

SUSTAINABLE ENERGY DEVELOPMENT PLANNING FOR REGIONS IN LITHUANIA: KAUNAS REGION CASE

Vaclovas Kveselis¹, Eugenija Farida Dzenajaviciene², Aurimas Lisauskas³

^{1, 2, 3}*Lithuanian Energy Institute, Breslaujos str. 3, LT-44403 Kaunas, Lithuania.*
E-mails: ¹vkv@mail.lei.lt; ²farida@mail.lei.lt; ³aurimas@mail.lei.lt

Abstract. Sustainable energy planning is a new process in Lithuania which was mainly fostered by actions both in public and private sectors. Sustainable energy development planning for regions in Lithuania means assessment of economic, environmental and social consequences and implementation of measures related to energy efficiency (refurbishment of buildings, municipal infrastructure, district heating, businesses, etc.), increased use of decentralised renewable energy sources and improvement of transport (development of public and private transport policies, use of RES, improvement of transport efficiency, etc.) as well as promotion of intelligent energy behaviour by energy consumers and businesses. Energy efficiency measures, renewable energy projects and other energy-related actions can be introduced in various activity areas of local and regional governments. However, the biggest impact here is laid at local level within the competence of the local governments, which act as consumer and service provider, planner, developer and regulator, advisor and, in certain cases, producer and supplier.

On the example of Kaunas Region the paper assesses motivation for sustainable energy development, overview of existing available data for sustainable energy planning, evaluate, which sectors of economic activity have the biggest potential for sustainable energy development in Lithuania's regions and what are the problems related to implementation of such planning. The paper also presents which requirements should be included into public procurement procedures to enable public bodies find best solutions in reaching energy efficiency goals. Special attention is paid to fulfilment of the sustainability criteria and defining achievable planning targets for sustainability actions.

Keywords: sustainable energy planning, energy efficiency, use of renewable energy sources, public procurement, sustainability criteria.

1. Introduction

Sustainable energy planning at local level is a new process particularly in Lithuania which was mainly fostered by actions both in public and private sectors. Sustainable energy development planning for regions in Lithuania means assessment of economic, environmental and social consequences and implementation of measures related to energy efficiency (refurbishment of buildings, municipal infrastructure, district heating, businesses, etc.), increased use of decentralised renewable energy sources and improvement of transport (development of public and private transport policies, use of RES, improvement of transport efficiency, etc.) as well as promotion of intelligent energy behaviour by energy consumers and businesses. Energy efficiency measures, renewable energy projects and other energy-related actions can be introduced in various activity areas of local and regional governments. However, the biggest impact here is laid at local level within the competence of the local governments, which act as consumer and service provider, planner, developer and regulator, advisor and, in certain cases, producer and supplier.

2. Background

A global problem like the climate issue requires international agreements and strategies. However, a local or regional perspective is central for the actual implementation of actions for emissions reduction, and allows in several aspects a higher degree of detail than what is possible with more aggregated approaches on higher geographical levels. Local circumstances and geographical considerations, which often are important factors in choice of energy technologies, are more easily integrated in the analysis (Börjesson and Ahlgren, 2010).

The main emphasis is given to review a potential development in the energy engineering science which may lead to a sustainable energy development. Seven major areas are listed with specific problems and their relevance to the sustainable energy development. This includes the following areas, such as energy resources and development; efficiency assessment; clean air technologies; information technologies; new and renewable energy resources; environment capacity; mitigation of nuclear power threat to the environment. Modern engineering science has to be oriented to those areas which

may directly assist in our future energy planning. In this respect it is a demanding need that our attention be oriented to the global aspect of energy development. Modern technologies will help to adopt essential principles of sustainable energy development. With the appropriate renewable energy resources introduction in our energy future and relief of nuclear energy threat, it will be possible to comply with the main principles to be adopted in the sustainable energy strategy (Afgan et al.; 1998).

Human pressures on the surrounding environment have had severe consequences over this period, coal burning has had adverse consequences traceable over the past 750 years, and the adverse environmental impacts of using other fossil fuels have aroused attention more recently. Heightened awareness of the need for sustainable development is a modern development, evident in international and national debates since the early 1970s. And finally the conclusion may be drawn that performance in promoting sustainable energy development in general, and expanding the use of 'new' renewable energy across the World in particular, has been patchy and on the whole very disappointing. The 'North' provide few good examples in addressing these issues, whether in the accelerated use of new renewable forms of energy; or of consistent environmental sensitivity to the negative impacts of supplying and using the various forms of primary or secondary energy. So far as prospects are concerned, the immediate outlook is also rather bleak (Jefferson, 2006).

