

RIGA TECHNICAL UNIVERSITY

Arta DENIŅA

**SUPPORT EFFICIENCY AND EFFECTIVENESS FOR
RENEWABLE ENERGY GENERATION IN LATVIA**

Summary of the PhD thesis

Field: Management Science
Sub-field: Entrepreneurship management

Riga 2013

RIGA TECHNICAL UNIVERSITY
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Doctorate in the doctoral programme “Management and Economics”
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**PHD THESIS
NOMINATED FOR DOCTORAL DEGREE IN ECONOMICS
AT RIGA TECHNICAL UNIVERSITY**

The PhD thesis was prepared at Institute of Manufacturing and Entrepreneurship of Faculty of Engineering Economics and Management of Riga Technical University. The defence of the PhD thesis to obtain doctoral degree in economics will be held on June 14 2013 at Faculty of Engineering Economics and Management of Riga Technical University, 6 Kalnciema street, Riga, room 309. at 12:00 a.m.

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DECLARATION

I hereby declare that I have elaborated this PhD thesis that has been submitted for the review to Riga Technical University for obtaining doctoral degree in economics. The PhD thesis has not been submitted to any other university to obtain scientific degree.

Arta Deniņa _____

May 21, 2013

The PhD thesis is written in Latvian. It consists of introduction, three chapters, conclusions and suggestions, bibliography, twelve annexes. In the PhD thesis there are 35 figures and 26 tables, in total there are 175 pages without annexes. The bibliography consists of 140 sources.

The PhD thesis and its summary are available for examination in the Scientific Library of Riga Technical University.

References of the PhD thesis can be sent to:
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GENERAL DESCRIPTION OF THE PHD THESIS

Topicality of the research

Promotion of the use of renewable energy sources (RES) is the central question in debates about sustainable development and limiting climate change. The increasing importance of RES in the world's fuel and energy balance highlights the positive impact of RES in a form of diverse effects related to economic, social and environmental welfare, and energy independence. Today renewable energy (produced from RES) technologies are the key in the present global transition to low carbon economies characterized by low level of greenhouse gas (GHG) emissions.

In the last decades promotion of electricity generated from renewable energy sources (RES-e) has become a central item on the agenda of many governments in many countries. Nowadays in more than 70 countries there are implemented medium and long-term strategies of economic support including special support instruments to stimulate the entrepreneurship of RES-e generation. **Within the scope of this PhD thesis the term *support for RES-e generation* means economic stimulus or aggregate stimulus (instruments), which are determined in political planning documents and in the legislation, with the aim to attract investments in the field of RES-e generation that otherwise (without support) would not be invested.** For the present the necessity of support for RES-e generation is generally determined by low competitiveness of RES-e technologies in comparison to traditional alternatives of producing electricity (energy produced from fossil fuels, nuclear energy).

With introduction of support for RES-e generation its efficiency and effectiveness has become one of the most actual sustainable development issues in the whole world. In order to ensure that support for RES-e generation is effective it has to, on one hand, facilitate development of RES-e generation, but, on the another hand, it has to provide that support related costs for the society (for enterprises and households) are as low as possible. Using various approaches in design of support instruments for RES-e generation, countries solve the issue of stimulating development of RES-e generation capacities and constraining support costs differently.

According to the author of this PhD thesis the term *efficiency and effectiveness of support for RES-e generation* means support driven development of RES-e generation (new RES-e plants, increase in installed electric capacity, increase in the produced RES-e amount, etc.) with certain costs related to implementation of support for RES-e

generation. Support efficiency and effectiveness for RES-e generation is a very actual issue in Latvia after the regain of independence in early 1990s. the following points highlights this importance:

- ✓ According to the requirements of EU Directive on promotion of the use of RES, till 2020 RES-e generation in Latvia has to be augmented to ensure increase of RES-e share in the total electricity consumption for at least 10% in comparison to the situation in 2011.
- ✓ If the current support instruments for RES-e generation in Latvia are not changed, there are risks of significant increase in the electricity tariffs that would influence both the wealth of households and the international competitiveness of enterprises.
- ✓ Support tariffs for RES-e generation in Latvia are among the highest among the EU member states; however, in general they have not managed to generate a significant growth of RES-e generation.
- ✓ Since 2010 in Latvia there has been a discussion about the future support system for RES-e generation that would be able to growth in RES-e generation sector. In 2012 Mr. Daniels Pavļuts, minister for economic affairs of the Republic of Latvia announced that it was necessary to replace the current support instrument for RES-e generation in Latvia with a new one because the former has failed to meet expectations.

Although support efficiency and effectiveness for RES-e generation is a very urgent problem in Latvia, there has been insufficient attention paid to solving it: in general the field of support efficiency and effectiveness for RES-e generation in Latvia has not been scientifically studied; there is no methodological base neither for economically reasonable support payments for RES-e generation and appropriate support period nor for assessing support efficiency and effectiveness for RES-e generation.

Taking into account the abovementioned reasons, the author has set **the aim of the PhD thesis**: to assess support efficiency and effectiveness for RES-e generation in Latvia and to work out suggestions how to improve it.

To reach the defined aim the following **objectives** are put forward:

- ✓ To analyse theoretical aspects of support for RES-e generation and concept of support efficiency and effectiveness providing relevant definitions and identifying affecting factors;

- ✓ To study the newest scientific thoughts about the positive impacts (effects) of the use of RES on economic, social and environmental welfare and energy independence; and about benefits and drawbacks of support for RES-e generation;
- ✓ To collect, aggregate, and analyse the information about techno-economic indicators of development of RES-e generation, and to assess dynamics of this development in the context of Latvia;
- ✓ To research the sector of RES-e generation in Latvia, to analyse its development tendencies and problems, and to assess the potential and perspectives for RES-e generation;
- ✓ To examine support regulations for RES-e generation in the EU and in Latvia; to identify drawbacks of these regulations in Latvia;
- ✓ To research the actual situation about the support systems for RES-e generation in the EU, to systematize information about support tariffs for RES-e generation in the EU member states and to make an interstate comparison;
- ✓ Taking into account the results of the author's assessment of historical growth of RES-e generation sector in Latvia and of the support regulations for RES-e generation in Latvia, to carry out analysis of support efficiency and effectiveness for RES-e generation in Latvia;
- ✓ To draw relevant conclusions about the discovered problems, tendencies, and regularities and to find solutions and elaborate suggestions to improve support efficiency and effectiveness for RES-e generation in Latvia.

The object of the research is support for RES-e generation; meanwhile **the subject of the research** is support efficiency and effectiveness for RES-e generation.

Hypotheses and theses for the defence

The author has advanced the following **hypothesis**: **the support system for RES-e generation in Latvia has important drawbacks and it is necessary to find solutions to improve support efficiency and effectiveness for RES-e generation.**

Theses for the defence:

- ✓ Support for RES-e generation is implemented through various instruments and each of them represents advantages and disadvantages.

- ✓ Since the establishment of support for RES-e generation in Latvia in 1995 it has not effectively and efficiently promoted development of RES-e generation.
- ✓ The methodology to determine the level of support tariffs for RES-e generation has not been elaborated economically justified and transparent.

Research methods

In the elaboration process of the PhD thesis the author has used the following research methods: the scientific analysis (analysing the types, technologies and costs of RES-e generation; impacts of RES-e generation on economic, social, environmental indicators and energy independence; support instruments for RES-e generation; reports and publications of scientists, scientific institutions and other organizations), the synthesis (examining growth of RES-e generation and its interaction with support related costs in order to work out suggestions to improve support efficiency and effectiveness for RES-e generation), the evolutionary method (exploring historical development of RES-e generation in Latvia and the EU), experts' method (researching reports of national and international scientific and other institutions and organizations about RES-e technologies, their techno-economical parameters in dynamics, about RES-e generation potential and development prospects, about advantages and disadvantages of different support instruments for RES-e generation). Solving specific tasks there were used techno-economic analyses, mathematical methods of statistics, logically constructive methods, and graphical methods. The author has used tables, figures, and maps to provide clear research results.

