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Delegation of the European Commission to Russia

Energy Efficiency at Regional Level in Arkhangelsk, Astrakhan and Kaliningrad Regions

Demonstration of Energy Demand Forecast in Kaliningrad Region

Draft Report

September 2007

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LIST OF ABBREVIATIONS

bos	basic oxygen steel
bbl	barrel
bcm	billion cubic metres
b/d	barrels per day
Btu	British thermal unit
CCGT	combined-cycle gas turbine
CHP	combined heat and power (plant)
CNG	compressed natural gas
CO	carbon monoxide
CO2	carbon dioxide
COG	coke-oven gas
CV	calorific value
GCV	gross calorifc value
GHG	greenhouse gas
GJ	gigajoule, or one joule x 109 (see joule)
GJ/t	gigajoule per tonne
J	joule
kWh	killowatt/hour, or one watt x one hour x 103
LNG	liquefied natural gas
LPG	liquefied petroleum gas; refers to propane, butane and their isomers, which are gases at atmospheric pressure and normal temperature
MBtu	million British termal units
MJ/m3	megajoule/cubic metre
Mm3	million cubic metres
MPP	main (public) power producer
MSW	municipal solid waste
Mtce	million tonnes of coal equivalent
Mtoe	million tonnes of oil equivalent
MW	megawatt, or one watt x 106
NCV	net calorific value
Nm3	normal cubic metre
NOx	nitrogen oxides
PV	Photovoltaic
Ttce	Thousand tonnes of coal equivalent
tce	tonne of coal equivalent; 1 tce = 0.7 toe
TFC	total final consumption (“end-use” or “useful” consumption)
TJ	Tera joule, or one joule x 1012
toe	tonne of oil equivalent
TPES	total primary energy supply
VOCs	volatile organic compounds

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1. Executive Summary

This report contains the findings of the development of an energy demand forecast for the period 2007-2020 which forms a demonstration of this planning tool for policy makers. It was based on the notions of transferring knowledge through frequent discussions/workshops with oblast staff and training of several experts on the use of the computer model with the aim of making recommendations to increase the planning capability in the regional administration.

The approach used is based on three elements. First, existing policy documents on economic and energy development etc. are analysed on their internal consistency. Then these were used to develop a set of realistic and consistent qualitative assumptions on the future development (a so-called scenario). Thirdly, these qualitative assumptions are then used to put a quantitative value to the parameters used in the computer model.

The basis of the forecast is formed by considering the existing economic and energy development scenarios for Kaliningrad Oblast. In 2007, the Oblast Administration produced "The Energy Development Strategy until 2015" to improve the energy security of the region. It evaluates possibilities to increase electricity and heat generation in the Oblast and fuel supply options for new energy sources. Most importantly, parameters of this strategy were used for the development of energy demand projections.

In this way, three scenarios have been developed.

The *"Baltic Dragon" scenario* is based on the optimistic variant of the existing economic forecast (20% economic growth per year) and includes the planned construction of six new small CHP plants. However, several assumptions have been adapted following an integrated approach with the help of a simplified macro-economic model. Among others, these changes concerned the rate of regional economic growth (taken at 10% per year), the (necessary) inflow of migrant workers and their housing facilities. Furthermore, this scenario is based on the following concept (more details can be found in chapter 4):

- The conditions of a free economic zone and the local market infrastructure will become attractive for a considerable and sustainable investment inflow;
- For strategic purposes, the federal government shall provide tangible economic support to Kaliningrad Oblast, even if oil and natural gas export revenues significantly decline;
- Low energy intensive assembling plants, transport and commercial sectors, including tourism, shall become the driving factors for economic growth;
- The Oblast administration shall manage to find resources for large-scale (explosive) residential and social construction needed to accommodate many migrants starting from 2007;
- The Oblast administration shall manage to obtain gas limits to provide fuel for the operation of the second unit of KTETs-2 and attract investments for the "Small energy sector development program" (construction of 6 mini-cogeneration plants, which would use gas, coal, peat, and solid waste);
- No special energy efficiency policies will be implemented.

Primary energy consumption under this scenario would almost triple: from 2,088 Ttce in 2005 to 6,122 Ttce in 2020. Natural gas consumption – if the second unit of KTETS-2 is constructed - will rise to 1.8 billion m3/y. When the mini-cogeneration plants construction program is implemented gas consumption will reach 1.32 bln. m3/y, but coal consumption will increase about ten times with negative effects on the environment. The overall energy intensity of the Regional Economic Product (GRP) will decline by around 30%, mainly due to increased gas prices and subsequent autonomous energy efficiency improvements. Electricity demand will increase considerably to 9.5 billion kWh/y mainly due to industrial growth. The need for electricity imports remains even when new generation capacity is commissioned. Electricity self-sufficiency will decrease to around 65%.

While analysing the results of this scenario, several constraints/risks to its realisation were determined. The main ones are:

- Industrial sector will become the driving force of the economic growth, but at the same time it will become the driving force of the electricity demand, which will triple in 2005-2020 under this scenario. Therefore, electricity import demand may exceed current transmission capacity of high-voltage networks. In order to limit import needs, the planned 6 mini-cogeneration plants and the second unit of KTETs-2 must be built in 2015 at the latest;
- With the construction of the second unit of KTETs-2, gas consumption may exceed 1.8 bln. m3 in 2020. Without corresponding increase of the gas supply system it may not be impossible to fully realize the economic growth potential envisaged under this scenario;
- The realisation of this scenario depends to a high degree on large investment inflows, not only by investors but also from the federal government support. This is highlighted for example by the need to construct 1.5 m2 living space per capita per annum for potential migrants; while the present average in Russia is only 0.3 m2 per capita per annum (for the long-term the target is 1 m2).
- Escalating gas prices may aggravate the need for fuel-switching towards coal and regional energy sources (peat, wood). The adverse environmental effects may considerably reduce the investment and migration attractiveness of the Oblast.

The second scenario is called *“Balanced Migration”* and is based on a modification of the “Baltic Dragon” scenario. The economic growth rates of the GRP are lower (7% per year). The inflow of migrants will therefore increase gradually, as housing conditions are being developed, and are a basic determinant for economic growth (with optimistic assumptions on the possible labour productivity growth). The federal government will be providing considerable economic support to Kaliningrad Oblast, although balanced with the status of the federal budget and oil and gas revenues.

Primary energy consumption under this scenario would increase from 2,088 Ttce in 2005 to 4,780 Ttce in 2020. With rising energy prices and autonomous technical progress, energy intensity of the GRP decreases by 21% in 2005-2020. Electricity consumption will increase to 6,83 billion kWh in 2020. Electricity self-sufficiency of the Oblast will not go down below 90% due to a more moderate economic growth and the construction of new plants. The share of renewable energy, peat and solid waste in the integrated fuel and energy balance will increase to 21%.

The constraints as mentioned under the “Baltic Dragon” scenario are considerably mitigated. Capacity and transport problems are far less hampering economic growth and the investment demand is also considerably lower. With fast growing gas prices, maximum gas consumption will be reached in 2008, only exceeding the 2006 level by 5% and making the gas supply system development more feasible.

The risk of environmental pollution through growing coal consumption by boiler-houses however is still present.

The third scenario considered in the report is called *“Sustainable Development”*. The assumptions are the same as in the “Balanced Migration” scenario with one big difference. The regional government starts to implement serious energy efficiency programs directed at improved industrial energy efficiency, heat supply improvement and reduction of electricity transmission and distribution losses.

Provided that sufficient financial resources are allocated and administrative capabilities are developed, these programs will lead to a 2.5% annual energy efficiency improvement in all types of economic activities and existing residential buildings.

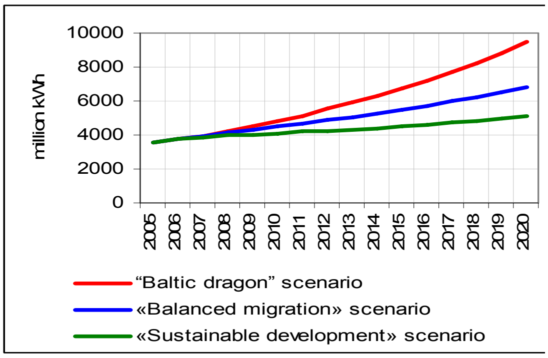
Besides, the mini-cogeneration plants development program shall be tailored in a way keeping the Oblast's electricity self-sufficiency at 100% after 2010.

Primary energy consumption under this scenario would increase only to 3,728 Ttce in 2020, thus decreasing considerably the risks of energy and capacity shortages. In the "Sustainable Development" scenario (with the same rates of economic growth as in the "Balanced migration" scenario) energy efficiency improvements will lower in the period of 2006-2020 the additional demand for

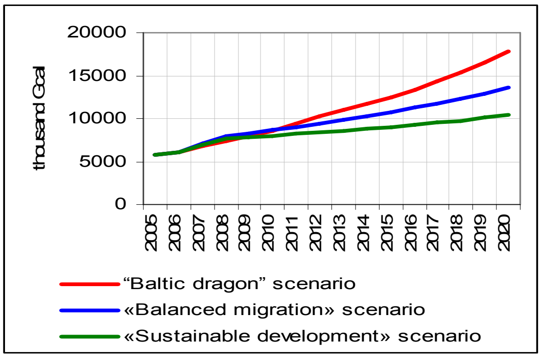
- o electricity by 55% (from 3,062 to 1,344 million kWh);
- o district heating by 43% (from 7,417 to 4,224 thousand Gcal);
- o coal by 27% (from 1,434 to 1,040 Ttce);

For natural gas, which becomes very expensive, the consumption decreases not by 157 million m3 but by 282 million m3.

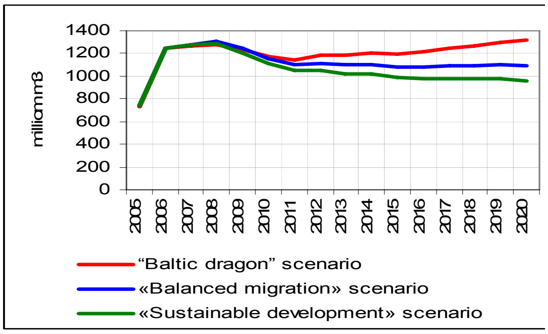
In the graphs below, energy consumption indicators show the results for the three scenarios.



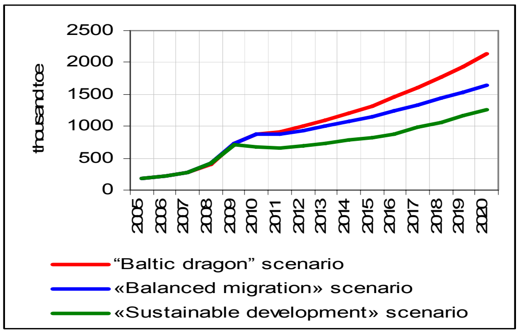
a) electricity consumption



b) district heat consumption



c) gas consumption



d) coal consumption

<u>Conclusions</u>

- ❖ Using a computerized model for energy demand forecasting is an excellent "planning tool" to improve macro-economic and energy policy because it allows for a thorough check on internal consistency of economic and energy policy and good insight in the policy-related driving forces, constraints and risk factors.
- ❖ All three scenarios used in this study indicate that the "Small energy sector development program" is an important element in the Kaliningrad economic development strategy due to the uncertainty of additional gas supplies and possible developments after the closure of the nuclear power station in Lithuania in 2009. It contributes to a greater degree of electricity self-sufficiency for the region.
- ❖ In general, the scenario results show that industry will be the driving force behind economic growth, but at the same time increases the need for additional electricity generation capacity.

- Given the specific situation of Kaliningrad region, introducing strong energy efficiency programs is a "no-regret" strategy. Under all circumstance it will contribute to alleviating possible limitations/constraints of an economic policy as well as mitigate risks due to uncertainty.
- "Social and Economic Development Program for Kaliningrad Oblast, 2007-2016" contains internal contradictions. They concern mainly the financing and migration aspects as well as(over-)optimistic economic growth rates.
- The main risks/constraints associated with the "Baltic Dragon" scenario are
  - The ability to find financing for housing construction for the large number of potential migrants.
  - Electricity import demand may exceed current transmission capacity of high-voltage networks.
  - With the construction of the second unit of KTETs-2, gas consumption may exceed the capacity of the gas supply system.
  - Escalating gas prices may increase the use of cheaper fuels (coal and peat) with a deteriorating effect on the regional environment. This may reduce the investment and migration attractiveness of the Oblast.
- Implementing energy efficiency programs will lead to a 2.5% efficiency improvement in all types of economic activities and existing residential buildings.
- Energy efficiency programs also mitigate key risks in the Oblast's economic development. Energy efficiency allows to decrease in the period 2006-2020:
    - additional demand for electricity from 3062 to 1344 million kWh;
    - additional demand for district heat from 7417 to 4224 thousand Gcal;
    - additional demand for coal from 1434 to 1040 thousand tce
    - and for natural gas, which becomes extremely expensive and much less affordable, consumption decreases not by 157 million m3 but by 282 million m3.

<u>Recommendations</u>

- It is recommended to assign specific responsibility in the regional administration for integrated economic and energy planning in terms of
  - Collecting and analyzing data and developing annually integrated fuel and energy balances and
  - Updating and testing of economic and energy policy scenarios.
- Further testing of existing economic and energy policies for inconsistencies using the computerized demand forecast model will improve the quality of decision making.
- It is necessary to build upon the current experience in building consistent and realistic regional development scenarios using a computerized model.
- The model that has been transferred to the regional administration's staff should be further developed, in particular the model's macro-economic and energy modules to fit the region's needs and its underlying assumptions.
- It is especially important to develop further the energy pricing module due to the wide-ranging consequences of changing energy prices for economic and energy policy decisions.
- There is a strong need from a strategic as well as economic point of view to develop and implement energy efficiency programs in the public sector (heat and electricity supply and distribution, schools, hospitals etc.) and to create conditions for the private sectors allowing for accelerated energy efficiency improvements.

1. Introduction

One of the tasks under the current EuropeAid project on “Energy Efficiency at the regional level in Astrakhan, Arkhangelsk and Kaliningrad regions” consisted of developing a regional integrated fuel and energy balances in the three regions. The results were presented in a project report on the Kaliningrad energy balance. The consultant continued with the development of an energy demand forecast for the period 2007-2020 as a demonstration of this planning tool for policy makers. It was based on the notions of transferring knowledge through frequent discussions/workshops with oblast staff and training of several experts on the use of the computer model with the aim of making recommendations to increase the planning capability in the regional administration.

This report contains the results obtained for the Kaliningrad region.

1.1 Approach

The approach used is based on three elements. First, existing policy documents on economic and energy development etc. are analysed on their internal consistency. Then these were used to develop a set of realistic and consistent qualitative assumptions on the future development (a so-called scenario). Thirdly, these qualitative assumptions are then used to put a quantitative value to the parameters used in the computer model. These steps are described in more detail in the remainder of this section

The basis of the forecast is formed by considering economic and energy development scenarios for Kaliningrad Oblast. In 2007, the Oblast Administration produced “The Energy Development Strategy until 2015” to improve the energy security of the region. It evaluates possibilities to increase electricity and heat generation in the Oblast and fuel supply options for new energy sources. Most importantly, parameters of this strategy were used for the development of energy demand projections.

Experts in energy development projections often have to use macroeconomic projections developed by other expert groups. Obviously, a reliable picture of the future cannot be obtained based on contradictory and poorly balanced economic development projections. Such projections should not be used unless tested for inherent consistency. This report provides an analysis of “The Social and Economic Development Program of Kaliningrad Oblast for 2007-2016”. Contradictions within this program undermine trust in the adequacy of energy supply system development to the targeted economic growth rates set for the Oblast and require additional estimates. The consultant also makes use of the two variants of economic development projections for Kaliningrad Oblast until 2012 developed in 2007 based on the RF Ministry of Economic Development and Trade formats.

Three scenarios for economic development and energy supply and demand dynamics were considered: “Baltic Dragon” (BD), “Balanced Migration” (BM), and “Sustainable Development” (SD). Energy balance projections were developed using the “ENERGYBAL”[1] model. For each scenario, a list of consistent assumptions on the development of macroeconomic parameters was formed. These parameters have to be logically and quantitatively consistent, after which the following two steps were made:

“Development concepts”, i.e. qualitative hypotheses regarding the targets and driving factors for economic development. The “Concepts” show the ways to achieve the goals and to eliminate development contradictions, bottlenecks and “limits to growth”, in order to balance economic, social, political, and institutional development factors;

Development scenarios. Implementation of these scenarios requires developing a inherently consistent system of assumptions that reflect qualitative characteristics of the “Concept” in

[1] ENERGYBAL is a computerised model for energy demand forecasts developed by CENEf, Moscow

the system of quantitative parameters, which are used as inputs into the “ENERGYBAL” model (exogenous variables).

Scenario runs using the “ENERGYBAL” model allow assessing corresponding energy development parameters; to reveal constraints/limitations, or “limits to growth”, related to the mismatch of future economic and energy development; and to identify possible ways to overcome these.

The “ENERGYBAL” model also allows for correcting both concepts and scenarios as required, and to quickly achieve consistent energy demand projections. Energy sector development perspectives are to be updated annually along with economic development perspectives and development/verification of long-term programs. In future, this can be done by the Oblast experts on their own because the consultant trained several experts in the use of the model. The “ENERGYBAL” model is developed exactly to make these efforts possible within the framework of established methods. When this model is mastered, it can be further developed by Kaliningrad Oblast experts. It will serve as a tool to quickly assess various development scenarios and test energy policy consequences and effectiveness.

1.2 Organisation of the report

The second chapter deals with general background information on the region’s economy and energy supply sector. Electricity and heat supply in the region, including different supply options are briefly presented and it concludes with different options for energy efficiency. Chapter three introduces the region’s economic development strategy, which is analysed and several inconsistencies are discussed. Chapter 4 shows the concepts and scenario development for the region as well as the results of the scenario runs.

Chapters 5 presents the conclusions and recommendations. Tables showing the input data and energy efficiency options can be found in the annexes.

Disclaimer:

In no way, this report and its findings, conclusions and interpretations reflect the official oblast government policy or opinions of administration officials. They are solely the consultant’s responsibility.

2 General economic and energy background

2.1 Regional economic situation

Kaliningrad Region is located at Baltic Sea surrounded by the Republic of Lithuania to the North and East, and the Republic of Poland to the South. There is no direct border to the remaining part of the Russian Republic.

The Region covers an area of 15,000 km^2 and has a population of approximately 940,000 inhabitants.

The Pegolja River flows through the Region from East through Kaliningrad to the Kaliningrad Gulf. The Neman River forms the Northern border to Lithuania. The main cities are Kaliningrad with approximately 425,000 inhabitants, Sovetsk, Svetlij, Chernyahkovsk, Gusev, Baltijsk and Neman.

The average temperature in Kaliningrad in January varies from minus 4.1 ^{o}C during the night to minus 2.2 ^{o}C during the day. The heating period is from the middle of April to the middle of October depending on the actual temperature.

The largest industrial sectors in Kaliningrad Oblast are:

- food industry
- fishing (catching, processing, canning) industry
- machinery and mechanical workshops
- pulp and paper industry
- coke production
- extraction of natural resources (oil, amber, peat, coal)

In numbers, the industrial structure is as follows (data for 2004):

Food (incl. fishing)	31 %
Machinery	25 %
Fuel	16 %
Pulp and paper	12 %
Energy	10 %
Other	6 %

The Kaliningrad region is highly depending on imported fuel and power, only a small fraction of the power demand is produced in the region by hydro power plants and wind turbines. The power production capacity is insufficient and more than 50% of the power demand is imported from Russia.

2.2 Energy consumption patterns

Kaliningrad Region imports about 95% of its primary energy sources from other parts of Russia through its neighbouring countries. The fuels imported are mainly coal, petroleum products and natural gas. Apart from these fuels, also a considerable amount of electricity is imported.

In 2005 the electricity consumption in the region was approximately 4 TWh, whereof 3.5 TWh was imported. The annual heat supply was 5,700 Tcal. Heat is mainly produced at heat only boiler stations using coal, but also gas, mazut, diesel and peat are used as fuels for heat production. The overall integrated fuel and energy balance and energy end-use in 2005 are shown in the tables below.

Table 2.1 Overall energy balance for 2005, Kaliningrad region (Ttce)

	Coal	Crude oil	Petroleum products	Natural gas	Hydro and renew.	Other solid fuels	Electri-city	Total
Production		1741.7		20.0	1.8	28.1		1791.7
Import	178.6		653.4	832.5			373.4	2037.9
Export		-1741.7					0.0	-1741.7
Primary energy consumption	**178.6**	**0.0**	**653.4**	**852.5**	**1.8**	**28.1**	**373.4**	**2087.8**

Source: Developed by the consultant (see report on Kaliningrad Integrated Fuel and Energy Balance)

Table 2.2 Integrated Fuel and Energy Balance: Energy end-use in 2005 (Ttce)

	Coal	**Crude oil**	**Petrol. Products**	**Natural gas**	**Hydro/ renew-ables**	**Other solid fuels**	**Power**	**Heat**	**Total**
Energy end-use	**54.6**		**359.7**	**169.5**		**19.3**	**340.4**	**698.3**	**1627.1**
Industrial	6.6		19.0	13.4		5.8	88.9	288.0	421.7
- Oil extraction			8.5	7.8			3.1		19.3
- Pulp							12.9	106.8	119.6
- Paper							8.5	32.5	41.1
- Cardboard							2.5	8.8	11.3
- Meat products							3.2	7.0	10.2
- Bakery products			0.0				0.4	3.1	3.4
- Other	6.6		10.6	5.6		5.8	58.4	129.7	216.7
Construction			7.4				7.2	0.2	14.8
Transport	0.0	0.0	227.3	0.0	0.0	0.0	13.3	18.4	259.0
- Aircraft			29.0						29.0
-Automobile			168.6						168.6
- Railway			29.2				6.1	11.2	46.5
- Water			0.5						0.5
- Urban electric							2.1		2.1
- Other transport							5.1	7.2	12.2
Agriculture			12.5				13.1	27.1	52.7
Utility sector	8.9		21.4	0.2		0.6	14.7	28.2	74.1
Commercial	26.3		44.4	7.9			80.2	16.7	175.5
Residential	12.9		27.6	148.1		12.8	122.9	319.8	644.1

Source: Developed by the consultant (see report on Kaliningrad Integrated Fuel and Energy Balance

For more detailed information on energy balances, see the project report "Kaliningrad Fuel and Energy Balance".

