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Section: Energy for Buildings

Evaluation of RES-E support policies in the Baltic States

Dagnija Blumberga[a], Aiga Barisa[a], Ivars Veidenbergs[a], Andra Blumberga[a], Reeli Kuhi-Thalfeldt[b]

[a]*Riga Technical University, Kronvalda Boulevard 1, Riga, LV 1010, Latvia*
[b]*Tallinn University of Technology, Ehitajate tee 5, 19086 Tallinn, Estonia*

Abstract

Electricity generation is a key sector to consider in a policy aimed at mitigation of greenhouse gases. Renewable energy sources can create substantial environmental and socio-economic benefits such as minimizing greenhouse gas emissions, improving energy security and promoting local economy. A wide range of policy measures are available for national governments to promote renewable electricity generation. Despite the positive effects of increased renewable energy share in national energy balance, it is often associated with high implementation costs. Given the importance of promoting renewable power deployment, and the high financial costs associated with support, it is essential for governments to be aware of performance and effects of introduced or planned policies. An evaluation can help to identify potential adaptations and allocate financial resources as efficiently as possible. This article evaluates policies in support of the deployment of renewable power generation. Power sectors of the three Baltic States – Lithuania, Latvia, and Estonia – are investigated. The aim of the study is to evaluate the existing policy measures and propose new solutions for further renewable electricity support. Analysis is based on system dynamics modeling approach. This modeling approach has been chosen due to its flexibility for extension and revision to address additional questions as they arise. Results suggest that electricity feed-in tariffs are effective in terms of installed capacity increase. However, the intensity of support for each source of renewable energy should be reasonably determined in order to contribute to achievement of national renewable electricity targets.

Keywords: energy efficiency; electricity; feed-in tariff; subsidies.

Nomenclature

€c	Euro cent
CHP	combined heat and power
CO_2	carbon dioxide
EU	European Union
HPP	hydropower plant
MW	megawatt
NCC	National Control Commission for Prices and Energy of Republic of Lithuania
PV	photo voltaic
R&D	research and development
RES	renewable energy sources
RES-E	electricity produced from renewable energy sources

1. Introduction

To combat climate change, the European Union (EU) has agreed on two ambitious targets for 2020: 1) to reduce greenhouse gas emissions by 20% compared to 1990 levels and 2) to increase the share of renewable energy sources in total energy consumption to 20% [1]. Verbruggen and Lauber [2] stress that in a sustainable energy future, electricity is going to play a role of increasing importance and that the transition of the present non-sustainable energy systems to systems with renewable energy as the standard will take place first and fully in the electricity sector.

Corresponding author: Aiga Barisa. E-mail address: aiga.barisa@rtu.lv
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The cost of electricity produced is the major factor based on which the technology choice for electricity generation is done [3]. Electricity generation from renewable energy sources is still more expensive than conventional fossil fuel technologies. However, such factors as the rapidly growing market for energy, the technological progress and potentially increasing fossil fuel prices over time point to increasing competitiveness of renewable energy technologies compared to fossil-fuel-based power plants [3]. Meanwhile national governments are applying a number of support policies to initiate the development of alternative markets for electricity generation.

1.1. Classification of renewable electricity support policies

Governments are implementing various carbon reduction and renewable energy policies to improve the sustainability of the electricity sector. Renewable electricity policy mechanisms generally can be categorized into price-based and quantity-based policies [4]. In price-based instruments, the regulator sets a price for a specific variable. E.g., generators of renewable energy receive financial support in terms of a subsidy per kilowatt of capacity installed, a payment per kilowatt hour produced and sold or a fixed premium above the electricity market price [5]. Both capacity and generation supplies can be qualified by renewable energy source, by technology, by ownership, and any other attributes upon which the terms of support can be applied and that are in some way measurable [2]. In quantity-based policies, the desired level of outcome is set and an artificial market is created in which participants act to fulfil the policy target. In such way price for the regulated variable is determined by the market [4]. These systems operates under the principle that a defined member of the electricity supply chain (consumer, generator or supplier) has to present a fixed minimum quantity of certificates originated per megawatt hour of renewable electricity generated [6].

Support expenditures are usually charged to public budgets [2] and are paid by all electricity consumers corresponding to their consumption level. Thus the increasing expenditure on renewable energy has become a source of concern for governments all over the world [7]. This was one of the reasons that contributed to the discontinuation of feed-in tariffs in Latvia till 2016.

