Russia

National Human Development Report in the Russian Federation 2009

Energy Sector and Sustainable Development

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UNDP Russia

National Human Development Report
in the Russian Federation
2009

Energy Sector and Sustainable Development

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The 2009 National Human Development Report (NHDR) for the Russian Federation has been prepared by a team of Russian experts and consultants. The analysis and policy recommendations in this Report do not necessarily reflect the views of the UN systems and other institutions by which the experts and consultants are employed.

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Readers are invited to inspect the latest Human Development Report for the Russian Federation. National reports such as this are published on the initiative of the United Nations Development Programme (UNDP) in many countries of the world. Global reports are also brought out annually. The reports are compiled by teams of independent experts.
The 13th Human Development Report for the Russian Federation assesses impact of the energy sector on the country's economy and human development. The global economic crisis has brought many problems, but it also offers a window of opportunity for Russia to transform its energy sector, which evolved in its present form during the late 20th century, into a modern, high-tech vanguard for the national economy in the 21st century, with due respect for the environment and human health. Issues, which are the traditional subject matter of human development reports – economic development, income levels, employment, education and health care – are discussed in the context of the energy theme.
The Report is intended for top managers, political scientists, scientific researchers, teachers and high school students.

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The authors also thank the Federal State Statistics Service (also called 'Rosstat') for data provided for the Report, as well as the participants of Public Hearings on the Report draft for their constructive comments.

Address to readers

The 2009 National Human Development Report (NHDP) for the Russian Federation, entitled 'Energy Sector and Sustainable Development', outlines issues associated with a prime concern in Russia today, which is development of the fuel & energy sector. The authors provide a detailed analysis of the situation, make forecasts and study the options for overcoming current negative trends in supply and consumption of energy resources.

The energy sector currently supports all other parts of the Russian economy, consolidates constituent entities of the Russian Federation and has major impact on formation of the country's main social and economic indicators. In order for the sector to develop, meet modern challenges and provide sustainable development of the country's economy, the government is conducting a policy that aims to maximize the efficiency of energy resource utilization and the potential of the energy segment.

Energy preparedness and environmental safety, as well as energy and budget efficiency are the cornerstones of long-term government energy policy. A key condition for achieving them is formation of an adequate, modern regulatory system, which could provide stability, as well as a proper legal environment and dynamic development of both the energy market and the fuel & energy sector.

Despite different approaches of various nations to the future of the world energy industry the international community, headed by the G8, has worked out an effective mechanism for resolving these complex issues through discussion. Its principles were clearly defined in the G8 St.Petersburg Declaration: diversification of energy transportation routes, increase of energy efficiency, market transparency, development of renewable energy sources and creation of national management institutions for energy efficiency.

An important step will be change of Russia's technical control legislation in order to increase energy efficiency and environmental safety of such industries as power generation, construction, transportation, and housing utilities. Power efficiency indicators will become mandatory requirements of the new technical control system.

Utilization of existing technical and structural potential for improved energy efficiency will enable greater balance between production and utilization of energy resources and significantly reduce greenhouse gas emissions without compromising high rates of economic growth. These goals will require creation of adequate incentive mechanisms to promote energy efficiency among power vendors and consumers.

I am absolutely convinced that the 2009 National Human Development Report for the Russian Federation will be of interest and help to a wide variety of politicians and officials, scientists and journalists, as well as to all those who are concerned about the development of Russia's energy industry.

Sergey I. Shmatko
Minister of Energy
of the Russian Federation

Dear Reader,

You have before you the 13th National Human Development Report for the Russian Federation, published by the United Nations Development Programme. The topic of this year's Report, *'Energy Sector and Sustainable Development'*, is of special interest today both in the context of Russia's development and of international development. Promoting innovative evolution of the energy sector and raising energy efficiency of the national economy represent major challenges for Russia. At the same time, the structure of the global energy sector is a focus of debate for the international community, and impact of the sector on the environment is of great concern to the United Nations.

As a major part of the Russian economy, the energy sector has large impact, both direct and indirect, on human life and determines to some extent the structure of economic development in the country. The sector is an important source of national incomes, affecting the health and well-being of people who may not be directly involved in energy business. In many regions and cities, energy firms determine the environment for self-realization by local people, professional training, employment and small business development. This pivotal role of the energy industry in Russia is the main topic of this Report.

The authors set out to analyze current impact of this backbone industry of the Russian economy on human development. One of the challenges we encountered during preparation of the Report is a tendency to view the energy industry and related issues in a purely technical light. Discussions about energy sector development tend to be limited to production and transportation of fuel and power, sectoral cash flow, industrial safety and environmental impacts, while impact of the sector on Russia's human development is left unconsidered.

Assessments given by the authors in this Report are not uncontroversial, because positive steps – whether increasing profits for national and regional economies, or developing new science and technology in the energy sector – are associated with a number of equally negative impacts, related to public health, pressure on the environment, and disincentives to development of energy-saving technologies.

Russia is a major player on the global energy market and a global energy donor, and still has to find the optimum combination of energy preparedness and environmental sustainability. We saw it as a matter of principle to study Russia's long-term challenges from the point of view of these interrelated, but potentially conflictual positions. Our report contains some very interesting conclusions about the role of the energy sector in Russia's economic and human development, and prospects for the country's sustainable development, as well as related risks.

I would like to express my sincere gratitude to the Ministry of Foreign Affairs of the Russian Federation, which has been our national partner in preparing National Human Development Reports for over a decade. UNDP activities in promoting the human development concept have also found the Ministry's support with respect to development of training programs and regional reports. I hope that this report will serve as a basis for discussion of key issues of post-crisis development and for deeper understanding of the energy sector's role in Russia's social and economic development, especially in its human development aspect.

Frode Mauring
UNDP Resident Representative

CONTENT

PREFACE

This is the 13th National Human Development Report for the Russian Federation. Such reports, covering human development issues in various countries, are elaborated by groups of independent experts and are published on the initiative of the United Nations Development Programme (UNDP) in many countries of the world.

The 2009 National Human Development Report for Russia remains true to the concept of previous national reports, prepared by various independent groups of Russian experts with assistance and support from the UNDP Representative Office in Moscow. Like its predecessors, the 2009 Report is not a mere accounting of the country's social and economic progress in the past year, but a thorough scientific and analytical case study.

The focal point of this 2009 National Human Development Report is the energy sector and sustainable development. Russia is rich in both energy resources and human resources, and the Report analyzes impact of the energy sector on national development and on the individuals who live in Russia. The sector makes a vital contribution to the country's main social and economic parameters, and is of vital importance for national income and the budget. In this respect, the global crisis has demonstrated the fragility of the economic growth, which Russia had enjoyed since the early 2000s. The national economy is still marked by structural disproportions, and dominance of the export-oriented fuel & energy sector is the most obvious of them. The Report shows the need for a change of direction towards the goal of energy efficiency, ending the country's addiction to raw material exports in favor of sustainable development, reduction of negative impact of the power segment on human health and the environment, and broad use of power-saving technologies. The current crisis can be seen as a window of opportunity for Russia to find and implement new approaches to national development, and to transform its existing energy sector into a high-tech asset for the 21st century, which no longer represents a burden on the environment and public health.

The authors have mostly used official Russian statistical data provided by the Federal State Statistics Service, ministries and agencies. When several sources were available official data was preferred. Information taken from other sources is accompanied by relevant references. Public survey data were also used in some instances.

The Report was prepared in close cooperation and with active feedback from state institutions and civil society.

Chapter 1: **The Energy Sector, the Economy, and the Crisis** surveys the impact of Russia's energy sector on the country's social, economic and human development. The world crisis, which entered its acute phase in the fall of 2008, has shown that Russia's economic recovery of the early 2000s was very fragile. The country's economy still has clear structural disproportions, most obviously domination of the economy by the export-oriented fuel & energy sector. The state budget, investments, and foreign trade are all strongly dependent on the situation on world energy markets. Dominance of energy-resource export in the national economy not only makes it vulnerable to global shocks, but shackles its long-term economic growth potential. Factors often grouped together under the heading of the 'resource curse', including Dutch Disease and problems associated with resource rent, can suppress motivation for investments in human development and its effective utilization by the state, private business and ordinary people.

Energy intensity of Russia's GDP was much lower in the economic rise of the 2000s compared with the early 1990s, and there has been sustained progress towards greater energy efficiency, although dependence of the national economy and budget incomes on energy exports has increased. However, overall energy efficiency in Russia remains low compared not only with developed countries, but also with developing countries. This situation dilutes relative advantages of the Russian economy in the energy sector, creating obstacles and postponing human development. Low energy efficiency and dominance of traditional energy carriers also leads to environmental impacts, creating public health hazards.

There is a consensus among Russian elites that sustainable development of Russia's economy can no longer be provided by extensive development of energy resources. The energy sector itself has shown worrying tendencies in the past two decades, notably a constantly shrinking ratio of proven oil & gas reserves to production volumes.

A goal-oriented government programme together with other changes, including some brought on by the international crisis, could change the trajectory of the national economy and open the way for alternative scenarios, which would prevent loss of human potential and help to achieve sustainable growth.

Fuel & energy specialization of the economies of some Russian regions in the 1990s served as a 'safety cushion' in a context of overall economic decline, but, with rare exceptions, did not become a factor of fast and sustainable economic development in those regions in the 2000s. These problems are analyzed in Chapter 2: **Energy Industry and the Regions: Human Development Challenges**. Fuel & energy regions remain the main donors to the national budget: the two autonomous districts of Tyumen Region provide 29% of all taxes received by the federal budget (the city of Moscow gives the same amount). These two districts, with the highest oil & gas reserves in Russia and, consequently, high personal and budget incomes, stand out by their success in increasing life expectancy, reducing infant mortality and improving their vocational education system. But high profits cannot cope with illnesses that depend on the state of society: social environment and lifestyles need to be improved. Most fuel & energy regions cannot spend significantly more on social programmes than regions, which lack fuel & energy resources, but which obtain large-scale financial aid from the federal budget. So specialization in fuel production does not give major advantages in social development.

Decline of industrial output, caused by the world crisis, has been less marked in fuel & energy regions than in other regions, but it has not been possible to avoid social impacts: budget incomes have fallen and half of the country's fuel & energy regions report a dramatic increase in unemployment. The crisis has demonstrated again that the existing relationship between the federal center and the regions lacks sustainability and fails to stimulate institutional modernization of fuel & energy territories.

The Chapter also offers analysis of the Human Development Index (HDI). In 2007 over one quarter of Russia's regions (22 out of 80) were rated as 'developed' by the HDI. The threshold for this group is 0.800. In 2006 Russia had almost twice fewer developed regions (12 in total). The improvement reflects growth of the income index. Nearly half of the developed regions are specialized in extraction of fuel & energy resources (more than half if regions specializing in processing of these resources are included). Consideration of the population chart for high HDI regions makes the progress more vivid: in 2007 one third of Russia's people lived in regions with high HDI, while only a year before only a quarter lived in such regions. In general, 2007 was very successful for Russia from the point of view of human development, but it should be remembered that the main factor in this success was income growth, which relied excessively on international market prices for oil and metals.

Chapter 3: **Personal Incomes, the Energy Sector and the Crisis** points out that progress of personal incomes and employment determine the vector of human development change in the aftermath of the crisis. Personal incomes in Russia on the eve of the crisis were 1.3 times higher than in the last years of the Soviet period. But development of the Russian market economy had created incomes from business and real estate, which came to represent a significant part of personal incomes, and these were the incomes, which suffered most from onset of the crisis. The chronic nature of the crisis became evident in early 2009 and the Russian labor market began to react in its traditional fashion: salaries shrank faster than employment rates.

Energy-related business has traditionally been highly paid and not very labor intensive. Employment and wages in different energy industries reacted differently to the crisis: the effect was serious in the oil segment, but much less serious in other energy industries. The overall energy sector reported smaller reduction of employment and payroll indicators compared with the national economy as a whole. The energy sector has relatively low intra-industrial payroll differentiation, and cannot be a source of personal income inequality due to its small number of employees.

The main impact of energy sector developments on living standards of ordinary people is via housing utilities. The share of expenditures on housing utilities in Russian household budgets is small compared with other countries. There are two main reasons for this: inadequate technical and institutional state of the housing utility segment in Russia, which entails low-quality services; and high differentiation of household expenditures on utilities, which means that significant tariff increase would force most Russian households to seek social assistance (subsidies) or become non-payers.

Rising living standards, popularization of high-tech living habits, as well as growing housing construction during the period of economic growth have resulted in increasing energy consumption by the public. These trends will continue, entailing further increase of the household share in overall energy consumption.

Chapter 4: **The Energy Sector and Public Health** points out that environmental pollution caused by the energy segment is a serious health hazard. Development of the energy segment should take account both of existing environmental conditions in various regions and new environmental requirements issued by international authorities. Many polluting fuel refineries and energy plants are located in population centers and some are in territories rated as environmental emergency areas. More efficient combustion of coal and reduction of its negative impact on the environment and public health are increasingly urgent priorities. The resurgence of coal as a power generating fuel needs to be accompanied by introduction of new, environmentally safe technologies.

The fuel & energy sector is one of the main sources of atmospheric emissions. Atmospheric pollution causes up to 40,000 deaths annually among urban populations, of which no less than 15-20% are the responsibility of the fuel & energy sector. The share is higher in some settlements with polluting coal-fired condensing power plants (CPPs) or combined heat & electricity plants (CHPs). Reduction of negative impact from all segments of the energy sector (extraction, transportation, refining, and production of heat and electric energy), requires implementation of modern technologies which are already widely used in developed countries.

Any substantial administrative decisions regarding expansion of the fuel & energy sector should in any case include health hazard assessments and action plans to reduce risk to an acceptable level. Environmentally unsound decisions on construction and/or expansion of sector facilities could further aggravate living conditions and public health.