2.3 Energy resources

Kaliningrad Region imports most of its fuels (mainly coal, petroleum products and natural gas) from other parts of Russia. There is however a potential for using also local fuels and waste such as peat, wood, wood waste and municipal waste. Also there may be a potential for increasing the utilisation of wind power and hydropower in the region.

Gas

Kaliningrad Region is supplied with natural gas through a pipeline, which starts in Minsk, passes through Lithuania and terminates in Kaliningrad. The pipe diameter from Minsk is 1220 mm and from the border to Lithuania and to Kaliningrad the pipe diameter is 530 mm. The pipeline operation pressure is 20-40 bar, which is rather low for a transmission pipeline. The present capacity is 1,450 mill. m^3, and today Kaliningrad region is using all this capacity.

Gasprom has plans for upgrading the capacity of the existing pipeline which includes a parallel line, a compressor, and an underground storage at the entrance from Lithuania. Another possibility for increased gas supply to Kaliningrad is to connect the Kaliningrad gas system to the planned North European Gas Pipeline on the bottom of the Baltic Sea from Russia (Vyborg) to Germany (Greifswald).

Compared to other fuels, natural gas is the absolute cheapest fuel due to a low federal price level which is only one sixth of the European gas price. This makes gas based power and heat production very feasible compared to other fuels. However, in a longer run the perspectives of the federal gas price is unsure.

Coal

Coal is used in smaller heat stations and in individual building boilers. Coal is supplied from Russia and distributed by truck within the region.

Mazut

Mazut is a common fuel in the region for larger boiler stations located in areas without gas supply. Mazut is delivered in train tank wagons to the heat station and unloaded to underground concrete pits from where it is pumped to storage tanks.

The unloading process to underground pits might cause pollution due to leakages in pits and underground installations. In winter times the mazut is heated with direct steam injection in the tank wagons, which results in oil polluted condensate, which again needs cleaning before it can be reused.

The Russian domestic price for heavy fuel oil is approximately identical with international level.

Peat

Kaliningrad region has rich peat resources. Totally are registered 282 peat areas with an area of 64,978 ha and a content of 1,660 mill. m3.

The present exploitation is low. The major part of the exploitation is garden peat for export and only a negligible part is used for energy production, as the region has only one larger boiler plant with a capacity of 6 MW.

The regional administration is planning to establish two new CHP plants based on peat - one in Gusev and one in Chernyahkovsk.

Biomass

The forest area in Kaliningrad region is rather low compared to neighbouring countries in the Baltic region. However, there may be some potential for using biomass in form of forest wood for energy production.

The region has two pulp and paper plants using local and imported wood for paper production. Bark and sawdust are residuals from the production which can also be used for energy production.

Straw from wheat, rye, barley and oat can be used in all size of boilers. The agricultural field output is app. 1,000 Gcal/km^2.

Municipal waste

The quantities of waste in Kaliningrad region are lower than the European average per person. However, Kaliningrad is currently experiencing a substantial development in all sectors which will improve living conditions and thereby also the production of waste.

Today, municipal waste is not utilised for energy production. There are plans on establishing a combined heat and power waste incineration plant in the city of Kaliningrad.

Hydro power

Today, Yantarenergo is operating three hydro power stations with a total installed capacity of 1.7 MW.

Wind power

The total potential of installed wind power capacity in Kaliningrad region was some years ago estimated to 1,100 MW. Today, Yantarenergo is operating one wind park with an installed capacity of 5.1 MW.

Geothermal energy

The underground in Kaliningrad region contains geothermal energy in the form of hot water that may be exploited for district heating. The temperatures are highest in the western part with temperatures up to 95 °C (Svetlij) which makes it profitable for exploration.

Until recently, Kaliningrad region imported most of its electricity from Russia through its neighbouring countries. In 2005, however, a new power plant, Tets-2 (unit 1) started in operation, and in 2006 this power plant generated 2,300 million kWh corresponding to 58% of the total need for electricity of 3,900 million kWh, see Figure below.

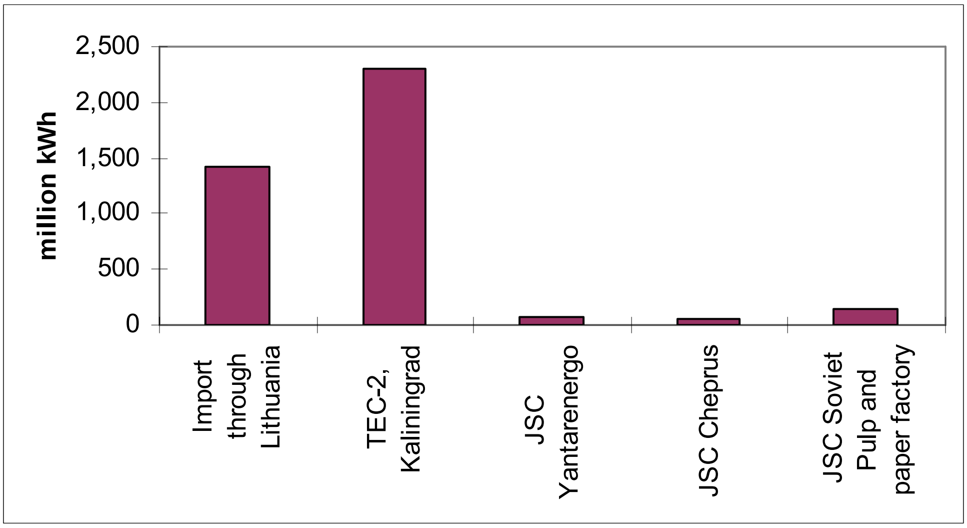


Figure 2.1 Electricity generation and import - 2006

Apart from Tets-2, there are some other CHP plants in the region as well as some hydro power facilities and some wind turbines. These production facilities are owned and operated by JSC Yantarenergo, JSC Cheprus and JSC Soviet Pulp and paper factory. In total, they accounted for 6% of the electricity consumption in 2006, whereas the remaining part, i.e. 36%, was imported through Lithuania.

2.4 Energy sector organization

Power sector

The main electricity producer is TETS-2 which is located in Kaliningrad city. In addition to this a number of minor hydro power plants and wind turbines located in the Region as well as industrial entities (pulp and paper factories) supply electricity to the public grid. The balance of the total electricity demand (approximately 36% in 2006) is provided by imported electricity from the Russian mainland through Lithuania.

The power plant, TETS-2, is designed as a combined heat and power plant, but as it presently lacks the possibility to supply heat to the district heating network it is operated as a condensing unit.

Another power plant, TETS-1, has recently been converted from mazut fired combined heat and power plant to gas fired heat only plant. There are plans to construct a new combined cycle combined heat and power plant at the location of TETS-1.

Electricity is transmitted through three systems, Kaliningrad Oblast East, Kaliningrad Oblast West and Kaliningrad City, while transmission of electricity including import of electricity is handled by a federal entity, Forem.

Heat sector

The largest municipalities in Kaliningrad Region supplied with district heating are:

Kaliningrad	Sovetsk
Svetlij	Chernyahkovsk
Gusev	Baltijsk
Neman	

Kaliningrad

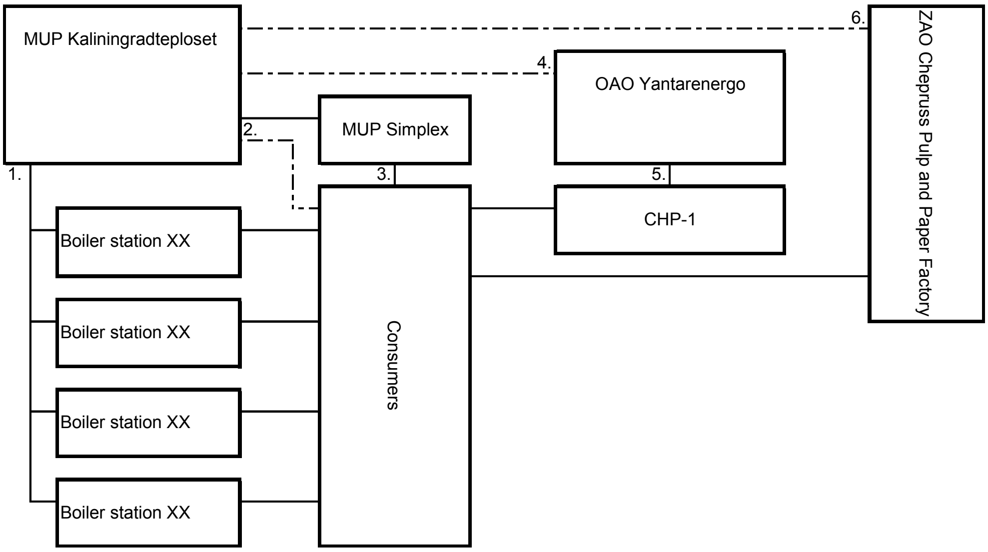
The district heating system is supplied by following main sources:

TETS-1 owned by OAO Yantarenergo and is operated as a heat only boiler station;

The heat only boiler stations of MUP Kaliningradteploset (Kaliningrad District Heating Company, KDHC). KDHC owns a number of heat only boiler stations of different sizes, which supplies to the DH systems.

ZAO Chepruss Pulp and Paper Factory, which produces electricity and heat on a CHP plant primarily for its own needs. Surplus power and heat is supplied to the power grid and district heating network of the city. The installed power capacity is 18 MW and the fuel is natural gas.

Heat Production and Distribution Structure of Kaliningrad City



Notes:

MUP Kaliningradteploset	1. Own and operates HOB stations and DH network North and South 2. Contract authority for heat supply contracts with consumers
MUP Simplex	3. Billing and collection of payment for heat from consumers
OAO Yantarenergo	4. Produces heat on CHP-1, which is sold to MUP Kaliningradteploset and distributed through DH network North and South 5. Own and operates CHP-1
ZAO Chepruss Pulp and Paper Factory	6. Produces power and heat. Surplus heat is sold to MUP Kaliningradteploset and distributed through DH network. Surplus electricity is sold to FOREM

Figure 2.2 Heat Production and Distribution of Kaliningrad City

Sovetsk

Sovetsk Pulp and Paper Factory produces electricity and heat on a CHP plant primarily for its own needs. Surplus power and heat is supplied to the power grid and district heating network of the city. The installed power capacity is 36 MW and the fuel is natural gas.

Svetlij

The CHP plant, GRES-2, owned by OAO Yantarenergo, produces electricity and heat which is supplied to the power grid and district heating network of the city. The installed power capacity is 114.8 MW and the fuel is heavy fuel oil (mazut).

Baltijsk

MO PF 476$_{th}$ Power Supply of the Navy produces electricity and heat on a CHP plant for its own needs. Surplus power and heat is supplied to the public power grid and district heating network of the city. The installed capacity is 50 MW.

Neman

Nemanskij Pulp and Paper Factory produces electricity and heat on a CHP plant for its own needs. There is no surplus power production. Surplus heat is supplied to the district heating network of the city. The installed power capacity is 18 MW and the fuel is natural gas.

An overview of the heat production facilities in Kaliningrad region is given in annex 1 to this report.

The total number of heat production units in these municipalities is 681 and the fuel distribution is presented in the table below.

Table 2.3 Boiler Stations in largest municipalities supplied with DH

	Gas	Coal	Mazut	Diesel Oil	Peat	Other
Number of boiler stations	37	579	31	26	3	5
Fuel consumption, 1,000 tce	840	248	475		98	
Fuel consumption % of total	50%	15%	29%		6%	

1) tce (tons of coal equivalents) equivalent to coal with a calorific value of 7,000 kcal/kg

2.5 Energy sector development

In May 2007, the regional administration is expected to take decision on a new energy strategy including the establishment of six new CHP plants in the region. These are:

Neman	gas fired CHP plant
Svetlij	coal fired CHP plant
Baltijsk	coal fired CHP plant
Kaliningrad city	municipal waste fired CHP plant
Gusev	peat fired CHP plant
Chernyahkovsk	peat fired CHP plant

These six CHP plants will increase the share of CHP in the region considerable and thereby also the overall fuel efficiency due to the fact that co-generation of heat and power is much more efficient than separate production. Furthermore, the six CHP plants will lead to an increase in regionally power generation which will lower the need for imported electricity. Finally, the use of coal, peat and municipal waste in five of the six plants will save app. 700 million m^3 of future gas demand per year that if supply potions would sbe available can be used for some other purposes instead, e.g. gasification of new municipalities..

Neman - new gas CHP

Neman municipality is supplied by district heating by Neman pulp and paper factory. But due to lack for heat supply, it is planned to construct a new CHP plant in 2007-2008. The plant will consist of three gas turbines with heat recovery boilers. The plant will have a total power capacity of 18 MW and heat capacity of 36 Gcal/h. The plant will cover heat and electricity supply in combination with the production facilities at the pulp and paper factory.

The plant is expected to have an annual electricity generation of 140 GWh, an annual heat production of 325 Tcal, and an annual gas consumption of 60 million m^3.

Svetlij - new coal CHP

The existing CHP station in Svetlij municipality has not produced electricity for the last ten years. It operates in heat mode only and supplies Svetlij municipality DH system with heat at very high costs. Heat losses in the network is more than 60%.

It is planned to establish a new CHP unit in 2007-2008. The plant will be fuelled by coal delivered from Ust-Luga (RF) to cargo terminal in Baltijsk by ferry. The plant will have a total power capacity of 75 MW and heat capacity of 90 Gcal/h. The ash and slag wastes will be used for construction materials and asphalt production and for roadway maintenance.

The plant is expected to have an annual electricity generation of 600 GWh and an annual heat production of 750 Tcal.

The district heating network is under rehabilitation.

Baltijsk - new coal CHP

Today, there are 12 insufficient boiler stations operating in Baltijsk municipality. The price of the heat produced is one of the highest in the region and make up 1600 rubles per Gcal.

It is planned to establish a new CHP unit in 2008-2010. The plant will be fuelled by coal delivered from Ust-Luga (RF) to cargo terminal in Baltijsk by ferry. The plant will have a total power capacity of 75 MW and heat capacity of 90 Gcal/h.

The plant is expected to have an annual electricity generation of 600 GWh and an annual heat production of 750 Tcal, and it will substitute several old mazut and coal fired boiler houses which will be closed down.

The district heating network is under rehabilitation.

Kaliningrad city - new waste CHP

In Kaliningrad city, there is a city dump very close to Kosmodemianovsk settlement. More than 22 million m^3 of municipal waste is stored there. Yearly, the volume of municipal waste increases by 140-150 thousand m^3. Furthermore, a lot of unusable wheels have accumulated in the region and the matter of its utilisation is still under consideration.

It is planned to establish a new CHP unit in 2008-2010 fuelled by municipal waste. The plant will have a total power capacity of 25 MW and heat capacity of 30 Gcal/h.

The plant is expected to have an annual electricity generation of 160 GWh and an annual heat production of 250 Tcal

Today, the existing HOB in Kosmodemianovsk settlement utilises and processes unusable wheels and about 150 thousand m3 of municipal waste per year. The heat is supplied to the district heating system of Kosmodemianovsk settlement.

Gusev - new peat CHP

Gusev is one of the main industrial municipalities of the region. Gusev municipality is only partly supplied with district heating; the remaining part is supplied from individual boilers or from block boilers.

It is planned to establish a new CHP plant in 2007-2010. The plant will be fuelled by peat produced by Krasnopolyanskaya peat processing company. The peat field is located within the radius of 15-35 km from Gusev. The plant will have a total power capacity of 125 MW and heat capacity of 150 Gcal/h.

The plant is expected to have an annual electricity generation of 1,000 GWh and an annual heat production of 1,000 Gcal. Ashes left after peat combustion will be used as high-quality fertilizers.

The district heating network is under reconstruction and modernisation, and all unprofitable boiler houses are being closed down one by one.

Chernyahkovsk - new peat CHP

Chernyahkovsk municipality is one of the main industrial municipalities in the region. A large part of the heat demand is covered by district heating, and there are 32 boiler houses including 21 coal fired boilers, 7 mazut fired boilers, and 4 diesel fired boiler houses.

For the further development of the municipality, it is planned to establish a new CHP plant in 2008-2010. The plant will be fuelled by peat produced by Skungirer Moor and Stangutsher Moor peat processing companies. The peat field is located within the radius of 15-40 km from Chernyahkovsk. The plant will have a total power capacity of 100 MW and heat capacity of 120 Gcal/h.

The plant is expected to have an annual electricity generation of 800 GWh and an annual heat production of 850 Tcal. Ashes left after pet combustion will be used as high-quality fertilizers. The district heating network is under development.

Supply options

Apart from the six new CHP plants as listed in the section before, the following changes of the supply (thermal supply) side could be considered:

- Connection of the existing power plant, TETS-2, to the to the district heating network in order to exploit its possibilities for production of heat.
- Construction of a new combined cycle combined heat and power plant at the location of TETS-1 including connection to the power grid and district heating network.
- Rehabilitation of Gusev District Heating System. See Gusev District Heating Rehabilitation Study 2002 - 2004.
- Hydro supply options
- Wind power
- Heat supply options
- Energy saving measures

Rehabilitation and extension of DH systems involves a number of different initiatives to improve energy efficiency. This section comprises a presentation of general energy efficiency initiatives and possible measures to reduce production costs and to improve the energy efficiency of the district heating sector including production plants, distribution systems, substations as well as consumer installations. The section also comprises proposals for CHP plants which may be considered as replacement for existing heat only boiler stations, but also providing additional power generating capacity and increasing the overall EE and reducing fuel consumption.

The suggested EE initiatives and the technical and financial consequences are based on experience and findings from a number of projects dealing with energy efficiency the district heating sector in Central and Eastern Europe. The stated expected technical and financial consequences are of general nature and should in all cases be regarded as indicative and adopted to the actual conditions for the plants in question.

For each DHC an individual assessment of the needs for investments should be made based on the actual conditions of the plant and the priorities of the management.

In general, the largest energy savings are obtained at the consumer level, secondarily at distribution level and thirdly at the production level.

Therefore it is essential to encourage demand side management initiatives in order to reduce the total energy use at the consumers. The modernisation or replacement of the substations, the distribution system and the production units must be based on this future reduced heat demand. Also the full benefits of introduction of speed variable pumps as part of a flow controlled distribution system is only obtained when automatic controls are introduced at consumer level and in substations.

This means that most probably the future peak demand will be reduced as compared to the present heat demand or, alternatively, there will be a basis for an extending the supply systems without having to invest in additional production capacity reducing the average heat supply costs.

Detailed technical and financial parameters for each EE Initiative are presented in Annex 2 to this report.

Increased DH supply

In Kaliningrad city, the DH coverage is very high, about 95-97%. In other big municipalities, the coverage is 55-60%.

In municipalities where the DH coverage is low, there may be a potential for increasing the DH coverage - either by connecting more consumers to the existing DH network or by extending the DH network.

Conversion of heat only boiler stations (HOB) to combined heat and power plants (CHP)

A conversion from HOB to CHP will increase the energy efficiency due to the high overall efficiency related to cogeneration of heat and power. Furthermore, it will lead to an increase in the electricity generation in the region which will lower the need for imported electricity.

Rehabilitation of boiler stations

Some boiler stations are rather old and operate with low fuel efficiencies. A rehabilitation of boiler stations may lead to considerable fuel savings. The rehabilitation of boiler stations can be combined with other efficiency measures such as e.g. conversion to CHP and/or conversion to local and renewable fuels.

Rehabilitation of district heating networks (transmission and distribution)

At least one third of the district heating networks are estimated to be in poor conditions. Rehabilitation of the networks will reduce both heat and water losses considerably. Possible rehabilitation initiatives are listed in the annex.

Conversion to local and renewable fuels

The use of local fuels decreases the dependency of imported fuels and furthermore it decreases fuel transportation costs. The main options for use of local fuels in the region are peat and wood waste.

Furthermore, there is also a potential for wind turbines, both on shore and off shore. However, the costs of wind power may be relatively high compared to gas.

3 Analysis of the regional socio-economic development program, 2007-2016

3.1 The program's socio-economic development concept

The "Social and economic development program of Kaliningrad Oblast" aims at achieving the standard of living and the quality of environment comparable with European standards; competitiveness of Kaliningrad Oblast in the Baltic region; and development of effective regional management of the regional development process.

To achieve these strategic goals, the program suggests development of a favorable investment and business climate through institutional reforms; development of a comfortable social climate in the Oblast; effective industrial policies; development of transport and energy infrastructures, communication technologies and access to modern information technologies as a connecting link in interregional and international cooperation; development of the tourist/recreational complex, hospitality infrastructure and an attractive image of the region. The goal of achieving the standard of living comparable with that in the European countries implies dynamic development of Kaliningrad Oblast, but does not identify the economic growth rates needed to achieve this task.

3.2 The program's development scenarios

In general, the Program's effectiveness is evaluated against the following macroeconomic indicators (on condition that financing is available):

- Average annual increase of investments in Kaliningrad Oblast at least by 15-20%;
- Average annual growth of industrial output at least by 15-20%;
- Average annual growth of GRP at least by 7%;
- 4-5-fold growth of Kaliningrad Oblast budget revenues during the Program implementation period.

Further in this report and in the appendices, growth parameters are fixed for two scenarios: moderate and optimistic, with respective GRP growth rates of 13% and 20% per annum for 2006-2020. Notably, against the average annual economic growth rates in 2000-2005 (7% annual GRP growth), the "moderate" scenario is, in fact, very optimistic, while the "optimistic" scenario is –economically speaking- unrealistic.

Option 1 of the Oblast economic projection until 2012 developed according to the formats of the RF Ministry of Economic Development and Trade looks more realistic. It projects 7% annual GRP growth in 2006-2012. Option 2 suggests 20% average annual GRP growth. However, it also suggests that investment inflow in the Oblast economy will only show 8% annual growth. Then it is not clear, why the returns on capital are growing so fast, allowing for 2.5 times faster growth of GRP compared to investments.

Not for all projection parameters (industrial output, residential incomes and expenses, occupancy structure, cargo transportation, retail turnover, etc.) data are available for both scenarios and for the whole period through 2016. Often the tables contain no indications of which scenario the values correspond to. In other words, the scenario conditions are not described clearly and in full detail, making the data difficult for analysis and usage in the ENERGYBAL model. In addition, internal inconsistencies found in these scenarios makes them even more difficult to use.