Feed-in tariffs are among major instruments used by public authorities to support renewable electricity supplies in their infant stages [2] and are the most popular RES-E support scheme in the European countries [8]. A feed-in tariff may be structured as either a fixed-price tariff thus guaranteeing electricity operators a set price for electricity sold to the grid, or a premium tariff, which adds a definite bonus to the wholesale market price perceived by generators. The duration, over which the tariff is paid, as well the tariff amount varies between policies applied in countries. In order to control the enrollment of RES-E generation, some countries cap the total capacity that can be installed or total tariffs that may be awarded under the scheme each year. Some countries have introduced a mechanism to gradually reduce the tariff rate thus adapting to increasing economic viability of RES-E technologies over time [8].

Other types of RES-E support policies include: tradable certificates, tax incentives and investment grants, net-metering policies, and tendering schemes all of which are applied in European countries separately and in combination with other policy incentives. However, Fouquet [6] concludes that so far, well-designed feed-in tariff systems for renewable energies with guaranteed access to the grid have proven the strongest reliability and success.

1.2. Context of renewable electricity support policies in the Baltic States

1.3. Latvia

High dependency on imported fossil fuel resources is seen as the main drawback of Latvian energy sector. In 2012, gross electricity consumption in Latvia was 6,848 GWh [9] which was a 10.6% increase compared to previous year and 19.5% increase compared to 2005 level. Electricity generation amounted to 6,168 GWh, from which 3,707 GWh were produced in hydropower plants and 407 GWh in other RES-E facilities; the rest coming from natural gas (2,347 GWh) [10]. In 2012, electricity imports amounted to 4,935 GWh and electricity exports – 3,244 GWh [9].

The share of renewable energy sources of gross national electricity consumption has been inconsistent over the past years: 41.2% in 2008, 49.2% in 2009, 48.5% in 2010 and 41.9% in 2011. In Figure 1 the development of RES-E generation and installed capacity in Latvia up to 2012 is illustrated.

Besides hydropower, wind power, biomass and biogas contribute to electricity generation from renewable energy sources in Latvia. As illustrated in Figure 1 wind energy has shown the most noticeable breakthrough over the past decade reaching 60 MW installed capacity in 2012; it is followed by 43 MW installed biogas capacity and 23 MW installed biomass capacity. It is expected [11] to increase the share of renewable energy sources to 59.8% of gross electricity consumption by 2020. Further the Latvian Energy Long Term Strategy 2030 (2012) [12] sets a target of a 50% share of energy from renewable energy sources in gross final energy consumption by 2030. This means 15% increase compared to 2011 level (35.2%) which will not be achievable without appropriate policy incentives.

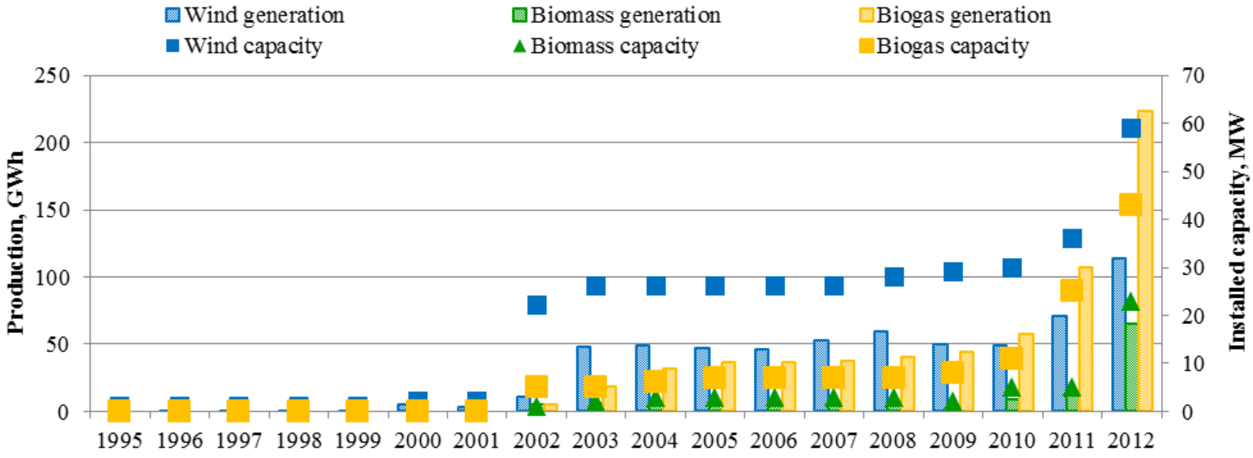

Fig. 1. Renewable electricity in Latvia (except hydropower) (Data source: [9])