Chapter 5: **Energy-efficient Russia**, defines Russia's energy efficiency ratings, presents the risks, which continuous energy-intensive development poses for human development and the economy, and substantiates the need to build an energy-efficient society, leading Russia's economy away from its resource-oriented development trajectory, which is turning the country into a resource appendage of the 'green' world economy, onto the road of sustainable development based on wide implementation of clean, energy-efficient technologies. Russia has reduced energy intensity of its GDP faster than most other countries, but still remains one of the most energy-inefficient countries in the world, since the reductions were mainly due to structural changes and the country has failed to narrow its technological gap with developed countries. Increasing global competition and shrinking scope for development based on raw material exports make dramatic increase in productivity, including energy productivity, vitally important for Russia's aspirations to match living standards in developed countries.

Russia's potential for increasing energy efficiency is among the biggest in the world, representing almost half of the country's present energy consumption. This resource could become the main contribution of the energy sector to future economic growth. However, there has been little progress in making use of this resource until recently, largely due to lack of support from the federal government for energy efficiency.

The Chapter contains analysis of energy saving potential and ways of realizing it in main sectors of the national economy: housing, industrial production, energy, transportation, and heat supply.

Chapter 6: **Opportunities for Renewable Energy Sources** looks at renewable energy sources ('renewables'), which are now viewed as one of the main vectors for long-term innovative development of the energy sector. The global boom in renewable technologies reflects the desire of countries to reduce pressure on the environment, but also their need to optimize structure of energy balances, cut dependence on exports or imports of fossil fuel, and start preparing for the new, low-carbon, stage of human and changeover to low-carbon economies.

Increased use of renewable technologies in Russia could create more jobs, improve living standards, and reduce migration of rural populations and outflow of people from northern and eastern territories. Development of renewable energy slows down environmental degradation and enhances public health and well-being.

Russia is now only in the first stages of developing a strong renewable energy industry. The business community has shown growing interest and much has been done in terms of legislation for development of renewables. But to date these efforts lack coordination and have met with a number of problems and controversies, including: lack of specific mechanisms for government support of renewables development, lack of public awareness, lack of professional staff, etc.

Increased use of renewables for production of heat and electric energy could promote development of Russia's high-tech machine-building sector and creation of new jobs in Russian regions. Public support should be the determining factor in promoting development of renewable energy resources.

Chapter 7: **The Energy Industry and Environmental Sustainability** deals with environmental impact of the oil & gas, coal and pipeline transportation industries (in comparison with other segments), looking at atmospheric emissions, waste water discharge, solid waste, land disturbance, and pipeline leakages, and giving an analysis of the impact of all these hazards on various ecosystems. The chapter assesses the extent to which high energy intensity of housing utilities can be blamed on Russia's cold climate. Falling investment efficiency of the extraction industries in terms of time and volumes produced reflects increasingly difficult extraction conditions.

Environmental impacts of over-development of the fuel & energy sector are studied along with other social and economic consequences. Russia's current situation deserves to be called 'energy and environmental malaise'. The country is currently a global environmental donor, because overall impact of Russia's economy on the environment is significantly less than useful input of Russia's ecosystems to global environmental stability. But Russia could lose this status if negative environmental impact from the fuel & energy sector increases.

The chapter offers examples of unsatisfactory environmental outcomes and the reasons for them, which also indicate ways of remedying the situation. Measures to achieve energy savings, increase energy efficiency of the economy, and protect the environment should be applied at all levels of the economy. Priorities at the national level are to change sectoral structure of the economy and support development of non energy-intensive industries.

Chapter 8: **The Energy Industry and Sustainable Development Indicators** looks at how the energy factor can be taken into account by sustainability indexes. The global economic crisis has highlighted the need to correct traditional development indexes. Macroeconomic indicators often ignore or distort actual economic, social and environmental processes. There are two main approaches to measuring sustainability: construction of an integral (aggregate) indicator (index); and development of a system of indexes, each of which presents a specific sustainability aspect.

The energy factor is widely reflected in sustainable development indexes. There are currently a number of indexes and corresponding systems, which were developed and are widely used by international organizations (United Nations, World Bank, European Community etc.) and by some countries. Energy intensity remains the key factor in all these approaches. For Russia energy intensity is the key factor for sustainable development of the country as a whole and the energy sector in particular. So it can act as a highly telling indicator of the country's development prospects.

The Adjusted Net Savings Index is very a useful tool for taking account of the energy factor, since it has a solid statistical base and can be used for calculations at national and regional level. Adjusted net savings include a wider range of human development assessments, and energy and environmental factors compared with traditional macroeconomic indexes. In particular, they take account of depletion of natural resources, which, in Russia's case, leads to an overall negative net value for the Adjusted Net Savings Index, even for the period since 2000, when GDP was growing.

The Chapter also describes experience and potential for adapting and applying energy indicators at national and regional levels. Such indicators need to be included in Russian state statistics at regional and national level, so that they can be more widely used in decision-making processes.

Chapter 1 The Energy Sector, the Economy and the Crisis

1.1. The energy sector and human development

Human development is only possible if energy needs are met to a sufficient extent. So the acute problems, which the international energy industry is facing today, must be of concern to the global community. Russia has a special role to play in this context, because it has both enormous human potential and vast energy resources. The country's comparative wealth in natural resources has made it one of the world's leading suppliers of energy. This role also has specific impact on human development trends inside Russia.

It is a characteristic feature of the world energy system at its current stage of development that centers of production and consumption do not coincide geographically. Formation of energy markets in the 20th century both at the level of macro-regions and on a global level played an important role in the economic growth of developed countries and of some developing countries. The formation of global markets greatly reduced the limitations, which developed countries would face, if they had to meet their huge energy requirements from their own resources.

Functioning of energy markets might cause a move towards an optimum in terms of a global economic equilibrium, but this has led to a number of externalities, which have complex and often unforeseen implications for sustainable development of the world economy and for human development.

Firstly, disproportions in global energy consumption promote global inequality. At the beginning of the third millennium developed countries produce less than one third of the world's primary energy, while consuming almost half of it. In 1991–2008 average per capita consumption of primary energy in OECD countries was three times higher than the world average, and that gap had widened in comparison with the preceding two decades.

The economies of power supplying countries are accordingly becoming more and more specialized in the world division of labor. Experience shows that such orientation slows down diversification of national economies and can lead to a slowdown of economic growth in the long run. The mechanisms of this 'paradox of abundance' or 'resource curse' are described further on, and they can have impact on human development by reducing motivation for investments in human resources, raising social tension, and holding back real growth of personal incomes.

Secondly, there are even more serious imbalances in production and consumption of hydrocarbons. The problem of energy poverty is not being dealt with quickly enough. Supply of energy (fuels and energy infrastructure) to low-income countries remains unsatisfactory, stalling industrial development and therefore hindering growth of real personal incomes. Africa remains a net exporter of energy resources even though per capita energy consumption on the continent is extremely low (three times lower than the world average). Lack of available energy reduces the quality and quantity of collective goods, including education and health care.

Thirdly, existence of low-cost energy resources (compared with alternative energy technologies), which do not carry additional costs associated with environmental and health hazards, postpones technology breakthroughs in the world energy industry, as was seen in 1986–2002. This preserves the socially non-optimal structure of energy consumption and, as a consequence, non-optimum production and consumption of goods and services. Scientific progress and its commercial application to energy saving are slowed down as a result.

Fourthly, both exporters and importers of energy face large-scale problems associated with energy security. Fuel importing countries depend on supplies from regions of the world, which sometimes lack political stability. Delivery routes become longer. Large-scale energy price deviations create serious problems for exporters (for their sustainability, well-being and investments). These factors create a threat of temporary external shocks for developed countries, as seen at the start of the 1970s, while developing countries face serious burdens on their balance of payments, driving up levels of national debt. The theory of market economics portrays this as natural utilization of comparative advantages, which is neither threatening nor unjust. But it adds to systemic risk in the world economy, for example by threatening energy imbalance if supplier countries do not obtain sufficient investments to support required levels of energy production. Because it has a fundamental (not occasional) nature, this phenomenon can lead not only to temporary drops in world GDP, but to long-term negative consequences for human development in the social and environmental spheres.

These are the main problems, which are usually highlighted when considering the present state of the world energy sector from the viewpoint of human development. They are relevant to Russia too, but with specific qualifications.

1.2. Russia's energy industry in conditions of global economic growth and crisis

The Russian economy had not begun broad modernization before onset of the global recession in the middle of 2008. Recovery of GDP to 1989 levels by 2007 was largely based on oil rent, so it is unsurprising that the crisis pulled Russia's GDP down by 8% in 2009. In the years of economic growth (1999–2008) dependence on export of hydrocarbons increased, and this was particularly true of the country's budget. The dependence reflected depth of the transition crisis, which brought 43% decline of the country's old-fashioned (Soviet-vintage) GDP, and a large measure of deindustrialization. Energy and semi-products (with a large part of energy in their value) became crucial for the country's industry and exports.

The role of Russia's energy industry (designed for the needs of the old Soviet bloc) in the world economy today tends to be underestimated. Russia produces about 11.5% of the world's primary energy, which is five times more than its share of world population or GDP. So the country should spend five times more of its GDP than other countries on maintenance and development of its fuel & energy industry. In fact, the overall investment ratio in Russian economy in 1999–2006 was about 17% of GDP, which is much lower than the world average (20-24%), and even in 2007–2008 the ratio only reached 21% of GDP with investments in the fuel and energy sector representing 4.5 percentage points out of the total. The country invested much less than its neighbors and rivals in world competition in human capital, the processing industries, and rehabilitation of infrastructure created in the 1960s–1980s.

Rapid growth of the world economy in the 2000s caused demand for power to skyrocket. Developing countries, whose economies are relatively energy inefficient, made a particularly large contribution to growth (Figure 1.1). Half of the world's increase in consumption of primary energy and about 40% of increase in oil consumption in 2001–2008 were due to China's fast-growing economy, which is more energy intensive than economies of developed countries. Measured by purchasing power parity (PPP), US GDP outran that of China by two times in 2008 (20.6% vs. 11.4% of world GDP), while the difference in energy consumption was only 15%.

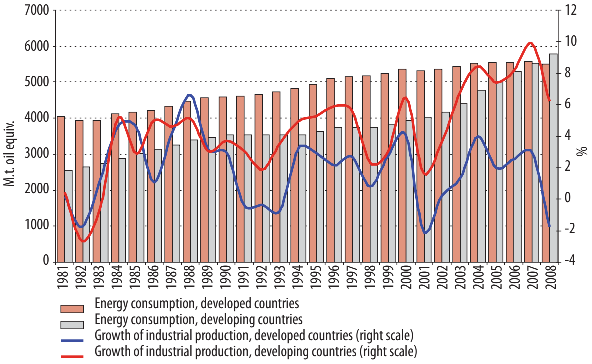
Growing demand for energy and the resulting energy price boom significantly increased income of countries specializing in energy exports, enhancing their economic and political status. This was particularly true for Russia, which accounted for nearly half of world increase in oil production in the first half of the 2000s, becoming one of the resource mainstays of global economic growth during the period. If, at the beginning of the decade, Russia had not been able to carry out rapid increase of fuel production (following the 1990 recession), it is possible that world energy prices would have risen much further by the mid–2000s. That could have entailed a major slowdown of world economic growth (Table 1.1).

By 2008 Russia had increased its share in world oil production from 9% to 12.4%. It overtook the US in 2002 and almost drew level with the world's leading oil producer, Saudi Arabia, in 2007, producing only 5% less. Including its natural gas and coal exports, Russia is the world's leading exporter of energy. Increase in oil production by 1.5 times and increase of oil prices on the world market by more than three times did much to restore Russia's economy to the level of the late 1980s by size of GDP. Revenue from exports of oil and oil products alone had grown from USD 36.2 billion in 2000 to USD 241 billion in 2008. The latter figure exceeds Russia's entire GDP in 1999.

In addition to its oil exports, Russia consistently supplied around one third of all natural gas imported to Europe and about 20% of total world production of gas through the 2000s. Since long-term contracts bind natural gas prices to prices for oil, Russia's natural gas industry has also received major dividends from booming oil prices.

The energy market suffered the most among commodity markets as a result of the crisis, and Russia's economy was bound to be seriously affected. After explosive growth in 2007–2008 to a level of USD 147/barrel the oil price plummeted to USD 30/barrel by the end of 2008, posing a major threat to budget stability and the overall Russian economy. Despite stabilization of oil prices in the range around USD 70/barrel the national currency, which is closely tied to energy prices, was devalued, foreign investments flowed out of the Russian financial

Figure 1.1
World energy consumption and industrial production (1981-2008)



Source: World Bank (World Development Indicators Online Database), British Petroleum (BP Statistical Review of World Energy, June 2009)

Table 1.1
Average annual growth of energy consumption and GDP (%, 1986–2008)

	GDP		Primary energy consumption		Oil consumption	
	1986-2002	*2003-2008*	*1986-2002*	*2003-2008*	*1986-2002*	*2003-2008*
World	*2.9*	*3.5*	*1.7*	*2.9*	*1.6*	*1.4*
Developed countries	*2.7*	*2.2*	*1.5*	*0.5*	*1.5*	*-0.1*
USA	3.0	2.5	1.5	0.1	1.4	-0.3
EC	2.4	2.3	0.4	0.1	0.7	0.0
Japan	2.2	1.7	1.9	0.1	1.1	-1.6
Developing countries	*3.8*	*6.7*	*1.9*	*5.7*	*1.8*	*3.6*
Brazil	2.3	4.0	3.1	3.7	2.9	2.5
Russia (GDP since 1990)	**-2.5**	**7.0**	**-1.4**	**1.3**	**-3.8**	**1.2**
India	5.5	8.7	5.1	5.9	5.9	3.3
China	9.5	10.7	4.1	11.2	6.5	7.1
Average real oil price, USD per barrel, 2008					28.7	63.2

Source: World Bank (World Development Indicators Online Database), British Petroleum (BP Statistical Review of World Energy, June 2009) market, and there was a reduction of both consumer and investment demand.

