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New Role of District Heating as Infrastructure for Increasing the Use of Renewable Energy Sources

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Abstract: Renewable energy sources (RES) will certainly play a key role in moving towards sustainable development of economy. As regards prospects for the use of solar energy, it is evident that the main market is the heating sector on the consumer side. The main and most important problems, determining that the absorption process on the consumer side is slow, are the lack of knowledge and organisation, large and deterrent amount of investments, and particularly differences of motivation between energy suppliers and consumers in the heating sector. The main purpose of the research is to identify required conditions for RES competition in the heating sector with other energy sources. The main focus is on heat energy that is produced by solar technology on consumer side. District heating (DH) may be an appropriate infrastructure for the implementation of RES technologies both on the production and on the consumption sides. Conclusions were drawn concerning assumptions when the use of solar technologies may be competitive and sustainable development problems of RES technologies.

Keywords: renewable energy sources, district heating, local energy development

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1. Introduction

Implementation of RES technologies is restricted by slow demand rates. The main problem is not only high initial capital costs, but also measure of public interest, which is not included into market transactions. Public interest is expressed not only directly through the continuous supply of energy resources in the future, the solution of social and environmental issues, but also through the implementation of EU Directives.

Integration of RES could be more successful after reliable methodological assessment of the positive effect for solving social, economic, rural development problems in regional development context.

However, the nature of RES determines that their usage is more appropriate not on the producer, but on the consumer side. In most cases, with rare exceptions, the utilization of RES is possible only partial with other energy resources. The worst thing is that different options are being compared like every type of fuel would be able to provide the entire volume of supply. In this regard biofuel is in a preeminent position, while it is relatively cheaper. Nevertheless, the substantial increase in demand of limited resources raises the price: this is the expression of the law of demand – supply, which is impossible to transform with any strategies or plans. On the other hand, biofuel is the product of the economic activity and its renewal depends on the extent of activity.

District heating (DH) technology is a promising tool to implement RES technologies and consequently to achieve energy and environment policy goals. DH has several advantages compared to individual heating systems. First of all, it is usually more energy efficient due to the simultaneous production of heat and electricity in combined heat and power generation plants. However, DH is less attractive for areas with low population densities. The future competition on the heat market will be based on RES, more efficient use of fossil fuels, district heating, and other energy efficiency measures [1]. The importance of DH in European Union could be justified by a more intensive use of RES applied to this type of heating system, and must be considered in the design of energy policies [2].

General characteristics of Lithuanian DH sector – its high heat market share, especially in big cities, indicate strong position and therefore the important role of cities energy supply. Although DH systems were developed in planned economy, they not always were based economically and networks in many cases were shortened after disconnections of collapsed industries. Initially designed pipes have appeared as oversized and then resulted in high heat losses. Bearing in mind general European energy policy strategy and targets, it is evident that DH technology in Lithuania will remain as the main technology supplying energy to buildings in large cities and towns [3].

2. The significance of district heating as an infrastructure for the promotion of RES demand

Many countries around the world pursue an energy policy focusing on energy efficiency and an increase in the share of RES for a variety of reasons, including energy security and climate change [4]. As IEA [5] recently pointed out, RES will have to play a central role in moving the world onto a more secure, reliable and sustainable energy path. The greatest scope for increasing the use of RES in absolute terms lies in the power sector. Although RES are expected to become increasingly competitive as fossil-fuel prices rise and renewable technologies mature, the scale of government

support is set to expand as their contribution to the global energy mix increases. The important role gains in national and international regulation of RES.

The incentive of energy producers and consumers for the efficient use of RES are the major goals of energy policy, as governed by the Energy Law of the Republic of Lithuania and National Energy Strategy. Promotion of local and RES usage and energy efficiency are established in the Energy Law of the Republic of Lithuania as priority objectives of energy sector regulation. Seeking to promote the use of RES, Ministry of Economy has issued an order regulating energy purchase. The Law on Energy from Renewable Sources defines that heat suppliers must connect all independent heat producers using RES to the DH systems. Heat suppliers have to apply priority rights when heat is produced by the independent producers from RES. Lithuania is one of the front-runners of the competition implementation in DH sector. The analysis of third party access [6] showed that regulated third party access may have small positive effects on competition, and at the same time it may have a significant impact on the possibility to run the integrated DH operations in a cost effective manner.