3.3 The inconsistencies in the program's development scenarios

3.3.1 UNSUSTAINABILITY OF FINANCIAL RESOURCES

It is assumed, that the federal budget will allocate 41.5% (177 bln. rubles) of the overall financing needed for program implementation (426 bln. rubles), i.e. 17.9 bln. Rubles annually, which is more than tax and non-tax revenues of the Oblast budget in 2006. This means, that the program relies on a risky assumption that the federal government is prepared for a multifold increase of its financial support to Kaliningrad Oblast through 2016. For example, oil and gas prices may decrease and thereby influencing the federal budget revenues or presidential election could bring about a revision of federal budget support programs and agreements. In any case, there is no formalized allocation of the necessary financial support in the federal budget.

13-20% annual GRP growth rates mean (with an assumption that the return on capital is stable), that the investment rate must be at least 30-40% per year. Such high investment rate assumption (and keeping the investment increase at 15-20% per year) must be based on a clear understanding of possible sources of such a dynamic investment growth. The Program claims, that the volumes of financing were identified based on the investment intention declarations submitted to Kaliningrad Oblast, but this seems an unreliable basis for estimates. Good intentions always considerably exceed real investments in practice. Without a clear answer it is impossible to assess the dynamics of fixed capital by sector and to evaluate the feasibility of the suggested development rates in all the sectors and economic activities.

3.3.2 GROWTH OF INDUSTRIAL OTPUT AND OIL EXTRACTION VOLUME

The Program suggests 15-30% annual growth of industrial output. In 2005, the share of mining in the industrial added value was 44%, of manufacturing industry 47%, and of electricity, natural gas and water production and distribution 8%. According to the Program, until 2010, oil and gas extraction will be dropping by 5% per annum, while electricity generation will show 5-6-fold growth. Then, to achieve declared industrial output growth rates, manufacturing growth must equal 30-40% per annum, i.e. show 2.5-5 fold increase in 2005-2010. It is not clear from the Program, which industries will ensure such development. In the projection made in 2007 until 2012 this aspect was reconsidered. This projection suggests, that oil extraction will increase to 1,800 thousand tons by 2012.

3.3.3 CARGO TURNOVER AND GRP GROWTH

Cargo shipment growth cannot be far behind the growth in GRP. In 2000-2005, the GRP was growing by 7% per annum, while cargo railway shipment growth was 10%, water shipment 5%, and automobile shipment 20% per annum. However, with projected by the Program GRP annual growth rates of 13-20%, industrial output of 15-30%, agricultural output of 8%, and retail trade of 24%, cargo shipment growth is only 5% per annum. It is not clear, why the correlation between GRP growth and cargo turnover would change so abruptly. This assumption does not seem realistic.

3.3.4 RESIDENTIAL INCOME GROWTH AND RETAIL TRADE

Retail trade turnover cannot continuously exceed residential income growth for a long time. Lack of correlation between residential income growth and retail trade turnover growth seems inconsistent. The Program claims, that average per capita income in the Oblast will reach 27,770 rubles per month in 2016 and will show a 13% annual growth. If the population increases to 1.49 mln., cumulative residential income in 2016 will be 496 bln. rubles, and the average annual growth will be 18.5%. At the same time, retail trade turnover in 2016 will be 460 bln. rubles, growing by 24% per year. In 2006, only 50% of residential income was spent on purchasing goods. This share will reduce, as average income grows. Even with around 1 million tourists per year, each spending 10 days in the Oblast, retail trade turnover will hardly increase till 250-260 as a maximum and is a long way off 460 billion rubles.

3.3.5 MAJOR LIMITATIONS TO GROWTH: LABOR SHORTAGE AND AVAILABLE HOUSING

Migration inflow projected in the “Social and economic development program of Kaliningrad Oblast for 2007-2016” is not balanced with the migrants accommodation potential. Labor is the most important production factor and is determined both by economic and demographic parameters. In order to ensure 13-20% annual GRP growth, and the given labor productivity increase of 6% per year, the number of employees must be growing by 6.6-13.2% and reach 1.1-2.2 mln. people by 2020 (population must therefore reach 2.2-4 mln. people). However, the scenario suggests that the number of employees will increase only to 880 thou. people in 2016, or by 4.7% per year on average. In this case, labor productivity must be growing by 8-15% per year and the population increases to 1.6-2.0 mln. people in 2020.

In recent years, Kaliningrad Oblast has seen a sustainable trend of population decline, despite net annual immigration of 3.5-3.8 thousand people. In 2000-2006 alone, population dropped by 18 thousand people. If it were not for the migration increase, population would drop to 806 thousand by 2020, or by 133 thousand people, and the number of employees by 97 thousand. In this case, if the 2001-2006 labor productivity growth rates persist (around 6% per year), the GRP can only increase by 4% per year.

To accommodate newcomers (20 m2 of living space per capita), at least 7.4 mln. m2 of housing must be built before 2010, while the Program suggests 6.2 mln. m2, or approximately 1.5 mln. m2 per year, while in 2006 only 501 thousand m2 of housing were built. Given housing construction costs of 12 thousand rubles/m2, this will require 88 bln. rubles in 2006-2010, or 17.8 bln. rubles per year on average. Notably, overall fixed capital investments in the Oblast in 2006 were slightly over 24 bln. rubles. Migrants cannot afford to purchase housing; they can rent it or get mortgage and gradually pay off. The renting housing system is yet to be developed, and besides, it is hard to find an investor, willing to risk investing in housing construction. Nor can the oblast budget allocate this financing. Without this large-scale housing construction, real estate prices will rapidly increase, making the Oblast no longer attractive for migration. In addition, the Program lacks an analysis of migration attractiveness factors in the Oblast.

A simplified sectoral model was developed to analyze the reliability of the economic growth rates assumptions. In this model, output dynamics by economic activities is determined by fixed capital dynamics, and manpower demand is determined based on the labor productivity dynamics assumptions. Then population dynamics and housing demand for the Oblast residents, as well as their ability to buy or rent this housing, were evaluated using the demographic model of the Oblast. If the Oblast is to become attractive for migration, housing supply must increase. In this case, migrants accommodation possibilities are balanced with the manpower demand.

Several iterations by this scheme showed, that even under a very optimistic assumption, that labor productivity will be growing by 6.5% per annum, average annual GRP growth rates will not exceed 10%. Even in this case, 200-300 bln. Rubles must be invested in 2007-2020 in the construction of social housing and hostels, because the number of migrants will reach 27 thousand people in 2007, and increase to 89 thousand by 2020.

4 Development scenarios for Kaliningrad Oblast

This chapter contains three different scenarios for a possible future development of Kaliningrad region. The following sections will set out the scenario concepts and assumptions and the basic input data into the model (ENERGYBAL) used to generate the energy demand over the forecasting period.

4.1 The "Baltic dragon" scenario

4.1.1 THE CONCEPT

This scenario assumes, that Kaliningrad Oblast, like rapidly growing Asian "dragons", will manage to keep very fast rates of economic growth during a long period of time, and that the Oblast GRP will be growing annually by 10% on average in 2007-2020.

The "Baltic dragon" scenario is based on the following concept:

- The conditions of a free economic zone and the local market infrastructure will become attractive for a considerable and sustainable investment inflow;
- Profit repatriation by investors, as well as incomes transfer by migrants, shall not considerably reduce the investment and consumption dynamics in the Oblast;
- For strategic purposes, the federal government shall provide tangible economic support to Kaliningrad Oblast, even if oil and natural gas export revenues significantly decline;
- Low energy intense assembling plants, transport and commercial sectors, including tourism, shall become critical «points of growth»;
- Sustainable salary growth shall make Kaliningrad Oblast attractive for migration, but shall not hamper capital inflow;
- Living conditions and effective migration policies shall make the Oblast attractive for manpower inflow from other regions and countries, without giving birth to national or other conflicts;
- The Oblast administration shall manage to find resources for large-scale (explosive) residential and social construction needed to accommodate, and provide the comfort of living to, many migrants starting from 2007;
- The Oblast administration shall manage to get gas limits to provide fuel for the operation of the second unit of KTETs-2 and attract investments for the "Small energy sector development program" (construction of 6 mini-cogeneration plants, which would use gas, coal, peat, and solid waste);
- The habit of addressing energy problems of the Oblast through expanding energy supply, rather than through improving energy efficiency, shall persist. No special energy efficiency policies shall be implemented.

Obviously, some statements of this development concept are contradictive. For example, fast growth of salaries can help keep the investment attractiveness of the Oblast only on condition of even faster growth of labor qualification and productivity. Capital inflow from outside the Oblast may well be followed by profit repatriation, rather than by further local investments. Abrupt growth of migration will lead to the fact that in 2020 migrants and their children will account for one third to a half of the Oblast population, which will make it difficult to preserve social stability. Aggravating relations between the native population and the newcomers may undermine the attractiveness of further migration. Therefore, the "Baltic dragon" must be pretty evasive. Besides, many migrants may transfer their incomes out of the Oblast, thus limiting local trade and the commercial sector development.

4.1.2 SCENARIO CONDITIONS

The above qualitative statements correlate with the dynamics of the basic variables of the ENERGYBAL model as described in the annexes.

Until recently, the Kaliningrad Oblast energy strategy has been based on the gasification process and commissioning of the second unit of KTETs-2. The Oblast administration was counting on getting 1.8 bln. m3 of natural gas in 2008 and 2.5 bln. m3 in 2009. However, Gasprom did not provide gas “limits” for the additional capacities of KTETs-2. Anatoly Chubais cooled down the optimism about the construction of the second unit of KTETs-2 by saying in May 2007 that he “will not authorize even one ruble investment in the construction of the second energy block, until there is a decision on gas supply”[2]. The construction budget is 9.3 bln. rubles. Of these, 1.674 bln. rubles are to be allocated in 2007, but until July financing has not been launched. The economic development projection until 2012, which was developed by the Oblast administration in 2007, declares, that the second unit of KTETs-2 will start electricity generation in 2010. This scenario assumes, that the second unit will still be built and provided with gas, but electricity generation will start later – in 2011.

The first block of KTETs-2 only generates electricity. The plant is located 15 kilometers to the south-west of Kaliningrad city. If it is to provide heat, too, a heat pipeline must be built to Kaliningrad city at the cost of around 1 bln. rubles. It is not clear, when this pipeline will be built, or how much heat can be generated, or if this heat can win the price competition with the existing 180 boiler-houses in the city, of which 144 have the capacity of less than 3 Gcal/hour and 138 are solid fuel-fired. The estimates are based on closing down gas-fired boiler-houses to release 70 mln m3 of natural gas, which are consumed to generate around 500 thousand Gcal annually. It is assumed, that the first unit of KTETs-2 can produce 1,660 thousand Gcal per year. According to the statistics, 2,315 thousand Gcal were provided to Kaliningrad city consumers in 2005. Given 10% heat distribution losses, KTETs-2 could potentially serve 65% of current heat market, and even more after the second unit is commissioned. In fact, for some parts of the city this would mean transition from decentralized heat supply to district heating.

According to the statistics, average specific fuel consumption by boiler-houses in the city is 165 kgce/Gcal (in reality, it seems higher than that). Reported heat distribution losses are 9%, while the actual level is at least 15%. This means, that heat from KTETs-2 (non-fuel tariff components equal) is competitive if specific fuel consumption equals 143 kgce/Gcal or less, or with an assumption that heat generation efficiency is 100%. KTETs-2 nameplate specific fuel consumption for heat generation is 155 kgce/Gcal. Therefore, its heat may lose competition, especially taking into account (a) high share of depreciation in KTETs-2 heat tariffs, (b) expected by 2010 doubling of relative gas price compared with coal (see below), and (c) apprehensions of both industrial plants and the municipality of the reliability of heat supply by KTETs-2. If heat provided by KTETs-2 is to win the market, it is important to allocate fuel costs to heat generation, based on the assumption that heat generation efficiency is over 100%, like it is done in Denmark, and accomplish a transition to seasonal heat tariffs. With an account of all these conditions, the projection assumes, that KTETs-2 will start heat generation in 2010 and increase it to 1.5 mln. Gcal by 2020.

With gas supply problems, the “Small energy sector development program” has become the most important direction of “Kaliningrad Oblast energy sector development strategy until 2015”. This program includes construction of 6 small capacity cogeneration plants in Baltiysk, Svetlogorsk, Gusev, Chernyakhovsk, Neman, and Kaliningrad. Overall potential electricity generation by these mini-cogeneration plants (3,800 mln. kWh in the “Strategy”) exceeds electricity generation increase due to the construction of the second unit of KTETs-2. The “Strategy” assumes, that Svetlogorsk and Baltyisk cogeneration plants will run at full load 7,222 hours/year. This excessively optimistic assumption was verified down to 6,666 hours/year. Therefore, potential electricity generation by these 6 cogeneration plants reduced from 3,800 to 3,300 mln. kWh.

[2] «Evroruble». 17.05.07-23.05.07. p. 1-3.

This program is viewed as a supplement to the construction of the second unit of KTETs-2 under the "optimistic" scenario of the "Strategy", and as an alternative to it under the "moderate" scenario. If it is a supplement, according to the "Strategy" the region becomes electricity excessive from 2010: (in 2015, electricity generation will exceed demand by 5,140 mln. kWh). In 2006, 2.6 bln. kWh were transmitted from the Oblast. It is not clear, if the Oblast is prepared for electricity export. The two options (construction of the second unit of KTETs-2 and the "Small energy sector development program") are further regarded as alternatives. They compete for investments. Investment demand for the construction of 6 mini-cogeneration plants is 14.9 bln. rubles. Along with the investments in KTETs-2 and in the development of electricity transmission lines, overall capital investment in the electricity sector of the Oblast in 2007-2011 will account for 37 bln. rubles (22% of all expected capital investment in 2007-2011), considerably aggravating the investment burden on the Oblast economy. This should be supplemented with the investment in the renewables development (a corresponding program will be formed later). This paper assumes hydro electricity generation increase to 23 mln. kWh, and wind electricity generation increase to 29 mln. kWh in 2020. Besides, if both options are implemented, excessive capacities will be formed after 2010, which would keep many investors away from additional investments in the electricity sector development in the Oblast.

Natural gas prices projection deserves a special attention. Until 2010, this projection much correlates with that of the RF Ministry of Economic Development and Trade. The price of natural gas for industrial consumers in 2010 will 2.9-fold exceed the 2005 level and, by current exchange rate, will equal 176 $/1000 m3 (average end-use price including VAT). The ruble/$ exchange rate is very likely to be 32-35 rubles/$ in 2010, but even then the price of natural gas will be 130-143 $/1000 m3. Moreover, according to the RF Government decree of 29.05.07 gas price markup will be introduced for new consumers in 2007, annually declining from 60% in 2007 to zero in 2011. Contractual gas price will vary in the range between the regulated and the market prices. In other words, the price for additional gas volumes may equal 138 $/1000 m3 already in 2007. The scenario is based on an assumption, that for the Oblast consumers gas price will be growing according to the schedule determined by the RF Ministry of Economic Development and Trade.

Electricity price for industrial consumers will grow by 71% in 2005-2010 and already in 2011 will reach 3 rubles/kWh, or 9-12 cents/kWh, despite even the fact that with the transition to free electricity market the federal government will provide subsidies to Kaliningrad Oblast electricity consumers. With such electricity price, many renewable energy sources and energy efficiency improvements will become competitive. Gas price hikes will also lead to 1.9-fold increase of heat prices. In 2010, prices for residual oil and gasoline will grow by 19%, and the coal price by 34%, compared to the 2005 level. Then in 2011, gas for power plants and boiler-houses will be 1.9 times more expensive, then coal.

Regarding energy efficiency improvement, an assumption was made that no specific regional energy efficiency programs will be implemented. Energy efficiency will be improved as a result of (a) consumers' reaction to energy, especially gas, price growth, and (b) price autonomous technical progress leading to energy efficiency improvements due to the renovation of production capacities and appliances.

This scenario projects fast (but not as fast, as in the super optimistic projections of the Oblast administration) economic growth and large-scale application of new equipment. Therefore, an assumption was made that autonomous technical progress will lead to 1% annual reduction of energy intensity in all consumption sectors, and that new residential buildings will be 30% more energy efficient (per 1 m2), than existing housing stock.

It is also assumed, that inflation rates will be gradually going down to 7% until 2010, and will account for 4% per year in 2011-2020. The climate will keep warm: the number of degree-days will equal 3,100-3,240.

4.1.3 ENERGY SECTOR DEVELOPMENT UNDER THE "BALTIC DRAGON" SCENARIO

Integrated Fuel and Energy Balance

With the assumptions of this scenario (the option of 6 mini-cogeneration plants construction) primary energy consumption in the Oblast will increase from 2,088 thousand tce in 2005 to 6,122 thousand tce in 2020, or nearly triple (see Fig. 4.1 and Table 4.1). This happens despite the fact that due to the energy price growth and autonomous technical progress the GRP energy intensity will drop by 29% in 2005-2020 compared to the 2005 level, or by 2.2% annually on average.

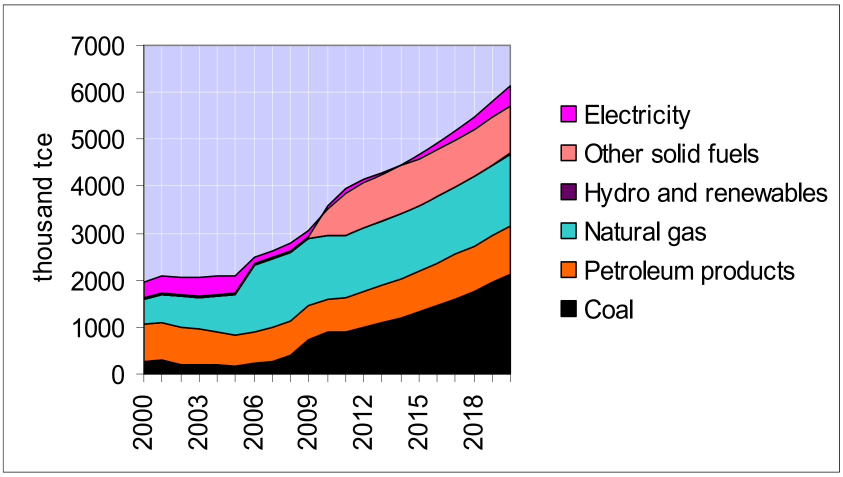


Fig. 4.1 Primary energy consumption under the "Baltic dragon" scenario (construction of 6 mini-cogeneration plants)

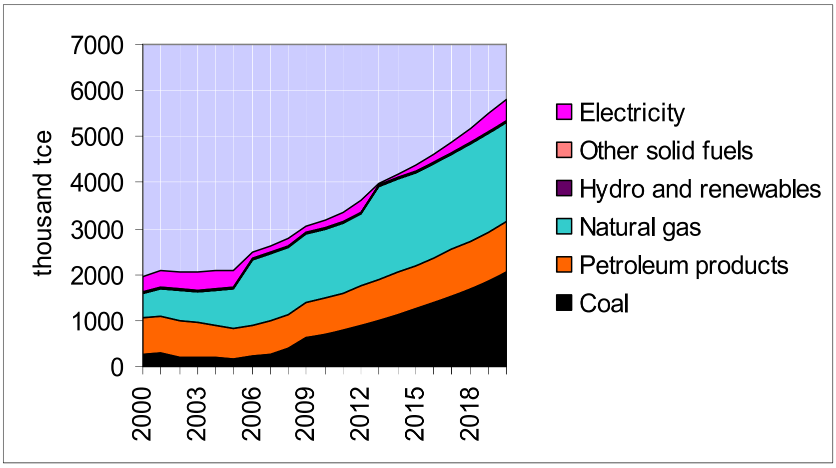


Fig. 4.2 Primary energy consumption under the "Baltic dragon" scenario (construction of the second unit of KTETs-2)

Due to the construction of mini-cogeneration plants the Oblast may temporarily (in 2010-2013) turn from a net electricity importer into a net exporter, but then will turn backwards. With limited possibilities of electricity export to other countries, this means that commissioning of mini-cogeneration plants in Gusev and Chernyakhovsk may be delayed until 2013-2014. This provides additional flexibility in the search for capital investment in the Oblast electricity sector.

Abrupt gas price growth leads to the fact that after the share of gas in the IFEB increases due to the commissioning of the first unit of KTETs-2, gas consumption will be growing very slowly, and its share will decline from 58% in 2006 to 25% in 2020, as it is substituted by coal and other solid fuels both at mini-cogeneration plants and boiler-houses. The share of coal in the IFEB will increase from 9% to 35% (coal consumption will grow 10-fold), and the share of other solid fuels from 1% to 17%.

