

## The Sustainable Growth Use of Renewable Energy Based on Spatial Energy Planning

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**Abstract**— The aim of the research is to apply the approach enabling assessment of external benefit for the use of renewable energy sources, which is usually not assessed for individual projects. Regional programs may be appropriate tools for reducing renewable energy adaptation costs, increasing competitiveness in the market and promoting the development. Support measures must shape uniform technological programs for long-term periods. The sustainable growth of renewable energy is based on the formulated methodology, which enables to achieve maximal benefit with minimal support for beneficiaries as well as for the state. Modified levelized cost of energy method enables analysis of economic benefit for the selected project investor, as well as relates the achieved results to macroeconomic indicators using external parameters. After the evaluation of external benefit for solar, wind, and geothermal energy projects, the results could be interpolated and used for assessment of selected technology or support scheme for wider use in the context of spatial energy planning in urban areas.

**Keywords**- *renewable energy, sustainable development, evaluation principles, external benefits.*

### I. INTRODUCTION

Economic research of Renewable Energy Sources (further in the text – RES) has intensified in the recent years through implementation of European Union directives, with particular emphasis on the role of a territorial aspect (cities, districts). Incentives for wider use of RES are declared both in the European Union and in Lithuanian laws. Adoption of the Directive 2009/28/EC “On the promotion of the use of energy from renewable sources” [1] required the development of a National Renewable Energy Action Plan for 2010-2020 and many other documents at the local level. This indicates that the development of RES takes an increasingly more significant role in the energy policy of all member states, including the Republic of Lithuania.

The main obstacle to the widespread use of RES is the failure to address the key issue – to measure the benefits to the society (reduction of pollution, energy supply for the future generations, huge and never-ending potential of energy resources such as solar and wind energy), when introducing RES-technologies and, on the basis of these benefits, to encourage investors. Therefore, when formally calculating, RES-technologies are not sufficiently competitive compared to fossil-fuel technologies. This work

deals specifically with the problem of the impact of RES-technologies. The impact analysis of RES-technologies on social welfare (on job creation) and on health (on the basis of environmental impact) has allowed the formation of a targeted, reliable methodology compatible with the status of existing statistical information. On the basis of it, algorithms calculating the impact for individual types of RES are formed.

Given that in the newly developed Energy Strategy the high hopes to use RES-technologies are linked to the extremely low used energy sources, such as solar, wind and geothermal energy, significant efforts are needed to organize the accounting and statistics of decentralized RES-producers. Apart from this important condition, it is difficult to expect the proper process management of mastering the RES. The analysis of positive and negative impact of RES usage in the research of Lithuania and other countries has shown that the major part of the positive impact of the RES development is related to Green House Gas (further in the text – GHG) and other pollutant emissions, job creation and rural development. The positive effects of biofuels, biogas and biofuel manufacturing sectors are mainly reflected on the increase of employment level in the regions, the reduction of heat prices and lower emissions of some fossil fuels, which in the long run could affect the decline in the incidence of certain diseases. The development of biogas production and use also plays an important role in solving the problem of organic waste management. The main positive effects of solar and wind energy technologies are the reduction of GHG emissions compared to the use of fossil fuels and biofuels as well as the creation of temporary jobs in Lithuania by installing new solar power plants or wind farms. Developing the manufacturing technology industry in Lithuania also has a positive effect on the creation of additional permanent jobs.

Section II describes the concept of external utility of implementation of RES technologies. Evaluation of such utility may show the advantages, which are underestimated in the investment decisions. Section III presents a solution of the identified scientific problem; it is based on a system of territorial urban planning. In Section IV is presented a description of how RES programs can consolidate related urban development programs. This may serve to formation financing assumptions and sources for their implementation. The methodology, which is based on

spatial planning, identifies certain aspects that usually are not covered by routine investment valuation techniques, namely, the existing problems in cities: high atmospheric pollution, unemployment, etc., may determine the validity conditions that allowing interpolating results to assess technology for spatial energy planning for solving problems mentioned above. Long distances to centralized electricity and heat networks are defined by geolocation factors and may determine financial acceptability of small decentralized renewable energy technologies due to their technical benefits.

## II. CONCEPT OF EXTERNAL BENEFIT OF RES TECHNOLOGIES

In recent years, consumption of fossil fuel and mitigation of climate change have become major challenges for governments all over the world. To engage these challenges, many countries are pursuing research, development, and demonstration of RES [2]. In the past few years, usage of RES rapidly increased all over the world. RES have become important alternative energy sources to realize energy diversification. During the last few years, political support for renewable energies has been growing continuously both at the national and international level [3][4].