The period of the research is from 2006 to 2013.

Theoretical and methodological base of the research

The theoretical and methodological base of the PhD thesis consists mostly of foreign authors' works: M. E. Porter's cognitions about competitive advantages for enterprises, sectors, and countries, views of S. Awerbuch, R. Sauter, M. Contaldi, A. Midttun, D. Jacobs, T. Faber, C. Huber, P. Whitehead about support instruments and systems for RES-e generation; as well as opinions of Latvian authors such as K. Siļķe, A. Sprūds, G. Klāvs, J. Reķis and of author groups within Institute of Environmental and Energy Systems at Riga Technical university of Latvia, Institute of Physical Energetics of Latvia, the joint-stock company "Augstsprieguma tīkls" about RES-e generation opportunities, potential and development prospects, and research reports from international organizations such as International Energy Agency and European Commission about methods to assess support

efficiency and effectiveness for RES-e generation, and from the European organization VGB Powertech about RES-e generation costs.

The statistical base of the PhD thesis consists of research reports and statistical data from international organizations such as International Energy Agency, European Commission, VGB Powertech, etc.; EU directives and regulations, statistical reports and databases of Statistical office of European Commission EUROSTAT, Statistical office of Estonia, Central Statistical Bureau of Latvia, the Bank of Latvia, Ministry of Economics of the Republic of Latvia, and of other Latvian and international organizations; Internet recourses; and unpublished materials, including unpublished materials from the joint-stock company Latvenergo and the Ministry of Economics of the Republic of Latvia.

Limitations of the research

Taking into account research constraints and the wide spectrum of issues related to support efficiency and effectiveness for RES-e generation, the following limitations are set in the PhD thesis:

- ✓ The term *support for RES-e generation* means only economic stimulus.
- ✓ A hydropower plant is *a small hydropower plant* if its installed electric capacity does not exceed 5 MW. Such restriction corresponds to the defined upper capacity limit in the legislation. Only small hydropower plants in Latvia are eligible to receive rights for RES-e generation support.
- ✓ A RES-e producer is an enterprise that has qualified to receive support for RES-e generation. The legislation in Latvia allows cogeneration plants to qualify for RES-e generation support; however, these producers are not included in this research.
- ✓ In the context of Latvia guaranteed purchase of RES-e for a regulated tariff that is higher than the electricity market price in this research is understood by term *support for RES-e generation*.
- ✓ Regulations in Latvia do not envisage allocating support to hydropower plants with the installed capacity higher than 5 MW for RES-e generation and they do not regulate the sale price for the produced electricity. For this reason these stations are not included in the economic analysis of support for RES-e generation.
- ✓ The information is provided based on regulations, laws, and statistical data base in force till 1st October 2012.

Other limitations of the PhD thesis are described in respective chapters.

Novelty of the research

The author's scientific and practical contribution in the development of this theme is described by the following scientific novelties:

1. Based on the detailed research in the sector of RES-e generation, for the first time a comparative economic profile of RES-e producers in Latvia has been worked out.
2. A comprehensive regional dislocation map of RES-e producers in Latvia including all RES-e producers has been created.
3. A comparison of support tariffs for RES-e generation in the EU member states has been carried out taking into account the results of the author's analysis of the legal base of Latvia and of the EU regulating setting of the support tariffs for RES-e generation, and nationally implemented support instruments.
4. For the first time there has been developed methodology for setting economically justified support payments for RES-e generators and for determining adequate period during which support for RES-e generation is to be received.
5. The informative base to ensure implementation of the methodology to assess support efficiency and effectiveness for RES-e generation has been worked out.
6. Suggestions to improve support efficiency and effectiveness for RES-e generation in Latvia have been elaborated.

Scientific publications

The main results of the research are reflected in 7 scientific publications, including articles in reviewed and internationally recognised publications:

1. Denina A., Zvanitajs J. *Obstacles to green electricity generation business*. // Conference proceedings. International Scientific Conference *Practice and research in private and public sector – 2012*. 26 – 27 April 2012, Vilnius, Lithuania; ISSN (on-line) 2029 – 7378, 7 p.;
2. Denina A., Zvanitajs J. *Assessment of efficiency of the support mechanism for electricity generation from renewable energy sources in Latvia*. // Conference proceedings. International Scientific Conference *Whither our economies*, 16 – 17 November 2011, Vilnius, Lithuania; ISSN (on-line) 2029 – 8501, 10 p.
3. Denina, A., Zvanitajs J. *Analysis of economic aspects of promotion of green electricity generation in Latvia* // *Applied Economics: Systematic Research*. Vol 4, Issue 2. – Kaunas: Vitautas Magnus University, 2010. p. 107. – 122. (ISBN 1822 – 7996;

- reviewed in EBSCO Publishing, Inc. Business Source Complete database <http://www.epnet.com>);
4. Denina, A., Zvanitajs J. *Effectiveness and efficiency of economic incentives for electricity generation from renewable energy sources in Latvia* // Applied Economics: Systematic Research. Vol 5, Issue 2. –Kaunas: Vitautas Magnus University, 2011. p. 163. – 177. (ISBN 1822 – 7996; reviewed in EBSCO Publishing, Inc. Business Source Complete database <http://www.epnet.com>);
 5. Deniņa A. *Support schemes for using renewable energy sources in Europe and its economic effectiveness and efficiency.* // Compilation of University of Latvia. Economics. Management. Vol. 737. – R: LU, 2008, 88. – 99.p. (ISBN 978-9984-45-022-3) (Deniņa A. *Atjaunojamo energoresursu izmantošanas atbalsta shēmas Eiropā un to ekonomiskā efektivitāte.* // Latvijas Universitātes raksti. Ekonomika. Vadības zinātne. 737. sējums. – R: LU, 2008, 88. – 99. lpp. (ISBN 978-9984-45-022-3));
 6. Zvanītājs, J., Deniņa A. *Support for producers of dissipation energy in Latvia and its importance of composing the electricity price* // Compilation of University of Latvia. Economics. Management. Vol. 743. – R: LU, 2009, 34. – 42.p. (ISBN 978-9984-45-153-4) (Zvanītājs, J., Deniņa A. *Atbalsts izkliedētās elektroenerģijas ražotājiem Latvijā un tā nozīmē elektroenerģijas cenas veidošanā.* // Latvijas Universitātes raksti. Ekonomika. Vadības zinātne. 743. sējums. – R: LU, 2009. 34. – 42. lpp. (ISBN 978-9984-45-153-4));
 7. Zvanītājs J., Deniņa A. *Efficiency and effectiveness for electricity regulations in Latvia in the context of long-term development* // Socio-economic complex of innovative technologies. III international scientifically practical conference. 14 – 16 November, 2007. Scientific compilation. – Podolsk, 2007. 158. – 164.p. (Я. Званитайс, А. Дениня. *Проблемы управления энергоэффективностью зданий в Латвии в контексте концепции долгосрочного развития* // Инновационные технологии социально-экономического комплекса. III международная научно-практическая конференция 14 – 16 ноября 2007. Сборник научных трудов. – Подольск, 2007. с. 158 – 164.).

