in the attitude towards smart energy transformation are given from respondents in Finland, Germany and Poland.

Identifying on the possible challenges of implementing low temperature district heating solutions, the majority of respondents indicated the risk of legionella in the low temperature energy system (74% of respondents), high installation costs (62% of respondents), technical risks (53% of respondents).

Concluding the results of the survey of the behaviour of consumers in the transition to smart energy concept, it was revealed that residents of the Baltic Sea Region agree with the key elements of a smart energy concept. It was confirmed that respondents' behaviour and attitude links to the transition to smart energy concept.

3. Discussion

Green energy, the smart energy concept and the low temperature district heating are seen as a future energy solution that solves a sufficiently wide range of problems and ensures more rational use of resources, reduction of energy supply costs, increase of efficiency, but at the same time it is noticeable that relatively little research has been done on how the perspective of low temperature district heating is assessed by entities closer to the final consumption chain. A survey of the population in the Baltic Sea region showed that smart energy and low temperature district heating solutions focused on household needs are mostly supported by the respondents representing the population of Germany, Finland and Poland.

4. Conclusion

A smart energy system is built on renewable energy generation and synergies to create an optimal solution for each specific sector as well as for the entire energy system. It is a cost-effective, sustainable, and secure energy system that reflects a green development policy. Energy conservation, increased use of renewable energies, smart grids to support renewable energy utilization, cleaner technologies, multigeneration, and efficient storage of energy carriers and chemicals can all be summed up as essential requirements for the transition to smart energy systems for a sustainable future. Focused on the goals of technological and economic efficiency, smart energy is a part of a sustainable future, which provides a supply for a basic need of companies and households – secure energy at competitive prices.

Low temperature district heating is expected as one of the enablers in the transition to low-carbon society. Main indicators of the low temperature district heating as a part of smart energy system are the capacity to supply the demanded amount of low-temperature thermal energy, to reduce thermal losses along the network, to integrate low enthalpy heat plants maintaining the current supply conditions, and to contribute to the transition towards a 100% renewable energy supply system between which different energy sectors are integrated. Low temperature district heating contributes to the achievement of smart energy system goals through rational use of resources and reduction of negative impact on the environment.

The low temperature district heating concept is associated with the following forms of risk: the return temperature is a result of customer demands and installations, and this cannot be controlled directly, potential legionella risk, less experience in implementing projects compared to traditional heating systems and ensuring the safe operation of the system, but the dissemination of experience and on modern digital technologies based management can help to achieve ecological benefits although reduced CO2 emissions, minimize heat loses and waste of energy, to reduce costs of energy production and to improve the image of heating companies.

According to the results of the study, the population of the Baltic Sea region is generally in favor of the low temperature district heating concept, its advantages being mainly related to the security and economic dimensions. The main challenges are related to the risk of legionella in the low temperature energy system, high installation costs and technical risks.

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