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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 Arkhangelsk Region

Draft Report

September 2007

This project is funded by the European Union

COWI

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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

- 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.
- The growth of capital investment demand in the electricity sector under the "Renewed Pomorie" scenario may considerably exceed the ability of the Oblast's electric utilities to attract investment.
- Electricity shortage may become a real constraint for high economic growth;
- Gradual increase in residual oil consumption by 2020 and significant growth of coal consumption will generate additional environmental risks.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 Arkhangelsk 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.

A summary of the characteristics and basic findings of the two scenarios are presented below.

"Social and Economic Development Program of Arkhangelsk Oblast for 2005-2008" and economic development projection for 2007-2010:	❖ Social development and improvement of housing conditions of population; ❖ GRP growth through technical modernization of industrial plants and development of innovative territorial/sectoral clusters for high value-added production; ❖ Transport infrastructure development; ❖ Rational use of natural resources: o Gasification of the Oblast; o Efficient use of conventional fuels; o Environmental protection and emissions caps.
The "Renewed Pomorie" scenario is based on the following concept:	❖ Average annual GRP growth in 2006-2020 will be 5.8%. Economic growth will be primarily driven by accelerated renovation of the physical, social, and business infrastructures in the Oblast; ❖ Relatively cheap and qualified manpower will become an attractive resource for considerable and sustainable investment inflow; ❖ The major "growth drivers" of the Oblast's economy will include: oil & gas sector, wood processing industry, machine building, transport, and commercial sector development; ❖ The Oblast administration will find resources for large-scale new housing and social construction; ❖ By 2010, the price of natural gas will go up to 3,190 rubles/1,000 m3, and by 2020 to 5,720 rubles/1,000 m3. The prices of other fuels will be growing up, too, although more slowly. Electricity tariff for the industrial sector will increase to 3 rubles/kWh in 2010 and 5 rubles/kWh in 2020;

	❖ GRP energy intensity will decline, as obsolete equipment is being replaced, and energy costs management systems are introduced to mitigate abrupt growth of fuel and energy prices. However, no specific additional Oblast-level or national energy efficiency programs or programs to promote the use of renewables will be implemented.
Under the assumptions of this scenario, primary energy consumption in the Oblast will increase from 8,591 Ttce in 2005 to 10,584 Ttce in 2020	❖ The GRP energy intensity will drop by 47% in 2005-2020 due to the growth of energy prices and to autonomous technical progress originated from replacement of obsolete equipment; ❖ Nevertheless, energy self-sufficiency of the Oblast (excluding oil and gas extraction in the Nenetsky autonomous district) will also drop from 14.6% to 8.3%; ❖ Electricity intensity of the GRP and industrial sector will decline in 2005-2020 by 16% and 13% respectively, yet electricity consumption will almost double reaching 16.2 bln. kWh in 2020; ❖ Electricity self-sufficiency of the Oblast will drop to 63% by 2020; ❖ To improve electricity self-sufficiency, it is necessary to additionally commission 1,200-1,500 thou. kW capacity at the cost of at least 30-40 bln. rubles in investment (taking no account of electricity network development); ❖ The Oblast's electricity sector is not prepared for such investment breakthrough, nor can it provide fuel for this additional electric capacity; ❖ Besides, there is no possibility to obtain 6 bln. kWh annually from the neighboring regions by existing transmission lines; ❖ Abrupt growth of gas price will lead to the fact that the share of gas in the IFEB will decline from 34.4% in 2005 to 30.8% in 2008. After Arkhangelsk co-generation plant and Severodvinsk co-generation plant-2 switch to gas in 2009, the share of gas in the IFEB will increase to 42.7% in 2009, but then, as the gas price grows, will drop back to 33% in 2020; ❖ The share of liquid fuel, the price of which grows much more slowly, than the price of gas, after dropping from 30.7% in 2006 to 20.6% in 2009 (due to the fuel switch of Arkhangelsk co-generation plant and Severodvinsk co-generation plant-2 in 2009) then again climes up to 27.5% by 2020 both due to the consumption growth in the transport sector and to some increase of fuel oil use by boiler-houses and power plants; ❖ The share of coal will increase from 19.4% in 2006 to 24.2% in 2020. If Arkhangelsk co-generation plant and Severodvinsk co-generation plant-2 switch to coal, the share of coal in 2010-2020 would account for 35%; ❖ The share of other solid fuels will decline from 15% in 2005 to 8.3%, and the share of wind energy will be negligible.

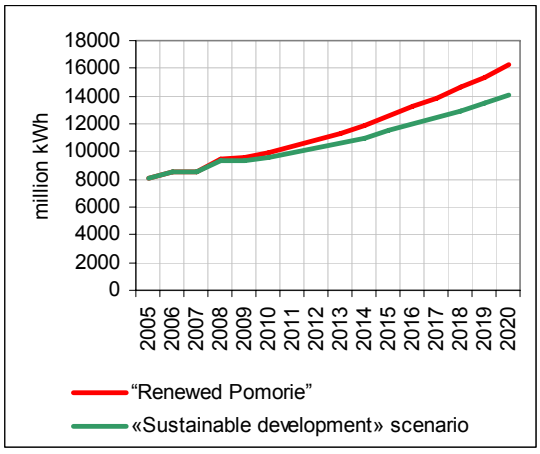
Basic risks of the "Renewed Pomorie" scenario:	❖ By 2020, primary energy self-sufficiency of the Oblast, as well as its energy security, will drop; ❖ The growth of capital investment demand in the electricity sector may considerably exceed the ability of the Oblast's electric utilities to attract investment; ❖ Electricity shortage may become a real brake for the economic growth; ❖ Gradual increase in residual oil consumption by 2020 and significant growth of coal consumption will generate additional environmental risks.
The "Sustainable development" scenario assumes, that several Oblast-level energy efficiency and renewable programs are implemented:	❖ Energy efficiency program in the industrial sector; ❖ Electricity transmission and distribution losses reduction program; ❖ Energy efficiency program in heat supply systems and other municipal utility systems (electricity- and water supply); ❖ Energy efficiency program in residential and public buildings; ❖ Renewable energy development program and a program to promote biomass and solid waste use by boiler-houses, power plants, and in all end-use sectors. ❖ These programs will result in 2.5% annual improvement of energy efficiency in all types of economic activities and in existing housing stock. ❖ The "Sustainable development" scenario was developed under an assumption that maximum potential progress will be made in the implementation of the Oblast's energy security strategy.
With the assumptions of the "Sustainable development" scenario, primary energy consumption in the Oblast will only increase to 9,937 Ttce in 2020	❖ Incremental energy demand to ensure economic growth will decline by 40% in the "Sustainable development" scenario versus "Renewed Pomorie"; ❖ Energy resource self-sufficiency of the Oblast will scale up from 15% in 2005 to 22.5% in 2020, showing dynamics of energy security parameters absolutely opposite to the "Renewed Pomorie" scenario; ❖ Electricity self-sufficiency will decline, but only to non-dangerous 73%. Therefore, the need for new generation capacities or electricity imports significantly shrinks; ❖ The share of gas in the IFEB will increase to 33% by 2020, the share of coal will drop to 17%, the share of liquid fuels to 23%, while the share of other solid fuels will increase to 22,5% substituting costly fossil fuels.
Compared to the "Renewed Pomorie" scenario, "Sustainable development" considerably mitigates the energy risks of economic growth:	❖ The risk of inability to leverage sufficient financing to develop the energy sector of the Oblast and related risk of electric capacity and gas shortages to ensure economic growth; ❖ The risk of significant deterioration of the environment and corresponding decrease of the Oblast's investment and migration attractiveness; ❖ This scenario is only feasible on condition that resources

will be allocated for the implementation of the Oblast-level energy efficiency programs and programs to promote renewable energy and flammable waste use. It allows for mitigation of two key risks of the Oblast's economic development until 2020.

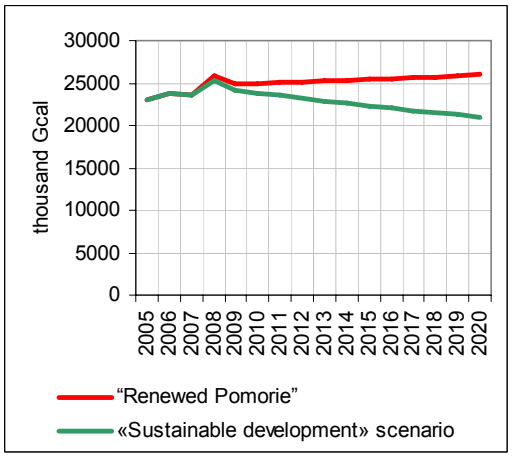
Improving energy efficiency in the "Sustainable Development" scenario substantially reduces risks of energy shortages to support dynamic economic growth

- ❖ High rates of economic growth in the "Renewed Pomorie" scenario (with weak energy efficiency policy) to be realized require a doubling of power demand, and over 60% increase in coal consumption (see figure below);
- ❖ There is a large risk that energy supply options will lag behind escalating energy demand thus reducing chances for Pomorie to be renewed;
- ❖ The most promising risks mitigation policy – is energy efficiency improvement policy. in the "Sustainable Development" scenario (with the same rates of economic growth as in the "Renewed Pomorie" scenario) energy efficiency allows to shrink in 2006-2020:
  - o additional demand for electricity from 7740 to 56144 million kWh;
  - o additional demand for coal from 927 thousand tce to none;
  - o additional demand for natural gas, which becomes extremely expensive and much less affordable, form 567 to 271 million m3 to;
- ❖ It also allows to block additional 2205 thousand Gcal demand for district heat and reverse it to decline by 2775 thousand Gcal/

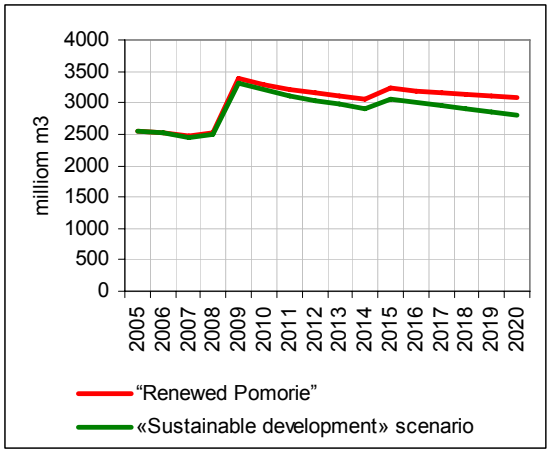
The following figures show energy demand for separate energy carriers in the two considered scenarios.



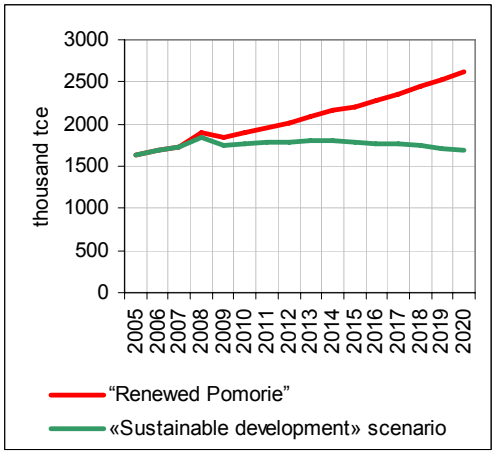
a) electricity consumption



b) district heat consumption



c) natural gas consumption



d) coal consumption

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.

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 Arkhangelsk regional 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 Arkhangelsk region.

1.1 Approach

This paper considers economic and energy development scenarios for Arkhangelsk Oblast until 2020. The data from "Social and Economic Development Program of Arkhangelsk Oblast for 2005-2008" and from projections for 2008-2010 were used for scenario development. The "Program" formulates basic problems associated with the social and economic development of the Oblast and the guidelines to address them. The projections until 2010 show quantitative estimates of macro-economic parameters. In 2007, the Department of Fuel & Energy sector and Housing & Municipal utility services of the Oblast Administration produced a document titled "Heat- and Electricity Sector Development Perspectives", which specifies the major regional energy policy for the near future and briefly assesses alternatives to meet energy demand. These three documents were used for the development of energy and economic scenarios for the Oblast until 2020.

The following steps were undertaken:

- ⇒ Identify economic development scenarios of the Oblast beyond 2010;
- ⇒ Formulate energy resource production growth concepts in the Oblast;
- ⇒ Assess the potential role of energy efficiency improvement in providing sufficient energy for the economic growth; and based on this
- ⇒ Evaluate energy demand growth perspectives and assess the evolution of Integrated Fuel and Energy Balance (IFEB) of the Oblast.

Two scenarios of economic and energy development of the Oblast were considered: "Renewed Pomorie" and "Sustainable Development". After this, the next steps were made:

- ❖ *"Development concepts"*, i.e. qualitative hypotheses regarding the targets and driving factors for the economic development, and energy resources the Oblast may further rely on to ensure its energy security. The "Concepts" show the ways to achieve the goals and to eliminate development contradictions, bottlenecks and "limits of growth", and so to balance economic, social, political, and institutional development factors;
- ❖ *"Development scenarios"*. Implementation of these scenarios requires development of an inherently consistent system of quantitative assumptions reflecting qualitative characteristics of the "Concept" in the system of parameters, which are used as inputs to the "ENERGYBAL" model (exogenous variables).

Scenario runs using the "ENERGYBAL" model allowed assessing corresponding energy development parameters; to reveal limitations, or constraints related to a mismatch of future economic and energy development, and the ways to balance economic and energy development of the Oblast.

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 can be found in the annexes.

Disclaimer:

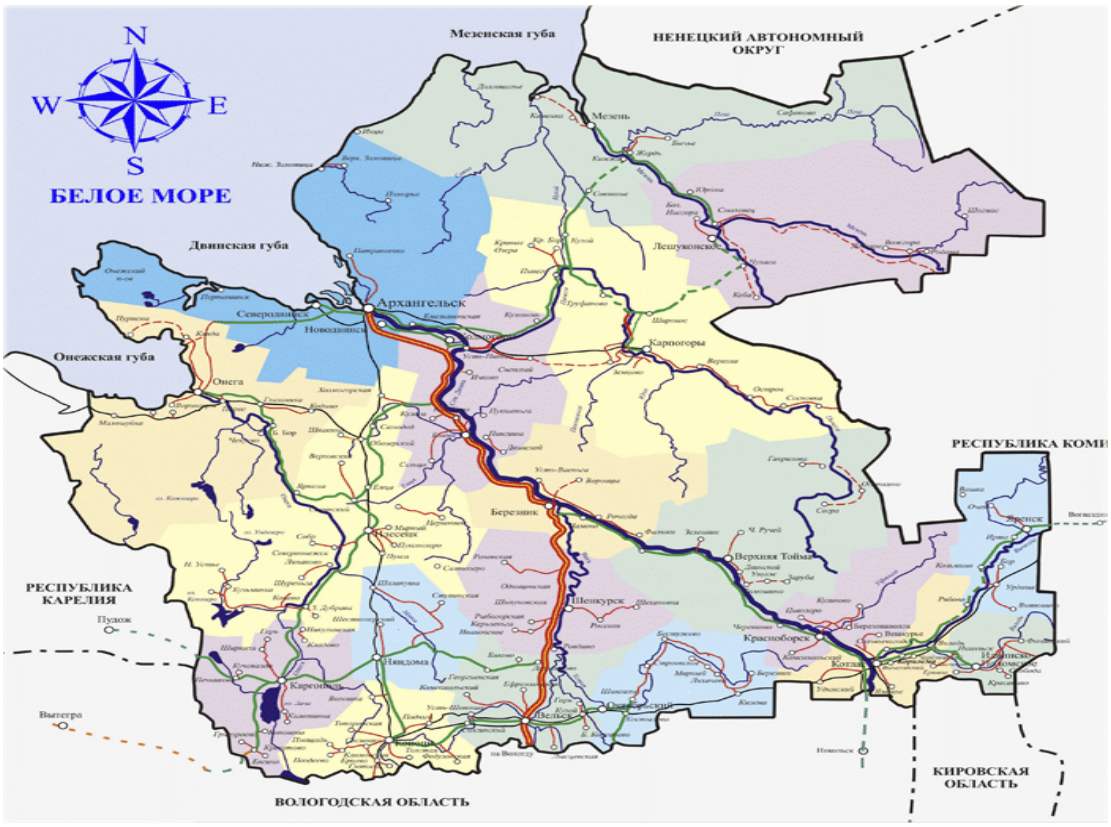
In no way, this report and its findings, conclusions and interpretations reflect the official oblast government policy or opinions of administration officials. They are solely the consultant's responsibility.