Other publications:

8. Denina A., Zvanitajs J. *Economic and governance aspects of promotion of use of renewable energy sources for electricity production: case of Latvia.* // Economics and Management. 1st International conference of young scientists November 25 – 27,

2010. Proceedings. – Lviv: Lviv Polytechnic, 2010. p. 76. – 77. (ISBN 978-617-607-000-9);
9. Deniņa A. *Importance of state promotion for electricity development generated from renewable energy sources.* // RTU IEVF Scientific conference of economics and entrepreneurship (SCEE`2010). Compilation of these of conference reports. – R: RTU, 15th October, 2010. 23. – 24.p. (ISBN 978-9934-10-061-1) (Deniņa A. *Valsts nozīme no atjaunojamajiem energoresursiem ražotas elektroenerģijas attīstības veicināšanā.* // RTU IEVF Ekonomikas un uzņēmējdarbības zinātniskā konference (SCEE`2010). Konferenču ziņojumu tēžu krājums.– R: RTU, 2010. gada 15.oktobris. 23. – 24. lpp. (ISBN 978-9934-10-061-1));
 10. Zvanītājs, J., Deniņa A. *Role of efficient energy use and its management in Latvia.* // Problems of development of national economy and entrepreneurship. 48th International Scientific Conference of Riga Technical University. October 11 – 13, 2007. Abstracts of presentations. – R: RTU, 2007. 66. p. ISBN 978-9984-32-769-3);

Participation in conferences

The main results of the PhD thesis have been presented and discussed in 10 **international scientific and scientifically-practical conferences:**

1. 48th International Scientific Conference of Riga Technical university. Riga, Latvia, 11 – 13 October 2007;
2. 65th conference of University of Latvia. Riga, Latvia, 2 February 2007;
3. 67th conference of University of Latvia. Riga, Latvia, 5 February 2009;
4. Conference *Renewable Energy Sources & Energy Efficiency*, Nicosia, Cyprus, 28 – 30 September 2007;
5. 51st International Scientific Conference of Riga Technical university. Riga, Latvia, 11 – 15 October 2010;
6. Conference of International Relation institute of European Diplomatic Academy *La place de l'Europe dans les scenarios energetiques mondiales.* Brussels, Belgium, 8 February 2011;
7. Conference IERE *Integration of Renewable Energies.* Dusseldorf, Germany, 23 – 25 May 2011;
8. 52nd International Scientific Conference of Riga Technical university. Riga, Latvia, 7 October 2011;

9. International Scientific Conference *Whither our economies*, 16 – 17 November 2011, Vilnius, Lithuania;
10. 2nd International Scientific Conference *Practice and research in private and public sector-12*, 26 – 27 April 2012, Vilnius, Lithuania.

Theoretical and practical significance

The **theoretical significance** of the author's contribution in the PhD thesis is reflected in the following fields:

- ✓ In the positive effects of RES-e generation related to socio-economy, environment and energy independence.
- ✓ In the analysis of support instruments for RES-e generation and identified advantages and disadvantages.
- ✓ In the development of methodology to determine support efficiency and effectiveness for RES-e generation and in the elaboration of these elements.

The **practical significance** of the PhD thesis is substantiated by:

- ✓ Analysis of RES-e generation as a sector of economy and its results can be used by public authorities and other institutions to prepare documents (reports, politic planning documents, etc.) about the development of electricity generation in Latvia.
- ✓ This PhD thesis contains compiled actual information about techno-economic parameters of RES-e technologies that has previously been published fragmentary in different sources. This information can be useful both for potential investors and for civil servants in government institutions; equally this information can be used by students, researchers, and other interested parties.
- ✓ The scientific analysis about regulations for RES-e generation in Latvia, including criteria to allocate support for RES-e generation and the methodology to determine the support tariff for RES-e generation, highlights the central drawbacks of the legislation. The Ministry of Economics of the Republic of Latvia can use this analysis and the methodology developed by the author ensuring setting of economically justified support tariffs for RES-e generation and the period during which the support is to be granted in order to improve support regulations for RES-e generation in Latvia.
- ✓ The comparison of the support tariffs for RES-e generation among EU countries will be helpful for the civil servants being responsible for drafting RES-e generation policy documents and designing RES-e support instruments. This information can be used to

do further research about the methodology to determine support tariffs for RES-e generation based on market principles.

- ✓ The results of the PhD thesis can be incorporated in existing courses in management and economics at universities and to develop new courses, which have not yet been offered.
- ✓ This PhD thesis and its results are important contribution in the economic discipline in Latvia because they describe the theme that has not been scientifically researched.

Volume and structure of the PhD thesis

The PhD thesis is an independent scientific research that is elaborated in Latvian language on 175 pages, not including appendixes. It is composed of the following parts: introduction, 3 chapters, conclusions and suggestions, bibliography, and appendixes. 35 figures and 26 tables are included in the PhD thesis. 105 information sources, excluding regulations have been used to carry out the research.

Introduction of the PhD thesis features justification of the topicality of the chosen theme, presentation of the defined goals and objectives, clarification of the subject and the object of the research, definition of the hypothesis and theses, description of the research methods used in the work, outline of the theoretical and methodological base of the work, limitations of the research, presentation of the research novelties, and outline of the theoretical and practical significance of the work. The author's scientific publications in relation with the theme of the PhD thesis and attended scientific conferences where the author has participated with presentations about the main results of the PhD thesis, are also included in introduction.

In the **first part** of the PhD thesis *Analysis of current situation to generate RES-e and development prospects* the author has carried out a detailed research in the field of historical development and its dynamics of RES-e generation in Latvia (number of RES-e generation enterprises, installed capacity and RES-e output); clarified the influence of geo-climatic conditions on RES-e producers' dislocation in Latvia by working out a comprehensive map of location of RES-e producers; worked out a comparative economic profile of RES-e producers in Latvia, characterizing enterprises of RES-e generation by several economic criteria – turnover and the number of employees; the author has also analysed assessments of RES-e generation potentials and development prospects elaborated by various organizations and provided her evaluation of these assessments.

The **second part** of the PhD thesis *Support for RES-e generation and its regulations* is dedicated to the research and analysis of regulatory support for RES-e generation in Latvia

and the EU; justifications for necessity to support RES-e generation; analysis of the global tendencies for RES-e techno-economical parameters and their dynamics; identification and analysis of advantages and disadvantage of support instruments for RES-e generation that are implemented in the EU member states; identification of the main methodological and practical problems in relation to regulations in the field of RES-e generation in Latvia.

In the **third part** of the PhD thesis *Indicators of support for RES-e generation and directions to improve support efficiency and effectiveness* the author, proposes methodological and organizational directions to improve support efficiency and effectiveness for RES-e generation using the results of comparison of the support tariffs for RES-e generation in EU member states.

At the end of the PhD thesis there are the author's conclusions and suggestions.

CONCISE SUMMARY OF THE PHD THESIS

1. ANALYSIS OF CURRENT SITUATION TO GENERATE RES-E AND PERSPECTIVE OF DEVELOPMENT

In the first chapter of the PhD thesis *Analysis of current situation to generate RES-e and development prospects* a detailed research about historical development of RES-e generation sector in Latvia from 1997 to 2011 has been performed. During 15 years there has been a moderate development: although the number of RES-e producers has increased for more than 10 times reaching 229 in 2011, in general they represent producers with small installed electric capacity (<1MW); annual RES-e output has increased by 3240% because of a low starting base, however, the reached output corresponds to only 243 GWh; total investments in RES-e generation have generated only 91 MW (in 1997 5 MW). RES-e producers account for only 3.5% share in the total installed electric capacity in Latvia and generate only 4% in the total electricity generation in the country.

While researching enterprises of RES-e generation, the author has elaborated a comparative economic profile of RES-e producers in Latvia (CEP) and a comprehensive regional dislocation map representing locations of RES-e producers. This map shows that the exact location of RES-e power plant is determined by the regional spread of local energy sources (figure 1.1). CEP allows making a comparison of RES-e producers taking into account the following criteria: income from RES-e realization and structure; average income per enterprise; the number of employees and structure; average number of employees per enterprise.

