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PLANNING OF FUEL AND ENERGY SUPPLY IN LATVIA BY USING MESAP PROGRAMMING MODEL

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Abstract

In order to develop different energy and fuel production and consumption scenarios and comparisons in Latvia, sufficiently detailed data characterising energy supply system need to be collected and analysed. Since there are large regional differences in Latvia regarding energy and fuel consumption and structure, the data need to be region-specific. Summarised national fuel and energy balance does not give sufficiently representative overview. Thus information were collected and used as baseline data for modelling with MESAP model. The results of modelling process were practised for strategic analysis of energy problems in Latvia. Besides planning departments of ministries, consulting companies, developmental agencies, research institutions and energy enterprises can use it.
Keywords: modelling, prognosis

INTRODUCTION

Analysis of all programmes and prognosis available in Latvia so far show that the issues of fuel and energy are hardly touched upon. In order to develop different energy and fuel production and consumption scenarios in Latvia and to compare them, MESAP programme was used [1].

DESCRIPTION OF MESAP PROGRAMM

The **M**odular **E**nergy **S**ystem **A**nalysis and **P**lanning (MESAP) software has been designed as a decision support system for energy and environmental management on a local, regional or global scale. MESAP consists of a general information system based on relational database theory, which is linked to different energy modeling tools. In order to assist the decision making process in a pragmatic way MESAP supports every phase of the structured analysis procedure (SAP) for energy planning. MESAP offers tools for demand analysis, integrated resource planning, demand – side management and simulation or optimization of supply systems. In addition, MESAP can be used to set up statistical energy and environmental information systems to

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produce regular reports such as energy balances and emission inventories.

The main design principles of MESAP are:

- centralized data management with a standardized data interface and information system capabilities;
- flexibility in the time and regional scale;
- availability of different suitable mathematical methodologies for different scopes of analysis;
- user friendliness concerning data entry, consistency checking and report generation;
- decision support for the scenario technique through transparent case management.

MESAP is based on an independent database management system. Database collects and stores all data necessary for the modeling process. Database is one of the basic elements or module layers of MESAP. MESAP system includes several modules that can be used for energy planning and analysis. Figure 1 shows the architecture of MESAP. With the help of MESAP module **PlaNet**, using the built-in scenario technology, the possible development of the energy system can be simulated. Modeling of energy development scenarios in Latvia used this module.

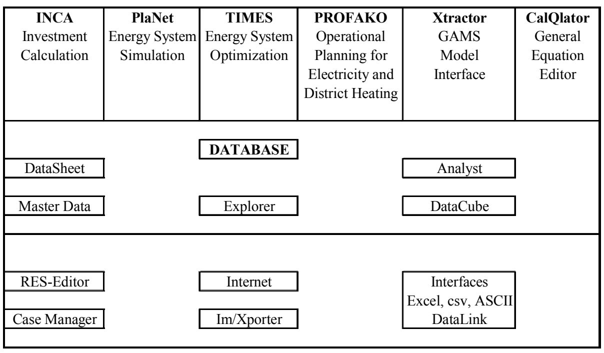

Figure 1: MESAP modeling architecture

Time Series Navigator allows the definition of time series, creation, update, and documentation of data values. **Case Manager** allows creation, description, and registration of scenarios, and to carrying sensitivity analysis. For visualisation of results, creation of tables and graphs, **Analyst** module is used. Input data and the results can be imported and exported from/to MS Excel.

Simulation modules **PlaNet-Flow** and **PlaNet-Cost** calculate energy and emission balance for any energy system, and the necessary capacities for energy transformation technologies. Cost calculation module is able to 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.

FUEL AND ENERGY BALANCE OF LATVIA

Table 1 summarised data on total inland consumption of fuel and electricity.