2 General economic and energy background

2.1 Regional economic situation

The Arkhangelsk region, including Nenets autonomous district, is the largest in the Northwest Russia, covering an area of 587400 Km2. It has 3000 Km of coastline on 3 Arctic seas and includes several islands such as Novaya Zemlya Archipelago, Franz Josef Land, Solovetskiye Islands and many other islands. A large portion of the territories is located beyond the Polar Circle. Overall there are 70,000 small and large rivers in the region. Historically, Arkhangelsk city has been one of the two important harbours (the other one is Murmansk) with access to the Polar sea.

The total population of the region as of January 2006 was 1.305 million – about 2.2 people per square kilometer. The population is highly urbanized (75% urban population and 25% rural population). The last 15 years the Arkhangelsk region, as in the whole of Russia is characterized by an annual 1% reduction of the population.



The Arkhangelsk region has significant wood resources occupying about 22,3 million hectares. Currently the total forest reserves are estimated at approximately two billion m3. The region is also rich in mineral resources. There are 78 oil and gas deposits, mainly in Nenets autonomous district and on the sea shelf (Timan-Pechora oil and gas province). It is estimated that oil reserves are over 1.2 billion tons and gas reserves are 620 billion m3. About 900,000 tons of bauxites are mined every year. Diamond reserves are estimated at 832 million carats and the development of the “Lomonosov” diamond deposit will contribute to the development of the region. There are also numerous deposits of coal deposits (3.7 billion tons), building materials (limestone, dolomites, cement materials), copper ores, zinc, lead, amber, jeweler agates and other minerals in the region.

The economic development of the region is based on traditional industrial braches, such as timber industry complex, fish industry, building industry and advanced commercial port infrastructure, including the Arkhangelsk seaport, which is the Northern gateway of Russia. Sea transport plays the major role in international trade of Arkhangelsk region, as well as in supplying some settlements. The three main economic centers within the region are Arkhangelsk (accounting for 30% of economic activity), Nenets autonomous district (15%) and Severodvinsk (15%). The economic activity in the Nenets autonomous district, as the main oil and gas center in the region, has experienced the highest level of growth with its share in the GDP doubling in the last four years.

More than 24000 enterprises and organizations of all patterns of ownership and managing are registered in the region. Most of the enterprises (84%) are in the private sector. The harsh climate conditions influence all aspects of life, including business and economy. The economy of Arkhangelsk region has traditionally been based on the exploitation of forests, fishing and transportation. High costs of building infrastructure has limited its development to a few key projects, such as main railway, the main motor road, a few ports, power stations etc. Outside of towns, infrastructure is almost non-existent. Economic activity is concentrated in a few key sectors.

Timber industry complex. A great number of sawmills, woodworking enterprises and pulp and paper mills are located in the region. The timber industry complex is a traditional leader of the regional economic potential. In 2004 the volume of woodcutting is 19,7 million m3 per year. The woodworking industry consists of more than 30 sawing and woodworking enterprises, which are basically located in the cities of Arkhangelsk and Onega. The annual volume of the saw-timber manufacture is more than 2 million m3; about 80% is intended for export. Arkhangelsk, Kotlas and Solombala integrated pulp and paper mills carry out chemical processing. In 2004 they produced 32,8% of the Russian pulp, 8,7% of the Russian paper and 25% of the Russian cardboard. Forestry, wood processing and pulp and paper are very important sectors of the economy, contributing over 40% to the regional production volume. Modernization and productivity enhancement on existing sawmills are the priorities for development of logging and wood processing sectors.

Fish industry. Fish industry is the major industry of the region. In 2004 the volume of the annual fish production was 120,000 tons, the processed and canned fish output is 93,000 tons. Besides fishery, enterprises conduct hunting coastal sea animals, salmon fishing and seaweed farming. Seaweed is a unique natural material for pharmaceutical and food industries. A seaweed plant, the only one in Russia and CIS is located in Arkhangelsk.

Defense industry. Due to its strategic location, defensive industries and shipbuilding used to play a significant role. Lack of finance has, however, severely cut back on their output. The Plesetsk space vehicle launching site, the only one in Europe is situated in Arkhangelsk region. Nowadays space vehicles within the programmes of international cooperation are launched as well as for military, economic and financing purposes.

Mineral resources complex. The Arkhangelsk region is recognized as fourth most important oil field in the world. About 80 deposits of oil and gas are discocered in the Northeast of the region, in the Nenets autonomous district. The reserves of the Shtockman gas condensate field are 121 million tons of gas condensate and 3.2 trillion m3 of gas. The largest diamond field area in Europe is explored in Arkhangelsk region

2.2 Energy consumption patterns

The tables 2.1 and 2.2 below show the total primary energy consumption (TPEC) in the region as well as the total final energy consumption (TFEC) for the year 2005. The figures were taken from the project report on the integrated fuel and energy balance of Arkhangelsk Oblast. The TPEC amounted to 8,591 Ttce. The share of natural gas is 35% while the other fossil fuels take up more than 60%. The TFEC in 2005 was 6,390 Ttce with industry and transport taking the lion’s share followed by the residential sector.

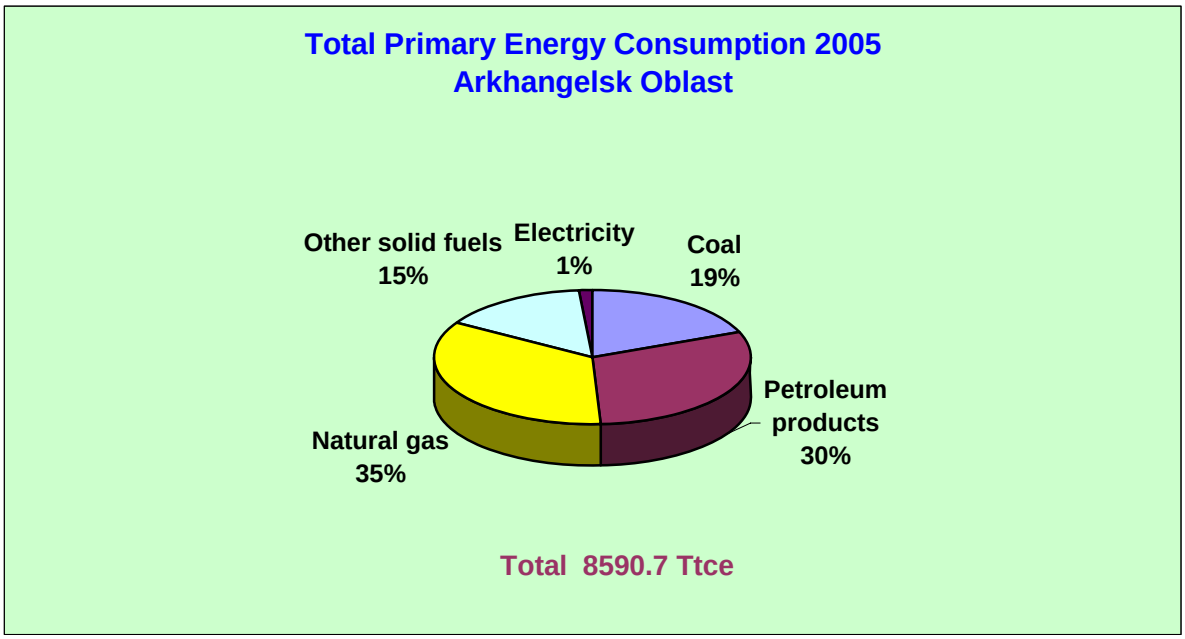


Fig. 2.1 Total Primary Energy Consumption Arkhangelsk Oblast, 2005 (Ttce)

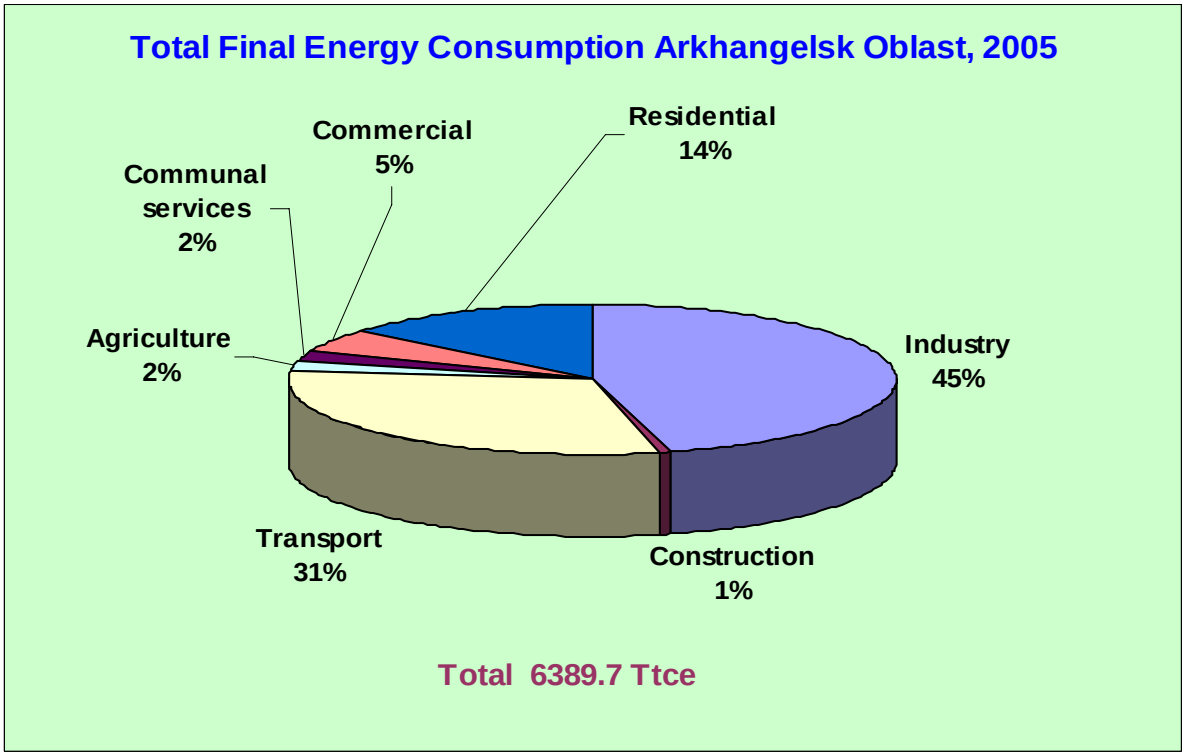


Fig. 2.2 Total Final Energy Consumption Arkhangelsk Oblast, 2005 (Ttce)

2.3 Energy resources

The Arkhangelsk region imports about 92% of its primary supply from other regions and only 8% is locally available, namely: firewood, by products of pulp and paper industry, resin industry and peat. The high dependency on imported fuel has resulted in electricity and heat tariffs that are considered the highest in the Russian Federation.

The largest proportion of primary energy consumption is represented by natural gas, which comes from the Western Siberia and from deposits in the Nenets autonomous district. The main consumers of natural gas are enterprises and municipalities of Kotlas, Koryazhma and the Kotlas district. The construction of a gas pipeline from "Nuksenitsa to Arkhangelsk" has been carried out in the Arkhangelsk region over the past 7 years. At present the gas pipeline extends as far as Velsk (147 Km from Nuksenitsa). It is planned to extend it for another 600 Km to reach Arkhangelsk and Severodvnisk.

Heavy fuel oil is mainly used by CHPs, heat and power plants operated by industrial enterprises and boiler houses for electricity and heat production. Coal is mostly used for heat and electricity production by CHPs and boiler facilities.

In order to provide the Far North and similar regions, which are characterized by a limited navigation period, with fuel and energy supplies the supplies are delivered annually during springtime by sea and river transport and in winter by temporary roads (winter roads). The fuel and energy consumption by these regions make up a minor part, approximately 1 – 1.5% of the regional consumption.

2.4 Energy sector organization

Power sector

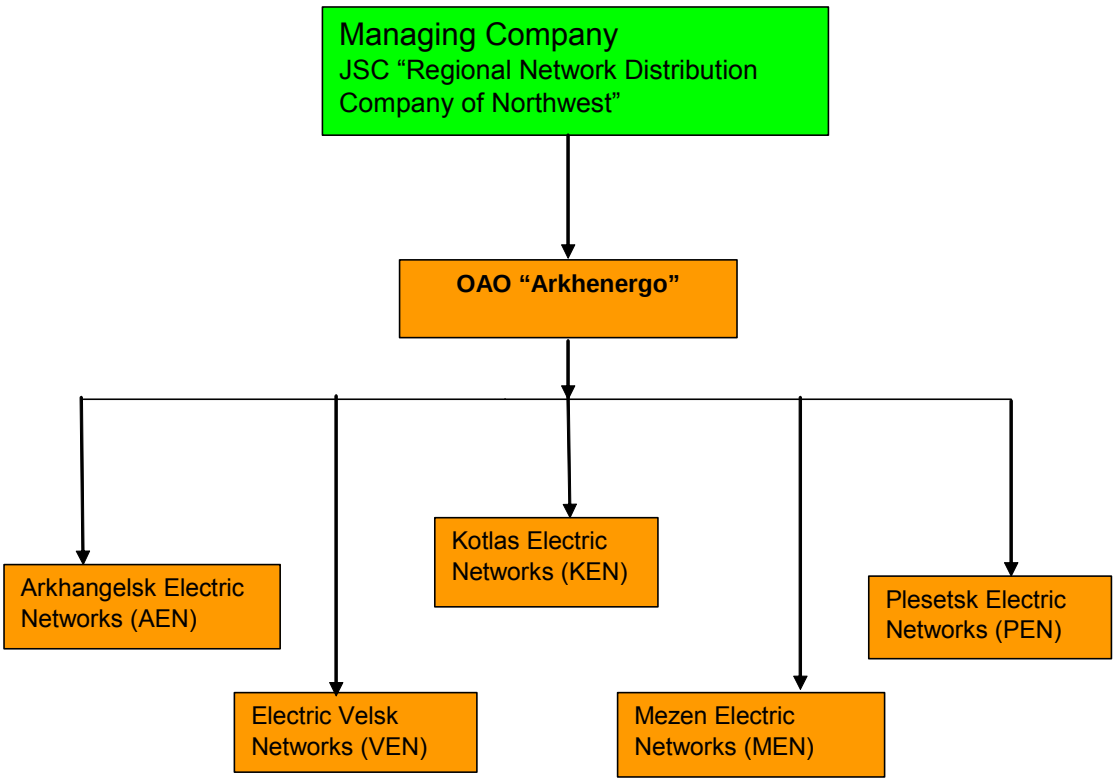
On 1st April 2005, as a result of restructuring the energy sector, according to RAO "UES Russia", 2 companies were established of OAO "Arkhenergo"; the Public Joint Stock company "Arkhangelsk Generating Company" (OAO "АГК") and the Public Joint Stock company "Arkhangelsk Sales Company" (OAO "Energosbit"), as its branch). Five months later (on 1st September 2005), the Public Joint Stock Company "Arkhangelsk Transmission Network Company" (OAO "Arkhenergo") responsible to transmit electricity within the network, Unified National Electricity System) was also registered.

In August 2005 the OAO "Arkhenergo" shareholders' board commissioned the Public Joint Stock Company "Regional Network Distribution Company of Northwest" (OAO "MPCK Severo – Zapada") with the OAO "Arkhenergo" executive powers. This company was registered as a juridical entity in December 2004 in St. Petersburg and is 100% a subsidiary of RAO "UES of Russia". The main function of OAO "Regional Network Distribution Company of Northwest" is to supply electricity through the distribution networks to all customers of the Northwest, including the Arkhangelsk region. There are 7 distribution companies under the authority of the "Regional Network Distribution Company of Northwest": OAO "Pskovenergo", OAO "Novgorodenergo", OAO "Karelenergo", OAO "Arkhenergo", OAO "Kolenergo", OAO "Lenenergo", and OAO "Yantarenergo".