The European Union is one of the most active developers of RES promotion methods and assurance measures. Its initiatives expressed in the Directives to reach a 20% share of energy from renewable sources, to increase energy savings by 20%, to reduce greenhouse gas emissions by 20% up to 2020 would lead to a drastic reduction of EU energy dependence on import [7]. Renewable energy contributes to Europe's 20% primary energy savings target as well, but this contribution is not yet recognized by policy makers [8].

Most experience with supporting RES is available in the electricity sector. The EU Directive 2001/77/EC required member states to increase the share of RES in electricity sector using national support instruments. In contrast, no legislative framework at EU level was available in the heating sector before the Directive 2009/28/EC [9] was implemented. Later, following the implementation of Directive 2009/28/EC, every member state has developed its own National Action Plan that fixes specific objectives for each member state in the use of RES for each sector, including heating.

The major changes appeared with introducing new energy policy goals by adoption the RES Directive (Directive 2009/28/EC), where DH is recognized as promising technique for reaching overall strategic energy goals: safety of energy supply by increasing independence from imported energy resources, wider use of waste energy from industries and integration of RES into energy supply infrastructures. Article 4 of the RES Directive required member states to submit National renewable energy action plans by 30 June 2010. These plans provide detailed roadmaps of how each member state expects to reach its legally binding 2020 target for the share of renewable energy in their final energy consumption.

Necessary preparations are carrying out in all EU countries by implementing RES Directive. The forecasts of Lithuania shows that biomass is the main opportunity for the implementation of these plans by 2020 (Table 1).

Table 1. Projection of RES in Lithuania 2009 - 2020 [10]

RES	2009, ktoe	2009, %	2020, ktoe	2020, %
Solar energy	0	0	1	0
Wind	14	2	99	5
Hydro energy	37	4	59	3
Biofuel	53	6	188	9
Geothermal	5	1	20	1
Biomass	763	88	1626	82
Total	872	100	1993	100

It should be noted that potential of solar and geothermal energy gains inadequate small role. Solar energy is a very important RES. However, there is an opinion that economic potential of solar energy in Lithuania is very limited due to its expensive technology and unsuitable climatic conditions. On the other hand, this approach is not entirely justified, because in Lithuania the annual average of solar energy is about 1000 kWh/m^2, while in southern Germany – 1260 kWh/m^2, and the North of Germany – 970 kWh/m^2, which means that the climatic conditions for solar energy in Lithuania are similar to Germany [11].

An analysis of RES use dynamics in Lithuania has showed that Lithuania has a relatively high RES potential. The main RES is biomass. However, alternative energy sources are not used sufficiently. In order to increase the usage of RES in Lithuania and to pursue the obligations to EU, it is essential to determine the causes that influence the slow development of renewable energy and to identify the main RES utilization problems.

The major part of RES that is used to generate DH energy consists of wood biomass in recent times. It is essential to increase the collection of logging residues and to improve the technologies of growing energy crops by the substantially expand the use of biomass resources. However, there are different opinions: the resources of biofuel are limited locally; the major part of costs consists of the collection and preparation of biofuel for the use. As biofuel is used wood, usually that is suitable for the construction and the production of furniture, the price of this resource is rising because of the competition. The cost of the collection and preparation of non-merchantable wood are exceptionally high. It is illustrated by the fact that currently the large amount of non-merchantable wood is accumulated, because it is considerably cheaper to make chips from logging than to handle, bundle and transport the residues of logging.

However, the nature of RES determines that their usage is more appropriate not on the producer, but on the consumer side. In most cases, with rare exceptions, the utilization of RES is possible only partial with other energy resources. The worst of it is that different options are being compared like every type of fuel would be able to provide the entire volume of supply. In this regard biofuel is in a preeminent position, while it is relatively cheaper.

The use of RES for DH could be implemented by decentralizing the production of heat, solving the problems of independent heat producer's connection to DH networks, adjusting the purchase of heat energy that is made from RES and by other measures to promote the use of RES for the production of thermal energy.