In Latvia, power generation from renewable energy sources is promoted through a complex support system based on a feed-in tariff, which also includes elements of a quota system and tenders. All renewable energy technologies (except hydro power > 10MW) are eligible for support. The tariff rates for electricity from renewable sources are calculated based on the price of natural gas and applying a certain coefficient depending on the plant size. Different regulation applies to electric and combined heat and power (CHP) plants. Feed-in tariffs are paid for a period of 20 years and rights for selling electricity within the mandatory procurement are granted in a tender procedure. A reduced feed-in tariff rate is stipulated for the operators of renewable electricity plants after the first ten-year period from the commencement of operation.

Average feed-in tariff rates paid for operators in 2012 are presented in Table 1. From Table 1 can be seen that support for electricity producers in 2012 was in range from 10.7 and 11.1 €c/kWh (wind power plants and large CHPs) to 18.5 and 19.5 €c/kWh for biomass and biogas power plants respectively.

Table 1. Average feed-in tariff rates applied in Latvia in 2012 [13]

Technology	Feed-in tariff, €c./kWh
Biogas	19.5
Biomass	18.5
Small hydropower (< 10 MW)	18.1
CHPs (<= 4 MW)	14.5
CHPs (> 4 MW)	11.1
Wind	10.7

Alternatively to feed-in tariff support mechanism, operators generating electricity in biomass and biogas power plants with installed capacity exceeding 1 MW may qualify for rights to receive a guaranteed payment for the electric capacity installed in a power plant. The same term is applied to cogeneration power plants with installed electric capacity exceeding 20 MW. In addition to feed-in tariffs, grants for renewable energy projects in all sectors are provided by the national Climate Change Financial Instrument (managed by the Ministry of Environmental Protection and Regional Development) and European Union Structural Funds and the Cohesion Fund. Support intensity is in range 40–50% of project's expenditure.

Despite the fact that feed-in tariffs have helped to develop the renewable electricity sector in Latvia, the support scheme for new installations was discontinued in 2011. This was result of increasing concerns about corruption, lack of transparency of the support system, and growing financial burden on electricity consumers. The Ministry of Economics of Latvia is currently working on the assessment and revision of the renewable electricity support scheme. Meanwhile the existing support scheme is on hold until 1 January 2016.

1.3.1. Lithuania

The structure of Lithuanian power generation changed significantly after the disconnection of the second reactor at the Ignalina nuclear power plant in 2010 which accounted for 80% of national power production. From energy exporting country Lithuania has become the most dependent EU Member State on electricity supply from abroad. Lithuania's national target is to reach 23% of renewables in final energy consumption (21% in the electricity sector) by 2020 compared to around 17% now [14]. Currently natural gas dominates in the electricity mix of Lithuania with a 55% share. From renewable energy sources hydropower plays the major role as shown in Figure 2. Meanwhile solar electricity has started to develop only recently having installed 8 MW by the end of 2012.

