SIMULATION OF ENERGY DEVELOPMENT SCENARIOS IN LATVIA ON REGIONAL LEVEL

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Abstract

Up to now the development scenarios of Latvian energy and fuel balance were mainly designed for the national level. However in the regional level there are significant differences both in energy consumption and fuel resources used. For the simulation and comparison of different energy development scenarios, MESAP (Modular Energy System Analysis and Planning) software, allowing making calculations at national and regional level without changing the structure of the model, was used. To perform a detailed regional modelling, Latvia was split in 6 regions, each having a separate forecasted electricity, thermal energy and fuel final consumption. For the regional modelling, similar RES structure to overall Latvian energy balance development options simulation was used. Three development scenarios in the regional level have been simulated: base scenario (I), scenario of maximal use of renewable energy resources and domestic energy resources (II) and maximum production of electrical energy and fuel diversification scenario (III). The choice of scenarios can be substantiated with a necessity to promote usage of renewable energy resources, as well as with decrease of electricity imports proportion in the energy balance of Latvia. The simulation results show, that the increasing demand of energy can be covered in several ways – by continuing to import power, maximally using the renewable and local energy resources, as well as using coal and biomass mix for the production of electricity.

Keywords: Modelling, Simulation, Energy, Regional.

Presenting Author's biography

M.sc.ing. Sergejs Vostrikovs obtained the engineer honours degree on the specialization power system in 1998 and the scientific degree of the master of engineering sciences in the field of mechanics and engineering (in 2001) at the Riga Technical University (RTU) in Latvia. Sergejs Vostrikovs is currently an explorer of RTU Department of Heat and Power Engineering. The research interests include analysis and prognosis of consumption of energy and fuel sources in Latvia.

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1 Introduction

1.1 Description of MESAP software

In the simulation and comparison of different energy development scenarios in Latvia was used the Modular Energy System Analysis and Planning (MESAP) software.

The MESAP philosophy is based on a process-engineering representation of real energy systems. The energy system is represented as a network of commodities and processes, the Reference Energy System (RES) [1].

Simulation software calculates energy and emission balance for any energy system and the necessary capacities for energy transformation technologies.

Energy flow calculation module is process engineering oriented simulation module that allows building and calculation of energy system from the demand to the primary energy. This module creates balances of physical flows (energy, fuel, emissions etc.). Market shares of technologies are variables to be entered in the module by the user.

Cost calculation module can calculate annual necessary investments, fuel costs, fixed and variable costs for each technology, as well as specific production costs. It allows calculation of all costs of energy system.

Development of energy system can be simulated by changing the demand and varying market shares. The required inputs for calculations are as follows:

- demand for the commodity;
- flow of the commodity from or to a specific process;
- market share of the process or consumption;
- ratio of two flows of the process characterising transformation of one commodity into another.

The module calculates variables of two types: the quantities of all remaining commodities (Quantity of commodity); and quantities of input and output flows of all processes (Quantity of a flow).

RES structure of energy system can be freely described, as there are no limits for processes, flows and their connections.

Additional function of the MESAP model – division into regions – allows more precise application of this structure for the purpose of the specific model. Since RES structure is the basis of the database, it cannot be changed when the modelled area is divided into regions. Only the data describing regions are changed in modelling. Technologies or processes that are not used in some regions can be excluded by assigning a zero value.

For the regional modelling, similar RES structure to overall Latvian energy balance development options simulation was used [3].

1.2 Regions of Latvia

Latvia is divided into the following 6 regions [2]:

- Centrs region;
- Kurzeme region;
- Zemgale region;
- Latgale region;
- Vidzeme region;
- Ziemeļvidzeme region.

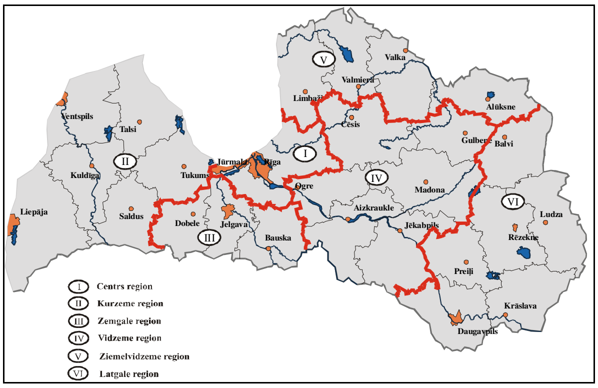

Fig. 1 Regions of Latvia

In the division in regions, the following main factors have been taken into account:

- Geographical location of regions.
- Structure of available fuel and energy types.