In 2011 total income from RES-e realization has increased by 33% in comparison to the previous year. Biogas plants account for the main part of the income increase because their individual income in the mentioned period has increased more than 2 times reaching 13 million Latvian lats (18 million euro), and the average income per enterprise was the biggest among the other RES-e producers. In 2011 the sector of RES-e generation in Latvia employed 13% more than in the previous period. On average in one enterprise of RES-e generation work from 1.42 (wind power plants) to 4.62 (biogas plants) employees.

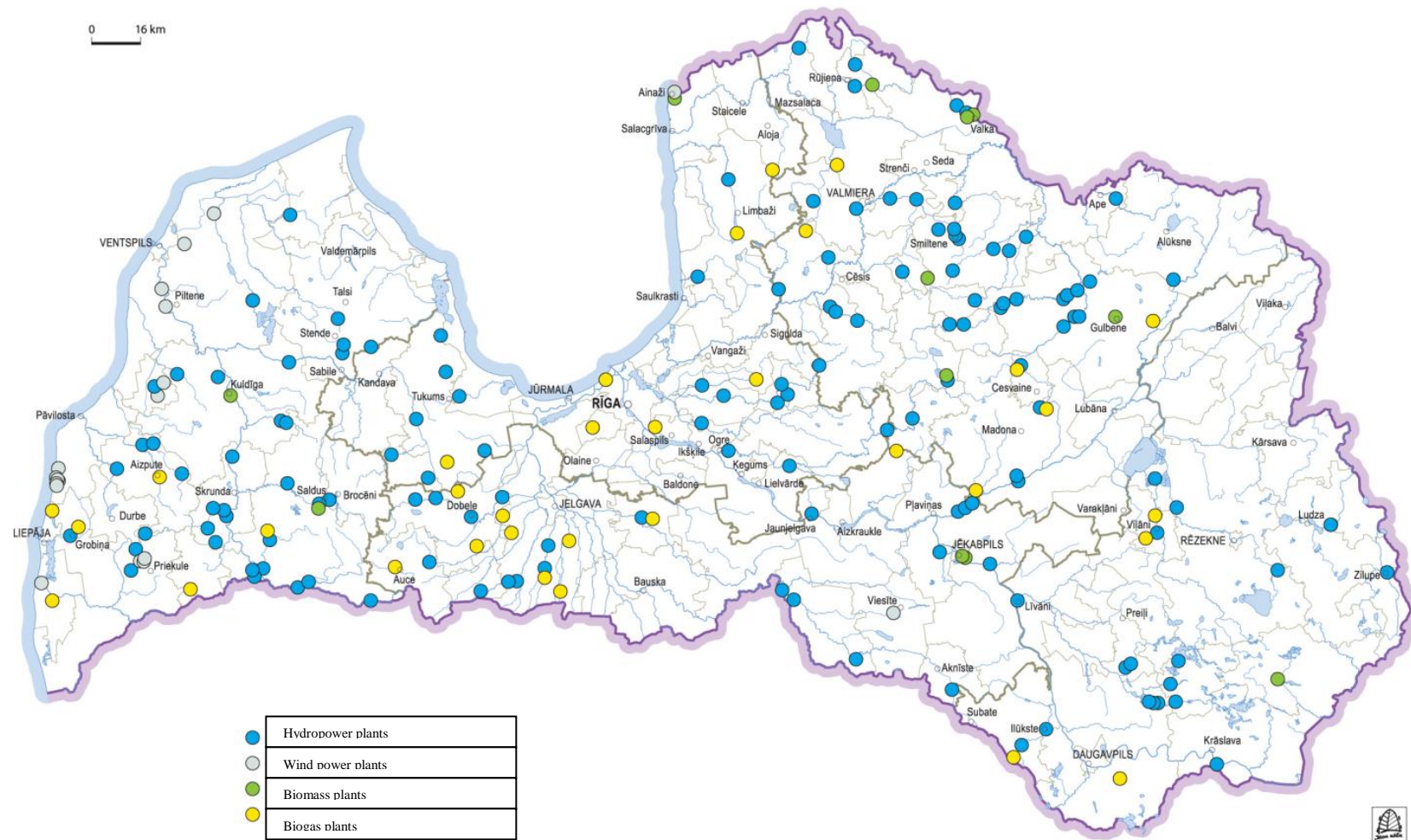


Figure 1.1 Regional dislocation map of RES-e power plants (the author)

In 2011 the share of output of RES-e generation reached only 11% - 18% of the total potential provided for 2020 in various research documents from organizations and institutions in Latvia. Only a small part of enterprises which have qualified to receive support rights for RES-e generation has started investment projects. This shows that the current support framework for RES-e generation fails to stimulate important development in RES-e generation sector.

The prospects for RES-e generation in mentioned research reports are very ambitious; nevertheless, it confirms growth opportunities for RES-e generation in Latvia. It would be useful in regard to making realistic prognoses of RES-e generation development if the historical data about realization of the support rights for RES-e generation in Latvia were better integrated into the models elaborating the prognoses. It is also necessary to critically assess information about investment plans provided by enterprises that have received support rights for RES-e generation.

2. SUPPORT FOR RES-E GENERATION AND ITS REGULATIONS

Although each economy sector represents different development tendencies, in the context of economic growth and creating competitiveness great attention should be paid to stimulation of development of industries through state support and implementing instruments.

Nowadays RES-e cannot yet provide a competitive alternative of electricity generation against traditional forms of electricity (electricity generation using fossil energy sources or nuclear energy) because of comparatively high generation costs and other factors that negatively impact RES-e competitiveness (difficult access to capital and RES-e technologies, lack of public support, etc.). Despite these drawbacks RES-e technologies are an important part of today`s transition towards low carbon economies worldwide.

Implementation of RES-e technologies is determined by driving forces (figure 2.1). Each of them represents positive effects that are made possible thanks to research and development, implementation and operation of RES-e technologies. Although there are disadvantages related to RES-e technologies, in total the positive gains outweigh drawbacks.

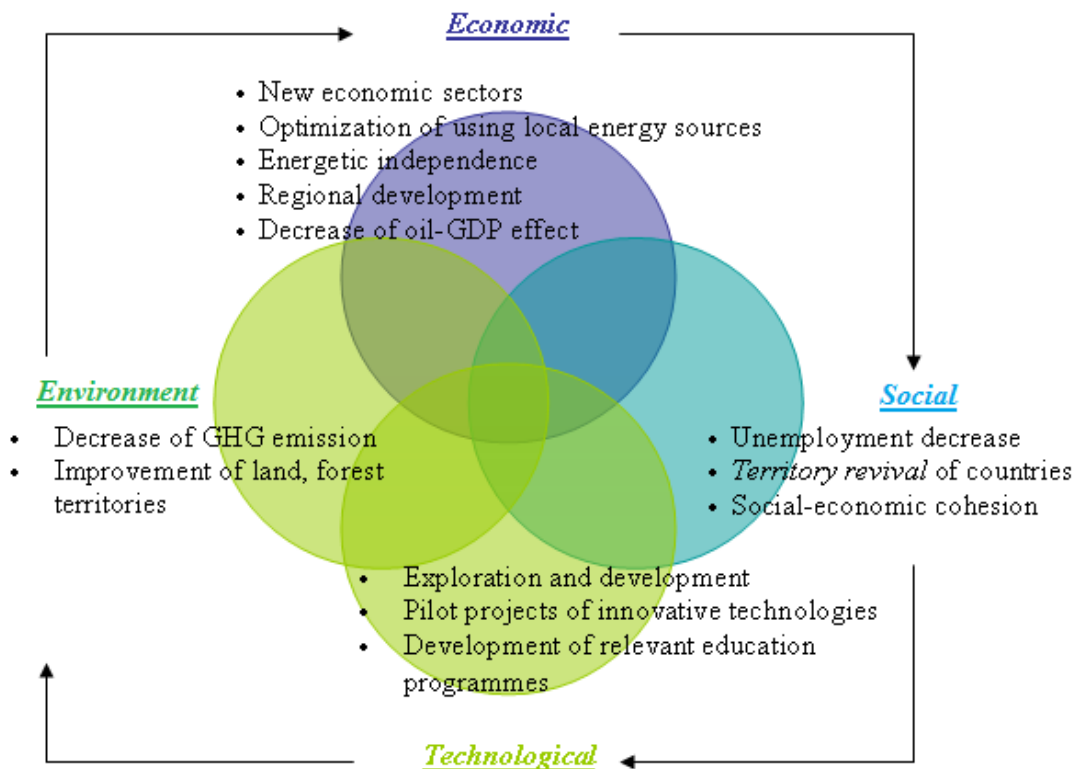


Figure 2.1 Model of driving forces (the author)