If the second co-generation plant is commissioned in Neman, and another in Svetlogorsk, and if the second unit of KTETs-2 is commissioned (in 2013) primary energy consumption will increase to 5,809 thousand tce in 2020, and the share of natural gas will equal 37% in 2020 (see Fig. 4.2)

Table 4.1 IFEB in 2020 under the «Baltic dragon» scenario (Ttce)

	Coal	Crude oil	Petroleum products	Natural gas	Hydro/Renewables	Other solid fuels	Power	Heat	Total
Production		2,060.6		20.3	6.2	1,012.4			3,099.5
Import	2,134.5		1,033.7	1,505.3			413.5		5,087.0
Export		-2061					0		-2061
Stock changes									0
Primary energy consumption	**2135**	**0**	**1,034**	**1,526**	**1.9**	**1,012**	**413**	**0**	**6,122**
Statistical discrepancies									
Power plants	-652.3	0.0	-141.2	-834.5	-1.9	-985.7	752.3	945.6	-917.8
Power generation	-327.8	0.0	-27.9	-555.2	-1.9	-615.0	752.3		-775.5
Other stations	-6.9	0.0	-27.9	-1.5	-1.9	0.0	26.6		-11.5
Mini CHPs	-320.88			-33.77		-615.00	405.9		-563.8
KTETs-2	0.0	0.0	0.0	-520.0	0.0	0.0	319.8	0.0	-200.2
Heat generation	-1,413.4	0.0	-375.9	-716.5	0.0	-385.9	0.0	2,553.0	-338.7
Other stations	-86.2	0.0	-113.3	-72.7	0.0	0.0	0.0	241.3	-47.6
Mini CHPs	-238.4			-51.64		-370.75		561.28	-99.5
KTETs-2	0.0	0.0	0.0	-155.0	0.0	0.0	0.0	143.0	-12.0
Boiler-houses	-1,088.9	0.0	-262.6	-437.1	0.0	-15.1	0.0	1,592.8	-211.0
Industrial	-894.2	0.0	-250.2	-311.7	0.0	-14.1	0.0	1,322.0	-148.2
General use	-194.7	0.0	-12.4	-125.4	0.0	-1.0	0.0	270.8	-62.8
Heat recovery units								14.6	14.6
Own needs				-31.2			-17.8		-48.9
Distribution losses				0.0			-215.9	-382.9	-598.9
Energy end-use	**393.3**	**0.0**	**629.9**	**222.8**	**0.0**	**11.6**	**932.0**	**2,170.0**	**4,359.6**

Table 4.2 Integrated Fuel and Energy Balance - Energy end-use by sector (Ttce)

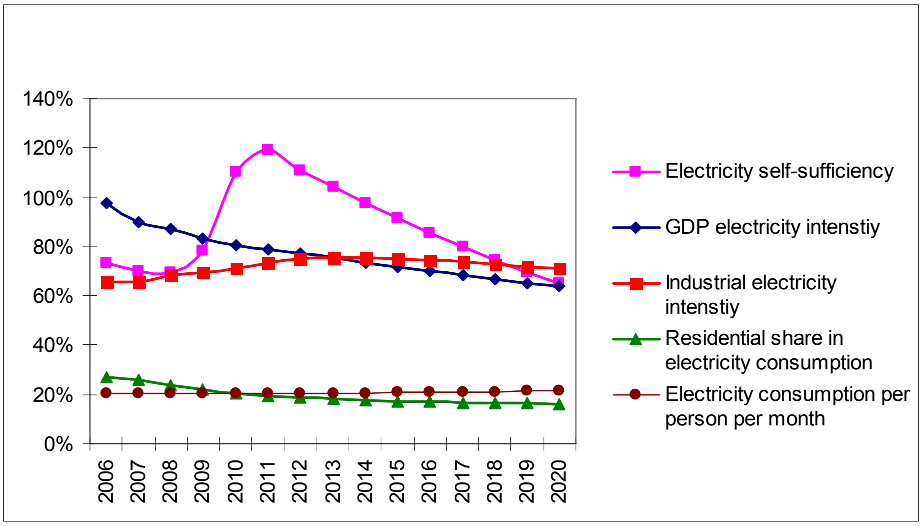
	Coal	Crude oil	Petroleum products	Natural gas	Hydro/Renewables	Other solid fuels	Power	Heat	Total
Energy end-use	**393.3**	**0.0**	**629.9**	**222.8**	**0.0**	**11.6**	**932.0**	**2,170.0**	**4,359.6**
Industrial	87.9	0.0	55.6	13.3	0.0	6.0	490.1	1,348.0	2,001.0
Oil extraction	0.0		5.7	5.5		0.0	7.8	0.0	19.0
Pulp	0.0		0.0	0.0		0.0	24.5	214.7	239.2
Paper	0.0		0.0	0.0		0.0	6.1	56.5	62.6
Cardboard	0.0		0.0	0.0		0.0	6.7	10.5	17.2
Meat products	0.0		0.0	0.0		0.0	15.1	34.9	50.1
Bakery products	0.0		0.0	0.0		0.0	1.7	10.1	11.9
Other	87.9		49.9	7.8		6.0	428.2	1,021.2	1,600.9
Construction	0.0		15.8	0.0		0.0	24.1	0.1	40.0
Transport	0.0	0.0	474.4	0.0	0.0	0.0	58.8	53.3	586.5
Aircraft	0.0		59.2	0.0		0.0	0.0	0.0	59.2
Automobile	0.0		355.1	0.0		0.0	0.0	0.0	355.1
Railway	0.0		22.5	0.0		0.0	41.3	35.1	98.9
Water	0.0		37.6	0.0		0.0	0.0	0.0	37.6
Urban electric	0.0		0.0	0.0		0.0	5.6	0.0	5.6
Other transport	0.0		0.0	0.0		0.0	11.9	18.1	30.0
Agriculture	0.0		21.8	0.0		0.0	58.5	11.4	91.8
Utility sector	49.4		6.9	0.0		0.0	14.1	19.5	89.9
Commercial	184.4		18.2	0.2		0.0	97.3	14.7	314.9
Residential	71.7		37.1	209.2		5.5	189.1	722.9	1,235.6

Source: Consultant's estimates

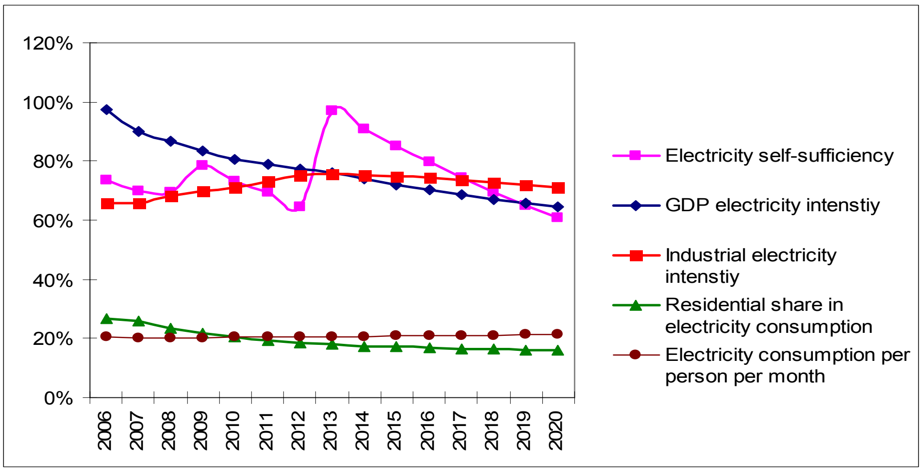
Electricity balance

Despite dynamic reduction of the GRP electricity intensity (by 36% in 2005-2020), electricity consumption will still grow 2.6-fold and account for 9,478-9,526 mln. kWh in 2020. Commissioning of 6 mini-cogeneration plants or 2 mini-cogeneration plants and the second unit of KTETs-2 will considerably weaken, and then temporarily eliminate, the Oblast's dependence on electricity imports, but then, with further economic growth, this dependence will restore (see Fig. 4.3 and 4.4).

By 2020, electricity self-sufficiency of the Oblast goes down to 61-65%. An attempt to completely provide itself with own-generated electricity will require additional capacities o generate 3,350-3,750 mln. kWh electriciy by 2020. If both 6 mini-cogeneration plants and the second unit of KTETs-2 are commissioned, electricity import demand in 2020 will go down to 1,183 mln. kWh. If no gas supply is available, then some more mini-cogeneration plants using other fuels will be required after 2015. In either case, transmission capacities of high-voltage networks from the neighboring countries are adequate, but need considerable investment in their renovation and compliance with the EU requirements, as well as in their development and providing conditions for the connection of new consumers in any area of the Oblast. If neither generation development, nor network renovation problem is addressed, lack of electricity will become a critical limitation factor for the Oblast's economic growth.



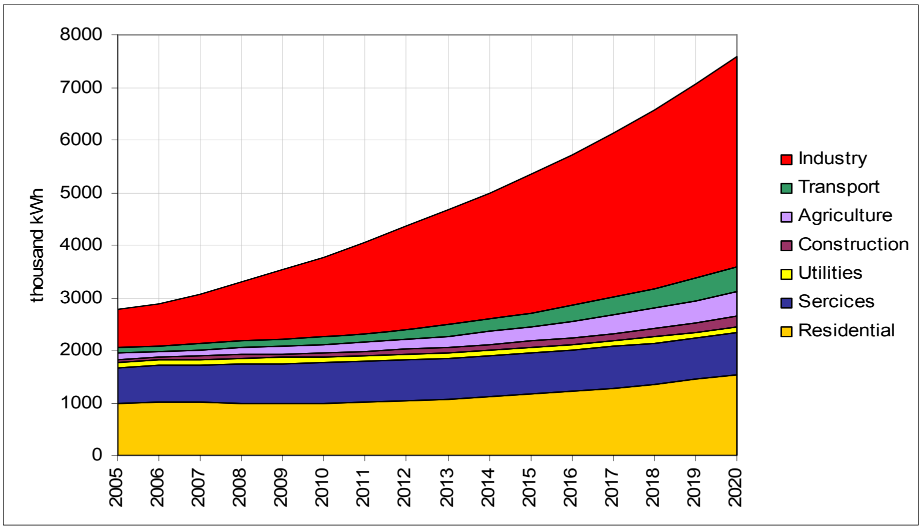
6 mini-cogeneration plants



Second block of KTETs-2

Fig. 4.3 Basic electricity consumption indicators by the "Baltic dragon" scenario

Electricity end-use consumption basically grows in the industrial sector as shown the two graphs below (Fig. 4.4).



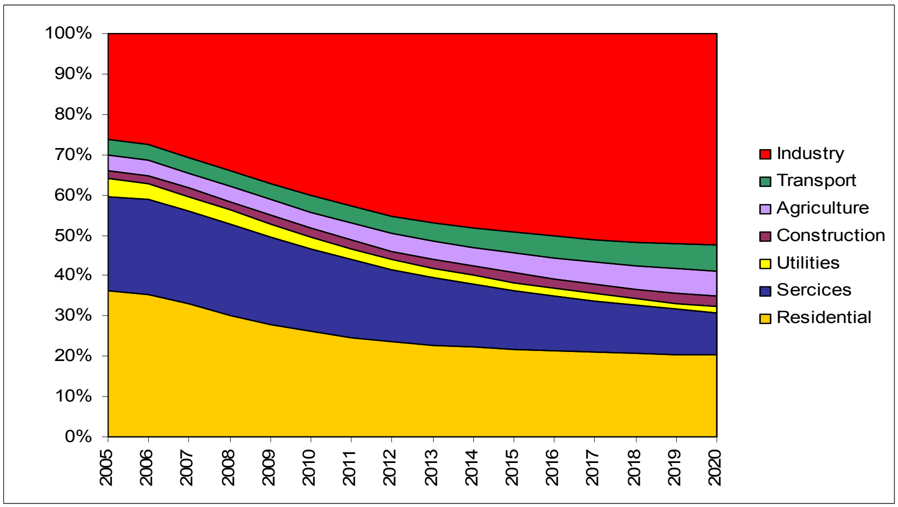


Fig.4.4. Electricity end-use dynamics and structure by the "Baltic dragon" scenario

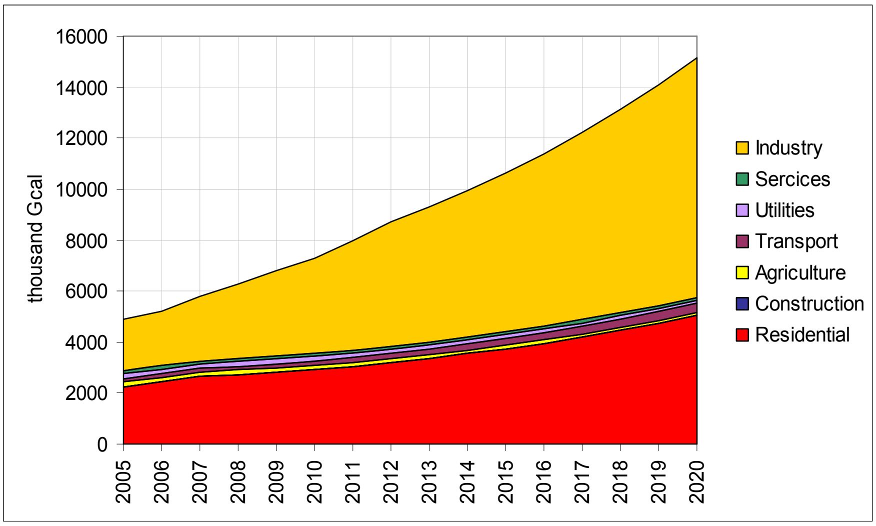
Table 4.3. Electricity balance by the «Baltic dragon» scenario (mln. kWh)

Year	Production	KTETs-2	Other	Mini-cogeneration plants	Renewables	Import	Consumption	Own needs	Supply to the grid	Transmission losses	Useful supply
2005	539	270	254	0	15	3,045	3,584	119	3,465	698	2,767
2006	2,766	2,528	201	0	15	1,002	3,768	143	3,564	677	2,887
2007	2,744	2,528	201	0	15	1,189	3,933	143	3,790	713	3,077
2008	2,907	2,550	201	140	16	1,290	4,197	143	4,054	762	3,291
2009	3,510	2,550	201	740	19	972	4,482	143	4,339	816	3,523
2010	5,273	2,550	201	2,500	22	-483	4,790	143	4,647	874	3,773
2011	6,126	2,600	201	3,300	25	-980	5,146	144	5,001	941	4,060
2012	6,129	2,600	201	3,300	28	-596	5,533	144	5,389	1,014	4,375
2013	6,132	2,600	201	3,300	31	-232	5,900	144	5,756	1,083	4,673
2014	6,135	2,600	201	3,300	34	166	6,301	144	6,156	1,158	4,998
2015	6,138	2,600	201	3,300	37	591	6,729	144	6,584	1,238	5,346
2016	6,141	2,600	201	3,300	40	1,051	7,192	144	7,048	1,326	5,722
2017	6,144	2,600	201	3,300	43	1,559	7,703	144	7,559	1,422	6,137
2018	6,147	2,600	201	3,300	46	2,106	8,253	144	8,109	1,525	6,583
2019	6,150	2,600	201	3,300	49	2,695	8,845	144	8,700	1,636	7,064
2020	6,153	2,600	201	3,300	52	3,325	9,478	144	9,333	1,756	7,578

Source: Consultant's estimates

Heat balance

Specific heat consumption per unit of GRP goes down by 25%. Nevertheless, heat demand by the "Baltic dragon" scenario increases dynamically (3-fold in 2005-2020), basically in the industrial and residential sectors. In the residential sector, the housing stock more than doubles (see Fig. 4.5). Heat generation balance will to a large degree depend on the competitiveness of heat supplied by mini-cogeneration plants and KTETs-2. But even if they provide maximum possible amounts of heat, there still will be a need for a considerable increase in heat generation by boiler-houses, industrial in the first place, after a certain reduction in 2008-2014.



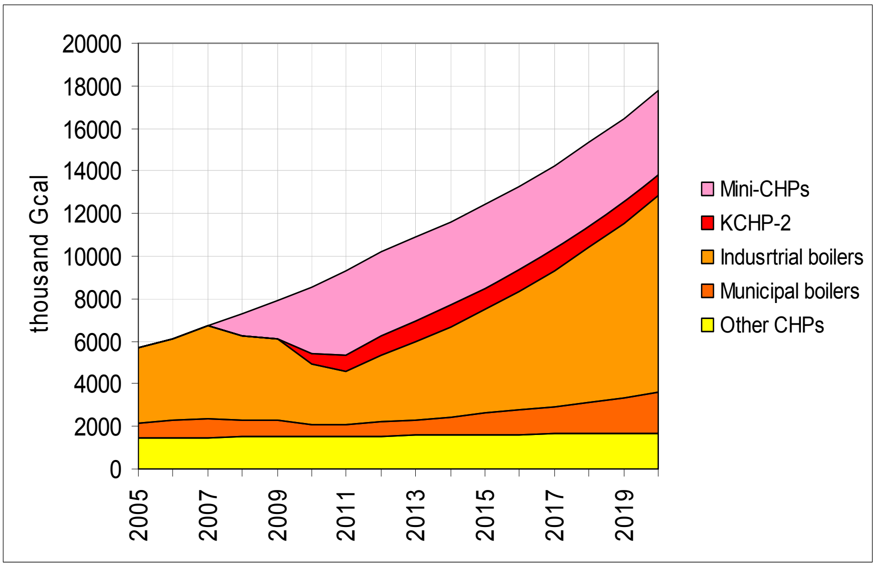
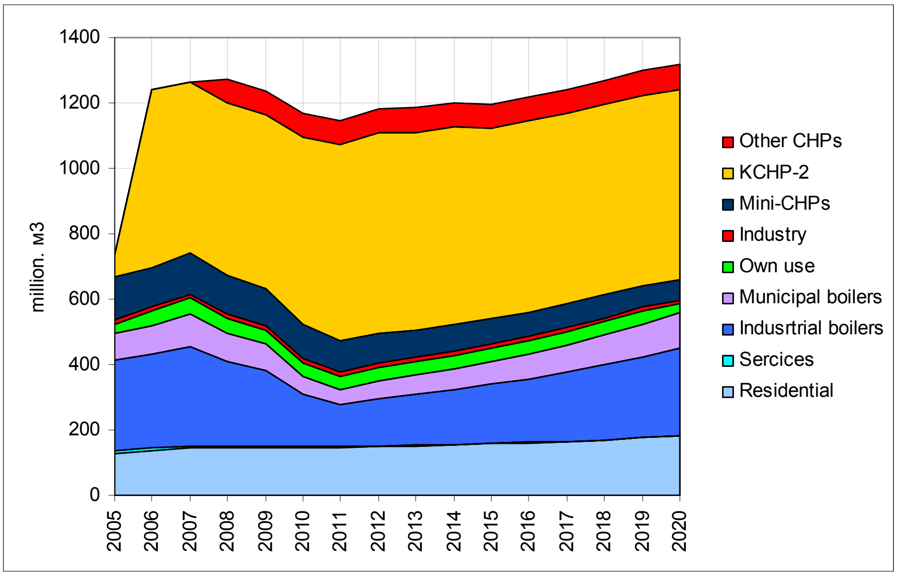


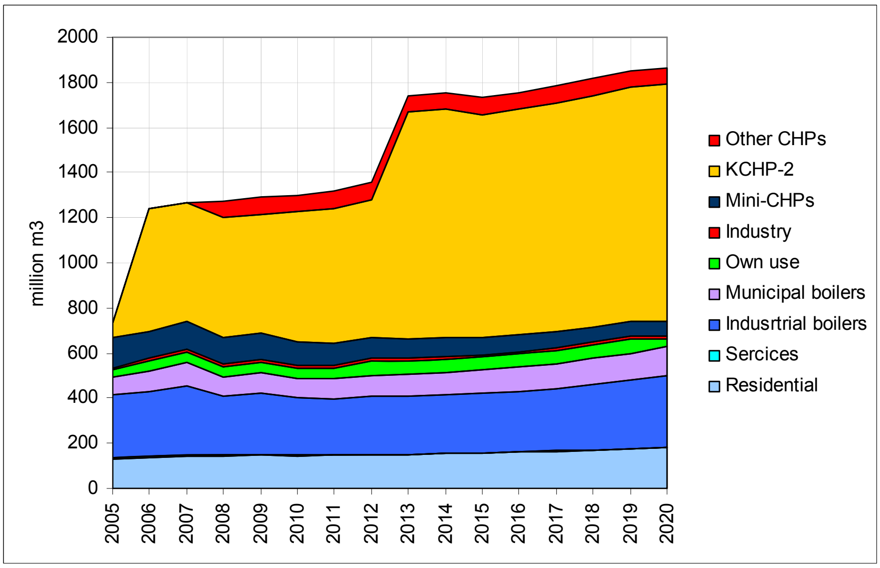
Fig.4.5. Heat consumption and production under the "Baltic dragon" scenario

Gas balance

Gas consumption volumes (1,316-1,850 mln. m3 in 2020) and changes in the gas consumption structure largely depend on the implementation of generation plans, gas price dynamics, and the strictness of environmental limitations to coal, peat, and solid waste use, i.e. on the availability of clean coal and peat technologies. With the above assumptions on gas price growth (see annex), gas consumption dynamics will be basically determined by KTETs-2 capacities commissioning (see Fig. 4.6).



Construction of 6 mini-cogeneration plants



Construction of the second block of KTETs-2

Fig.4.6. Natural gas consumption dynamics by the “Baltic dragon” scenario

Gas price dynamics is a critical factor determining future gas consumption. Notably, even with very high gas price, gas consumption still grows, requiring pipelines transmission capacity increase to at least 1.8 bln. m3 per year and construction of underground gas storage, if the second unit of KTETs-2 is commissioned.

Gas demand growth is largely determined by heat supply systems consumption. With relatively slow growth of gas prices, it is industrial boiler-houses that will be responsible for significant gas consumption increase. Therefore, special attention must be given to energy efficiency improvement of industrial heat supply systems.

Liquid fuel balance

Liquid fuel consumption will double in 2005-2020 (see Fig. 4.7). Transport will be responsible for around 40% of this consumption increase. A considerable growth of gas price will also increase residual oil consumption by boiler-houses and power plants.