By 01.01.2005 OAO "Arkhenergo" comprised of the following 12 branches: "Arkhangelsk CHP", "Severodvinsk CHP-1", "Severodvinsk CHP-2", "Arkhangelsk electric networks", "Velsk electric network", "Kotlas electric networks", "Mezen electric networks", "Plesetsk electric networks", "Severodvinsk heating network", "Energosbit", "Arkhangelsk heating network" and "Arkhangelsk electricity transmission network". On 3rd June 2005 OAO "Arkhenergo" management board decided to liquidate 6 branches; OAO "Arkhangelsk TPP", "Severodvinsk CHP-1", "Severodvinsk CHP-2", "Severodvinsk heating network", "Arkhangelsk heating network", and "Energosbit") and proceed with changes in the Regulations of OAO "Arkhenergo". On 22nd September 2005 the management board liquidated a branch of the OAO "Arkhangelsk electricity transmission network" and introduced further changes to the Regulations of OAO "Arkhenergo".

By end of 2005 the OAO "Arkhenergo" is comprised of 5 branches: "Arkhangelsk Electric Networks", "Velsk Electric Networks", "Kotlas Electric Networks", "Mezen Electric Networks" and "Plesetsk Electric Networks". The OAO "Arkhenergo" administrates these branches, financially and technologically (see diagram below).

Under the agreement No. 24, dated 10.10.2005 OAO "Arkhenergo" has transferred executive authorities to the managing company OAO "Regional network distributional company of the Northwest".



Power Generation

In **2005**, in Arkhangelsk Oblast electricity was generated by 907 power plants with the total capacity of 2,023.3 MW (Inventory "The energy capacity electricity consumption by Arkhangelsk Oblast enterprises in 2005").

The total capacity of all power plants in the Oblast with individual capacities above 500 MW equaled 1,879 MW (93% of the overall capacity).

In the latest years, the RAO "UES Rossii" power plants have been responsible for 45 to 49% of overall electricity generation. These power plants and the industrial co-generation plants are responsible for 98% of the overall electricity generation in the Oblast. The remaining 834 power plants include small diesel power plants with average installed capacity of 173 kW. These are responsible for practically all capacity increase between 2002-2005.

Heat Generation

As of early 2006, there were 984 heat sources (2,888 boilers) in Arkhangelsk Oblast. Most of them (84%) are small boilers with the capacity below 3 Gcal/hour (3,5 MW). The number of such boiler-houses has been steadily declining in the recent years. In 2001-2005, 133 such boiler-houses were closed down.

Data for 2005:

- 67 boiler-houses were gas-fired

- 52 liquid fuel-fired

- 865 (mostly small ones) coal- and wood-fired, often with manual fuel supply to outdated, extremely inefficient (50-60% efficiency) boilers, **long prohibited by Rostechnadzor for operation**.

Investments in energy sector

There is a certain experience in the implementation of energy efficiency programs in the Oblast. In September 2006, a social and economic target program "Renovation of

Arkhangelsk Oblast municipal utility infrastructure for 2007-2010" was adopted, which, apart from the above mentioned subprogram on efficient use of local fuels (635 mln. rubles), includes the following subprograms:

- Renovation of heat sources and heat supply systems (1,185 mln. rubles);
- Efficient use of natural gas (314 mln. rubles);
- Renovation of water supply and sewage systems (1,755 mln. rubles).

The program includes a list of projects and costs, but no estimates of the effects. For example, the program of heat supply systems renovation includes: construction of boiler-houses, replacement of boilers; renovation of heat networks and residential heat supply systems; installation of variable-speed drives; replacement of burners; installation of pipes with foam polyurethane insulation; installation of meters; renovation of water treatment systems.

The major goal of the program is to reduce the wear and tear of main assets of the municipal utility sector by 10%. In 2006, depreciation was 70% in heat network, 75% in water network, 57% in electric network, and 55% in sewage network. Heat losses through hot water leaks determined by poor pipe insulation amount to 50%, cold water losses – to 20%, and electricity losses – to 17%. Department of fuel and energy complex and municipal utility sector is assigned the responsibility for the program implementation.

Analysis of the program showed, that it, in fact, does not include any end-use efficiency measures, including in residential and public buildings. At the same time, the experience of Arkhangelsk energy efficiency centre shows, that the project implemented in Arkhangelsk pioneer centre resulted in 56% electricity savings; in Novodvinsk School No. 4 – in 33% heat and 33% electricity savings; and in Novodvinsk School No. 1 – in 46% electricity savings.

The Arkhangelsk Deputy Council has 28 September 2006 approved a regional law concerning the Arkhangelsk regional socio-economic target programme on "Arkhangelsk region municipal infrastructure facilities modernisation, 2007-2010".

The law includes a list of 60 proposed projects and a total budget of 3,888 mRUB up to year 2010. The projects include upgrading of water and sewage system, energy savings project and projects for renewable energy. The development stage of the projects varies. For some projects, feasibility studies and business plans have been worked out and some projects are only on the project idea stage.

Funding for all the projects, approximately 50% of 3,888 mRUB, has not yet been found.

2.5 Energy sector development

Potential supply options

The following units serve as input data for the scenario development:

Leshukonskoye biomass CHP

Fuel: biomass (wood)

Capacity: 4.2 MWe, 12.8 MWth

According to the feasibility study for the Leshukonskoye biomass CHP the unit will deliver 15.9 GWh electricity and approximately 28 Tcal heat.

This unit is a new CHP unit that is assumed to be built in Leshukonsky District. The main source of electricity in the Leshukonsky District has traditionally been small diesel generators, that supply electricity to remote communities or to the integrated networks serving several smaller communities.

Construction of a biofuel CHP and power transmission lines in Leshukonskoe would allow the closing down of the three major diesel power stations in Leshukonskoe, Yuroma and Tsenogora and the two smaller power stations in Belotschelye and Selitsche with the total

electricity output of 14.83 GWh per annum and annual consumption of diesel fuel at 3807 tones.

Combined Cycle 1 and 2

Fuel: natural gas

Capacity: 255 Mwe, 159 MWth (278 MWe in condensing mode)

It is assumed that these kind of units may be built when natural gas has reached Arkhangelsk and Severdovinsk after year 2009. The units will be run as a Combined Heat and Power (CHP) plant during 5000 hours/year and in condensing mode during 2800 hours/year.

Coal CHP 1 and 2

Fuel: coal

Capacity: 255 MWe, 255 MWth (283 MWe in condensing mode)

It is assumed that these kind of units may be built in areas where there is no natural gas available. The units will be run as a Combined Heat and Power (CHP) plant during 5000 hours/year and in condensing mode during 2800 hours/year.

Biomass CHP 1

Fuel: biomass (wood waste)

Capacity: 255 MWe, 255 MWth (283 MWe in condensing mode)

It is assumed that these kind of units may be built in areas where wood waste is available. The units will be run as a Combined Heat and Power (CHP) plant during 5000 hours/year and in condensing mode during 2800 hours/year.

Hydro supply options

No new hydro power is included in the actual scenarios. Small hydropower plants that used to be operated have now almost completely ceased to function. According to some sources there is a potential for hydro power in the Oblast. It is therefore recommended that this will be investigated further.

Wind power

Two wind power projects have been included in the scenarios. The projects are the “Karneka wind energy plant” (500 kWe) and the “Dolgoshchetie wind energy plant” (90 kWe).

Heat supply options

The CHP units mentioned above will also produce heat that may be delivered to a district heating system. Besides the CHP units a number of Heat Only Boilers (HOB) will be needed. The HOBs will be using natural gas if available, otherwise oil.

Energy saving measures

Arkhangelsk Oblast Energy Efficiency Centre (AOEEC) has carried out a number of energy efficiency projects regarding modernization of district heating systems, improvements of energy efficiency in buildings and industrial enterprises and electrical supply systems. The results from these projects indicate that there is big energy saving potential in Archangelsk.

In order to reduce the heat energy consumption the installation of heat substations with control equipment in buildings connected to a DH system has been studied in similar projects. Installation of substations with control equipment in buildings will probably reduce the heat consumption with 25-40 %. The total energy saving is depending on the number of substations that is installed.

The energy saving measures that are recommended are:

- replacing old inefficient heat production units with new more effective ones

- installation of new modern well insulated district heating pipes when the old ones are changed
- installation of heat substations with control equipment in multifamily houses
- replacing old inefficient power production units with new more effective ones
- reduction of distribution losses in the electricity distribution systems

The final selection of energy efficiency measure has to be based on detailed feasibility analyses.

3 Basic aims of the regional socio-economic development till 2020

3.1 Major problems of socio-economic development of Arkhangelsk region

The "Social and Economic Development Program of Arkhangelsk Oblast for 2005-2008" identifies the following major problems associated with its social and economic development:

- High mortality rate in the working age leads to a reduction of population and increased demographic burden on the employees;
- Low standard of living, significant social and economic differentiation, and high unemployment rate lead to a high migration rate and so to a higher reduction of population;
- Low industry renovation and modernization rates. Most industrial sectors and a large part of the infrastructure need fundamental renovation of fixed assets to reduce production costs and improve the competitiveness of the critical industries;
- Rapidly growing energy prices and tariffs among other factors lead to increased production costs along with a deterioration of the plants' financial status;
- Inadequate housing construction rates combined with a large share of obsolete housing stock is becoming problematic;
- Transport infrastructure bottlenecks do not allow for efficient use of all types of transport;
- Unfavorable environmental situation;

Analysis of problems existing in different sectors reveals practically complete depreciation of fixed assets and (very) low modernization rates.

3.2 Strategic development goals

The "Social and Economic Development Program of Arkhangelsk Oblast for 2005-2008" specifies the following six strategic development goals of Arkhangelsk Oblast:

1. Social development and improvement of housing conditions of population – health care, education, culture, and social security development;
2. Growth of GRP and tax revenues of all budget levels through technical modernization of industrial plants;
3. Development of innovative territorial/sectoral clusters, business infrastructure and business environment – setting up a scientific and production cluster in Severodvinsk, an innovation cluster in Mirny, a regional forestry cluster in the forestry/industrial sector, introduction of new technologies in the agricultural/industrial sector;
4. High added value production, including wood processing;
5. Transport infrastructure development – renovation of existing water transport and sea ports development;
6. Rational use of natural resources, environmental protection and energy efficiency:
    - Gasification of the Oblast (construction of the Nyuksenitsa – Arkhangelsk gas pipeline and gas transporation network);
    - Efficient use of fuels traditional for the northern territories (peat, charcoal, and wood waste);

- ❖ Fire protection of forests, rational use and protection of the Oblast's water resources, air protection, and evaluation of maximum permissible emission levels for Arkhangelsk, Severodvinsk, and Novodvinsk.

3.3 Economic development projection for 2008-2010

Economic development projection for 2008-2010 was developed by Arkhangelsk Oblast administration in compliance with the formats provided by the RF Ministry of Economic Development and Trade (Form 2p)[1]. It is a quite detailed projection containing growth parameters, dynamics of prices, residential/public incomes and expenditures, and production levels of basic products for two scenarios. However, these two scenarios differ only insignificantly in terms of the critical parameters of economic dynamics. According to these scenarios, in 2008-2010 the Oblast's GRP will increase by 15.6-18.9%. In 2008, the growth will equal 11.8-12.9%, and in the following two years will be considerably slower (only 2% annually on average).

Development perspectives after 2010 are vague: it is not clear, if the growth will keep very slow (2-3%), or may accelerate (the "Renewed Pomorie" scenario). The resource base for high growth rates includes wood processing; development of efficient and sustainable agricultural production and renovation of the food industry; development of diamond deposits; exploration and extraction of bauxites in Iksinskoye, Plesetskoye, and Denislavskoye deposits; oil and gas exploration in Mezenskaya cyneclise; development of the building materials industry, etc.

3.4 Economic development projection for Arkhangelsk Oblast until 2020

Projections for 2011-2020 are based on the simplified macroeconomic model of Arkhangelsk Oblast. The model parameters were calibrated based on the reported data and the data from the projection developed by the Oblast administration until 2010.

The projection logic is structured as follows: potential investment dynamics in various types of economic activities is evaluated to assess fixed capital dynamics, manpower demand, and production dynamics. Obviously, the degree of uncertainty of the Oblast's economic development after 2010 is considerably higher; this fact is reflected in the scenarios.

3.5 Strategic directions of the Oblast's energy supply sector development

The paper "Heat- and electricity sectors development perspectives", developed by the Department of fuel & energy sector and housing & municipal services, identifies the following major directions of ensuring the Oblast's energy security:

A. Gasification:
   - ❖ Accomplishment of Nyuksenitsa – Arkhangelsk gas pipeline construction in the Plesetsk – Arkhangelsk – Severodvinsk part;
   - ❖ Renovation of existing cogeneration plants, including installation of energy efficient equipment and the switch to natural gas;

B. Promoting the use of local and renewable energy resources:
   - ❖ Introduction of renewable energy sources;
   - ❖ Construction of mini-cogeneration plants, which would use local fuels or own waste;

[1] The projection was made for Arkhangelsk Oblast alone, with no account of Nenetsky autonomous district (NAD). The major part of statistical data include NAD. The NAD population is nearly 40 thousand people (3% of overall population), but the District is responsible for a considerable part of the GRP due to oil and gas extraction.

- ❖ Switch of small boiler-houses to local fuels;

C. Optimization:

- ❖ Of electricity supply schemes in distributed electricity supply zones, with simultaneous renovation of electricity generating equipment and construction of electricity transmission lines, so as to increase transmission capacities between Arkhangelsk and Kotlas energy knobs (primarily in Leshukonsky and Mezensky districts) and to close down inefficient diesel power plants;
- ❖ Of heat supply schemes and systems to improve their efficiency;

D. Renovation of, and large-scale introduction of energy efficiency technologies at:

- ❖ Power plants;
- ❖ Fuel supply systems;
- ❖ Industrial facilities;
- ❖ Heat supply systems and other facilities of the housing and municipal utility sector.

Arkhangelsk Oblast administration selected the accomplishment of Nyuksenitsa – Arkhangelsk gas pipeline construction and the switch to natural gas of power plants in Arkhangelsk, Severodvinsk, and Novodvinsk as the strategic objectives of its energy policy. In Severodvinsk, it is possible that a nuclear low capacity cogeneration plant will be built based on the floating energy block with a KTL-40C reactor.

Obviously, the implementation and efficiency of these strategic directions until 2020 may be very different. Among other factors, much will depend on how actively the Oblast Administration will be implementing the above energy policies. The “Sustainable development” scenario was developed based on an assumption, that the Oblast will make the maximum possible progress in the implementation of its energy security policy.

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4 Development scenarios for Arkhangelsk Oblast

This chapter contains two different scenarios for a possible future development of Arkhangelsk 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 "Renewed Pomorie" scenario

4.1.1 THE CONCEPT

The "Social and Economic Development Program of Arkhangelsk Oblast for 2005-2008" notes, that the major economic goal is to develop an efficient multi-sectoral economy based on innovative technologies, technical renovation of industrial plants, and introduction of modern technologies of raw materials processing.

The "Renewed Pomorie" scenario is based on the following concept:

- Economic growth will be primarily driven by high growth factors, accelerated renovation of fixed assets, improved qualification of manpower, accelerated renovation of the physical, social, and business infrastructures in the Oblast;
- Relatively cheap and qualified manpower will become an attractive resource for considerable and sustainable investment inflow;
- The major "growth points" of the Oblast's economy will include: oil & gas sector, wood processing industry, machine building (due to larger orders placed by the Russian electricity sector, nuclear energy, and the military for equipment that can be produced in the Oblast), and development of transport (including natural gas) and the commercial sector;
- Accumulation rate in the GRP will be kept at least at 20%. Investments will be primarily allocated to the renovation and replacement of obsolete equipment. Technically obsolete plants with highly worn-out equipment will be actively decommissioned releasing infrastructure and manpower resources (for training and further use in the new plants);
- Sustainable salaries growth will make the Oblast attractive for living, decreased migration outflow, and will develop the conditions for sustainable housing demand growth;
- The Oblast's administration will find resources to launch large-scale housing and social (re-)construction programs;
- Selected energy policies will be partially implemented. However, the habit of addressing energy supply problems primarily through additional energy generation increase, rather than through energy efficiency improvements, will persist. No special energy efficiency policies will be implemented in the Oblast.