The central problem in assessing competitiveness of RES-e and in designing economically justified support instruments for RES-e generation is the lack of credible data on electricity generation (technology efficiency, electricity generation cost, etc.). There are a limited number of information sources that provide objective data about RES-e generation costs in the global context. Furthermore, in Latvia no comprehensive information about RES-e generation costs has ever been published. Analysing electricity generation data in the mentioned sources, the author concludes that:

- ✓ Electricity generation costs are different in the global context, and they depend on different approaches and methodologies used to obtain data.
- ✓ Each electricity generation alternative is characterized by individual cost structure.
- ✓ In general costs for RES-e generation are higher than in the case of traditional forms of electricity generation.
- ✓ Global tendencies represent potential for further decrease in investment cost of RES-e technologies thanks to technical improvements and total increase in production output of these technologies. In the future this will contribute to enhancing competitiveness of RES-e technologies and strengthening their position in the market.

In order to ensure that support for RES-e generation is effective and efficient, on one hand, it is necessary to promote demand for RES-e and investments in new RES-e generation capacity. On the other hand, support for RES-e generation has to be based on economic principles guaranteeing that support related costs for electricity consumers (both households and enterprises) are as low as possible.

Support instruments for RES-e generation differ among countries. Support systems for RES-e generation consist of combinations of the support instruments. The main support instruments for RES-e generation are the following:

- ✓ Obligatory purchase for RES-e;
- ✓ Tariff that is higher than electricity market price;
- ✓ Payment or bonus for generating environmentally friendly electricity (premium schemes);
- ✓ RES-e share in electricity generation reached through special instruments – certificates (*green certificates*);
- ✓ Payment for installed electric capacity;
- ✓ Tax reductions for purchases of RES-e technologies;
- ✓ Priority contention to electricity grids;
- ✓ Priority dispatch of RES-e, etc.

The author has elaborated classification of support instruments (table 2.1). Economic support instruments for RES-e generation are differentiated by their influence (direct or indirect) and by directions of employment (investments in RES-e generation capacity or in RES-e generation output).

The practice in the EU demonstrates that countries often choose to implement not only one support instrument but their combination and by dosing so compensates drawbacks of one instrument with advantages of the other.

The main pros of the classical forms of feed-in tariff systems are the following: guaranteed market place for generated RES-e during a certain period (usually 10 to 20 years) for a tariff that is higher than electricity market price; in designing support system a possibility to differentiate support for each RES-e technology taking into account individual costs for investments and generation. The most important cons are inertia to create competitiveness among RES-e producers and risks of over-financing because of fixed long-term tariffs and ignorance of global decrease in RES-e generation costs.

Table 2.1

Classification of support instruments for RES-e generation (the author)

<i>Types of instruments by their influence</i> <i>Directions of instrument usage</i>	<i>Support instruments with direct influence</i>		<i>Support instruments with indirect influence</i>
	Price-driven strategies	Quantity driven strategies	
Directed to investments in RES-e electric capacity	Investment stimulus Tax relief Reduced % rate for a loan	Tariff tender of selling RES-e for new RES-e generation capacities	Taxes for environment
Directed to RES-e generation	Feed-in tariffs Premium schemes	Green certificates	Voluntary contracts

The main advantage of green certificate systems is enhancement of competitiveness among RES-e producers and thus promoting cost efficiency since RES-e producers are interested to implement the cheapest RES-e technologies as regards their costs. The main disadvantage of these systems is difficulties to plan cash flow of investment project because green certificate market does not provide a stable price in long-term. Also green certificate systems encourage implementation of the cheapest RES-e technologies that have reached market maturity. New, innovative RES-e technologies with no stable market position have little chance to be implemented.

Premium schemes are as a medium between feed-in tariff systems and green certificate systems as contains both advantages of feed-in tariff systems (guaranteed long-term tariff higher than electricity market price) and advantages of green certificate systems (gains from cost efficiency).

Feed-in tariff systems are the most widespread support form for RES-e generation in the EU member states. Nevertheless, tendencies show that premium schemes become more and more popular thanks to their advantages that are demonstrated through the market orientation and comparatively lower support tariffs for RES-e generation. Premium schemes certainly bring greater benefits to electricity consumers in comparison to feed-in tariff systems.

Rules for promoting RES-e generation in the EU are set in the Directive 2009/28/EK. This Directive foresees that in 2020 20% of the total electricity consumption in the EU has to be covered by RES. Part of this goal translates as 35% share of RES-e in the total electricity generation in the EU. Each Member State has to contribute in reaching the overall goal goal through national goals and plans. In Latvia the regulation of the Cabinet of Ministers of the Republic of Latvia of 16th March, 2010 No. 262 *Regulation Regarding the Production of Electricity Using Renewable Energy Resources and the Procedures for the Determination of the Price* incorporates the annual national RES-e goal, criteria for qualification for support for RES-e generation and the methodology to determine support tariffs for RES-e. Prior to this regulation RES-e generation and RES-e tariffs were regulated by several other legislative acts.

Analysing legislative framework for RES-e generation in Latvia, the author concludes that since 1995 when support for RES-e generation was established in Latvia regulations in the field of support for RES-e generation have been fragmentary, chaotic, inconsistent, and have ignored economic principles. In result they have failed to stimulate important development of new RES-e generating capacity and its output.

At time when this PhD thesis has been elaborated the main support instrument for RES-e generation in Latvia is the obligatory purchase of RES-e. This mechanism foresees that RES-e that is produced in a power plant in Latvia that has qualified for the rights to participate in the obligatory purchase mechanism is sold and a tariff per electricity unit higher than electricity market price is paid. The level of support tariffs for RES-e generation is determined by the methodology set in the legislation.

Since 2010 the Cabinet of Ministers of the Republic of Latvia has ruled that RES-e share in the total electricity consumption in Latvia has to reach 54.57% annually. In reality the produced amount corresponds to only 48.5% (2010) and 41.9% (2011). The strategic plan of the Ministry of Economics of the Republic of Latvia determines even a higher RES-e goal in the total electricity consumption – 59.8%. Additional costs of obligatory purchase in comparison to the same amount of the purchased electricity in the electricity market are paid by electricity consumers proportionally to their electricity consumption. They pay obligatory purchase component in the electricity tariff.

Current support system for RES-e generation in Latvia is not sustainable:

- ✓ Obligatory purchase mechanism during 15 years of implementation has not been able to generate significant development of RES-e generation; the relative increase both in new capacity and RES-e output has taken place on a very small base.

- ✓ Payments of implementation of RES-e obligatory purchase mechanism increase significantly each year, reaching 27 million Latvian lats (~32 million euro) in 2011. In addition, RES-e obligatory purchase payments for electricity consumers (households) increase each period, and account for 11.5% to 15% of the bill for electricity.
- ✓ Investments in RES-e generation made until now put in the relative terms to the total RES-e capacity and generation output that has been granted in the framework of obligatory purchase mechanism to RES-e power plants (existing and to be constructed) cover only 12% of the total capacity of RES-e power plants and approximately 20% of the amount of RES-e generation output.