The traditional regional division of Latvia – Kurzeme, Latgale, Vidzeme, and Zemgale – is used as the basis. Vidzeme is subdivided into Vidzeme and Ziemeļvidzeme regions, as the territory of Vidzeme region is much larger than others, and this is inconvenient for comparison of the results. Centrs is taken as a separate region. This region includes Riga, Riga district with 7 towns, 17 rural municipalities, and resort town Jurmala. Centrs significantly differs from other regions with population density – there live more than million people, which is equal to 41% of the total population of the country (see Fig. 2).

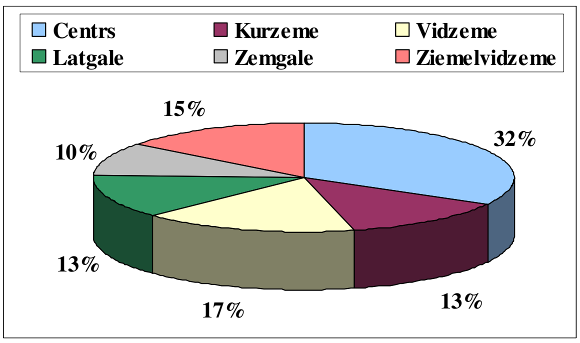

Fig. 2 Energy consumption of regions

There are significantly less wood resources in Zemgale than in other regions, but Vidzeme, Ziemelvidzeme and Kurzeme are rather rich in wood resources.

The same pattern appears with natural gas availability – in Centrs and Zemgale region, natural gas is far more available than in other regions. There is more peat in Latgale, Vidzeme, and Ziemelvidzeme.

The wind energy is mostly usable in Kurzeme region, as only in the western coast of Latvia the wind speeds and intensity are sufficient for economically justified use of wind generators [10].

2 Fuel and energy balance of Latvia's regions

The primary consumption in Latvia is secured by the local and renewable (wood, peat, straw, hydro resources, wind, biomass) and imported (oil products, natural gas, coal) energy resources. Latvia is dependent on the import of primary resources. In 2005 the consumption of primary resources was 54.7 TWh and only 35% of it was covered by local energy resources.

Tab. 1 Fuel and Electricity Consumption in Latvia 2005, GWh [4, 5, 6, 7]

	Centrs	**Kurzeme**	**Vidzeme**
Oil products	6102	2891	2248
Coal	444	83	83
Peat	0	0	6
Natural gas	7106	1263	2053
Wood	1638	2458	4096
Hydroenergy	2993	67	67
Electricity import	0	333	500
Latvia total	**18284**	**7095**	**9053**

Tab. 1 (continued) Fuel and Electricity Consumption in Latvia 2005, GWh [4, 5, 6, 7]

	Latgale	**Zemgale**	**Ziemel-vidzeme**
Oil products	1606	1445	1766
Coal	222	56	89
Peat	13	0	6
Natural gas	1895	2527	948
Wood	2785	819	4587
Hydroenergy	67	67	67
Electricity import	528	250	536
Latvia total	**7115**	**5163**	**7999**

Considering the fuel and power balance of Latvia for 2005, it can be seen, that there are three dominating types of energy resources – natural gas, wood and oil products.

Oil products (petrol, diesel) are mostly used in transportation. The whole potential of wood resources is used. The use of natural gas in power industry and heating has positive characteristics from the environmental and technological point of view, but natural gas is a fuel material conceiving high risk, as there is dependency from a singe supplier – Russia.

Renewable energy resources take significant place on the primary energy resources balance (36% in 2005), but there is still some unclaimed potential, usage of which could contribute to decreasing the dependency from the imported energy resource.

In each region, the amount of available renewable energy resources (mainly hydro energy and wood biomass) is different (see Fig. 3).