4.1.2 SCENARIO CONDITIONS

The above qualitative statements correlate with the basic scenario variables of the ENERGYBAL model (see Tables A.3-A.6 in Annex 2). Until 2010, the scenario uses data of Option 2 (high scenario) of the projection developed by the Oblast administration, and beyond 2010 it uses the estimates obtained by the consultants using the simplified model of the Oblast's economy under an assumption that accumulation rate in the GRP will be 20%. In this case, average annual GRP growth rate in 2006-2020 is 5.8%, which roughly coincides with the estimates of the Russian GDP increase for the next few years. In other words, the share of Arkhangelsk Oblast in Russia's economy will remain at the current level or even increase a little bit.

Analysis of switching some energy facilities to natural gas deserves special attention in view of expected considerable growth of natural gas prices. Until 2010, this gas price growth projection coincides with the projection made by the RF Ministry of Economic Development and Trade. According to this projection, in 2010 the natural gas price for industrial consumers will be 2.6 times more than the 2005 level and will equal 3,193 rubles/1,000 m3, or with current ruble/USD exchange rate, 123 USD/1,000 m3. Prices for residual oil and gasoline in 2010 will increase by 37-39% compared to the 2005 level, and the coal price by 35%. Then heat produced by gas-fired boiler-houses in 2010 will be 30-50% more expensive, than heat produced by coal-fired boiler-houses. If gas prices keep growing this fast until 2020, heat from gas-fired boiler-houses will become even more expensive, than heat from residual oil-fired boiler-houses.

The switch of Arkhangelsk cogeneration plant and Severodvinsk cogeneration plant-2, as well as of boiler-houses, from fuel oil to natural gas and coal is a good strategy, but the choice between gas and coal will largely depend, among other factors, on the prices for these fuels. The most important arguments of the Oblast administration in favor of gas include lower capital costs (627 mln. rubles versus 5,774 mln. rubles for coal option, or 0.25 rubles increased cost of 1 kWh) and more environmental safety. However, by the fuel price criteria, coal obviously takes the lead (0.25-0.30 rubles price reduction per 1 kWh in 2010).

Therefore, the most rational strategy would be to develop both gas and coal use in parallel, which would allow for flexible fuel switching to keep the fuel component of heat and electricity tariffs at affordable levels. In accordance with the Oblast administration's strategy, this scenario assumes, that renovation of both cogeneration plants will start in 2009. Three options are considered: fuel selection depending on the fuel prices; the switch of Arkhangelsk cogeneration plant and Severodvinsk cogeneration plant-2 to natural gas (additional gas demand will be about 1 bln. m3) or to coal from 2009. Besides, an assumption is made that heat capacity of Arkhangelsk cogeneration plant will be increased to cover heat capacity shortage in Arkhangelsk.

This scenario also assumes, that a cogeneration plant(s) will be commissioned in/after 2015 to cover electricity shortage, and that this (these) cogeneration plant(s) will be producing 1 bln. kWh of electricity and 1 mln. Gcal of heat using natural gas (70%) and other solid fuels (biomass and other production waste).

Electricity price for the industrial sector may increase between 2005-2010 by 73% and reach nearly 3 rubles/kWh, or 12 cents/kWh. With such electricity prices, many renewable energy sources, as well as energy efficiency improvements, become viable. It is assumed, that wind electricity generation will increase to 5.05 mln. kWh in 2020. Gas price hikes and growing prices for other fuels will lead to a heat price increase to 1,070 rubles/Gcal in 2010.

It is also assumed, that no specific regional energy efficiency programs will be implemented. Energy efficiency improvements will result from (a) consumers' reaction to energy, primarily natural gas, price growth, and (b) autonomous technical progress, which will lead to improved energy efficiency, as industrial equipment and population's appliances are replaced with modern models.

This scenario is based on a relatively fast economic growth and large-scale application of new equipment to replace the old models. Therefore, an assumption is made that autonomous technical progress will lead to 1% annual energy intensity reduction in all sectors. It is also assumed, that new residential buildings will be 30% more energy efficient (per 1 m2), than the existing housing stock.

It is further assumed, that the inflation rate until 2010 will be gradually declining to 6% (in accordance with the projection until 2010), and in 2011-2020 will be 4% on average annually.

The climate will stay cold: the number of degree-days will equal 5,400-5,470.

4.1.3 ENERGY SECTOR DEVELOPMENT UNDER THE "RENEWED POMORIE" SCENARIO

Integrated Fuel and Energy Balance

Under the assumptions of this scenario, primary energy consumption in the Oblast will increase from 8,591 Ttce in 2005 to 10,854 Ttce in 2020 (see Fig. 4.1 and Table 4.1). This happens despite the fact, that the GRP energy intensity will drop in 2005-2020 by 47% compared to the 2005 level, or by 4.1% on average annually, caused by growing energy prices and autonomous technical progress.

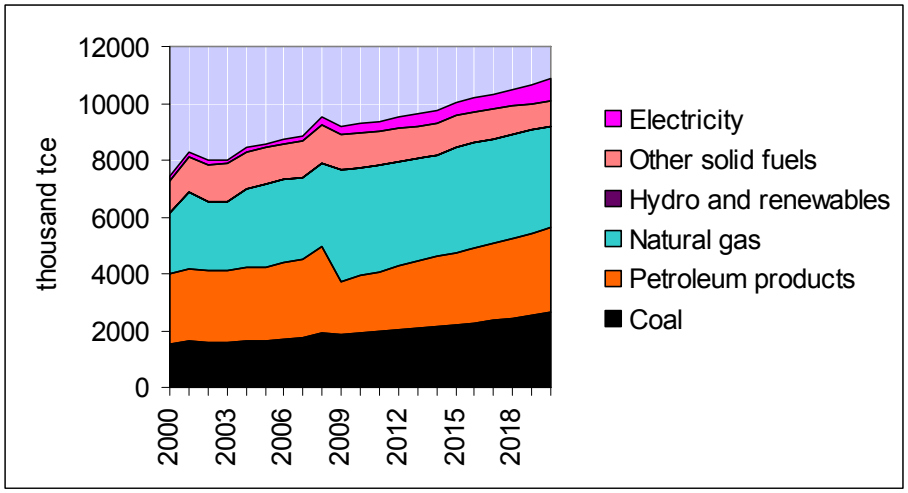


Fig.4.1 Primary energy consumption dynamics in the "Renewed Pomorie" scenario

Under the assumptions for own electricity generation growth, net electricity import demand will increase by 2020 from 1.3 to 6 bln. kWh. Growing gas prices will lead to the gas share decline in the IFEB from 34.4% in 2005 to 30.8% in 2008. However, after Arkhangelsk cogeneration plant and Severodvinsk cogeneration plant-2 switch to gas in 2009, the share of gas in the IFEB will increase to 42.7% in 2009, but then, as the gas price grows, it will gradually decline to 33% in 2020. Absolute gas consumption also somewhat decreases between 2010-2020. The share of liquid fuel, the price of which grows much more slowly, than the price of gas, after dropping from 30.7% in 2006 to 20.6% in 2009 (due to the fuel switch at Arkhangelsk cogeneration plant and Severodvinsk cogeneration plant-2), then increases to 27.5% by 2020 both due to the consumption growth in the transport sector and to a certain increase of residual oil use by boiler-houses and power plants. The share of coal will sustainably grow from 19.4% in 2006 to 24.2% in 2020. If Arkhangelsk co-generation plant and Severodvinsk co-generation plant-2 switch to coal, the share of coal in 2010-2020 will account for 35%. The share of other solid fuels will sustainably decline from 15% in 2005 to 8.3%, and the share of wind energy will be negligible.

Energy resource self-sufficiency of the Oblast (excluding oil and gas extraction in the oil & gas sector) will drop from 14.6% to 8.3%, basically due to the reduction of the use of other solid fuels, and primarily the pulp & paper factory's waste, and to the reduction of the role of the pulp & paper factory's cogeneration plant in the heat- and electricity balance of the Oblast.

Table 4.1 IFEB in 2020 under the « Renewed Pomorie » scenario (Ttce)

	Coal	Crude oil	Petroleum products	Natural gas	Hydro/Renewables	Other solid fuels	Power	Heat	Total
Production		18,447.0		741.8	0.5	899.0			20,088.2
Import	2,623.2		2,985.8	2,841.4			762.9		9,213.3
Export		-18,447					0		-18,447
Stock changes									0
Primary energy consumption	**2,623**	**0**	**2986**	**3583**	**0.1**	**899**	**763**	**0**	**10,854**
Statistical discrepancies									
Power plants	-2,073.7	0.0	-1,175.2	-2,029.2	-0.1	-739.1	1,234.7	2,985.7	-1,796.9
Electricity generation	-778.9	0.0	-884.2	-894.5	-0.1	-191.8	1,234.7		-1,514.8
Existing plants	-778.9	0.0	-884.2	-754.5	-0.1	-131.8	1,111.7		-1,437.8
New plants	0.0	0.0	0.0	-140.0	0.0	-60.0	123.0	0.0	-77.0
Heat generation	-1,577.7	0.0	-514.2	-1,225.6	0.0	-668.7	0.0	3,711.0	-275.2
Existing plants	-1,294.8	0.0	-290.9	-1,026.3	0.0	-547.3	0.0	2,842.7	-510.9
New plants	0.0	0.0	0.0	-108.5	0.0	0.0	0.0	143.0	34.5
Boiler-houses	-282.9	0.0	-223.3	-90.8	0.0	-121.4	0.0	646.1	-72.3
Industrial	-282.9	0.0	-223.3	-88.0	0.0	-121.4	0.0	643.6	-72.0
Agricultural	0.0	0.0	0.0	-2.8	0.0	0.0	0.0	2.5	-0.3
Heat recovery units								79.1	79.1
Own needs							-180.2		-180.2
Distribution losses				0.0			-143.8	-170.7	-314.5
Own needs				-31.2			-17.8		-48.9
Distribution losses				0.0			-215.9	-382.9	-598.9
Energy end-use	**266.6**	**0.0**	**1,587.4**	**1,463.1**	**0.0**	**38.4**	**1,673.7**	**3,540.3**	**8,569.4**

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	**266.6**	**0.0**	**1,587.4**	**1,463.1**	**0.0**	**38.4**	**1,673.7**	**3,540.3**	**8,569.4**
Industry	262.8	0.0	41.6	169.3	0.0	15.9	769.6	2,452.1	3,711.3
Oil and gas extraction	0.0		2.3	77.7		0.0	121.5	88.1	289.6
Harvesting and drying of wood	0.0	0.0	0.0	0.0	0.0	1.5	13.6	74.9	90.0
Pulp	0.0		0.0	0.0		0.0	163.3	883.3	1,046.6
Paper	0.0		0.0	0.0		0.0	24.1	120.6	144.7
Cardboard	0.0		0.0	0.0		0.0	114.5	141.2	255.7
Cement	249.6		2.1	0.0		0.0	24.6	3.2	279.5
Water raise and supply	0.0		0.0	0.0		1.2	3.8	3.7	8.6
Bread and bakery products	0.0	0.0	0.0	0.0	0.0	0.0	22.3	1.7	24.0
Other	13.2		37.1	91.5		13.3	281.8	1,135.6	1,572.6
Construction	0.0		1.8	0.0		0.0	106.5	3.9	112.2
Transport	0.0	0.0	1,410.1	1,228.4	0.0	0.0	401.4	78.1	3,118.0
Aviation	0.0		336.8	0.0		0.0	0.0	0.0	336.8
Automobile	0.0		356.9	0.0		0.0	0.0	0.0	356.9
Railway	0.0		365.8	0.0		0.0	238.1	55.5	659.4
Water	0.0		350.5	0.0		0.0	0.0	0.0	350.5
Urban electric	0.0		0.0	0.0		0.0	0.8	0.0	0.8
Other transport	0.0		0.0	1,228.4		0.0	162.5	22.7	1,413.6
Agriculture	0.0		126.6	0.0		0.0	80.0	16.3	222.9
Municipal utility sector	2.2		0.1	0.4		1.8	38.9	28.2	71.7
Commercial	0.0		0.2	18.9		0.0	119.5	192.4	331.0
Residential	1.5		7.0	46.2		20.6	157.9	769.1	1,002.3

Source: Consultant's estimates

Electricity balance

The GRP and industrial electricity intensity drops by 16% and 13% respectively in 2005-2020. Therefore, electricity consumption grows more slowly, than GRP, yet nearly doubles by 2020 reaching 16.2 bln. kWh.

According to the "Projection", electricity consumption in the Oblast (excluding the oil&gas sector and distributed electricity supply) grows up in 2005-2010 by 5% to 8 bln. kWh. In 2008, electricity consumption growth is projected only at 0.7%. It is assumed, that residential sector and "other consumers" will increase consumption in 2008 by 473 mln. kWh, and industrial consumers will reduce consumption by 420 mln. kWh, or by 10%. Notably, it is in 2008 that the "Projection" predicts industrial output growth by 35%, and processing industry output growth by 43%. Obviously, the "Projection" does not adequately correlate electricity consumption growth with economic development parameters. In this scenario, electricity consumption in 2008 may grow by 10.7%, rather than by 0.7%.

By 2020, with the economic growth, electricity self-sufficiency of the Oblast drops to 63% (see Fig. 4.2).

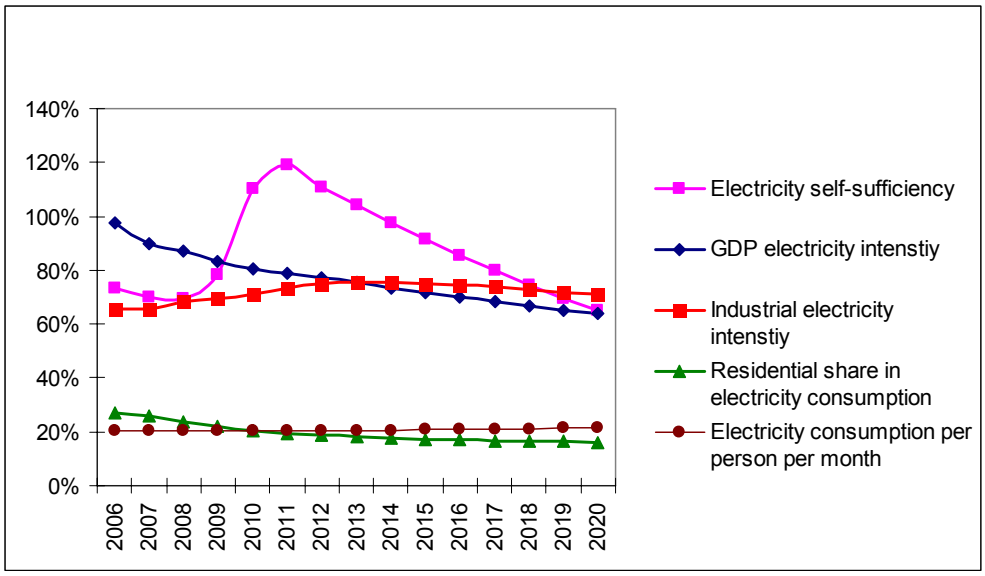


Fig. 4.2 Basic electricity consumption indicators in the "Renewed Pomorie" scenario

An attempt to completely provide itself with own electricity generation would mean for the Oblast the commissioning of significant (1,200-1,500 thou. kW) additional generation capacity, which is 60-75% of existing capacity. This would require at least 30-40 bln. rubles in investment, or 2-3 bln. rubles annually, taking no account of electricity network development (and if network development is taken into account, investment demand would probably be twice that, or 4-6 bln. rubles annually). Overall investments in the Oblast (excluding the oil & gas sector) of 39 bln. rubles in 2006, and investments in the electricity- and municipal utility services sectors of 0.6 bln. rubles. In other words, they would have to increase by order of magnitude in the very near future to address the electricity self-sufficiency problem. The Oblast's electricity sector is not prepared for such investment increase, nor can it provide fuel for this electric capacity increase.