By summer 2009 world demand for energy was still much lower than in 2008 (Figure 1.2). Russia's exports of oil and (to an even greater extent) natural gas diminished as a result. Gas exports were down by more than 40% at the end of H1 2009 compared with H1 2008, although the fall was partly due to the Ukrainian gas transit problem in January. However, OPEC's successful policy for reducing supply (by almost 4 million barrels per day) enabled oil prices to stabilize at a relatively high level in historical terms. This gives ground for optimism, but forecasts of leading international analysts for Russia's economic growth rates through the crisis period remain very cautious. The IMF estimates that Russia was among 15 countries, which suffered most during the acute phase of the crisis (in 2009).

1.3. The role and place of the fuel and energy sector in Russia's economy. Current state of the sector and potential for modernization

Stable international demand for oil is a key factor enabling Russia to overcome effects of the crisis (Russian oil export volumes have remained flat) and the 'price per barrel' remains highly important for macroeconomic prospects: such is the importance of the fuel & energy sector for the national economy. The fuel & energy sector is the biggest source of budget income. The sector provided 43%[1] of all federal budget earnings in 2008, and should have represented the same share of the 2009 budget, according to the draft approved in the fall of 2008[2]. Due to the crisis and its effect on the energy markets, the revised version of the budget, approved in April 2009, reduced the share of energy revenues to 30.6%[3]. Oil & gas revenues include mineral extraction tax, as well as export duties for oil, oil products and natural gas. Actual budget revenues from the oil & gas sector, including income tax of oil companies, VAT, excise fees and other charges are substantially higher.

Russia's extraction sector has become a focus for foreign investments, attracting 15-20% of annual capital investment from abroad in the mid–2000s. Leading world oil & gas companies (BP, Shell, ConocoPhillips and others) have become involved. Measured by its relative size, mineral resource extraction (mainly energy) is the leading sector in the Russian economy by volume of foreign investments, rivaled only by electricity, gas supply and water, where large foreign investments in the last couple of years are a temporary phenomenon linked with restructuring of the country's electricity monopoly (Table 1.2).

Total fixed capital investments in the energy extraction industries in 2008 were 12.8% of fixed capital investments throughout the Russian economy. The figure for the electric power, water and natural gas supply segment was 7.7%, while the figure for the whole manufacturing was 15.6%.

The fact that two thirds of Russia's merchandise exports consist of oil, oil products and natural gas demonstrates the country's specialization as a fuel & energy exporter. The same point is proved by 20% share of exported hydrocarbons in GDP (this share is an often-cited measure of dependence on the energy sector). However, the high level of these indicators in Russia in recent years is largely a consequence of favorable conditions on international energy markets.

It would be statistically more correct to look at physical volume indicators, focusing on output of primary energy per one USD of GDP, based on PPP.

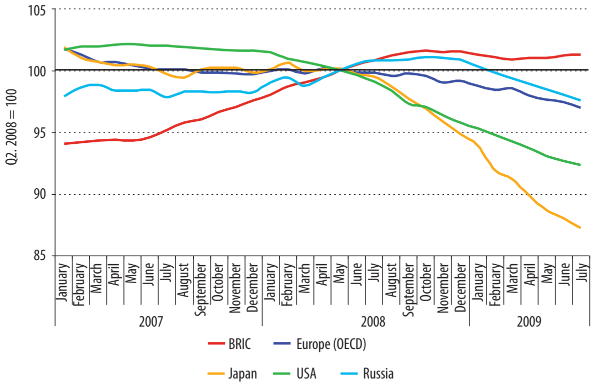
The data in Table 1.3 show that Russia is indeed approaching OPEC countries as regards

[1] In accordance with Federal Law No. 19, as amended on March 3, 2008
[2] In accordance with Federal Law No. 204, dated November 24, 2008
[3] In accordance with Federal Law No.76, dated April 28, 2009

the share of energy in the national economy, although that does not necessarily entail that diversification of the national economy has been curtailed in recent years. In this context it would be useful to have an accurate assessment of the share of the fuel & energy sector in GDP, but this is hard to obtain, since fuel & energy has large impact on a number of other sectors, including trade and the financial sector. The role of the fuel & energy sector is probably much greater than is suggested by indicators obtained by analyzing gross output or gross value added, if only because a part of the value added, which the sector in fact creates, is registered in other sectors.

Dependence on revenues from exported energy resources entails serious risks for a

Figure 1.2
Demand for oil on the world market by regions, 2007-2009 (12-month moving average)



Source: US Department of Energy (Short-Term Energy Outlook, August 2009)

Table 1.2
Breakdown of foreign investments in Russia's economy in 2008 (% of total)

Type of business	Direct	Portfolio	Other	Overall	Gross value added in the industry
Agriculture, hunting, forestry, fishing	1.9	0.0	0.5	0.8	4.9
Mineral extraction	18.4	6.9	9.7	11.9	9.2
Of which, fuel & energy extraction	*17.2*	*6.9*	*6.8*	*9.5*	
Processing industries	21.9	16.2	36.9	32.7	17.4
Production and distribution of electric power, water and natural gas	8.6	57.4	0.3	3.3	3
Construction	3.5	0.0	3.2	3.3	6.5
Wholesale and retail sales, small repairs	14.8	1.8	26.4	23.0	20.6*
Transportation and communications	4.7	1.0	4.7	4.7	9.4
Financial	6.3	2.4	4.3	4.8	4.7
Real estate operations, rental and other services	18.7	14.1	13.5	14.8	11
Other	1.1	0.1	0.5	0.6	13.3
Total	100	100	100	100	100

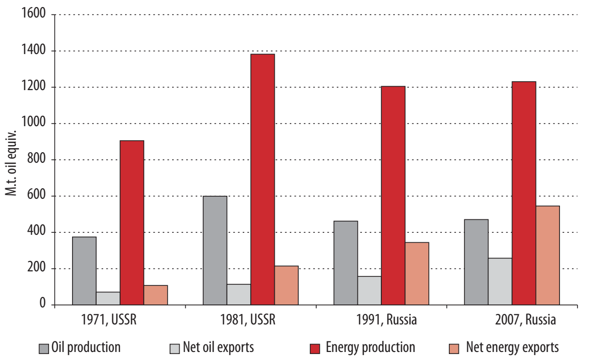
Source: The Federal State Statistics Service (Central Statistics Database).
** Part of value added in trade is oil rent, which shifts the data to some extent.*

Table 1.3
Role of the energy sector in gross production: relation between primary energy production and GDP of selected countries/regions (tonnes of oil equivalent per thousand USD in 2000 at PPP)

	1990	2000	2007
World	0.26	0.22	0.19
OECD	0.16	0.14	0.12
Russia	0.84	0.94	0.77
EC-27	0.11	0.09	0.07
OPEC	1.33	1.42	1.17

Source: IEA (IEA World Energy Statistics and Balances – Energy Balances of Non-OECD Countries – Economic Indicators Vol. 2009, release 01)

Figure 1.3
Russian energy exports



Source: IEA (IEA World Energy Statistics and Balances – Energy Balances of Non-OECD Countries – Economic Indicators Vol. 2009, release 01)

country. The real earnings of a large share of its population, as well as the education and health care systems, are dependent on resource rent, either directly or through the mechanism of the government budget. So there is a threat of poverty, social instability, limited access to medical and educational services, and reduction of overall living standards in case of a fall in export earnings. This threat is not only short-term (causing such temporary difficulties as were seen in 2008–2009), but also long-term, in case of development and large-scale application of alternative energy technologies by importing countries. We doubt that such technological breakthroughs are likely in the next 10-15 years, but a changeover of this kind is more probable by 2030. Export earnings could also decline due to lack of investments in extraction segments, which would confront Russia with a dilemma: whether to limit exports or domestic consumption. This problem does not exist at present, but the worrying trends mentioned above make it important to give thought to such a scenario.

Russia itself consumes around half of the primary energy, which it produces. This includes over two thirds of extracted natural gas and coal, and around on third of crude oil. It is therefore quite wrong to describe Russia as a 'petrostate', functioning as an energy donor to the developed world. Energy efficiency of the European Community, the main recipient of Russian energy, depends on efficient utilization of these imports, which represented about 40% of all primary energy consumption in the EC in 2008.

It is true, however, that the share of energy consumed domestically has significantly declined during Russia's changeover to a market economy. This is evidence that the country's economy has become more energy efficient, requiring smaller volumes of energy. Energy intensity of Russian GDP has declined by more than 40% since the peak in 1994–1996 and is 25-30% lower than in the 1980s. This process has not been met by relevant increase in energy consumption (since growth of internal industrial production and consumer demand has not been sufficient to cause a significant growth of absolute consumption).

The Russian fuel & energy sector was increasingly geared to exports by the mid–2000s (Figure 1.3). Increased export orientation of Russia's energy industry can be tracked over a longer period of time, though comparison with the USSR can be misleading: in the USSR Russia was in effect an exporter of energy resources to other Soviet republics, but (naturally) international trade statistics did not show this fact until after the collapse of the union state.

The trend began to reverse from 2004 as a larger share of crude oil was consumed inside the country for refining into oil products (Figure 1.4). The share of oil products, which were exported, increased. However, this positive trend has been partly offset by decline in depth of processing: 75% of the increase in export of oil products in 2006–2008 was represented by fuel oil. There have been efforts to raise the yield of light products, but diesel fuel export has grown much more slowly than export of fuel oil, and exports of automobile-grade gasoline even decreased in 2008.

The fuel & energy sector became a steady source of rent for Russia in the 2000s thanks to natural limitations on global supply of energy resources in the medium term. Theoretically, this rent could have emerged in another sector, most obviously metallurgy, but developments on world markets were such that the fuel & energy sector became the cornerstone of Russia's medium-term macroeconomic stability.

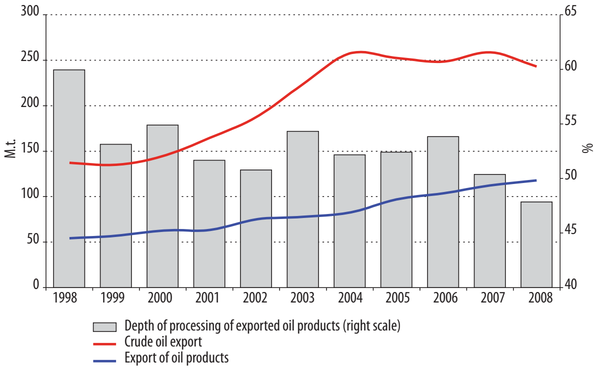
The role of Russia's fuel & energy segment could have negative impact on both the speed and the quality of economic growth in the long run. Two phenomena, which have characterized Russia's economy in recent years, are specifically at issue: structural disproportions and natural resource rent.

These two phenomena have been used by economists to develop theories of what is often called the 'resource curse': deceleration of economic growth in countries, which are rich in mineral resources. These theories have existed for over 20 years. They are not fully accepted in academic circles and have been opposed by a number of researchers. Nevertheless, they are often used for comprehensive analysis of the experience and economic outlook in various countries, including Russia.

Most studies related to the 'resource curse' deal with countries that export fuel & energy resources. Brief historic examination of GDP and inflation leads to the conclusion that these national economies are generally characterized by lower growth and higher macroeconomic instability (Figure 1.5).

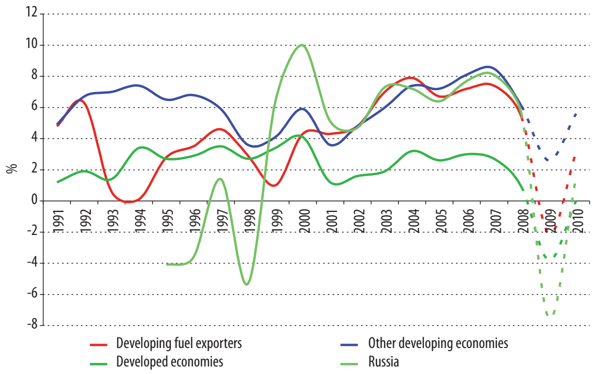
Such a generalized approach is less than adequate on a number of grounds. Nevertheless, the experience of several countries, which failed to achieve high levels of development despite

Figure 1.4
Quality indicators for Russian liquid hydrocarbon exports



Source: The Federal State Statistics Service (Central Statistics Database)

Figure 1.5
GDP of Russia and IMF country groups (1991-2010)

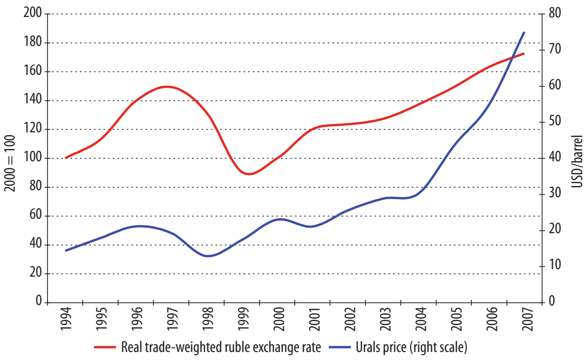


Source: IMF (World Economic Outlook Database)

having extensive fuel & energy resources that had been in production for some time, suggest that natural resource wealth can place additional limitations on economic development.

The best-known phenomenon of this kind is 'Dutch disease', which combines deleterious effects from use of revenues and reallocation of resources. The mechanism associated with revenue use is as follows: inflow of foreign currency ('petrodollars') from export of natural resources becomes excessive when international prices for the resources are high, causing a significant surplus on the balance of payments. It the local currency is floating against other currencies, its nominal and real exchange rate will tend to appreciate, undermining competitiveness of the country's other industrial sectors and agriculture on both domestic and international markets (Figure 1.6).