The emphasize of benefit from sustainable energy development is currently placed on rural development. Recent modeling efforts and case studies to evaluate the economic viability of off grid renewable energy technologies for rural application in developing countries has been investigated (Byrne et al, 1998). Analyses indicate that levelized costs of off-grid, household-scale renewable energy systems are cost-competitive with conventional gasoline gen-sets and PV/wind hybrid systems appear to be an economic means of providing year-round electricity service and meeting the rising energy demands of remote households.

A society seeking sustainable development ideally must utilize only energy resources which cause no environmental impact. However, since all energy resources lead to some environmental impact, it is reasonable to suggest that some of the concerns regarding the limitations imposed on sustainable development by environmental emissions and their negative impacts can be in part overcome through increased energy efficiency. (Dincer and Rosen, 1999) provide a comprehensive discussion of the future of energy use and the consequent environmental impacts in terms of acid precipitation, stratospheric ozone depletion and the greenhouse effect, some solutions to current environmental issues in terms of energy conservation and renewable energy technologies, some theoretical and practical limitations on increased energy efficiency, and discussions of the relations between energy and sustainable development, and between the environment and sustainable development. And they

come to very important conclusion that for societies to attain or try to attain sustainable development, much effort must be devoted not only to discovering sustainable energy resources, but also to increasing the energy efficiencies of processes utilizing these resources.

Achieving sustainable solutions to today's energy and environmental problems requires long-term planning and actions. Energy issues are particularly prevalent at present and renewable energy resources appear to provide one component of an effective sustainable solution. The same authors discuss in their article (Dincer and Rosen, 2005) possible future energy-utilization patterns and related environmental impacts, potential solutions to current environmental problems, renewable energy technologies and their relations to sustainable development, and how the principles of thermodynamics via exergy can be beneficially used to evaluate energy systems and technologies as well as environmental impact. The paper comes to several important conclusions, such as: moving towards sustainable development requires that environmental problems be resolved; sustainable development requires a sustainable supply of energy resources that, in the long term, is sustainably available at reasonable cost and can be utilized for all required tasks without causing negative societal impacts; and for societies to attain or try to attain sustainable development, effort should be devoted to developing renewable energy resources and technologies.

The importance of energy efficiency improvement programs are emphasized also in research (Tanatvanit et al.; 2003), where brief review of energy use patterns in three economic sectors; namely, residential, industrial and transport sectors was provided. This paper forecasts the growth in energy demand and corresponding emissions to the year 2020 for those three sectors by using a model based on the end-use approach. The energy savings from the energy conservation strategies, such as energy efficiency improvement and energy demand management, are assessed and also the implications on electricity generation expansion planning are examined. The integrated resource planning (IRP) model is used to find the least-cost electricity generation expansion plans. Energy conservation options, including energy efficiency improvement programs, are introduced in the residential and industrial sectors. If all options are simultaneously implemented, the potential of energy savings and CO₂ mitigation in 2020 can be significant, not only the imported fossil energy but also the environmental emissions, particularly greenhouse gas emission, can be reduced through energy conservation activities and biomass utilization.

Sustainable Energy planning is usually related to Development of Sustainable energy strategies. Sustainable Energy Development Strategies typically involve three major technological changes: energy savings on the demand side, efficiency improvements in the energy production, and replacement of fossil fuels by various sources of renewable energy (Lund, 2007). Large-scale

renewable energy implementation plans must include strategies for integrating renewable sources in coherent energy systems influenced by energy savings and efficiency measures. Based on the case of Denmark, this paper discusses the problems and perspectives of converting present energy systems into a 100% renewable energy system. The conclusion is that such development is possible. If necessary renewable energy sources are present, and if further technological improvements of the energy system are achieved the renewable energy system can be created. Especially technologies of converting the transportation sector and the introduction of flexible energy system technologies are crucial.

