

**RIGA TECHNICAL UNIVERSITY**  
Faculty of Engineering Economics and Management  
Institute of Civil Engineering and Real Estate Economics

**Gita Actiņa**

# **Development of Management System of Energy Efficient Processes in Latvia**

**Summary of Doctoral Thesis**

Field: Management Science  
Subfield: Public Administration

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DOCTORAL THESIS  
PROPOSED TO RIGA TECHNICAL UNIVERSITY FOR THE PROMOTION TO THE  
SCIENTIFIC DEGREE OF DOCTOR OF ECONOMICS

The Doctoral thesis has been developed at the Department of Civil Engineering and Real Estate Economics and Management of the Institute of Civil Engineering and Real Estate Economics of the Faculty of Engineering Economics and Management, Riga Technical University (RTU). To be granted the scientific degree of Doctor of Economics, the present Doctoral Thesis has been submitted for the defense at the open meeting of RTU Promotion Council "RTU P-9" at 10:00 on 27 June 2015, at the Faculty of Engineering Economics and Management of Riga Technical University, 6 Kalnciema Street, Room 309.

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DECLARATION OF ACADEMIC INTEGRITY

I hereby declare that the Doctoral Thesis submitted for the review to Riga Technical University for the promotion to the scientific degree of Doctor of Economics, is my own and does not contain any unacknowledged material from any source. I confirm that this Thesis has not been submitted to any other university for the promotion to other scientific degree.

Gita Actiņa \_\_\_\_\_

\_\_\_\_\_ 2015

The Doctoral Thesis is written in Latvian and comprises an introduction, three chapters, conclusions and proposals, bibliography with 236 reference sources, 35 figures and 14 tables. The Thesis has 205 pages (not including 10 appendices).

The Doctoral Thesis and its Summary are available at the Scientific Library of Riga Technical University, 10 Ķīpsalas Street, Riga.

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## GENERAL OVERVIEW OF THE RESEARCH

Within the framework of the conference “Rio + 20”<sup>1</sup>, which took place in June 2012, a necessity for the creation of institutional structures at the global, national and regional levels to promote the sustainable development of the State was considered to be one of major current events. With the entry into force of the Directive 2012/27/EU<sup>2</sup> of the European Parliament and of the Council “On energy efficiency, which amends earlier Directives 2009/125/EC and 2010/30/EU and repeals the Directives 2004/8/EC and 2006/32/EC”, raising energy efficiency as a prerequisite for sustainable development of national economy is a priority, which is set at the national level in all the Member States of the European Union (EU). The Directive 2012/27/EU urges the local governments to set up a system of measures to promote energy efficiency — in production, supply and final consumption. In Article 5, Paragraph 7, of the Energy Efficiency Directive, the following requirements are moved forward for energy planning of local governments: “Member States shall encourage public bodies, including at regional and local level, and social housing bodies governed by public law, with due regard for their respective competences and administrative set-up, to: adopt an energy efficiency plan, freestanding or as part of a broader climate or environmental plan, containing specific energy saving and efficiency objectives and actions, with a view to following the exemplary role of central government buildings; put in place an energy management system, including energy audits, as part of the implementation of their plan; use, where appropriate, energy service companies (ESCO, and energy performance contracting to finance renovations and implement plans to maintain or improve energy efficiency in the long term)”<sup>3</sup>.

“National Development Plan of Latvia for 2014–2020”<sup>4</sup> as well as “Latvia’s Sustainable Development Strategy until 2030”<sup>5</sup> and “National Reform Program of Latvia for the

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<sup>1</sup> Institutional framework for sustainable development. Rio Conference or Earth Summit. Rio+20. United Nations Conference on Environment and Development (UNCED). [Elektroniskais resurss] Resurss apskatīts — 2013. gada 01. oktobrī — <http://www.unccd2012.org/isfd.html>

<sup>2</sup> Eiropas Parlamenta un Padomes Direktīva 2012/27/ES, par energoefektivitāti, ar ko groza Direktīvas 2009/125/EK un 2010/30/ES un atceļ Direktīvas 2004/8/EK un 2006/32/EK. 2012. gada 25. oktobris. L 315/12 [Elektroniskais resurss] Resurss apskatīts — 2014. gada 10. oktobrī — <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:LV:PDF>

<sup>3</sup> Andžela Pētersone. Latvijas enerģētikas politika un enerģētikas plāni pašvaldībās. LR Ekonomikas ministrija. 11.09.2014. Prezentācija. 5.–7. slaidis. [Elektroniskais resurss] Resurss apskatīts-2014. gada 10. augustā -[http://www.lvif.gov.lv/uploaded\\_files/sadarbiba/seapplus/National\\_final\\_event/Prezentācijas/Andzela\\_Petersone\\_Energy\\_policy.pd](http://www.lvif.gov.lv/uploaded_files/sadarbiba/seapplus/National_final_event/Prezentācijas/Andzela_Petersone_Energy_policy.pd)

<sup>4</sup> Pārresoru koordinācijas centrs. Latvijas Nacionālais attīstības plāns 2014.–2020. gadam. Apstiprināts ar 2012. gada 20. decembra Latvijas Republikas Saeimas lēmumu. [Elektroniskais resurss] Resurss apskatīts — 2013. gada 10. decembrī — [http://www.pkc.gov.lv/images/NAP2020%20dokumenti/20121220\\_NAP2020\\_Saeim%C4%81\\_apstiprin%C4%81ts.pdf](http://www.pkc.gov.lv/images/NAP2020%20dokumenti/20121220_NAP2020_Saeim%C4%81_apstiprin%C4%81ts.pdf)

<sup>5</sup> Latvijas Republikas Saeima. Latvijas Ilgtspējīgas attīstības stratēģija līdz 2030. gadam. Tendences un izaicinājumi: enerģētiskā neatkarība un enerģijas nodrošinājums. 2010. gada jūnijs. 44.–49. lpp.

Implementation of the “EU 2020” Strategy” include a section on energy production and energy efficiency. The target of the national energy efficiency for 2020 corresponds to the energy savings quantification: 0.670 Mtoe (28 PJ), which is the primary energy savings. Latvia, in connection with implementation of the Directive 2012/27/EU, should reach the national indicative energy efficiency target, which should provide two binding targets:

- savings of energy delivered to the end consumers of the State should reach 1.5% annually (total 0.261 Mtoe (10.9 PJ) up to 2020);
- each year, 3% of state-owned building areas should be renovated (maximum estimate — total 678,460 m<sup>2</sup>, with the corresponding amount of energy savings throughout the period from 2014 until 2020 being 0.0044 Mtoe (0.18 PJ)).

The planned savings do not state the absolute reduction in energy consumption, but the growth restriction, which is provided by the energy efficiency measures to be undertaken.

The requirements of the EU Directive 2012/27/EU “On Energy Efficiency” are focused on setting up the national energy efficiency system that would promote energy savings for all its participants: energy producers, transmission facilities and end consumers.

Under the EU directives, the established Latvia’s national energy and energy efficiency policies reflect the global targets and common interests of the community; however, in pursuit of this target, interests and needs of local governments, businesses and households should be taken into account.

Energy policy documents in Latvia developed at national level define the targets to be achieved at national and regional levels. Currently, the regional energy policy documents are not completely developed in Latvia. Energy-planning documents are not developed at the level of municipalities, especially in those regions where there are no energy agencies. As well as the management system of the development of the energy sector is not developed, which would incorporate companies and households at regional and municipal level. Although Riga and Zemgale Energy Agencies exist, they are non-governmental organizations, operating only within their competence.

In order to reach the targets of energy efficiency, the scheduled activities are primarily related to the insulation of multi-family residential buildings, improving the energy efficiency in public and industrial buildings, implementation of effective lighting infrastructure for municipal public areas, increasing the energy efficiency in heat production, as well as increasing the energy

efficiency in transport sector. In order to achieve better results, companies and households should be able to influence both the creation of regional and national development plans, offering the regional energy planning agencies their individual plans and visions of the future development. This stage is currently underdeveloped due to the lack of State energy agencies that could take on the intermediary role between energy consumers — local governments, companies and households, and the national energy development institutions.

The Doctoral Thesis meets the subfield Public Administration in the division of the Management Science, because the results of the research are focused on the management of operational processes of local governments, which, in turn, both directly and indirectly affects the processes of business management: planning, implementation, monitoring and further development in each particular region.

### **Topicality of the present research**

The topicality of the present Doctoral Thesis is determined by the issues of economic use of energy, reduction in the amount of harmful emissions (CO<sub>2</sub>), and sustainable development, for the solution of which the need for institutional structures at national and regional levels was considered to be one of major events in the United Nations Conference on Sustainable Development “Rio+ 20”, which was held in 2012. The topicality of the issue determines the need of solving the theoretical and practical problem of energy efficiency management system for further analysis of energy efficiency issues at national, regional and municipal levels, as well as the level of businesses and households. The lack of research in Latvia at end-user level (perspective view) determines the selection of subject of the Doctoral Thesis and its topicality.

### **The Aim of the Doctoral Thesis**

The aim of the Thesis is to develop a model of energy efficient process management system for regional planning in Latvia, and to develop a methodological solution for the creation of energy efficient process management system, based on the study of factors affecting the processes of energy efficiency in Latvia, the targets and directions of development of Latvia's energy policy, as well as the theoretical guidelines of management processes.

### **The tasks set to achieve the aim of the Doctoral thesis**

1. To analyze the role of energy efficient process management system in overall progress of energy sector development at regional planning level.
2. To identify and group a set of factors affecting the achievement of the set targets of energy efficiency.
3. To identify and group the functions and assignments of energy efficient process management according to their implementation levels.
4. To study and evaluate the potential opportunities of energy efficient solutions in regions of Latvia, to create the database for the energy efficient process management system.
5. To identify the importance of the needs of end-users (local governments, businesses and households) in energy efficient process management system for reaching the set targets of energy efficiency.
6. To study the definitions of individual concepts of the scientific language corps in the energy sector, provide their historical development, theoretical and analytical characterization. Discuss the nature and historical development of the concept of energy efficiency in order to raise the awareness of a single concept in the aspect of management science.
7. To develop a methodological solution for the creation of a model of energy efficient process management system at regional planning level in Latvia, basing on scientific and practical experience.

### **The Object of the Doctoral Thesis**

The research object is energy efficiency in the energy sector at regional planning level, reaching the targets of energy efficiency in accordance with the Directive of the European Parliament and the Council 2012/27/EU on energy efficiency.

### **The Subject of the Doctoral Thesis**

The research subject is the management system of energy efficient processes at regional planning level as a factor affecting the national energy policy to achieve the indicative targets of energy efficiency by 2020.

### **Hypothesis and Theses Statement to be defended**

**Hypothesis:** The identified factors affecting the development of national energy sector and requirements for improvement of energy efficiency defined at EU level determine the need to develop a model for management system of energy efficient processes in Latvia at regional planning level, promoting the demand of energy efficient solutions for end-users: households and companies.

### **Theses:**

1. In order to achieve the targets of energy efficiency and meet the interests of all parties concerned (the State, local governments, businesses and households), it is of crucial importance to have access to information on management processes of energy-efficient solutions and their systematization.
2. Variability of factors affecting the achievement of energy efficiency targets evidences the need to understand and formulate the concept of management of energy efficient processes in studies of energy sector in the aspect of the management science.
3. Scientific and theoretical guidance for management processes, their theoretical and analytical vision are the grounds for development of a model for management system of energy efficient processes.
4. Complex evaluation of interaction between factors affecting the development of energy sector with other sectors, points to the need for improvement of the energy efficiency management system.

### **Theoretical and Methodological Framework of the Doctoral Thesis**

Theoretical and methodological framework of the research is based on the knowledge of Latvian and foreign management science, theoretical and practical knowledge of scientists and specialists, doctors in energy economics, research papers, articles and scientific publications relating to the management of energy efficient processes. The most significant of these are as follows:

- the research and publications of Latvian scientists, such as V. Praude, J. Beļčikovs, L. Ribickis, A. Sauhats, J. Barkāns, J. Ekmanis, P. Šipkovs, D. Turlajs, N. Zeltiņš, V. Zēbergs, D. Blumberga, J. Vanags, I. Geipele, R. Škapars, G. Šlihta, et. al.;



- the research and publications of foreign scientists, such as V. R. Grifins (W. R. Griffin), M. R. Beijs (M. R. Baye), K. Boldings (K. E. Boulding), L. Fon Bertalanfi (L. von Bertalanffy), M. H. Meskons (M. H. Mescon), H. I. Ansoffs (H. I. Ansoff), T. R. Rodlers (T. R. Rohleder), E. A. Silvers (E. A. Silver), K. Landsgrafa (K. Landgraf), V. Hansens (W. Hansen), et. al.

### **Information sources of the Doctoral Thesis**

Informational base of the research consists of scientific literature, publications, monographs, statistical publications of Latvian and international organizations, such as the Central Statistical Bureau (CSB), informative materials of the State Land Service, data of the National Real Estate Cadastre Information System, informational materials of the Organization for Economic Co-operation and Development (OECD), the World Energy Council (WEC), etc. To reflect the legal and institutional framework, such important sources of information are used in the research as the regulatory enactments of the European Union and the Republic of Latvia, the development of planning and policy documents, etc.

### **Methods**

In order to achieve the aims of the Doctoral Thesis, the conventional qualitative and quantitative methods of economics and management science are used in the process of the research: analysis and synthesis, induction and deduction, logical constructive, graphics, methods of historical approach, analysis and collection of information, comparison, data grouping; sociological research methods: the analysis of documents and expert survey, the focus group method, study of normative documents, as well as collection and analysis of statistical data

### **Period and Restrictions of the Research**

The author of the Doctoral Thesis uses her scientific research in the sphere of encouraging the development of sustainable energy in Latvia's planning regions during the period 2004 to 2014, when she was employed as a manager of the Latvian energy efficiency network at the Energy Efficiency Centre of the Institute of Physical Energetics, within the framework of regional energy development projects, and as a scientific assistant in research projects.

Requirements of Article 5, Paragraph 7, of “Energy Efficiency Directive” determine the encouraging of energy efficiency management system in the Member States, taking into account the respective competencies of public bodies and the administrative organizations, encouraging them, including the regional and local structures and social housing bodies governed by public law, to adopt national energy efficiency action plans and to consider the implementation of the energy management system.

The statistics of data on Latvia’s total energy balance covers the period up to 2013. Since 2009, the Central Statistical Bureau no longer collects data of balance sheets for electric power in a separate regional breakdown, which makes difficult to source data of electric power at local government and regional levels.

The Doctoral thesis is based on the convergence of two sectors: energy and management science. In order to prevent the interference between the above sectors and to build up a common awareness of the terminology used in the Doctoral thesis, the analysis of (individual) elements of the scientific language body of the energy sector was carried out for their transformation in the meaning of management science.

Planning regions do not receive information about the consumption of energy sources, electricity and heat in companies and households, as such type of request for information from energy end consumers is not a part of the rights of the planning regions.

The database of energy certification of buildings so far is not freely available, which makes difficult to collect data on energy consumption in buildings and structures. Unfinished territorial reform also makes difficult to obtain information in local governments. There is still no clear distribution of responsibilities in control and accounting of energy resources.

The opinion survey of the sector specialists on the macroeconomic, inter-State, commercial and technological factors affecting the development of the energy sector in Latvia has been carried out in May 2013 and in June 2014.

### **Main Contribution and Scientific Novelty**

Within the framework of the Doctoral thesis, the following scientific novelties are developed:

1. *An improved model of the management system of energy efficient processes* is developed at regional planning level in Latvia and a methodological solution is offered for development of *the model of the management system of energy efficient processes*.