Looking at renewable energy use since 2006, it was a natural gas price boom, increase of social and political pressure for fast development in clean energy, and financial crisis, which required adequate government measures to stimulate the economy. The industry of renewables could be important to generate employment and stimulate growth [5]. Investment in RES may bring considerable profits, so more and more enterprises will be involved in this field. The increased use of RES in the heat market can significantly alleviate the negative effects of high energy costs on the national economy. Successful commercialization of indigenous, non-fossil energy resources is expected to promote regional economic development and employment, enable to increase national energy security and to reduce a substantial portion of the increasing trade deficit necessity to import fossil fuels [6].

The use of renewable energy in rural as well as urban areas became the significant development thus adding to mitigation of climate change [7][8], reducing differences between rural and urban dwelling options [9], bringing new RES options for diversifying energy supply [10][11][12]. The role of local governance for energy and urban development appears highly important here [13].

The stimulation of energy producers and consumers to use RES is one of the major goals of energy policy in Lithuania. Policies and measures that aim to enhance the use of RES are mainly driven by EU policy. Unstable state energy policy and changes of incentive measures destabilize the investment initiatives. The lack of economic evaluation on both demand and supply sides is the main challenge to achieve the expected goal. Unreasonably huge role is assigned to biomass in usage projections of RES. Biomass is an energy resource that is the result of economic activity

and depends on continuity of economic activity. Meanwhile, the use of an inexhaustible solar and geothermal energy potential is insufficient.

The scientific problem is evaluation of the social utility of RES that can show the advantages, which is underestimated in the investment decisions [14]. The most important benefits of RES are inexhaustibility and possibility to ensure sufficiency of energy resources for future generations. Also, utilization of particular RES technologies, such as solar energy, solves environmental issues. Therefore, RES may be additionally financed from other sources. The main issue is the diversity of RES utilization opportunities and incentives. The energy phenomenon is inexhaustibility of RES that could change exhaustible types of fossil fuel, such as oil and natural gas, and could be replaced with few different types of energy. This could be solar, wind, and geothermal energy. On the other hand, social utility of RES differs from the social utility of oil and natural gas, because RES guarantees the supply of energy resources for future generations.

Renewable energy policy is a complex system, where a balance among three aspects of sustainability – environment, economy, and social life – is needed. A good performance and well-balanced RES policy requires efforts from different stakeholders. Although each country has different starting conditions, namely, developed technical infrastructure and own energy resources, development of energy from RES should be shaped on the basis of long-term macroeconomic policy [15]. This means that a good and scientifically-based theoretical background is needed as well as indicators reflecting economic development and a method for assessing the impact of certain type of energy from RES on these indicators are required. In other words, this is a reliable energy supply at an affordable price, which causes as positive environmental impact as possible.

Support for RES is required to promote a wider use of renewable energy. What is more, energy market failure is a serious obstacle to promote the development of RES. External positive benefits of using RES, such as public interest, are not evaluated here. This benefit is related to introduction of new technologies, their development, and positive impact on environment [16][17]. Subsidies for RES must be based on a positive external utility. Therefore, one of the most effective methods could be integration of RES technologies into regional energy development [18]. Regional programs may be appropriate tools for subordinating market mechanisms (reducing renewable energy adaptation costs, increasing competitiveness in the market and promoting the development), which are required to overcome market barriers [19][20].

As a rule, the impact of RES-technologies on economic and social indicators is supported by statistical correlation analysis based on historical trends in RES development and their impact on macroeconomic indicators. However, the anonymity of this method and the probability of a certain error cannot provide a clear understanding of the actual impact of specific parameters when analysing specific projects under individual RES-technologies [21]. Also, this method does not provide tools or ways to optimize the

development of the RES-Sector or to put in place support measures to maximize macroeconomic benefits with minimal resources. Therefore, valuation is inseparable from the microeconomic analysis of the project chosen by the individual investor (taking into account the economic benefits to the developer), using external parameters for macroeconomic indicators [22]. Results obtained in one project may be interpolated to assess the potential impact of the support scheme at the urban level.

Levelized Cost Of Energy (LCOE) is one of the most popular approaches for comparison of different energy generation options on equal basis - present value of total life-cycle cost. The elaborated LCOE approach, which was applied in a paper of V. Bobinaite and D. Tarvydas [23] gives an opportunity to quantitatively assess the influence of certain RES support measures on the cost of energy production. Also, it provides the investors a tool which could be used to compare different RES investment projects.