One of the analysed possibilities is the use of solar energy for the preparation of hot water in apartment buildings. The state supports (in accordance with the procedure Government compensates 15% of investments) the measures of energy efficiency improvement by the Programme for the Renovation (Modernisation) of Multi-apartment Buildings. The funding of RES (solar, wind, etc.) mechanisms is also included. In the future there is a chance that in newly constructed houses will be solar collectors for the preparation of hot water and they will use the heat provided by sun. If there is a financial potential, anyone can install solar collectors. Furthermore, the other reasons are to protect the environment and to use renewable energy resources. Nowadays the main and determining factor for the decision of the use of solar energy for preparing hot water is limited by financial resources.

Solar collectors can be installed on the roof of the building, fixed to a wall or assemble on the ground. It is important that as much as possible solar radiation would reach the surface of solar collector. Table 2 presents that 50.2 % of all households are centrally provided with hot water from city (district) heating network (city 71.3 %, village 2.5%) and 1.6 % centrally provided from the local boiler-room (city 2.17%, village 0.6 %).

Table 2. Dwellings by type of hot water supply (% of all dwellings) [12]

	Total	**Urban area**	**Rural area**
Centralised hot water supply from the city/town (district) heating system	50.2	71.3	2.5
Centralised hot water supply from a local boiler	1.6	2.1	0.6
Individual hot water supply	31.2	20.4	55.8
No hot water supply	17.8	7.2	41.6

As pointed out in Lithuanian National Renewable Energy Action Plan, the National Strategy for the Development of Renewable Energy Sources, among other priorities of the development of energy from renewable sources, envisages utilization of the existing DH infrastructure and further development of necessary infrastructure while creating conditions for the development of RES. It is envisaged that biofuel, which is consumed in the DH sector, should become the biggest contributor to the increase in the consumption of RES. Taking into account technological possibilities of the DH sector and economic advantage, heat production from RES in this sector should be increased by not less than to 60 % by 2020.

A wider use of renewable energy can help to diversify of energy supply and to meet the targets of sustainable development. An overview of the present Lithuanian and EU legal regulation of the use of RES pointed out, that promotion of the use of RES is among the priorities of energy policy in Lithuania.

It can be stated that the potential of the use of solar energy could be considerably larger in households that are in the area of DH system.

3. Evaluation of the RES efficiency in the context of sustainable development

Transition economies, especially Lithuania and other Baltic states, are positively disposed to the promotion of RES. Sustainable development goals for transition economies are also tightly related with climate change mitigation, because these countries have high-energy intensities of economies, low energy efficiency in energy production and consumption sectors, therefore the sustainable development goals for these countries include greenhouse gas mitigation challenges as well [13]. Many countries view renewables as a way of promoting the development of small and local businesses in selected areas and diversifying supply patterns at the regional level. RES (including biomass, solar, wind, geothermal and hydropower) that use indigenous resources have the potential to provide energy services with zero or almost zero emissions of both air pollutants and greenhouse gases. In addition, the greenhouse gas abatement due to a more intensive use of RES would contribute to improve the EU target related to climate change, this being the fourth target in its energy strategy [2].

However, integration of sustainable energy projects, e.g. RES technologies, may be successful after reliable methodological assessment of positive effect of such projects for solving social, economic, rural development problems in regional development context. Scientific problem is to define the economic background for policies and measures aiming to sustainable energy development [14].

Most of investors, while choosing places for their investments, usually analyses strategic plans and these are critical factors for choosing place for investments or at least choosing possible variants.

The need to support RES is defined by the shortcomings of market, which make not equal conditions for comparability and competitiveness of various types of fuel and energy.

There are few main reasons why currently in our country, like in many other countries, solar energy is distantly used. We hypothesize that current situation exists not only because of the lack of economic support. The more significant reasons are lack of organization, gaps of public education and dissemination of knowledge in society, also too high expectations of getting the support from the state. Generally it is operated on standard opinions that are partially right, but more important factors, which effect varies in time, are not considered. Knowledge is usually concentrated and presented in a narrow approach, when some facts are emphasized and some are suppressed. For example, it is an opinion that economic potential of energy made from solar thermal energy is modest because of expensive technologies and inappropriate climatic conditions. This fact is easily denied by the countries with similar climatic conditions, where the development of solar energy is vigorous and rapid next to other types of RES.

A breakthrough is noticed even in Lithuania in 2008 - 2011, especially after the tariffs for the electricity generated using solar energy and provided to networks were announced. Also there are many examples that even without the high support from state numbers of consumers install solar energy devices. However, these facts are outside the official statistics yet.