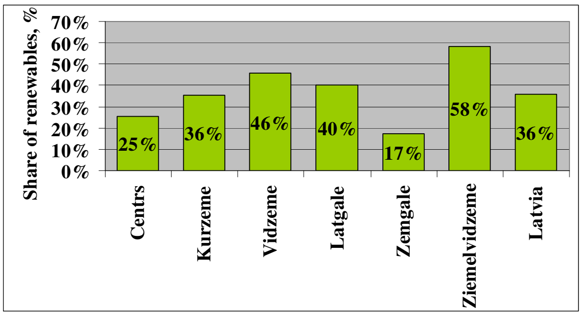

Fig. 3 Share of renewable energy resources by regions, %

The highest proportion of renewable energy resources is north of Vidzeme and Ziemelvidzeme, as in these regions mainly wood is used for thermal energy production.

3 Prognosis of fuel and energy demand of Latvia's regions

The following relevant data need to be entered into the model:

- Electricity consumption;
- Heat consumption;
- End consumption of fuel.

Data from the report describe the following infrastructures using fuel:

- Energy transformation sector;
- Industry;
- Households;
- Others (service, agriculture, building etc.).

If compared to developed countries of Europe, the electricity consumption of Latvia is low. But the analysis of potential demand forecast and basing on the developed scenarios of economic development [2], [8], it can be concluded, that power consumption up to 2010 will increase by approximately 3-8% year.

The model assumes that the consumption of power will increase by 4.5% a year (see Fig. 4).

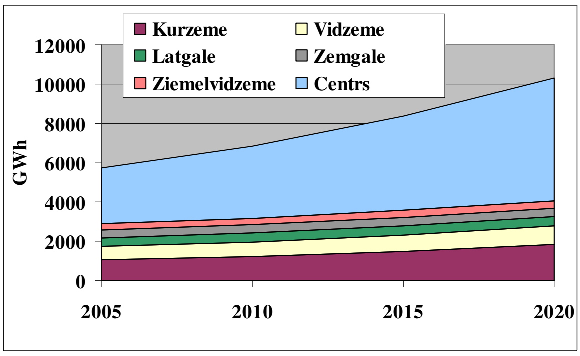

Fig. 4 Prognosis of electricity demand in Latvia, 2005 - 2020

Prognosis says that the heat demand (Fig. 5) could decrease by about 40% in the period 2005 to 2020.

There are two basic reasons:

– Decrease of the heat load connected to district heating systems.
– Efficient heat consumption.

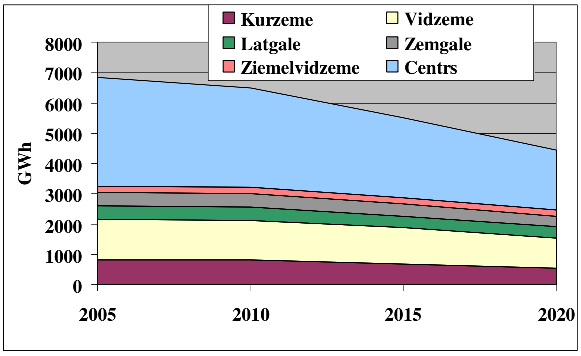

Fig. 5 Prognosis of heat demand in Latvia, 2005.-2020

Current development tendencies show that end consumption of fuel in industry will not change significantly in the modelling period, as neither rapid growth nor decrease in production is expected.

End consumption in households will rise due to following factors:

– new consumers (recently activities in the residential building sector)
– increase in living standard;
– development of local heat sources instead of district heating.

End consumption by other consumers (service, construction, agriculture) will also increase due to:

– new consumers;
– development of local heat supply.

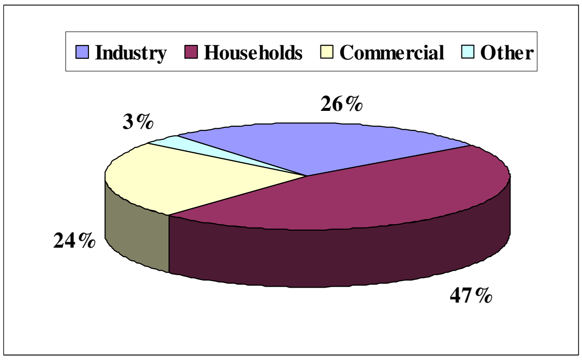

Fig. 6 Shares of end energy consumption

The total end consumption of fuel material will increase in all regions (Fig. 7), because the households and service sector builds up the bulk of it (>70%).