### III. SPATIAL ASPECT FOR THE ASSESSMENT OF BENEFIT FROM USING RES TECHNOLOGIES IN URBAN AREAS

The use of renewable energy in rural as well as urban areas became the significant development thus adding to mitigation of climate change, reducing differences between rural and urban dwelling options [24], bringing new RES options for diversifying energy supply [25]. The role of local governance for energy and urban development appears highly important here [26].

The stimulation of energy producers and consumers to use RES is one of the major goals of energy policy in Lithuania. Policies and measures that aim at enhancing the use of RES are mainly driven by EU policy. The scientific problem is evaluation of the social utility of RES that can show the advantages, which is underestimated in the investment decisions [27][28]. Moreover, it is transfer of their economic interpretations on uniform rules and economic laws into specified dimension, in this case trying to reduce different opinions as much as possible [29].

The main indicators of external benefit are considered to be the use of domestic capital; taxes paid to the state budget and newly created job positions. Combination of different types of RES may create a large external effect and make a significant impact not only on individual consumers of RES, but also on the society. Therefore, the benefit from using RES, especially in urban areas, should be evaluated during the decision making process.

Each RES has different value in terms of external benefit, thus respective promotion schemes can and must differ significantly. This depends on the environmental situation in certain area. External conditions and current infrastructure for RES technologies differ, thus spatial planning, such as urban energy development plans, is the most appropriate tool for the benefit assessment. All countries pay little attention to the support of RES technologies on the demand side. Support for the consumers is the most appropriate via support programs (and not by supporting scattered consumers), as it enables to achieve actual effect. The external benefit analysis for small wind

power plants, geothermal heat pumps, and solar collectors was performed to find their niche in urban and rural areas. The external effect indicators for different scenario cases are shown in Table 1. Data in Table 1 show the comparison of external benefit using different types and scale of RES technologies. The main indicators of external benefits are considered to be the use of domestic capital; taxes paid to the state budget and newly created job places.

TABLE 1. EXTERNAL BENEFIT OF USING SOLAR, WIND AND GEOTHERMAL ENERGY TECHNOLOGIES (CASE OF LITHUANIA)

Indicators	Wind power plants		Geothermal heat pump and solar collectors in multifamily building	Solar collectors in district heating system
	4 kW	10kW	126kW	7000kW
Production, MWh	6,8	17,5	185	4500
Domestic capital, 1000 EUR	8.02	21.08	25.01	1380.88
Social insurance, 1000 EUR	0.81	1.51	9.27	119.23
Personal income taxes, 1000 EUR	0.29	0.55	3.46	44.46
New jobs (man months)	2.3	4.2	31.9	409.4

Combination of different types of RES may create a large external effect and make significant impact not only on individual consumers of RES, but on the society as well. Therefore, the benefit from using RES, especially in urban areas, should be evaluated during the decision making process. If direct support is applied for RES or environmental technologies, the impact will depend on the volume of support and the source of funding. For example, if the direct assistance is financed from the state budget, the promotion measures would increase the budget deficit in addition to the positive aspects mentioned above. Therefore, it is essential that the promotion would be cost-effective: the benefits should exceed the negative effects. Inexhaustible types of RES (wind, solar, and geothermal energy) enable greater benefit than the subsidies it might require, while penetration into the market is growing.

The idea of eco-villages has been analysed since the last decades of XX century all over the world. Modelling methods were used for resources management and sustainability assessment [30]. The most recent research concentrates on eco-innovations, eco-efficiency and eco-effectiveness, cultivations of eco-sustainability on various social-economic-environmental levels. The investigations also involve the role of eco-cultural diversity, renewable energy in eco-communities and understanding the eco-complexity and ecosystem approach [31].

The principle of ecological movement can be expressed by the quote “think globally, act locally”. Progress in solving environmental problems can be achieved more quickly if the principles of our activities and the functions of natural laws system are harmonized. This was the main

principle of the development of green settlements. The energy sector of green settlements duplicates the processes in the nature which is a perfect example of waste-free technology. The volume of waste generated in energy sector can be reduced by increasing the usage efficiency of primary energy sources and promoting the use of RES. The negative impact to the environment can be mitigated through more efficient use of RES in energy sector developed under the circular economy model and bioregional development principles. The use of RES in the regions can create unique environment for resource utilization. The exploitation of energy resources must not exceed the nature’s resilience limits otherwise RES can be treated as non-renewable resources. The development of regional energy sector, according to the principles of circular economy, is encouraging the use of a wide range of local and renewable resources.

