***Research on Methodology for the deep decarbonisation of the economy***

Dr. Egidijus Norvaiša, Lithuanian Energy Institute, Kaunas, Lithuania, +370 37 401955, [Egidijus.Norvaisa@lei.lt](mailto:Egidijus.Norvaisa@lei.lt)

Dr. Arvydas Galinis, Lithuanian Energy Institute, Kaunas, Lithuania, +370 37 401957, [Arvydas.Galinis@lei.lt](mailto:Arvydas.Galinis@lei.lt)

Eimantas Neniškis, Lithuanian Energy Institute, Kaunas, Lithuania, +370 37 401950, [Eimantas.Neniskis@lei.lt](mailto:Eimantas.Neniskis@lei.lt)

## Overview

To limit anthropogenic climate change, the average annual temperature increase of earth’s atmosphere must be reduced to 2°C, compared with the pre-industrial period. For this reason global annual greenhouse gas emissions by 2050 should be reduced by 42-57% compared to 2010 level and by 2100 reduction should reach 73-107% according to Intergovernmental Panel on Climate Change [1]. To implement the mentioned goals of deep decarbonisation it is essential to completely avoid emissions from power sector, to electrify other sectors of economy (transport, industry, etc.) and to increase energy efficiency [2, 3]. Such level of emission reduction requires radical transformations of the whole economy. Realistic and detailed models and methods are required to simulate and optimize such transition pathways. To support decision-makers efforts to choose the optimal strategy for deep decarbonisation we are developing methodology for complex analysis of required technological changes in the economy.

This paper is based on the ongoing project of Lithuanian Energy Institute on developing a methodology and modelling system for integrated analysis of deep decarbonisation of the economy (2018-2021). The aim of this paper is to present first results and the development progress of the methodology concentrating on power sector which serves as the basis for decarbonisation of the whole economy.

## Methods

The complex interconnections between sectors of economy, the problem of choosing the relevant methodology for the analysis, setting of temporal, spatial and technological boundaries in the applied analysis tools, uncertainty of input parameters and other issues makes the development of a decarbonisation strategy a very complex task. Tools like planning and optimization models are required to explore and analyse long-term future decision space under various constrains and assumptions [4]. After literature analysis phase we have decided to employ bottom-up optimization modelling tool MESSAGE [5]. It is based on a detailed technical and economic description of the modelled sectors and capable to provide framework for analysing long-term decarbonisation scenarios as recommended by the scientific literature [6, 7]. The principle of this modelling software is optimization of an objective function, defined as total costs of energy system.

Reducing the carbon emissions from the power sector is an essential element of any low-carbon energy transformation strategy. As the energy sector shifts towards a system based on low carbon energy sources and is increasingly integrated with other complex infrastructure systems like transport, new tools and modelling approaches are need to tackle the novel research challenges [4]. Accordingly we have started our work by researching what methodologies should be applied to describe technologies of power sector in the long-term models in the context of deep decarbonisation. Moving towards low-carbon energy systems, renewable energy sources will become main energy supply alternatives and will play an essential role in future [2, 8]. On the other hand, a high degree of electrification of transport, industry and other end-use sectors is foreseen in future scenarios, which indirectly affects the power sector.

Important challenge is to model variable renewable energy sources (like wind power) in the long-term energy system optimization models. The problem arises because long-term (until 2050 at least) decisions on investments and implementation pathways as well as short-term (hourly) and seasonal energy supply techno-economic characteristics must be considered simultaneously in the methodology [2]. So, more complex modelling approaches must be implemented for better estimation of these technologies required for transition to decarbonized energy system. To solve this issue we propose the specific methodology for modelling of renewables by defining probability curves of resource availability for each time slice. To study the impact of our and commonly used different modelling approaches on the results of long-term decarbonisation scenarios, we constructed country energy system model. It is based on Lithuanian energy system and represents the power system with high share of renewables in the future (strategic goal in the country is to increase share of RES electricity up to 100%) [9].

## Results

In current research we analysed few hypothetical scenarios of Lithuanian power sector development with high shares of renewables in the future electricity mix. To test our modelling approache we compared few different methodologies for temporal representation and wind power modelling in the energy system model. Our research revealed that depending on methodology chosen the differences between the modelling results can be very significant. Different modelling approaches (keeping the same data and assumptions) leaded to significant changes in resulting electricity supply portfolio. If we do not specify the probability curves of renewables availability for each time slice the forecasted production of wind power plants was not much affected. But analysed electricity production of fossil fuel based power plants decreased by 16-23%, the volume of export by 95-80% depending on year analysed. The installed capacities of thermal power plants were by 35% lower if we model renewables in simplified way (no probability curves of wind availability were set). In addition, total costs for long-term development and operation of the energy sector were lower by 7.5%. So, from these results we can conclude that choice of modelling methods is very important and may have significant impact on analysing decarbonisation pathways, providing conclusions and policy recommendations.

Carefully chosen methodologies is highly relevant for quality and reliability of analysis results, so we will continue our research by developing modelling methodologies capable to correctly model other economy sectors important for decarbonisation process.

## Conclusions

The current work have been focusing on literature analysis, development of power sector model and the complex and innovative modelling approaches to integrate various technological options into this model for better estimation of decarbonisation pathways. Other sectoral models like transport, industry, etc. are under development and will be integrated into common modelling system at the later stages of the work.

The methodology based on probability curves of renewables availability, incorporated into long-term model proved to be effective method to increase quality and accuracy of long-term modelling results by including short-term dynamics of renewables without significant enlargement of model size.

Insufficient details in the long-term planning models could under- or overestimate the potential, value and costs of different technologies analysing possible future decarbonisation pathways.

**Acknowledgment:** The ongoing project has received funding from the Research Council of Lithuania (LMTLT), agreement No. S-MIP-19-36.

## References

1. Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, … J. C. Minx (Eds.). Cambridge: Cambridge University Press., February 2015, Online ISBN: 9781107415416
2. G. Pleßmann, P. Blechinger. How to meet EU GHG emission reduction targets? A model based decarbonisation pathway for Europe’s electricity supply system until 2050. Energy Strategy Rev., 15 (2017), pp. 19-32.
3. C. Gerbaulet, C. von Hirschhausen, C. Kemfert, C. Lorenz, P.-Y. Oei. European electricity sector decarbonisation under different levels of foresight. Renewable Energy, 141 (2019), pp. 973-987, ISSN 0960-1481.
4. J. DeCarolis, et al. Formalizing best practice for energy system optimization modelling. Applied Energy, 194 (May 2017), pp. 184-198.
5. MESSAGE: Model for Energy Supply Strategy Alternatives and their General Environmental Impact. International Atomic Energy Agency, Vienna, 2003.
6. Deep Decarbonisation Pathways Project (2015). Pathways to deep decarbonisation 2015 report, SDSN - IDDRI.
7. K. Vaillancourt, O. Bahn, E. Frenette, O. Sigvaldason. Exploring deep decarbonisation pathways to 2050 for Canada using an optimization energy model framework. Appl Energy, 195 (2017), pp. 774-785.
8. W. Zappa, M. Junginger and M. van den Broek, “Is a 100% renewable European power system feasible by 2050?,” Applied Energy, Vols. 233-234, pp. 1027-1050, 1 1 2019.
9. “National Energy Independence Strategy of the Republic of Lithuania. ENERGY FOR LITHUANIA'S FUTURE,” Vilnius, 2018.