The opportunity of the use of solar energy and the potentially huge consumer's market are not getting enough attention in the Government documents. Therefore, for the reason that this type of energy in Lithuania would be used more, it is necessary the effective support from the Government that would form a basis for a competitive price of solar energy. However, the support does not have to be in direct subsidies or other financing forms that are paid from budget or by consumers. "Cheapness" or "expensiveness" is more psychological, varying in time concept. Moreover, both cheapness and

expensiveness are temporary conceptions that strongly depend on the use extent of technologies. For example, in Europe is noticeable an evident trend of decreasing costs of solar hot water systems. The price decreased by 40 % from 1995 to 2006 and reached about 3300-3500 Lt/kW; the forecast is that the price will drop to 1500–1600 Lt/kW by 2025. Prices in Lithuania are about 2500-3100 Lt/kW at the moment.

The other standard opinion is about the "cheapness" of biofuel, which seemingly should rescue the heat sector. The prime cost of the heat increased about 30 % in all municipalities (except of Lazdijai) in the last decade; it is maintained that this increase of price was determined by the rises in cost of fuel (the price of natural gas was 358 Lt/toe in 2000, in 2010 – 1271 Lt/toe; the price of fuel oil was 455 Lt/toe in 2000, in 2010 – 1135 Lt/toe; the cost of biofuel was 176 Lt/toe in 2000, in 2010 – 625 Lt/toe) [15]. As the authors state in the same paper, the increase of biofuel prices and the unification of prices in all Baltic and Northern countries indicates that this type of fuel is transported in longer distance, the transportation costs form increasingly smaller part of the final cost, when the prices of solid fuel are increasing. In the market of Lithuania the prices of woodfuel are similar to the prices in neighbour states, and biofuel becomes the product of the regional market. Unfortunately, it has to be admitted that there is a one direction movement – to the Scandinavian countries.

From the attitude of RES supply support tools for technology creators and suppliers means compensation of social RES production costs as traditional resources are not evaluated correctly because of market errors. From the attitude of RES demand one should investigate correct evaluation of social benefits, which may show those advantages, which are not seen in investment solutions, e.g. inexhaustibility and possibility to ensure energy resources for future generations. RES are a wide group of energy resources and the assessment of those resources is depending on the potential, secure and sufficient supply, environmental and renewable character and impact to solving of social problems.

The improvement of renewable energy technologies will assist sustainable development and provide a solution to several energy related environmental problems [16]. As some RES technologies, e.g. solar energy, also solve environmental problems, thus can be additionally funded from other sources. Additional support should be based on the fact that the use of solar energy would rather make a significant contribution to deal with the implementation of Directives issues. It is evident that the particularly relevant support would be subsidies for investments and soft loans. The amount of a support has to be based on the external benefit that would be adequate for utility.

The background of the research is the following conceptual statements [14]:

- The support of state and private market participants to RES business is considered as correction of market shortcomings to solve sustainable development problems;
- Prices of all energy resources must be based on social costs with assumption that methodologically possible to justify all aspects in the use of fuel and energy – security, environmental, social and renewability;
- RES benefit can be assessed according to real benefit now and in the future, which is not fixed in investment efficiency with assumption that various sustainability criteria may have single denominator on single methodological background;
- Justification of RES support measures is based on comparison of fuel and energy resources used by energy system, on competitive ability while assessing various sustainable development aspects by single criterion;

- RES competitive ability is evaluated not in general approach, but in specific territorial environment till certain optimal level, where marginal costs and marginal benefit of all types of energy become equal.

With regard to define the guidelines for sustainable energy development in economic understanding, firstly we should clearly evaluate current or necessary infrastructure, related to the used type of fuel.