2. *Analytical evaluation of management of energy efficient processes: the implementation processes of energy efficient solutions and at the planning region level is carried out in Latvia. Basing on overall analysis of energy planning structure implemented by national authorities, factors affecting the implementation of national energy strategy relating to energy efficiency are identified and grouped. Factors affecting the management of energy efficient processes are identified and grouped.*
3. *Theoretical aspects of management of the identified energy efficient processes are evaluated for filing and monitoring the improvement of implementation of functions and tasks of the management system of regional energy efficiency processes towards the activity oriented to achieve the State targets in energy efficiency.*
4. *As a result of study of factors affecting the development of national energy sector and management of energy efficient processes, a set of internal and external environmental factors affecting the implementation of energy efficient processes, as well as a scheme of institutions involved in energy efficient process management system and a scheme of interaction of factors affecting the management subjects of energy efficient processes and their operation are developed.*
5. *The needs of the interested entities for different energy efficient process management levels are evaluated and a system of determining the interaction of mutual relations between involved and interested subject groups in the management system of energy efficient processes is developed for achieving the energy efficiency targets.*
6. *The groups of management methods of energy efficient processes are determined and a catalogue of the functions and tasks of the management system of energy efficient processes is created.*
7. *The lexicographical analysis of separate concepts of the scientific language corps of energy sector in the aspect of management science is carried out to clarify their explanation, which is the basis for further research of energy efficient process management system. A clarified definition of the concepts “energy efficient processes”, “management subject of energy efficient processes” and “management system of energy efficient processes” are proposed.*
8. *For the first time in Latvia, the analysis of the management system of energy efficient processes in the context of sustainable policy of regional energy is carried out.*

### **Approbation and Practical Application of Research Results**

The results of the Doctoral Thesis have theoretical significance and provide opportunities for practical application in the improvement of regional energy planning and management to achieve the energy efficiency targets. These results by the submission date of the Doctoral Thesis are approved within the research projects of regional energy development worked out in the Energy Efficiency Centre of the Institute of Physical Energetics:

1. Project No. 2 “Energy Diversity Analysis of Latvia Regions and Development of Measures for Efficient Use of Energy Ensuring Sustainable Energy Supplies” of the national research program “Technologies for Innovative Production and Use of Energy Resources and Provision of Low Carbon Emissions by Means of Renewable Energy Resources, Support Measures for the Mitigation of Environmental and Climate Degradation”, 2009–2014.
2. Intelligent Energy Europe, the project “ASPIRE: Achieving Energy Sustainability in Peripheral Regions of Europe” Grant agreement No. EIE/06/027/SI2.439975, 2006–2011.
3. European regional development, Innovation and Environment Regions of Europe sharing solutions, EU 2020 Going Local, Contract No. 5/5-29 “From Detached Lisbon and Gothenburg Strategies to Regularized Indigenous EU 2020 (EU Objectives 2020 and Regional Agenda), 2010–2013.
4. The national research program “Research and Development of Modern Methods and Technologies in Energetics: for Environment — Friendly Renewable Kinds of Energy, Energy Supply Reliability and Efficient Use of Energy”, 2009–2011.

The main results of the thesis were presented in the form of a report, discussed and positively evaluated on December 11, 2014, for the following subdivisions of the sector:

- Division of the Physical and Technical Sciences, Latvian Academy of Sciences;
- Board of the Latvian Member Committee of the World Energy Council;
- National Confederation of Energy.

The results of the research related to the Doctoral Thesis are presented in 20 published scientific articles, of which 11 have been published in internationally indexed peer-reviewed scientific issues:

1. Actina G., Geipele I., Zeltins, N. (2015). Planning and managing problems of energy and energy efficiency at regional and district level in Latvia: case study. // Industrial

Engineering and Operations Management: Proceedings of The Fifth International Conference on Industrial Engineering and Operations Management (IEOM) Hyatt Regency Dubai, March 3–5, 2015. — pp. 1482.–1488. e-ISBN: 978-0-9855497-2-5; print-ISBN: 978-1-4799-6064-4; ISSN: 2169-8767. DOI: 10.1109/IEOM.2015.7093843IEEE Xplore® Digital Library<?xml:namespace prefix = "o" ns = "urn:schemas-microsoft-com:office:office" />

2. Actina G., Geipele I., Zeltins, N. (2014). *Role of building thermal inertia as a selection criterion of edifice renovation strategy and energy plan development in Latvia: case study*. Energy, Environmental and Geological Engineering: *Proceedings of the 3rd International Conference on Frontier of Energy and Environment Engineering*, Taiwan, December 6–7, 2014, Paper ID: 1071-128-icfeee-1031. — Submitted to WOS database.
3. Zeltins N., Zebergs V., Actina G., Vrublevskis V. (2014). *Impact of the Thermal Inertia of Buildings of the Energy Efficiency*. RTU Scientific articles. Heat and Thermal Physics. Series: Transport and Engineering. — apstiprināts publicēšanai.
4. Actina G., Geipele I., Zeltiņš N. (2014). *Reģionālo publisko ēku energoefektivitātes pasākumu izvēle atkarībā no ēkas siltumnerces*. Book of Abstracts of the 55<sup>th</sup> International Scientific Conference of Riga Technical University „Scientific Conference on Economics and Entrepreneurship” SCEE'2014, Latvia, Riga: Riga Technical University, October 14–17, 2014. — pp. 1–2. ISBN 978-9934-8275-2-5.
5. Actina G., Zeltins N., Geipele I. (2014). *Recommendations on implementation of governmental energy and energy efficiency policy planning and managing institutions at regional level in Latvia*. Proceedings of WEC Central & Eastern Europe regional energy forum (FOREN 2014), Palace of the Parliament, Bucharest, Romania. June 22–26, 2014. — pp. 201–211. ISSN 2284-9491.
6. Zeltins N., Actina G., Zebergs V., Vrublevskis V., Odineca T. (2014). *Impact of the thermal inertia of buildings upon the selection criteria of the energy efficiency measures, saved energy and its cost*. Proceedings of 14th IAEE European Energy Conference Sustainable Energy Policy and Strategies for Europe. Rome, Italy. October 26–31, 2014. CD version.
7. Actina G., Zeltins N., Geipele I. (2013). *Recommendations on Energy and Energy Efficiency Policy Development Planning at Regional Level*. Abstracts of the Riga Technical University 54th International Scientific Conference. Section: Real Estate

- Economics and Construction Entrepreneurship, Riga: Institute of the Civil Engineering and Real Estate Economics, September 26–29, 2013. — pp. 5–6. e-ISBN 9789934104671.
8. Actina G., Zeltins N., Zebergs V., Niedrite I. (2013). *The Policy Coherence for The Implementation of Sustainable Energy Action Plans on National, Regional and Municipal Levels*. Proceedings of Energy for Sustainability Multidisciplinary Conference (EfS 2013), Portugal, Coimbra, September 8–10, 2013. — pp. 9–19. CD version.
  9. Petrovs B., Zeltins N., Zebergs V., Semenako A., Actina G. (2012). *Water-Loop Heat Pump Systems: Latvian Experience*. Book of Abstracts of the 53th International Scientific Conference of Riga Technical University „Scientific Conference on Economics and Entrepreneurship”, Latvia, Riga: Riga Technical University, October 11–12, 2012. — pp. 602–603. ISBN 978-9934-10-360-5.
  10. Actina G., Zebergs V., Zeltins N., Niedrite I. (2012). *National and regional energy policies and strategies from the Latvian point of view* FOREN2012: The Role of Governments, International Organizations and NGOs in addressing it. The Energy Trilemma. Overlook on Strategic Programs at European and Regional Level. „Mesagerul energetics. Buletin informativ al Comitetului National Roman al Consiliului Mondial al Energiei”, ANUL XII, NR. 130, August, 2012. — pp. 6–9. ISSN: 2066-4974.
  11. Actina G., Akermanis A., Zebergs V., Zeltins N., Odineca T. (2012). *Situation with Heat Supply in Latvia: Current Problems and Search of Their Solution*. FOREN2012: The Role of Governments, International Organizations and NGOs in addressing it. The Energy Trilemma. Overlook on Strategic Programs at European and Regional Level. „Mesagerul energetics. Buletin informativ al Comitetului National Roman al Consiliului Mondial al Energiei”, ANUL XII, NR. 131, September, 2012. — pp. 5–8. ISSN: 2066-4974.
  12. Actina G., Puikевичa-Puikєvska I., Teteris G., Geipele I. (2012). *Energy efficiency strategically planning: SWOT analysis*. FOREN2012: The Role of Governments, International Organizations and NGOs in addressing it. The Energy Trilemma. Overlook on Strategic Programs at European and Regional Level. „Mesagerul energetics. Buletin informativ al Comitetului National Roman al Consiliului Mondial al Energiei”, ANUL XII, NR. 132, October, 2012. — pp. 5–9. ISSN: 2066-4974.

13. Actina G., Zebergs V., Zeltins N., Semenako A. (2012). *Woodchips — the Main RES for the Fulfillment of the EU Target for Latvia*. Proceedings of Conference “Bioenergy from forest 2012”, Hotel Rantasipi, Jyväskylä, Finland. August 8–10, 2012. — pp. 32–40.
14. Geipele I., Actina G., Zeltins N. (2012). *Energy Efficiency Sustainable Development in Latvia at National and Regional Perspective*. Riga Technical University 53rd International Scientific Conference: Dedicated to the 150th Anniversary and the 1st Congress of World Engineers and Riga Polytechnical Institute. RTU Alumni: Digest, Latvia, Riga, October 11.–12., 2012. — pp. 745–745. ISBN 9789934103605.
15. Geipele I., Actina G. (2011). *Energoefektivitātes paaugstināšanas noteikšanas metodes dzīvojamo un sabiedrisko ēku ekspluatācijā*. 52. RTU Starptautiskā zinātniskā konference : RTU IEVF Ekonomikas un uzņēmējdarbības zinātniskā konference (SCEE' 2011): konferences ziņojumu tēžu krājums, Latvija, Rīga, 4.–7. oktobris, 2011. Rīga: RTU Izdevniecība, 2011. — 117.–117. lpp. ISBN 978-9934-10-202-8.
16. Actina G., Puikevica-Puikvaska I., Teteris G., Zeltiņš N. (2011). SVID analīzes pielietojuma metodika, plānojot energoefektivitātes pasākumus reģionos. *Apvienotais pasaules latviešu zinātnieku III kongress un Letonikas IV kongress "Zinātne, sabiedrība un nacionālā identitāte" : sekcija "Tehniskās zinātnes" : tēžu krājums*, Latvija, Rīga, 24.–25. oktobris, 2011. Rīga: RTU Izdevniecība, 2011. — 176.–176. lpp. ISBN 9789934102271.
17. Actina G., Zeltiņš N., Zēbergs V. (2008). Puikevica-Puikvaska I., Gračkova, L., Silantjeva I. *Managment Methods for Achieving Faster and Higher Energy Efficiency for End Users*. RTU scientific articles, Heat & Power and Thermal Physics. Vol. 1, 2008. — pp. 27–40. ISSN 1691-5054.
18. Actina G., Zeltins N., Kreslins V., Petrovs B. (2008). *Multicriterial Evaluation Methods for the Selection of Competing Energy-Efficient Technologies*. RTU scientific articles, Heat & Power and Thermal Physics. Vol. 1: Transport and Engineering, Rīga: RTU Press, 2008. — pp. 109–121. ISSN: 1691-5054.
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20. Zeltins N., Zebergs V., Actina G., Vrublevskis V. (2015) The Operational and Maintenance Specificity of Heating Systems Depending on the Thermal Inertia of Buildings // Proceedings of REHVA Annual Conference 2015 «Advanced HVAC and Natural Gas Technologies», Riga, Latvia, May 6–9, 2015. RTU Press, Riga 2015 — pp. 210 — 2015. ISBN978-9934-10-685-9

***Presentation of the research results at conferences and seminars:***

The author of the Doctoral Thesis has participated in 12 international and scientific conferences, and in various scientific seminars in 5 countries (Finland, Lithuania, Portugal, Romania, United Arab Emirates), presenting the results of the research in 15 reports:

1. *The Fifth International Conference on Industrial Engineering and Operations Management* at Hyatt Regency United Arab Emirates: Dubai, March 3–5, 2015.
2. *RTU 55th International Scientific Conference. Section: Real Estate Economics and Construction Entrepreneurship*. Institute of the Civil Engineering and Real Estate Economics, Latvia: Riga, October 14–17, 2014.
3. *WEC Central & Eastern Europe regional energy forum (FOREN 2014)*. Palace of the Parliament, Romania: Bucharest, June 22–26, 2014.
4. *RTU 54th International Scientific Conference. Section: Real Estate Economics and Construction Entrepreneurship*. Institute of the Civil Engineering and Real Estate Economics, Latvia: Riga, September 25–27, 2013.
5. *Energy for Sustainability Multidisciplinary Conference E/S2013, Energy for Sustainability 2013, Sustainable Cities: Designing for People and the Planet*. Institute for Research and Technological Development in Construction Sciences on behalf of the University of Coimbra, Portugal: Coimbra, September 8–10, 2013.
6. *RTU 53th International Scientific Conference. Section: Real Estate Economics and Construction Entrepreneurship*. Institute of the Civil Engineering and Real Estate Economics, Latvia: Riga, October 12–14, 2012.
7. 11th BMDA conference “*The role of management empowering innovations and creativity*”, Lithuania: Kaunas, May 9–10, 2013.
8. Energy forum „*National and regional energy policies and strategies — FOREN 2012*”, Romania: Bucharest, June 15–22, 2012.
9. “*Bioenergy from forest 2012*”, Hotel Rantasipi, Finland: Jyväskylä, August 8–10, 2012.



10. RTU 52th *International Scientific Conference. Section: Real Estate Economics and Construction Entrepreneurship*. Institute of the Civil Engineering and Real Estate Economics, Latvia: Riga, October 2–6, 2011.
11. Third Joint World Congress of Latvian Scientists and Fourth Congress of Lettonica "Science, society and national identity" — subsection „*Real Estate Economics and Contractor*” (section „Economics and management sciences”). Latvia: Riga, October 24–27, 2011.
12. 34th IAEE International Conference, entitled “Institutions, Efficiency and Evolving Energy Technologies”, Stockholm, Sweden: 19–23.06.2011.

### **The structure and scope of the Doctoral Thesis:**

The Doctoral Thesis is an independent scientific research, developed and completed in Latvian. The Thesis has 205 pages, excluding the annexes.

The Thesis consists of an introduction, 3 chapters, 9 sub-chapters, conclusions and proposals, bibliography with 236 reference sources, as well as of 10 annexes. The Thesis includes 35 figures and 14 tables that explain and illustrate the contents of the research.

The first chapter of the Doctoral Thesis is devoted to the coverage of theoretical aspects of the management system of energy efficient processes. In this chapter, the scientific literature is collected, analyzed and evaluated with the aim of creating the awareness of explanations of individual concepts of the scientific language corpus of the energy sector in the aspect of management science, to characterize the historical development of the concept “energy efficient processes” and propose its clarified definition. Basing on definitions of binding concepts in energy and management science sectors, a clarified definition of the concepts “management of energy efficient processes”, “management subject of energy efficient processes” and “management system of energy efficient processes” is offered in the aspect of management science research. Within the subsections, the scientific literature and regulatory documents are analyzed, identifying the theoretical basis of management system of energy efficient processes in order to develop a model of such system for regional planning level in Latvia. Management methods of energy efficient processes are defined and classified. Identification of factors affecting the energy efficient processes and the analysis of management system of energy efficient processes are performed. Basing on the performed research, a breakdown table of factors affecting the management of energy efficient processes is created according to the impact area:

impact on energy market, impact on energy end-users, socioeconomic content of the factors, legal nature and origin.

The second chapter of the Doctoral Thesis is dedicated to the development of energy sector and the analytical characteristics of the management of energy efficient processes in Latvia. The chapter contains the evaluation of mutual interaction between social, demographic, economic and ecological factors and the energy sector, which explains the need for management system of energy efficient processes, taking into account the development trends of energy as a sector of national economy at global level, and their interaction with the social factor: the number of population and poverty level changes, the limited fossil fuel reserves and use of new energy resource opportunities, reduced environmental pollution and improved solutions for ecological system, as well as changes in economic development and global trends. Within the section, the management issues of achievement of energy efficiency targets of in Latvia are reflected. The hierarchy of institutions involved in the management system of energy efficient processes is described, which explains the interaction between factors affecting the operation of subjects (the process of implementation of energy efficient solutions) of management of mutual relations and energy efficient processes, the needs of the subject groups of the management system of energy efficient processes, based on the collection of binding regulatory enactments and policy planning documents. Within the section, the analytical evaluation of interaction in the implementation of the management function of different hierarchical levels of energy efficient processes is carried out and all institutions involved in the management system of energy efficient processes are described, interrelations of which are reflected in the scheme of organizations involved in the management system of energy efficient processes. Basing on the summary and evaluation of tasks and functions of regional energy agencies, a catalogue of functions and tasks of management system of energy efficient processes is compiled, breaking down the functions and tasks of the management system of energy efficient processes in accordance with their targets, in order to address the issues of micro (internal) or a macro (external) environment.