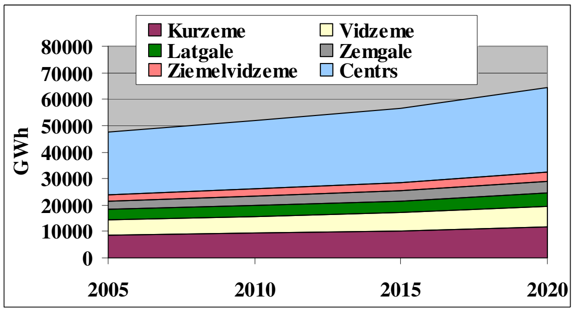

Fig. 7 Prognosis of end energy consumption in Latvia, 2005.-2020

4 Possible development scenarios

The modelling period accepted is years 2005 to 2020. Following scenarios were chosen for further modelling [2], [3]:

– Base scenario (I);
– Maximal use of renewable energy resources and domestic energy resources (II);
– Maximum production of electrical energy and fuel diversification scenario (III).

Base scenario is modelled using following main assumptions:

– Up to now (beginning of 2007) planned power plants are constructed - in 2008 a 400 MW natural gas combined cycle unit in region Centrs, as well as cogeneration plants with joint capacity of 50 MW in remaining regions. The predicted fuel material to be used in these plants is natural gas;
– The shortage of necessary resources in all regions is covered by import.

Maximal use of renewable energy resources and domestic energy resources scenario is modelled using following assumptions:

– A wind power plant with capacity of 200 MW is constructed in Kurzeme region;
– Hydro power plants with 100 MW total capacity are constructed in Daugavpils and Jekabpils, as well as smaller hydro power plants with joint

capacity of 20 MW are constructed in whole territory;

- Biomass and biogas cogeneration plants with joint capacity of 80 MW are constructed all over the country and peat cogeneration plants with joint capacity of 20 MW are constructed in north Vidzeme and Latgale;
- In region Centrs a 400 MW natural gas combined cycle unit and cogeneration plants with 50 MW capacity are constructed in other regions;
- The shortage of necessary resources is covered by import.

Maximum production of electrical energy and fuel diversification scenario:

- In the region Centrs a 400 MW natural gas combined cycle cogeneration plant, as well as cogeneration plants with joint capacity of 50 MW in regions are constructed;
- In Kurzeme region, a coal and 15% biomass mix power plant with 400 MW capacity is constructed;
- Biomass and biogas cogeneration plants with 30 MW joint capacities are constructed all over the country.

5 Results of development scenario simulations

The results of the modelling on the regional level are demonstrated in Fig. 8 – Fig. 11.

Figures show energy resources affected by changed the most:

- Natural gas;
- Renewable energy resources (wood, wind, hydro energy) and local (turf) energy resources;
- Coal;
- Imported power.

The rest (mainly oils) energy resources are affected by the changes minimally, and they are similar in all scenarios.

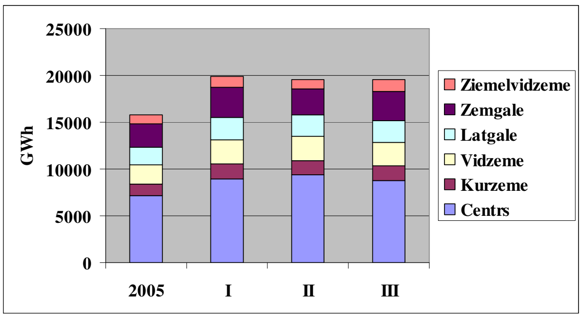

Fig. 8 Results of modelling - natural gas, GWh

(2005 – current situation; I – scenario I; II- scenario II, III – scenario III)