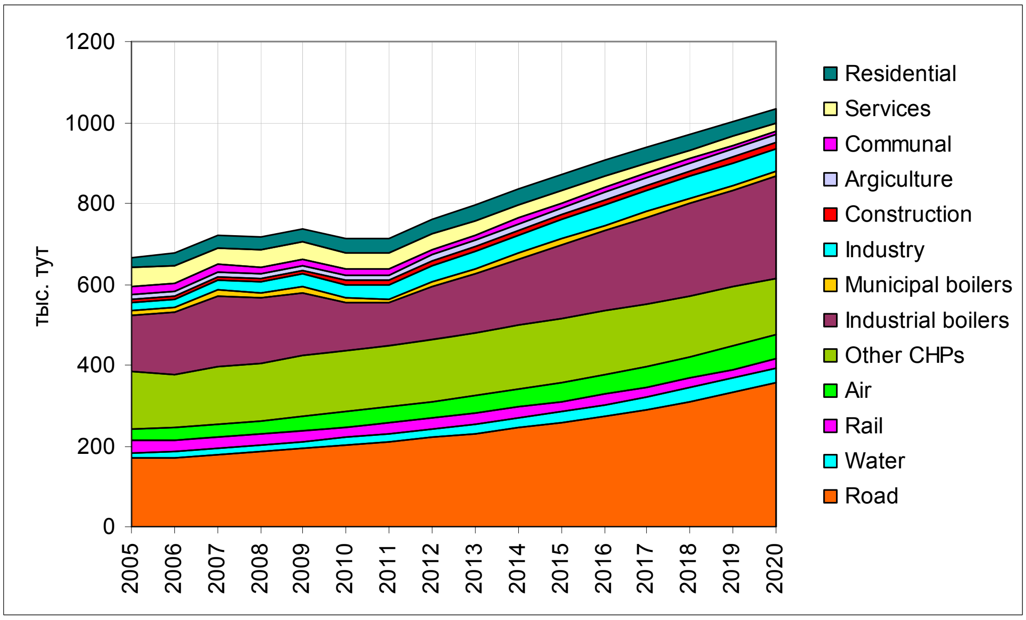
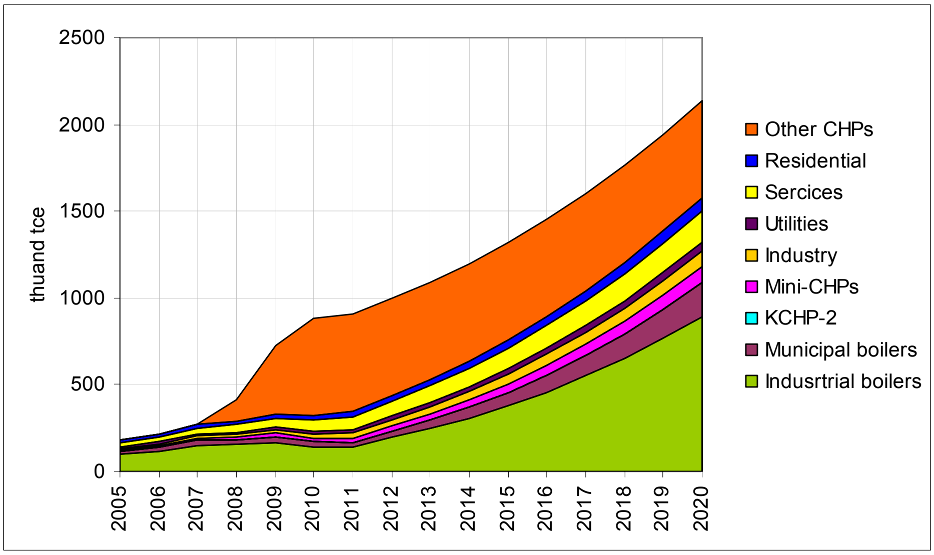


Fig.4.7 Liquid fuel consumption dynamics by the "Baltic dragon" scenario

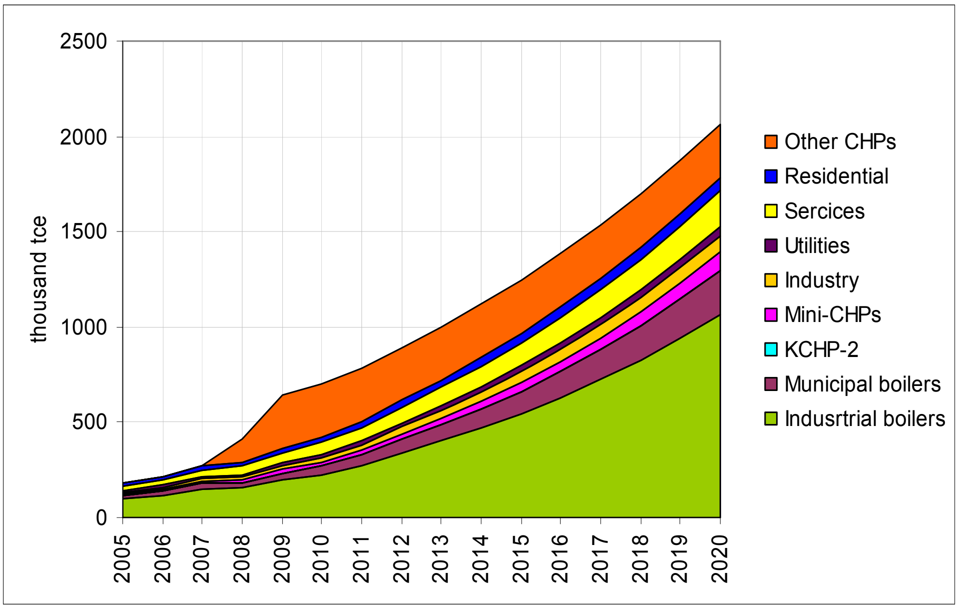
Coal balance

Coal consumption will show practically 10-fold increase due to the commissioning of two coal-fired mini-cogeneration plants and to growing coal consumption by industrial boiler-houses forced by rapid growth of gas price (see Fig. 4.8).

Without any coal consumption limitations and/or introduction of new clean coal technologies at boiler-houses pollutants emissions in the Oblast may grow abruptly. Emissions control at industrial boiler-houses will become an important condition of preserving a stable environmental situation in the Oblast.



6 mini-cogeneration plants option



Commissioning of the second unit of KTETs-2

Fig.4.8 Coal consumption and the IFEB basic coal indicators under the "Baltic dragon" scenario

Besides, it is important to develop the transport infrastructure to deliver coal both by railway and sea transport. Transportation of such significant volumes of coal will result in considerable growth of cargo turnover and energy consumption by the transport sector.

4.1.4 PRACTICAL FEASIBILITY OF THE "BALTIC DRAGON" SCENARIO

From the general economic point of view, implementation of the "Baltic dragon" scenario faces two problems: making the Oblast attractive for investors and providing conditions for the attraction and accommodation of migrants. The most serious economic limitation for this scenario is identification of financial sources for housing construction for potential migrants (construction of 1.5 m2 housing per Oblast resident per year, while the Russian average value is 0.3 m2). Investment demand is at least 18 bln. rubles/year until 2010. This seems unrealistic.

From a social point of view, the most critical task with such an inflow of migrants is to maintain social stability, keeping in mind that in 2020 migrants and their children may account for around 47% of the Oblast residents. It is the most critical, yet poorly investigated, risk under this scenario. Migration limitation by national or other principles with the purpose of keeping social stability will considerably reduce manpower inflow and hamper dynamic economic growth.

Regarding the energy aspect of this scenario, the following basic risks should be noted:

- By 2020, electricity self-sufficiency of the Oblast, even after 6 mini-cogeneration plants or the second unit of KTETs-2 are commissioned, will decrease to 61-65%. Electricity import demand may exceed current high-voltage network transmission capacities. To ensure electricity self-sufficiency, both construction of 6 mini-cogeneration plants and commissioning of the second unit of KTETs-2 are required in 2015 at the latest;
- Industrial sector will become the driving force of the economic growth; but it will also become the electricity demand driving force. Under this scenario, electricity demand will triple between 2005-2020;
- With the construction of the second unit of KTETs-2, gas consumption in 2020 may exceed 1.8 bln. m3. Without corresponding development of the gas

supply system it may be impossible to implement the economic growth potential;

- Fast growth of the gas price may aggravate the danger of covering “the Baltic dragon” with soot and coal ashes. Deteriorating environment may considerably reduce the investment and migration attractiveness of the Oblast.
- Without aggressive energy efficiency policies in the industrial sector and in the entire heat supply chain these risks may significantly hamper economic development in the Oblast.

4.2 The “Balanced migration” scenario

4.2.1 THE CONCEPT

This scenario assumes that migration to Kaliningrad Oblast will take place as favorable conditions are developed for manpower inflow from other regions (salaries growth, formation of the image of a socially stable region, housing construction to accommodate the newcomers, adequate social, recreational, and transport infrastructure, etc.).

The “Balanced migration” scenario is based on the following concept:

Development of favorable conditions for migration will determine the inflow of migrants;

Migrants inflow will gradually increase, as infrastructure is developed, and will determine possibilities for the enhancement of economic growth (with optimistic assumptions on the possible labor productivity growth);

The housing attractiveness factor[3] will be kept high enough to keep the residents from leaving the Oblast;

The Oblast’s attractiveness for migration will be determined by:

Dynamic salaries growth. In 2006, Kaliningrad Oblast ranked only in the 8th among 10 North-West regions in terms of average salary and stayed below the Russian average. Only dynamic growth of salaries may become the “magnet” for qualified manpower from other regions;

Lower housing prices compared with other regions (a possibility to sell housing in another region and buy one in Kaliningrad Oblast)[4], and/or

Large-scale *housing construction for rent* to provide migrants with affordable housing;

Elimination of visas to enter EU countries for the Oblast residents and to enter Russia for EU residents;

The conditions of a *free economic zone* and the local market infrastructure will become attractive for a considerable and sustainable investment inflow;

The federal government shall provide tangible economic support to Kaliningrad Oblast, but this support will be determined by the state of the federal budget and oil and natural gas export revenues;

Comparatively non-energy intense assembling plants, transport and commercial sectors, including tourism, shall become critical «points of growth”;

Lack of manpower will result in certain reduction of return on capital (by 0.5% per year in all sectors);

The habit of addressing energy problems of the Oblast through expanding energy supply, rather than through improving energy efficiency, shall persist. No special Oblast-level energy efficiency policies will be implemented.

Obviously, this concept differs from that of the “Baltic dragon” scenario in more realistic assumptions on the migration parameters and on the development of the Oblast labor resources.

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[3] Working under the World Bank Northern Restructuring Pilot Project CENEf introduced the “housing attractiveness factor”, which equals the quotient of the housing price in the secondary market divided by the annual housing and municipal utilities bill of an average family. Housing price in the secondary market of Kaliningrad Oblast, as of late 2006, was 18,240 rubles/m2. For 2007 it may be assessed at 22,500 rubles. Federal standard for housing and municipal utility services for the Oblast in 2007 equals 49.7 rubles/month, or 596 rubles/year. The housing attractiveness factor in 2007 nearly equals 40. This is high enough to keep the residents from leaving the Oblast.

[4] Housing prices in the primary market are rapidly catching up with the average Russian values. In 2007, housing affordability factor in the Oblast equals 16.5, which significantly limits housing purchase possibilities for the average income population.

4.2.2 SCENARIO CONDITIONS

The above qualitative statements correlate with the dynamics scenario of basic managing variables of the ENERGYBAL model as described in the annexes). All other conditions are the same as in the "Baltic dragon" scenario.

According to this scenario, average annual GRP growth rate in 2005-2010 will be 7.8% and will be gradually slowing down, but will be above the average Russian level during the whole period. Production growth rates assessment in agriculture and other sectors are also much more realistic. Average per capita income in 2020 will reach 20.7 thousand rubles in 2006 prices, which is 2.5-fold higher, than the 2006 level, and somewhat higher, than in the previous scenario. Incomes will be growing faster than in Russia on average, making the Oblast attractive for migrants.

The Oblast population will increase to 1,081 thousand people by 2020, and the number of employees to 520-550 thousand people. Average annual growth of labor productivity is 8.7%. Net population increase due to migration will be growing gradually and in line with the Oblast's capacities: from 8.5 thousand people in 2007 to 31 thousand people in 2020.

By 2020, housing commissioning will reach a very high (1.1 m2 per capita per year), yet a more realistic, level than in the "Baltic dragon" scenario (1.7 m2). Assessment of overall investment in the housing construction is also more realistic: in 2007-2020, it is only 57% of the housing construction program costs by the "Baltic dragon" scenario. Availability of living space will increase from 20.4 m2 per capita to 27.2 m2 (versus 24.8 m2 in the "Baltic dragon" scenario).

4.2.3 ENERGY DEVELOPMENT UNDER THE "BALANCED MIGRATION" SCENARIO

Integrated Fuel and Energy Balance

Under the assumptions of this scenario, primary energy consumption in the Oblast will increase from 2,088 Ttce in 2005 to 4,780 Ttce in 2020 (see Fig. 4.9 and Table 4.4/4.5). Energy intensity of the GRP will show 21% decline determined by both energy price growth and autonomous technical progress.

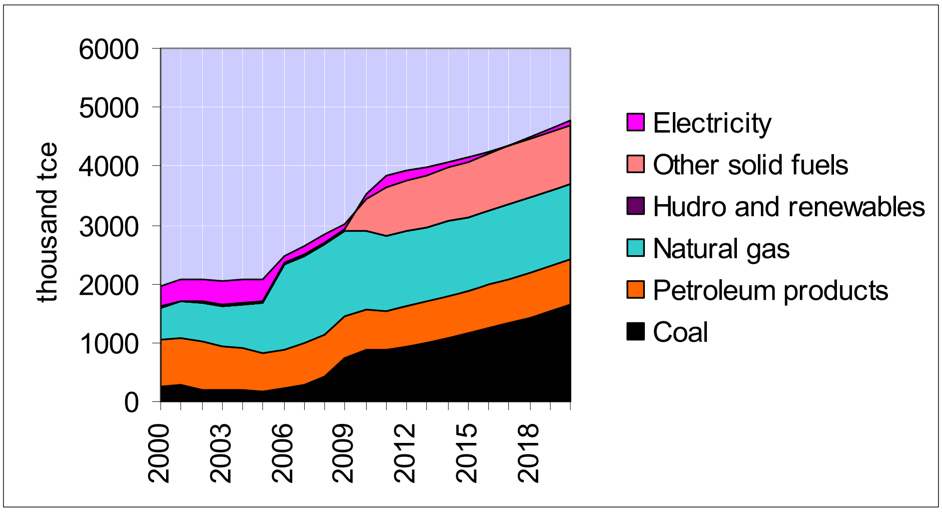


Fig.4.9. Primary energy consumption dynamics by the "Balanced migration" scenario

Like in the previous scenario, commissioning of coal-fired mini-cogeneration plants and abrupt gas price growth for boiler-houses lead to the growth of the share of coal in the IFEB to 34.5%. However, coal consumption will only increase to 1,650 mln. tce versus 2,135 mln. tce in the previous scenario. Net electricity import will not exceed the 2005 level until 2020, and in 2010-2017, and providing the necessary conditions are developed, there will be a possibility for electricity exports. Primary energy self-sufficiency of the Oblast will be growing due to the growing use of renewables, peat and solid waste, whose share in the IFEB will reach 21% by 2020.

Table.4.4. IFEB of Kaliningrad Oblast in 2020 under the «Balanced migration» scenario (Ttce)

	Coal	Crude oil	Petroleum products	Natural gas	Hydro/Renewables	Other solid fuels	Power	Heat	Total
Production		2,060.6		23.2	6.2	1,003.1			3,093.1
Import	1,650.2		768.6	1,245.7			87.8		37,52.2
Export		-2,061					0		-2,061
Stock changes									0
Primary energy consumption	1,650	0	769	1,269	1.9	1,003	88	0	4,780
Statistical discrepancies									
Power plants	-651.8	0.0	-144.6	-831.6	-1.9	-985.7	752.3	945.6	-917.8
Power generation	-327.8	0.0	-27.9	-555.2	-1.9	-615.0	752.3		-775.5
Other stations	-6.9	0.0	-27.9	-1.5	-1.9	0.0	26.6		-11.5
Mini CHPs	-320.88			-33.77		-615.00	405.9		-563.8
KTETs-2	0.0	0.0	0.0	-520.0	0.0	0.0	319.8	0.0	-200.2
Heat generation	-1,010.4	0.0	-282.2	-524.7	0.0	-379.6	0.0	1941.1	-255.9
Other stations	-85.7	0.0	-116.7	-69.8	0.0	0.0	0.0	241.3	-47.6
Mini CHPs	-238.4			-51.64		-370.75		561.28	-99.5
KTETs-2	0.0	0.0	0.0	-155.0	0.0	0.0	0.0	143.0	-12.0
Boiler-houses	-686.4	0.0	-165.5	-248.3	0.0	-8.9	0.0	979.3	-129.7
Industrial	-562.1	0.0	-157.3	-176.3	0.0	-8.3	0.0	812.8	-91.1
General use	-124.3	0.0	-8.2	-72.0	0.0	-0.6	0.0	166.5	-38.6
Heat recovery units								16.2	16.2
Own needs				-22.9			-17.8		-40.7
Distribution losses				0.0			-154.7	-291.2	-445.8

Table.4.5 Integrated Fuel and Energy Balance - Energy end-use by sector (Ttce)

	Coal	Crude oil	Petroleum products	Natural gas	Hydro/Renewables	Other solid fuels	Power	Heat	Total
Energy end-use	**312.0**	**0.0**	**458.5**	**166.1**	**0.0**	**8.5**	**667.6**	**1,649.9**	**3,262.6**
Industrial	61.1	0.0	36.8	7.9	0.0	4.0	337.3	1,017.0	1,464.0
Oil extraction	0.0		3.3	3.0		0.0	4.2	0.0	10.5
Pulp	0.0		0.0	0.0		0.0	27.1	237.8	264.9
Paper	0.0		0.0	0.0		0.0	7.3	65.4	72.6
Cardboard	0.0		0.0	0.0		0.0	4.5	7.4	11.9
Meat products	0.0		0.0	0.0		0.0	15.1	34.9	50.1
Bakery products	0.0		0.0	0.0		0.0	1.7	10.2	11.9
Other	61.1		33.5	4.9		4.0	277.3	661.4	1042.1
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aircraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Automobile	0.0		9.5	0.0		0.0	13.9	0.1	23.5
Railway	0.0	0.0	344.9	0.0	0.0	0.0	46.0	42.6	433.6
Water	0.0		45.4	0.0		0.0	0.0	0.0	45.4
Urban electric	0.0		252.2	0.0		0.0	0.0	0.0	252.2
Other transport	0.0		18.4	0.0		0.0	32.6	28.7	79.6
Agriculture	0.0		28.9	0.0		0.0	0.0	0.0	28.9
Utility sector	0.0		0.0	0.0		0.0	4.3	0.0	4.3
Commercial	0.0		0.0	0.0		0.0	9.1	13.9	23.1
Residential	0.0		16.7	0.0		0.0	43.3	9.1	69.1

Electricity balance

Against the background of 34% GRP electricity intensity reduction in 2005-2020, electricity consumption will increase to 6,830 mln. kWh by 2020 versus 9,478-9,526 mln. kWh by the “Baltic dragon” scenario.

Commissioning of mini-cogeneration plants will reduce the Oblast’s dependence on electricity imports, but with further economic growth this dependence will become stronger, while electricity self-sufficiency will not go below 90% (see Fig. 4.10). Electricity import in 2020 will halve compared to the 2005 level. This means, that there will be no need for additional large-scale construction of generation capacities, or for transmission capacities development. Moreover, in 2011-2014, the Oblast may become an electricity exporter.

Electricity end-use consumption basically grows in the industrial sector (see Fig. 4.11), however, this growth is not as significant, as in the previous scenario.

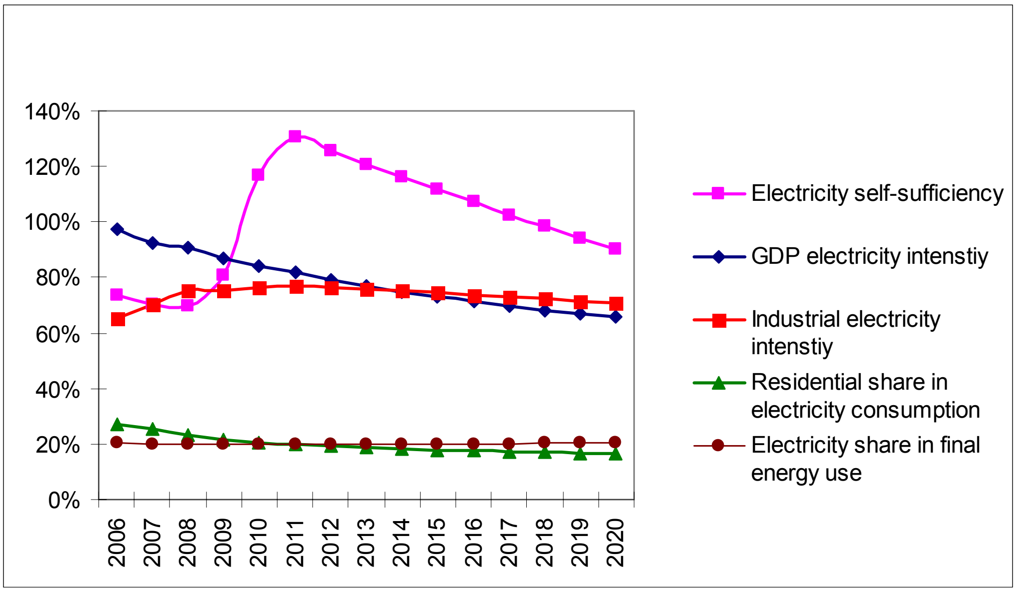


Fig.4.10. Basic electricity consumption indicators by the “Balanced migration” scenario

Table 4.6 Electricity balance under the «Balanced migration» scenario (mln. kWh)

Year	Production	KTETs-2	Other	Mini-cogeneration plants	Renewables	Import	Consumption	Own needs	Supply to the grid	Transmission losses	Useful supply
2005	539	270	269	0	15	3,045	3,584	119	3,465	698	2,767
2006	2,766	2,528	201	0	15	1,002	3,768	143	3,563	677	2,886
2007	2,744	2,528	201	0	15	1,157	3,901	143	3,758	707	3,051
2008	2,907	2,550	201	140	16	1,270	4,177	143	4,033	759	3,275
2009	3,510	2,550	201	740	19	823	4,333	143	4,190	788	3,402
2010	5,273	2,550	201	2,500	22	-761	4,512	143	4,368	822	3,547
2011	6,126	2,600	201	3,300	25	-1,433	4,693	144	4,549	856	3,693
2012	6,129	2,600	201	3,300	28	-1,256	4,873	144	4,729	890	3,839
2013	6,132	2,600	201	3,300	31	-1,060	5,072	144	4,927	927	4,000
2014	6,135	2,600	201	3,300	34	-853	5,282	144	5,138	966	4,171
2015	6,138	2,600	201	3,300	37	-638	5,500	144	5,356	1,007	4,348
2016	6,141	2,600	201	3,300	40	-408	5,733	144	5,588	1,051	4,537
2017	6,144	2,600	201	3,300	43	-158	5,986	144	5,841	1,099	4,743
2018	6,147	2,600	201	3,300	46	106	6,253	144	6,108	1,149	4,959
2019	6,150	2,600	201	3,300	49	384	6,534	144	6,390	1,202	5,188
2020	6,153	2,600	201	3,300	52	677	6,830	144	6,685	1,258	5,428

Source: Consultant's estimates

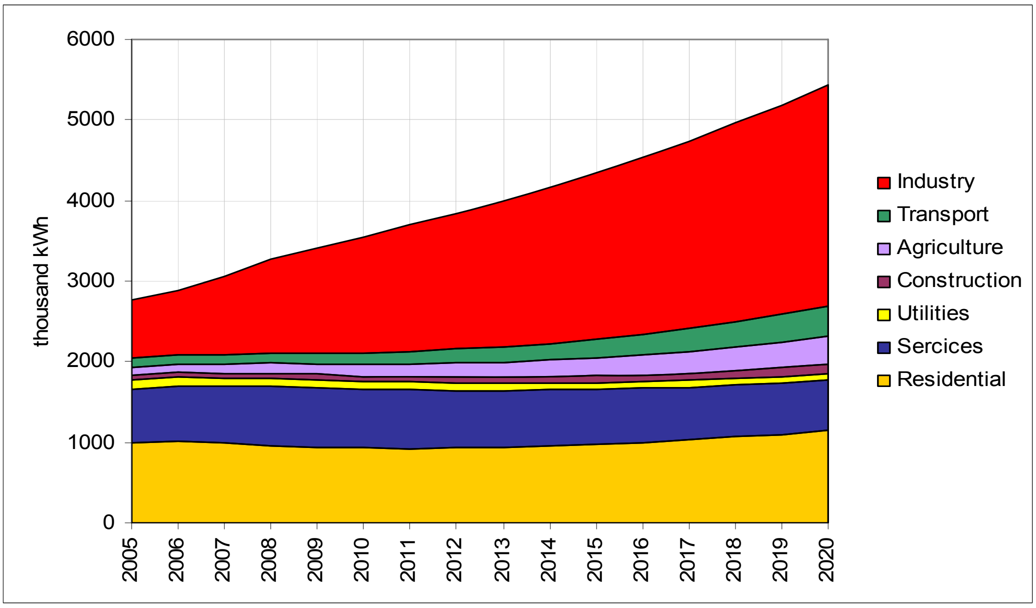


Fig.4.11 Electricity end-use dynamics and structure by the "Balanced migration" scenario

Natural gas balance

As the Neman co-generation plant is commissioned and KTETs-2 starts generating 1 mln. Gcal per year, gas consumption will grow. However, then substitution of gas with coal starts at industrial boiler-houses determined by growing gas prices. Thus overall gas consumption drops a little bit and keeps within the limits adequate to the existing Oblast's gas supply system. Notably, even with very high gas prices, gas consumption is yet higher than the 2006 level (see Fig. 4.12).