Also the Ministry of Economics of the Republic of Latvia has admitted that it is necessary to significantly improve support regulations for RES-e generation and to develop new principles that would be a base for a new support instrument for RES-e generation in Latvia.

In the result of analysis of support regulations for RES-e generation in Latvia the author has identified the following drawbacks:

- ✓ Regulated support for RES-e generation distorts electricity market because it artificially stimulates demand for RES-e technologies and RES-e. Furthermore, such support does not allow market principles to determine both RES-e output and the level of RES-e support tariff.
- ✓ In the case of regulated support where tariffs for RES-e generation are higher than electricity market price enterprises are not interested to decrease their electricity generation costs and to apply new or better ways to rival in this sector. At the same time electricity consumers cannot receive benefits offered by the market because the concurrence among RES-e producers practically does not exist.
- ✓ RES-e producers are discriminated against each other because the form of qualifications for RES-e obligatory purchase mechanism and the terms of condition to receive support for RES-e generation differ (i.e., support tariffs, period to receive support, etc.)
- ✓ The methodology of setting support tariffs for RES-e generation has been set by experts in the sector because the Ministry of Economics of the Republic of Latvia that is responsible for promotion of RES-e generation lacks knowledge about economic aspects of RES-e generation. The methodology contains formulas that do not provide economically justified support tariff for RES-e producers and are elaborated using principles that are not transparent.

- ✓ Support tariffs for RES-e generation are not differentiated against whether or not a RES-e power plant has previously received economic support (i.e., double tariff in the 1990s). Furthermore, RES-e producers have had an opportunity to receive several support instruments at the same time (obligatory purchase mechanism, investment grants). There is a risk of inadequate profit and a negative influence on support efficiency for RES-e generation.
- ✓ The methodology to set support tariffs for RES-e generation includes a coupling with the price of natural gas. This is a significant drawback since makes it difficult to plan cash flow of investment project. The price of natural gas in the current month can differ from the price in the previous month by 40%.
- ✓ There are important drawbacks in criteria and organizational aspects of the system of assessing applications for qualifications for participation in the RES-e obligatory purchase mechanism.

2. INDICATORS OF SUPPORT FOR RES-E GENERATION AND DIRECTIONS TO IMPROVE SUPPORT EFFICIENCY AND EFFECTIVENESS

In order to ensure that support for RES-e generation is effective and efficient, it should stimulate investors to choose options (RES-e technologies, RES-e generation capacity, location of power plants, etc.) that guarantee the lowest cost to electricity consumers (enterprises and households).

In the assessment of efficiency and effectiveness of the support for RES-e generation several approaches and indicators can be used. Two fundamental approaches are based on RES-e generation cost (*RES-e generation cost approach*) and on RES-e generation support costs for electricity consumers (*costs for consumers approach*). The author has chosen *costs for consumers* approach and support tariffs for RES-e generation and their interstate comparison as the indicators to assess support efficiency for RES-e generation. In the result of analysis of support tariffs for RES-e generation in the EU and their comparison the author has drawn the following conclusions:

- ✓ Support tariffs for RES-e generation are different among countries and these differences are determined by the implemented support instrument for RES-e generation and the methodology to set the tariffs.
- ✓ In premium schemes the tariffs in general are lower than in the feed-in tariff systems.

- ✓ Neighbouring countries can synchronize their support tariffs for RES-e generation, support systems for RES-e generation and the methodology to determine tariffs as it has been seen in the case of Finland and Estonia.
- ✓ Support tariffs for RES-e generation are among the highest in the EU.

In the framework of the analysis of support efficiency and effectiveness for RES-e generation it is necessary to assess how the determined support tariffs for RES-e generation promote new investments in RES-e generation. Analysing Estonia's experience in implementation of its premium scheme, the author argues that premium schemes and lower support tariffs for RES-e generation compared to feed-in tariffs can provide significant development in the field of RES-e generation.

In Latvia in general support efficiency and effectiveness for RES-e generation can be characterized as low. This is illustrated by high support tariffs for RES-e generation, on one hand, and by a very moderate development of new RES-e capacity and output, on the other.

The fundamental principles for improving support efficiency and effectiveness for RES-e generation in Latvia are determined in methodological and organizing directions. As methodological directions the author believes a methodological base for assessing support efficiency and effectiveness for RES-e generation is the key. The author proposes to include her elaborations regarding setting economically justified support tariffs for RES-e generation and period during which support is to be granted (the methodology). The central element of this methodology is the imitative system developed by the author (3.1 figure).

As organizational directions the author proposes implementation of a premium scheme and establishment of an institution of the council of RES-e experts. Implementation of a premium scheme in Latvia would facilitate improvements of support efficiency and effectiveness for RES-e generation and would eliminate drawbacks of the current support system.

The central objective of the council of RES-e experts is to strengthen currently insufficient knowledge capacity about economic aspects of RES-e generation and to provide guidance, consultations and expertise to the government and public institutions (including the Ministry of Economics of the Republic of Latvia) in the mentioned issues through independent, justified and transparent opinion.

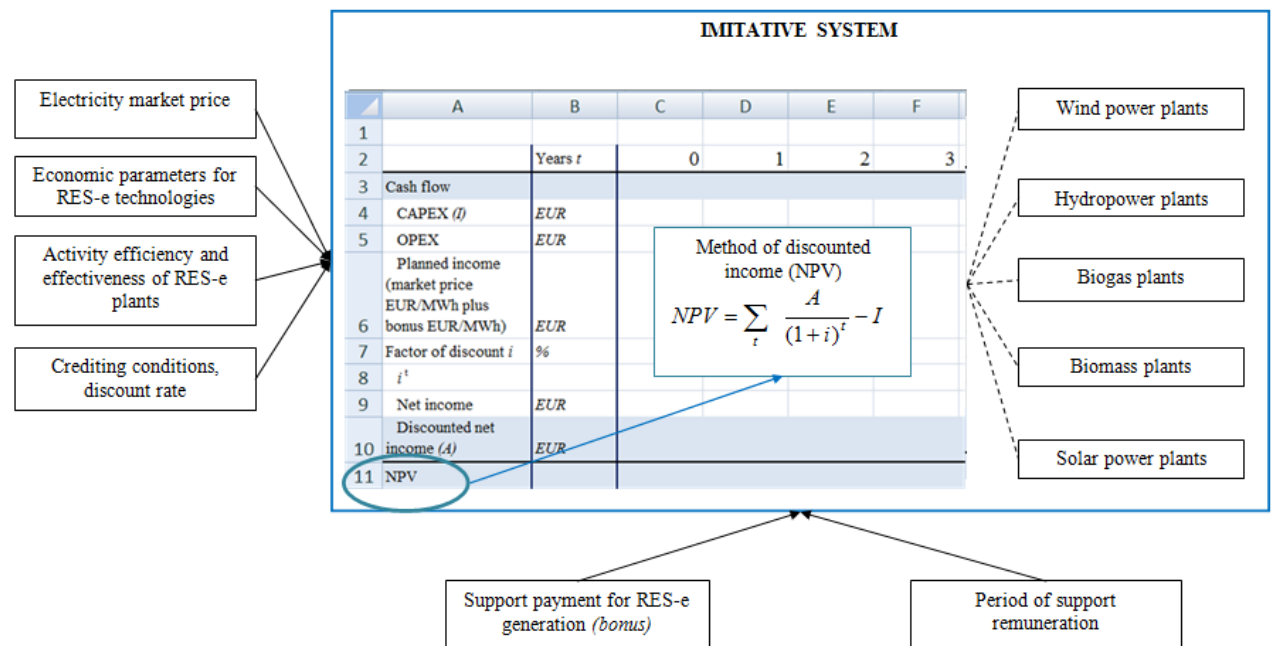


Figure 3.1 Methodology to set economically justified support payments for RES-e generation and period during which support is to be granted (the author)

In order to ensure elaboration and implementation of the methodology to assess support efficiency and effectiveness for RES-e generation, the author has developed informative base (figure 3.2). This instrument (informative base) takes into account the main directions that determine support efficiency and effectiveness for RES-e generation: development of RES-e generation (building of new power plants, increase in installed electric capacity, increase in generated RES-e output), on one hand, and RES-e support related costs, on the other (support tariffs for RES-e generation, total support payments for RES-e producers, RES-e component in the electricity tariff). The author's contribution is shown in each of five blocks of the informative base (figure 3.2).