Economic theory explains the main reason why there is not enough demand in the market for some products and services, although they are very beneficial for the society. The reason is that the external benefit of the product or service generally is not included in the direct market operations and in prices [17]. In other words, external costs are not included in the market prices, and can therefore be considered a market failure, which can be corrected by an internalisation of the external costs through policy instruments such as environmental fees and taxes [18]. It is particularly important moment in terms of RES. Demand of RES technologies does not indicate the benefit of the society (social benefit), which is gained by using the energy made from RES. The benefit disperses between different users which can be people, future generations, cities, companies. People, even if they do not participate in the market transactions, sometimes can get part of the product benefit for free. The external environmental benefit of using RES is probably the best example of external benefit. Therefore due to the RES use for energy production, the negative environmental influence is being reduced, organic fuel resources are being economized, new technologies are being installed, etc. Figure 1 shows the "green" (made from renewable energy resources) curve of energy supply S, that involves the expenditures of producing the "green" energy. The main expenditures include machinery and equipment, new technologies, employee's wages and other expenditures for the training of staff, qualification improvement courses, etc.

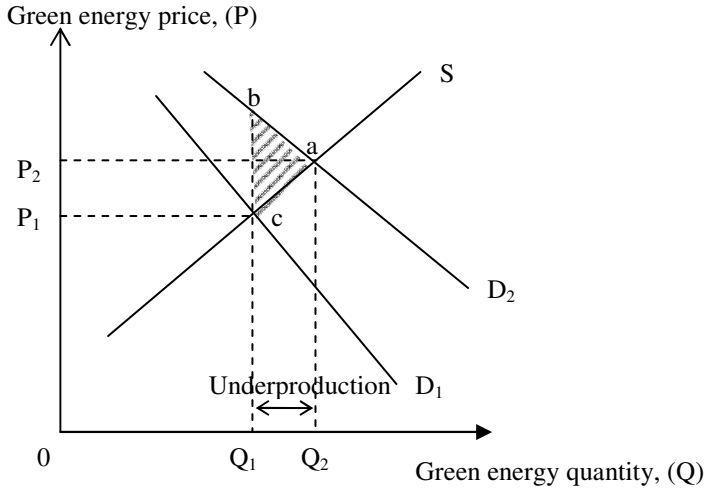

Figure 1. The probable influence of external benefit evaluation on RES demand

If the benefit from the „green" energy consumption is unknown or unvalued, consumers will choose the volume of purchased energy by the demand curve D_1. The "green" energy will be bought less than it would be economically reasonable: quantity Q_1 instead of Q_2. However, when buying the „green" energy made of RES they reduce the pollution to all residents. Everybody avoids diseases and other negative consequences that occur from the polluted environment. This benefit is not included in the

demand D_1. The curve of demand should be D_2, where the external benefit is evaluated. The main problem is to include the benefit into the expression of economic indexes.

Marginal benefit of every additional unit of energy from the quantity of Q_1 to Q_2 exceeds their marginal production costs. External benefit that is shown in the triangle "abc" is unrealizable and represents the inefficiency of the market. We note that the benefit can be known, declared; but this knowledge is not converted to concrete practical calculating mechanisms. However, conclusive calculations are not enough. There is a need of significantly increasing structural changes in order that the process of RES development would start and even become massive. Especially important is that knowledge becomes the main driving force of this process.

Without the state intervention competitive market will produce "green" energy in the point "c", where the market supply curve S crosses the demand curve D_1. The market equilibrium price P_1 will be at this point and the quantity of produced "green" energy will reach Q_1. However, if not only private but also external benefit would be evaluated, the new equilibrium price would be P_2 and the quantity of produced "green" energy would increase to Q_2, where the marginal benefit is equal to the marginal costs. Social benefit is marked in the triangle "abc".

It must be noticed that the main criterion is not the price of solar collector and its installation, but also the price of a heat unit that is produced by solar collector and effectively consumed. It is possible and even necessary to calculate how much the produced heat for the individual-family house or apartment buildings will cost with chosen type of solar collector. The application of this method allows estimation of all technical aspects of economic projections to the levelised cost of the heat unit. Initial calculations show that the increasing heat prices make the use of solar collectors for domestic hot water preparation competitive in some cities. The use of solar collectors for the preparation of hot water in apartment buildings is currently the most perspective direction and its potential is evaluated up to 40 percent of heat amount that needed for hot water.

Moreover, if ecological, economic and social benefit would be comprehensive evaluated in a long term period and on that basis would be given support for users who produce energy using solar energy, the demand for advanced solar technologies would increase noticeably. These facts certainly cannot determine the choice, although, in our opinion, it is necessary to be on a way of objective knowledge and education but not of the presentation of one side information. It is very important in the initial period, when the first failures of inadequate decisions can block the way to advanced technologies that usage depends on successful examples.