In addition, there is no possibility to obtain such capacity or energy by existing transmission lines from the neighboring regions (Komi and Karelia republics, Vologodskaya and Kirovskaya Oblasts). If neither own generation capacity development, nor network development problems are addressed, electricity shortage may become a factor hampering economic growth of the Oblast in the "Renewed Pomorie" scenario.

Useful consumption of electricity basically grows in the industrial sector and transport, both railway and pipeline (see Fig. 4.3). Despite 65% residential consumption growth, its share in

the consumption of overall electricity supplied to the grid drops from 10.8% in 2006 to 8.7% in 2020.

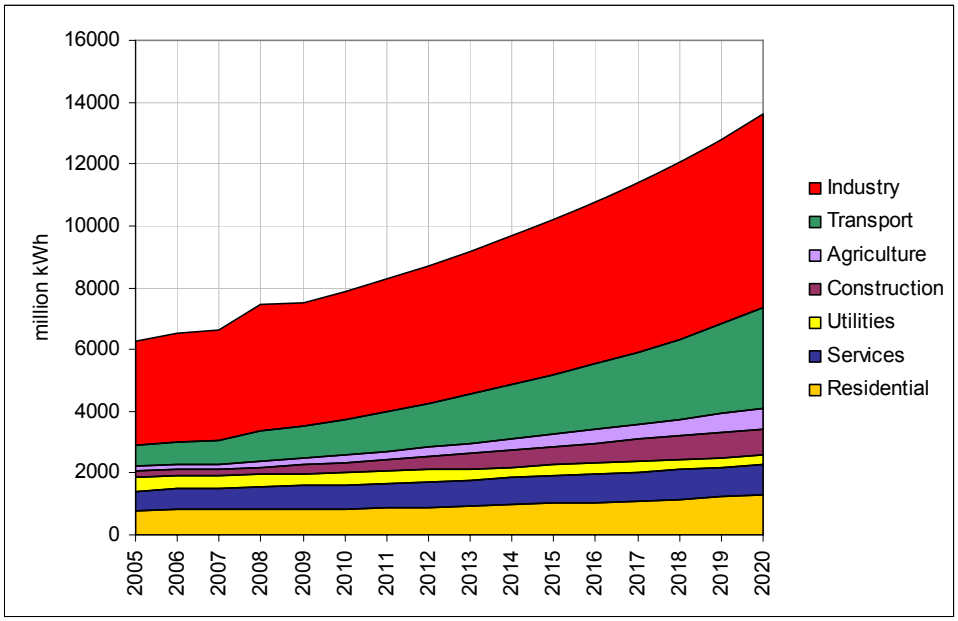


Fig. 4.3 Electricity end-use development in the "Renewed Pomorie" scenario

Table 4.3. Electricity balance by the «Renewed Pomorie» scenario (mln. kWh)

Year	Production	New plants	Existing plants	Net Import	Consumption	Growth rates	Own needs	Supply to the grid	Transmission losses	Useful supply
2005	7,112	0	7,112	938	8,050	3.2%	991	7,059	774	6,285
2006	7,200	0	7,200	1,297	8,497	5.6%	1,030	7,468	918	6,550
2007	7,230	0	7,230	1,359	8,589	1.1%	1,034	7,555	928	6,627
2008	7,310	0	7,310	2,196	9,506	10.7%	1,045	8,460	1,027	7,433
2009	7,350	0	7,350	2,241	9,591	0.9%	1,051	8,540	1,007	7,533
2010	7,497	0	7,497	2,452	9,949	3.7%	1,072	8,877	1,015	7,862
2011	7,647	0	7,647	2,760	10,407	4.6%	1,094	9,313	1,030	8,283
2012	7,800	0	7,800	3,071	10,871	4.5%	1,115	9,755	1,044	8,711
2013	7,956	0	7,956	3,403	11,359	4.5%	1,138	10,222	1,056	9,166
2014	8,115	0	8,115	3,778	11,893	4.7%	1,160	10,733	1,070	9,703
2015	9,277	1,000	8,277	3,339	12,617	6.1%	1,327	11,290	1,098	10,192
2016	9,463	1,000	8,463	3,766	13,229	4.9%	1,353	11,876	1,111	10,765
2017	9,652	1,000	8,652	4,240	13,892	5.0%	1,380	12,512	1,125	11,387
2018	9,845	1,000	8,845	4,764	14,609	5.2%	1,408	13,201	1,140	12,061
2019	10,042	1,000	9,042	5,347	15,389	5.3%	1,436	13,953	1,154	12,799
2020	10,243	1,000	9,243	5,998	16,241	5.5%	1,465	14,777	1,169	13,608

Some totals may differ from its components because of rounding.

Source: Consultant's estimates

Heat balance

Useful heat supply in this scenario only grows up by 17% (see Table 3.7). To a large degree, this is the result of heat tariff growth (see Table 3.4) determined by both growing fuel prices and increasing investment component of heat tariff, which is directed to heat supply systems renovation. The result is nearly halved GRP heat intensity in 2005-2020. The share of boiler-houses in the heat generation structure drops (see Fig. 4.4).

Table 4.4 Heat balance by the «Renewed Pomorie» scenario (thou. Gcal)

Years	Useful supply	Industry	Con-struction	Agriculture	Transport	Municipal services	Com-mercial	Resi-dential
2005	21,108	14,420	53	240	243	379	1,136	4,637
2006	21,727	14,821	47	243	251	368	1,231	4,767
2007	21,585	14,701	51	261	265	337	1,192	4,777
2008	23,658	16,672	54	288	311	333	1,252	4,748
2009	23,013	16,008	57	297	327	321	1,285	4,719
2010	23,019	16,057	59	297	348	303	1,295	4,660
2011	23,203	16,175	61	287	369	290	1,312	4,710
2012	23,364	16,283	61	270	388	277	1,317	4,767
2013	23,515	16,382	60	252	407	265	1,320	4,831
2014	23,696	16,502	57	232	426	253	1,326	4,900
2015	23,866	16,610	53	212	445	243	1,330	4,973
2016	24,038	16,717	48	192	465	232	1,333	5,050
2017	24,216	16,827	43	172	485	223	1,337	5,129
2018	24,393	16,934	38	152	505	214	1,340	5,211
2019	24,573	17,040	32	132	526	206	1,343	5,294
2020	24,757	17,148	27	114	546	198	1,345	5,379

Some totals may differ from its components because of rounding.

Source: Consultant's estimates

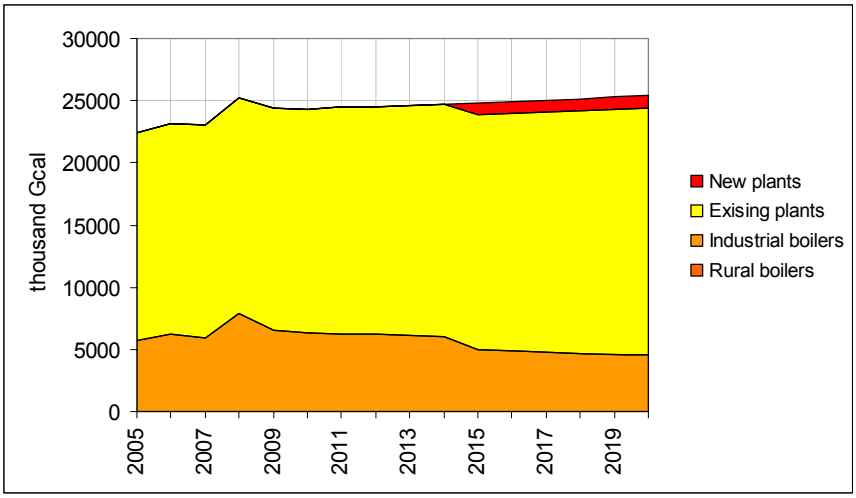
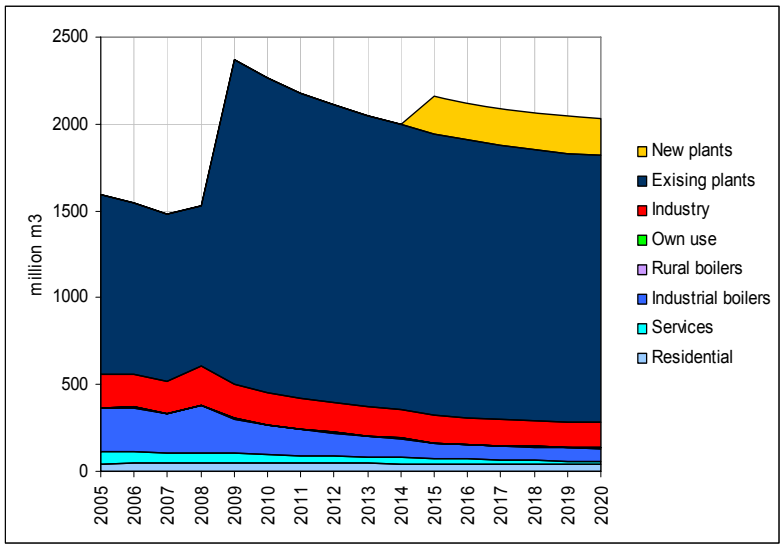


Fig. 4.4 Heat generation structure in the "Renewed Pomorie" scenario

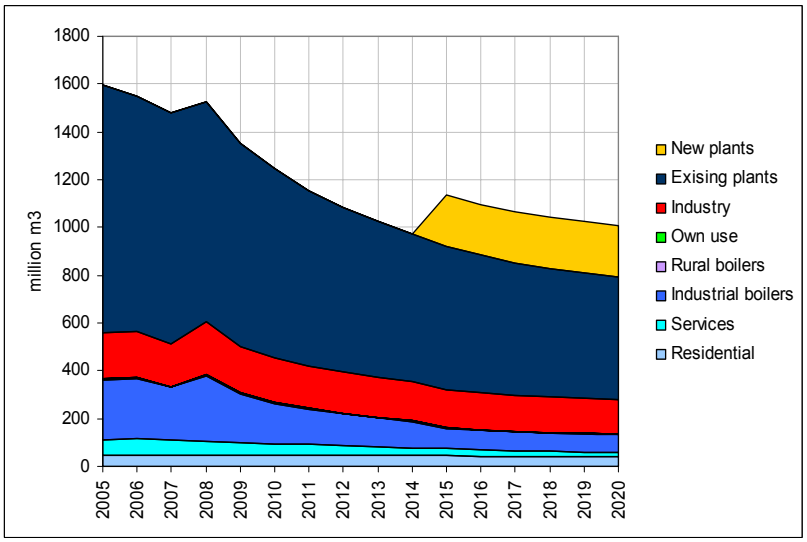
Natural Gas balance

Natural gas balance fluctuations largely depend on the implementation of the Oblast gasification plans (construction of gas pipeline Plesetsk – Arkhangelsk – Severodvinsk), fuel switching by power plants from residual oil, generation capacity development, gas price dynamics, and the strictness of environmental limitations of coal use and availability of clean coal technologies.

Under the assumptions of the "Renewed Pomorie" scenario, natural gas consumption grows in two steps: in 2009 due to the switch of Arkhangelsk cogeneration plant and Severodvinsk cogeneration plant-2 to gas, and in 2015 due to the commissioning of new cogeneration plant(s). After each increase, gas consumption somewhat declines due to the substitution of gas with cheaper fuels at other heat- and electricity sources (see Fig. 4.5). If Arkhangelsk cogeneration plant and Severodvinsk cogeneration plant-2 switch to coal, gas consumption drop will be determined by very significant price growth.



switch of Arkhangelsk cogeneration plant and Severodvinsk cogeneration plant-2 to natural gas



switch of Arkhangelsk cogeneration plant and Severodvinsk cogeneration plant-2 to coal

Fig. 4.5 Natural gas consumption variants in the "Renewed Pomorie" scenario

Table 4.5 Natural gas balance in the «Renewed Pomorie» scenario (mln. m3)

Years	Consu mption	New plants	Exis-ting plants	Boi-lers	Indust-rial boilers	Rural boiler-houses	In-dustry	Tran-sport	Com-mercial	Resi-dential
2005	2,555	0	1,036	256	253	3	192	960	67	44
2006	2,525	0	985	257	254	4	191	973	67	46
2007	2,468	0	963	225	222	3	183	986	61	47
2008	2,529	0	918	278	274	4	224	999	59	47
2009	3,386	0	1,870	205	202	4	196	1,011	55	47
2010	3,292	0	1,814	172	169	4	185	1,023	50	46
2011	3,213	0	1,756	153	149	3	177	1,034	46	45
2012	3,155	0	1,714	137	133	3	171	1,045	41	45
2013	3,103	0	1,676	124	120	3	166	1,054	37	45
2014	3,059	0	1,642	114	111	3	161	1,063	33	44
2015	3,227	214	1,622	89	86	3	158	1,069	30	44
2016	3,195	214	1,597	84	82	3	155	1,074	26	43
2017	3,167	214	1,576	81	79	3	152	1,076	24	43
2018	3,142	214	1,560	79	77	3	150	1,075	21	42
2019	3,117	214	1,546	78	76	2	148	1,070	18	41
2020	3,092	214	1,536	78	76	2	146	1,060	16	40

Some sectors with small quantities of natural gas consumption are not shown in this table.
Source: Consultant's estimates

Liquid fuel balance

After a rise in the near future, liquid fuel consumption will abruptly drop in 2009, following the fuel switch of Arkhangelsk cogeneration plant and Severodvinsk cogeneration plant-2. It will then restore by 2020 (see Fig. 4.6 and Table 4.6). The reason for this is faster growing gas prices. Besides, liquid fuel consumption by all types of transport grows too. However, until 2020, residual oil consumption keeps considerably below the 2009 level. In general, with the assumptions made, the role of liquid fuel in the IFEB will be going down.