The third chapter of the Doctoral Thesis describes the model of the management system of energy efficient processes and the methodological solution of developing the management system of energy efficient processes. Within the framework of the section, identification of factors affecting the implementation of the Latvian National Energy Strategy is reflected, using the quantitative research model: a survey, evaluation of factors affecting Latvian energy sector and

energy efficient processes given by the specialists of the sector — both scientists and energy-related merchants and their representatives. The dynamics of changes in impact degree and significance of factors affecting the energy sector is characterized, summarizing the results of surveys carried out in 2013 and 2014 and thus substantiating the scheme of factors affecting the management of energy efficient processes, and determining the groups of factor to be considered in the planning process of energy development. The third chapter presents the results of the survey for identification of management issues of potential energy efficiency, management issues of energy efficient processes and evaluation at regional planning level in Latvia. Using the model of the quantitative research — a survey, information has been collected on heat and electricity generation, energy consumption, the number and type of heated buildings, as well as street lighting and road transport industry data in planning regions and their subordinated local governments of Latvia, which may serve as the basis for development of energy efficiency plans of local governments and for development of regional energy strategy and policy. The survey results have demonstrated the drawbacks of energy efficient processes and the need for development of a model of the management system of energy efficient processes. Basing on the research results reflected in Chapter 1 and Chapter 2 of the Doctoral Thesis, a scheme of the model of the management system of energy efficient processes for regional planning level in Latvia and the methodological solution for development of the management system of energy efficient processes are presented in this section.

Based on the conclusions, proposals for encouraging the development of the management system of energy efficient processes to solve the existing problems have been made, with an emphasis on the significance of the management system of the energy efficient processes at regional planning level in Latvia.

The model of the management system of energy efficient processes for the planning region level developed by the author and the methodological solution of the development and improvement of the management system of energy efficient processes provides a solution for the EU Directive 2012/27/EU for encouraging the attainment of energy efficiency targets and is focused on decision of energy end-users to build, influence and shape the energy efficient solutions through all types of energy — electricity and heat — efficiency. This justifies the need to continue the research of the management system of energy efficient processes for improvement

of methodological solutions offered by the author. Conclusions and proposals of current research are intended for future scientific, factual and practical development of given subject in Latvia.

The Doctoral Thesis is developed in the Department of Civil Construction and Real Estate Economics and Management of the Institute of Civil Construction and Real Estate Economics of RTU Faculty of Engineering Economics and Management.

## OUTLINE OF CONTENTS OF THE DOCTORAL THESIS

In order to demonstrate the course of research in the Doctoral Thesis, the author offers a diagram of research architecture, reflecting the parts of the Thesis, as well as major activities of research and developments (Figure 1).

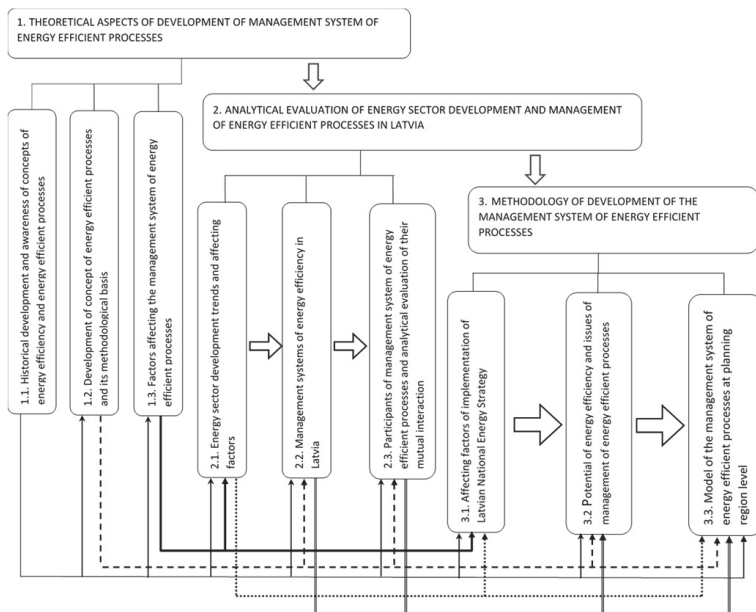


Fig. 1. Architecture of the Doctoral Thesis

## MAIN SCIENTIFIC ASPECTS OF THE DOCTORAL THESIS

### 1. THEORETICAL ASPECTS OF DEVELOPMENT OF MANAGEMENT SYSTEM OF ENERGY EFFICIENT PROCESSES

All energy sectors and development of energy policy should be considered not only at national level, but also in European and global context. At present time, the main target of Latvia's energy policy is a competitive economy with two energy policy underlying targets<sup>6</sup>:

- Enhancing the security of energy supply, which provides available, stable energy supply to energy consumers, reducing the geopolitical risks, diversifying the sources and ways of supply of energy resources, developing an infrastructure of interconnections, creating the backup facilities and participating in development of international regulatory framework.
- Sustainable energy — development of energy sector with economic, social and environmental harmonization. The State intends to achieve it by improving the energy efficiency (EE) and encouraging a highly efficient production technology, as well as the opportunities for use of renewable energy resources (AER).

In the course of the Doctoral Thesis, the author uses the concept “*energy*” for characterization of national economy sector, which includes the optimization of power generation, conversion, transmission and storage provisioning, management of the existing facilities and processes, efficiency of energy consumption and economic efficiency, improvement of safety and security measures, as well as the design, construction and putting into service of new energy facilities, including alternative energy types, under prerequisites of sustainable development.

The promotion of *energy efficiency* plays an essential role in the energy policy at global, EU and national (each Member State) levels, due to its contribution to the reduction in the greenhouse effect, gas (GHG) emissions and use of fossil energy resources. In 2007, the Council of Europe set a target for all Member States to increase the energy efficiency by 20% until 2020<sup>7</sup>.

Basing on research results included in the Doctoral Thesis, the author proposes the following definition: “*energy efficient processes*” are an entirety of implementation of energy efficient solutions or a complex of related services, with a particular value, resulting in changes of energy consumption value of an object or a process. In order to understand the nature and

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<sup>6</sup> Ekonomikas ministrija. Enerģētikas Attīstības Pamatnostādnes 2014.–2020. gadam. (Informatīvā daļa). Projekts, Rīga, 2014. — 10. lpp.

<sup>7</sup> LR Ekonomikas ministrija. Enerģētikas Attīstības Pamatnostādnes 2014.–2020. gadam. (Informatīvā daļa). Projekts, Rīga, 2014. — 57 lpp.

importance of energy management and achieving the targets of energy efficiency, the author goes on with the analysis of the concept “management”, applied in the energy sector in support of the need for research carried out in Chapter 3 of the Doctoral Thesis, and the significance of the developed management system of regional energy efficient processes.

With increasing role of energy efficiency in energy sector, the impact of energy efficient processes management on performance indicators also acquires importance — the State energy efficiency target by 2020. Analysis of scientific literature within the framework of the Doctoral Thesis allows the author to conclude there are more possibilities for translation of the concept while the terms used in the Latvian language are often understood as identical and used as synonyms.

In order to influence the energy market, the management method of energy demand is used, for which the English term “*demand side management*” (*DSM*) is used. According to the *Official Journal of the European Union*, the explanation “*energy efficiency/demand-side management*” has a global or integrated approach, aimed at influencing the size and schedule of consumption to reduce the primary energy consumption and the peak loads by giving precedence to investments in energy efficiency measures, or other measures, such as interruptible supply contracts, rather than investments to the increase in generation capacity, if these investments in energy efficiency measures are the most effective and economical option, taking into account the positive impact of reduced energy consumption on the environment, as well as the security of supply and distribution cost related matters<sup>8</sup>. The essence of this method is to influence the energy demand of consumers using a variety of methods, such as financial incentives and education<sup>9</sup>. The main target of the demand management method is to ensure that energy consumers use less amount of energy during periods when the total energy demand due to consumer activities reaches the maximum level, or the end-use of energy is transferred to a less active period, such as nights and weekends<sup>10</sup>.

The differences and interpretation of clarification of management concept definitions are based on close connection between theory and practice in the field, as well as on its multi-layered nature. Management consists of an entirety of a certain system, which should constantly be

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<sup>8</sup> Official Journal of the European Union. EUR-Lex. [Electronic resource] — Resource viewed: 28.08.2014. — <http://eur-lex.europa.eu/legal-content/LV/TEXT/PDF/?uri=DD:12.2:32003L0054:LV>

<sup>9</sup> Chiu W. Y., Sun H., Poor H. V. Energy Imbalance Management Using a Robust Pricing Scheme. IEEE Transactions on Smart Grid, vol. 4, no. 2, 2013., pp. 896–904. ISSN: 1949-3053, DOI: 10.1109/TSG.2012.2216554

<sup>10</sup> Blazevich J., Davis A., Mikelsons K., Zebergs V., Zeltins N. Development of Baltic Energy Sector in Central Europe Energy Market // 18th World Energy Congress, Buenos Aires, Argentina, CD — Technical Papers. 2001. — 16. lpp.

improved and supplemented depending on changes in the situation<sup>11</sup>. After analysis and summarization of literature sources, the author concludes that management must be considered as a functional economic activity, also as science, practice, management and control technique, the art to manage, action that provides a rational use of resources and time, as a skill to achieve the set targets, using the intelligence, planning, control, motivation and action processes<sup>12</sup>.

Conclusions made by the author of the Doctoral thesis coincide with the views of researchers of the sector: management can be viewed either as a separate discipline or as an interdisciplinary field of science that includes the theories of economics, management science, marketing, sociology and psychology aspects, while the business and technological development being the factors affecting the management.

The term “demand management method” was formulated in 1973 and 1979, during the period of energy crisis, and in 1980 this term was publicly introduced by the Electric Power Research Institute (EPRI)<sup>13</sup>.

While studying the energy market issues, the term “peak management” has been found, associated with affecting the investments required for energy generation to meet the maximum energy demand, such as use of energy storage units to store the excess power generated during the low energy demand period and applying it during the active hours<sup>14, 15</sup>.

In order to prevent conflicts in the quest for innovation issues, and to create a common approach to the solution of energy consumption and energy efficiency issues in sectors without duplication, the author proposes to encourage the cooperation between the two sectors in a single field of research: management system of energy efficient processes. In Figure 2, the author presents the interaction between the energy and management science. The scheme shows the sectorial cooperation: a systemic analysis of information and achievements to arrive at a single destination.

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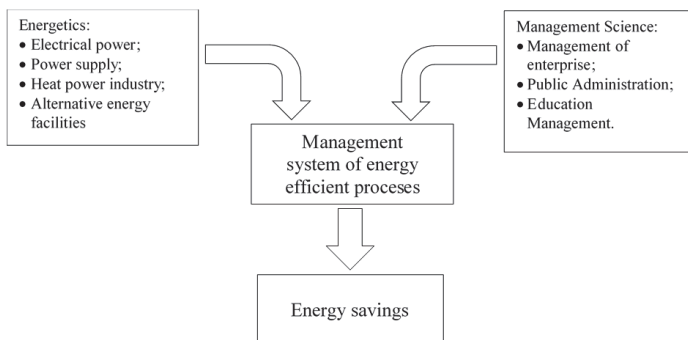
<sup>11</sup> Baye M. R. Managerial economics and business strategy. 8th ed. London. McGraw Hill Education, 2013. — p. 636 ISBN: 9780077154509

<sup>12</sup> Максимов М. М., Игнатева А. В., Комаров А. М. и др. Менеджмент. — Москва. ЮНИТИ. 1998. — 325 стр.

<sup>13</sup> Balihepalli V. S., Murthy K., Pradhan V., Khaparde S. A., Shereef R. M.. Review of Demand Response under Smart Grid Paradigm. Innovative Smart Grid Technologies - India (ISGT India), IEEE PES, 2011. — pp. 236–243. ISBN: 978-1-4673-0316-3, DOI: 10.1109/ISGT-India.2011.6145388

<sup>14</sup> Palensky, P. Demand Side Management: Demand Response, Intelligent Energy Systems, and Smart Loads. IEEE Transactions on industrial informatics, vol. 7, no. 3, 2011. — pp. 381–388. ISSN: 1551-3203, DOI: 10.1109/TII.2011.2158841

<sup>15</sup> Actina G., Grackova L., Zebergs V., Zeltins N. Management Methods of Energy Efficiency and Reduction of Greenhouse Gas Emissions. Proceedings of 16th Forum: Energy Day in Croatia: Energy Future in the Light of the Relations and Integration Processes in Europe. International Atomic Energy Agency. 2007. — pp. 40–45.



**Fig. 2. Interdisciplinary interaction in development of management of energy efficient processes**  
*[developed by author]*

At the level of energy end-users, the management of energy efficient processes is defined by the author as follows: management of energy efficient processes is an entirety of functions and tasks, with the aim of obtaining the maximum economic effect and reduction in energy consumption as a result of implementation of energy efficient processes and energy efficient solutions.

Referring to the above, the author describes the management subject of energy efficient processes as the economic, technological and social relations of the participants in the energy sector (the State, municipalities, corporate entities and households), interaction of which can be seen as a series of linked energy efficient processes in the management system of energy efficient processes (where the system is a part of the overall interaction of elements). Consequently, both systematic and process approaches are applicable in the management of energy efficient processes.

In order to encourage development of the management system of energy efficient processes in Latvia and its regions, a close cooperation between both research directions is needed. Achievement of energy efficiency targets by 2020 does not depend on a single procedural system and needs the creation of an advanced system of cooperation for technical solutions of energy and the sectorial management (education of energy companies (manufacturers and suppliers), end consumers, specialists in the sector)<sup>16</sup>.

<sup>16</sup> Actina G., Zebergs V., Zeltins N., Niedrite I. National and regional energy policies and strategies from the Latvian point of view // „Mesagerul energetics” Buletin informativ al Comitetului National Roman al Consiliului Mondial al Energiei, ANUL XII, NR. 130, august 2012, — pp. 6–9. ISSN: 2066-4974



The management of energy efficient processes at regional level is considered as a specific direction of management practices since the management object is focused on the interaction between the processes of achieving the energy efficiency targets in the sector and development of national economy<sup>17</sup>. In the research of management of energy efficient processes, the author uses both the systematic and process approaches.

The systematic approach has been developed based on the system theory, which is a set of knowledge of human thinking process and subsequent thought materialization in practical human life. This theory is based on the principles of consistency and subordination<sup>18</sup>.

From the perspective of the systematic approach, management is the improvement of a single system, its development in accordance with the interaction of objects contained in the system, where the system is a set of existing and interacting elements. Management of the system provides the regulation of the unified whole, characterized by the solution, regulation and control of internal processes<sup>19</sup>.

The process approach is interpreted as a series of management of continuous, interconnected actions<sup>20</sup>. According to the definition by A. I. Naumov, the organization's management is as an organization of a certain type of the process of mutual operations in the accumulation and use of resources of the organization to achieve the set targets<sup>21, 22</sup>.

The process approach to the management covers the use of such typical concepts as the function, sub-function, procedure and operation. The management function is understood as follows: effects on the employee behavior (both individual and collective) by specific methods and techniques, in order to implement the targets of the organization<sup>23</sup>. In turn, the process approach to the analysis of the management system of energy efficient processes is, related to the identification of activities to be undertaken, a statement of the order of the works to be done, as well as related to the provision of implementation of the previously established order, follow-up

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<sup>17</sup> Actina G., Zeltins N., Geipele I. Recommendations on implementation of governmental energy and energy efficiency policy planning and managing institutions at regional level in Latvia // Proceedings of WEC Central & Eastern Europe regional energy forum (FOREN 2014) — 22–26 June 2014, Palace of the Parliament, Bucharest, Romania. 2014. — pp. 201–211. ISSN 2284-9491.