IV. BALANCING OF RES SUPPORT FORMS BY USING SPATIAL PLANNING METHOD

Different types of RES have a very broad and distinctive scale of use, therefore, each renewable requires its own specific support. This topic has been focussed on the potential analysis of wind, solar, and geothermal energy for small scale applications. Every renewable has a wide developing scale of technologies, which is becoming cheaper due to the growth of supply. What is more, every renewable has different significance level in terms of external benefit, thus support schemes can differ significantly. This depends on the environmental situation in various areas. External conditions and current infrastructure, where RES technologies could be applied, differ as well; therefore, spatial planning via urban energy development plans is the most appropriate tool for benefit assessment.

Most countries support RES technologies mainly on the supply side, while existing opportunities to use solar energy at the consumers’ side, such as small systems of solar collectors in multi-apartment buildings, are significant as well. Support for the consumers is the most appropriate via support programs (and not by supporting scattered consumers), as it enables achieving actual effect. Renovation of buildings by districts enables planned actions, which could solve technical and financial problems for district heating companies due to reduced consumption.

Application of the schemes mentioned above for small producers increases administration costs and is often not acceptable due to high complexity level. Therefore, territorial administration is needed. The main problem is that the programs for implementation of legally delegated functions have no consolidating unity. This might lead to serious problems: renovation of multi-apartment residential houses would reduce the heat consumption significantly. As a result, the district heating tariffs would increase due to growing fixed heat generation and supply costs.

Although the EU directives and national laws provide for the functions of the municipalities of the Republic of Lithuania in developing software documents for the energy sector in general and for RES-technologies are rather

precise, in practice, plans are just beginning to be formed. Having analyzed the current laws of the Republic of Lithuania, it is clear that they regulate in a sufficiently detailed manner the responsibilities of municipalities and the development of the use of RES. But the main problem is that separate programs are being developed for the implementation of individual EU directives, which do not have a consolidated unity. Meanwhile, functions such as the Special Needs Planning Development Plan, as well as future Environmental Protection Plans, which are already beginning to plan for the implementation of commitments made under the Paris Agreement, are directly linked to the development of RES, are formed separately. In this way, the financial resources and modest forces of specialists working in municipalities are dispersed. A stable and balanced program with carefully selected subsidizing, enabling the interaction between consumers and heat suppliers, is necessary for solving these problems, as proposed in Fig. 1.

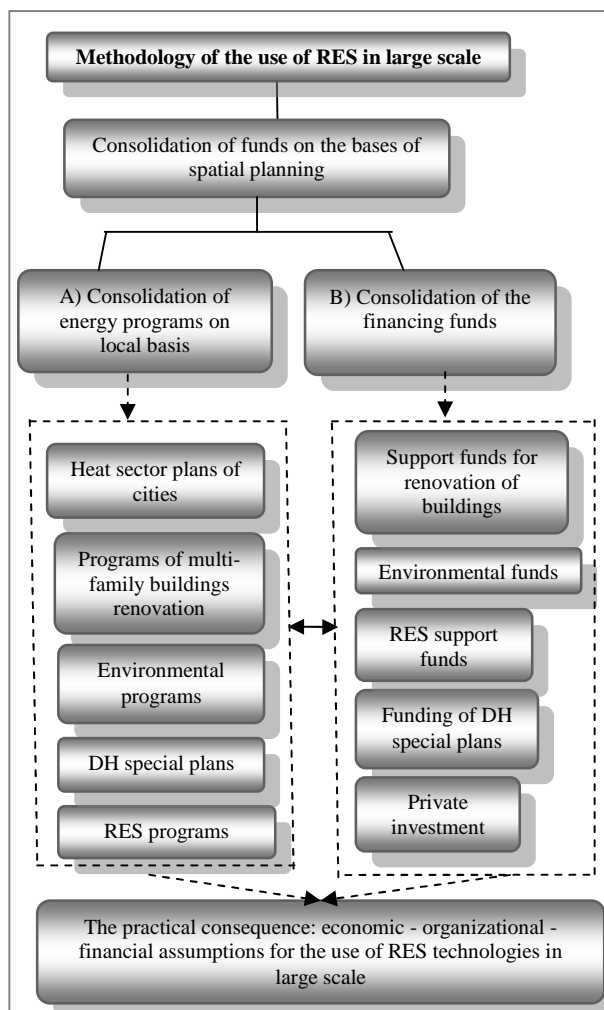


Figure 1. Methodology of the use of RES in large scale.