Energy Resource	Total	Local	Imports
Coal	2.9		2.9
Wood	53.7	53.7	
Peat	1.0	1.0	
Heavy oil	6.2		6.2
Natural gas	60.0		60.0
Electricity	17.6	7.4*	10.2
Other	6.9		6.9
Total	**148.3**	**62.1**	**86.2**

Table 1: Fuel and Electricity Consumption, 2002, PJ [2], [5], [7]

* - Produced in Hydro Power plants

Due to rapid increase in oil product prices, consumption of heavy oil has significantly decreased over the last few years, and utilisation of natural gas has grown. Renewable energy resources accounted for 41% in the fuel balance of Latvia of 2002. Share of wood fuel is increasing. Utilisation of coal and peat is gradually falling, but there is increase in consumption of other fuels, including liquefied gas and diesel. These processes are presented in the Figure 2.

In the electricity balance of Latvia, hydro energy takes the major share. The amount significantly varies depending on the climate. E.g. hydro energy accounted for 47% of the total supply in 1997, 68% in 1998, 43% in 1999, 45% in 2000 and 37% in 2002. It is assumed that the annual average production in hydro power plants is 2200 GWh or 7.4 PJ of electricity.

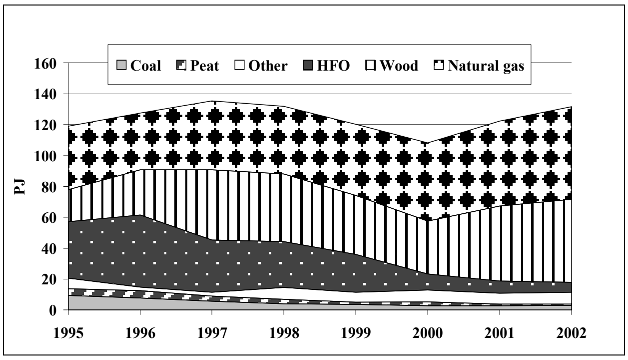

Figure 2: Fuel Balance 1995-2002, PJ

Electricity balance of Latvia in the last few years is presented in Figure 3.

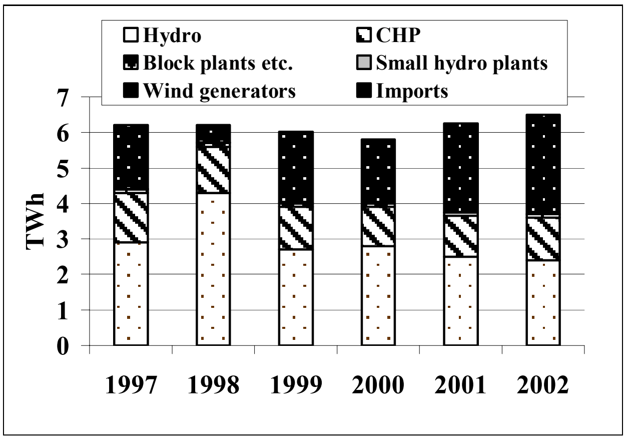

Figure 3: Electricity Balance of Latvia, 1997 - 2002, PJ [5]

ENTRY OF BASELINE DATA IN THE MODEL

Heat Demand

Total heat demand in Latvia increased by 8,5% in 2002, if compared to 2000, and accounted for 7,5 million MWh. Distribution of the demand by regions is presented in the following Table.

Region	2002
Centrs	3691,8
Kurzeme	938,7
Latgale	1444,3
Vidzeme	561,4
Zemgale	552,3
Ziemelvidzeme	311,5
Total	**7500,0**

Table 2: Heat Demand By Regions, Latvia, 2002, GWh

The following distribution of heat demand among consumer groups is used:

- industries 29,5%;
- households 63,6%;
- other consumers 6,9%.

This distribution varies in different regions. The following Table presents distribution of heat demand among consumer groups in different regions.