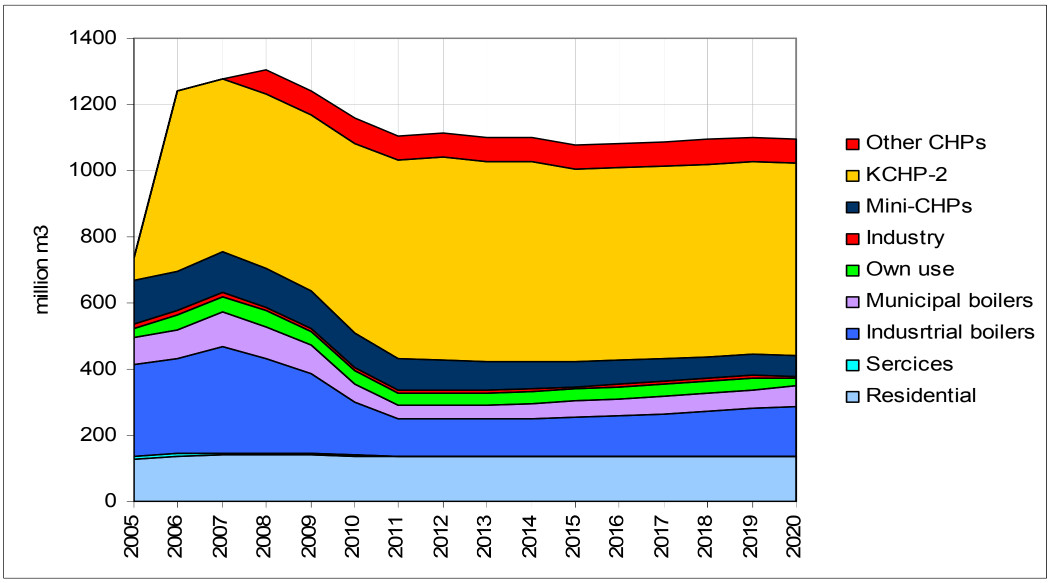


Fig.4.12. Natural gas consumption dynamics by the "Balanced migration" scenario

Coal balance

Like in the "Baltic dragon" scenario, coal consumption will be growing due to the commissioning of two coal-fired mini-cogeneration plants and to growing coal consumption by industrial boiler-houses determined by rapidly growing gas price (see Fig. 4.13). However, coal demand is 23% lower, than in the "Baltic dragon" scenario. This mitigates, although does not eliminate, the problem of pollutants emission control at industrial boiler-houses. Addressing this problem will become a critical condition of keeping a favorable environmental situation in the Oblast.

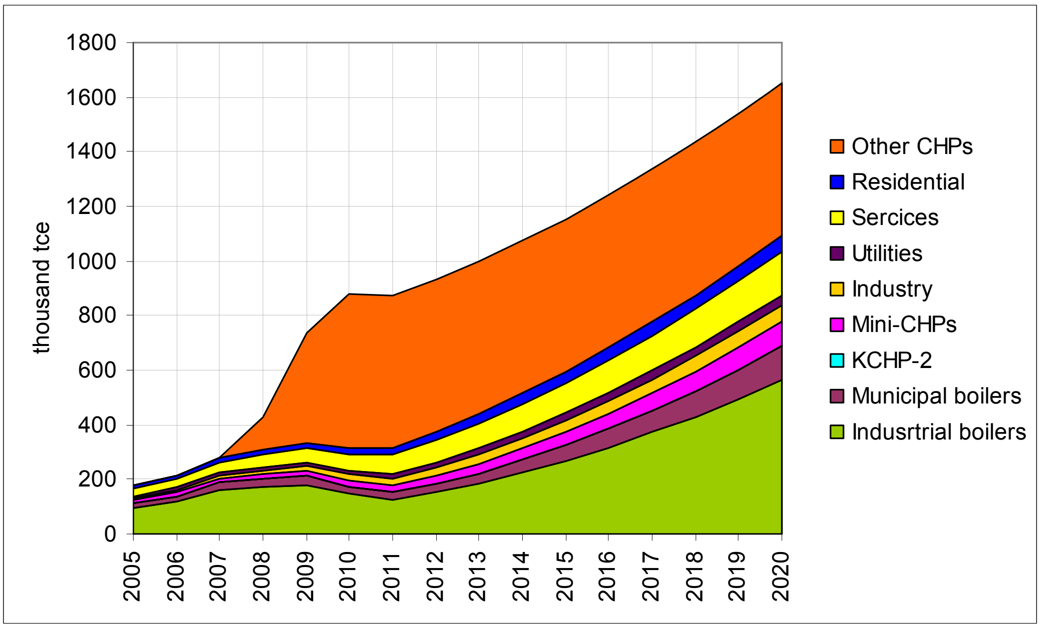


Fig.4.13 Coal consumption and IFEB basic coal indicators under the "Balanced migration" scenario

4.2.4 PRACTICAL FEASIBILITY OF THE "BALANCED MIGRATION" SCENARIO

The "Balanced migration" scenario eliminates basic risks associated with the "Baltic dragon". It will allow it to attract investors, as well as migrants, as conditions are developed for their conflict-free and comfortable living in the Oblast.

Many risks are also mitigated in the energy aspect of this scenario:

By 2020, primary energy self-sufficiency of the Oblast will go up to 23% (with no account of crude oil), while electricity self-sufficiency will not go down below 90%. In this case, the economic growth will not be hampered by fuel shortage or the electricity sector;

With fast growing gas prices, maximum gas consumption will take place in 2008, only exceeding the 2006 level by as little as 5%. Such gas supply system development task is quite realistic.

However, the risk of environmental deterioration determined by growing coal consumption by industrial boiler-houses persists.

4.3 The “Sustainable development” scenario

4.3.1 THE CONCEPT

In this scenario all assumptions made under the “Balanced migration” are preserved, and one more is made: the Oblast administration launches several Oblast-level energy efficiency programs, including:

- Energy efficiency program in the industrial sector;
- Energy efficiency program in heat supply systems; and
- Electricity transmission and distribution losses reduction program.

4.3.2 SCENARIO CONDITIONS

Implementation of these three programs will lead to 2.5% annual improvement of energy efficiency due to accelerated introduction of efficient equipment, materials, and management systems in all types of economic activities and existing housing stock. Besides, an assumption is made, that in accordance with the “Strategy”, electricity transmission losses will go down to 13% in 2015 and to 10% in 2020, while heat losses will go down to 10% of useful supply. It is assumed that energy efficiency in the electricity- and heat sectors will be improving as shown in Table A.8.

Electricity generation by mini-cogeneration plants will be growing in a way that would keep the Oblast’s electricity self-sufficiency close to 100% (net electricity import-export would not exceed +100 mln. kWh/year). All the other assumptions under the “Balanced migration” scenario are kept the same.

4.3.3 ENERGY DEVELOPMENT UNDER THE “SUSTAINABLE DEVELOPMENT” SCENARIO

Integrated Fuel and Energy Balance

In this scenario, the GRP energy intensity will drop in 2005-2020 by 38%, or by 3.2% annually due to the growing energy prices and enhanced introduction of new, energy efficient equipment. Therefore, with the assumptions of this scenario primary energy consumption in the Oblast increases from 2,088 Ttce in 2005 to only 3,728 Ttce in 2020 (see Fig. 4.14 and Table 4.6) versus 4,780 Ttce in the “Balanced migration” scenario (economic growth rates equal) and 6,122 Ttce in the “Baltic dragon” (with somewhat higher growth rates).

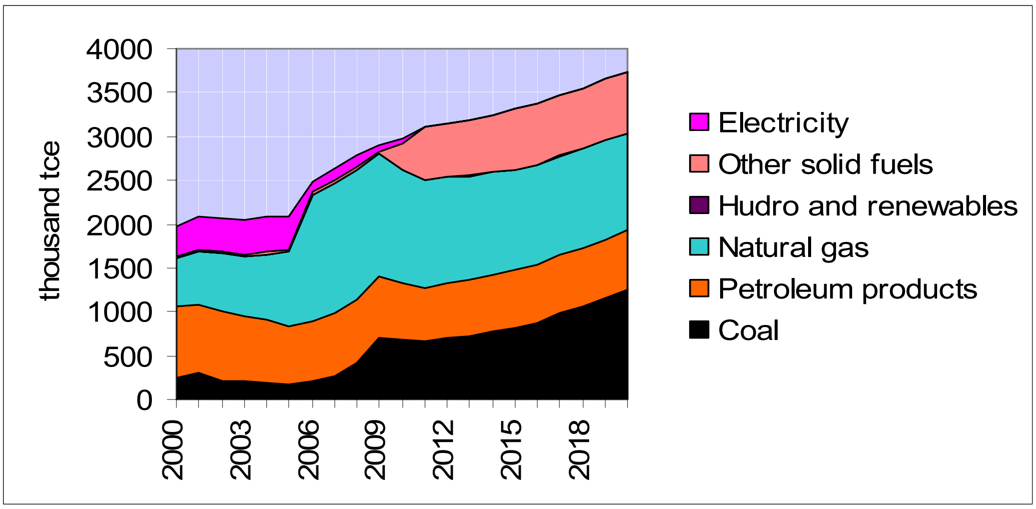


Fig.4.14 Primary energy consumption dynamics by the “Sustainable development” scenario

Primary energy self-sufficiency (without crude oil) in 2020 is 18.6%. The share of natural gas drops, but only to 30%. Coal consumption grows, but in 2020 is nearly half the value in the

“Baltic dragon” scenario. In 2011, electricity self-sufficiency reaches 100% and stays at this level until 2020.

Table 4.7 IFEB in 2020 under the «Sustainable development» scenario (Ttce)

	Coal	Crude oil	Petroleum products	Natural gas	Hydro/ renewables	Other solid fuels	Power	Heat	Total
Production		2,060.6		23.2	6.2	689.8			2,779.8
Import	1,256.7		667.6	1,089.6			-0.5		3,013.4
Export		-2,061					0		-2,061
Stock changes									0
Primary energy consumption	**1,257**	**0**	**668**	**1,113**	**1.9**	**690**	**-1**	**0**	**3,728**
Statistical discrepancies									
Power plants	-651.8	0.0	-144.6	-831.6	-1.9	-678.2	629.3	945.6	-733.3
Power generation	-327.8	0.0	-27.9	-555.2	-1.9	-307.5	629.3		-591.0
Other stations	-6.9	0.0	-27.9	-1.5	-1.9	0.0	26.6		-11.5
Mini CHPs	-320.88			-33.77		-307.50	282.9		-379.3
KTETs-2	0.0	0.0	0.0	-520.0	0.0	0.0	319.8	0.0	-200.2
Heat generation	-676.5	0.0	-202.7	-402.6	0.0	-375.3	0.0	1484.4	-172.8
Other stations	-85.7	0.0	-116.7	-69.8	0.0	0.0	0.0	241.3	-47.6
Mini CHPs	-238.4			-51.64		-370.75		561.28	-99.5
KTETs-2	0.0	0.0	0.0	-155.0	0.0	0.0	0.0	143.0	-12.0
Boiler-houses	-352.4	0.0	-86.0	-126.2	0.0	-4.6	0.0	525.7	-43.5
Industrial	-293.3	0.0	-82.1	-92.0	0.0	-4.3	0.0	436.4	-35.3
General use	-59.1	0.0	-3.9	-34.3	0.0	-0.3	0.0	89.4	-8.2
Heat recovery units								13.0	13.0
Own needs				-17.9			-17.8		-35.7
Distribution losses				0.0			-61.1	-134.9	-196.0

Table 4.8 Integrated Fuel and Energy Balance - Energy end-use by sector (Ttce)

	Coal	Crude oil	Petroleum products	Natural gas	Hydro/ renewables	Other solid fuels	Power	Heat	Total
Energy end-use	**252.5**	**0.0**	**437.1**	**137.0**	**0.0**	**7.0**	**549.9**	**1,349.4**	**2,732.8**
Industrial	49.3	0.0	29.6	6.3	0.0	3.3	272.0	820.1	1,180.6
Oil extraction	0.0		2.7	2.4		0.0	3.4	0.0	8.4
Pulp	0.0		0.0	0.0		0.0	21.9	191.8	213.7
Paper	0.0		0.0	0.0		0.0	5.8	52.6	58.4
Cardboard	0.0		0.0	0.0		0.0	3.7	5.9	9.6
Meat products	0.0		0.0	0.0		0.0	12.2	28.2	40.4
Bakery products	0.0		0.0	0.0		0.0	1.4	8.2	9.6
Other	49.3		27.0	3.9		3.3	223.7	533.4	840.6
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aircraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Automobile	0.0		7.7	0.0		0.0	11.2	0.1	19.0
Railway	0.0	0.0	344.9	0.0	0.0	0.0	46.0	42.6	433.6
Water	0.0		45.4	0.0		0.0	0.0	0.0	45.4
Urban electric	0.0		252.2	0.0		0.0	0.0	0.0	252.2
Other transport	0.0		18.4	0.0		0.0	32.6	28.7	79.6
Agriculture	0.0		28.9	0.0		0.0	0.0	0.0	28.9
Utility sector	0.0		0.0	0.0		0.0	4.3	0.0	4.3
Commercial	0.0		0.0	0.0		0.0	9.1	13.9	23.1
Residential	0.0		13.5	0.0		0.0	34.9	7.3	55.7

Source: Consultant's estimates

Electricity balance

Actively implemented energy efficiency programs will allow for 718 mln. kWh reduction of electricity demand! GRP electricity intensity will go down by 51% in 2005-2020. Electricity consumption will increase to 5.112 mln. kWh in 2020 versus 6,830 mln. kWh in the "Balanced migration" scenario and 9,478-9,526 mln. kWh in the "Baltic dragon" scenario.

Mini-cogeneration plants capacity demand will considerably change: Neman co-generation plant (gas-fired) will be commissioned in 2008, Svetlogorsk plant (coal-fired) in 2009, Kosmodemiansk plant (solid waste) in 2010, Chernyakhovsk plant (peat) in 2011, Baltiysk plant (coal) in 2017. There will be no demand for electricity generated by Gusev plant until 2020, which will result in 3.5 bln. rubles capital investment savings and considerably reduce the energy sector investment burden on the economy after 2008. With such mini-cogeneration development program, implementation of energy efficiency programs makes the need for the second unit of KTETs-2 (another 9.3 bln. rubles in investment) questionable – huge potential savings.

Table 4.9. Electricity balance by the «Sustainable development» scenario (mln. kWh)

Year	Production	KTETs-2	Other	Mini-cogeneration plants	Renewables	Import	Consumption	Own needs	Supply to the grid	Transmission losses	Useful supply
2005	539	270	269	0	15	3,045	3,584	119	3,465	698	2,767
2006	2,766	2,528	201	0	15	1,002	3,768	143	3,563	677	2,886
2007	2,744	2,528	201	0	15	1,120	3,864	143	3,721	700	3,021
2008	2,907	2,550	201	140	16	1,084	3,991	143	3,848	654	3,194
2009	3,510	2,550	201	740	19	525	4,035	143	3,891	623	3,269
2010	3,673	2,550	201	900	22	421	4,094	143	3,951	593	3,358
2011	4,226	2,600	201	1,400	25	-27	4,199	144	4,054	608	3,446
2012	4,229	2,600	201	1,400	28	22	4,251	144	4,106	575	3,531
2013	4,332	2,600	201	1,500	31	-19	4,313	144	4,169	542	3,627
2014	4,335	2,600	201	1,500	34	71	4,406	144	4,261	533	3,729
2015	4,538	2,600	201	1,700	37	-38	4,500	144	4,355	523	3,833
2016	4,541	2,600	201	1,700	40	60	4,601	144	4,456	512	3,944
2017	4,744	2,600	201	1,900	43	-31	4,713	144	4,569	503	4,066
2018	4,847	2,600	201	2,000	46	-15	4,832	144	4,687	492	4,195
2019	5,000	2,600	201	2,150	49	-18	4,982	144	4,838	508	4,330
2020	5,153	2,600	201	2,300	52	-41	5,112	144	4,968	497	4,471

Source: Consultant's estimates

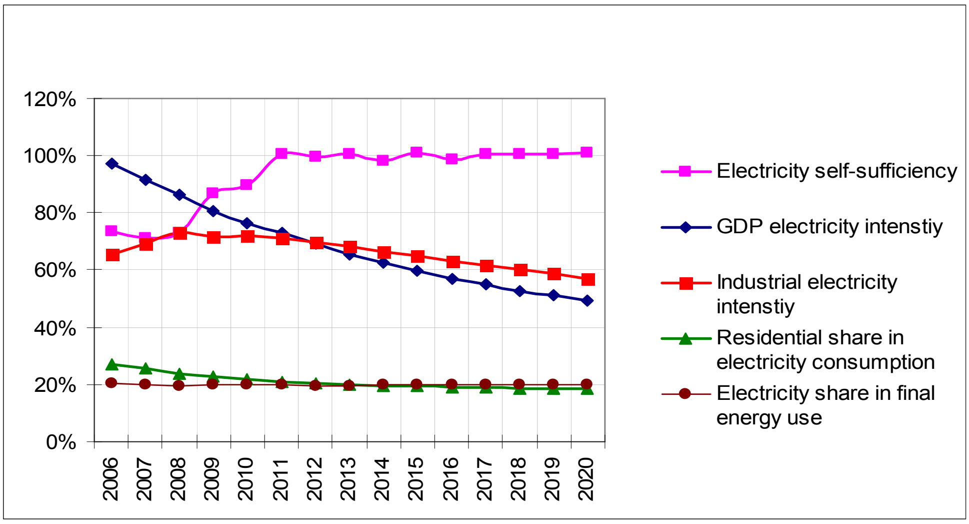


Fig.4.15 Electricity consumption basic indicators dynamics by the "Sustainable development" scenario

Natural gas balance

Gas consumption will grow due to the fact that heat will be supplied from KTETs-2 to part of Kaliningrad city and due to the construction of Neman co-generation plant, but then it will drop due to the coal switch of industrial boiler-houses (see Fig. 4.16). Gas consumption is peaking in 2008.

Coal balance

Coal consumption in 2020 goes down from 2,135 thou. tons by the "Baltic dragon" scenario and 1,640 thou. tons by "Balanced migration" to 1,257 thou. tons (see Fig. 4.17). After part of Kaliningrad city starts getting heat from KTETs-2 and Svetlogorsk cogeneration plant is commissioned, coal consumption by industrial boiler-houses will drop. But then, with abrupt growth of gas prices, it will be going up again.

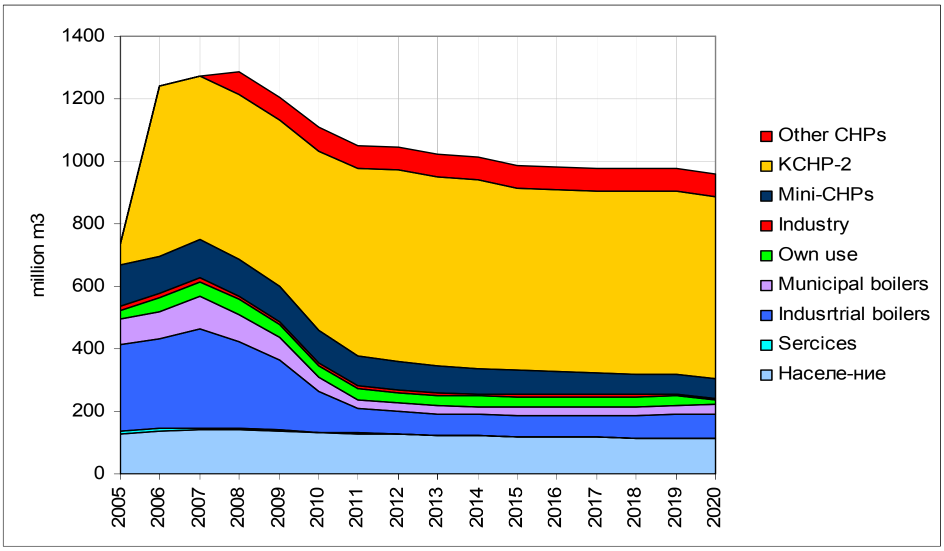


Fig.4.16. Natural gas consumption dynamics by the "Sustainable development" scenario

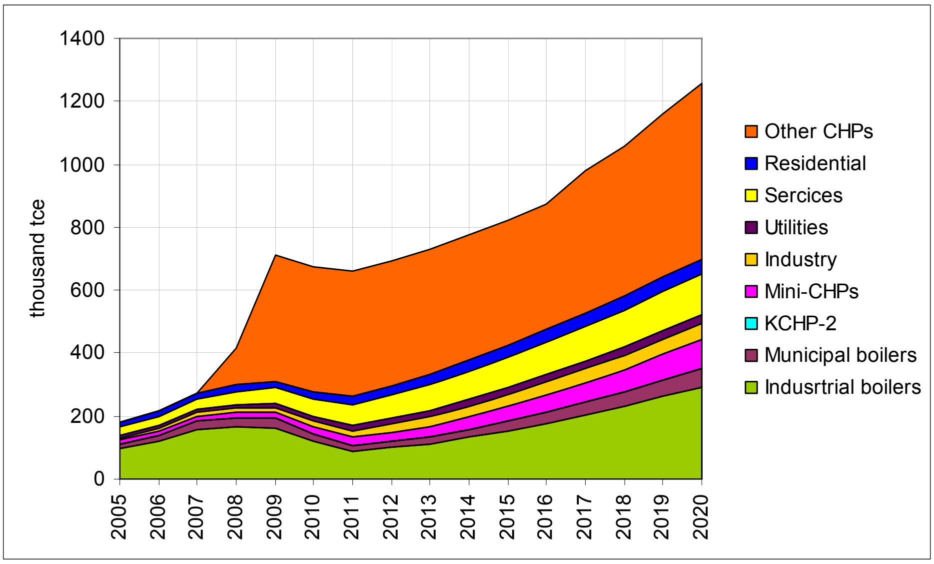


Fig.4.17. Coal consumption dynamics by the "Sustainable development" scenario

However, in this scenario coal consumption by industrial boiler-houses (where emissions control is most difficult) is three times lower, than in the "Baltic dragon" scenario. This considerably mitigates the problem of emissions control at boiler-houses and makes this scenario more acceptable from the environmental point of view. Exactly for this reason it was called "Sustainable development".