Recently studies on sustainable development were started in Lithuania, mainly by the group of energy economists, who have investigated sustainable energy planning in Baltic Sea region and specifically in Lithuania's conditions. (Streimikiene, 2002) deals with the main aspects of unsustainability of the current energy systems and presents the main targets and measures of energy policy leading towards sustainable energy development. The main policy issues in order to promote and facilitate the transition to a more sustainable energy future in Transition countries such as Lithuania are: energy availability and security of supply; energy intensity and efficiency; energy pricing, subsidization and internalization of externalities; cleaner fossil fuels, renewable energy, and research & development; market opening, liberalization and economic efficiency. The most critical issues that sustainable energy strategies and the policies derived from them need to address are how to widen access to reliable and affordable modern energy supplies, and how to ease the negative health and environmental impacts of energy use. Given proper frameworks, pricing signals, and regulatory regimes, markets can efficiently deliver on the economic objectives of sustainable development. But markets alone cannot be expected to meet the needs of the most vulnerable consumers groups and to protect the environment. Where markets fail to protect these and other important public benefits, targeted government policies and consistent regulatory approaches will be needed.

Integration of New Member States to the European Union has created a new situation in the frame of implementation of the Lisbon strategy and EU Sustainable Development. (Streimikiene et al.; 2007) presents a detailed overview of possibilities to use the EU Structural Funds available for new member states (NMS) to finance sustainable energy projects and to overcome market failures related with negative externalities of pollution, positive externalities of knowledge and adoption of new pollution reduction technologies and incomplete information. EU Structural Funds is a good tool which can be used to attract investments for the financing of new technologies, including the use of RES and EE improvements which are doubly underpowered by energy markets and needs state support.

(Klevas et al.; 2007) shows that the use of regional social-economic-environmental indicators is the main key to integrate sustainable energy development at the program deployment level. The indicators to be used should describe the contribution of energy programs to the sustainable development, medium- and long-term trends and interrelationship between them and the typical energy indicators. Municipalities may play a considerable role by promoting sustainable energy since local authorities are fulfilling their functions in the energy sector via a number of roles.

(Streimikiene, 2007) discloses the importance of selecting appropriate indicators for the implementation of sustainable energy development through the selected efficient policies and monitoring of progress towards its achievement, also showing that such process needs monitoring and reporting tools for the progress achieved towards sustainable energy development in the region. In general, achieving sustainable development on global scale will require the judicious use of resources, technology, appropriate economic incentives and strategic planning at the local, national and regional levels. It also requires regular monitoring of impacts of selected policies and strategies to see whether they are furthering sustainable development or whether they should be adjusted.

3. Energy planning at local level in Lithuania

Different from energy planning on national level, lower level planning (on regional, municipal levels) was not practically performed in Lithuania till recently. While elaborating regional development strategies regions usually apply prospective planning methods, such as SWOT analyses, development of investment projects in local infrastructure, etc. First of all this can be said in relation to district heating (DH) sector, where municipalities are obliged to elaborate and revise special heat supply plans. Unfortunately, we should recognize that there is no single methodology and auxiliary measures established for development of such plans. Regardless to applying of widely promoted and developed methods of integrated resource planning (IRP) these are used rather occasionally in municipal energy planning and usually under international research and collaboration projects only. This is also related to development of models for the needs of national energy sector.

The concept of sustainable development requires introducing of energy resources extracting, conversion and supply to final consumers systems and infrastructure as well as efficiency improvement and conservation measures; and reduction of negative impact to environment.

One of the most important tasks is nowadays agenda of energy policy – reduction of emissions which mitigate climate change. Though large energy generators using fossil organic fuel and transport are also the biggest sources of such emissions, still measures implemented at local level may add significantly to reduction of its' demand for energy generation through using local renew-

able energy sources and implementing energy saving measures.

Decentralization of energy market introduces more dialogue into regional energy planning process. Stakeholders in energy planning process usually have different interests and priorities. Undefined energy prices in future, lack of resources, growing negative impact to environment and restrictions make regional energy planning and modeling more complicated (Myrakian et al.; 2008). Unfortunately, we should mention that due to such reasons as lack of energy experts in the most of smaller municipalities, lack of financial means and regional energy statistics, municipalities do not show any intentions to perform sustainable energy planning actions in their areas of responsibility. These areas are usually public sector, involving transport, streets lightening and energy supply to public and residential buildings and partly tertiary sector. Activities, which could be implemented in industry, non-public transport and tertiary sectors most often gets outside of municipal interests. Besides municipalities also lack experts who are able of handling model software tools.

The general goals for strategic planning of sustainable energy can't be separated from total economic and social development of specific region or municipality under investigation. It should also support local communities in implementing wider goals – such as preserving of environment, reliable providing of energy services, fostering of economic development, improvement of employment and entrepreneurship skills.