<sup>18</sup> Boulding K. E. General Systems Theory — The Skeleton of Science. In: Management Science Vol. 2 No. 3, 1956, 197–208. Reprinted in E:CO Vol. 6 Nos. 1–2, 2004. — pp. 127–139.

<sup>19</sup> Mescon H. M., Albert M., Khedouri F. Management. 3rd ed. New York. Harper & Row. 1988. — 777 pp. ISBN-10: 20 Ricky W. G. Management, 11th Edition. Texas A&M University. 2013. — p. 89. ISBN-13: 978-1111969714

<sup>21</sup> Наумов А. И. «Менеджмент». Гардарика, МОСКВА. 1998. — 52. стр. ISBN 5-7762-0055-5

<sup>22</sup> Ансофф И. Стратегическое управление. Москва. Экономика. 1989. — 48. стр. ISBN: 5-282-00652-9, ISBN: 0-13-451808X

<sup>23</sup> Praude V. Menedžments. 2. grāmata. Trešais pārstrādātais papildizdevums. — Rīga. Burtene. 2012. — 11. lpp. ISBN: 978-9984-833-088

review, evaluation and improvement of the following actions to be undertaken<sup>24</sup>. For an effective management of the system based on the process approach and the provision of its improvement, it is necessary to identify the processes that determine the characteristics of the processes, their targets and tasks<sup>25</sup>.

Taking into account the close link of the energy and energy efficiency to real estate, as determined by the “Law of energy performance of buildings”<sup>26</sup>, the author believes that, based on the functions of the real estate market<sup>27</sup>, the following management functions of energy efficient processes should be adapted:

- informative — provision of energy end consumers with information about importance of energy efficiency, technological innovations and their funding opportunities within the specified quality and quantity, meeting the interests and needs of consumers;
- regulatory — analysis of energy-efficient projects and efficiency of investments, the end-user tutorials explaining the financial opportunities and determining the degree of urgency in implementation of projects;
- mediatory — coordination of needs and targets between different energy-efficient process management hierarchical levels (national, municipal, corporate and household), sectorial policy and coordination of strategic development between the levels;
- encouraging — choice of decision by energy end-user and its influence on achievement of higher energy efficiency outputs;
- controlling — control and audit of implementation of municipal energy efficiency projects to achieve the targets of regional sustainable policy and implementation of national energy strategy.

The author, when analyzing and evaluating the organization of achievement of energy efficiency targets during the energy efficient processes, has determined the barriers of structural units in overall structural system. The process of achieving the national and regional energy efficiency targets involves several structural systems, therefore, use of the process approach allows gear them to a closer cooperation. One of the most important advantages of the process

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<sup>24</sup> Rohleder R. T., Silver A. E. A tutorial on business process improvement. Journal of Operations Management, Volume 15, Issue 2. Elsevier B. V. 1997. — pp. 139-154. DOI:10.1016/S0272-6963(96)00100-3

<sup>25</sup> Koubarakis M., Dimitris Plexousakis D. A formal framework for business process modelling and design. Information Systems. Elsevier. 2002. — pp. 299–319. DOI: 10.1016/S0306-4379(01)00055-2

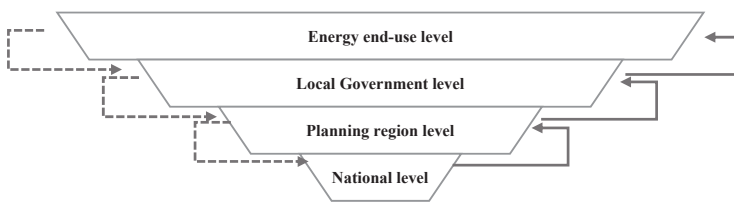
<sup>26</sup> Eku energoefektivitāte. LR ekonomikas ministrija. [Elektroniskais resurss] — Resurss apskatīts — 2014. gada 08. augustā — [https://www.em.gov.lv/nozares\\_politika/majokli/eku\\_energoefektivitate/](https://www.em.gov.lv/nozares_politika/majokli/eku_energoefektivitate/)

<sup>27</sup> Vanags J. Nekustamā īpašuma ekonomika. — Rīga: RTU Izdevniecība, 2010. — 297lpp.

approach is that when making any changes to the system it is easier to figure out what other changes are needed in order the progress of the processes would not be hampered.

The *Management system of energy efficient processes* defines the theoretical basis and practical operation generally in the management of energy efficient processes at all levels of hierarchy (national, regional, municipal, business), creating a toolkit of principles, methods, infrastructure, forms and organization for management of the energy efficiency field in the aspect of sustainable regional development.

The author considers it appropriate to look at the levels of implementation of the management of energy efficient processes, indicating their interactions — the implementation of the energy sector development contained in the National Development Plan, on the basis of conditions of implementation of the regulatory documents at local level and the effect of the needs of end-users on the targets included in the National Development Plan (Figure 3).



**Fig. 3. Levels of implementation of management of energy efficient processes** <sup>28</sup>

*[developed by author]*

Analysing the levels of implementation of management of energy efficient processes, the author concludes that each level has corresponding factors affecting the decision-making, which are essential at all levels of management of energy efficiency processes:

- increased energy efficiency and energy saving opportunities;
- energy consumption standards — energy certificates for buildings and technologies;
- improvement of energy ecology — measures for prevention of global warming, reduction in emissions of harmful substances.

Factors affecting the decision-making, development of regional energy policies and national development plans are as follows <sup>29</sup>:

<sup>28</sup> Eiropas Parlamenta un Padomes Direktīva 2012/27/ES, par energoefektivitāti, ar ko groza Direktīvas 2009/125/EK un 2010/30/ES un atceļ Direktīvas 2004/8/EK un 2006/32/EK. 2012. gada 25. oktobris. L 315/12 [Elektroniskais resurss] Resurss apskatīts — 2014. gada 10. augustā — <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:LV:PDF>

- energy consumption per capita in the region and changes in its dynamics;
- structure of energy consumption — electricity, heat energy, structure of energy resources used in the region;
- changes in number of population — dynamics of changes in energy consumers;
- introduction of high technologies — opportunities for introduction of efficient, energy-saving technologies in innovative ways.

The research author finds that the management of energy efficient processes is the operation of national, regional, municipal institutions, companies and the society, geared to the provision of use of energy resources, electricity and heat, as well as to the provision of justice in economic relations, using scientific and practical instruments in the implementation of targets and tasks of national strategy in the energy sector.

Table 1

**Groups of methods of management of energy efficient processes [developed by author]**

Groups of management measures	Solutions for management of EE processes
<b>Informative methods:</b>	
Analysis of regulatory information	EU regulatory enactments
	National strategy of economic development
	Concept of sustainable development of national energy sector
	National ecological policy
Environmental analysis	Assessment of technological options
	EE potential analysis
	Analysis of needs of end customers
	Analysis and evaluation of available funding
<b>Incentive methods:</b>	
<i>Administrative</i>	
Preventive	EE project analysis
	EE project constraints and selection
	EE project controls
	EE project audit
Regulatory	Licensing of EE expert activities
	Certification of facilities
	EE expert certification
	Legal supervision and counselling
Financial	EE project rationing
	<i>Economic</i>
	Tax rebates
	Subsidies
Financial	Quota system
	Credit guarantees
	Attraction of financing

<sup>29</sup> Zebergs V., Zeltins N., Grackova L. Biomass strategies and policies: local, regional and national bio energy developing // 19<sup>th</sup> European Biomass Conference and Exhibition — From Research to Industry and Markets, ICC Berlin — International Congress book of proceedings. Germany, 2011. — 8. pp.

It should be concluded that the factors primarily affecting the processes of decision-making at national level, for instance, the development of energy strategy and the National Development Plan, are the degree of national energy capacity and urbanization, as well as changes thereof.

Taking into account a complex and long-term nature of the projects for improvement of regional energy consumption indicators, as well as a high financial capacity in the management of energy effective processes at regional level, the following is considered important <sup>30</sup>:

- openness and coherence of decision-making in the process of planning and implementation of cooperation between regions, municipalities and companies;
- interrelated and complex solutions of energy issues;
- analysis of all measures related to the strategic and sustainable development.

According to Table 1, it is possible to systematize the methods of management of energy efficient processes, dividing into the groups of methods by the types of management impact. Information methods in the management system of energy efficient processes are associated with data processing, analysis and transfer to other participants of the system. The incentive methods in the interests of the management of energy efficient processes can be divided into two groups: administratively incentive methods and economically incentive methods. The group of administratively incentive methods can be subdivided into preventive measures (project analysis, selection, control, and audit) and regulatory measures (licensing, certification, legal supervision).

Taking into account that the decisions of energy end-users on energy efficiency measures are made on a voluntary basis, the informative and incentive methods are most effective for the management of energy efficient processes.

With the development of scientific and practical work in the field of management of energy efficient processes, Latvia acquires an opportunity to solve problems in the field of achieving the energy efficiency targets, involving not only the bodies of the State and local governments, but also the main energy end-user groups, which form the basis for the creation of the management system to achieve the national energy efficient targets.

With growing level of national development, difference between levels of development in individual regions is increasing. In order to balance these differences, on the basis of the LR law

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<sup>30</sup> Michna J., Ekmanis J., Zeltins N., Zebergs V., Siemianowicz J. Management Of Energy And Environment Conservation: Current Methodical Problems // Latvian Journal of Physics and Technical Sciences, NR 1. 2011. — pp. 28-42

“On the Regional Development”<sup>31</sup> the sustainable energy policy guidelines have been created (and freely available): “Guidelines for Energy Development 2014–2020” (The Action Plan for Sustainable Energy Development in Riga Planning Region 2014–2020, “Latvia’s Sustainable Development Strategy 2030” are still in the process of development).

Before starting the working-out of the energy sector development program at the regional level, the specific development situation in the region at a given time should be evaluated and recorded. In this way, it is possible to identify gaps and find appropriate solutions for the issue, as well as to determine in what direction and how to create the regional energy strategy for realization of long-term priorities and achievement of targets set in the Directive of the European Union of 2012/27/EU by 2020.

For better evaluation of scenario for developments in the management of energy efficient processes and an understanding of opportunities for efficient use of national economic policy instrument for development of the management system of energy efficient processes, identification and grouping of the influencing factors are needed. The influencing factors of the management system of energy efficient processes can be grouped according to the following characteristics:

1. Impact on energy market:
  - Factors affecting supply and demand.
2. Impact on energy end-users:
  - Factors affecting households’ decisions;
  - Factors affecting merchants’ decisions;
  - Factors affecting decisions of public organizations;
  - Factors affecting decisions of state institutions.
3. Socioeconomic content:
  - Monetary factors;
  - Factors affecting investment flows;
  - Educational factors of participants in the system;
  - Factors affecting interests of certain special groups;
  - Factors affecting the offer of implementation of energy efficiency projects.
4. Legal nature:
  - Factors affecting transactions in energy sector;

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<sup>31</sup> Reģionālās attīstības likums. Saeimā pieņemts 21.03.2002. 12 [Elektroniskais resurss] Resurss apskatīts — 2014. gada 11. Jūlijā — <http://likumi.lv/doc.php?id=61002>

- Factors affecting the process of adoption of regulatory acts, their content and implementation.

#### 5. Origin:

- Internal — micro-factors that constitute interaction of energy producers and end-users with other participants of national economy;
- External factors — macro-environmental factors within the competence of state institutions;
- National-level factors resulting from interactions of subjects of the management system of energy efficient processes;
- Transnational and global factors within the competence of the EU and the OCED countries;
- Global factors resulting from interactions of cross-border economic systems.

In Table 2, the author has grouped the energy sector and factors affecting the energy efficient developments, which serve as the basis for choice of the survey questions and performance of the survey, and for creation of management system of regional energy efficient processes, as described by the author in Chapter 3 of the Doctoral Thesis.

Indirect impact means the reactions to specific factors in the mediated way, for instance, delay or postponing the achievement of energy efficiency targets, a small degree of impact of the facts on the common sphere. Direct impact means the predictability of the factor, possibility to determine the degree of impact. For energy development in regions, the national tax strategy is also important as it is associated with productive employment, decline in shadow economy, innovations and capital investments. Hence, development of main guidelines of regional energy sector should also take into account the tax policy related documents.

Respecting the basic principles of sustainable development in achieving the main targets defined in the regional energy sector to shape the energy and energy efficiency policy, the following financial sources can be used: the Regional Fund; the State investments under the State investment program; the European Union's structural funds and the State budget financing; private investments.

Methodological solution for development of management of energy efficient processes is offered by the author in Chapter 3 of the Doctoral Thesis, which describes and characterizes the Model of the Management System of Energy Efficient Processes at regional planning level in Latvia.

Table 2

**Distribution of factors affecting the management of energy efficient processes [developed by author]**

Field	Factor	Level of impact	Type of impact
Social factors	Vocational education — lack of specialists in engineering sciences	Direct effect	Lack of specialists in the field of energy and related fields affect development of energy infrastructures and provision of efficiency.
	Extent of urbanization	Direct effect	Efficient distribution of energy resources, amount of CO <sub>2</sub> , type of heating system.
	Social inequality	Direct effect	Proportional difference of utility costs in households with different income levels.
	Human rights and security	Indirect effect	Right to receive energy services, energy supply security and reasonable price policy
	Demographic situation	Direct effect	Impact of the population number on the development of energy sector and opportunities of attracting investments.
	Level of education	Indirect effect	Level of education and awareness ("green thinking") affects people to support energy efficient projects.
	Preservation of cultural potential	Indirect effect	Provision of cultural and historical buildings with electricity and heat according to their specific needs. High level of investments in energy efficient projects and their economic efficiency.
	Health	Indirect effect	Provision of ecologically clean environment in the implementation of energy efficiency projects, provision of healthy indoor climate.
	Crime rate	Direct effect	Provision of secure supply of electricity and heat (theft of power cables and prevention of damage to heating mains). Increase in cyber vulnerability of energy systems in connection with interactive mutual linking of databases.
	Corporate social responsibility	Indirect effect	Voluntary activities of companies representing the energy sector affect the level of public awareness, as well as promote the implementation of environmental improvement projects.
	Level of employment and wages/salaries	Direct effect	Solvency of the population determines the opportunities of crediting energy efficient projects.
	Taxation policy	Direct effect	Changes in tax policy, providing tax rebates to promote interest in energy efficient projects.
Economic factors	Inflation	Direct effect	High levels of costs for implementation of energy efficient projects, investment profitability risk due to inflation, energy price fluctuations
	Migration	Indirect effect	Outward migration of population from less developed regions increases the payment burden of remaining population and the opportunities to attract funding.
	Investments	Direct effect	Impact of credit interest rates offered by third-party funding on the choice of energy consumers in relation to the need for implementation of energy efficient projects.
	Competitiveness	Indirect effect	Opportunities to reduce costs in manufacturing and service sector promote the competitiveness of companies.
	Pricing policy	Direct effect	Dependence of pricing policy changes on the costs of energy consumed in the process of service provision.
	Credit system, availability of funds	Direct effect	Negative attitude of banks towards implementation of energy efficient projects in less developed regions.
	Income level, employment	Direct effect	Development of energy industry and implementation of energy efficient projects contribute to generation of new jobs, providing income for residents of the country.
	National economic growth	Indirect effect	Impact of energy accessibility and energy pricing policy on development of other sectors of national economy affects overall growth in the country.
	Innovations	Direct effect	Availability of innovative technological solutions and efficiency.
	Legal status of heated areas	Indirect effect	Situation when the owner of heated area is not known or due to the owner's debts it is alienated, payments have not been made for the provided heat and electricity services.
	Tariffs and payments for resources	Direct effect	The effect of energy production subsidies, quotas and the mandatory procurement component on the energy price for the end-user.
	Environmental pollution (CO <sub>2</sub> )	Direct effect	Regional charge for CO <sub>2</sub> emissions affects the energy price policy.
Ecological and environmental factors	Development of infrastructures	Direct effect	Innovative concepts for use of new transport types and fuel sources, opportunities for implementation of electric vehicles and natural gas vehicles. The effects of high costs of underdeveloped regional infrastructure, unequal allocation of resources.
	Environmental quality indicators	Direct effect	Indoor climate improvement within the framework of energy efficient projects. Provision of conditions of environmental conservation in implementation of new projects of power generation.
	Ecological regulations	Direct effect	Limitation of pollutant emissions as a result of power generation for major energy-producing companies.
	Emission quotas	Indirect effect	Impact of emission quotas on regional ecological system and energy pricing policy.
	Environmental conservation restrictions	Direct effect	Impact of location of natural parks and reserves on implementation of new power generation projects.
Political and legal factors	Russia's energy diplomacy	Direct effect	Energy dependence on Russia's energy policy and its impact on opportunities to store shale gas.
	Corruption dampening	Indirect effect	Level of corruption in the country affects the development of energy sector and energy efficient policy.
	EU cohesion	Direct effect	The lack of common energy policy and its impact on energy market and regional infrastructure.