4. Justification of RES support measures

RES are a broad group of energy resources and the assessment of those resources is one-to-many depending on the potential, sufficient and secure supply, environmental and renewable character, and impact to solving of social problems.

Demand of new and existing RES technologies is not adequately restricted by slow demand rates. Therefore there is a need of additional attention from policy makers and other system actors that have an interest in speeding up the diffusion of renewable energy [19]. The main concern is to make measurements of public interest. Nevertheless, it is expressed through continuous supply of energy resources in the future, solution of social problems in rural areas, and also inability of private sector to invest in current conditions.

RES projects may increase the security of energy supply for the company, district or even region. Completed and ongoing projects for RES implementation provide improved comfort and have multiplicity effects on new jobs that are dispersed across the community both socially and spatially, and involving small and medium size enterprises. In the Figure 2 the structure of RES consumers is presented.

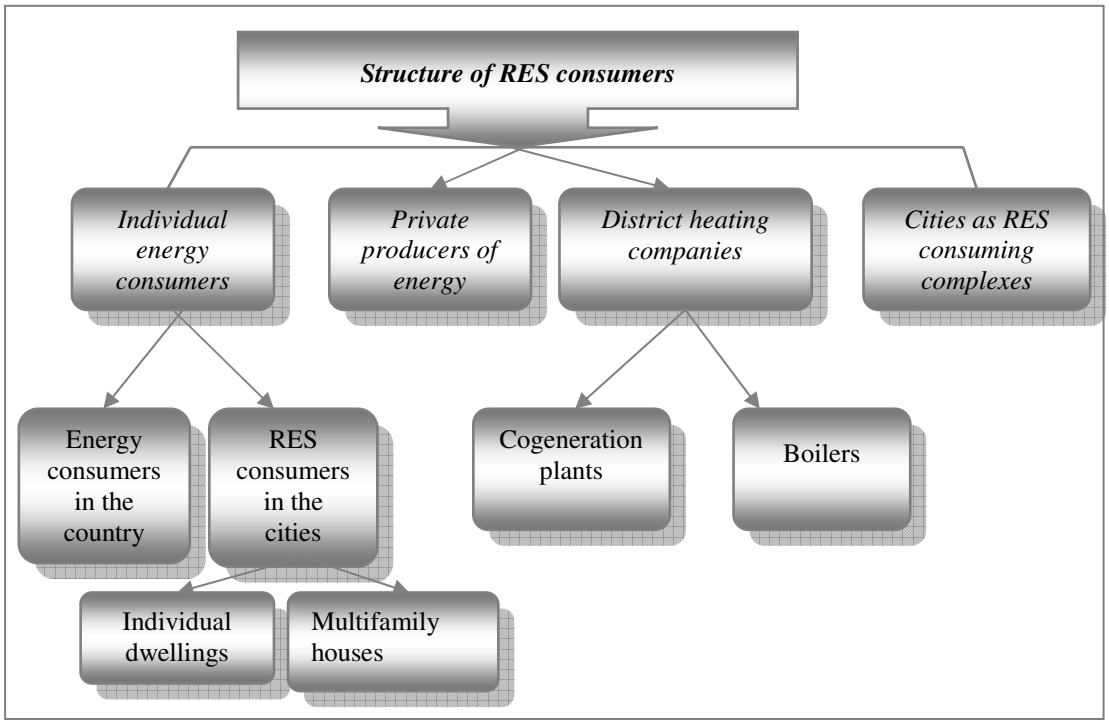

Figure 2. The structure of RES consumers

Economic assessment of the use of various fuel and energy forms must enclose not just prices of various technological solutions, operational costs, environmental and other taxes. This is just part of aspects to be evaluated. There are also aspects which are not less important, however, evaluation of these aspects is complicated and it seems not to be defined by the statements of economic theory. For instance, the security of energy supply is the goal, which subordinates all other aspects, and economic assessment optimizes them. However, most often such costs require high investment and are not assigned to any specific project.

Territorial aspect means definition of responsibilities and implementation of management principle for assessment of energy resources sustainability aspects. Therefore, perspective organizational and financial forms of technologies integration using Structural funds are cities and regional energy programs. Furthermore, after reliable methodological evaluation of positive impact, integration of RES could be more successful for solving economic, social, rural development problems in regional development context.