Centrs	
Industries	16
Households	64
Other consumers	20
Kurzeme	
Industries	27
Households	54
Other consumers	19
Vidzeme	
Industries	23
Households	56
Other consumers	22
Latgale	
Industries	45
Households	42
Other consumers	13

Table 3: Distribution of Efficient Heat Consumption among Consumer Groups in 2002, % [6], [7]

Ziemeļvidzeme	
Industries	35
Households	43
Other consumers	22
Zemgale	
Industries	27
Households	43
Other consumers	30

Table 3 (continued): Distribution of Efficient Heat Consumption among Consumer Groups in 2002, % [6], [7]

Heat losses

In 2002, heat losses accounted for 17,8% in Latvia. This amount has been used for all regions.

Fuel types

The following fuel types are used for the production of heat in the district heating systems: natural gas, heavy oil, coal, diesel, peat, and wood.

Heat is produced in CHP plants and boiler plants.

Electricity Demand

In 2002, electricity demand in Latvia was 5 046 million kWh, which is by 7% more than in 2000. Distribution of electricity demand among regions of Latvia is presented in Table 4.

Region	2002
Centrs	2325,3
Kurzeme	899,6
Latgale	653,2
Vidzeme	436,1
Zemgale	394,8
Ziemeļvidzeme	337
Total	**5046**

Table 4: Electricity Demand by Regions, GWh

Table 5 shows electricity production and supply sources, and the produced electricity in 2002.

Electricity losses

In 2002, electricity losses in Latvia accounted for 16.7%[1]. This amount has been used in calculations for all regions.

Total supply	6,5
Electricity production	3,7
Latvenergo	3,6
Hydro plants	2,4
CHP	1,2
Block plants etc.	0,1
Wind generators	0,002
Imports	2,8

Table 5: Electricity Production and Supply Sources in Latvia, 2002, TWh

End Consumption of Fuel

Total end consumption of fuel was 19.1 million MWh in Latvia in 2002. Of these, 6.6 million were consumed by industries, 8.6 million by households, and 3.8 million by other consumers. The following Table presents distribution of end consumption among regions.

[1] - Latvia has so high electricity losses – the electrical system was built in soviet time and in this time were other norms of efficiency

Region	Total	Industries	House-holds	Others
Centrs	7858	2969	3647	1242
Kurzeme	2475	744	1265	467
Latgale	3047	1370	1253	424
Vidzeme	2501	750	1066	686
Zemgale	1494	372	755	366
Ziemel-vidzeme	1690	442	581	667
Total	**19 065**	**6647**	**8566**	**3852**

Table 6: End Consumption of Fuel in 2002, GWh

DESCRIPTION OF ENERGY PRODUCTION SOURCES OF LATVIA

In the calculation model, the following energy producing units are separated as specific processes: CHP plants *TEC-1*, and *TEC-2*, small CHP plants, hydro power plants of the Daugava cascade, small hydro power plants, wind power plants, and boiler plants grouped according to fuel type. If several fuel types are used, the boiler plant is theoretically divided into parts. Further in the text, each of these processes is described in more detail including the main indicators necessary as input data for the model.

TEC-1 and TEC-2

TEC-1 has four turbine sets, six steam boilers, and two water boilers. Installs electric capacity is 129,5 MW, and heat capacity - 616 MW.
TEC-2 is the largest CHP plant in Latvia. It has four turbines and four water boilers. Installed electric capacity is 390 MW, and heat capacity - 1237 MW.

Item	Unit	TEC-1	TEC-2
Electricity output	GWh	240	923
Heat output	GWh	921	1825
supplied electricity/ supplied heat	GWh/ GWh	0.26	0.48
Total efficiency	%	72	80

Table 7: Main Operation Indicators of TEC-1 and TEC-2, 2002

Small CHP plants

Besides the abovementioned *TEC-1* and *TEC-2* of the electricity supply company *LATVENERGO*, there are several other CHP plants belonging to industries and heat supply companies.

In 2002, these plants produced about 17 GWh of electricity.

The following Table summarises data on fuel types in these CHP plants, specified by regions.