## 2. ANALYTICAL EVALUATION OF ENERGY SECTOR DEVELOPMENT AND MANAGEMENT OF ENERGY EFFICIENT PROCESSES IN LATVIA

Long-term demand for all forms of energy is associated with regional demographic changes (population growth changes in regions that consume the most energy), as well as with increased urbanization processes. Analysis of statistical data shows that the energy industry also affects the national economic growth: it contributes to job creation, increase in the gross domestic product per capita and the level of decline in poverty in the country, although it is also associated with price growth for energy providers and subsequent increases in tariffs<sup>32, 33</sup>. The target of management of energy efficient processes is to balance the conflicts of interests and in conditions of limited resources to achieve the most efficient results.

Average growth rate of world population 1990 to 2010 was 1.4%, while in previous 20 years — 1.8%<sup>34, 35, 36</sup>. The highest population growth rate 2.4–2.8% was observed in African and Middle Eastern countries, the lowest — about 0.2–0.01% — in OECD and CIS countries. According to statistical projections, the world population number by 2050 will grow up to 9.7 billion, while in Latvia it will shrink to 1.4 million<sup>37, 38</sup>. Besides, population of developing countries will constitute 4/5 of entire world population. Despite the increase in GDP, its growth per capita in these countries is negligible. Accordingly, the level of energy consumption per capita in 2050 will not rise significantly and it will not lag behind the OECD countries<sup>39</sup>.

Analysing and summarizing the scientific and analytical publications on energy and social patterns of the changes, the author concludes that the energy sector in relation to demographic and population changes in the standard of living is an essential factor in the process of planning and implementation phase of energy efficient processes, particularly in less developed regions.

In the total energy balance, average 22% of the consumed energy are produced from coal, which is the leading fuel type in power generation: 52% of total utilized resources. Hydro

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<sup>32</sup> Key World Energy Statistics 2014. International energy agency (IEA). France: Chirac - OECD/IEA, 2014. — p. 82.

<sup>33</sup> CESifo Group. Euro-zone economic outlook. 9. Januar 2008 - . [Elektroniskais resurss] — Resurss apskatīts — 2014. gada 28. oktobrī —

[http://www.cesifo-group.de/ifoHome/presse/Pressemitteilungen/Pressemitteilungen-Archiv/2008/Q1/press\\_6402757.html](http://www.cesifo-group.de/ifoHome/presse/Pressemitteilungen/Pressemitteilungen-Archiv/2008/Q1/press_6402757.html)

<sup>34</sup> 2013 world population Data sheet. Population Reference Bureau 2013. — pp. 7–18

<sup>35</sup> The Eurostat yearbook 2002. The statistical guide to Europe Data 1990-2000. European Communities, France, 2002. — p. 11.

<sup>36</sup> Crude rates of population change by NUTS 2 regions. Eurostat. [Elektroniskais resurss] — Resurss apskatīts — 2014. gada 28. oktobrī — <http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&language=en&pcode=ts00099&plugin=0>

<sup>37</sup> The Eurostat yearbook 2002. The statistical guide to Europe Data 1990-2000. European Communities, France, 2002. — p. 12.

<sup>38</sup> 2014 World population data sheet. [Elektroniskais resurss] — Resurss apskatīts — 2014. gada 28. oktobrī <http://www.prb.org/wpds/2014/>

<sup>39</sup> Drivers of the Energy Scene, A Report of the World Energy Council.. World Energy Council, 2003 — 23. lpp.

resources provide 5–6% of global power generation<sup>40</sup> while utilization of nuclear energy has reached 17–18%<sup>41</sup>.

In 1987, the United Nations (UN) in the World Commission on Environment and Development report “Our common future”<sup>42</sup>, also known as the Brundtland Commission’s report, for the first time had mentioned the concept of sustainable development, which was defined and internationally applied after 1992 Rio de Janeiro United Nations Conference “Environment and Development” (“Environmental Summit”, “Rio Earth Summit” or “Rio Conference”). Sustainable development is defined as “development that supports today’s needs without creating a threat to the needs of future generations”<sup>43</sup>. Sustainable development can be provided by strict environmental requirements and high economic indicators that do not interfere with the surrounding environment, it means that the economic development must not degrade the environment, as well as today’s decisions are to ensure a high quality of life for future generations<sup>44, 45</sup>.

20 years after the United Nations Conference on Environment and Development, the Conference “Rio + 20” was held in June 2012 in Rio de Janeiro. Its target was to renew the political support of commitments, to evaluate the progress and execution of previous commitments adopted by the Conference, as well as to evaluate the future challenges. The two main topics of discussions at the conference were: building of the “green economy” for sustainable development and poverty reduction, and improvement of international coordination for sustainable development by creating an institutional framework that includes the global, national and regional levels<sup>46</sup>.

Priorities of Latvian national energy policy are focused on the stability of energy supplies for inhabitants and national economic development. In order to achieve the targets of Latvian

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<sup>40</sup> Statistic. International Energy Agency. [Elektroniskais resurss] — Resurss apskatīts — 2014. gada 02. jūlijā — <http://www.iea.org/statistics/statisticssearch>

<sup>41</sup> Wellmer F. W., Becker-Platen J. D. Global Nonfuel Mineral Resources and Sustainability. [Elektroniskais resurss] — Resurss apskatīts — 2014. gada 02. oktobrī — <http://pubs.usgs.gov/circ/2007/1294/paper1.html>

<sup>42</sup> UN Documents. Gathering a body of global agreements. Report of the World Commission on Environment and Development: Our Common Future. Transmitted to the General Assembly as an Annex to document A/42/427 — Development and International Co-operation: Environment. [Elektroniskais resurss] — Resurss apskatīts — 2014. gada 18. februārī — <http://www.un-documents.net/wced-ocf.htm>

<sup>43</sup> Ilgtspējīga attīstība. Vides aizsardzības un reģionālās attīstības ministrija. [Elektroniskais resurss] — Resurss apskatīts — 2011. gada 28. oktobrī — [http://www.varam.gov.lv/lat/darbibas\\_veidi/ilgtspējiga\\_attistiba](http://www.varam.gov.lv/lat/darbibas_veidi/ilgtspējiga_attistiba)

<sup>44</sup> AGENDA 21. United Nations Conference on Environment & Development. Rio de Janeiro, Brazil, 3 to 14 June 1992. [Elektroniskais resurss] — Resurss apskatīts — 2011. gada 28. oktobrī — <http://sustainabledevelopment.un.org/content/documents/Agenda21.pdf>

<sup>45</sup> Elmar Römpezyk. Gribam ilgtspējīgu attīstību. — Rīga. Friedrich-Ebert-Stiftung. 2007. — 152 lpp

<sup>46</sup> Rio+20 United Nations Conference on Sustainable Development. Objective & Themes. [Elektroniskais resurss] — Resurss apskatīts — 2011. gada 28. oktobrī — <http://www.uncsd2012.org/objectiveandthemes.html>

national energy policy, it is firstly necessary to provide the access of energy end-users to commercial energy resources, followed by reliability and stability of energy supply guarantees. As long as the first-and second-level requirements are not identified and met, establishment of regional energy policy is impossible. Serious attention must be paid to environmental issues, such as climate changes and environmental pollution.

The target of management of energy efficient processes is primary energy savings in the amount of 0.670 Mtoe (28 PJ), which must be achieved by 2020 according to the energy efficiency Directive EU 2012/27/EU. Within the indicative target, the achievement of two sub-targets must also be ensured <sup>47</sup>:

- Annual savings 1.5% of energy delivered to the country's energy end-users — total 0.261 Mtoe (10,9 PJ) by 2020 (achievement of the target to be ensured by energy producers);
- 3% of state-owned building areas must be annually renovated, maximum estimate — total 678,460 m<sup>2</sup>, with respective energy savings 0.0044 Mtoe (0.18 PJ) throughout the period 2014–2020.

In 2013, final consumption of electricity in Latvia was 6,576 GWh, but in 2012 — 6,448 GWh, the growth being 1.98% GWh. Reduction of heat consumption in 2013 compared to 2012 is 3.2% <sup>48, 49</sup>. In the gross electricity consumption structure, three dominant sectors of consumption prevail: commercial and public services (35.8%), industry and construction (23,9%), and household sector (23.6). Energy consumption in the energy sector in Latvia is presented in Table 3.

Table 3.

**Breakdown of energy sector according to energy consumption <sup>50</sup> [developed by author]**

	TWh	%
Electricity	7.23	14
Transport	13.15	27
District heating	7.31	15
Local and individual heating	21.58	44
Total:	49.26	100

<sup>47</sup> Eiropas Parlamenta un Padomes Direktīva 2012/27/ES, par energoefektivitāti, ar ko groza Direktīvas 2009/125/EK un 2010/30/ES un atceļ Direktīvas 2004/8/EK un 2006/32/EK. 2012. gada 25. oktobris. L 315/12 [Elektroniskais resurss] Resurss apskatīts — 2014. gada 10. oktobrī —

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:LV:PDF>

<sup>48</sup> Latvijas Energobalance 2012. gadā. Centrālā statistikas pārvalde. [Elektroniskais resurss] — Resurss apskatīts — 2014. gada 18. septembrī — [http://www.csb.gov.lv/sites/default/files/nr\\_33\\_latvijas\\_energobalance\\_2013\\_14\\_00\\_lv.pdf](http://www.csb.gov.lv/sites/default/files/nr_33_latvijas_energobalance_2013_14_00_lv.pdf)

<sup>49</sup> Latvijas Energobalance 2013. gadā. Centrālā statistikas pārvalde. [Elektroniskais resurss] — Resurss apskatīts — 2014. gada 18. septembrī — <http://www.csb.gov.lv/dati/e-publicacijas/energobalance-2013gada-40642.html>

<sup>50</sup> A. Akermanis. Centralizētās siltumapgādes (un energoapgādes situācija): vai energoefektivitātes direktīvas ieviešana ir ceļš uz tarifu pieaugumu siltumapgādei (?). Enerģētikas forums. Ceļā uz ilgtspējīgu energoapgādi Latvijā. Rīga, 25.02.2015., 27.–31. lpp.

As shown in Table 4, the average energy intensity in EU member states gradually decreases, while in Latvia it is increasing with every year, therefore the author concludes that current management system of energy efficiency activity is not efficient and needs to be improved.

Basing on information in Tables 3 and 4, as well as on the energy efficiency target scheme, the author concludes that the greatest potential for achievement of energy efficiency targets is in local and individual heating supply, as well as in commercial and public service domain. To influence participants in the management system of these energy efficient processes, it is necessary to develop a model for the management of energy efficient processes at the level of planning regions, as reflected in Chapter 3 of the Thesis.

Table 4.

**Primary and final energy intensity in EU-28 and in Latvia <sup>51</sup> [developed by author]**

	Primary energy intensity (toe/1,000EUR)						Final energy intensity (toe/1,000EUR)					
	2007	2008	2009	2010	2011	2012	2007	2008	2009	2010	2011	2012
EU-28 (average energy intensity index)	0.152	0.151	0.149	0.152	0.144	0.143	0.152	0.151	0.149	0.152	0.144	0.143
Latvia	0.31	0.306	0.357	0.382	0.334	0.329	0.31	0.306	0.357	0.382	0.334	0.329

Referring to the data available from Eurostat, the electricity price for households in the first half of 2013 was the sixth lowest in the EU, but in the second half of 2013 — the fifth lowest among the EU countries. Electricity price (including taxes) for households (with annual consumption 2,500–5,000 kWh) in the first half of 2013 in Latvia was 137.8 EUR/MWh, but in the second half — 135.8 EUR/MWh <sup>52</sup>.

Opening of electricity market is a hot topic, because energy prices are likely to rise directly in the household segment. Households by 01 January 2015 were able to buy electricity according to tariff approved by the Public Service Regulation Commission (PSRC) on 15 February 2011. Until opening of the market on 01 January 2015, electricity users with the inlet protection apparatus current levels up to 40 A shall pay for the first 1200 kWh consumed during 12-month period 01 April 01 to 31 March 31 according to the Start tariff 0.1164 EUR/kWh, which includes

<sup>51</sup> Eurostat. Final energy consumption intensity (ENER 021) — Assessment published Jan 2015. [Elektroniskais resurss] — Resurss apskatīts — 2015. gada 18. janvārī —

<http://www.eea.europa.eu/data-and-maps/indicators/final-energy-consumption-intensity-3/assessment>

<sup>52</sup> European Environment Agency. EN31 Energy prices. [Elektroniskais resurss] — Resurss apskatīts — 2015. gada 18. Febbruārī — <http://www.eea.europa.eu/data-and-maps/indicators/en31-energy-prices>

trade in electricity at a price of EUR 0.0131 per kWh. The Basic tariff EUR 0.1515/kWh is applied to power consumed starting from 1201 kWh during the same period<sup>53</sup>.

Forecasts of JSC “Latvenergo” specialists suggest that with opening of electricity market the average cost of electricity purchase by households could be approximately 17 cents/kWh<sup>54</sup>.

Renewable energy resources occupy the third place in primary energy balance in Latvia. The two most common types of renewable energy are timber and water-power resources.

In comparison with 1990, the proportion of fuel wood in energy consumption in 2013 has increased by 92.4%. Wind energy and biogas are used in significantly less amounts. Solar energy is currently used only in very small amounts in the form of pilot projects<sup>55</sup>. Analysing Latvia-based renewable energy types, it can be concluded that the main types of resources are solid wood, biomass, wind power, biogas and hydropower<sup>56</sup>.

Latvia's long-term energy strategy 2030<sup>57</sup> provides to ensure the final consumption of electricity by using hydropower, biomass, biogas and waste, while in heat production — by biomass and biogas, and in transport — with biofuel.

In the light of energy sector development globally and in Latvia, the author further analyses the management system of Latvian energy sector, which is the basis of research carried out in Chapter 3 of the Thesis in relation to the need for development of the management system model for energy efficient processes in regions of Latvia.

Basing on analysis of main scientific and practical knowledge and the performed research, the author presents a graphical scheme of institutions involved in the management system of energy efficient processes (Figure 4). The management system of energy efficient processes involves four inter-subordinated hierarchical levels, ensuring the information flow and promoting the attainment of joint and individual targets.

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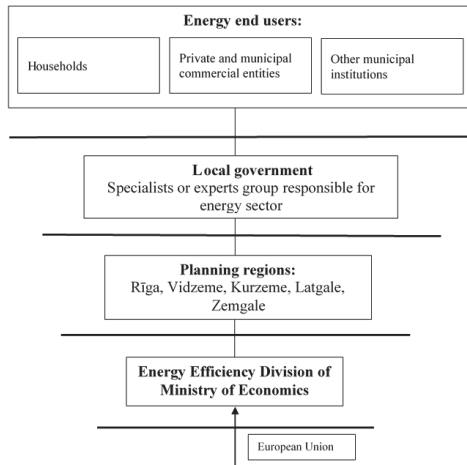
<sup>53</sup> Sabiedrisko Pakalpojumu Regulēšanas Komisija. Tarifi. [Elektroniskais resurss] — Resurss apskatīts — 2014. gada 12. decembrī - <http://www.sprk.gov.lv/lapas/Elektroenerģija#Tarifi87>

<sup>54</sup> Ekonomikas ministrija. Enerģētiskās Attīstības Pamatnostādnes 2014.–2020. gadam. (Informatīvā daļa). Projekts. Rīga, 2014. — 30. lpp

<sup>55</sup> Latvijas Enerģobalance 2013. gadā. Centrālā statistikas pārvalde. [Elektroniskais resurss] — Resurss apskatīts — 2014. gada 18. septembrī — <http://www.csb.gov.lv/dati/e-publikacijas/energobalance-2013gada-40642.html>

<sup>56</sup> LR prognožu dokuments par AER īpatsvara bruto enerģijas galapatēriņā līdz 2020. g. sasniegšanu, Ekonomikas ministrija, 2009. g. dec., 3. lpp.