Figure 1.6
Urals price and real trade-weighted exchange rate of the Russian ruble (1994-2007)



Source: World Bank (World Development Indicators Online Database), US Department of Energy (http://www.eia.doe.gov/emeu/international/oilprice.html)

The Central Bank may then intervene, slowing the nominal appreciation by currency interventions, but increase of money supply will stoke inflation and this negative effect could also, in turn, strengthen the real exchange rate.

The resource reallocation effect arises from transfer of labor force and capital from processing industries and agriculture to the raw materials exporting segment and other sectors of the national economy, which do not directly compete with imports, i.e. the so-called 'non-tradable' sector, including construction, retail trade, transportation and communications.

These effects do not directly reduce economic growth but they lead to structural disproportions, as a result of which the economy can become more exposed to external price shocks related to a specific group of commodities (energy commodities). There is also a long-term threat of economic slowdown if the fuel & energy sector fails to update its technology and becomes immune to innovation.

Natural resource rent can also have the effect of suppressing economic growth. If the rent is high, rent-seeking behavior becomes prevalent and a large share of resources may be used for redistributive instead of productive activities. The fact of a resource rent, which is distributed in accordance with specific rules, can worsen and distort incentives for government, business and the general public. This factor is particularly dangerous when the country lacks the well-established institutions of a market economy.

Structural disproportions together with prevalent rent-seeking economic behavior can have impact, through a number of channels, on parameters of the key factor for economic growth, namely human potential[4], because means of stimulating and implementing investments in human potential are reduced.

Reasons for low investments in human potential include wealth inequality, Dutch Disease, and improper redistribution policy by the state. Inequality caused by uneven development of various sectors and regions or by concentration of geographically localized natural resources in the hands of a small group of people undermines both vertical mobility (e.g. through impairment of access to education among poorer social groups), and incentives for a significant part of the population. Dutch Disease leads to diminishing demand for skilled labor because the processing industry shrinks while the capital-intensive resource segment may only need a limited number of highly-skilled employees. The government may try to redistribute revenues, but this can also undermine incentives, since people look to the paternalistic state instead of developing their own strengths, educational potential and careers. The state may provide its citizens with free education, but will people see the sense of developing their own human capital when there are insufficient highly qualified jobs in any case? This sort of scenario leads to increasing social and material stratification and, consequently, to more social tension.

Possibility of this scenario poses a grave threat to sustainable development in Russia. In order to avoid it the state needs to pursue several priorities. A wise industrial policy should be aimed at diversification of the economy,

[4] The issue of negative structural disproportions in Russia's economy is studied in more detail in a work by V.Danilov-Danilyan: Energy Efficiency as the Key Direction for Russia's Economic Development//Vestnik Ekologicheskogo Obrazovaniya, 2001, No.19.

elimination of structural and territorial imbalances and creation of new jobs. Moderate and flexible re-distributive policy should provide citizens with equal rights for their development and preservation of their human potential without destroying incentives provided by the market economy. This mostly means government support for the education and health care sectors, combined with smooth development of market mechanisms within these sectors.

1.4. Development scenarios for the fuel & energy sector in the context of the economic development model

The economic crisis has had severe impact on the Russian economy, but it can be regarded as a window of opportunity both for adjustment of state economic policy and for real changes in the national economy. The opportunities arise from reduction of natural resource rent and devaluation of the national currency, which create opportunities for domestic industrial and agricultural manufacturers, but, most of all, from a new understanding in Russia's government and business establishments of the fragility of such prosperity as has been achieved to date. These factors in combination could promote real changes in the growth and development features of the Russian economy.

Although diversification of the national economy is an important objective, Russia's fuel & energy sector as such has a crucial role in the positive development scenario, which has just been outlined, because of its scale and its role as a energy supplier to all other sectors. We look at several possible scenarios for development of Russia's fuel & energy sector in the context of national economic development.

The scenarios we propose are slightly different from those reviewed in the Long-term Development Concept for Russia up to 2020 (approved in September 2008) and the accompanying Social and Economic Development Forecast[5]. These differences are due to impact of the world economic crisis on progress of the national economy and some divergences in assessment of the development potential of Russia's fuel & energy sector. Possible consequences of the global recession and the economic crisis for the Russian economy cannot be fully gauged at present, and scenario parameters will have to be amended in the future.

Implementation of the innovation scenario (the main scenario in the Long-term Development Concept), which calls for a dramatic increase in the level of structural diversification of Russia's economy up to 2020, now looks unlikely. Several years will be required to overcome the crisis and to restore the national and global economy, so the innovative breakthrough stage, foreseen in the Concept, will be postponed. In this Chapter it is assumed that the diversification scenario will not be realized until after 2020.

However, innovation processes could be well underway by 2020 in the traditionally dominant fuel & energy sector. The second of the three scenarios outlined below, is our own innovation scenario where the key role is played by increasing energy efficiency (probably to a level corresponding to the innovative scenario in the Long-term Concept) and development of new technologies in the fuel & energy sector.

Inertial scenario

In such a scenario global demand for energy resources would remain fairly strong in the post-crisis recovery stage. High earnings from exports of oil & gas are capable of maintaining the fuel & energy sector and the Russian economy as a whole. It is therefore possible that neither the state nor big business will implement a serious innovation policy (despite frequent declarations). This could lead to:

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[5] http://www.economy.gov.ru/wps/wcm/myconnect/economylib/mert/welcome/economy/strategyandinnovation/longtermstratdirectarea/

- Russia's energy efficiency remaining less than half that of developed countries;
- Slower progress towards energy efficiency in Russia during the coming decade and increased export of energy-intensive commodities with low levels of processing (metals, paper etc.);
- Oil & gas continuing to dominate primary energy consumption structure for the coming decade (75% of the total). The hydro-electric and nuclear energy industries would grow, but relatively slowly. Efficiency of the oil & gas industry could be increased to some extent by an end to gas flaring;
- Continued dominance of natural gas as the feedstock to fuel-fired power stations, despite limited changeover to coal in some locations;
- Continued low levels of oil product export (2-2.5 times less than exports of crude oil by volume);
- Government energy priorities remain focused on increase of extraction capacities and development of transport infrastructure for the oil & gas industry. Development of nuclear and hydro-electric generating due to interest of government companies in these segments;
- Most innovative activity remains in the oil & gas sector and supporting industries.

Innovative energy scenario

Decreasing income from oil & gas exports due to general worsening of the international energy market after the world crisis or to difficulties in further development of energy resources lead the government and business to partial restructuring of the fuel & energy sector and of the economy as a whole. The government's long-term investment policy takes account of new global tends towards energy efficiency. These factors in combination could have the following consequences:

- Shift of government and private investments from extensive development of the fuel & energy sector to its modernization. Achievement of greater refining depth and increase of oil product export volumes towards the level of crude oil exports;
- Energy efficiency innovations and much greater use of existing mechanisms for energy saving;
- Development of market institutions in the energy sector, including ending of subsidized energy use and improvement of contract mechanisms;
- Indirect energy efficiency incentives for industry and households including flexible pricing mechanisms, subsidies, exemptions and other economic instruments to encourage voluntary energy saving behavior;
- Increasing the share of renewable energy sources (not including large hydro-electric stations) to 4-5% of total electricity generation (stated objective of the Ministry of Energy);
- Significant narrowing of the gap in energy intensity of GDP between Russia and developed countries. The ratio of energy production to GDP in Russia is still 3-4 times higher than the world average;
- Government focus on freeing additional fuel & energy resources through improved energy efficiency. Targeting of competitive advantages in 'new energy' (energy efficiency and use of alternative energies);
- Focus of innovation in the fuel & energy sector and related industries, as well as in the defense industry, led by state companies.

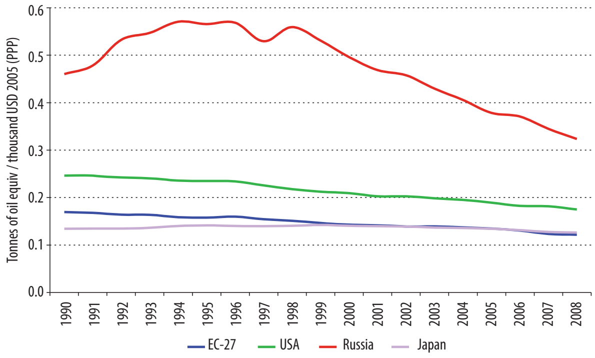
Diversification scenarios (after 2020–2025)

Diversification scenarios assume that, in the long-term, the government chooses and implements a diversification policy. Good institutional environment is created for development of other economic sectors (in addition to the fuel & energy sector and defense industry).

- Energy efficiency of the Russian economy comes closer to that of developed countries (though Russia remains much more energy intensive due to export-oriented production of energy-intensive commodities such as paper, fertilizers and metals);

- Establishment of competitive mechanisms in domestic fuel & energy markets to reduce costs for consumers and motivate energy efficiency;
- Government energy policy becomes focused on competitiveness of other industries. Support of 'national energy champions' ceases to be the main priority;
- Shift of government focus to other sectors forces the fuel & energy sector to seek private investments, including foreign investment. The share of energy production in GDP is dramatically reduced;
- Innovation activity spreads quickly through manufacturing and agriculture.

Figure 1.7
Energy intensity of GDP in selected countries (1990-2008)



Source: World Bank (World Development Indicators Online Database), British Petroleum (BP Statistical Review of World Energy, June 2009)

1.5. Environmental and energy efficiency of the Russian economy

The targets of Russia's Energy Strategy up to 2020 have been successfully implemented to date, but a number of fundamental problems are likely to arise in the medium and long terms.

The main issue is heavy strain exerted on the fuel & energy sector by Russia's high energy intensity, which exceeds that of developed countries by more than two times, despite progress achieved in recent years (Figure 1.7). The Ministry of Energy estimates that only 20% of the existing potential for energy efficiency is actually used. This will have negative impact on competitiveness of the national economy in the long run due to high spending on energy.

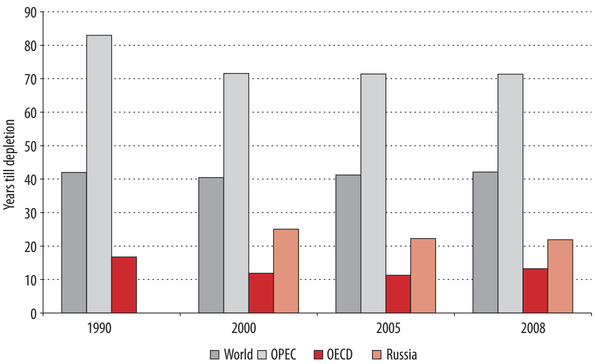
Per capita energy consumption in Russia is much higher than the average level of developing countries and comparable with levels in developed countries. However, the Russian figure is much lower than in countries with comparable climate: it is 15-30% lower than the countries of northern Europe and 40% below Canada, while energy intensity of GDP in Russia is 1.5-2.5 times higher than in these countries. So high nominal levels of domestic energy supply are canceled out by inefficient use. It seems unreasonable to count insufficient access to energy as a factor that slows down development of Russia's human potential, but less apparent limitations related to inefficient use of available energy do exist. This is reflected in practice by a whole range of infrastructure problems in the energy sector, which put limitations on living standards (e.g. access to electric energy and natural gas) and impair business development.

Exceptionally high energy intensity of Russia's economy, perpetuated in part by mechanisms of energy subsidies, has negative effect on the environment and threatens to further reduce life expectancy or, at least, to raise health care costs.

Special studies, including a report by the World Bank[6], have shown that application of existing commercial technologies throughout the country could save up to 45% of the energy, which Russia now consumes (the potential saving is roughly equal to total energy consumption in Germany). This could not be done quickly and would cost about USD 320-340 billion. But the enormous potential for savings show how much could be achieved by future economic and energy policies. It would be important to decide what to do with the energy volumes, which are freed by greater efficiency: either exporting them profitably or reducing overall extraction rates. Comparative merits of

[6] Energy Efficiency in Russia: Untapped Reserves / World Bank Working Paper # 46936. World Bank, IFC, 2008

Figure 1.8
Proven oil reserves: years until depletion at current rate of extraction (1990-2008)



Source: British Petroleum (BP Statistical Review of World Energy June 2009)

these two approaches have not even been discussed to date, but, when the time comes, they will represent a difficult choice requiring public discussion. Russian leaders are taking some steps to increase energy efficiency. Presidential Decree No.889, 'On measures to increasing energy and environmental efficiency of the Russian economy' (June 2008) calls for 40% reduction of energy intensity by 2020 compared with 2007. A new draft law, 'On energy efficiency and improvement of energy efficiency' was presented to the State Duma in October 2008, as stipulated by the Decree, and was approved by the Duma and the Federation Council in November 2009. There is a threat that anti-crisis measures will now override energy efficiency measures in the government's list of priorities, but the President's address to the Federation Council in November 2009 made energy efficiency one of the key vectors for modernization, raising hopes that the issue will receive due attention in the medium term.

Rational long-term use of natural resources is an important part of Russia's sustainable development, helping to ensure quality of life for future generations.

Forecasts of imminent oil reserve depletion worldwide or in a single country have been common currency for over a century, and have proved to be exaggerated. Improvement of extraction technologies and energy price fluctuations, which make development of new fields economically feasible, move the depletion date further and further into the future. It can be confidently predicted that world oil production will not come to an end in 2050, as present reserve statistics suggest, even taking account of forecast increase in oil consumption.

However, the threat of depletion of Russia's proven and accessible oil resources in 20-30 years time has become a real threat, mainly because of inadequate exploration in the past decade and more difficult extraction conditions, which require work in remote regions with harsh climate. Even during the recent boom years (2002–2008) the depletion date came nearer (from 26.3 to 21.9 years) (Figure 1.8). Reserve replacement is progressing very slowly and the crisis has clearly worsened the situation. The situation with natural gas reserves is better, mainly due to huge deposits, which are sufficient for 70 years of production. But the expected depletion date for natural gas has moved closer by 9.4 years in the last decade, canceling out reserve replacement. It should be stressed that these trends were observed during the energy price boom, when profitability of energy resource development was at a high level.