Primarily it should be clearly estimated current or necessary infrastructure, related to the used type of fuel, with regard to the establishment of guidelines for sustainable energy development in economic understanding. For solution of the problems of economic theory acknowledged approach of the analysis of social welfare was used, on the basis of which market errors are investigated and their expression – marginal social costs and marginal social benefit using energy sources are evaluated.

For economic policy making at state scale should be used non-standard approaches that allow synthesis of various researches, which test theoretical hypotheses and define assumptions for various RES development scenarios for long term perspective of several decades. This should be performed by using quantitative and analytical tools, which determine the best future technologies, enabling implementation of EU environmental goals and energy policies. Technologies sustainability assessment, which is being performed during the project, helps to define competition of future energy generation technologies.

The evolving of sustainable development implies balance of all resources or optimization. Such approach requires guidelines of economic theory, how and why it is possible. Practical idea has developed the approach, which is called Integrated Resources Planning (IRP). This approach allows avoiding partial optimization. The main idea of IRP is that optimization is being done to the entire systems and not to separate units [14].

The major problem is avoiding drawbacks of partial optimization when using IRP approach. To certain extent energy system is rather efficient, because any investment must give economic payback. This does not necessarily mean a separate investment project, no matter how large it is, it may be insufficiently optimized or have some drawbacks. However, optimization is possible from the attitude of total costs [20].

The basic methodological tool for economic assessment of specific energy resource is the price of energy resource, based on social marginal costs. Price value is market signal for consumers to react, for example to choose more or less energy efficient technologies, appliances, less heat consuming households, etc. This is also the most important expression of social aspect in energy consumption.

Extended economic analysis is applied for evaluation of the project feasibility for any type of RES, in various cases for separate project or on national scale. Such analysis is supplemented with environmental indicators, which determine project implementation impact to environment or evaluate external energy generation costs. Emissions of pollutants into atmosphere have the most important impact to the value of external energy generation costs. Assessing expression of the monetary value of major emissions, it is achievable external energy generation costs, which enable to supplement classic cost-benefit analysis with environmental indicators. Consequently, environmental indicator would reveal that RES projects are more efficient compared to traditional sources, without regard to high capital investment necessary to implementation of such projects.

Various economic aspects may be assessed by using universal approach, enabling reliable estimation of various aspects with single denominator in comparable and clear form, which has direct link to pricing. This is the approach used for life cycle costs of energy estimation via extended economic analysis.

4. Conclusions

An enormous potential of the use of solar energy is in the sector of apartment buildings. This potential can be realised by renovation of the apartment buildings and by modernization of the heating sector. The use of solar collectors for the preparation of hot water in apartment buildings is currently the most perspective direction and its potential is evaluated up to 40 percent of heat amount that needed for hot water.

The use of solar energy also solves the environmental problems; therefore it can be additionally funded from other sources. Additional support should be based on the fact that the use of solar energy would rather make a significant contribution to deal with the implementation of Directives issues. It is evident that the particularly relevant support would be subsidies for investments and soft loans. The amount of the support has to be based on the external benefit that would be adequate for utility.

As regards prospects for the use of solar energy, it is evident that the main market is the heating sector on the consumer side. The main and most important problems, determining that the absorption process on the consumer side is slow so a huge potential is not absorbed, are the lack of knowledge and organisation, deterrent amount of investments and especially differences between energy suppliers and consumers in the heating sector.

Only in case of high demand progressive RES technologies may have economic background for a successful development. Regrettably, the awareness of energy consumers frequently contains just fragments in comparison to the full effective knowledge, which forms demand based on public benefit.

Territorial aspect means definition of responsibilities and implementation of management principle for assessment of energy resources sustainability aspects.

The interaction of the environment and new technologies involves the interplay of two sets of market failures. The result of these interfaces is that the rate of investments is below the socially optimal level in environmentally friendly technologies, including the use of RES, because of the absence of public policy. Environmentally friendly technologies are undoubtedly underpowered by markets: non integrated external benefits of innovation and non integrated external costs of pollution, and diffusion of new technologies.

Integration of energy projects into DH systems may create external positive effect concerning environmental and other regional development goals.

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Conflict of Interest

The authors declare no conflict of interest.

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