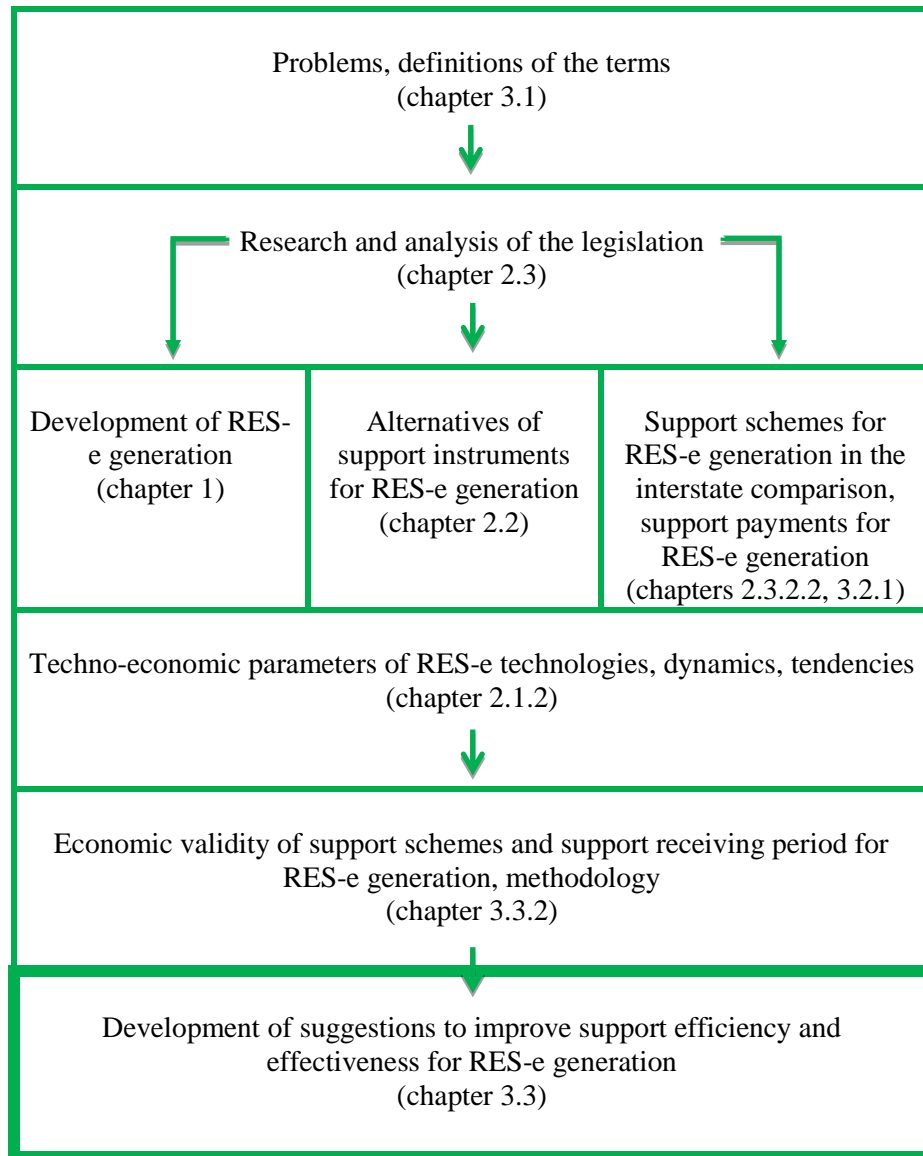


Figure 3.2 Informative base for implementing methodology of assessing support efficiency and effectiveness for RES-e generation (the author)

Assessment of support efficiency and effectiveness for RES-e generation can be done using different approaches and methods. In this PhD thesis the author's contribution is only one of the ways how to solve this issue.

CONCLUSIONS AND SUGGESTIONS

In the result of the PhD thesis analysis of theoretical, regulatory and practical aspects of efficiency and effectiveness of RES-e generation support and affecting factors have been carried out taking into account the detailed research of 15 year-long economic development of RES-e generation sector in Latvia; main problems related to support efficiency and effectiveness for RES-e generation in Latvia have been identified using the interstate comparison of RES-e tariffs among the EU countries; solutions to improve support efficiency and effectiveness for RES-e generation have been elaborated. These results enable to draw the following **conclusions**:

- ✓ There is no unified and internationally accepted definition for the term *support for RES-e generation* despite its 35 year-long existence. Nowadays room for manoeuvre to define this term is particularly wide because each country designs RES-e generation support and appropriate instruments that respond to its own situation and needs (geo-climatic conditions to generate RES-e, RES-e generation potential, achieved techno-economic level of RES-e technologies, economic situation, etc.). Despite diversity in formulating *support for RES-e generation*, the common objective is to stimulate implementation of RES-e technologies and to limit GHG emission.
- ✓ Support efficiency and effectiveness for RES-e generation can be analysed in several levels. One of the levels is the *external* or macro dimension that looks into development dynamics of RES-e generation and support payments for RES-e producers as the main factors influencing support efficiency and effectiveness for RES-e generation. In the *internal* or micro level the extent to which RES-e generation costs correspond to support tariffs for RES-e generation determines support efficiency.
- ✓ RES-e technologies are a solution to globally increasing energy demand caused by growing number of inhabitants and their welfare improvements, and by development of different production processes and transport electrification because RES-e technologies as clean technologies have many advantages in comparison with the traditional alternatives producing electricity as regards to climate change and sustainable development.
- ✓ Development of RES-e generation (designing and manufacturing) and putting into operation and serving these technologies stimulates economic growth Also in the

countries, where the designing and manufacturing of RES-e technologies do not take place the implementation of RES-e technologies has a positive effect on improving social-economic development, energy dependence, and supply security.

- ✓ Taking into account that RES-e technologies cannot yet compete with the traditional technologies producing electricity (using fossil energy sources or nuclear energy), countries have created different support instruments to stimulate developments in the field of RES-e generation. Each of these instruments can be characterized by individual advantages and disadvantages. The main types of support instruments for RES-e generation are feed-in tariffs, premium schemes, and green certificate schemes.
- ✓ In the future RES-e technologies have to become an integral part of the electricity market. As RES-e technologies become more competitive thanks to R&D efforts, technical improvements and global tendencies of investment cost reductions, the economic necessity to support RES-e generation will diminish. Premium schemes are best suited in the transition from totally regulated support for RES-e generation to free market where electricity generating technologies compete without any support.
- ✓ RES-e generation costs and their structure are different in each country. They are determined by individual factors (RES type and its potential, efficiency and effectiveness of RES-e technologies, etc.).
- ✓ The real costs of RES-e generation in Latvia have never been researched and published. The lack of this information and the insufficient knowledge in *Department of renewable energy sources* of the Ministry of Economics of the Republic of Latvia that is responsible for designing and implementation of policies to support for RES-e generation about economic issues of electricity generation are the main problems that explain why the methodology of setting support tariffs for RES-e generation actually was determined by experts in this sector.
- ✓ In time period from 1997 till 2011 there has been a gradual development in RES-e generation sector in Latvia both as regards the number of enterprises and total RES-e capacity and output. However, only since 2005 one can talk about diversified RES-e generation in Latvia. Until then the only RES-e producers were hydropower plants and wind power plants.
- ✓ Over the past few years RES-e generation from biogas has experienced the most notable growth due to the fact that several support instruments for RES-e generation have been available simultaneously – both the obligatory purchase mechanism and

investment grants, while the rest of RES-e types have been moderate in their development.