A development model based on extensive increase of traditional energy resource production does not look sustainable for Russia. Significant investments are needed for development of new deposits and more attention should be paid to use of renewable sources of energy. Russian use of renewables is currently extremely limited: the Ministry of Energy estimate for 2008 was less than 1% of electric power, not counting large hydro-electric stations with more than 20MW capacity.

As a result of the economic crisis in the 1990s and relatively energy-sparing recovery since then, greenhouse gas (GHG) emissions in Russia have dropped by 34% compared with 1990. But there has been little progress towards low-carbon energy production, which could safeguard what has been achieved and obtain further emissions reduction. The share of coal, oil & gas in Russian energy consumption is still around 90%. The level is not much different in a number of developed countries, including the USA, but the main developed countries have made a number of decisions supporting low-carbon energy production (e.g. the G8 Action Plan for Energy Preparedness, signed in St.Petersburg in 2006). Both the USA and the EC have recently adopted ambitious programs for greater use of renewables, and this is also a target of the Russian leadership, which has said that the renewables share should rise to 19-20% by 2020 (including large hydro-electric stations)[7].

Decisions taken by the government in June 2009 suggest that Russia is not keen to lead the way in meeting commitments on emission reductions by 2020, which are to be agreed in Copenhagen in December 2009. The decision to put a -15% limit on reductions as compared with 1990 leaves Russia room for maneuver, and even allows it to return in the post-crisis period to the power-intensive development path, which seemed to have been abandoned in 1999–2008, though such a backward step looks very unlikely. The whole world is preparing for major shifts in approaches to energy efficiency, but these shifts will probably require much more time and resources than climate enthusiasts predict. The programme of US President Obama and the EC's 20-20-20 programme are unlikely to be implemented in the near future. But developments towards energy efficiency will continue and Russia, as a responsible country, will take part in this process.

1.6. Summary and recommendations

The important role played in Russia's economy by the energy sector means that any modernization program must take special account of its specific features.

Firstly, modernization requires reduction of dependence on energy exports. Economic diversification can be based on development of power-intensive industries and deeper levels of processing. But added competitiveness due to energy wealth tends to be undermined by inefficient energy use.

Secondly, Russia needs a multi-sectoral, diversified programme for increase of energy efficiency. The large energy efficiency gap between Russia and developed countries cannot be overcome by piecemeal measures. The world's leading countries are already committed to greater energy efficiency, including promotion of low-carbon technologies. The process has only just begun, but Russia must avoid falling behind.

Thirdly, minimization of rent-seeking behavior by government and private businesses is vital for development of new sources of industrial development, in the high-tech sector as well as the power-intensive semi-product sector. Overcoming rent-seeking behavior has been a condition of success in countries with large natural rents. Modernization of the institutional environment is the key to success in this task.

The fuel & energy sector has specific needs, which require special attention in the medium term. Faced with depletion of natural resources, the sector must carry out investment projects to find and develop new fields, and to make better use of existing fields.

Finally, and most importantly, all of the changes outlined above have to be focused on sustained, long-term development based on increase of human potential. The actions, which are taken, must stimulate both economic growth and investments in human development. Environmental efficiency of the economy as a whole and of the fuel & energy complex, in particular, also have high priority.

[7] http://minenergo.gov.ru/activity/vie/

Box 1.1. Correlation between climate change, the energy sector and human development

Climate change is one of the most dramatic geopolitical and economic problems of the century, since it poses a real threat to human development and better quality of life worldwide in both the short and long term. Production and combustion of fossil fuels are one of the main causes of registered increase in GHG emissions and resulting quickening of the global climate change process. In Russia over 72% of GHG emissions are related to use of fossil fuels.

Climate monitoring records by the national hydrometeorological network, as well as scientific publications by Russian and foreign scientists on global climate change and its consequences show significant negative and, in some cases, positive impact from climate change on Russia's natural environment and socio-economic development, both nationally and by regions. The Assessment Report on Climate Change and its Impact on the Russian Federation, prepared in 1998 by experts of the State Hydrometeorological Committee (Roshydromet), the Russian Academy of Sciences and specialists from the country's universities[8], did much to focus attention on severity of the problem.

Climate change will have negative impact on many parts of the national economy and the energy sector may be among the hardest hit. Energy facilities in Siberia and northern territories are particularly vulnerable due to thawing of permafrost, which covers two thirds of Russia's territory. It is expected that depth of seasonal melting will increase by 30-50% by 2050, which will create new technical challenges for the resource extraction industry in the Russian Arctic and Siberia. Communities and energy infrastructure in traditional permafrost areas are particularly at risk. In Western Siberia 21% of all accidents on trunk oil and gas pipelines have mechanical causes, including failure of foundations and deformation of supports.

Further melting of the permafrost could damage even larger facilities, such as oil depots. Special technical projects will be needed in order to prevent an increase of oil and gas pipeline fractures.

Forecast change of flow volumes in rivers will change the of water influx to large reservoirs. Forecasts predict a 5-10% increase of water influx to the Volga-Kama reservoir series and to reservoirs in the North-Western Federal District. Water influx to reservoirs on the Angara and Yenisei rivers, and also on the Viluy, Kolyma, and Zeya rivers will increase by between 0% and 15%. Changes in river flow due to expected climate changes will force reassessment of reservoir operation procedures with respect to main users (especially power generating facilities) and the environment.

Russia's transportation infrastructure is also at risk. Increasing volume and frequency of precipitation, and the fact that winter precipitation will increasingly be in the form of rain, rather than snow, will tend to destabilize road beds and weaken support walls. Prolonged dry periods could result in soil subsidence beneath structures and buildings. Larger temperature fluctuations will speed up road degradation. Permafrost melt is already destroying winter ice roads, which are vitally important for the oil and forestry segments.

Russia is more subject to weather extremes than other countries of Europe and Central Asia and vulnerability of the country's economy reflects its large tracts of territory with unfavorable ecological conditions and poor condition of the country's infrastructure.

Benefits from climate changes in Russia include reduction of heating costs, greater potential for agriculture and forestry, ability to develop shipping along the Northern Sea Route, as well as greater access to, and hence production of, mineral resources and biological marine resources.

Both positive and negative climate change impacts require complex and professional study. It is important to develop climate risk assessment and forecasting research, as well as studies of their possible benefits for the energy industry and other segments so that these factors can be taken into account when making long- and medium-term strategic decisions.

[8] Assessment Report on Climate Change and its Impact on the Russian Federation: General Summary, Roshydromet, 2008

Although the United Nations Climate Change Conference in Copenhagen in 2009 did not mark a breakthrough in putting the climate issue at center stage of the world economy and national economies, its results will have major impact for strengthening and expansion of the drive towards low-carbon development, which the leading nations of the World are embarked upon. The Copenhagen Accord (the political document developed and adopted by world leaders at the Conference) confirmed the commitment of most developed countries to keep global warming under 2°C and start immediate actions for prevention of and adaptation to climate change, to organize relevant financing and technologies, and to stop forest devastation in developing countries. The strategic measures for energy saving and GHG emissions reduction at the national level that have already been adopted or are under development will influence global markets (both markets for traditional fuel & energy, and the new market for GHG emission certificates) and will encourage transfer and distribution of energy-efficient and low carbon technologies.

Adoption of the Climate Doctrine of the Russian Federation, signed by the Russian President on November 17, 2009, is an important step forward. The Doctrine sets out attitudes towards the goal, principles, content and means of implementation of a unified climate change policy in the Russian Federation. The strategic goal of the Russia's climate change policy is to ensure safe and sustainable national development, including the institutional, economic, environmental and social (including demographic) aspects of such development, in the context of climate change and related threats and challenges. The Doctrine pays special attention to development of Russian climate science, which many prominent experts believe to be in need of strong state support.

Objective media coverage of problems related to climate change and its implications, including 'popular science' approaches to climate awareness, is a priority for Russia. Successful development and implementation of Russia's climate change policy will depend on greater environmental awareness and understanding of climate change issues among government officials, business people, civil society and the general public.

Almost simultaneous adoption of the Climate Doctrine and of the Energy Policy of Russia up to 2030 (approved by Governmental Decree No.1715-r, dated November 13, 2009) bodes well for close integration of energy and climate policies with respect to action plans and socio-economic development programmes.

Chapter 2 Energy and the Regions: Human Development Challenges

2.1. Fuel & energy regions: their role in Russia's economy and development

The industries that comprise Russia's fuel & energy sector are spread unevenly across its regions, and therefore play different roles in different regional economies. About a quarter of Russia's administrative regions, with one sixth of Russia's population, specialize in extraction and primary processing of fuel resources. However, federal budget revenues from extraction and export of fuel resources are redistributed throughout the country.

The largest oil & gas producing region is Tyumen, specifically the Khanty-Mansi and Yamal-Nenets Autonomous Districts, which are constituent parts of the Region. Tyumen Region provides 12% of Russia's industrial production (including 8% from Khanty-Mansi alone) and the same share of Gross Regional Product (GRP). These figures are understated, because many fuel & energy companies use transfer pricing to relocate profits in favor of their Moscow-based headquarters or offshore companies in order to minimize taxation. The fact that Moscow has the biggest share of Russian GRP (23%) is largely due to concentration of profits in head offices of large companies in the city. Besides, a statistical quirk locates 10% of all fuel & energy extraction in Russia in the city of Moscow. Corporate reporting juggles figures to distort the actual input of extraction regions to fuel & energy production, creating special advantages for the Moscow city budget thanks to huge amounts of profit tax from the country's leading corporations.

The main regions for Russia's fuel & energy sector are obvious from figures that show raw fuel and electricity production. Territorial concentration of most sub-sectors is very high, especially in oil & gas extraction. Tyumen Region with its autonomous districts accounts for 91% of gas and 66% of oil production (Table 2.1). Coal is mined in many regions, but the two leaders – Kemerovo Region and Krasnoyarsk Territory – account for 70% of all production. Electric power production is most dispersed, but the leader is again Tyumen Region, followed by Siberian regions, which have a well-developed hydro-power industry (Irkutsk Region and Krasnoyarsk Territory) and the cheapest electric power in the country as a result. Moscow and the leading

Table 2.1
Leading regions for fuel extraction and electric power production (share in national production in 2007-2008, %)

Crude oil extraction*	%	Natural gas extraction	%	Coal extraction	%	Electric power production	%
Tyumen Region	66	Tyumen Region	91	Kemerovo Region	58	Tyumen Region	9
incl. Khanty-Mansi Autonomous District	57	incl. Yamal-Nenets Autonomous District	87	Krasnoyarsk Territory	12	incl. Khanty-Mansi Autonomous District	7
incl. Yamal-Nenets Autonomous District	9	incl. Khanty-Mansi Autonomous District	4	Chita Region	4	Irkutsk Region	6
Republic of Tatarstan	7	Orenburg Region	3	Republic of Komi	4	Krasnoyarsk Territory	6
Orenburg Region	4	Astrakhan Region	2	Republic of Sakha (Yakutia)	4	Moscow	5
Sakhalin Region	3			Irkutsk Region	3	Sverdlovsk Region	5
Nenets Autonomous District	3			Republic of Khakassia	3	Saratov Region	4
Republic of Komi	3			Primorsky Territory	3	Leningrad Region	4

incl. gas condensate

industrial region of the Urals – Sverdlovsk Region – are also major producers of electric power.

The fuel & energy industries play an important role in regional economies, creating well-paid jobs and providing large revenues for regional budgets. However, domination of such segments and formation of single-industry regional economies increase development risks due to instability of fuel prices and depletion of natural resources in the long term. Single-industry oil & gas regions include Tyumen and the Nenets Autonomous District and, in the past last few years, Sakhalin Region (Figure 2.1). In 8-9 other regions contribution of the fuel & energy sector to regional industrial output is higher than the national average. The Republic of Bashkortostan, Samara Region and Perm Territory should also be included in the list: these regions are specialized in primary processing of oil & gas as well as having sizeable extraction industries, so that total contribution of the fuel & energy industry to their economies is higher than suggested in Figure 2.1. Moscow is included among oil & gas producing regions because of the statistical eccentricities mentioned above. Oil & gas production in Arkhangelsk and Tyumen Regions is concentrated in their constituent autonomous districts.

Specialization in oil & gas production helped these regions to survive the 1990s crisis with much less serious industrial recessions compared with the Russian average. The Republic of Udmurtia, where the defense industry dominates the economy, was an exception. Coal-mining regions were not spared the privations of the transition period. The coal industry has undergone restructuring and mass layoffs, particularly in traditional mining areas, where many mines had been loss-making for a long period (Rostov, Tula and Chelyabinsk regions, Perm Territory), and in the northern and eastern territories where costs of coal mining are high due to harsh climate and remoteness.