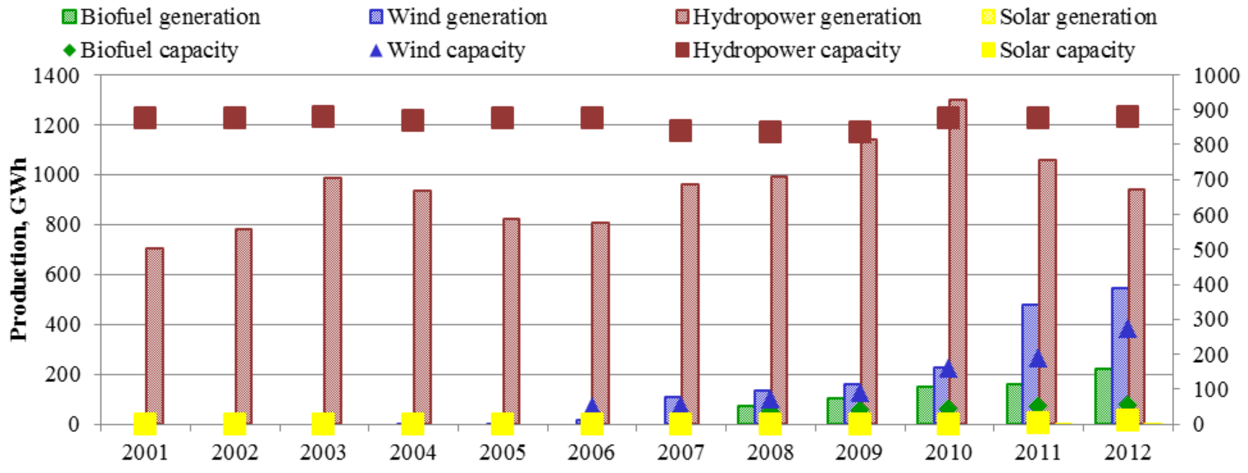

Fig. 2. Renewable electricity in Lithuania (Data source: [15])

In Lithuania, combination of three policy initiatives is applied to promote electricity generation from renewable energy sources, feed-in tariffs, grants, and tax regulation respectively.

Feed-in tariffs for renewable energy plants with a capacity exceeding 10 kW are awarded in tenders. The National Control Commission for Prices and Energy (NCC) quarterly sets the maximum feed-in tariff for the subsequent tender procedures and the tender is won by the participant offering the lowest feed-in tariff. Renewable electricity generated in plants with installed capacity less than 10 kW is purchased at a guaranteed price set by the NCC (payment applies to 50% of the electricity generated from RES during a calendar year). The feed-in tariffs are applied for the small-scale HPP (capacity less than 10 MW), wind power and biomass plants, as well as solar energy. Following feed-in tariff rates are applied in Lithuania [16]. Hydropower plants up to 10 MW: 7.4 €c/kWh; wind power plants: 8.6 €c/kWh; biomass power plants: 8.6 €c/kWh; solar PVs up to 100 kW: 46.5 €c/kWh; solar PVs in rage 100 kW-1 MW: 44.5 €c/kWh, and solar PVs over 1 MW: 43.1 €c/kWh. Feed-in tariff support scheme was started to be applied in Lithuania from 1 April 2002, and will be managed until 31 December 2020.

Furthermore, the producers of renewable electricity may apply for grants from the Lithuanian Environmental Investment Fund and the Fund for the Special Programme for Climate Change Mitigation. Maximum subsidy intensity makes up to 80% of the total project expenses. Certain environmental criteria must be met by the project to receive full financing. Electricity production in wind power plants, as well as production of biogas is supported under the Rural Development Programme of Lithuania.

Besides the subsidies, the Fund of the Special Programme for Climate Change Mitigation grants loans for renewable energy projects. All loans granted shall be financed partly from the programme's budget and partly from the funds of a credit institution (minimum 20% of the loan). The loan is paid out by a credit institution on behalf of the Ministry of Environment. All technologies used for renewable electricity generation are eligible for this scheme. Small scale (up to 250 kW) biofuel, wind and solar installations are applicable for investment support under EU Structural Funds.

In addition, Lithuanian Law on Excise Taxes provides exemption from excise tax for electricity generated from renewable energy sources. Operators of biofuel plants also benefit from environmental pollution tax relief in respect of pollutants emitted into the atmosphere from stationary pollution sources.

1.3.2. Estonia

The main resource for electricity generation in Estonia is the local oil shale and its products (shale oil and oil shale gas) which accounts for 88% of national power production. Thus, Estonia is almost fully independent from the import of fuel upon the production of electricity.

Electricity production in Estonia amounted to 11,966 GWh in 2012, of which 12.3% were produced from renewable energy sources (hydropower, wind, and biomass). Taking into account the extensive environmental impact of oil shale-fired power plants, the government of Estonia is drawing attention to necessity to increase the use of renewable energy sources in the electricity sector [17]. Much emphasis in this context is placed on the development of wind energy and biomass CHPs. One of the targets is to ensure that 20% of the gross electricity consumption in produced in cogeneration plants by 2020. [18]. The deployment of RES-E generation in Estonia up to 2012 is illustrated in Figure 3.