4. Characteristics of models applied for the needs of regional and local planning

Models for local and regional planning are based on the same methods as those applied for national and transnational energy systems. For this purpose one could use complex models, such as WASP (developed and used for development of nuclear energy) or EFOM (for optimization of energy flows). However, local planning needs require optimal models and implementing software which could be easily mastered by municipal planners without using specific computing skills. More narrow limits for the object can be used for local planning since no macro-economic analysis is required in the task of such modeling.

Rather comprehensive analysis of models in energy sector is presented in (Dementjeva and Smirde, 2009), which makes the conclusion that LEAP (Long-range Energy Alternatives Planning system) model is best applied for small countries. Fig 1 shows classification of models according to specific purpose of energy planning.

Three levels of models can be applied for regional planning: spreadsheets, simulation and optimization models. Spreadsheets usually estimate technologies, greenhouse gases emissions and costs and can be applied rather for specific individual project or localized solution. RET screen is the typical example of such model.

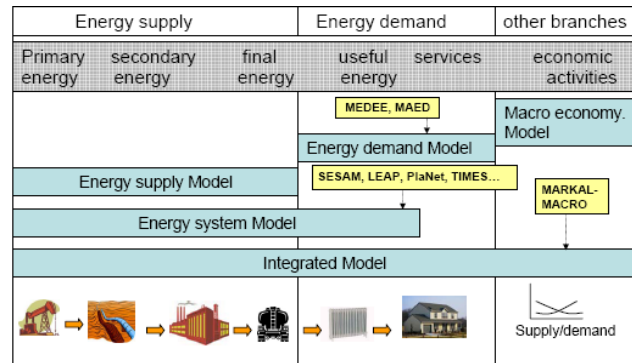


Fig 1. Classification of models according to specific purpose of energy planning (Myrakian et al.; 2008)

Simulation models are most appropriate for local strategic planning and besides issues defined in spreadsheet also simulate demand, trends and use several development scenarios. LEAP model is typical example here. Most sophisticated optimization models include also optimization actions (e.g. MESSAGE model) (Fig 2).

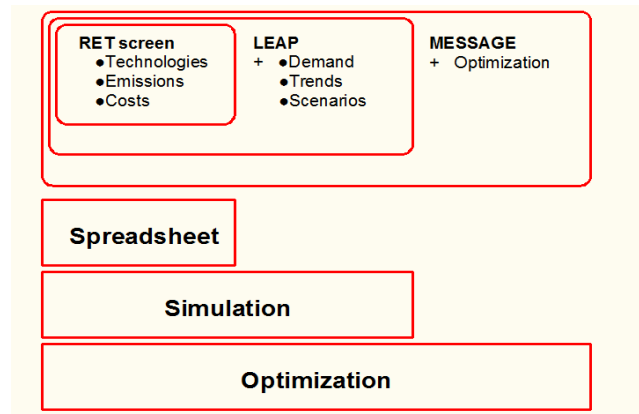


Fig 2. Characteristics of three typical modeling software tools

5. Assessment of sustainable energy development modeling possibilities in Lithuania

Besides above mentioned software tools which could be applied for local planning purposes, valuable experience was gained during our common LEI study (Galinis et al.; 2010) while adapting MESSAGE model for planning needs of municipalities in Lithuania. The study evaluated RES potential and possibilities to implement this potential at municipal level as well as its' impact for national energy sector. Optimization model was reasonably selected for such task. The aim of optimization task is minimization of energy costs with assumed restrictions, related to international obligations of Lithuanian Republic according to RES promotion directive and Climate – Energy package. The outcome of the modeling was achieved for every municipality though optimization was performed on national level.

One of the biggest problems related to mathematical models is filling it with required input data. Optimal quantity of information (optimization) is usually achieved

through introduction of default “standard” data, such as climate characteristics, technological data, characteristics of energy resources, etc. Macro-economic data and data on specific economic sectors are available in the data basis of the Department of Statistics.

And the main problem of regional or local modeling is that most data, including energy demand by types of fuel and energy, biomass, waste resources, etc. are not accumulated by municipalities. In best case such data could be available in regional statistics of other branches of economic activity (forestry, agriculture, etc.)

Filling in technological data for the use of RES requires much effort and work since there is no experience on the use of technologies in Lithuania which are available in other countries, such as waste incineration, biogas production and purification, use of forestry management waste, etc.; and we must use the results of investigation performed in other countries. For this reason the results of modeling, reliability of such results should be verified after having received new information, reflecting local conditions in Lithuania and sometimes in specific municipality.