4.3.4 PRACTICAL FEASIBILITY OF THE "SUSTAINABLE DEVELOPMENT" SCENARIO

Unlike "Balanced migration", the "Sustainable development" scenario is only feasible on condition that adequate financing and administrative resources are allocated for the implementation of Oblast-level energy efficiency programs. It allows for the mitigation of two key risks of the Oblast economic development until 2020:

Inability to mobilize sufficient financing for the energy development in the Oblast, and the relating risk of electric capacity and gas shortage to ensure the economic growth;

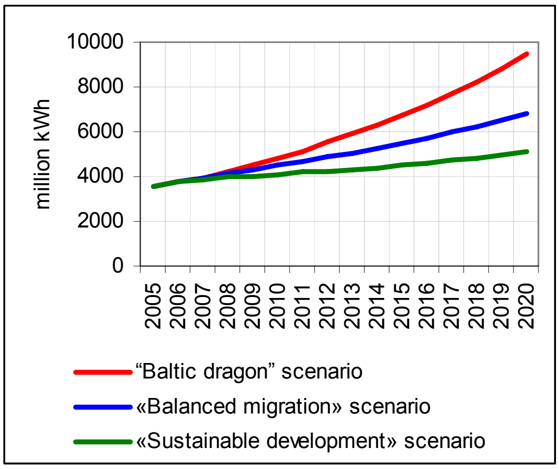
Considerable environmental pollution and corresponding reduction of the Oblast's attractiveness for investment and migration.

5 Conclusions and Recommendations

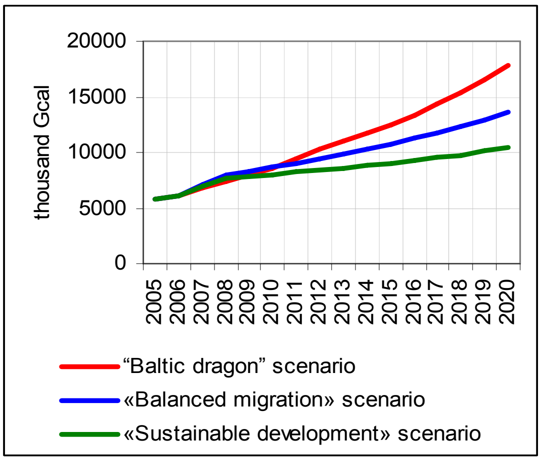
5.1 Conclusions

- Using a computerized model for energy demand forecasting is an excellent "planning tool" to improve macro-economic and energy policy because it allows for a thorough check on internal consistency of economic and energy policy and good insight in the policy-related driving forces, constraints and risk factors.
- All three scenarios used in this study indicate that the "Small energy sector development program" is an important element in the Kaliningrad economic development strategy due to the uncertainty of additional gas supplies and possible developments after the closure of the nuclear power station in Lithuania in 2009. It contributes to a greater degree of electricity self-sufficiency for the region.
- In general, the scenario results show that industry will be the driving force behind economic growth, but at the same time increases the need for additional electricity generation capacity.
- Given the specific situation of Kaliningrad region, introducing strong energy efficiency programs is a "no-regret" strategy. Under all circumstance it will contribute to alleviating possible limitations/constraints to economic development as well as mitigate risks due to uncertainty.
- "Social and Economic Development Program for Kaliningrad Oblast, 2007-2016" contains internal contradictions. They concern mainly the financing and migration aspects as well as(over-)optimistic economic growth rates.
- The main risks/constraints associated with the "Baltic Dragon" scenario are
    - The ability to find financing for housing construction for the large number of potential migrants.
    - Electricity import demand may exceed current transmission capacity of high-voltage networks.
    - With the construction of the second unit of KTETs-2, gas consumption may exceed the capacity of the gas supply system.
    - Escalating gas prices may increase the use of cheaper fuels (coal and peat) with a deteriorating effect on the regional environment. This may reduce the investment and migration attractiveness of the Oblast.
- Implementing energy efficiency programs will lead to a 2.5% efficiency improvement in all types of economic activities and existing residential buildings.
- Energy efficiency programs also mitigate key risks in the Oblast's economic development. Energy efficiency allows to decrease in the period 2006-2020:
    - additional demand for electricity from 3062 to 1344 million kWh;
    - additional demand for district heat from 7417 to 4224 thousand Gcal;
    - additional demand for coal from 1434 to 1040 thousand tce
    - and for natural gas, which becomes extremely expensive and much less affordable, consumption decreases not by 157 million m3 but by 282 million m3.

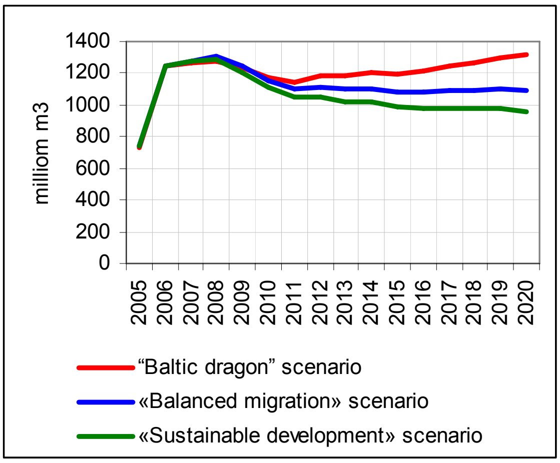
- The following figures show energy demand for separate energy carriers in the three considered scenarios.



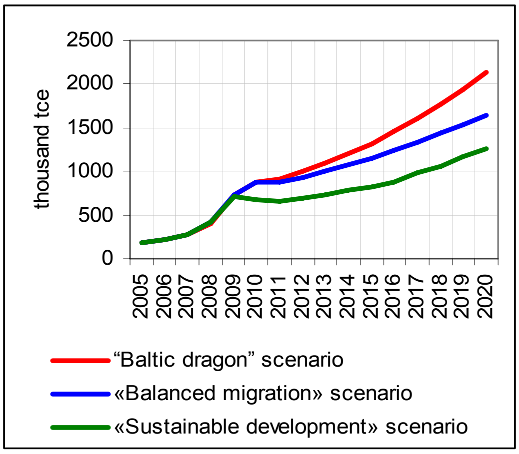
a) electricity consumption



b) district heat consumption



c) gas consumption



d) coal consumption

5.2 Recommendations

- It is recommended to assign specific responsibility in the regional administration for integrated economic and energy planning in terms of
  - Collecting and analyzing data and developing annually integrated fuel and energy balances and
  - Updating and testing of economic and energy policy scenarios.
- Further testing of existing economic and energy policies for inconsistencies using the computerized demand forecast model will improve the quality of decision making.
- It is necessary to build upon the current experience in building consistent and realistic regional development scenarios using a computerized model.
- The model that has been transferred to the regional administration's staff should be further developed, in particular the model's macro-economic and energy modules to fit the region's needs and its underlying assumptions.
- It is especially important to develop further the energy pricing module due to the wide-ranging consequences of changing energy prices for economic and energy policy decisions.
- There is a strong need from a strategic as well as economic point of view to develop and implement energy efficiency programs in the public sector (heat and electricity supply and distribution, schools, hospitals etc.) and to create conditions for the private sectors allowing for accelerated energy efficiency improvements.

Annexes

Annex 1 Heat production facilities in Kaliningrad region

Municipality	Population by year 2000	Share of DH supply, %	Number of boiler stations of different sizes (with respect to installed heat production capacity)					Fuel use, %					Average age DH system's, years	CHP
			>100 MW	>20 MW	>5 MW	>1 MW	>0 MW	Gas	Coal	Mazut	Peat, firewood	Diesel oil		
Bagrationovsk	33,000	35	-	-	-	-	21	-	76	-	-	24	40	No
Baltijsk	33,900	70	1	-	2	-	31	-	13	78	-	9	40	No
Gvardejsk	28,000	50	-	1	2	-	63	-	34	63	-	3	40	No
Gurievsk	46,700	50	-	1	-	1	31	45	40	5	-	-	30	No
Gusev	36,800	80	1	-	-	-	1	100	-	-	-	-	40	Yes
Zelenogradsk	30,400	60	-	-	-	1	43	33	67	-	-	-	30	No
Krasnoznamensk	13,000	40	-	-	-	-	11	30	70	-	-	-	40	No
Kaliningrad	427,200	85	6	9	7	2	441	57	25	13	-	4	40	Yes*
Ladushkin	4,100	35	-	-	-	1	8	77	23	-	-	-	40	No
Mamonovo	9,000	25	-	-	-	-	13	-	92	-	-	8	40	No
Neman	23,500	65	1	-	-	-	62	-	6	93	-	1	40	No
Nesterov	17,300	40	-	1	-	-	31	-	100	-	-	-	40	No
Ozersk	18,000	40	-	-	-	-	22	-	100	-	-	-	40	No
Pionerskij	12,200	70	-	-	-	-	19	17	66	17	-	-	40	No
Polessk	18,800	45	-	-	-	-	33	-	100	-	-	-	40	No
Pravdinsk	20,000	45	-	-	-	-	9	-	60	26	14	-	40	No
Svetlogorsk	18,500	75	-	2	-	-	36	53	45	2	-	-	30	No
Svetlij	22,000	90	1	-	1	-	9	-	2	98	-	-	30	Yes
Slavsk	4,800	35	-	-	-	1	18	-	16	84	-	-	40	No
Sovetsk	43,400	85	1	-	-	-	33	-	20	80	-	2	40	Yes
Chernyakhovsk	58,400	60	-	3	4	-	38	-	15	78	7 (peat)	-	40	No
Total	**919,000**	**-**	**11**	**17**	**16**	**6**	**973**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

* In Kaliningrad there are some large CHP plants. However, they are not operating in CHP mode. Tets-1 is operating in heat only mode and Tets-2 is operating in condensing mode due to the fact that this plant has not yet been connected to the district heating network. *Source: KREEC*

Annex 2 Energy efficiency options

Heat generation

EE Initiative	Description	Average specific investment 1000 EUR per unit [3)]	Benefits Average expected energy savings	Payback years (average)
No-Cost EE Initiatives				
Optimisation of heat plant operation [1)]	Optimisation of temperature levels, pump operation etc.	0 - 2.2 per MWh	Increase of energy efficiency by approx. 3 %	½
Low-Cost EE Initiatives				
Information Management System	System to monitor production parameters	1.1 per plant	Energy saving approx. 2% due to better control of the process.	1.5
Improvement of existing oil/gas boilers	Optimisation of control system incl. replacement of motor for ventilator with a variable speed motor.	1.7 per MWh	Energy savings approx. 3%	2
New oil/gas burners		5 per MWh	Energy savings approx. 7%	3
Change of reserve fuel from HFO to LFO	The change will eliminate the energy used for heating HFO	0	Approx. 1 %	Depends on no. of operating hours on oil fuel
Reduction of flue gas temperature	When flue gas temperatures at gas/oil boilers exceeds 180 - 200 ^{o}C, the installation of an economiser is recommended.	1.1 per MW fuel input	Increase in boiler efficiency of 6 % as well as increase of the capacity of the boiler	1

Heat generation (continued)

Medium to High-Cost EE Initiatives				
New oil/gas boilers replacing old oil/gas boilers	Efficiency 92 - 95 % for new gas boilers and 90% for new oil burners	220 per MWh	Energy savings 4%	3
New oil/gas boilers replacing old coal boilers	Efficiency 92 - 95 % for new gas boilers and 90% for new oil burners	220 per MWh	Energy savings 8%	7
New gas fired CHP unit - Gas turbine - Gas engine	A unit covering 50 - 60 % of peak demand and 85 - 90 % of yearly heat consumption is considered	450 - 900 per MWh	Reduction of total energy consumption for heat and power production with 40 - 45 % compared to traditional plants	12 [2)]
Coupled gas turbine to existing CHP plant	Improving the efficiency of existing steam based power plants by adding a gas-turbine	1100 per MWh	Increase of overall efficiency - actual value specific to the existing plant - DEA	Pay back time depends on the characteristics of the existing plant
New Biomass boiler unit - HOB or CHP	For utilisation of local resources available	1100 per MWh	fossil fuels reduced by 85 - 90 %	10 Depends on price of biomass
New Waste Incineration Plant - HOB or CHP		2000 per MWh	as above	20 Depends on price for treating the waste

1) Possible costs of needed training are not included
2) The payback period is highly depending on the development of the power sales prices
3) MWh - MW heat; MWe - MW electrical

Conversion of HOB stations to CHP plants

EE Initiative	Description	Average specific investment 1000 EUR per unit 3)	Benefits Average expected energy savings	Payback years (average)
Medium to High-Cost EE Initiatives				
New gas fired CHP unit - Gas turbine - Gas engine	A unit covering 50 - 60 % of peak demand and 85 - 90 % of yearly heat consumption is considered	450 - 900 per MWh	Reduction of total energy consumption for heat and power production with 40 - 45 % compared to traditional plants	12 2)
Coupled gas turbine to existing CHP plant	Improving the efficiency of existing steam based power plants by adding a gas-turbine	1100 per MWh	Increase of overall efficiency - actual value specific to the existing plant - DEA	Pay back time depends on the characteristics of the existing plant
New Biomass boiler unit - HOB or CHP	For utilisation of local resources available	1100 per MWh	fossil fuels reduced by 85 - 90 %	10 Depends on price of biomass
New Waste Incineration Plant - HOB or CHP		2000 per MWh	as above	20 The economy is depending on the fee which will be paid for treating the waste

1) Possible costs of needed training are not included
2) The payback period is highly depending on the development of the power sales prices
3) MWh - MW heat; MWe - MW electrical

Heat Transmission and Distribution

i.

EE Initiative	Description	Average specific investment 1000 EUR per unit 3)	Benefits Average expected energy savings	Payback years (average)
No-Cost EE Initiatives				
Review of temperature levels	Reduced supply and return temperature in heat distribution network	0	Reduction of heat loss by approx. 3% in distribution system by reducing the temperatures.	0
Low-Cost EE Initiatives				
New pumps with speed control by frequency converters	The full benefit of speed controlled pump requires that substations equipped with heat elevators are converted into substations with pumps and flow control equipment	8.5 per MWh	A saving of more than 50 % of the electrical power used for pumping can be expected.	3
Procurement of thermographical equipment for monitoring of heat losses of the network	The renovation program should be based on an thermographical survey, identifying pipe sections with unacceptable heat losses	280 per set of thermographical equipment	Preparation of a detailed pipeline rehabilitation program. The thermographical equipment may be shared between several DHCs	Approximately 1 year depending on the conditions of the network.
Instruments for testing water quality	Testing of water quality for feed water and circulating water is essential to evaluate and adjust the performance of water treatment plants	6.5 per set of testing equipment	Reduced corrosion and increased the lifetime of networks. Test kit for measuring hardness, conductivity, pH, and dissolved Oxygen.	Approximately 1 year depending on the quality of the water.

Medium to High-Cost EE Initiatives				
New water treatment plant, where the existing one can not meet the required water quality.	Optimisation of water quality to avoid internal corrosion	1.1 per MWh	Reduced corrosion and increased the lifetime of networks.	1
Replacement of insulation of pipelines above ground.	Pipelines identified by thermographical survey should be prioritised.	66 per km	Reduction of heat losses by 40%	3
Conversion of foam concrete network to pre-insulated pipes	As above The conversion requires that the max. temp is below 130^{o}	330 per km	Reduction of heat losses by at least 20% as well as elimination of water losses	10
Conversion of foam concrete network to new pipes in concrete channels		850 per km	Reduction of heat losses by at least 15% as well as elimination of water losses	10

1) Possible costs of needed training are not included

3) MWh - MW heat; MWe - MW electrical

Substations and Metering

ii.

EE Initiative	Description	Average specific investment 1000 EUR per unit 3)	Benefits Average expected energy savings	Payback years (average)
No-Cost -Cost EE Initiatives				
Public awareness campaign in combination with the introduction of a billing system based on energy actually used.	Information on the possibilities for reduction of energy consumption by reducing indoor temperatures and saving on hot tap water	0	A greater consciousness on energy maters and better habits regarding energy usage. Energy saving 2 - 4 %	0
Low-Cost EE Initiatives				
Installation of meters at existing substations combined	Basis for charging the consumers according to consumption	1.1 per meter	Energy saving 10%	2 depending on size of substation
Medium to High-Cost EE Initiatives				
Renovation of existing indirect substations	Includes new controls, pumps and energy meters	2.2 per substation	Energy saving 12% Return temperatures and flow will be reduced, reducing the distribution loss.	6

1) Possible costs of needed training are not included

Consumer Level - EE Initiatives

EE Initiative	Description	Average specific investment 1000 EUR per unit 3)	Benefits Average expected energy savings	Payback years (average)
No-Cost EE Initiatives				
Check on function of valves and have service done where necessary	Improve the possibility to save on heat when it is not needed	0.1 per apartment	Reduced heat consumption 10%	0 - 1
Low-Cost EE Initiatives				
Sealing of leaks in windows etc.	Solving the most immediate heat loss problems	0.01 per apartment	Reduced heat loss 5%	< 1 Limited lifetime of sealing strips ~2 years
Medium to high-Cost EE Initiatives				
Thermostatic valves and heat allocation meters	May require some pipe-work depending on the existing building installation. E.g. radiators connected in series or in parallel.	0.3 per apartment	A total reduction of 30 - 35% is expected when made in combination with modernised or new substations and introduction of a billing system based on individual energy consumption.	2
New windows	Thermo glass windows. A reduction of the K-value of a factor 2 - 3.	6 per apartment	Reduced heat loss 20%	7
Insulation of walls and roof	A reduction of the K-value of a factor 2 is likely to be obtained.	10 per apartment	20%	17

1) Possible costs of needed training are not included

Energy Efficiency Interventions - Heat Production Plants

Action	Specific investment 1000 EUR	Unit	External costs %	Local costs %	Main Benefit	Energy Savings (average) %	Saved new capacity %	Saving in operational expenses %	Approx. payback (average) Years	Remarks
Optimisation of operation parameters	0-2,2	per MWh	75	25	Improved efficiency	2 - 8%, (3%)	0	0	0 - 1, (½)	Maintain steady temperature based on actual heat loads
Information Management System	1,1	per plant	80	20	Better control of combustion process	0	0	5	1,5	Automatic adjustment of fuel air ratios, O2 content, etc.
Change of reserve fuel from HFO to LFO	0		0	0	No energy consumption for oil heating	1%	0	10	individual	Depends on the no. of operating hours on fuel oil
Installation of Economiser	1,1	per MWh	50	50	Improved efficiency	4-8%, (6%)	10	0	1	Relevant, when flue gas temperaure is above 280 - 200 °C
Improvement of exist. oil/gas	1,7	per MWh	80	20	Improved efficiency	1 - 4%,	0	5	1 - 3, (2)	incl. new controlable ventilator motor
New oil/gas burners	4,4	per MWh	90	10	Improved efficiency	6 - 8%,	0	10	1 - 4, (3)	
Conversion from coal to gas /oil	300	per MWh	75	25	Improved efficiency; 65% -> 92%	25 - 30%, (28%)	0	30	5 - 10, (7)	
New gas/oil boiler installation	220	per MWh	75	25	Improved efficiency; 85% ->	8%	0	25	5 - 10, (7)	
Straw fired heat plants, 1 - 9 MW	330 - 550	per MWh	70	30	Efficiency -> 92%	10%	0	0	10	Depending on Biomas prices
Wood chips heat plant	330 - 500	per MWh	70	30	Efficiency ->115%	25%	0	0	10	Flue gas condensing assumed

Energy Efficiency Interventions - Transmission and Distribution Systems

Action	Specific investment 1000 EUR	Unit	External costs %	Local costs %	Main Benefit	Energy Savings (average) %	Saved new capacity %	Saving in operational expenses %	Approx. payback (average) Years	Remarks
Review of temperature levels	0		0	0	Reduction of heat loss	2 - 5% (3%)	2		0	In particular reduction of the return temperature should be considered
Thermographic investigation	280	1 set	100	0	Detection of pipelines with poor heat insulation	-	-		1 - 2 (1)	Price for a complete set equipment incl training - may serve several DHC's
Testing of water quality	5,5	1 set	100	0	Avoid corrosion	-	-		0-1 (1)	Should be present at all DHC's
New Water Treatment Plant	1,1	per MWh	100	0	Avoid corrosion	-	-		1 - 2 (1)	
New preinsulated pipes (average DN 200)	330	per Km	40	60	Reduction of heat loss	20%	5	Before 3% per year After 0,5% per year	9 - 12 (10)	Les pump costs 5%
New pipes in concrete channels (Average DN 400)	850	per Km	30	70	Reduction of heat loss	15%	5	Before 3% per year After 1% per year	9 - 12 (10)	
New insulation to pipes above ground (Average DN 400)	66	per Km	30	70	Reduction of heat loss	40%	10		1 - 5 (3)	
Variable flow pumps	8,5	per MWt	70	30	Reduction of power	> 50%		Before 22 kwh/Mwth After 9 KWh/Mwth	2 - 3 (3)	Energy savings in % of power consumption for pumps