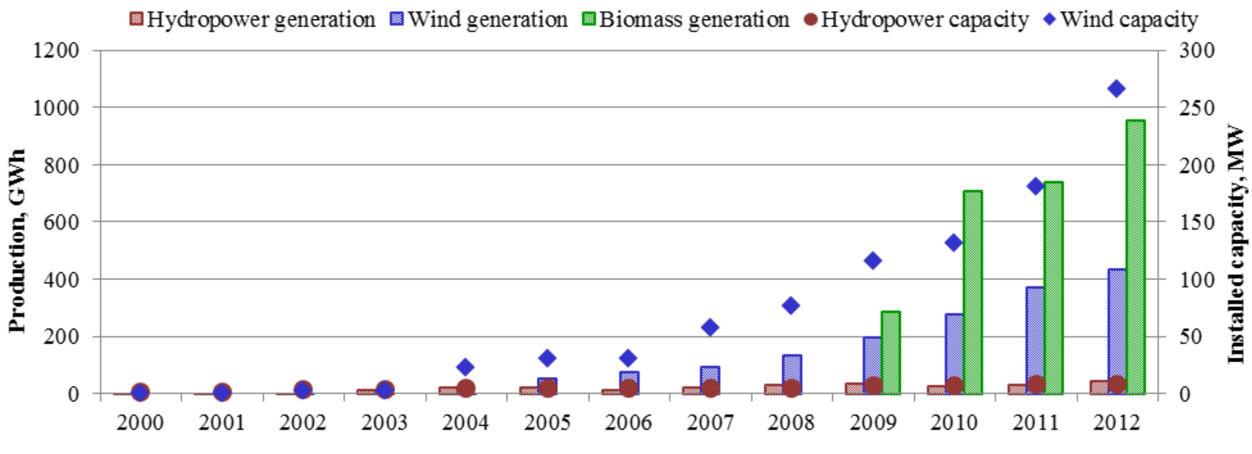

Fig. 3. Renewable electricity in Estonia (Data source: [19])

In Estonia, electricity generation from renewable energy sources is promoted through a premium tariff. The bonus payment on top of the electricity market price amounts to 5.4 €c/kWh and does not differ for the individual technologies. However, CHP plants with a production capacity below 10 MW using waste, peat or oil-shale retorting gas are eligible for a tariff amounting to 3.2 €c/kWh.

Investment support is available for bioenergy and wind energy installations, as well construction of CHP plants and infrastructure related to it (up to 60% of the eligible investment costs). In addition, R&D measures are implemented under the National Technology programme and the Development Plan for Enhancing the Use of Biomass and Bioenergy for the Period 2007 to 2030.

2. Modelling the Baltic power sector

2.1. System dynamics

System dynamics is a computer-aided modelling approach to policy analysis and design. System dynamics was developed in 1950s by professor Jay Write Forrester and is applied to dynamic problems arising in complex social, managerial, economic, or ecological systems [20]. The approach utilizes various control factors such as feedback loops and time delays to observe how the system reacts and behaves to trends [21]. System dynamics has been used to analyze energy issues since the 1970s, when large models were developed to increase the general understanding of energy policy [22]. A comprehensive literature review of system dynamics applications in the past is given in [23-24]. More recently system dynamics has been applied to analyze energy consumption and carbon emissions in industry [25-26] and in specific areas such as urban territories [27], world heritage areas [28], and industrial regions [29]. Blumberga *et al.* [30] and Kunsch & Springael [31] have used system dynamics to analyze energy efficiency and CO_2 emission reduction policies in the residential sector, while [5, 32] have analyzed possibilities for solar PV deployment. In electricity sector, system dynamics models have been developed to analyze options for CO_2 mitigation [33] and renewable energy integration [21], and to electricity generation planning as described in [34-35].

2.2. Model description

Key stocks and flows of the proposed system dynamics model are presented in Figure 4. It shows the underlying connections between elements of the studied system. Installed capacity stocks (MW) with corresponding investment in-flows and depreciation out-flows form the base structure of the model. For the sake of simplicity only two resource flows, renewable and fossil energy respectively, are shown. However, the real model consists of several resource flows corresponding to national electricity generation mix in Latvia, Lithuania and Estonia.