6. Evaluating of sustainability criteria in development models

As it was mentioned above sustainability criteria evaluated in energy development models are restricted with costs analysis and optimization (economic criteria); and environment pollution with input into climate change prevention (environmental criteria). Only costs for energy and changes in household energy consumption can be assessed among social criteria. However, modeling and analysis of energy demand is implemented in macro-economic or energy equilibrium models only. Optimization and simulation models usually set demand option on the basis of results of above used models or specific targeted energy demand. Possibilities to assess sustainable development criteria using directly the results of used MESSAGE model are shown in Table 1. Here energy indicators for sustainable development are those defined and used by Eurostat (Energy Indicators, 2005)

Table 1. Possibilities to assess sustainability criteria using results of MESSAGE model

Criteria	Does model provide data for assessment of criterion on regional level?
Social criteria	
SOC1 – Share of households (or population) without electricity or commercial energy, or heavily dependent on non-commercial energy	+
SOC2 – Share of household income spent on fuel and electricity	+
SOC3 – Household energy use for each	+

income group and corresponding fuel mix	+
SOC4 - Accident fatalities per energy produced by fuel chain	+
Economic criteria	
ECO1 - Energy use per capita	+
ECO2 - Energy use per unit of GDP	+
ECO3 - Efficiency of energy conversion and distribution	+
ECO4 - Reserves-to-production ratio	-
ECO5 - Resources-to-production ratio	+
ECO6 – Industrial energy intensities	-
ECO7 – Agricultural energy intensities	-
ECO8 - Service/commercial energy intensities	-
ECO9 – Household energy intensities	-
ECO10 – Transport energy intensities	-
ECO11 - Fuel shares in energy and electricity	+
ECO12 - Non-carbon energy share in energy and electricity	+
ECO13 – Renewable energy share in energy and electricity	+
ECO14 - End-use energy prices by fuel and by sector	+
ECO15 - Net energy import dependency	+
ECO16 - Stocks of critical fuels per corresponding fuel consumption	-
Environmental criteria	
ENV1 - GHG emissions from energy production and use per capita and per unit of GDP	+, only CO ₂
ENV2 – Ambient concentrations of air pollutants in urban areas	-
ENV3 - Air pollutant emissions from energy systems	+
ENV4 – Contaminant discharges in liquid effluents from energy systems including oil discharges	-
ENV5 - Soil area where acidification exceeds critical load	-
ENV6 - Rate of deforestation attributed to energy use	-
ENV7 - Ratio of solid waste generation to units of energy produced	-
ENV8 - Ratio of solid waste properly disposed of to total generated solid waste	-
ENV9 - Ratio of solid radioactive waste to units of energy produced	-
ENV10 - Ratio of solid radioactive waste awaiting disposal to total generated solid radioactive waste	-

The aims of RES Directive and EU Climate and Energy package and the Covenant of Mayors are introduced into optimization models as restrictions for target function. Simulation models and above the sustainability criteria defined for implementation of National energy policy are formulated as scenarios. Using simulation models additional analysis of modeling results by scenarios is required from the attitude of defined criteria (economic, environmental and social).

7. Modeling results for municipalities of Kaunas Region from the attitude of sustainable energy development

This analysis uses the results of one of modeling scenarios for municipalities of Kaunas Region. The analysis of the modeling results was performed for three main criteria – RES share, CO₂ emissions and changes of energy demand, which are in conformity with targets and tasks of EU Climate and Energy package and RES promotion Directive.

Calculations were performed using already existing RES support instruments (preferential electricity purchase tariffs from renewable CHP plants, obligations to buy electricity from biomass CHP, etc.)

The results of the modeling permitted to compare the demand for district heating (DH) in municipalities of Kaunas region with current heat generation using solid and gaseous biofuel and biofuel potential from forest cutting activities in the forests of Kaunas region. Birštonas, Kaišiadorys and Raseiniai municipalities cover more than half of their fuel demand using biofuel at present already (Fig 3).