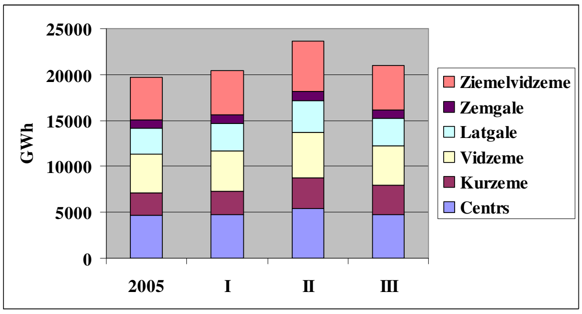

Fig. 9 Results of modelling - renewable resources, GWh

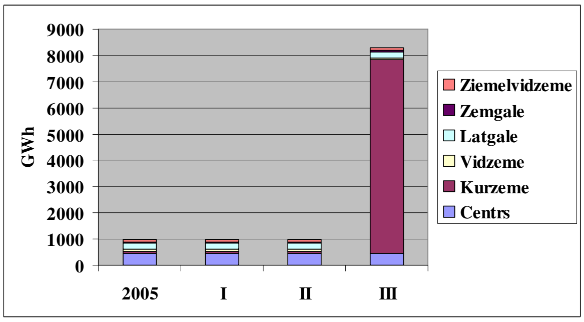

Fig. 10 Results of modelling - coal, GWh

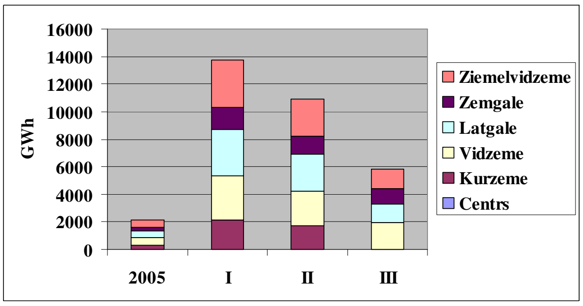

Fig. 11 Results of modelling - electricity import, GWh

6 Conclusions

The simulation results show, that the increasing demand of energy can be covered in several ways – by continuing to import power, maximally using the renewable and local energy resources, as well as using coal and biomass for the production of electricity.

From the modelling at the regional level, it can be concluded:

1 The application of cogeneration potential is not capable of solving power consumption increase in the country (an exception is the region Centrs, where large hydro power plants and thermal power plants are located already now). Cogeneration potential is limited by the consumer heat load and thermal energy consumption, which tend to decrease (see Fig. 5). Calculations show [9] that heat load potential in heating season (October to April) is 530 MW, but in summer only 130 MW.

2 Renewable power resources (hydro energy, wind energy, wood biomass) potential is not enough to

cover increasing demand for power (an exception is the region Centrsw, where large hydro power plants are located).

- Possibilities of wind energy usage in Latvia are limited, as Kurzeme region, where are technical facilities to install wind generators are, is little, and many protected areas are located there (see Fig. 12). Besides, the annual hours of usable wind energy is insignificant – approximately only 1800-2200 hours.
- The hydro power plant capacity potential in Latvia is insufficient for power consumption provision. The operating hours for hydro power plants is on average 2000-2400 hours, depending on the water flow in rivers.
- Wood biomass is widely used in thermal energy production (approximately 8,6 million m^3 per year) and exports (approximately 3 million m^3 per year). The estimated wood resource potential in Latvia is 8-11 million m^3, so it can be concluded, that this potential is already used and special attention should be paid to increase the efficiency.

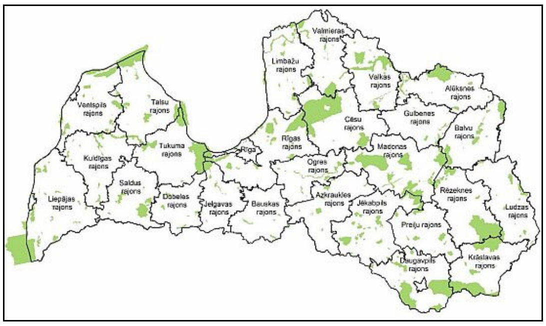

Fig. 12 Protected areas in Latvia (Natura 2000)

3 In case of coal usage, it is possible to decrease the amount of imported power, as well as diversify the used fuel balance.

- Coal is a common, widely available resource on the world market, well transportable and storable.
- Coal can be burnt in combination with biomass and other solid fuels (peat, waste, etc.), decreasing the environmental effect and broadening the usage of renewable energy resources.
- Coal price can be more easily forecasted and less depending on oil price fluctuations.
- Coal burning, in comparison with natural gas, results in more harmful emissions, but, by using recently developing technologies, it is possible to decrease them to minimum.

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