Investment decisions are fundamentally based on total revenues gained by investors [34] and electricity price is an important factor determining the willingness to invest in new electricity generation capacity [36]. Therefore it is assumed that investment decision among all provided technologies is done based on electricity generation costs. The average cost of electricity production is determined by four components: 1) technology investment costs, including planning and site work; 2) operation and maintenance (O&M) costs; 3) fuel cost, and; 4) relevant premium, e.g. cost of CO_2 emissions (negative) or state support incentives (positive). This is an equilibrium model thus the larger the investment share of one technology (e.g., renewable-energy-based), the smaller share of all investments reaches the other technology (e.g., fossil-fuel-based). Total annual investments in terms of MW per year are equal to total annual depreciation which is affected by technology lifetime. Annual electricity generation from each mode of resource is determined taking into account the installed capacity and technology specific full load hours. The exact values are determined the capacity factor multiplied by 8,760 hours.

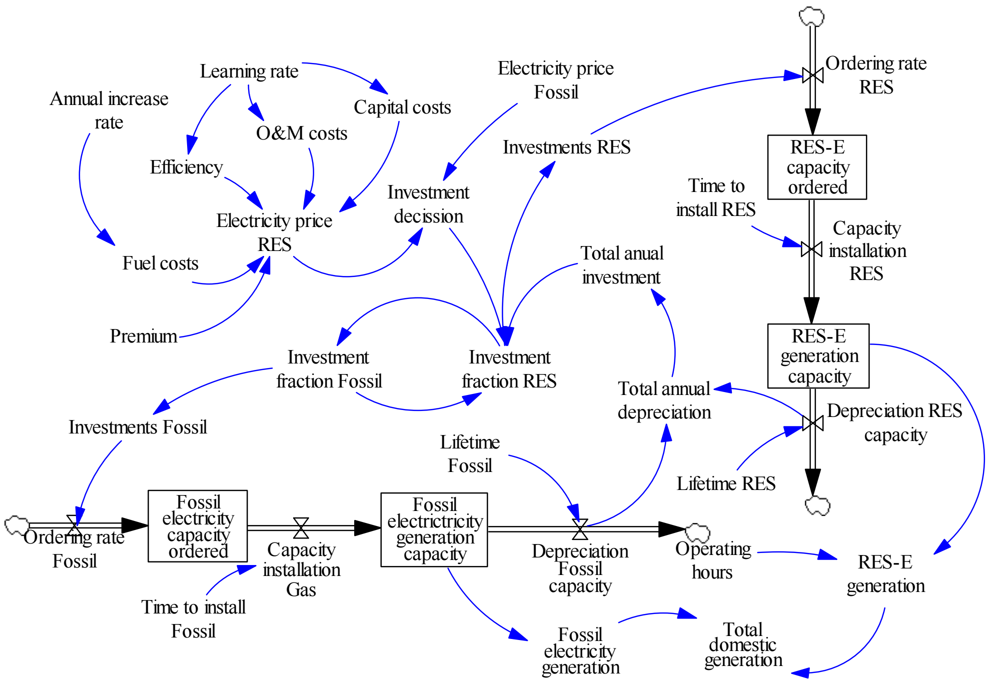

Fig. 4. Key stocks and flows of the system dynamics model

Based on previously described structure a system dynamics model representing electricity generation and demand till 2020 was developed and applied to conditions specific for each Baltic State. Powersim Studio 8 modelling software was used for model building. Aim of the model is to assess the performance of renewable electricity support instruments in promoting renewable electricity capacity development in the Baltic States.

2.3. Scenario assumptions

Table 2 summarizes findings on policy measures for support of electricity generation from renewable energy sources applied in the Baltic States. From Table 2 one can see that subsidies and feed-in tariffs (including premium tariff in Estonia) are the most widely applied policy instruments to promote the use of renewable energy sources in power generation. For further analysis in this study only feed-in/premium tariff instrument is chosen. Feed-in tariff rates included in the model are presented in Table 3.