Energy Efficiency Interventions - CHP Plant Alternatives

Type of Plant	Specific investment 1000 EUR	Unit	External costs %	Local costs %	Total efficiency	Heat eficiency	Power eficiency	Power to heat ratio	Saving in operational expenses %	Approx. payback (average) Years	Remarks
Coal fired CHP - 400 Mwe, (range 200 - 1000 MWe)	1350 950	per MWe per MWh	75	25	91	54	37	0,7	25	15 - 20 (17)	
Coupled gas turbine to existing CHP. Capacity increase; 0.15 - 0,3 times existing capacity	1250 1100	per MWe per MWh	90	10	90	47	43	0,9	25	10 - 15 (12)	
Ngas/steam CHP, 200 - 400 Mwe	880 750	per MWe per MWh	80	20	93	52	41	0,8	40	15 - 20 (17)	
Ngas combined Cycle, debending on size, 15 - 400 MWe	770 - 1550 660 - 1350	per MWe per MWh	90	10	88	48	40	0,85 -1,3	40	7 - 20 (12)	Depending on the size of CC CHP plant the power to heat ratio may vary from 0,85 to 1,30
Gasturbine 5 - 15 Mwe	660 - 1000 440 - 660	per MWe per MWh	90	10	90	55	35	0,65	40	7 - 15 (12)	
Straw fired steam turbines 10- 100 MWt	3300 1100	per MWe per MWh	80	20	84	62	22	0,35	0	20	
Waste fired CHP 10 - 50 MWt	5500 2000	per MWe per MWh	80	20	82	61	21	0,35	0	20	
Dual fuel gas engines 0,5 - 16 MWe	1000 880	per MWe per MWh	90	10	90	47	43	0,9	0	7 - 15 (12)	
Gas engine, lean burn 0,1 - 4,5 MWe per engine	850 - 1000 660 - 800	per MWe per MWh	90	10	89	49	40	0,8	0	7 - 15 (12)	

Energy Efficiency Interventions - Transmission and Distribution Systems

Action	Specific investment 1000 EUR	Unit	External costs %	Local costs %	Main Benefit	Energy Savings (average) %	Saved new capacity %	Saving in operational expenses %	Approx. payback (average) Years	Remarks
Review of temperature levels	0		0	0	Reduction of heat loss	2 - 5% (3%)	2		0	In particular reduction of the return temperature should be considered
Thermographic investigation	280	1 set	100	0	Detection of pipelines with poor heat insulation	-	-		1 - 2 (1)	Price for a complete set equipment incl training - may serve several DHC's
Testing of water quality	5,5	1 set	100	0	Avoid corrosion	-	-		0-1 (1)	Should be present at all DHC's
New Water Treatment Plant	1,1	per MWh	100	0	Avoid corrosion	-	-		1 - 2 (1)	
New preinsulated pipes (average DN 200)	330	per Km	40	60	Reduction of heat loss	20%	5	Before 3% per year After 0,5% per year	9 - 12 (10)	Les pump costs 5%
New pipes in concrete channels (Average DN 400)	850	per Km	30	70	Reduction of heat loss	15%	5	Before 3% per year After 1% per year	9 - 12 (10)	
New insulation to pipes above ground (Average DN 400)	66	per Km	30	70	Reduction of heat loss	40%	10		1 - 5 (3)	
Variable flow pumps	8,5	per MWt	70	30	Reduction of power	> 50%		Before 22 kwh/Mwth After 9 KWh/Mwth	2 - 3 (3)	Energy savings in % of power consumption for pumps

Energy Efficiency Interventions - Substations and Metering

Action	Specific investment 1000 EUR	Unit	External costs %	Local costs %	Main Benefit	Energy Savings (average) %	Saved new capacity %	Saving in operational expenses %	Approx. payback (average) Years	Remarks
Installations of meters at existing substations	1,1	per unit	50	50	Reduced heat consumption	5 - 15% (10%)	0	-	2	The meter installation should be combined with a charging system based on consumption
New Substation with plate heat exch.	10	per unit	70	30	Increased efficiency and reduced return temperature	20%	4	For old direct substations; 1,8%. For old indirect substations; 2,2%. For new substations; 1,5%	5 - 10 (8)	
Modernisation of indirect substation	2,2	per unit	30	70	Increased efficiency and reduced return temperature	10 - 15% (12%)	2	of new invest	5 - 8 (6)	

Energy Efficiency Interventions - Demand Side

Action	Specific investment 1000 EUR	Unit	External costs %	Local costs %	Main Benefit	Energy Savings (average) %	Saved new capacity %	Saving in operational expenses %	Approx. payback (average) Years	Remarks
Check on function of valves etc.	0,1	per flat	0	100	Reduced heat consumption	10%	0	-	1	
Insulation of walls	10	per flat	20	80	Reduced heat consumption	20%	20	-	15 - 20 (17)	
Sealing and tightening of windows ar	0,01	per flat	20	80	Reduced heat consumption	20%	20	-	6 - 8 (7)	Limited technical lifetime of the investment
Replacement of windows	6	per flat	20	80	Reduced heat consumption	20%	20	-	6 - 8 (7)	
Thermostatic valves and heat allocators	0,3	per flat	50	50	Reduced heat consumption	20%	0	-	1 - 2 (2)	The installation should be combined with modernised/ new substations and a charging system based on consumption.

Annex 3 Input data tables for “Baltic Dragon” scenario

Table A.1 Basic macroeconomic assumptions in the "Baltic dragon" scenario

Year	GRP growth rate	Popula-tion	Industrial output index	Manufac-turing output index	Construc-tion SOW index	Agricultu-ral output index	Retail trade turnover index	Services	Real residen-tial income index	Commis-sioning of residen-tial buildings	Railway cargo turnover	Cargo shipment by water transport	Number of cars
	%	x000	%	%	%	%	%	%	%	x000 m2	mln. t-km	kton	pcs.
2007	113.1%	962.0	118.2%	129.0%	122.1%	104.2%	111.0%	120.2%	113.1%	763	3,225	2,974	248,915
2008	110.3%	981.2	114.0%	122.7%	102.4%	104.1%	110.0%	117.1%	110.3%	788	3,451	3,182	258,956
2009	111.3%	1,003.5	114.7%	120.7%	111.3%	104.6%	110.1%	116.2%	111.3%	880	3,692	3,405	270,128
2010	110.5%	1,027.5	113.6%	118.2%	106.3%	104.7%	109.7%	114.7%	110.5%	938	3,951	3,643	282,131
2011	109.8%	1,054.9	111.1%	116.8%	109.8%	105.1%	109.7%	114.0%	109.8%	1,040	4,227	3,898	295,460
2012	109.7%	1,086.1	110.8%	115.7%	109.7%	105.5%	109.7%	113.5%	109.7%	1,153	4,523	4,171	310,283
2013	109.5%	1,121.4	110.1%	114.7%	109.5%	105.8%	109.7%	113.0%	109.5%	1,278	4,840	4,463	326,776
2014	109.7%	1,161.3	110.5%	114.0%	109.7%	106.1%	109.7%	112.6%	109.7%	1,415	5,179	4,776	345,144
2015	109.6%	1,206.0	110.2%	113.4%	109.6%	106.5%	109.7%	112.2%	109.6%	1,565	5,541	5,110	365,624
2016	109.5%	1,256.3	109.8%	112.9%	109.5%	106.7%	109.7%	111.9%	109.5%	1,730	5,929	5,468	388,470
2017	109.6%	1,312.5	110.1%	112.5%	109.6%	107.0%	109.7%	111.6%	109.6%	1,911	6,344	5,850	413,970
2018	109.5%	1,375.3	109.9%	112.1%	109.5%	107.3%	109.6%	111.4%	109.5%	2,109	6,788	6,260	442,445
2019	109.4%	1,445.2	109.6%	111.8%	109.4%	107.5%	109.6%	111.2%	109.4%	2,325	7,263	6,698	474,253
2020	109.4%	1,523.1	109.4%	111.5%	109.4%	107.7%	109.6%	111.0%	109.4%	2,562	7,772	7,167	509,790

Source: Consultant's estimates using a simplified macroeconomic model

Table A.2 Basic products output under the «Baltic dragon» scenario

Year	Electricity generation	Oil extraction	Gas extraction	Pulp prod.	Paper prod.	Cardboard prod.	Meat prod.	Bread prod.
	mln. kWh	kton	mln. m3	kton	kton	kton	kton	kton
2007	539	1,218	17.3	189	68	23	23	13
2008	2,744	1,441	15.8	194	70	24	23	14
2009	2,744	1,550	16.5	214	74	25	26	15
2010	2,907	1,600	16.8	225	78	26	28	22
2011	3,510	1,700	16.8	248	85	29	31	31
2012	5,273	1,800	17.5	270	93	31	34	41
2013	6,126	1,800	17.5	313	108	36	38	45
2014	6,129	1,800	17.5	376	130	43	42	47
2015	6,132	1,800	17.5	387	133	45	46	51
2016	6,135	1,800	17.5	399	137	46	50	54
2017	6,138	1,800	17.5	411	142	47	55	56
2018	6,141	1,800	17.5	423	146	49	61	58
2019	6,144	1,800	17.5	436	150	50	67	64
2020	6,147	1,800	17.5	449	155	52	74	70

Table A.3 Electric- and heat sector generation structure and efficiency under the «Baltic dragon» scenario

Year	Electricity generation				Heat generation			Specific fuel consumption				Efficiency		Losses	
	KTETs-2	other	hydro	wind	KTETs-2	Other CHP	Share ind. boilers	KTETs-2	other	KTETs-2 (heat)	Other (heat)	Ind. boilers	HOB	electricity	Heat distr.
	mln. kWh	mln. kWh	mln. kWh	mln. kWh	thou. Gcal	thou. Gcal	%	gce/kWh	gce/kWh	kgce/Gcal	kgce/Gcal	%	%	%	%
2007	270	254	10	5	0	1,468	80.7%	293.0	195.0	155.0	171.2	89.0%	81.2%	-20.2%	-17.6%
2008	2,528	201	10	5	0	1,483	80.7%	250.0	195.0	155.0	171.2	89.5%	80.8%	-19.0%	-17.6%
2009	2,528	201	10	5	0	1,483	80.0%	241.0	195.0	155.0	171.2	89.9%	81.2%	-18.8%	-17.6%
2010	2,550	201	11	5	0	1,498	80.0%	241.0	195.0	155.0	171.2	89.9%	81.2%	-18.8%	-17.6%
2011	2,550	201	12	7	0	1,513	80.0%	241.0	195.0	155.0	171.2	89.9%	81.2%	-18.8%	-17.6%
2012	2,550	201	13	9	500	1,528	80.0%	230.0	195.0	155.0	171.2	89.9%	81.2%	-18.8%	-17.6%
2013	2,600	201	14	11	800	1,543	80.0%	220.0	195.0	155.0	171.2	89.9%	81.2%	-18.8%	-17.6%
2014	2,600	201	15	13	900	1,559	80.0%	220.0	195.0	155.0	171.2	89.9%	81.2%	-18.8%	-17.6%
2015	2,600	201	16	15	1,000	1,574	80.0%	210.0	195.0	155.0	171.2	89.9%	81.2%	-18.8%	-17.6%
2016	2,600	201	17	17	1,000	1,590	80.0%	210.0	195.0	155.0	171.2	89.9%	81.2%	-18.8%	-17.6%
2017	2,600	201	18	19	1,000	1,606	80.0%	200.0	195.0	155.0	171.2	89.9%	81.2%	-18.8%	-17.6%
2018	2,600	201	19	21	1,000	1,622	80.0%	200.0	195.0	155.0	171.2	89.9%	81.2%	-18.8%	-17.6%
2019	2,600	201	20	23	1,000	1,638	80.0%	200.0	195.0	155.0	171.2	89.9%	81.2%	-18.8%	-17.6%
2020	2,600	201	21	25	1,000	1,654	80.0%	200.0	195.0	155.0	171.2	89.9%	81.2%	-18.8%	-17.6%

Table A.4 Mini-cogeneration plants program under the «Baltic dragon» scenario

Year	Neman	Svetlo-gorsk	Baltiysk	Kalinin-grad	Gusev	Chernya khovsk	Total	Neman	Svetlo-gorsk	Baltiysk	Kalinin-grad	Gusev	Chernya khovsk	Total
	gas	coal	coal	solid waste	peat	peat		gas	coal	coal	solid waste	peat	peat	
	mln. kWh	mln. kWh	mln. kWh	mln. kWh	mln. kWh	mln. kWh	mln. kWh	thou. Gcal	thou. Gcal	thou. Gcal	thou. Gcal	thou. Gcal	thou. Gcal	mln. kWh
2005														
2006														
2007														
2008	140						140	325	750					1,075
2009	140	600					740	325	750	750				1,825
2010	140	600	600	160	1,000		2,500	325	750	750	250	1,000		3,075
2011	140	600	600	160	1,000	800	3,300	325	750	750	250	1,000	850	3,925
2012	140	600	600	160	1,000	800	3,300	325	750	750	250	1,000	850	3,925
2013	140	600	600	160	1,000	800	3,300	325	750	750	250	1,000	850	3,925
2014	140	600	600	160	1,000	800	3,300	325	750	750	250	1,000	850	3,925
2015	140	600	600	160	1,000	800	3,300	325	750	750	250	1,000	850	3,925
2016	140	600	600	160	1,000	800	3,300	325	750	750	250	1,000	850	3,925
2017	140	600	600	160	1,000	800	3,300	325	750	750	250	1,000	850	3,925
2018	140	600	600	160	1,000	800	3,300	325	750	750	250	1,000	850	3,925
2019	140	600	600	160	1,000	800	3,300	325	750	750	250	1,000	850	3,925
2020	140	600	600	160	1,000	800	3,300	325	750	750	250	1,000	850	3,925

Table A.5 Energy prices under the «Baltic dragon» scenario

Year	Electricity					Gas		Heat		Gasoline	Diesel fuel	Residual oil	Coal	Peat
	Industry	Transport	Agriculture	Other	Residential	Industry	Residential	Industry	Residen-tial					
	rubles/kWh	rubles/kWh	rubles/kWh	rubles/kWh	rubles/kWh	rubles/thou. m3	rubles/thou. m3	rubles/Gcal	rubles/Gcal	rubles/t	rubles/t	rubles/t	rubles/t	rubles/t
2007	1.76	1.56	1.76	1.76	1.63	2,241	2,883	1,150	1,070	20,778	17,520	5,741	1,269	635
2008	2.05	1.82	2.05	2.05	1.90	2,802	3,604	1,352	1,352	21,817	18,396	6,028	1,333	666
2009	2.36	2.09	2.36	2.36	2.18	3,578	4,602	1,614	1,614	22,908	19,316	6,330	1,399	700
2010	2.69	2.39	2.69	2.69	2.49	4,569	5,877	1,927	1,927	24,054	20,282	6,646	1,469	735
2011	2.96	2.62	2.96	2.96	2.74	5,026	6,465	2,061	2,061	25,256	21,296	6,979	1,543	771
2012	3.10	2.76	3.10	3.10	2.87	5,277	6,788	2,134	2,134	26,519	22,361	7,328	1,620	810
2013	3.26	2.89	3.26	3.26	3.02	5,541	7,127	2,208	2,208	27,845	23,479	7,694	1,701	851
2014	3.42	3.04	3.42	3.42	3.17	5,818	7,484	2,286	2,286	29,237	24,653	8,079	1,786	893
2015	3.59	3.19	3.59	3.59	3.32	6,109	7,858	2,366	2,366	30,699	25,885	8,483	1,875	938
2016	3.77	3.35	3.77	3.77	3.49	6,415	8,251	2,448	2,448	32,234	27,180	8,907	1,969	985
2017	3.96	3.52	3.96	3.96	3.67	6,735	8,663	2,534	2,534	33,846	28,539	9,352	2,068	1,034
2018	4.16	3.69	4.16	4.16	3.85	7,072	9,097	2,623	2,623	35,538	29,966	9,820	2,171	1,086
2019	4.37	3.88	4.37	4.37	4.04	7,426	9,552	2,715	2,715	37,315	31,464	10,311	2,280	1,140
2020	4.59	4.07	4.59	4.59	4.24	7,797	10,029	2,810	2,810	39,181	33,037	10,826	2,394	1,197

Annex 4 Input data tables for “Balanced Migration” scenario

Table A.6 Basic macroeconomic assumptions under the «Balanced migration» scenario

Year	GRP growth rate	Popu-lation	Industrial output index	Processing industry output index	Construc-tion SOW index	Agricul-tural output index	Retail trade turnover index	Index of charge-able services to popula-tion	Real residen-tial income index	Commis-sioning of residential buildings	Railway cargo turnover	Cargo shipment by water transport	Number of cars
	%	x000	%	%	%	%	%	%	%	x000 m2	mln. t-km	kton	pcs.
2007	108.9%	943.8	113.2%	122.5%	98.4%	102.9%	107.9%	116.8%	108.9%	569	3,165	2,918	244,193
2008	109.4%	945.4	112.4%	119.7%	109.5%	103.3%	108.0%	116.2%	109.4%	622	3,323	3,064	249,503
2009	108.4%	948.2	111.0%	116.9%	103.8%	103.3%	107.6%	114.2%	108.4%	646	3,489	3,218	255,255
2010	106.9%	951.4	109.1%	113.8%	97.4%	102.8%	106.6%	111.9%	106.9%	629	3,664	3,378	261,245
2011	107.3%	956.4	108.7%	112.8%	107.5%	103.1%	106.6%	111.3%	107.3%	676	3,847	3,547	267,861
2012	107.2%	965.1	108.4%	112.1%	107.4%	103.4%	106.6%	110.8%	107.2%	726	4,039	3,725	275,719
2013	107.1%	975.0	108.1%	111.4%	107.3%	103.6%	106.6%	110.3%	107.1%	780	4,241	3,911	284,111
2014	107.0%	986.1	107.8%	110.8%	107.2%	103.8%	106.6%	109.9%	107.0%	836	4,453	4,107	293,076
2015	106.9%	998.4	107.6%	110.3%	107.2%	104.0%	106.6%	109.6%	106.9%	896	4,676	4,312	302,666
2016	106.8%	1,012.0	107.4%	109.9%	107.1%	104.2%	106.6%	109.3%	106.8%	959	4,909	4,528	312,934
2017	106.7%	1,027.0	107.1%	109.5%	107.0%	104.4%	106.6%	109.0%	106.7%	1,026	5,155	4,754	323,939
2018	106.6%	1,043.6	106.9%	109.2%	106.9%	104.5%	106.6%	108.7%	106.6%	1,097	5,413	4,992	335,745
2019	106.5%	1,061.8	106.7%	108.9%	106.8%	104.7%	106.6%	108.5%	106.5%	1,172	5,683	5,241	348,419
2020	106.4%	1,081.6	106.5%	108.6%	106.8%	104.8%	106.5%	108.3%	106.4%	1,251	5,968	5,503	362,037

Source: Consultant's estimates using a simplified macroeconomic model

Table A.7 Basic products output under the «Balanced migration» scenario

Years	Electricity generation	Oil extraction	Gas extraction	Pulp prod.	Paper prod.	Cardboard prod.	Meat prod.	Bread prod.
	mln. kWh	kton	mln. m3	kton	kton	kton	kton	kton
2007	539	1,338	20	282	104	26	15	34
2008	2,744	1,126	20	363	134	27	22	37
2009	2,744	992	20	363	134	27	31	39
2010	2,907	992	20	392	145	28	41	42
2011	3,510	992	20	404	149	29	45	44
2012	5,273	992	20	416	154	30	47	47
2013	6,126	992	20	429	158	31	51	50
2014	6,129	992	20	441	163	32	54	53
2015	6,132	992	20	455	168	33	56	56
2016	6,135	992	20	468	173	34	58	59
2017	6,138	992	20	482	178	35	64	63
2018	6,141	992	20	497	183	36	70	67
2019	6,144	992	20	512	189	37	77	71
2020	6,147	992	20	527	194	38	85	75

Annex 5 Input data tables for the “Sustainable Development” scenario

Table A.8 Electric- and heat sector generation structure and efficiency under the «Sustainable development» scenario

Year	Electricity generation				Heat generation			Specific fuel consumption				Efficiency		Losses	
	KTETs-2	other	hydro	wind	KTETs-2	Other CHP	Share ind. boilers	KTETs-2	other	KTETs-2 (heat)	Other (heat)	Ind. boilers	HOB	electricity	Heat distr.
	mln. kWh	mln. kWh	mln. kWh	mln. kWh	thou. Gcal	thou. Gcal	%	gce/kWh	gce/kWh	kgce/Gcal	kgce/Gcal	%	%	%	%
2007	2,528	201	10	5	0	1,483	80.0%	241.0	195.0	155.0	171.2	89.9%	81.2%	-18.8%	-17.6%
2008	2,550	201	11	5	0	1,498	80.0%	241.0	195.0	155.0	171.2	90.1%	82.0%	-17.0%	-17.6%
2009	2,550	201	12	7	0	1,513	80.0%	241.0	195.0	155.0	171.2	90.3%	82.8%	-16.0%	-16.0%
2010	2,550	201	13	9	500	1,528	80.0%	230.0	195.0	155.0	171.2	90.5%	83.6%	-15.0%	-15.0%
2011	2,600	201	14	11	800	1,543	80.0%	220.0	195.0	155.0	171.2	90.7%	84.4%	-15.0%	-15.0%
2012	2,600	201	15	13	900	1,559	80.0%	220.0	195.0	155.0	171.2	90.9%	85.2%	-14.0%	-14.0%
2013	2,600	201	16	15	1,000	1,574	80.0%	210.0	195.0	155.0	171.2	91.1%	86.0%	-13.0%	-13.0%
2014	2,600	201	17	17	1,000	1,590	80.0%	210.0	195.0	155.0	171.2	91.3%	86.8%	-12.5%	-12.5%
2015	2,600	201	18	19	1,000	1,606	80.0%	200.0	195.0	155.0	171.2	91.5%	87.6%	-12.0%	-12.0%
2016	2,600	201	19	21	1,000	1,622	80.0%	200.0	195.0	155.0	171.2	91.7%	88.4%	-11.5%	-11.5%
2017	2,600	201	20	23	1,000	1,638	80.0%	200.0	195.0	155.0	171.2	91.9%	89.2%	-11.0%	-11.0%
2018	2,600	201	21	25	1,000	1,654	80.0%	200.0	195.0	155.0	171.2	92.1%	90.0%	-10.5%	-10.5%
2019	2,600	201	22	27	1,000	1,671	80.0%	200.0	195.0	155.0	171.2	92.3%	90.8%	-10.5%	-10.5%
2020	2,600	201	23	29	1,000	1,688	80.0%	200.0	195.0	155.0	171.2	92.5%	91.6%	-10.0%	-10.0%