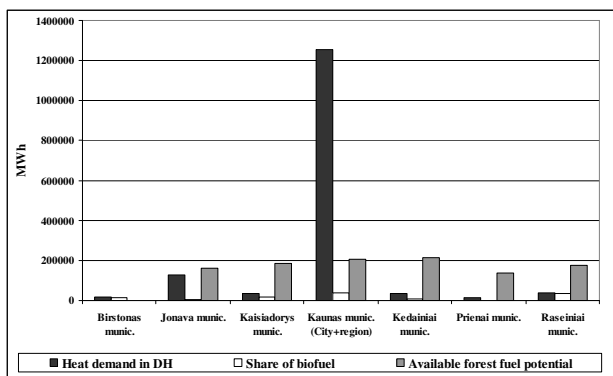


Fig 3. The use of biofuel and potential to be used in district heating of Kaunas Region

However, total share of biomass fuel used for DH in the regions hardly reach 8%, which is defined by the use of natural gas in Kaunas CHP plant, which covers the DH needs in Kaunas city with population over half of that of the whole region. Assessment of forest biomass potential shows that these resources could cover over 70% of DH need of Kaunas Region.

The share of RES in total fuel-energy balance, including decentralized heat generation reached approximately 11% in 2008. Most of such fuel is used in Raseiniai municipality (there are no natural gas network in this municipality), and the least in Birštonas municipality, which is the smallest one in the region (Fig 4).

Calculated increase of the share of various RES in energy balance is shown in Fig 5. Wood, straw and biogas fuel should be considered as the main resources from the attitude of the least costs. Kaunas City could also use solid combustible fraction of municipal waste for energy generation.

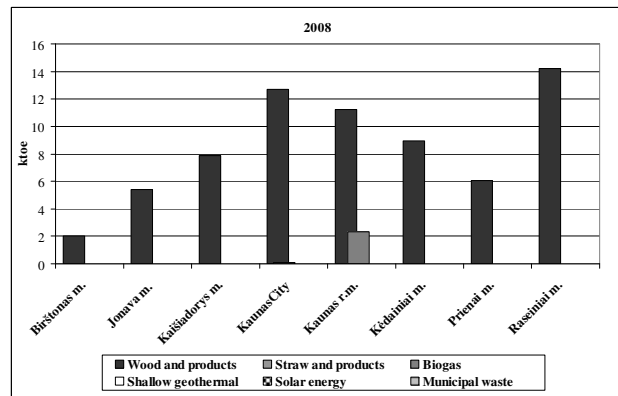


Fig 4. The use of renewable energy sources in municipalities of Kaunas region in 2008, ktoe

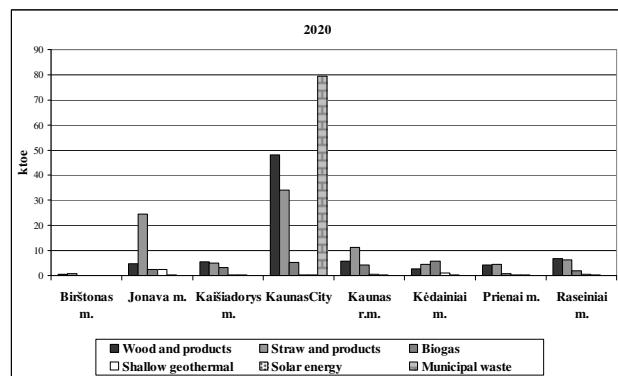


Fig 5. Consumption of energy from RES in municipalities of Kaunas Region in 2020, ktoe (modeling results)

Fuel energy balance data only show that energy generation from RES should grow (Fig 6). This figure includes also biomass from municipal waste which could be used in Kaunas City. The data also reflect expected increase in total energy demand due to economic development.

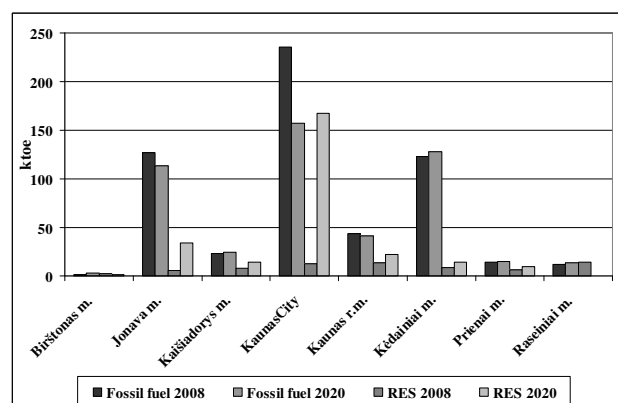


Fig 6. The changes in the use of fossil fuel and RES in municipalities in Kaunas Region during the period 2008-2020, ktoe

The share of fuel produced from RES should grow from current 25.5% to 35.2% according to the simulation results. Simulation results, showing the change of RES

share in fuel balance of municipalities in Kaunas Region are presented in Fig 7.