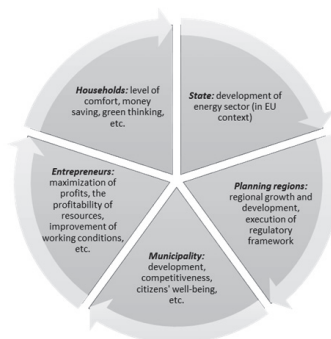
<sup>57</sup> Latvijas Enerģētiskās ilgtermiņa stratēģija 2030. gadam. AS “Latvenergo”. [Elektroniskais resurss] — Resurss apskatīts — 2014. gada 18. septembrī — <http://www.latvenergo.lv/portal/page/portal/Latvian/files>



**Fig. 4. Scheme of institutions involved in the management system of energy efficient processes**  
*[developed by author]*

Implementation of the system of planning and development of energy sector is currently a primary responsibility of the Department of Energy Efficiency of the Ministry of Economics, in cooperation with the ministries of Environment and Agriculture. At ministerial level, normative documents are being drawn up, which are binding on energy sector planning at regional and local government level. At state administration level, national interests are taken into account in the planning documents, which are linked to overall national economic growth and development, competitiveness with other countries, as well as agreed with the allies — compliance with the directives of the European Union, global-level implementation of agreements (the Kyoto Protocol). Regional and local government interests are closely linked and designed for a direct connection to the State policy. Their main goals are to ensure the development of energy sector, which would promote regional and municipal economic development, improvement of living standards, positive changes in social and demographic situation, as well as conservation and improvement of regional ecological system.

In Figure 5 the author schematically represents the system of interaction between the needs of participants (stakeholders) in the management system of energy efficient processes, which would be the optimal for development of the management system of energy efficient processes in the country.



**Fig. 5. Interaction between the needs of subjects of management system of energy efficient processes**  
*[developed by author]*

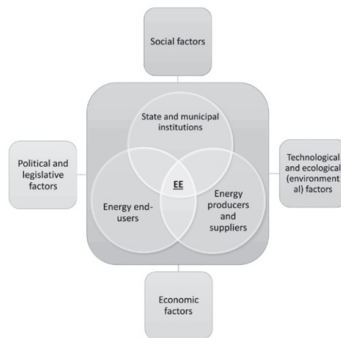
The group of energy end-users includes households, private and municipal commercial companies, as well as other consumers of electricity and heat. Within their operation, this group is also planning changes in energy consumption and associated funding. The author's practical experience shows that even though this group, particularly households, is considered to be the main potential for achieving the energy efficiency targets set out in the directives of the European Union, individual plans and targets for improvement of energy efficiency of the end-users are not fully included in the analysis of the process of achievement of national energy efficiency targets.

In the scheme of interaction between the needs of participants (stakeholders) in the management system of energy efficient processes developed by the author, merchants and households are also included as equivalent participants. Main interests of energy end consumers can be considered as saving of financial resources for achievement of targets: maximization of merchants' profit; improvement of indoor climate and living comfort for households.

Based on factors affecting the management of energy efficient processes identified in Chapter 1, it is possible to characterize the impact of interaction between factors affecting the achievement of energy efficiency, the subject of the management system of energy efficient processes and the management of energy efficient processes (Figure 6). Actions mutually coordinated between the State and local government institutions, energy producers and suppliers, as well as energy end-users are the basis for the achievement of energy efficiency targets by 2020 according to the EU Directive 2012/27/EU.

Interests and needs of households and merchants, which do not relate directly to the energy sector, are not currently included in the management system of energy efficient processes in a sufficient extent, thus creating unsubstantiated development planning documents in energy sector, which are incorporated based on approximately computed output data.

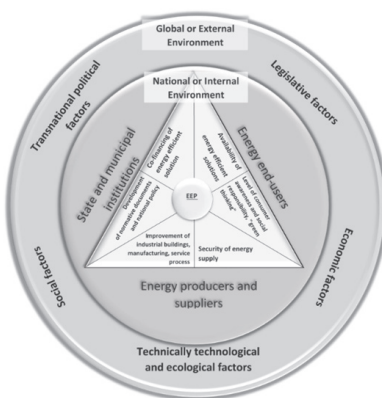
Choice of management methods in energy efficient processes depends on the impact of internal and external factors on the subjects of the management system of energy efficient processes (Figure 7). Within this research, the external environment is considered to be a set of global-level factors, but the internal environment — a set of national-level factors affecting the implementation of energy efficiency processes (EEP).



**Fig. 6. Scheme of interaction of factors affecting the subjects of management of energy efficient (EE) processes and their operation [developed by author]**

National and local government levels of ensuring the operation of the management system of energy efficient processes are mostly related to the development of normative documents, working out of the development strategy and long-term planning in energy sector. At national level, target-setting is affected by global economic changes, technological development, international political relations, demographic changes and population migration, interstate agreements on ecological solutions, as well as by the threat of ecological disaster. At the level of energy producers and suppliers, the global, or the external environmental factors affect the ability to provide power supply to the end-users, as well as to improve energy production and delivery processes. At the energy end-user level, the attainment of energy efficiency is associated with the awareness level of end-users and the availability of energy efficient processes in the light of technological innovations, available financial resources, ecological solutions, etc.





**Fig. 7. The entirety of external and internal environmental factors affecting the implementation of energy efficient processes [developed by author]**

Table 5 shows a complex of functions and tasks of energy agencies according to their impact on the micro- and macro-environment of the management system of energy effective processes in order to explain the graphical presentation of functions of the management system of energy efficient processes (Figure 8).

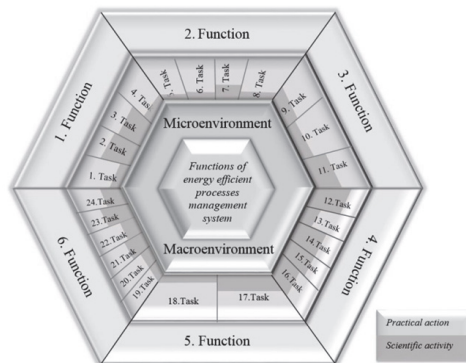
Table 5

**Functions and tasks of management system of energy efficient processes [developed by author]**

Micro-environment — internal environment				Macro-environment — external environment			
1	2	3	4	5	6	7	8
No.	Functions	No.	Tasks	No.	Functions	No.	Tasks
1.	Administrative — develop and update the concept of development of heat supply and the action plan of development of sustainable energy, organize and supervise their implementation, prepare the annual progress report on the implementation process.	1.	Establish and maintain a register of building heating and air conditioning equipment in Riga.	4.	Link (the State-local governments) — participate in development of draft legislative enactments, policy planning and regulatory documents Within competence: collaborate with the State and local government institutions, non-governmental organizations and other legal and natural persons within the competence.	12.	Prepare the energy demand and supply forecasts as a basis for making decisions on energy development.
		2.	Provide evaluation of energy, ecological and economic consequences of the measures.			13.	Prepare visuals and hand-outs on the issues and solutions for energy efficiency and renewable energy resources.
		3.	Establish and maintain local renewable energy equipment register in the administrative area, as well as annually renew the registry database on the amount of energy consumed from this equipment.			14.	Provide evaluation of energy, ecological and economic consequences of the measures.
						15.	Prepare the energy demand and supply forecasts as a basis for making decisions on the development of energy supply.

1	2	3	4	5	6	7	8
		4.	Collect and update information on energy efficiency and renewable energy resources, to create information databases.			16.	Data analysis and information collection.
2.	Control — provide energy inspector services to achieve increased energy efficiency in residential and public sectors.	5.	Selectively test the operational mode of power supply equipment for public buildings (schools, pre-school educational establishments, administrative buildings, etc.) and provide advice on optimum temperature regime.	5.	International communication — cooperate with foreign and international bodies and organizations, in matters within their competence.	17.	Encourage the use of economically viable and ecologically clean energy-efficient technologies.
		6.	Perform supervision of energy certification according to the requirements of the regulatory enactments.			18.	Encourage investment attraction in increasing the energy efficiency and use of renewable energy resources.
		7.	Establish and maintain a register of renovated multi-family houses and public buildings, through monitoring of energy consumption in buildings for 5 years after the renovation of buildings.	6.	Informative (at national and international level) — publish informational materials and provide information to media about issues within competence of the Agency, organize energy days.	19.	Participate in organizing exhibitions about energy efficiency and renewable energy resources.
		8.	Randomly perform on-site inspections of energy efficient facilities and renewable energy equipment, and provide advice on improving the equipment operation.			20.	Maintain and update the Energy Agency website
3.	Informative (regional level) — to establish and maintain the Agency's structural unit — Information Centre for Energy Efficiency, which provides access to information for citizens.	9.	Provide advice in the field of energy supply, energy efficiency and renewable energy resources.			21.	Encourage economically viable and ecologically clean energy-efficient technologies.
		10.	Arrange and update exhibitions at the Information Centre for Energy Efficiency dedicated to energy efficiency and renewable energy.			22.	Encourage implementation of public and private partnerships.
		11.	Arrange seminars, conferences and activities of the Expert Discussion Club on issues of energy efficiency and use of renewable energy and solutions.			23.	Provide advice in the field of energy supply, energy efficiency and renewable energy resources.
						24.	Arrange seminars, conferences and activities of the Expert Discussion Club on issues of energy efficiency and the use of renewable energy and solutions.

Breakdown of functions is designed according to their impact on the activities of regional-level energy efficient processes, the decision making process of energy efficient solutions and the national-level management system of energy efficient processes. Within the research of the Doctoral Thesis, at regional level the operative micro-environment of functions of the management system of energy efficient processes relates to regional energy efficient processes, but the macro-environment is the national level management of energy efficient processes.



**Fig. 8. Catalogue of functions and tasks of management system of energy efficient processes**  
*[developed by author]*

Figure 8 shows the breakdown of functions and tasks of the management system of energy efficient processes according to belonging of issues to be solved to either the micro-environment or macro-environment. Figure 8 demonstrates the proportion between practical action and scientific activity in each task of the management system of energy efficient processes, basing on experience gained when the author worked in the position of the Head of the Latvian Energy Efficiency Network and in the position of the scientific assistant at the Energy Efficiency Centre of the Institute of Physical Energy.

The author of the Doctoral Thesis believes that the most important hierarchical level to achieve the energy efficiency targets by 2020, according to the European Union 2012/27/EU, by improving the operation of the current management system of energy efficient processes, relates to energy end-users. The main energy consumers are households, followed by transport, manufacturing and service sectors, and the achievement of the energy efficiency targets is

associated with them. Despite the functions of above-mentioned planning and energy agencies, no accurate data exists in Latvia on final energy consumption by all natural and legal persons that can be considered as energy consumers. Information about end-users is collected by energy suppliers to maximize their profit and by the Central Statistical Bureau within their functions and competence. Precise data for provision of management of energy efficient processes at regional and local government levels is not freely available. In the light of the opening of electricity market in 2015 and the emergence of new energy suppliers, obtaining data on final energy consumption at regional and local government levels may be too difficult.

### **3. METHODOLOGY OF DEVELOPMENT OF THE MANAGEMENT SYSTEM OF ENERGY EFFICIENT PROCESSES**

The main objective of the survey of experts in the energy sector is to identify the main problems for successful implementation of the existing national energy strategy in the context of global development of energy sector, and to ensure the developments of the management system of energy efficient processes related to them, as well as to analyse scenarios of potential activities for encouraging factors, processes and energy efficiency, affecting the attainment of energy efficiency targets set out in the European Union Directive 2012/27 EU.

Choice of questions and factors included in the survey is based on the dynamics of changes in energy sector and the dynamics of economic, social and demographic changes in the country, which are analysed in Section 2 of the Thesis, as well as interaction relationships within environmental changes

To evaluate the factors affecting the implementation of the National Energy Strategy and the regional energy efficiency plan, the author has carried out surveys in both 2013 and 2014.

The research group was made up of professionals in energy sector and related spheres: oil and gas; coal; nuclear energy; renewable energy resources; energy production; energy delivery and brokerage services; finance; the Government; public bodies; other related fields. Views of science and business experts on the development of energy sector, as well as evaluation of affecting factors from the point of view of business or research, are necessary for the process of strategic decision-making at different levels of sectorial planning, taking into account the impact of decisions taken in other sectors of national economy, overall economic growth in the country and

changes in competitiveness. General group of respondents was made up of 100 representatives of science (scientific institutes, universities and public organizations) and 100 representatives of regional energy companies. Respondents representing the energy sector in the business group of specialists were selected according to the structure of planning regions, sending out 20 surveys within each planning region.

In both 2013 and 2014, the opinion surveys were distributed to 200 specialists related to the energy sector. In 2013, responses were received from total 100 respondents, of which 52 were specialists working in energy-producing or related transporting companies in Latvia, but 48 were scientists representing Riga Technical University, Latvia University of Agriculture, Institute of Physical Energy or Academy of Sciences of Latvia. In 2014, the ratio of the surveyed specialists in the sector was 69 representatives of business against 64 representatives of science sector. In total, 133 specialists of energy sector were surveyed in 2014. Changes in activity of the respondents can be explained by changes in the method of survey data collection — interviews of the respondents carried out by the author for obtaining the results of the survey.

The form of opinion survey for identification of factors affecting Latvian energy sector and energy efficiency processes to find out the views of specialists and scientists of the sector was prepared in the Latvian language and intended to be filled out anonymously, specifying the respondent's age and the represented sector: oil and gas, coal, nuclear energy, renewable energy, energy producers, suppliers, service providers, finance and the Government, academic, association or energy unions or associations, other fields by specifying the represented one. The survey forms were filled out personally (interviews with respondents) or distributed using electronic resources. Low rate of response to surveys sent electronically can be explained by their long form (twelve typed pages). The biggest response was observed from the Riga planning region, which is due to the consistency of the system in Riga, as well as to the largest concentration of energy producing companies in Riga region. Characteristics of the groups of respondents are presented in Table 6.

Measurable indicators in the target audience (representatives of the sector, employed in business, responsible managers and their deputies) and specialists of the sector, representatives of scientific research sector (scientific institutes, universities or public organizations) demonstrated the presence of the respondents' views and understanding of major factors and processes affecting the energy and energy efficiency.

Table 6.

**Factors affecting Latvian energy sector and energy efficiency processes [developed by author]**

<b>Factor</b>	<b>No.</b>	<b>Factor</b>	<b>No.</b>
Large scale accidents	1.	US trade and policy influence	20.
Global recession	2.	Trade barriers	21.
Capital market restrictions	3.	Regional interconnections	22.
Energy prices and instability	4.	Innovative market structure and policy	23.
Commodity prices and instability	5.	Energy subsidies	24.
Currency uncertainty	6.	Decentralized systems	25.
Energy, water and food link	7.	Sustainable cities	26.
Uncertainty of global climate framework	8.	Carbon dioxide capture and storage (CCS)	27.
Talent shortage	9.	Renewable energy	28.
Lack of energy	10.	Biofuels	29.
Energy availability	11.	Intelligent networks	30.
Extreme weather threat	12.	Electric vehicles	31.
Cyber threat	13.	Electricity storage	32.
Corruption	14.	Nuclear power	33.
Terrorism	15.	Hydropower	34.
Chinese/Indian growth	16.	Unconventional fossil fuels	35.
Russian energy diplomacy	17.	Liquefied natural gas (LNG)	36.
EU cohesion	18.	Hydrogen energy	37.