Periodization of economic age and assessment of various RES support forms, with regard to the specifics, has

different goals and tasks from the macroeconomic perspective.

There are two blocks of local programs and financing sources, which are to be described: A) and B).

#### A. Consolidation of cities energy programs on the uniform basis of knowledge economy

Lithuanian legal system of self-government has granted fairly broad opportunities to participate in increasing energy efficiency and development of renewable energy. Law on Local Self-Government in Lithuania distinguishes independent functions of municipalities, such as preparation and implementation of municipal strategic planning documents and planning documents implementing them. Law on Energy from Renewable Sources initiates preparing local RES development plans. Municipalities also administer the implementation of measures of Rural Development Programme such as carrying out the delegated function of the State. Law on Local Self-Government establishes that municipalities organize the heat supply within their territory. Law on Heat Sector regulates the special planning of heat, which is one of the implementation mechanisms of those obligations. In addition to broad responsibilities for the preparation of planning documents, the role of municipalities has been reinforced for renovation (modernization) of multi-family buildings in recent years.

The need for single energy policy formation with an economic support system for RES (as one of the compounds) has been notified for several years already.

Such program consolidation might be organizational and the integration of technologies could be financed using Structural Funds.

#### B. The second block shows consolidation of the financing funds program for sustainable development.

It is necessary not only to foresee the results that are expected in the use of RES but also to form the best prerequisites and financial resources that it would be possible to realize positive external effects. However, considering the possibility of incorporating efficient use of resources and RES into planning documents of municipalities, there is an issue of financing. Independent functions of municipalities, including implementation of the program documents, are funded from local budgets. These funds are limited; therefore, it is difficult to expect a decision of allocating funds to these areas on a larger scale. Therefore, the main role of municipalities is organizational, which would allow mobilizing larger resources. A special issue is lack of energy specialists who could prepare complex programs.

Scattered generation character and the fact that most of these installations can be implemented on demand side are left for private initiative. In order to involve hardly competing energy sources, the institution for investment management is required. Municipalities could act as institutions seeking for the development of wide scale RES technologies. Actual legislation in Lithuania shows that municipal powers and responsibilities regarding RES are regulated in detail. There are no barriers, except financing

issues for the actions of municipalities. Some of them have signed the Covenant of Mayors; some have adopted RES development action plans, however, only a few of them are actually acting.

The promotion of RES on wider scale was implemented in EU by creating green settlements or so-called eco villages. [32]. For example, the state funded the project Climate Menu in Netherlands, which enabled towns to select sectors which needed exceptional attention in order to meet national obligations. Environmental policy is implemented by towns, where the best possibilities are concentrated and problems are the most visible.

## V. CONCLUSION

A particular obstacle to the widespread use of RES is the lack of evaluation of the benefits to society (reduction of pollution, energy supply of the future for generations, huge and never-ending potential of energy resources such as solar, wind energy) when introducing RES-technologies. Therefore, when formally calculating, RES-technologies are not sufficiently competitive compared to fossil-fuel technologies. This work deals specifically with the problem of the impact of RES-technologies.

The analysis of the positive and negative impact of the use of RES on research in Lithuania and other countries has shown that the major part of the positive impact of the development of RES is related to GHG and other pollutant emissions, job creation and rural development, increase in employment in the regions, the reduction of heat prices and the lower emissions of some fossil fuels. Investigation has allowed the formation of a targeted, reliable methodology compatible with the status of existing statistical information.

Each RES has a different value in terms of external benefit, thus respective promotion schemes can and must differ significantly. This depends on the environmental situation in certain area. External conditions and current infrastructure for RES technologies differ, thus spatial planning, such as urban energy development plans, is the most appropriate tool for the benefit assessment.

Combination of different types of RES may create large external effect and make a significant impact not only on individual consumer of RES, but on the whole society as well. Therefore, the benefit from using RES, especially in urban areas, should be evaluated during the decision making process.

Urban programs should be the main form for the consolidation of investment funds and promotion on the basis of possible rational use of investment as a complex macroeconomic effect can be measured and achieved on the territorial basis.

## ACKNOWLEDGEMENT

This research was supported by the Research Council of Lithuania (09.3.3-LMT-K-712-06-0236).

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