The period of economic growth, which lasted for a decade (1999–2008), saw highest growth rates in two oil & gas producing regions, where development of new deposits started at that time: the Nenets Autonomous District (industrial output quadrupled compared with 1990) and Sakhalin Region (output rose by 1.8 times compared with 1990). These results are shown in Figure 2.2. Tatarstan also enjoyed strong growth of industrial output in 1999–2008 (by 1.3 times) thanks to large government investments. Nearly all other regions with a sizeable fuel & energy sector only approached levels of the end of the Soviet era or, at best, slightly surpassed them. Oil & gas production did not provide strong and consistent economic growth in these regions after 2000. Tomsk Region and Yamal-Nenets Autonomous District showed declines of industrial output from 2004. The

Figure 2.1
Share of fuel resource extraction in regional industrial output in 2007, %

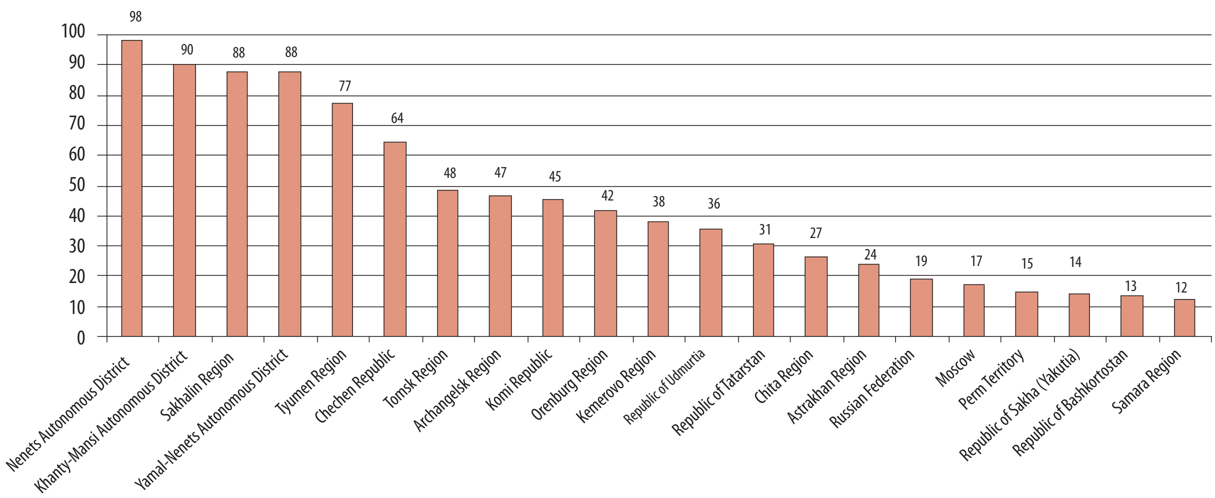
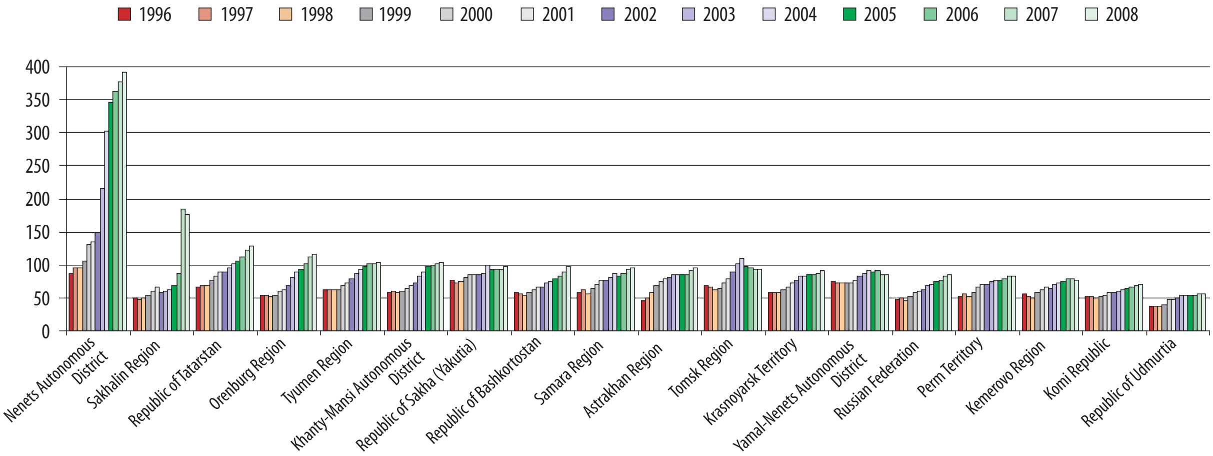


Figure 2.2
Accrued industrial growth of regions where the fuel & energy sector has large relative or absolute size, % to 1990 (1990=100%)



slowest growth rates were in the Komi Republic and Republic of Udmurtia, where oil deposits are approaching exhaustion, and in coal-mining Kemerovo Region, though one should bear in mind that industrial growth in these regions depends on machine-building, metallurgy or forestry, as well as on the fuel & energy sector.

Development prospects in regions depend on investment levels. Extraction of fuel resources is the most capital-intensive industrial sector, so main oil & gas regions rank high by investments, along with the 'federal cities' Moscow and St.Petersburg and with regions, that have large metallurgy industries. Nevertheless, only the biggest oil & gas producing regions and regions with newly developed fields have clear investment advantages. Per capita investment rates in such regions are 4-15 times higher than the national average, even when adjusted for their relatively high consumer price levels (Table 2.2).

In general, specialization of regional economies in fuel & energy gave them a safety net during the recession of the 1990s, limiting their economic decline, but, with few exceptions, it did not become the driving force for fast and sustained economic development in the 2000s.

Table 2.2
Regions with highest per capita investments in fixed assets in 2000-2008, % to national average* (Russian Federation=100%)

Nenets Autonomous District **	1533	Vologda Region	129
Yamal-Nenets Autonomous District	900	**Astrakhan Region**	129
Khanty-Mansi Autonomous District	480	St. Petersburg	121
Tyumen Region	468	**Tomsk Region**	120
Sakhalin Region	387	Lipetsk Region	112
Chukotka Autonomous District	212	Moscow	109
Leningrad Region	192	Moscow Region	108
Republic of Sakha (Yakutia)	164	Krasnodar Territory	108
Republic of Tatarstan	157	Kaliningrad Region	105
Komi Republic	151	**Republic of Bashkortostan**	104

** Figures were calculated in constant prices and adjusted to reflect cost of living in each region (the price coefficient for a fixed number of commodities and services used for interregional measurements by Rosstat (the Federal State Statistics Service))*
*** Oil & gas producing regions are in bold*

2.2. Budget capacity and structure of social expenditures

The fuel & energy sector has impact on regional development through the state of energy markets, investment issues and other industrial factors, but also through the policies of government and large fuel & energy companies, which redistribute a great deal of the value arising from energy production. These policies influence the budgets of regions that specialize in fuel & energy, but they also influence the budgets of the federal cities (Moscow, St.Petersburg) due to large tax earnings from the headquarters of fuel & energy companies, which are located in those cities.

The biggest oil &gas producing regions are the main 'bread-winners' for the Russian budget. The two autonomous districts in Tyumen Region provide 29% of all revenues to the federal budget, which are collected in the country's administrative regions, equaling the contribution made by Moscow. This concentration of tax earnings in just three regions reflects the fact that Russia's fuel & energy companies have large businesses and pay much tax. The main taxes, paid by oil & gas companies, are channeled to the federal budget (as opposed to regional budgets): all of VAT, a part of income tax, and (since 2005) almost all of the mineral extraction tax.

Centralization in the federal budget of major taxes in oil & gas regions leads to specific proportions between federal and regional budget revenues in these regions. Taxes that are collected in Russian regions are, on average, divided equally between the two levels of the budget system (federal and regional), but 82% of all taxes collected in 2007–2008 in Khanty-Mansi Autonomous District went to the federal budget, while figures for the Nenets and Yamal-Nenets Autonomous Districts were 72-76%, and 63-64% for Komi Republic, Republic of Udmurtia, Orenburg and Tomsk Regions. These figures compare with 20-40% of all taxes collected in other regions that went to the federal budget. The largest oil & gas producing regions, together with metallurgy regions and the federal cities, are 'budget donors', contributing to instead of receiving adjustment subsidies from the federal budget.

Profit tax is the main source of income for regional governments in fuel & energy regions, contributing 20-45% of their budget revenues. In Moscow, where the largest fuel & energy companies have their head offices, the share of this tax is even higher: in 2007 it was 66% of all Moscow budget revenues and 49% in 2008. Profit tax revenue is unstable, declining sharply during recession periods, particularly in regions where mineral resource mining and primary processing are the main industries. This source of tax revenue is vulnerable to corporate policies as well as to economic crises. For various reasons companies may move the addresses of their units from one region to another, depriving the abandoned region of a strong source of budget revenue.

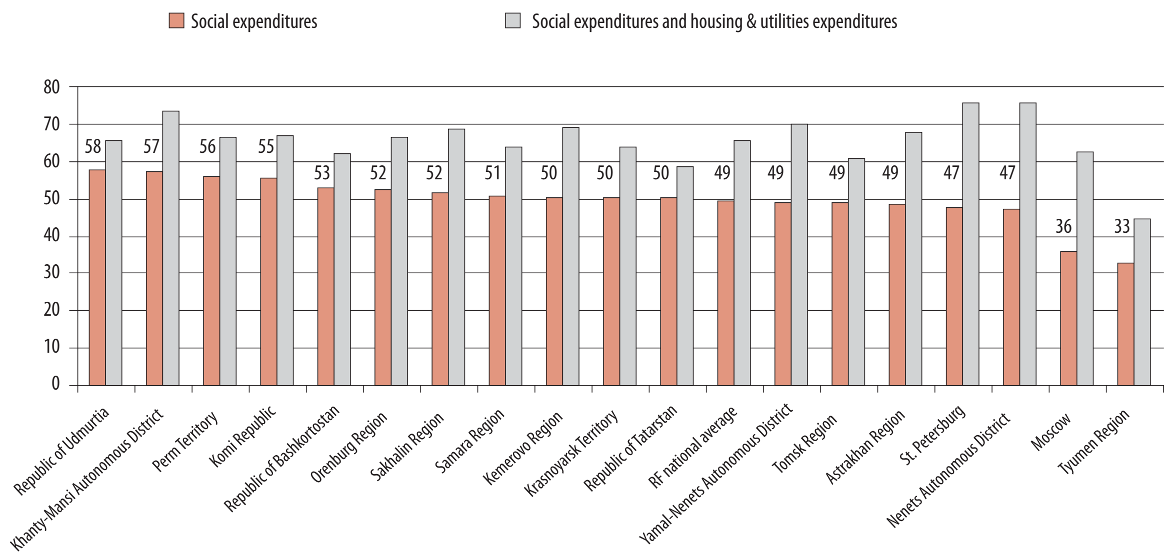
As a result extraction regions are exposed not only to risks posed by fluctuations on international energy markets, but also to budget risks, including the policy of centralizing energy tax revenues in the federal budget. Thus in 2009 the government decided to completely centralize mineral extraction tax. The long-established idea that extraction regions have strong fiscal capacity is becoming a myth: only the three leading oil & gas producing regions have high per capita budget revenues.

Human development in the regions is impossible without increase of budget expenditures for social programs and without general prioritization of social issues. On average across Russia, about half of regional budgets are spent on social items, though most regions devote more than half of their spending to social needs. The share of social expenditures is higher than the national average in many fuel & energy regions (Figure 2.3), with the exceptions of Tyumen Region (without its Autonomous Districts) and Moscow, where social expenditures are only a third of total spending. The latter exceptions are explained by very high budget revenues, which enable these regional governments to spend much more budget money on investments in the economy. Moscow's budget revenues account for 20% of all revenues of Russian regions, because Moscow gathers profit tax from all major corporations registered in the country. Revenues of the Tyumen regional budget increased by six times in 2003–2008 (from 27 to 163 billion rubles), compared with threefold growth in other regions of Russia. These figures are not merely reflections of economic growth, but also of institutional advantages: the Tyumen regional budget receives some of the taxes from its resident autonomous districts with their oil & gas wealth, Moscow obtains tax from large oil & gas companies registered there, etc.

Regional budgets have highly varied priorities in financing of social items. The biggest shares of spending on education (a quarter of all budget spending) are in Perm Territory, Tomsk Region, Republic of Tatarstan, Republic of Bashkortostan, Komi Republic and Nenets Autonomous District. On average regions spend about 21% of their budgets on education, but in Tyumen Region this figure is only 11% and in Astrakhan Region it is 16%. Health care and sport have top priority in Khanty-Mansi Autonomous District (20% of all spending, compared with 13% average for all regions), while Tomsk Region and the Nenets Autonomous District spend only 8% of their budgets on these items, and Tyumen Region and Krasnoyarsk Territory give them a 10% share. Social policy spending is highest in Komi Republic and in Samara Region (15% against average 12% for all regions) and two thirds of these funds are spent as social payments to individuals and families. Housing & utilities have top priority in the federal cities and in Yamal-Nenets Autonomous District (21-29% of budget spending compared with 16% average for all regions). But this is a forced priority: regional governments are postponing reform of the housing & utility sectors because of concern about social consequences.

These figures reflect social priorities of regional governments, but a more precise assessment of regional investments in human development can be obtained by studying per capita social expenditures. In order to make a just comparison, they need to be adjusted for price differences between regions and objective differences in the cost of budget services based on climate, remoteness, population density, etc. The Ministry of Finance uses a specially developed Budget Expenditures Index, which takes account of all these differences, and Rosstat

Figure 2.3
Share of social and housing & utilities spending in all expenditures of consolidated budgets of Russian regions in 2008, %



(the Federal State Statistics Service) has developed a coefficient for interregional comparisons, which reflects differences in the cost of a fixed list of commodities and services. These two correcting coefficients differ from each other to a considerable extent, especially for northern and eastern regions and the federal cities, so that adjustments made using them produce different results. Table 2.3 shows per capita budget expenditures, including social expenditures, calculated by three methods: nominal, using the Rosstat coefficient, and using the Budget Expenditures Index.

The choice between types of adjustment has major impact on the final result, so per capita budget comparisons are relative. But some conclusions can be drawn, despite the divergences. First, per capita financing of social expenditures is much higher in the three northern autonomous districts, with large fuel resource production and scant population, as well as in the federal cities. But most fuel & energy regions do not have strong advantages in their fiscal capacity and cannot spend much more on social items than other regions, which have the benefit of large subsidies from the federal budget.