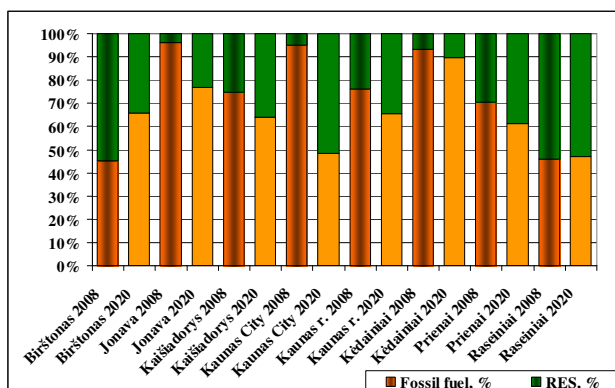


Fig 7. The share of fossil fuel and RES in fuel balance in years 2008 and 2020 in municipalities of Kaunas Region, %

The other important sustainability criterion – reduction of greenhouse gas (GHG) emissions, which is also one of target functions with regard to EU goals defined in Energy and Climate package, which are reduction of GHG emission by at least 20%. The Covenant of Mayors suggests even more ambitious targets.

The results of the modeling and recalculation of the changes in the use of fossil fuel into changes of GHG emissions in CO₂ equivalents by municipalities show total reduction of GHG emissions by 20% in Kaunas Region. However, quantitative changes in separate municipalities are not similar, starting with increase of emissions in Birštonas, Kaišiadorys, Prienai and Raseiniai municipalities and showing significant reduction in Kaunas City, Jonava, Kaunas and Kėdainiai regional municipalities (Fig 8).

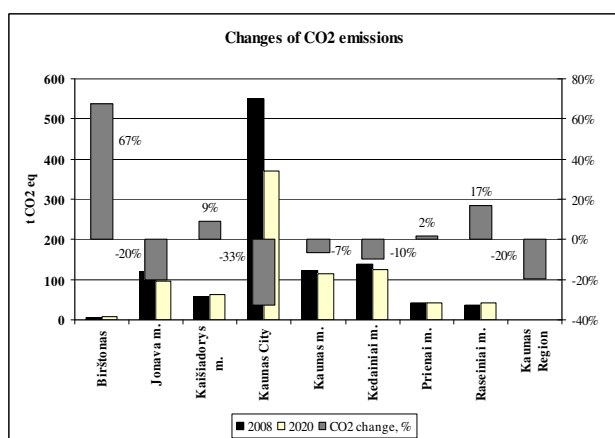


Fig 8. The change of GHG emissions in Municipalities of Kaunas Region

Growth of CO₂ emissions in some municipalities can be related with the growth of energy demand, which is covered using cheaper technologies using fossil fuel. Be-

sides, in absolute units, this growth is not significant as is levered by significant reduction of GHG emission in Kaunas City and Jonava Municipality.

Reduction of energy demand through improvement of energy efficiency is also one of the targets of energy policy. However, different from reduction of emissions or increasing the share of RES, the defined target of 20% reduction in final energy consumption is related to economic development, i.e. inevitable growth of energy demand via increase of economic development, especially in energy intensive sectors of economy. For this reason energy saved from more efficient use is reflected not directly but in comparison to the growth of energy demand and unchanged energy efficiency.

Energy demand for modeling purposes was elaborated using other methodologies, which evaluate the forecasted changes of macro-economic indicators, reduction of energy demand due to “natural” technological progress, impact from the use of energy efficiency measures and other factors (prices elasticity, etc.).

The changes of final energy consumption (demand) in municipalities of Kaunas Region are presented in Fig 9.

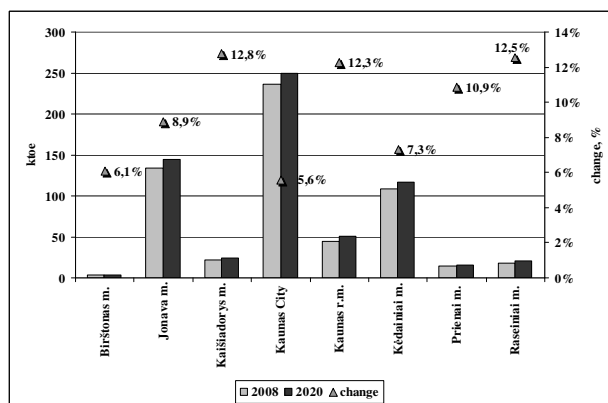


Fig 9. The changes in final energy consumption used in modeling

The main differences from changing the restrictions of modeling object (in national, regional or municipal levels) could be described in the following conclusions.