Region	Natural gas	Heavy oil	Peat
Latgale	80,5	7.2	12.3
Vidzeme	1.0	99.0	0.0
Kurzeme	19.4	80.6	0.0
Zemgale	83.0	17.0	0.0

Table 8: Fuel Mix in Small CHP Plants in 2002, Specified by Regions, %

The indicator of supplied electricity/supplied heat in these plants, compared to *TEC-1* and *TEC-2*, is rather low - 0.02[2] on average.

Hydro power plants of the Daugava Cascade

The Daugava Cascade consists of three hydro power plants: *Plavinu*, K*eguma*, and *Rigas*. Their total installed capacity is 1517 MW. In 2002, output of these hydro power plants was about 2434 GWh of electricity[3].

Small hydro power plants and wind power plants

On Latvian rivers in 2002, there were small hydro power plants with total installed capacity of about 30.1 MW. Annual output is about 60.2 GWh.

Latvenergo owns a wind power plant in Ainazi, with total installed capacity 1.3 MW. In 2002, it produced 2.1 GWh of electricity. Capacity of the wind power plant in Ventspils rajons Uzavas pagasts is 1 MW.

Boiler plants

In 2002, 4,2 million MWh was produced in boiler plants of general use, and 0.9 million MWh – in boiler plants belonging to industries. The following Table summarises data on average efficiency of boiler plants using different fuels.

Fuel	Efficiency, %
Coal	0.55
Natural gas	0.9
Diesel	0.9
Heavy oil	0.84
Peat	0.69
Wood	0.65

Table 16: Boiler Plant Efficiencies, 2002

Emission Factors

The model determines amounts of SO_2, CO_2, and NO_x emissions.

In order to find emission factors, the Second National Report of Latvian under UN General Convention on Climate Change was used [3].

On 10 December 1997, Latvia signed the Kyoto protocol, which requires reduction of greenhouse gas (GHG) emissions. According to the protocol, Latvia needs to reduce emissions of greenhouse gases by 8% by the period 2008-2012. CO2 accounts for major part of GHG (about 90% in 1995). One of the CO2 emission sources is combustion of fossil fuel. Heavy oil causes by 37% more SO2 emissions than the natural gas (78:56,9 kg/GJ). Combustion of coal makes 95 kg CO2/GJ. Thus, to foster fulfilment of Kyoto requirements, utilisation of coal and heavy oil should be reduced, replacing these fuels with natural gas and wood, where possible.

PROGNOSIS ON FIXED MODEL PARAMETERS (ELECTRICITY, HEAT, AND END CONSUMPTION)

Electricity Consumption Prognosis

Table 8 shows electricity consumption prognosis. In the period 2000 to 2020, a small and gradual increase is expected. It will mainly be caused by the consumption growth in household and service sectors. Life standard will increase, and consumers will buy more household appliances, and limit their needs less. No significant changes are expected in the sector of industry. Consumption will also increase in other sectors, e.g. commercial sector, transport, street lighting.

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2 - small CHP plants has very low installed electrical load compared with installed heat load

3 - the output of electricity from HPP is low compared with installed load because the river Daugava has a small fall, HPP were built in soviet time, too

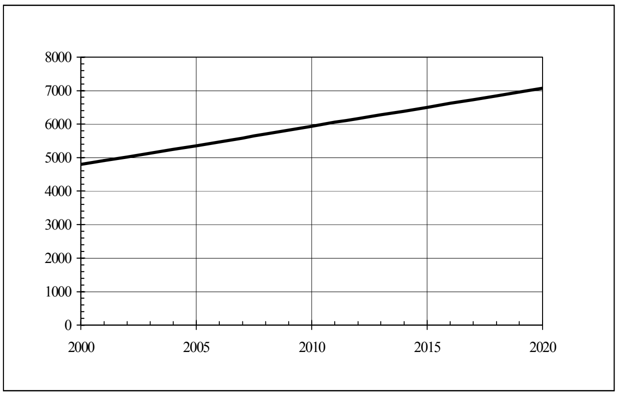

Figure 4: Electricity Consumption Prognosis, GWh

Heat Demand Prognosis

Prognosis say, that the heat demand (Figure 5) could decrease by about 35% in the period 2000 to 2020. There are two basic reasons:

1.decrease of the heat load connected to district heating systems ;

2.efficient heat consumption will be reduced significantly by installation of automatic regulation in heat substations. The process is already ongoing, and it will even speed up due to implementation of heat meters. Consumption of domestic hot water will be the first to decrease, as installation of DHW regulation equipment requires less resource. Efficient heat consumption for heating will fall when independent heating connection will gradually replace current system. Energy efficiency measures in buildings will also contribute to the reduction of heat consumption by reducing the overheating effect.

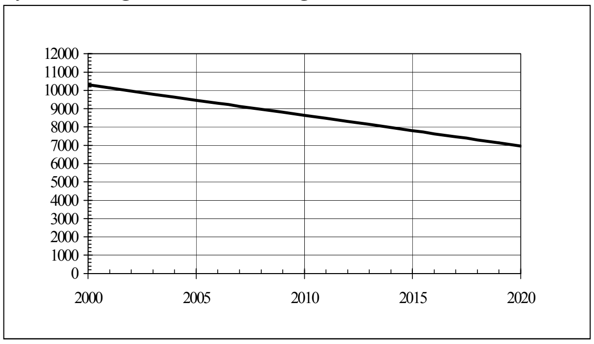

Figure 5: Heat Demand Prognosis, GWh

Fuel End Consumption Prognosis

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 a little due to two factors:

- Increase in living standard. People will not limit their consumption so much;
- Part of the consumers using district heating will disconnect and install their own local heat sources.

End consumption by other consumers will also increase due to:

- New consumers;
- A significant part of consumers of this sector will choose local heat supply.

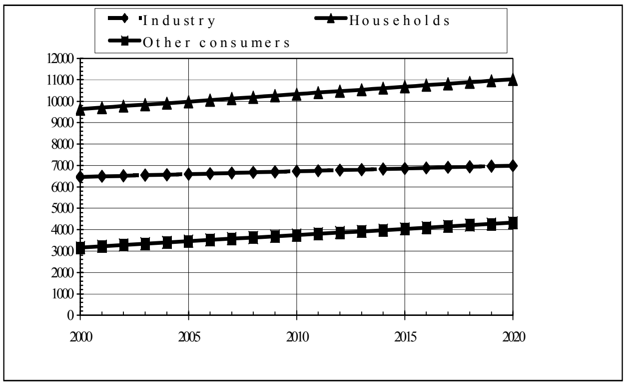

Figure 6: Fuel End Consumption Prognosis, GW

In order to develop different energy and fuel production and consumption scenarios by using a MESAP programming model and comparisons in Latvia, sufficiently detailed data characterising energy supply system need to be collected and analysed.

CONCLUSIONS

The information of energy and fuel production in Latvia were collected and used as baseline data for modelling with MESAP model. The results of modelling process were practised for strategic analysis of energy problems in Latvia. Besides planning departments of ministries, consulting companies, developmental agencies, research institutions and energy enterprises can use it.

REFERENCES

[1] F. Baumhögger, I. Baumhőgger, J. M. Baur, R. Kőhner, U. Schellmann, Ch. Schlenzig, T. Steidle, A. Schweiker MESAP manual // Institute of energy economic and the rational use of energy "IER" University of Stuttgart, 1998

[2] Annual reports on economy development issued by the Ministry of Economy of Latvia, Riga, 2002
[3] Annual national reports of Latvia On Climate Change, Riga, 2000
[4] Annual report of natural gas supplier in Latvia *Latvijas gaze*, 2002
[5] Annual report of electricity supplier *Latvenergo*, 2002
[6] Annual report of Riga district heating company *Rīgas siltums, 2002*
[7] Official energy balance in Latvia, Central Statistics Bureau of Latvia, 2002