- ✓ In 2011 in Latvia only 10% to 20% from the total RES-e generation potential have been reached. The central problem for the slow realisation of the potential has been the legislative framework that has been unclear, fragmentary, and unstable. It has not been able to provide attractive investment environment despite the fact that support tariffs for RES-e generation in Latvia have been amongst the highest in the EU.
- ✓ The most important employment effect in Latvia has been provided by hydropower plants where work three-fourth of all employed in RES-e generation in Latvia. The smallest number of workers is employed in biomass power plants. This contradicts with the theory where the biomass power plants are deemed to demonstrate the best employment effect. The small number of workers in biomass power plants in Latvia can be explained by the fact that these producers outsource some services from other enterprises.
- ✓ The issue of promotion of RES-e generation has gained an interdisciplinary dimension on an EU level because intensification of exploitation of RES is one of the main goals of such policy sectors as economy, transport, and energy.
- ✓ As regards RES exploitation for energy production, including RES-e generation, regulations of the EU strictly outline the development of RES exploitation in the EU till 2020 through individual national targets in final energy consumption. In practice these regulations setting legally binding targets conflict with the national competence of member states to determine the development of RES exploitation and its pace.
- ✓ The ignorance of the Latvian governments about the issues of support efficiency and effectiveness for RES-e generation and assessment methodology, frequently changing support regulations in the field of RES-e generation especially regarding setting of support tariffs for RES-e generation, which has not been economically justified, methodologically correct, and transparent, are the main factors that delay not only effective and efficient development for RES-e generation in Latvia but also impedes to achieve the set target by the EU regulations (40% power in the aggregate consumption in 2020). In case the target is not met there are risks for legal and financial sanctions.
- ✓ The support tariffs for RES-e generation in the EU vary because of several factors: different support systems and methodologies to set the tariffs, different RES-e generation costs, regional differences as regards geographical spread of RES and their potentials, diverse levels of economic and technological development. Nevertheless,

one can conclude that in general premium systems characterize low support tariffs for RES-e generation than in the case of feed-in tariff systems.

- ✓ In order to promote economic development and international competitiveness of Latvia, it is necessary to gradually create competition among RES-e producers. Introduction of a support system for RES-e generation based on market principles and economically justified methodology for setting of support tariffs should facilitate implementation of this task.
- ✓ Methodological and organizational directions are the base for an improved support efficiency and effectiveness for RES-e generation in Latvia. The most essential methodological direction is the development of the methodological base to assess support efficiency and effectiveness for RES-e generation where one of the elements is methodology to set economically justified support tariffs for RES-e generation. The most important organizational direction is establishment of the Council of RES-e experts.
- ✓ In the result of the author's research the theses formulated in the beginning of the PhD thesis are approved.

In order to improve the entrepreneurial environment in the area of RES-e generation in Latvia, that would stimulate effective and efficient development in the sector through transparent and economically justified support principles and mechanisms, in the result of her scientific research the author proposes the following **suggestions to** public authorities:

To the Central Statistical Bureau of the Republic of Latvia

- ✓ In Latvia statistical data about RES-e generation is insufficient level showing the underestimated economic importance of the sector of RES-e generation. In order to enable objective assessment of both the development tendencies in RES-e generation and support efficiency and effectiveness for RES-e generation in Latvia, the Central Statistical Bureau of the Republic of Latvia **should** regularly **organize compilation work** and **publishing** of those economic indicators of RES-e generation that currently are not part of the statistics data bases, including employment in RES-e generation, contribution of RES-e generation sector to GDP, annual support payments to RES-e generators broken down by renewable energy sources, etc.).

To the State Chancellery of Latvia

- ✓ The State Chancellery of Latvia **should elaborate the necessary legislative proposals for establishment of advisory council of RES-e experts**, subordinated to the Prime Minister of Latvia. The author's contribution and explanations as regards necessity of such council, its objectives, as well as criteria to qualify as RES-e expert should be used in implementing this task. The Council of RES-e experts would strengthen knowledge about economic aspects of RES-e generation in Latvia and would promote economically justified and independent decision-making process concerning design and implementation of support for RES-e generation in Latvia.

To the Ministry of Economics of the Republic of Latvia

The Ministry of Economics of the Republic of Latvia:

- ✓ **Should elaborate** legislative documents for implementation of premium tariff system in Latvia as soon as possible in order **to promote market principles** in support system for RES-e generation, which is in line with the positions of the global electricity producers and trade corporations as well as with those of economic policies designers, and **to limit** support related **costs** to electricity consumers.
- ✓ In the framework of premium tariff system **should determine** the bonus amount for each RES-e technology. The methodology developed by the author will provide economically justified and transparent setting of the support and period during which support for RES-e generation is to be granted.
- ✓ In setting of the support level **should involve** Council of RES-e experts.
- ✓ **Should draft** necessary normative documentation base for implementation of the methodology and **publish** the methodology in the official website of the Ministry of Economics of the Republic of Latvia.
- ✓ **Should develop** the methodological base to assess support efficiency and effectiveness for RES-e generation which will help to determine directions for improvements involving Council of RES-e experts in the development of methodological base.
- ✓ **Should foresee** regular assessments of support efficiency and effectiveness for RES-e generation.
- ✓ **Should define** the terms *support for RES-e generation* and *efficiency and effectiveness of support for RES-e generation*. The definitions proposed by the author can be used as the base to complete this task.

- ✓ **Should elaborate** instrument (as an element of methodological base) which will help to:
 - ✓ to regularly assess support payments (including amount of bonus);
 - ✓ to demonstrate global decrease in investment costs in the amount of bonus through regular reviews of the bonus;
 - ✓ to determine the moment when the support for RES-e generation is no longer provided.
- ✓ **Should use** the informative base developed by the author to implement methodology to assess support efficiency and effectiveness for RES-e generation.
- ✓ In order to promote investments in RES-e generation **should establish** *one stop agency* where to systemize different requirements for RES-e generation and to provide information about issues related to RES-e generation.

To the Ministry of Economics of the Republic of Latvia, the Ministry of Agriculture of the Republic of Latvia, the Ministry of Environmental Protection and Regional Development of the Republic of Latvia, the Public Utilities Commission of the Republic of Latvia

- ✓ **Should review** administrative requirements related to project implementation for RES-e generation and come up with suggestions how they can be optimized (to promote improvements of support efficiency and effectiveness for RES-e generation).

To “Augstsprieguma tīkls” Inc.

- ✓ When elaborating annual assessment reports about electricity system:
 - ✓ **Should include** capacity prognosis for each RES type and **separate** installed capacity prognosis for onshore and offshore wind power plants, as well as for solid biomass and biogas plants.
 - ✓ **Should take into account** RES-e obligatory purchase rights provided by the Ministry of Economics to RES-e producers. It will help to develop a realistic assessment of prognosis for new investments in RES-e generation in Latvia.

Arta DENIŅA

**SUPPORT EFFICIENCY AND EFFECTIVENESS FOR RENEWABLE
ENERGY GENERATION IN LATVIA**

Summary of the PhD thesis

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