The lowest per capita social expenditures are in Bashkortostan, Udmurtia and Orenburg Region, but they also have less fiscal capacity. Tyumen Region stands out by having the biggest gap between overall per capita expenditures and per capita expenditures on social items (a threefold difference). The Region was one of the first in

Table 2.3
Per capita expenditures of consolidated regional budgets and per capita social expenditures* of Russian regions in 2008 (thousand rubles per capita)

	Per capita budget expenditures, total			Of which, per capita social expenditures		
	Nominal	Adjusted using the Rosstat coefficient	Adjusted using the Budget Expenditures Index	Nominal	Adjusted using the Rosstat coefficient	Adjusted using the Budget Expenditures Index
Nenets Autonomous District	233	153	147	**110**	72	69
Yamal-Nenets Autonomous District	150	102	96	**74**	50	47
Khanty-Mansi Autonomous District	124	89	79	**71**	51	45
Sakhalin Region	100	68	46	**52**	35	24
Moscow	126	89	134	**45**	32	48
St. Petersburg	79	73	97	**37**	35	46
Tyumen Region (without autonomous regions)	111	110	71	**36**	36	23
Krasnoyarsk Territory	54	51	40	**27**	26	20
Komi Republic	46	39	30	**25**	22	16
RF regional average	**44**	**44**	**44**	**22**	**22**	**22**
Republic of Tatarstan	39	47	47	**20**	23	24
Perm Territory	35	34	38	**20**	19	21
Kemerovo Region	40	48	44	**20**	24	22
Tomsk Region	38	37	28	**19**	18	14
Astrakhan Region	36	41	46	**18**	20	22
Samara Region	35	33	42	**18**	17	21
Orenburg Region	31	37	35	**16**	19	18
Republic of Udmurtia	28	34	32	**16**	19	18
Republic of Bashkortostan	27	31	29	**14**	16	15

** Education, health care, fitness and sport, social policy and mass media*

Russia to carry out social sector reform in 2007 and took first place in a rating by the Ministry of Regional Development for government efficiency, with special commendation for eliminating 'inefficient social spending'. Unfortunately, efficiency improvements in social spending are equated by federal authorities and (in many cases) regional governments with spending less budget money, although social modernization depends on steady growth of government investments in the most efficient human development instruments.

2.3. Social situation: achievements and problems

Regions specializing in fuel and energy production are scattered across the country and their social development depends on differing factors and specifics. Nevertheless, they can be sensibly divided into three groups:

- Sparsely populated northern regions with single-industry oil & gas economies (Khanty-Mansi, Yamal-Nenets and Nenets Autonomous Districts);
- Regions of European part of Russia (most of them located in the Volga Federal District) with a longer history of oil & gas extraction, less dependence on fuel & energy, and with bigger cities and higher population density;
- Other northern and eastern regions of the country, including coal-mining regions, whose social and demographic features place them between the above two groups (Komi Republic, Krasnoyarsk Territory, Sakhalin Region etc.).

The demographic situation in regions depends on when their industrialization began, and on the duration and scale of migratory flows. Autonomous districts of the north where oil & gas exploration began relatively recently are the most prosperous. Mass migration in the 1970s and 1980s increased population of these areas by 10 times, and the newcomers were mainly young people. There was a second wave of migration, on a much smaller scale, in the 1990s, drawn by relatively high wages in the northern oil & gas producing regions. Thanks to their young population the Khanty-Mansi and Yamal-Nenets Autonomous Districts still enjoy relatively high natural population growth (8-9 per 1000 in 2007–2008). The Nenets Autonomous District also has positive natural population growth (3 per 1000). This contrasts with overall excess of mortality over reproduction in Russia since the early 1990s. Also there is a large share of people of working age (over 70%) in the northern oil & gas production areas, and the share of children (20%) greatly exceeds the share of the elderly (7-12%).

In the regions of the Volga Federal District and southern Siberia large-scale industrialization started in the middle of the last century, so their populations have already aged, though not as dramatically as in the Central and North-Western parts of Russia. The demographic situation in older oil & gas producing regions and in the major coal mining regions of southern Siberia is similar to the national average, both as concerns natural loss of population (2-3 per 1000) and in the age structure (62-63% of people are of working age, 16-18% are children and young people, and 18-22% are senior citizens).

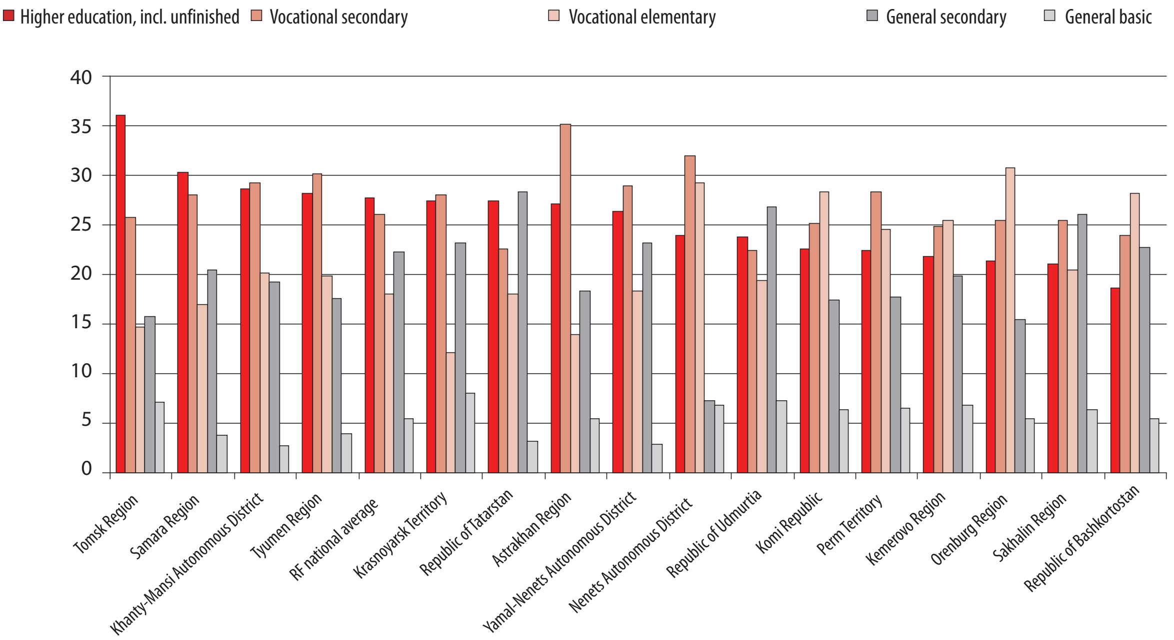
The demographic advantages of northern autonomous regions will not last forever. Since the mid–2000s they have been experiencing a migratory outflow. The outflow was small at the outset, but in 2008 it soared by 10 times to 77 per 10,000 population in the Yamal-Nenets Autonomous District and reached 36 per 10,000 in the Nenets District. Only the Khanty-Mansi Autonomous District showed some migration increase in 2007–2008, when oil prices were at their peak. But this trend is unlikely to last, since the period of super-profits from oil is now over and the present crisis does not favor creation of new jobs. Without input from immigration the population of Russia's northern areas will age, and the regions will face the same demographic problems, two generations into the future, as now face fuel & energy regions where industrialization began earlier.

Immigration by young and highly skilled workers since Soviet times has made the population of northern resource-mining regions better educated than the national average. Populations in some other fuel & energy sector regions with large regional centers also have above-average levels of education. But the advantages are usually concentrated in vocational secondary education, as in other industrial areas of the country. Results of labor market sampling by Rosstat show that in 2007 the largest part of the workforce in most fuel & energy regions had vocational secondary education, and workforces in other fuel & energy regions (Orenburg Region, Komi Republic and Bashkortostan) were dominated by people with vocational elementary education (Figure 2.4). Tomsk and Samara Regions stand out by having workforces, which are dominated by employees with higher education, mainly because Tomsk is a leading university center in Siberia and the urban agglomeration of Samara and Togliatti, with two million inhabitants, has a very well-developed higher education system. In neither case is the dominance of well-educated employees a result of the regions' specialization in oil business.

Data for whole regions do not reflect the skill level of people employed in the fuel & energy sector. The oil & gas industries are not very labor-intensive, and employment in the coal industry has declined significantly during the transition period. In most regions with a large share of fuel resource production, the share of employment in extraction industries is only 1-3% of the total. Shares are higher in Sakhalin and the Komi Republic (5-7%) and in Kemerovo Region (10%), and are highest in the northern autonomous districts, where the share of employment in extraction industries amounts to 16-27% (because the economies of these districts are single-industry).

These figures show that conditions in the fuel & energy sector have major impact on employment in single-industry oil & gas producing districts and in Kemerovo Region. In other regions the state of the labor market is determined by a wider range of factors. Resource-mining territories in northern and eastern parts of the country suffer more from unemployment because they have large numbers of single-industry towns and settlements, where the service sector is underdeveloped and few new jobs are created.

Figure 2.4
Share of employees with various levels of education, % (based on Rosstat sampling in 2007)



As a rule, these regions have above-average levels of youth unemployment.

The situation in specific regions depends on the character of their labor market and corporate policies of large corporations. Employment problems in oil & gas mining areas are the result of the Soviet strategy for development of northern territories. Many migrants were urged to move permanently to areas with adverse climate and high cost of living. Development of social infrastructure and housing for these migrants and their families required huge expenditures. Financing was poor and social amenities in the northern territories were scarce. The standard of living there is still lower than the national average. There was a partial exodus from northern territories in the 1990s, but in regions with oil &gas extraction such remigration effects were relatively small-scale and brief (limited to the early 1990s) because high salaries persuaded people to stay.

Oil companies optimized their employment structure in the early 2000s. Some auxiliary processes were outsourced and not all of them were able to survive on their own. The effect in Khanty-Mansi Autonomous District was to postpone increase of employment rates in the first years of economic growth (Figure 2.5). Oil companies also started to make fuller use of rotation schemes, bringing in employees from other regions, primarily from regions where oil production was declining. In 2002 rotation workers were 12% of all employees in Khanty-Mansi Autonomous District, but their share on the regional employment market was halved in subsequent years, as oil companies were forced to take account of negative impact for local inhabitants from increased competition for jobs.

In the Yamal-Nenets Autonomous District Gazprom made special efforts to maintain employment despite high costs, and sharp rises in unemployment were avoided. But such a policy only postponed resolution of the problem of inefficient and excessive employment, as has become evident in the new economic crisis of 2008–2009, which has been accompanied by a dramatic decline in gas production.

Unemployment in coal-mining regions peaked in the 1990s, after which employment restructuring programs were implemented in the coal industry, though with mixed success. Employment in coal-mining declined as a result of economic difficulties and corporate policies. Russia's biggest coal-mining regions are in southern Siberia, which has a relatively temperate climate and a number of large cities where former coal industry workers had a chance of finding new work. Shrinkage of the coal industry in the more northerly Komi Republic produced greater tensions, despite large-scale migration away from the Region.

By the end of the period of economic growth labor market conditions in fuel & energy regions were relatively good and the level of unemployment, as calculated in accordance with recommendations of the International Labor Organization, was close to the national average (Figure 2.5). Nevertheless, the employment level in fuel & energy regions, especially those with single-industry economies, is largely dependent on international fuel prices and therefore lacks stability.

Human development in fuel & energy regions is promoted by higher incomes. The ratio of average per capita personal incomes to the subsistence level in the single-industry oil &gas producing autonomous districts is 4.5-5 times. This level is only surpassed in Moscow, where it is 5.5 times. In other regions, which produce large quantities of fuel resources, the ratio is higher than the national average (3.3) or is close to it. Relatively high salaries of those employed in the fuel & energy sectors (particularly oil & gas production) have impact on income levels of the entire regional population. In the 1990s and early 2000s salaries in fuel & energy resource production industries exceeded average regional salaries by three times. This gap had narrowed somewhat by 2007 (to 2.5 times) due to wage increases in the budget-financed sector.

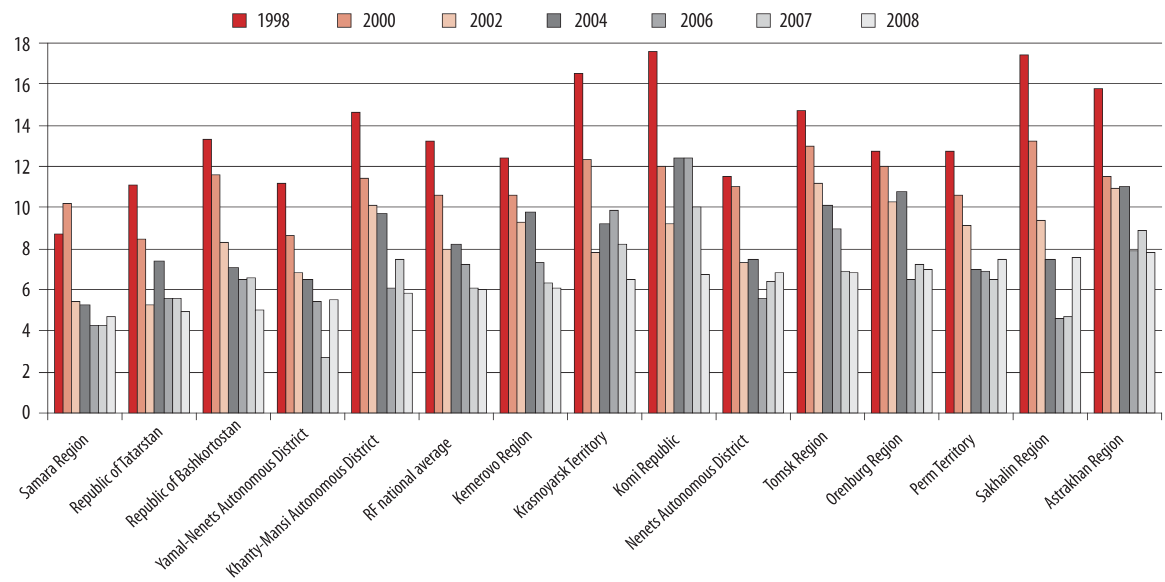
Strong differences in wages between industries and high cost of living in most fuel &

energy regions exacerbate the income gap between different groups of the population. The ratio of incomes of the wealthiest 10% of people to incomes of the poorest 10% in the autonomous districts of Tyumen Region and in the Nenets Autonomous District is 19-22 times, in Samara Region it is 19 times, and in Perm and Krasnoyarsk Territories, Komi Republic and Bashkortostan it is 18 times (the national average is less than 17 times). Of the 15 regions with the biggest income gap, 10 specialize in fuel extraction. However, all of them are far behind Moscow where the ratio is 41 times.