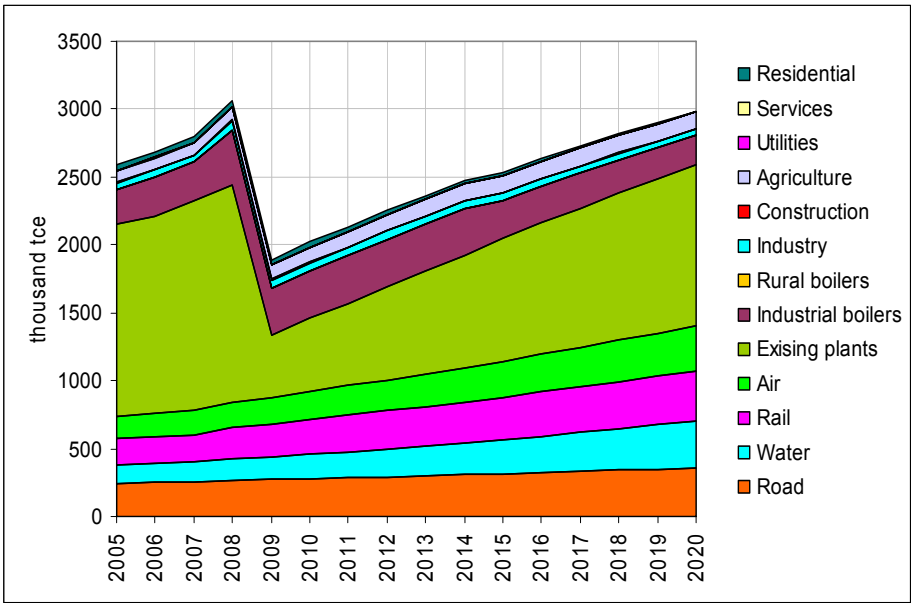


Fig. 4.6 Liquid fuel consumption dynamics in the "Renewed Pomorie" scenario

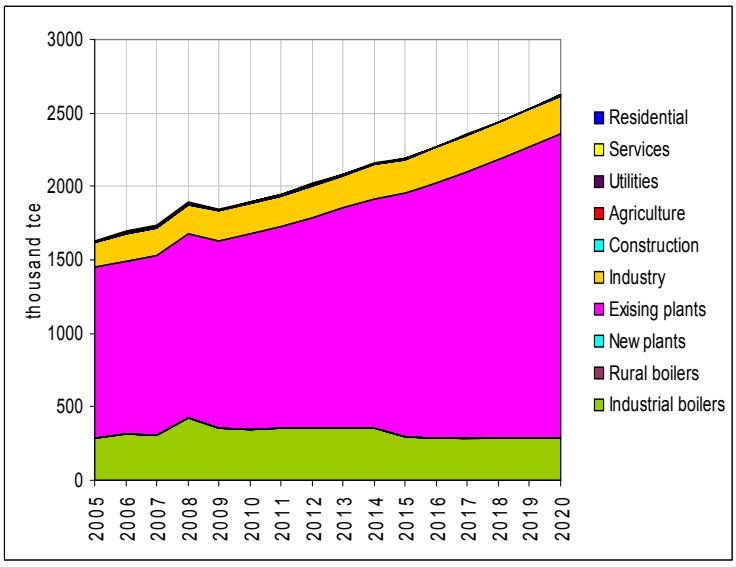
Table 4.6 Liquid fuel balance in the «Renewed Pomorie» scenario (mln. tce)

	Consump-tion	Existing plants	Boilers	Industry	Agricul-ture	Air transport	Railway transport	Cars	Water transport
2005	2,588	1,415	249	56	84	159	200	246	132
2006	2,688	1,455	288	56	82	170	196	255	137
2007	2,796	1,539	290	53	87	179	199	258	145
2008	3,059	1,600	406	69	97	188	233	266	156
2009	1,890	455	351	60	105	197	241	273	167
2010	2,022	541	351	60	112	207	255	279	178
2011	2,134	603	355	59	117	217	269	286	191
2012	2,255	682	355	58	120	228	281	293	204
2013	2,365	754	351	57	122	239	293	300	218
2014	2,472	822	346	56	124	251	304	308	234
2015	2,534	906	281	54	126	264	315	316	250
2016	2,633	969	272	52	128	277	325	324	267
2017	2,728	1,028	261	49	128	291	336	332	286
2018	2,818	1,082	249	47	129	305	346	340	306
2019	2,904	1,131	237	44	128	321	356	348	328
2020	2,986	1,175	223	42	127	337	366	357	351

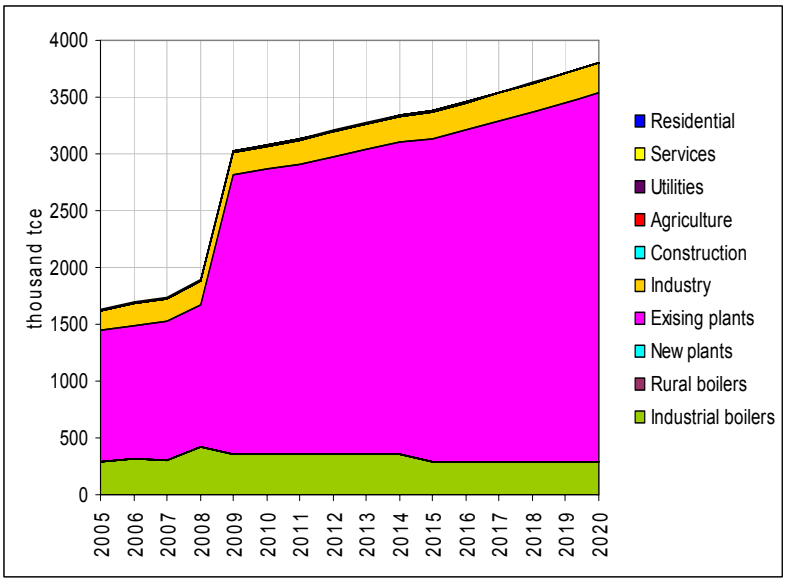
Some sectors with small quantities of liquid fuel consumption are not shown in this table.
Source: Consultant's estimates

Coal balance

With rapidly growing gas prices, coal consumption by existing plants and industrial boiler-houses will be fast increasing, even with the switch of Arkhangelsk cogeneration plant and Severodvinsk cogeneration plant-2 to gas. In this case, coal consumption will increase by 61%. If these two cogeneration plants switch to coal, coal consumption will show an even more dynamic growth (see Fig. 4.7 and Table 4.7).



switch of Arkhangelsk cogeneration plant and Severodvinsk cogeneration plant-2 to natural gas



switch of Arkhangelsk cogeneration plant and Severodvinsk cogeneration plant-2 to coal

Fig. 4.7 Coal consumption variants in the "Renewed Pomorie" scenario

Table 4.7. Coal balance in the «Renewed Pomorie» scenario (Ttce)

	Consumption	New plants	Existing plants	Boiler-houses	Industry	Municipal services	Residential
2005	1,632	0	1,161	286	167	7	10
2006	1,696	0	1,169	318	192	7	10
2007	1,733	0	1,220	308	190	6	9
2008	1,893	0	1,255	421	202	6	8
2009	1,847	0	1,273	356	205	6	8
2010	1,898	0	1,330	350	206	6	7
2011	1,949	0	1,372	352	213	6	6
2012	2,019	0	1,437	352	219	5	6
2013	2,086	0	1,500	351	225	5	5
2014	2,157	0	1,567	351	231	5	4
2015	2,193	0	1,658	291	236	4	4
2016	2,272	0	1,734	290	242	4	3
2017	2,355	0	1,813	288	247	3	3
2018	2,440	0	1,896	286	253	3	2
2019	2,530	0	1,983	285	258	3	2
2020	2,623	0	2,074	283	263	2	1

Some sectors with small quantities of coal consumption are not shown in this table.
Source: Consultant's estimates

In this case, only strict control over pollutants emissions of power plants and industrial boiler-houses will become the critical condition of preserving the favorable environmental situation in the Oblast.

4.1.4 PRACTICAL FEASIBILITY OF THE "RENEWED POMORIE" SCENARIO

From the general economic point of view, there are two problems associated with the implementation of the "Renewed Pomorie" scenario: making the Oblast attractive for investors and renovating fixed assets in practically all sectors.

Regarding the energy aspect of this scenario, the following basic risks must be highlighted:

- By 2020, primary energy self-sufficiency of the Oblast, as well as its energy security, will drop;
- By 2020, electricity self-sufficiency of the Oblast will drop to 63%, if additional generation capacities are not commissioned;

- The growth of demand for capital investment in the electricity sector and/or for electricity imports will by order of magnitude exceed both the ability of the Oblast's electric utilities to attract investment and current transmission capacity of high-voltage electric network;
- Under these circumstances, electricity shortage may become a real brake for the economic growth in the "Renewed Pomorie" scenario and will make it impossible to achieve 5-6% GRP annual growth rate;
- The industrial sector will become the economic growth driving force, but at the same time industry and transport will also become electricity demand driving force (in this scenario, electricity demand nearly doubles by 2020);
- The switch of Arkhangelsk cogeneration plant and Severodvinsk cogeneration plant-2 to natural gas will hamper liquid fuel, primarily residual oil, consumption. However, with rapidly growing gas prices, substitution of residual oil cannot but bring tangible economic effect. Moreover, consumers will be looking for larger coal use opportunities, developing additional environmental risks associated with this scenario.
- Without aggressive energy efficiency policies in all sectors, these risks may become an important factor hampering economic growth in the Oblast.

4.2 The "Sustainable development" scenario

4.2.1 THE CONCEPT

This scenario keeps all assumptions of the "Renewed Pomorie", but makes one more: with the purpose of improving the energy security of the Oblast and reducing the above development risks under the "Renewed Pomorie" scenario. It is assumed that the Oblast administration will launch several agressive Oblast-level energy efficiency programs and programs to promote renewable energy sources development, including:

- Energy efficiency program in the industrial sector;
- Electricity transmission losses reduction program;
- Energy efficiency program in the heat- and other municipal utility supply systems (electricity and water);
- Energy efficiency program in residential and public buildings;
- Renewable energy sources development program.

Arkhangelsk Oblast has already developed the basics of the institutional infrastructure to implement these programs, including Arkhangelsk Oblast Energy Efficiency Center and Energy Efficiency Fund. The Department of fuel & energy sector and housing & municipal services has experience in the implementation of an Oblast-level program "Renovation of municipal utility sector facilities of Arkhangelsk Oblast in 2007-2010" with a budget of 3.9 bln. rubles and expected savings of 90 kton of coal and 64 kton of residual oil, but with an increase of 118 mln m3 natural gas and 27 thou. m3 wood biomass consumption.

It is important to significantly activate and regulate these activities with a focus on monitoring the results of the energy efficiency and renewables development measures

4.2.2 SCENARIO CONDITIONS

These programs will result in 2.5% annual energy efficiency improvement due to accelerated commissioning of efficient equipment, materials, and management systems in all types of economic activities and in the housing stock. An assumption was made, that wind electricity generation will increase to 45 mln. kWh by 2020, and hydro electricity generation by mini-hydro plants to 5.5 mln. kWh. Another assumption is that economic motivation is provided for biomass and solid waste use by boiler-houses, power plants, and in all end-use sectors. One more assumption concerns stabilization of heat generation by existing cogeneration

plants at the level of 17,818 thou. Gcal after 2009. All the other assumptions of the "Renewed Pomorie" scenario are preserved.

4.2.3 ENERGY DEVELOPMENT UNDER THE "SUSTAINABLE DEVELOPMENT" SCENARIO

Integrated Fuel and Energy Balance

In this scenario, GRP energy intensity drops by 52%, or by 4.7% annually, both due to the growing energy prices and to accelerated commissioning of new, energy efficient equipment. Therefore, with the assumptions of this scenario, primary energy consumption in the Oblast will only increase from 8,591 Ttce in 2005 to 9,937 Ttce in 2020 (see Fig. 4.8 and Table 4.8-4.9).

Energy demand increase to ensure economic growth is reduced by 40% in the "Sustainable development" scenario! Additional energy efficiency resource at the Oblast's disposal under this scenario is 917 Ttce per annum, or 11% of overall energy consumption in 2005.

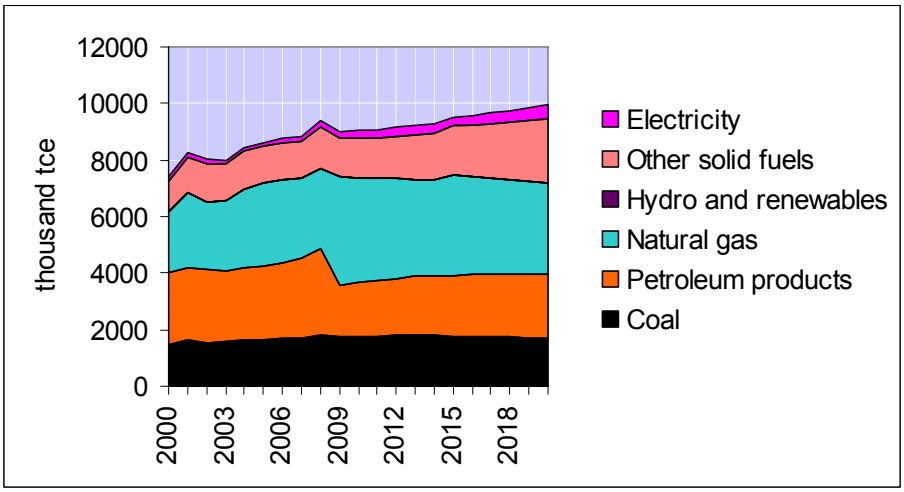


Fig. 4.8 Primary energy consumption in the "Sustainable development" scenario

Demand for new generation capacities or for electricity imports is still there, but considerably declines. The share of gas in the IFEB grows up to 33% by 2020, the share of coal goes down to 17%, the share of liquid fuels to 23%, and of other solid fuel grows up to 22.5%, as solid fuel substitutes costly fossil fuels, helping to improve energy resource self-sufficiency of the Oblast from 15% in 2005 to 22.5% in 2020, thus showing dynamics of energy security parameters absolutely opposite to the "Renewed Pomorie" scenario.

Table 4.8 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		**18,447.0**		**741.8**	**5.6**	**2,233.0**			**21,427.3**
Import	1,688.6		2,272.2	2,495.1			505.9		6,961.8
Export		-18,447					0		-1,8447
Stock changes									0
Primary energy consumption	**1,689**	**0**	**2,272**	**3,237**	**0.1**	**2,233**	**506**	**0**	**9,937**
Statistical discrepancies									
Power plants	-1,410.9	0.0	-670.6	-1,800.0	-0.1	-1,969.8	1,229.7	2,691.0	-1,930.7
Electricity generation	-724.1	0.0	-777.7	-885.6	-0.1	-349.5	1,229.7		-1,507.3
Existing plants	-724.1	0.0	-777.7	-745.6	-0.1	-289.5	1,106.7		-1,430.3
New plants	0.0	0.0	0.0	-140.0	0.0	-60.0	123.0	0.0	-77.0
Heat generation	-746.6	0.0	60.0	-934.0	0.0	-1,763.4	0.0	2,998.2	-385.7
Existing plants	-686.8	0.0	107.1	-805.9	0.0	-1,620.3	0.0	2,548.0	-457.9
New plants	0.0	0.0	0.0	-108.5	0.0	0.0	0.0	143.0	34.5
Boiler-houses	-59.7	0.0	-47.1	-19.6	0.0	-143.1	0.0	242.4	-27.1
Industrial	-59.7	0.0	-47.1	-18.6	0.0	-143.1	0.0	241.4	-27.0
Agricultural	0.0	0.0	0.0	-1.1	0.0	0.0	0.0	0.9	-0.1
Heat recovery units								64.8	64.8
Own needs							-180.2		-180.2
Distribution losses				0.0			-125.0	-137.9	-262.9
Energy end-use	**217.9**	**0.0**	**1,554.5**	**1,417.3**	**0.0**	**120.1**	**1,430.5**	**2,860.3**	**7,600.5**

Source: Consultant's estimates

Table 4.9 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	**217.9**	**0.0**	**1,554.5**	**1,417.3**	**0.0**	**120.1**	**1,430.5**	**2,860.3**	**7,600.5**
Industry	215.0	0.0	33.7	137.8	0.0	28.6	627.3	1,997.7	3,040.1
Oil and gas extraction	0.0		1.9	63.7		0.0	99.5	72.2	237.2
Harvesting and drying of wood	0.0	0.0	0.0	0.0	0.0	1.2	11.2	61.3	73.6
Pulp	0.0		0.0	0.0		0.0	133.8	723.6	857.4
Paper	0.0		0.0	0.0		0.0	19.8	98.7	118.5
Cardboard	0.0		0.0	0.0		0.0	93.8	115.6	209.5
Cement	204.3		1.7	0.0		0.0	20.2	2.6	228.8
Water raise and supply	0.0		0.0	0.0		1.9	2.6	2.5	7.1
Bread and bakery products	0.0	0.0	0.0	0.0	0.0	0.0	18.3	1.4	19.6
Other	10.7		30.1	74.1		25.4	228.3	919.9	1,288.5
Construction	0.0		1.4	0.0		0.0	87.2	3.2	91.9
Transport	0.0	0.0	1,410.1	1,228.4	0.0	0.0	401.4	78.1	3,118.0
Aviation	0.0		336.8	0.0		0.0	0.0	0.0	336.8
Automobile	0.0		356.9	0.0		0.0	0.0	0.0	356.9
Railway	0.0		365.8	0.0		0.0	238.1	55.5	659.4
Water	0.0		350.5	0.0		0.0	0.0	0.0	350.5
Urban electric	0.0		0.0	0.0		0.0	0.8	0.0	0.8
Other transport	0.0		0.0	1,228.4		0.0	162.5	22.7	1,413.6
Agriculture	0.0		103.6	0.0		0.0	65.5	13.3	182.4
Municipal utility sector	1.8		0.1	0.3		3.4	30.7	22.3	58.6
Commercial	0.0		0.2	15.4		0.0	97.6	157.2	270.4
Residential	1.1		5.4	35.3		88.1	120.8	588.4	839.1

Source: Consultant's estimates

Electricity balance

This scenario parameters and electricity self-sufficiency dynamics of the Oblast are much better. Electricity self-sufficiency still declines, but only to 73%, instead of 63% (see Fig. 3.9 and Table 3.12). Electricity consumption in this scenario grows up to 14.1 bln. kWh (versus 16.2 bln. kWh).