Table 2. Renewable electricity support policies

Country	Subsidy	Loan	Feed-in tariff	Premium tariff	Tax regulation
Estonia	✓			✓	
Latvia	✓		✓		✓
Lithuania	✓	✓	✓		✓

Table 3. Feed-in/premium* tariff rates used in modelling, €c/kWh

Country	Wind	Biomass	Biogas	Bioenergy	Solar	Natural gas
Estonia	5.0	5.0	5.0	5.0	5.0	5.0
Latvia	10.5	18.5	19.5	–	42.6	14.5
Lithuania	8.6	–	–	8.6	45.0	–

* Estonia

Following resource flows corresponding to historical use pattern and projected future development were chosen in each of the Baltic States:

- Latvia: onshore and offshore wind power, electricity generation from biomass and biogas. Fossil fuel resource flow is represented by natural gas CHPs.
- Lithuania: onshore wind power, biofuel, and solar energy. Fossil fuel resource flow is represented by natural gas CHPs.
- Estonia: onshore and offshore wind power and electricity generation from biomass. Fossil fuel resource flow is represented by oil shale power plants.

The main interest of this research is to look for possibilities of increasing the share of renewable energy sources, therefore development of nuclear power in Lithuania or any other of the Baltic countries is not considered. In addition to the above mentioned renewable energy sources, it is assumed that hydropower production remains at current level in Latvia and Lithuania, but no new investments for increasing the installed hydropower capacity are done.

3. Results and discussion

Modelling results are illustrated in Figure 5. It shows the projected deployment of installed capacity of renewable electricity production facilities in Estonia, Latvia, and Lithuania till 2020. Results are further compared with installed capacity development forecasts outlined in national renewable energy action plans.

In Latvia, the model shows inability of existing policy to reach national targets for almost all RES-E technologies except biogas. Following results for installed RES-E capacities by 2020 were obtained: onshore wind 140 MW (236 MW projected); offshore wind 34 MW (180 MW projected); biomass 50 MW (108 MW projected); solar 0 MW (4 MW projected), and biogas 150 MW (92 MW projected). In order to follow projected RES-E development pattern and achieve targets outlined in the national renewable energy action plan, changes in feed-in tariff rates should be made. Following feed-in tariffs are suggested: onshore wind 11.0 €c/kWh; offshore wind 12.5 €c/kWh; biomass 19.0 €c/kWh and biogas 19.3 €c/kWh.

Model forecast for Lithuania: onshore wind 570 MW (500 MW projected); bioenergy 74 MW (224 MW projected), and solar power 15 MW (10 MW projected). In order to promote power production from domestic bioenergy resources, feed-in tariff rate should be increased to 10.5 €c/kWh. Model forecasts for Estonia: onshore wind 520 MW (400 MW projected); offshore wind 80 MW (250 MW projected), and biomass 87 MW (no projections in the national renewable energy action plan). In order to follow projected RES-E development pattern, following premium tariff rates are suggested: onshore wind 5.1 €c/kWh and offshore wind 6.0 €c/kWh.

A comparison of existing and proposed feed-in tariff rates in Latvia, Lithuania and Estonia is presented in Figure 6.