8. Conclusions

1. Performed calculations show that existing RES potential and existing economic incentives allow reaching the targets of EU Climate and Energy Package and RES Directive even without additional support measures.
2. Conventional energy sector modeling tools are more appropriate for evaluating economic sustainability rather than comprehensive sustainability assessment. Modest possibilities exist for environmental sustainability evaluation, however they do not suggest data for assessment of social sustainability.
3. Optimal solution on national level should not be the same as that optimal and meeting sustainability criteria

solution for specific municipality or region. This means that the results of optimization task on national level cannot be directly transferred to local level, in case implementation of sustainable development is based on local initiatives, such as e.g. Regional programs, Covenant of Mayors, etc.

4. Modeling on local level loses internal links of energy market – there is possible redistribution of fuel and energy resources from one model planning region to another. This means that simulation models for some types of energy (e.g. electricity, natural gas) introduce category of large energy systems and energy from such systems can be supplied without restrictions.
5. In case decision making process is based on optimization results achieved on national level, there is always conflict possibility related to inadequacy between input and benefit on local decision-making level, or in other words, territorial aspect of sustainable development can be eliminated.

Acknowledgements

The authors would like to express their acknowledgement to our colleague Dr. Arvydas Galinis and his working group who have performed modeling and kindly provided us with the results for our analysis.

References

- Afgan, N. H.; Gobaisi, D. A.; Carvalho, M. G.; Cumo, M. 1998. Sustainable energy development. *Renewable and Sustainable Energy Reviews*, 2235-286.
- Börjesson, M.; Ahlgren, E. O. Biomass gasification in cost-optimized district heating systems – A regional modeling analysis. *Energy Policy*, 38 (2010): 168-180.
- Byrne, J.; Shen, B and Wallace, W. 1998. The economics of sustainable energy for rural development: A study of renewable energy in rural China. *Energy Policy*, Vol. 26, No. 1, pp. 45-54.
- Streimikiene, D.; Klevas, V.; Bubeliene, J. 2007. Use of EU structural funds for sustainable energy development in new EU member states. *Renewable and Sustainable Energy Reviews* 11 1167–1187
- Streimikiene, D. 2007. Monitoring of energy supply sustainability in the Baltic Sea region. *Energy Policy* 35 1658–1674.
- Streimikiene, D. 2002. Sustainable energy development. *Environmental research, engineering and management*, No.1(19), P.20-29.
- Dementjeva, N.; Smirde, A. 2009. Analysis of energy models and their adaptability for Estonian energy market. *Energetika*. Vol. 55. No. 2. P. 107-115.
- Dincer, I.; Rosen, M. A. 1999. Energy, environment and sustainable development. *Applied Energy* 64 427-440
- Dincer, I.; Rosen, M. A. Thermodynamic aspects of renewables and sustainable development. *Renewable and Sustainable Energy Reviews* 9 (2005): 169–189
- Energy Indicators for sustainable development: guidelines and methodologies. International atomic energy agency, UN Department of Economic and Social Affairs, International Energy Agency, Eurostat and European Environment Agency, Vienna, 2005.
- Galinis A. (Research group leader). 2009. The use of renewable energy sources (biofuel, hydro, solar, geothermal energy) and municipal waste in municipalities of the country for generation of energy. Lithuanian Energy Institute. Research Study, Kaunas, December 2009.
- Henrik Lund. Renewable energy strategies for sustainable development. *Energy* 32 (2007): 912–919
- Jefferson, M. 2006. Sustainable energy development: performance and prospects. *Renewable Energy*, 31 571–582
- Mirakyan, A.; Lefait, L.; Lewald, N.; Imbert, P. 2009. The Dynamics of regional (subnational) integrated energy planning and requirements of methods and models. International Energy Workshop [cited 5 March 2009]. Available on the Internet: <<http://www.iea.org/work/2008/iew/Wednesday/Mirakyan.pdf>>
- Tanatvanit S.; Limmeechokchai, B.; Chungpaibulpatana, S. 2003. Sustainable energy development strategies: implications of energy demand management and renewable energy in Thailand. *Renewable and Sustainable Energy Reviews* 7 367–395
- Klevas, V.; Streimikiene, D.; Grikstaite, R. 2007. Sustainable energy in Baltic States. *Energy Policy* 35 76–90.