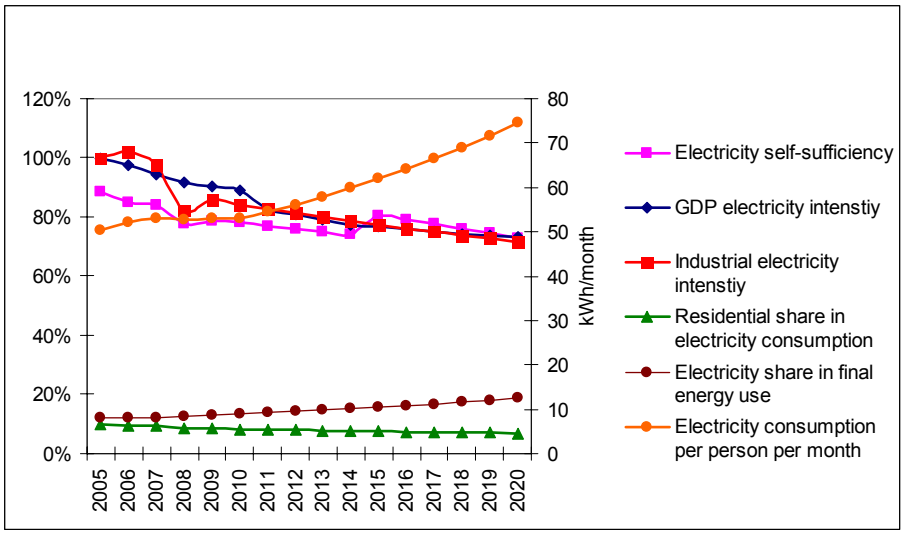


Fig. 4.9 Electricity consumption in the "Sustainable development" scenario

Table 4.10. Electricity balance by the «Sustainable development» scenario (mln. kWh)

Year	Production	New plants	Existing plants	Net Import	Consumption	Growth rates	Own needs	Supply to the grid	Transmission losses	Useful supply
2005	7,112	0	7,112	938	8,050	3.2%	991	7,059	774	6,285
2006	7,200	0	7,200	1,296	8,496	5.5%	1,030	7,466	918	6,548
2007	7,200	0	7,200	1,451	8,651	1.8%	1,030	7,621	934	6,687
2008	7,200	0	7,200	1,783	8,983	3.8%	1,030	7,953	970	6,983
2009	7,200	200	7,000	2,068	9,268	3.2%	1,030	8,238	973	7,265
2010	7,200	200	7,000	2,358	9,558	3.1%	1,030	8,528	975	7,553
2011	7,200	200	7,000	2,723	9,923	3.8%	1,030	8,893	982	7,911
2012	7,200	200	7,000	3,072	10,272	3.5%	1,030	9,242	986	8,256
2013	7,200	200	7,000	3,422	10,622	3.4%	1,030	9,592	988	8,604
2014	7,200	200	7,000	3,789	10,989	3.5%	1,030	9,960	989	8,971
2015	7,200	200	7,000	4,158	11,358	3.4%	1,030	10,328	988	9,340
2016	7,200	200	7,000	4,537	11,737	3.3%	1,030	10,707	986	9,721
2017	7,200	200	7,000	4,932	12,132	3.4%	1,030	11,102	983	10,119
2018	7,200	200	7,000	5,343	12,543	3.4%	1,030	11,514	978	10,536
2019	7,200	200	7,000	5,777	12,977	3.5%	1,030	11,948	973	10,975
2020	7,200	200	7,000	6,240	13,440	3.6%	1,030	12,410	968	11,442

Some totals may differ from components because of rounding.
Source: Consultant's estimates

Natural gas balance

Gas consumption in this scenario also grows in an undulate manner, but never gets above the "Renewed Pomorie" level (see Fig. 4.10 and Table 4.11). Most prominent gas consumption drop is seen in the industrial boilers, determined by fast growing gas prices and reducing share of industrial boilers in the heat balance.

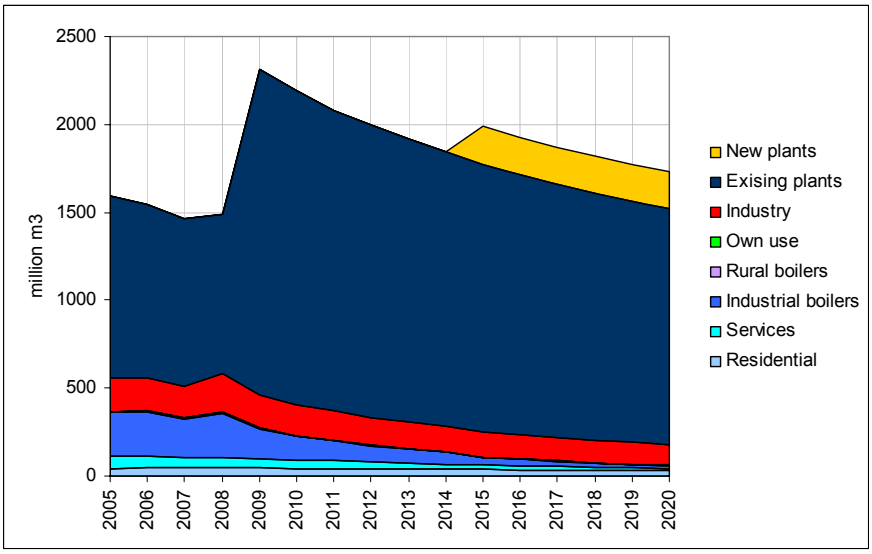


Fig. 4.10 Natural gas consumption in the "Sustainable development" scenario

Table 4.11. Natural gas balance by the «Sustainable development» scenario (mln. kWh)

Years	Consumption	New plants	Existing plants	Boilers	Industrial boilers	Rural boilers	Industry	Transport	Commercial	Residential
2005	2,555	0	1,036	256	253	3	192	960	67	44
2006	2,521	0	982	256	253	4	191	973	67	46
2007	2,458	0	956	222	219	3	183	986	61	47
2008	2,488	0	903	259	255	4	221	999	58	46
2009	3,324	0	1,846	176	173	3	190	1,011	53	45
2010	3,215	0	1,782	140	137	3	177	1,023	48	43
2011	3,118	0	1,714	116	114	3	167	1,034	43	42
2012	3,042	0	1,661	97	95	3	158	1,045	38	41
2013	2,971	0	1,609	82	79	2	151	1,054	34	40
2014	2,909	0	1,562	70	67	2	145	1,063	30	39
2015	3,057	214	1,525	45	43	2	139	1,069	26	38
2016	3,002	214	1,482	37	36	1	134	1,074	23	36
2017	2,949	214	1,442	31	30	1	130	1,076	20	35
2018	2,898	214	1,405	26	24	1	126	1,075	18	33
2019	2,846	214	1,370	21	20	1	122	1,070	15	32
2020	640	2,153	2,793	214	1,339	17	119	1,060	13	30

Some sectors with small quantities of natural gas consumption are not shown in this table.
Source: Consultant's estimates

Liquid Fuel balance

Liquid fuel consumption abruptly drops, after Arkhangelsk cogeneration plant and Severodvinsk cogeneration plant-2 switch to gas, and never grows up again (see Fig. 4.11 and Table 4.12). Residual oil is a primarily reserve fuel. Residual oil consumption growth after 2009 in the "Renewed Pomorie" scenario is substituted by other solid fuels consumption growth. Throughout the whole period until 2020, gasoline and diesel fuel consumption in the transport sector grows.

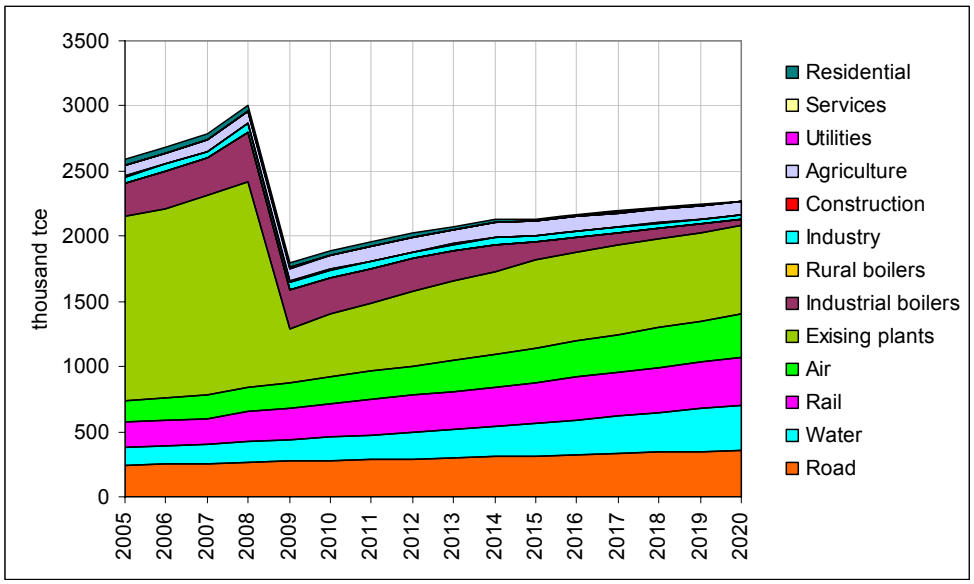


Fig. 4.11 Liquid fuel consumption in the "Sustainable development" scenario

Table 4.12 Liquid fuel balance in the "Sustainable development" scenario (mln. tce)

	Consumption	Existing plants	Boiler-houses	Industry	Agriculture	Air transport	Railway transport	Automobiles	Water transport
2005	2,588	1,415	249	56	84	159	200	246	132
2006	2,683	1,452	287	56	82	170	196	255	137
2007	2,783	1,529	287	53	87	179	199	258	145
2008	3,003	1,576	378	67	96	188	233	266	156
2009	1,794	417	300	58	102	197	241	273	167
2010	1,887	483	284	57	107	207	255	279	178
2011	1,953	519	271	56	110	217	269	286	191
2012	2,022	568	252	54	111	228	281	293	204
2013	2,077	605	231	52	111	239	293	300	218
2014	2,124	634	209	50	112	251	304	308	234
2015	2,133	670	139	47	112	264	315	316	250
2016	2,165	680	119	45	111	277	325	324	267
2017	2,194	685	98	42	110	291	336	332	286
2018	2,220	684	80	39	109	305	346	340	306
2019	2,246	679	62	37	106	321	356	348	328
2020	2,272	671	47	34	104	337	366	357	351

Some sectors with small quantities of liquid fuel consumption are not shown in this table.
Source: Consultant's estimates

Coal balance

In this scenario, coal consumption shows some growth by 2014, but then, by 2020, goes down to the 2006 level.

With rapidly growing gas prices, coal consumption by existing plants and industrial boiler-houses will be growing fast (see Fig. 4.12). This is determined by both absolute reduction of heat demand in this scenario, and by substitution of coal with other solid fuel, primarily biomass. In this scenario, the burden on the environment considerably reduces.

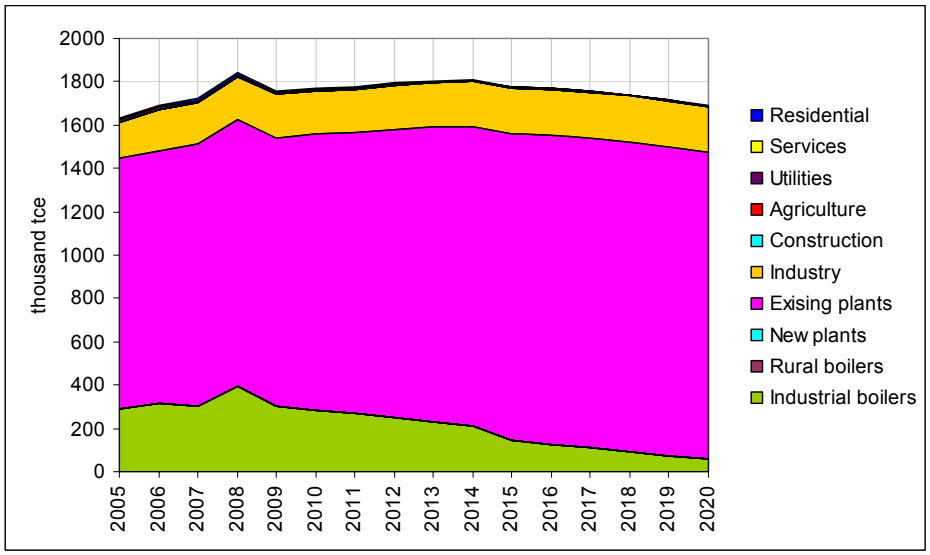


Fig. 4.12 Coal consumption in the "Sustainable development" scenario

Other solid fuels balance

Unlike in the "Renewed Pomorie", in the "Sustainable development" scenario consumption of other solid fuels does not decline, but grows (see Fig. 4.13). Primarily this growth takes place at the cogeneration plants of the pulp & paper factory, which are more and more substituting costly fossil fuels with biomass, and partially at new cogeneration plants. Solid flammable waste use is also growing in the industrial sector, while biomass use is growing in the rural areas.

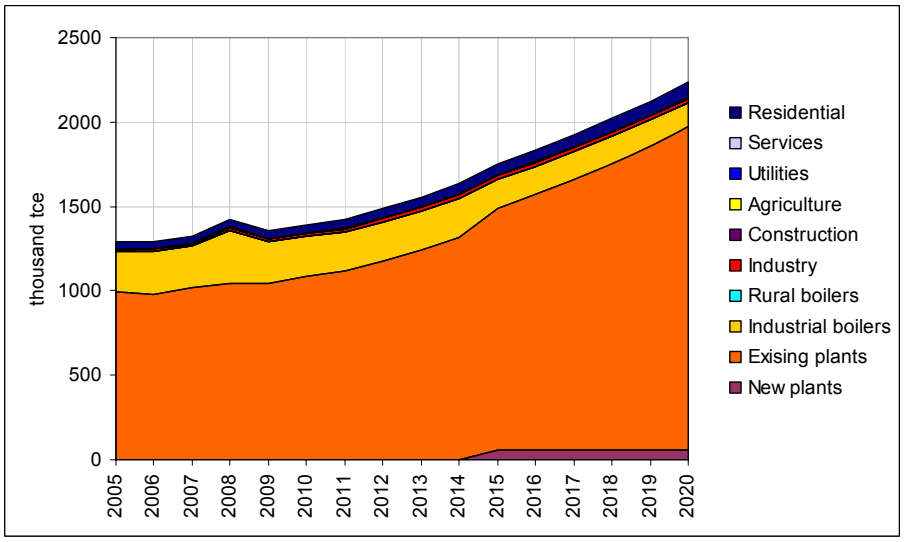


Fig. 4.13 Liquid fuel consumption in the "Sustainable development" scenario

4.3.4 PRACTICAL FEASIBILITY OF THE "SUSTAINABLE DEVELOPMENT" SCENARIO

Compared to the "Renewed Pomorie" scenario, "Sustainable development" considerably mitigates the energy risks of economic growth:

- By 2020, primary energy self-sufficiency of the Oblast does not decline, but grows;
- By 2020, electricity self-sufficiency of the Oblast goes down much more slowly;

- Investment demand for new generation capacities reduces by at least 10 bln. rubles, and with an account of transmission network development by 15-20 bln. rubles;
- Electricity sector does not hamper economic growth to 5-6% annually;
- With the switch of Arkhangelsk cogeneration plant and Severodvinsk cogeneration plant-2 to gas, residual oil consumption will significantly drop. Promoting biomass and other solid flammable waste use will also allow it to practically block coal use growth;
- The Oblast development by this scenario allows for pollutants emission reduction.