At the beginning of the survey form the respondents were asked to provide information about the represented field and the age of the respondent (in age groups <30; 30–45; 45–60; >60). In total, the respondents were asked 37 questions, which were divided into 4 specific groups:

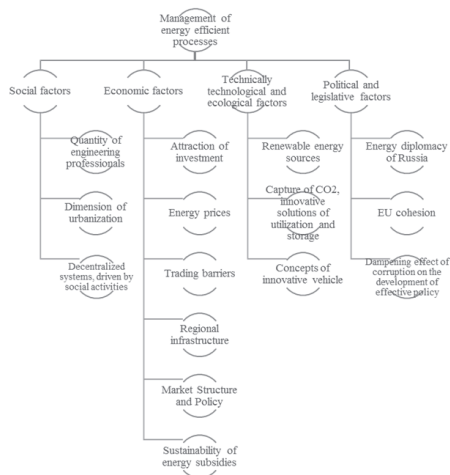
- Macroeconomic factors;
- Technology and development vision factors;
- Business environment factors
- Geopolitical factors.

When carrying out the expert opinion survey and analysing the results obtained in 2013 and 2014, the fact was taken into account that the development of Latvian energy sector is inseparable from the European Union and the direction and policy of energy sector development in other world countries (OECD), because due to insufficient availability of energy resources Latvia depends on foreign energy and supplies of energy resources.

Based on the compilation of opinions of 2014 in the energy sector, the author was able to determine the level of impact by individual indicator in each factor group on the management

system of energy efficient processes and the degree of urgency in solving the most important issues.

Comparing the factors, changes in topicality and compiling the specialists' views on the topicality of each group of factors and the impact on the energy sector and energy efficiency processes in 2014, the author has created a breakdown of factors affecting the management of energy effective processes, as shown in Figure 9.



**Fig. 9. Breakdown of factors affecting the management of energy effective processes [developed by author]**

Diagram on Figure 9 contains factors that have the highest level of impact in achievement of energy efficiency targets and in development of the management system of energy efficient processes in Latvia and its regions, according to the results of the survey of specialists in the energy sector in 2014.

The factors affecting the management of energy effective processes can be grouped into four groups: social factors, economic factors, ecological factors, political and legal factors. In the group of social factors, the most significant factors are the number of engineering specialists, urbanization level and decentralized systems, driven by changes in social activities. In the group of economic factors, the most topical issues are the attracting investments, energy prices, barriers to trade, regional infrastructure, energy market structures and policies, as well as sustainability of energy subsidies.

Ecological factors that must be taken into account in the operation of the management system of energy efficient processes are as follows: use of energy resources, CO<sub>2</sub> capture, utilization and opportunities of introducing the innovative storage solutions and implementation of innovative vehicle concepts in the regions.

In the group of political and legal factors, the most significant issues are as follows: energy diplomacy, the European Union's cohesion and dampening impact of corruption on sectorial development and development of efficient policy.

The determined groups of factor affecting the management of energy efficient processes serve as a basis for the management system of regional energy efficient processes that allow the specialists of the sector (at all levels of the hierarchy of the management of energy efficiency processes) and energy end-users to better navigate through all phases of developments in the management of energy efficient processes.

To raise the awareness of the potential for energy efficiency for achievement of energy efficiency targets in accordance with the Directive of the European Union 2012/27/EU and for identification of issues of the management system of energy efficient processes, the author has carried out a survey of five local governments of the planning regions.

The content of the author's developed survey is based on the legislative package determining the guidelines created by the European Union and the Latvian National Energy Efficiency Guidelines, which set out the targets in the policies of energy, energy efficiency and climate:

- For industries, power plants and boilers, which are included in the emissions trading system — by 2020 the emissions should be reduced by 21% compared to 2005 levels;
- For other sectors — households, service providers, small industries, agricultural sector, waste managers, etc. — CO<sub>2</sub> emissions by 2020 should be reduced by 10% compared to 2005 levels.
- By 2020, 40% of the total final energy consumption should be provided by renewable energy resources;
- Improvement of energy efficiency, achievement of primary energy savings in 2020 — 0.670 Mtoe (28 PJ).

To identify the regional energy efficiency potential, the sample respondents were selected according to the planning regions of Latvia and their subordinate local governments; the survey forms were sent to 110 local governments and 9 major urban municipalities, which were intended



to be filled out by officers responsible for the strategic planning or energy metering and monitoring (Table 5).

The survey form included 7 questions divided into two groups: “final energy consumption” and “energy production and transmission”.

The first set of questions covers the awareness of the existing situation with the final energy consumption in the sector of municipal buildings — municipal residential buildings, municipal public buildings, industrial production buildings; public street lighting and public transport sectors.

The second set of questions covers the awareness of the indicators of power generation and the transmission system in the local government — power generation and supply; heat production and supply, heat losses in the networks.

Low response rate and the number of incompletely filled out survey forms demonstrate the need for the management system of regional energy efficient processes. Maintenance of database of regional energy efficiency potential will promote the quality of work of the management system of energy efficient processes and the achievement by 2020 of targets set out in the Directive of the European Union 2012/27/EU.

Table 7

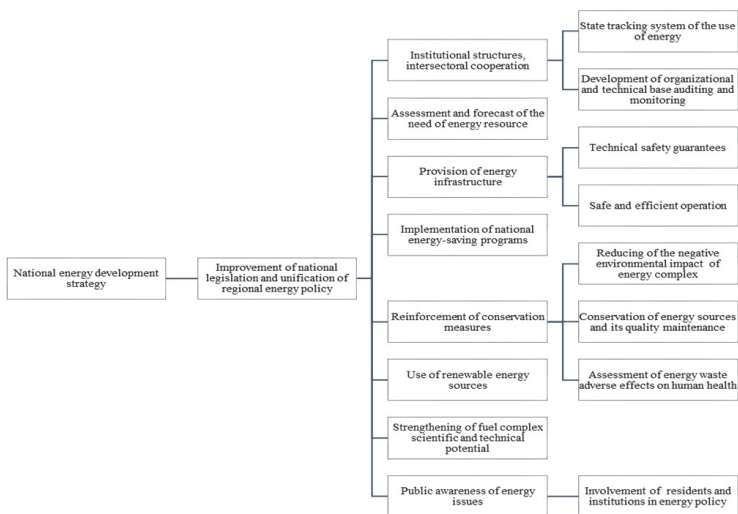
**Number and characterization of respondents of the survey [developed and calculated by author]**

Signs	Data within the research	
	Local governments of planning regions	
	Municipalities	Cities
Area	The Republic of Latvia	The Republic of Latvia
Time of the survey	04–06/2013	04–06/2013
Survey unit	Responsible officer	Responsible officer
General group/number of respondents	110	9
Competence of the respondents	By rank	By rank
Number of the survey forms filled out	46	4

Operation of the management system of energy efficient processes (EEP) directly affects the quality of life improvements of local residents in the light of natural opportunities of the region’s ecosystem and a competitive business development. At regional level, the management system of energy efficient processes means an interaction of interrelated elements of the energy sector, a process of planning of their long-term development and control. At regional level, the functions of the management system of energy efficient processes include the current situation evaluation

and the development of plans of energy efficiency measures to be taken by local governments, as well as monitoring of implementation of planned measures and monitoring of energy consumption after realization of energy efficiency projects.

Development and improvement of the management system of energy efficient processes have a direct impact on the development and implementation of sustainable regional energy policy, including the development, evaluation, implementation and control of short-term plans of efficient measures taken by local governments of the region's area for encouraging further economic development of the region, creating the coherent regional development plans. The tasks of the management system of energy efficient processes at national level are presented in Figure 10.



**Fig. 10. Tasks of management system of energy efficient processes at national level**  
*[developed by author]*

The task of national-level management of energy efficient processes is to promote the inclusion of the priorities of the energy sector in the national and economic strategy, according to internally (nationally) and externally (globally) affecting factors, the research of which is carried out in Chapter 2.1 and 3.1. of the Thesis.

The first phase in development of the management system of regional energy efficient processes is the formulation of main guidelines for local and regional energy policy in accordance with the guidelines of national energy development and respective directives of the European Union, Latvian laws and regulatory enactments on solution of issues of energy supply, energy efficiency, renewable energy resources, conservation and environmental quality.

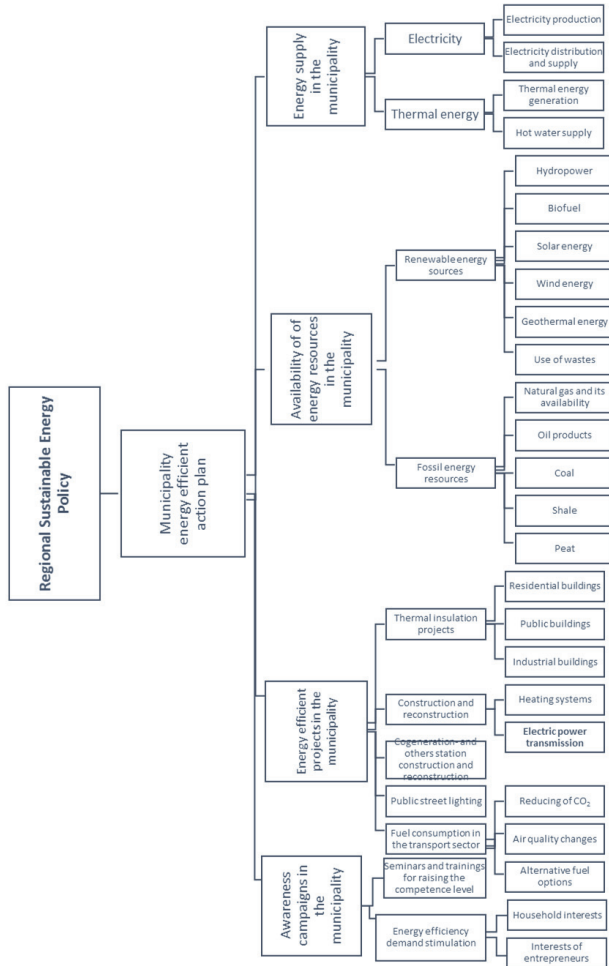
Operation of the management system of energy efficient processes in regions is associated with the implementation of national priorities at local government level, encouraging the use of renewable energy resources for heat and electricity production, planning and implementing measures for the security of energy supply, and encouraging the demand for energy-efficient solutions in the interests of commercial companies, industries, service sector and households, in cooperation with organizations of administration and management of buildings, as well as creating a policy for conservation of climate in the country and regional ecosystem.

The structure of regional energy efficient processes (Figure 11), which is a part of regional energy policy and sustainable development strategies and the quality of which depends on efficient and successful operation of the management system of regional energy efficient processes, is composed of four task groups:

- power supply in the local government: data collection about power and heat production and supply companies (number of manufacturers, capacity of energy-producing plants, type and consumed amount of utilized energy resources, final energy consumption and other indicators);
- availability of energy resources in the local government: availability of renewable and fossil energy resources, and their use;
- energy efficient projects in the local government: insulation projects for residential, public and industrial buildings; construction and reconstruction of heating and power networks, CHP and other power generation stations; construction and reconstruction, technical and economic evaluation of public street lighting and fuel consumption in transport sector;
- information campaigns in local governments: encouraging the demand for energy efficient solutions within the local government in the interests of energy end-users — households, commercial companies.

The target of the strategy of development of regional energy policy and sustainable energy is to encourage a positive economic development of the State and local governments, addressing the

issues of increasing the safety of energy supply and implementing the energy efficiency projects in local governments.



**Fig. 11. Structure of regional energy efficient processes [developed by author]**

In order to also involve the final consumers (households and merchants that are not directly related to the energy sector) in implementation of energy efficient processes, it is recommended

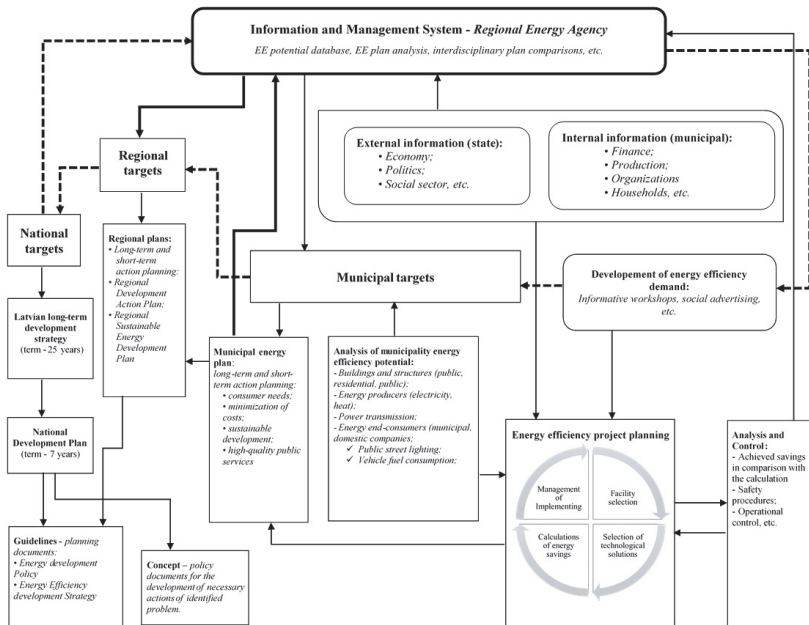
to take into account their needs and wishes. To solve this problem, the author proposes to develop the management system of energy efficient processes at regional level, the functions and tasks of which would be implemented by a publicly funded regional energy agency. The need to establish such organization is justified by the results of the author's survey in relation to the energy efficiency potential of local governments (data on energy production and final consumption) and by observations within the professional activities — in a local government (region), which does not have the Energy Agency with its characteristic function, data collection on energy production and final consumption is cumbersome, restricting the possibility to create and maintain a reliable database, as well as affecting the planning of energy efficient processes and comparison of results.

Figure 12 shows a model of the management system of energy efficient processes, including the regional energy agency as the sole institution providing the implementation of EEP management functions at regional level. The scheme is developed based on the author's research of analytical evaluation of operation of current management system of energy efficient processes in Latvia, as shown in Sections 2.2 and 2.3 of the Thesis.

In Figure 12, the management cycle of regional energy efficient processes is shown by a dashed line that represents interaction between participants of the management system of energy efficient processes. The author proposes to establish a state-funded energy agency as the primary planning institution for the development of energy sector in the region, the tasks of which include the collaboration with all subjects of the management system of energy efficient processes at all hierarchical levels of management of energy efficient processes.

According to Figure 12, the principal institution of the management model of energy efficient processes at regional level, which is responsible for energy efficiency and development of energy sector-related issues and processes at regional level, is the Energy Agency that can be created as an independent body, or a subdivision of the planning region with a partial or full state funding. It establishes the targets included in the documents of national level strategic planning, representing the interests of energy end-users, included in the regional sustainable energy development documents prepared in the light of requirements of sectorial normative documents and providing advice to local governments for implementation thereof according to opportunities of local governments.

Implementation of the model of the management system of energy efficient processes at regional level in accordance with the “National Development Plan 2014–2020” and “Guidelines for Energy Development 2014–2020”, is directed towards the level of public awareness on energy efficiency issues, the increased interest merchants and inhabitants in energy efficiency measures that pay off over a period longer than 5 years, the development of financial solution for high initial investments into individual energy efficiency activities, the decisions of owners of multi-family buildings influencing the acceptance of renovation of buildings.



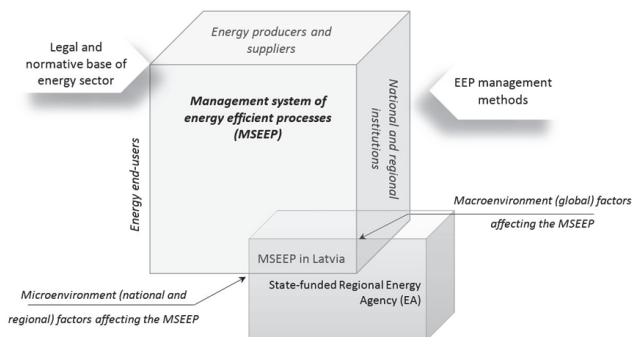
**Fig. 12. Model of management system of energy efficient processes for regional planning level in Latvia**  
*[developed by author]*

Operation of the model of management system of energy efficient processes allows to use the European Union’s structural funds for energy efficiency improvements, for implementation and promotion of energy efficiency improvement measures, comprehensive cooperation of energy supply merchants with energy consumers, also for implementation of changing measures in information and consumer activities. Recommendations for the energy audits and energy efficient

solutions developed by the regional energy agency will contribute to competitiveness of companies and increased solvency of households, which in turn will provide the opportunity of reallocating the funds intended for other purposes, as a result of implementation of energy efficiency measures.