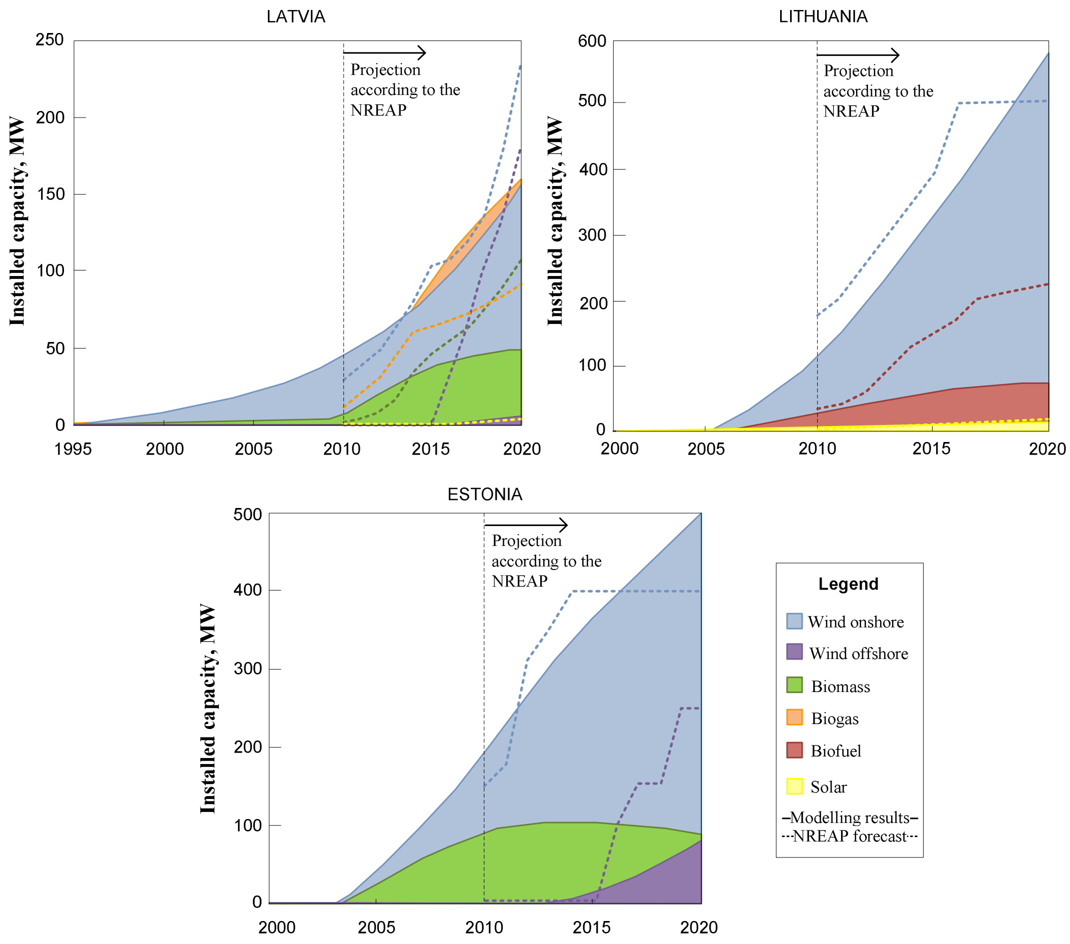

Fig. 5. Installed RES-E capacity in the Baltic States: Comparison of modelling results and NREAP forecasts

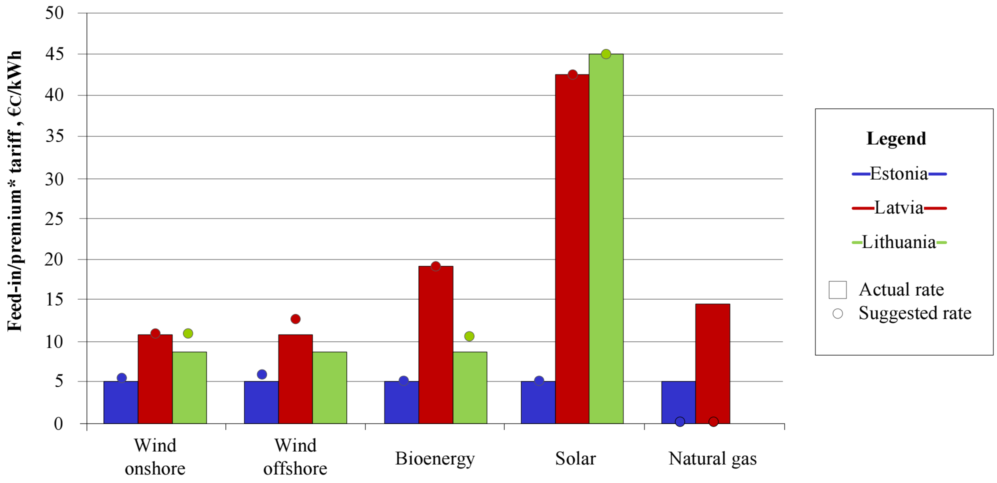

Fig. 6. Modelling results: Suggested feed-in tariff rates

4. Conclusions

This study has presented results of a dynamic model aimed to evaluate renewable power deployment in Latvia, Lithuania and Estonia until 2020. A system dynamics modelling approach was applied to simulate the future development of electricity sectors in Baltic States based on electricity cost analysis.

Feed-in tariff is the main policy mechanism to support renewable electricity generation the Baltic States. Modelling results affirm the ability of feed-in tariffs to increase installed RES-E capacity. However, adjustment of feed-in tariff rates is suggested in order to reach national renewable electricity targets.

Acknowledgements

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