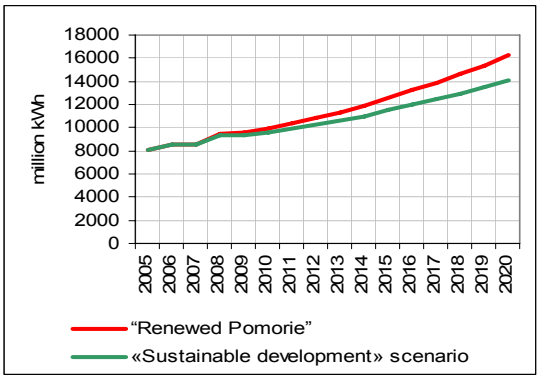
This scenario is only feasible on condition that resources will be allocated for the implementation of the Oblast-level energy efficiency programs and programs to promote renewable energy and flammable waste use. It allows for mitigation of two key risks of the Oblast's economic development until 2020:

- The risk of inability to leverage sufficient financing to develop the energy sector of the Oblast and related risk of electric capacity and gas shortage to ensure economic growth;
- The risk of significant deterioration of the environment and related decrease of the Oblast's investment and migration attractiveness.

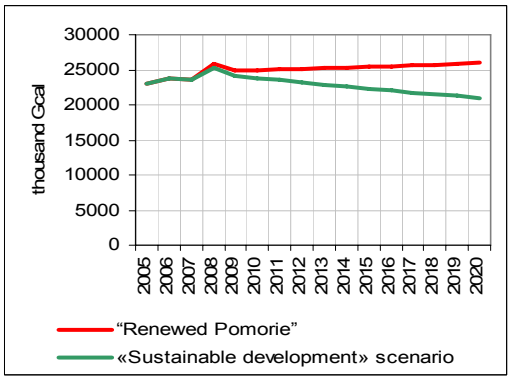
5 Conclusions and Recommendations

5.1 Conclusions

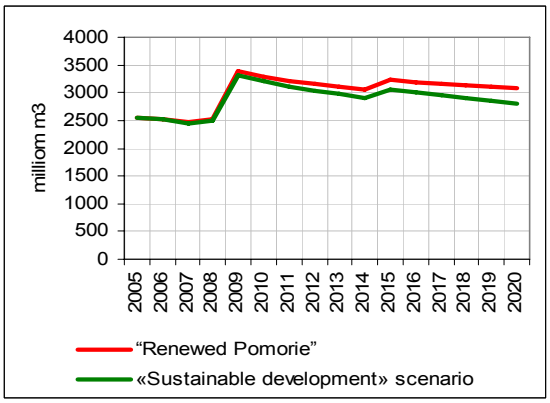
- Using a computerized model for energy demand forecasting is an excellent "planning tool" to improve macro-economic and energy policy because it allows for a thorough check on internal consistency of economic and energy policy and good insight in the policy-related driving forces, constraints and risk factors.
- The growth of capital investment demand in the electricity sector under the "Renewed Pomorie" scenario may considerably exceed the ability of the Oblast's electric utilities to attract investment.
- Electricity shortage may become a real constraint for high economic growth;
- Gradual increase in residual oil consumption by 2020 and significant growth of coal consumption will generate additional environmental risks.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.
- Implementing energy efficiency programs will lead to a 2.5% efficiency improvement in all types of economic activities and existing residential buildings.
- Given the specific situation of Arkhangelsk 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.
- The following figures show energy demand for separate energy carriers in the two considered scenarios.



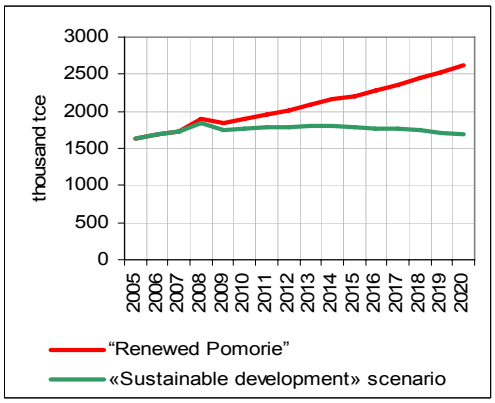
a) electricity consumption



b) district heat consumption



c) natural 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 Integrated Fuel and Energy Balance for 2005

Table A.1 Integrated Fuel and Energy Balance for 2005, Arkhangelsk region (Ttce)

	Coal	Crude oil	Petroleum products	Natural gas	Hydro and renew.	Other solid fuels	Electricity	Heat	Total
Production		17321.6		736.2		1287.1			19344.9
Import	1587.9		2587.5	2219.2			164.4		6559.0
Export		-17321.6					-36.2		-17358
Stock changes	-44.6								-45
Primary energy consumption	**1632.4**	**0.0**	**2587.5**	**2955.5**	**0.0**	**1287.1**	**128.2**		**8590.7**
Statistical discrepancies				-10.7					-10.7
Power plants	-1160.9		-1414.5	-1200.8		-996.4	874.8	2393.6	-1504.3
Electricity generation	-529.1		-747.7	-562.6		-123.8	874.8		-1088.4
Heat generation	-918.3		-915.4	-934.7		-1107.7		3299.4	-576.6
Co-generation plants	-631.83		-666.8	-638.3		-872.6		2393.6	-415.9
Boiler-houses	-286.4		-248.6	-296.4		-235.2	-12.9	819.4	-260
Industrial	-286.4		-248.6	-292.8		-235.2	-12.7	816.2	-260
Agricultural				-3.6				3.1	-0.5
Heat recovery units								86.0	86.0
Own needs							-121.9		-121.9
Distribution losses							-95.2	-281.0	-376.2
Final energy consumption	**185.0**		**924.4**	**1468.9**		**55.5**	**773.0**	**3018.4**	**6389.7**

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

Table A.2 Integrated Fuel and Energy Balance for 2005, Arkhangelsk region, Ttce (continued)

	Coal	Crude oil	Petroleum products	Natural gas	Hydro and renew.	Other solid fuels	Electricity	Heat	Total
Final energy consumption	**185.0**		**924.4**	**1468.9**		**55.5**	**773.0**	**3018.4**	**6389.7**
Industry	167.5		56.0	222.1		12.6	418.9	2062.0	2939.1
Oil and gas extraction			3.7	71.9			33.3	129.2	238.0
Harvesting and drying of wood						1.6	7.6	57.7	66.9
Pulp							143.5	994.5	1138.0
Paper							50.6	126.1	176.7
Cardboard							60.7	208.5	269.2
Cement	156		3.6				12.1	2.0	174.2
Water raise and supply							12.6	1.3	13.9
Bread and bakery products						1.9	2.8	4.8	9.5
Other	11.0		48.8	150.2		9.1	95.9	537.7	852.7
Construction			1.7				26.4	7.6	35.7
Transport			737.5	1112.4			82.8	34.8	1967.5
Aviation			159.0						159.0
Automobile			246.1						246.1
Railway			200.1				69.2	27.6	297.0
Water			132.3						132.3
Urban electric							0.8		0.8
Other transport				1112.4			12.7	7.2	1132.3
Agriculture			83.6				16.8	34.3	134.8
Municipal services	7.5		1.6	6.3		5.1	53.5	54.2	128.1
Commercial			1.3	77.1			78.7	162.5	319.6
Residential	10.1		42.7	51.0		37.9	95.8	663.1	900.6

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

For more detailed information on energy balances, see the project report "Arkhangelsk Fuel and Energy Balance" (April, 2007).

Annex 2 Input data tables for “Renewed Pomorie” scenario

Table A.3 Basic macroeconomic assumptions in the "Renewed Pomorie" 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	104.6%	1,277.4	104.7%	105.8%	113.6%	114.0%	111.0%	104.4%	108.0%	186	47,111	3,994	217,586
2008	112.9%	1,263.6	133.6%	143.2%	113.3%	113.0%	110.2%	103.1%	106.0%	204	56,500	4,274	224,114
2009	100.8%	1,249.7	92.7%	91.0%	113.5%	109.3%	109.0%	103.0%	107.0%	225	59,716	4,573	230,837
2010	104.3%	1,235.6	103.8%	104.1%	112.9%	108.8%	108.3%	102.9%	107.0%	247	64,811	4,893	237,762
2011	111.0%	1,221.3	103.5%	103.3%	116.4%	105.5%	105.4%	104.3%	106.0%	272	69,772	5,235	244,895
2012	105.9%	1,206.9	104.1%	104.1%	114.0%	103.9%	104.8%	104.5%	106.0%	299	74,453	5,602	252,242
2013	105.7%	1,192.7	104.2%	104.1%	112.3%	103.9%	104.9%	104.6%	106.0%	329	79,149	5,994	259,809
2014	105.6%	1,178.7	104.3%	104.2%	110.9%	103.8%	105.0%	104.8%	106.0%	362	83,894	6,413	267,604
2015	105.5%	1,164.8	104.3%	104.2%	109.8%	103.8%	105.1%	104.9%	106.0%	398	88,709	6,862	275,632
2016	105.4%	1,151.1	104.4%	104.3%	108.9%	103.8%	105.2%	105.0%	106.0%	438	93,611	7,343	283,901
2017	105.3%	1,137.6	104.4%	104.3%	108.1%	103.7%	105.3%	105.1%	106.0%	481	98,614	7,857	292,418
2018	105.2%	1,124.0	104.4%	104.3%	107.4%	103.6%	105.4%	105.2%	106.0%	529	103,728	8,407	301,190
2019	105.1%	1,110.6	104.4%	104.3%	106.8%	103.6%	105.5%	105.3%	106.0%	582	108,959	8,995	310,226
2020	105.0%	1,097.1	104.4%	104.3%	106.3%	103.5%	105.6%	105.4%	106.0%	641	114,313	9,625	319,533

Source: Consultant's estimates using a simplified macroeconomic model

Table A.4 Basic products output under the « Renewed Pomorie » scenario

Year	Electricity generation	Oil extraction	Gas extraction	Pulp prod.	Paper prod.	Cardboard prod.	Wood prod. And drying	Cement production	Bread prod.
	mln. kWh	kton	mln. m3	kton	kton	kton	kton		kton
2007	7,230	12,851	640	2,072	350	817	1,541	851	50
2008	7,310	13,236	640	2,092	360	825	1,618	893	51
2009	7,350	13,633	640	2,113	340	834	1,698	928	51
2010	7,497	14,042	640	2,134	340	842	1,783	950	52
2011	7,647	14,464	640	2,156	343	850	1,873	998	52
2012	7,800	14,897	640	2,177	347	859	1,966	1,047	53
2013	7,956	15,344	640	2,199	350	867	2,064	1,100	53
2014	8,115	15,805	640	2,221	354	876	2,168	1,155	54
2015	9,277	16,279	640	2,243	357	885	2,276	1,212	54
2016	9,463	16,767	640	2,266	361	894	2,390	1,273	55
2017	9,652	17,270	640	2,288	365	903	2,509	1,337	55
2018	9,845	17,788	640	2,311	368	912	2,635	1,404	56
2019	10,042	18,322	640	2,334	372	921	2,767	1,474	56
2020	10,243	18,872	640	2,358	376	930	2,905	1,547	57

Table A.5 Electric- and heat sector generation structure and efficiency under the « Renewed Pomorie » scenario

Year	Electricity generation			Heat generation			Specific fuel consumption				Efficiency		Losses		
	New plant	hydro	wind	New plant	Existing CHP	Share ind. boilers	New plant	Existing CHP	New plant (heat)	Existing plant (heat)	Ind. boilers	HOB	Electricity distribution	Heat distr.	Own needs
	mln. kWh	mln. kWh	mln. kWh	thou. Gcal	thou. Gcal	%	gce/kWh	gce/kWh	kgce/Gcal	kgce/Gcal	%	%	%		%
2007	0	0	0	0	17,075	99.6%	200.0	276.0	155.0	168.7	77.5%	85.8%	10.8%	8.5%	14.3%
2008	0	0	0	0	17,246	99.6%	200.0	276.0	155.0	168.7	77.9%	86.2%	10.8%	8.2%	14.3%
2009	0	0	1.20	0	17,818	99.6%	200.0	276.0	155.0	168.7	78.9%	86.6%	10.5%	7.9%	14.3%
2010	0	0	1.20	0	17,996	99.6%	200.0	276.0	155.0	168.7	79.9%	87.1%	10.2%	7.6%	14.3%
2011	0	0	1.20	0	18,176	99.6%	200.0	276.0	155.0	168.7	80.9%	87.5%	9.9%	7.3%	14.3%
2012	0	0	3.05	0	18,358	99.6%	200.0	276.0	155.0	168.7	81.9%	87.9%	9.6%	7.0%	14.3%
2013	0	0	4.07	0	18,542	99.6%	200.0	276.0	155.0	168.7	82.9%	88.4%	9.3%	6.7%	14.3%
2014	0	0	4.07	0	18,727	99.6%	200.0	276.0	155.0	168.7	83.9%	88.8%	9.0%	6.4%	14.3%
2015	1,000	0	4.07	1,000	18,914	99.6%	200.0	276.0	155.0	168.7	84.9%	89.2%	8.7%	6.1%	14.3%
2016	1,000	0	4.07	1,000	19,103	99.6%	200.0	276.0	155.0	168.7	85.9%	89.7%	8.4%	5.8%	14.3%
2017	1,000	0	4.07	1,000	19,294	99.6%	200.0	276.0	155.0	168.7	86.9%	90.0%	8.1%	5.5%	14.3%
2018	1,000	0	4.07	1,000	19,487	99.6%	200.0	276.0	155.0	168.7	87.9%	90.0%	7.8%	5.2%	14.3%
2019	1,000	0	4.07	1,000	19,682	99.6%	200.0	276.0	155.0	168.7	88.9%	90.0%	7.5%	4.9%	14.3%
2020	1,000	0	5.05	1,000	19,879	99.6%	200.0	276.0	155.0	168.7	89.9%	90.0%	7.2%	4.6%	14.3%

Table A.6 Energy prices under the « Renewed Pomorie » scenario

Year	Electricity					Gas		Heat		Gasoline	Diesel fuel	Residual oil	Coal	Wood
	Indus-try	Transport	Agriculture	Other	Residen-tial	Industry	Residen-tial	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	2.00	1.56	2.00	2.00	1.63	1,566	1,203	640	640	24,098	18,736	5,217	1,168	234
2008	2.33	1.82	2.33	2.33	1.90	1,958	1,504	752	752	25,062	19,485	5,425	1,215	243
2009	2.68	2.09	2.68	2.68	2.18	2,500	1,921	898	898	26,064	20,264	5,642	1,263	253
2010	3.06	2.39	3.06	3.06	2.49	3,193	2,453	1,072	1,072	27,107	21,075	5,868	1,314	263
2011	3.21	2.50	3.21	3.21	2.61	3,384	2,600	1,117	1,117	28,191	21,918	6,103	1,366	273
2012	3.37	2.63	3.37	3.37	2.74	3,587	2,756	1,163	1,163	29,319	22,795	6,347	1,421	284
2013	3.54	2.76	3.54	3.54	2.88	3,803	2,921	1,212	1,212	30,491	23,707	6,601	1,478	296
2014	3.72	2.90	3.72	3.72	3.02	4,031	3,097	1,263	1,263	31,711	24,655	6,865	1,537	307
2015	3.90	3.04	3.90	3.90	3.17	4,273	3,282	1,316	1,316	32,980	25,641	7,139	1,598	320
2016	4.10	3.20	4.10	4.10	3.33	4,529	3,479	1,372	1,372	34,299	26,667	7,425	1,662	332
2017	4.30	3.36	4.30	4.30	3.50	4,801	3,688	1,429	1,429	35,671	27,733	7,722	1,729	346
2018	4.52	3.52	4.52	4.52	3.67	5,089	3,909	1,489	1,489	37,098	28,843	8,031	1,798	360
2019	4.74	3.70	4.74	4.74	3.86	5,394	4,144	1,552	1,552	38,581	29,996	8,352	1,870	374
2020	4.98	3.89	4.98	4.98	4.05	5,718	4,393	1,617	1,617	40,125	31,196	8,686	1,945	389