Introduction of the model of the management system of energy efficient processes at regional level provides the opportunity to carry out a coherent and planned improvement of the consumer and heating system energy efficiency in local governments, while the already developed projects of energy efficient solutions encourage the economic activity and employment in local governments and in the entire region.

As criteria of introducing the model of the management of energy efficient processes, the resulting indicators can be considered, which are set out in “Energy Development Guidelines 2014–2020”.



**Fig. 13. Methodological solution for development of management system of energy efficient processes**  
*[developed by the author]*

According to information provided in Figure 13, the operating principles of the management system of energy efficient processes, in response to the impact of the factors affecting the choice of energy effective solutions, must be as follows:

- multi-tiered — all factors that affect the choice of energy efficient solutions can be grouped by the levels of the management system of energy efficient processes;
- complexity — the process of the development of the factor impact must be based on the output data indicators and mathematical methods in support of technological solutions;

- standardization — all objects of the management system of energy efficient processes should be defined nationally;
- openness — the system must be adapted for incorporation of new management models of energy efficient processes to affect the choice of energy efficient solutions of energy end-users;
- accessibility — the system must be available for representatives of all hierarchical levels of the management system of energy efficient processes and should maintain the binding industry information databases.

As the awareness of energy end-users about the direction of national and municipal energy policy is of great importance since the final energy consumption in households is considered one of the main potentials for attaining the targets of energy efficiency, great emphasis should be laid on ensuring the flow of information between the State and energy end-users — households and companies.

The created model of the management system of energy efficient processes for regional planning level and methodological solution for creation of the management system of energy efficient processes are among preconditions for implementation of the tasks of the European Union's Directive 2012/27/EU, which can affect the decisions of energy end-users on application of energy efficient solutions in their use of all types of energy: electricity and heat. This justifies the need to continue research on the management system of energy efficient processes in order to improve the methodological solution offered by the author.

## CONCLUSIONS AND PROPOSALS

Responsibility of Latvia as a Member State of the European Union is to achieve the targets set out by the European Parliament and Council Directive EU/27/2012 on energy efficiency, which amends previously adopted Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC by 2020. The achievement of the targets can contribute to the development of the management system of energy efficient processes at national and regional levels, which is directly related to the opinion formation of energy end-users — companies and households, and encouraging the demand for energy effective solutions.



The need for the development of the management system of energy efficient processes is based on the EU Directive 2012/27/EU, which requires the local governments to establish energy efficiency plans, which include implementation of specific targets for energy efficiency and energy saving measures, and the Conference "Rio + 20" held in June 2012 on topical subjects: the necessity of establishing institutional structures on global, national and regional institutional levels to encourage the national sustainable development.

Carrying out the research on functioning of the management system of energy efficient processes at regional level, proposed hypothesis is confirmed; the author also observes different types of drawbacks and lack of feedback between energy end-users and the responsible institutions that provide the development strategy for the energy sector and development of plans, thereby confirming the need for a methodological solution for the development of the management system of regional energy efficient processes in Latvia.

Basing on theoretical guidelines and analytical knowledge developed in the Doctoral Thesis, as well as evaluating the multi-layered procedural nature of the management system of energy efficient processes and realizing the development trends in Latvia energy sector and worldwide, the author presents the results of the research in the following conclusions:

1. Within the framework of the research of energy sector development and factors affecting the management of energy efficient processes, analysing the scientific and practical materials in the English language, the author concludes that for characterization of energy as a sector of national economy in the English language, a single term is not used that would denote energy as a sector of national economy as a whole. Several terms are used in various scientific, practical and applied sources of literature, where each term has its own, slightly different, specific definition. Lack of uniform terminology can lead to misunderstanding and in the preparation of translations of scientific and practical materials in English and in Latvian.

2. To achieve the energy efficiency targets set out in the European Union and the development of national economy sectors in Latvia, the management methods in energy effective processes and the ways of efficient use of energy resources are studied by scientists of management science, energy sector and economists-researchers, thus a situation is created when the research objects and novelties are duplicated and compete with each other.

3. Basing on lexicological research of the concepts in energy sector, the author proposes a clarification of the definition "energy efficient processes": energy efficient processes are an

entirety of implementation of energy efficient solutions or a complex of related services, with a specified value, resulting in changes in the value of energy consumed by objects or processes.

4. The management of energy efficient processes is an entirety of functions and tasks with the aim of obtaining the maximum economic effect and the reduction of energy consumption, as a result of implementation of energy efficient processes and energy efficient solutions.

5. The subject of the management of energy efficient processes: economic, technological and social relationships between energy sector participants, mutual interaction of which involves a series of related processes in the management system of energy efficient processes.

6. The management system of energy efficient processes is an entirety of the theoretical basis and practical actions at all hierarchical levels, creating a complex of principles, methods, infrastructures, forms and means of organization for the management of the field of energy efficiency in the aspect of a sustainable regional development. For implementation of functions of the management system of energy efficient processes, both the systematic and procedural approaches are applicable.

7. Factors affecting the energy effective processes: elements of national legislation, other sectors of national economy and social system, entirety of which affects the choice of energy efficient solutions by final energy consumers.

8. Development of the management system of regional energy efficient processes can contribute to a sustainable development of energy sector both in the region and in the country as a whole if the functions of the management of energy effective processes at regional level are geared towards the provision of a competitive business environment and improvement of living conditions of local residents, taking into account the nature of surrounding environment and its improvement requirements within the region.

9. As a result of industrial development, global demand for energy continues to grow. The interaction of the energy sector development with the national economic, demographic and environmental changes is an essential factor in choice of management methods in the management system of energy efficient processes.

10. Balanced national energy policy is based on public understanding of most important issues of energy security and the need to achieve the energy efficiency targets. The goal of the management system of energy efficient processes is to balance the conflicting interests in the

management system of various energy efficient processes, and to achieve the most efficient results in conditions of limited financial and energy resources.

11. Choice of the management methods of energy efficient processes for the implementation of functions of the management system of energy efficient processes at national level depends on the effect of internal (national-level) and external (global-level) factors on the subjects of the management system of energy efficient processes.

12. According to the results of the survey of energy sector specialists, social factors affecting the choice of the management system of energy efficient processes and implementation of functions and tasks of the management system of energy efficient processes are: insufficient number of engineering specialists in regions of Latvia, scope of regional urbanization scale and decentralized systems affected by changes in the social activities.

13. The results of the survey of energy sector specialists have shown that economic factors affecting the choice of the management system of energy efficient processes and the functions and tasks of the management system of energy efficient processes are: attracting investment in the solution of energy efficient projects, energy prices and instability thereof, trade barriers, infrastructure in regions, energy market structures and policies, as well as the impact of energy subsidies on the development of the energy sector.

14. According to the results of the survey of energy sector specialists, ecological factors, which affect the implementation of functions and tasks of the management system of energy efficient processes as well as the choice of the management methods of energy efficient processes, are the use of renewable energy resources, CO<sup>2</sup> capture, utilization and opportunities of implementation of innovative solutions, and implementation of the concept of choice of innovative vehicles in regions.

15. In the group of political and legal factors, topical factors that have a large impact on the level of energy sector development in Latvia, on the implementation of functions and tasks of the management system of energy efficient processes, as well on the choice of the management methods of energy efficient processes, are: Russian energy diplomacy, cohesion of the European Union, dampening effects of corruption on the development of the sector, and working out the effective policies.

16. Management system of energy efficient processes involves four hierarchically inter-subordinate levels: national, regional, local government, and end-user, which as a result of

interaction and continuous flow of information contribute to the achievement of joint national targets and individual targets of energy end-users. The following institutions involved in the management system of energy efficient processes: the Ministry of Economics in cooperation with the Ministries of Environment and Agriculture; planning regions — Riga, Vidzeme, Latgale, Zemgale and Kurzeme; specialists of local governments in the energy sector or groups of specialists; energy end- users — households, private and local government companies, other institutions of local governments.

17. The entirety of functions and tasks of the management system of energy efficient processes is focused on the provision of interaction of the needs and interests between participants (stakeholders) in the management system of energy efficient processes. The subjects of the management of energy efficient processes are the State and local government institutions, energy producers and suppliers, as well as energy end-users.

18. Achievement of energy efficiency targets set out in the European Union's Directive 2012/27/EU is possible through the cooperation between all subjects of the management of energy efficient processes — State institutions, energy producers and suppliers, as well as energy end-users, taking into account social, economic, political, legal, and environmental factors influencing the process of decision making for energy efficient solutions.

19. Development of Latvian energy sector and implementation of functions and tasks of the management system of energy efficient processes is associated with sectorial associations and professional organizations formed of specialists, which operate in the energy sector and are established for consolidation of knowledge and experience of professionals in the field for representation of interests within the sector, creation of national policy and management of energy efficient processes. They are involved in consultancy and research purposes.

20. Basing on the results of analysis of the energy efficient potential, the author concludes that the information flow between the hierarchical levels of the management system of energy efficient processes, mainly national level and energy end-user level, does not function properly enough. A break in the information flow can be observed in the direction from energy end-users to the state institutions, therefore the planning of energy sector development the achievement energy efficiency targets set out in the European Union's Directive 2012/27/EU is primarily oriented to the improvement of efficiency in energy-producing companies and in properties owned by local governments.

21. The survey of local and regional authorities on determination of the energy potential has shown that planning at regional level, which is currently implementing the functions and tasks of the management of energy efficient processes in cooperation with existing energy agencies, is unable to provide proper management of energy efficient processes because of their restricted legal rights and, consequently, limited availability of information. The regional planning tasks include planning of the entire region's development, including regional plan of sustainable energy, but the agencies have no right to require information needed for implementation of the management of energy efficient processes from commercial companies. Final energy consumption metering and database maintenance in local governments are not carried through the lack of specialists.

22. Energy agencies are associations that carry out the management of energy effective processes only in a few local governments: Energy Agency of Riga — only in the municipality of Riga; Zemgale Regional Energy Agency — in local governments that are its members.

23. The main reason of problems with development of sustainable energy sector in regions of Latvia is the lack of coordination between the sectorial policy-making and the implementation process, and the lack of strong enough mutual feedback between energy end-users, local governments, management institutions of energy efficient processes at the level of the state and planning regions, which are responsible for inter-sectorial coordination of the priorities in national development.

24. Taking into account the present situation in the attainment of energy efficiency targets and the increase in energy intensity level, despite the existing measures of the management of energy efficient processes, the model of the management system of energy efficient processes developed by the author for regional planning level in Latvia and the methodological solution for creation of the management system of energy efficient processes are the tools to influence the decisions of energy end-users in relation to energy efficient solutions, safeguarding and efficient use of all energy types — electricity and heat energy, and achievement of targets of the European Union's Directive 2012/27/EU.

25. The obtained results justify the need to continue the research of the management system of energy efficient processes in order to improve the methodological solutions proposed by the author.

Based on conclusions obtained during the research, the author of the Doctoral Thesis moves forward the following **proposals**, which may serve as guidelines for research of the management system of energy efficient processes, as well as the constructive practical solutions:

1. For prevention of conflicts in the quest of scientific innovation issues and in order to build a common approach to the solution of issues of energy resources consumption and energy efficiency, without sectorial dubbing, the author proposes to encourage the cooperation between specialists of energy management science in the joint field of research — the management system of energy efficient processes.

2. The procedural approach determines the implementation of all functions and tasks of the management system of energy efficient processes for all hierarchical levels to attain all targets set in accordance with the European Union and domestic regulatory frameworks. Systematic approach determines the improvement of the management system of energy efficient processes, based on complex evaluation, which set out in the EU Directive 2012/27/EU (and in the subsequent regulatory enactments), of the achievement of energy efficiency targets and identification of management issues of the implementation processes of energy efficient solutions. Provision of interests of subjects of the management system of energy efficient processes, encouraging the development of energy sector and achievement of energy efficiency targets, requires to combine the procedural and systemic approaches in order to improve the development and introduction of the management system of energy efficient processes.

3. A precondition for achievement of energy efficiency targets is an interaction of the needs of all subjects (stakeholders) of the management system of energy efficient processes. It is necessary to include energy end-users — commercial companies that are not representatives of energy sector and households — in the management system of energy efficient processes, taking into account their needs and possibilities, for determination of energy efficiency targets and development of plans for the implementation of energy efficient solutions at the level of local governments.

4. Along with the development of scientifically significant and practical operations in the field of the management of energy efficient processes, to address the issues of achievement of energy efficiency targets at regional and local government levels, thus establishing the basis for the creation of an organized management system of energy efficient processes and ensuring the

cooperation with energy end-users, affecting the demand for energy efficient solutions for households and companies.

5. The management system of energy efficient processes is associated with a variety of internal and external factors that affect changes in demand for and supply of energy efficient solutions, therefore the tasks of the management system of energy efficient processes should be modified and applied in accordance with the situation.

6. Improving the operation of the management system of energy efficient processes, it is necessary to establish a theoretical basis and practical operation of the management system of energy efficient processes at all hierarchical levels, implementing the author's proposed principles, methods and organizational resources for achievement of energy efficiency targets within national framework in the interests of all the participants of the system.

7. To encourage national, regional and local development, differences in economic development and growth rate levels of local governments should be reduced. Creation of a supportive business environment and provision of equal living, working and environmental conditions within local governments will promote a sustainable development of energy sector in regions and a balanced and economically justified change in the dynamics of energy consumption.

8. Encouragement of implementation of sustainable development of energy sector and energy efficient solutions can be affected by the national tax strategy that is associated with the creation of a productive business environment and its development, introduction of innovations, capital efficiency and attracting investors. State-level institutions of the management system of energy efficient processes, when creating major guidelines for development of energy sector, should also take into account the regulatory enactments related to the tax policy.

9. Taking into account that only two energy agencies currently exist in Latvia and they are intended to operate up to 2020, it is necessary to establish the state-funded regional energy agencies within the framework of each planning region, which would implement the management functions and tasks of energy efficient processes at regional level in all local governments of Latvia.

10. At local government level, the use of management methods of energy efficient processes should be ensured for identification of factors causing losses of heat and power, their prevention

and control within the framework of implementation projects of the developed energy efficient solutions, and for promotion of sustainable development of the regional energy sector.

11. Within the framework of the management system of energy efficient processes, an effective communication between all hierarchical levels in this systems be ensured — households, companies, local governments, regions and the State, to achieve the energy efficiency targets.

12. In the interests of energy end-users, the management system of energy efficient processes has to attract investors in projects of energy efficient solutions, providing the projects' energy end-users with information on co-financing by the European Union and information on domestic opportunities.

13. To achieve the energy efficiency targets, great importance is given to providing the energy end-users with information on innovative energy-efficient solutions, technical quality of buildings and equipment, technical provision of use of technical equipment — heating boilers, and improvement of thermal performance of buildings. Within the framework of functions of state-funded regional energy agencies, informational and training seminars should be organized for managers and operators of residential buildings.

14. To improve the management methods for achievement of existing energy efficiency targets and prevention of obstacles identified in the present research, the author proposes to develop even more precise long-term and short-term plans for the implementation of energy efficient solutions in local governments, including their economic justification.

15. For further approbation of the development of the management system of energy efficient processes, the results of operation of the management system of energy efficient processes should be evaluated regularly at regional level and at the level of local governments, providing the update of information and comparison of the implemented projects with the established plans of implementation of energy efficient solutions in local governments, which is essential both for the implementation of the policy of sustainable regional energy development and for a coordinated sustainable development of all sectors of national economy at national and local government levels.

16. Approbation of the model of the management system of energy efficient processes developed by the author in other Member States of the European Union, which have similar issues of the management of energy efficient processes, can be an important contribution to encouraging a sustainable development of the energy sector.



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