Large wage differences between sectors and high cost of living in many fuel and energy-oriented regions create special difficulties for low-income groups. High cost of living makes it necessary to divert more budget resources to support people on low incomes. Single-parent families, families with many children, households with handicapped members, the unemployed, and some other groups are particularly at risk. Retirees are vulnerable to poverty in northern and eastern territories, where the average pension lags 10-25% behind the minimum subsistence level. The problem was partially resolved by pension increases in the past few years, but in some Far Eastern regions the average pension was lower than the subsistence level even in 2007 (by 9% in Sakhalin Region and by 6% in Sakha (Yakutia)). Indigenous populations in Russia's northern territories also receive low incomes, especially those living in rural areas. The problem is less acute further south due to lower subsistence levels, particularly in the Republics of Tatarstan and Bashkortostan, where the agricultural sector is better developed and receives funding from the budget.

Negative impact of polarization of incomes is compensated by large-scale social policy. A very low poverty rate (6-7% in 2007) in the autonomous districts of Tyumen Region is not only due to high personal incomes. It is also due to per capita social expenditures of local budgets, which are 1.6-2 times higher than the national average (adjusted for differences in the cost of living). Rapid economic growth also contributes to reduction of poverty rates. Regions where new oil & gas fields are being developed (Nenets Autonomous District and Sakhalin) have seen rapid growth of budget revenues, leading to a sharp reduction of the poverty rate (by 3-6 times). In Tatarstan, the effect of rising budget revenues in reducing poverty was assisted by a low subsistence level. Nevertheless, in half of fuel & energy producing

Figure 2.5
Unemployment rate (ILO definition) as % of economically active population



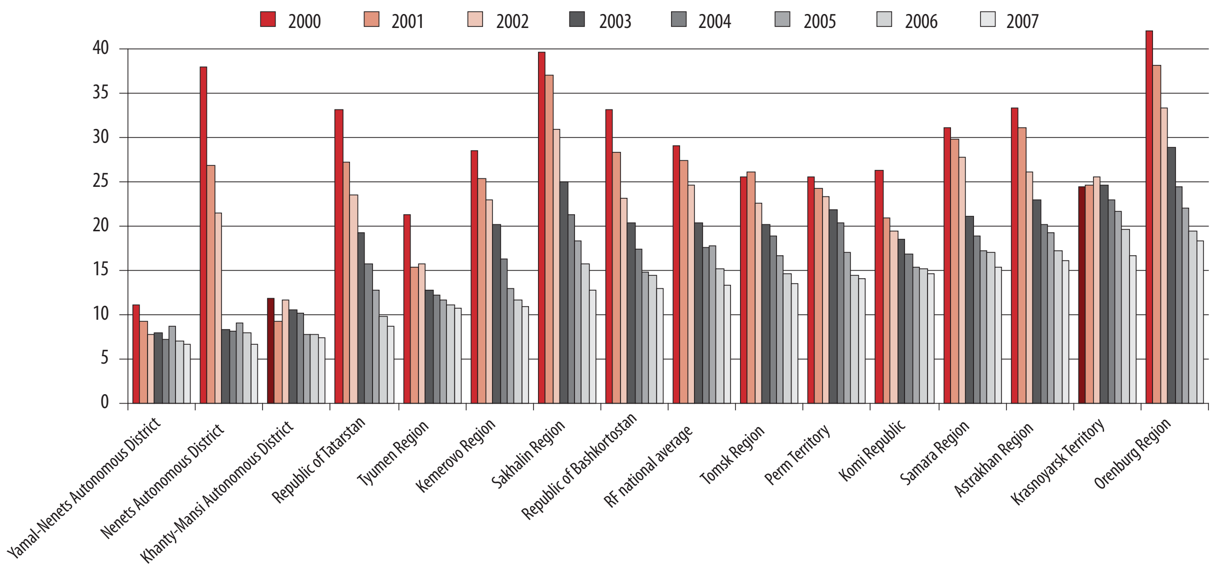
regions the poverty rate is higher, though not much higher, than the national average (Figure 2.6). Orenburg Region is in the worst situation, with a poverty rate of 18%, due to a large share of rural population.

Human development depends on health and education as well as on income levels. Educational coverage of children and young people and improvement of educational infrastructure are particularly important. Tomsk Region is beyond compare with respect to higher education. The number of students per 10,000 population in Tomsk Region is 1.7 times higher than the national average. In Tatarstan this index is 14% higher than the national average. However, most fuel & energy regions do not have large university centers. Vocational secondary education is relatively well provided in Astrakhan Region (the number of students at this level per 10,000 population is 1.5 times higher than the national average), and also in Bashkortostan, Perm and Krasnoyarsk Territories and in Orenburg Region (about 25% higher than the national average).

In Soviet times the northern autonomous districts received inputs of skilled labor from other regions. Since 1990 the districts have seen a boom in paid education. Many higher educational establishments from elsewhere in Russia opened branches in the districts, offering very low teaching standards. Regional government in Khanty-Mansi District then backed creation of a network of local educational institutions as part of an innovational development policy, gradually forcing out the branches. Three educational districts were organized with centers in Khanty-Mansi, Surgut and Nizhnevartovsk. This increased access to higher, vocational secondary and vocational elementary education for young people from rural areas and towns. Each center has a specialization: environment (Khanty-Mansi), oil & gas exploration (Surgut), construction and the power industry (Nizhnevartovsk). This programme placed a heavy financial burden on the regional budget, and some institutional funding problems had to be resolved: since 2005 Russian law has made higher education the jurisdiction of the federal government and stipulates that funding should come from the federal budget. Nevertheless, the number of students in Khanty-Mansi Autonomous District grew by 10 times between 1995 and 2008, compared with national average increase of 2.5 times.

Capacity problems in pre-school and school education are unresolved in most regions, though the problem is less acute in schools. Only

Figure 2.6
Poverty rate in regions specialized in fuel & energy production, %



Khanty-Mansi and Yamal-Nenets Autonomous Districts are forced to accommodate a larger share of school pupils in special afternoon shifts (25-29%, compared with a national average of 13.5%). This is a long-standing problem of the northern districts, reflecting their underdeveloped social infrastructure and young population. In Soviet time pupils in the districts had to be accommodated in three shifts. A high share of school pupils studying in the afternoon in Kemerovo Region (22%) reflected long-term deterioration of social infrastructure in coal-mining cities. While problems with school capacity are the exception, shortage of pre-school facilities is a common problem for all regions of Russia. But it is particularly acute in northern and eastern territories, where women are more economically active and more likely to be in employment. Kindergartens are most overcrowded in Sakhalin Region (118 children for 100 places), in Tomsk and Kemerovo regions (116) and in Khanty-Mansi Autonomous District (113).

Health, which is the second major component of human development, can be measured in various ways, and they present a rather confusing picture of the situation in fuel & energy regions. The most important health indicator – life expectancy at birth – is highest in the autonomous districts of Tyumen Region (69.3-70.2 years in 2007 vs. the national average of 67.5 years). Life expectancy for men in these districts (63.8-66.6 years) is even higher than the national average (61.4 years). High per capita incomes enable better diet and recreation, and high levels of budget funding ensure good-quality medical care. Strong competition for highly-paid jobs also motivates a healthy lifestyle. This 'carrot and stick' effect has proved effective in achieving high life expectancy.

Nevertheless, even high-income regions have some intractable health problems. The lowest life expectancy among oil & gas regions is in the Nenets Autonomous District (62 years), where a quarter of the population is indigenous minorities of the Far North, living mostly in rural areas. Male life expectancy in rural areas is extremely low at 48 years, due to widespread alcoholism. Other fuel & energy regions in the east of Russia, with a longer history of industrialization and underdeveloped social infrastructure, also have low life expectancies: coal-mining Kemerovo and Chita Regions (63-64 years), Sakhalin Region (64.5 years) and Perm Territory (65 years). Male life expectancy is particularly low (57-58 years) due to unhealthy life styles in industrial towns and settlements, as well as in rural areas. People's incomes in these regions are not as high as in Tyumen, and budget funding is much lower.

Tuberculosis is a common problem in eastern parts of the country, but the explanation is in high concentration of penitentiary institutions, adverse climate and an underdeveloped health care system, rather than the fuel & energy specialization of regional economies. HIV/AIDS is a typical problem for many export-oriented resource manufacturing regions. Higher personal incomes, combined with underdeveloped social environment, promote drug addiction, which in turn promotes HIV/AIDS. Data of the AIDS Prevention and Control Center for the period from 1989 to mid-2009 shows particularly high levels of infection in Samara Region (1171 per 100,000 people), especially in Togliatti. In large fuel & energy regions the worst situation is in Orenburg (912 per 100,000) and in Khanty-Mansi Autonomous District (852 per 100,000).

Infant mortality is the most telling indicator for standards of health care and health care funding, though differences in living standards and ethno-cultural factors also play an important role. Priority funding of health care and creation of special high-tech medical centers have helped to bring down infant mortality and keep it at low levels in Khanty-Mansi District (Figure 2.7).

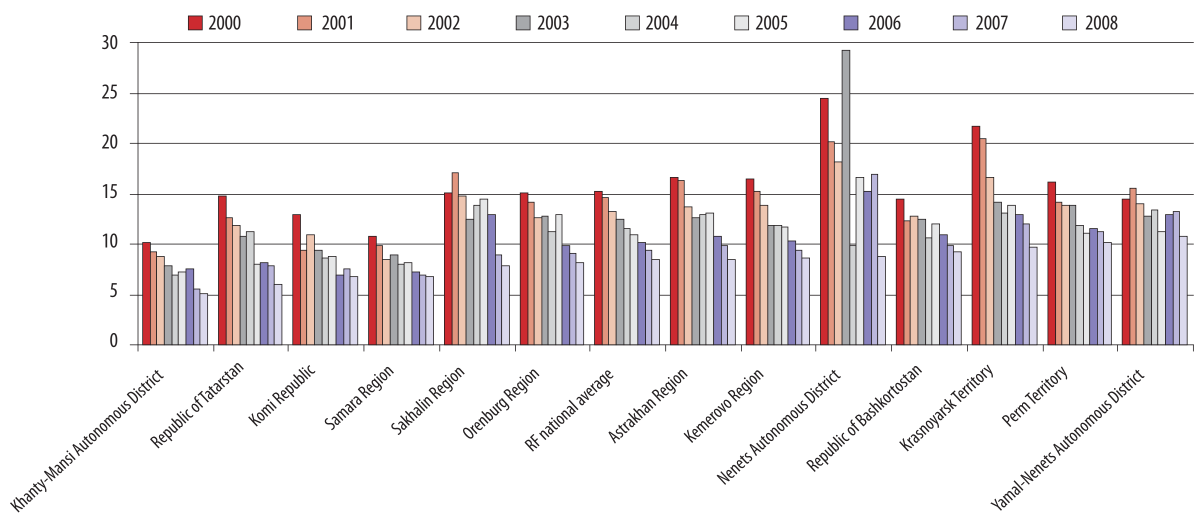
Analysis shows that only regions with vast fuel resources, where personal incomes and budget revenues are consequently very high, have been able to increase life expectancy and reduce infant mortality. But even high incomes are not enough to overcome social diseases. The whole social environment and lifestyle needs to be upgraded, and the educational system requires more complex development. In regions where budget and household incomes are not so high, fuel and energy orientation does not give any clear social development advantages.

2.4. The crisis and its social aftermath in fuel & energy regions

In the new economic crisis, which began in the fall of 2008, specialization in the fuel industry acted as safety net for regions once again, though not for all regions. Levels of industrial output held up best in single-industry oil extraction regions: in Khanty-Mansi Autonomous District and Tomsk Region industrial output in H1 2009 was only 2% lower y-o-y (i.e. compared with the same period of the previous year), while Sakhalin Region and Nenets Autonomous District showed y-o-y growth of 22-39%. These figures compare with average shrinkage of Russian industrial production by 15% y-o-y in the first half of 2009. In oil producing regions with more diversified economies severity of the crisis was partly determined by the state of other industries: decline of industrial output was moderate (between 8% and 14%) in Bashkortostan, Tatarstan and Orenburg Region, but problems in the machine-building industry led to a particularly acute recession (29% output decline) in Samara Region. The situation in the gas industry has been more difficult than in the oil industry, so recession rates in major gas-producing regions have been much higher (15% in Yamal-Nenets Autonomous District and 19% in Astrakhan Region). Kemerovo Region experienced the worst decline among coal-mining areas (19%), but that was mainly due to problems in the local steel industry, which suffered particularly badly as a result of the economic crisis.

The social aftermath of the crisis has two vectors. The first has been a sharp decline in budget revenues of more developed regions, regardless of acuteness of their industrial decline. Before the crisis the share of profit tax in budgets of these regions was as high as 20-45%. Falling prices on international markets dramatically reduced corporate incomes, and profit tax payments in resource-oriented regions fell by between 2 and 9 times. As a result, own budget revenues (both tax and non-tax) in Kemerovo and Tyumen regions fell by 30-35%, revenues in Khanty-Mansi Autonomous District and Krasnoyarsk Territory were down by a quarter, and the budget of Samara Region lost 20% of revenues raised inside the region. A forecast by

Figure 2.7
Infant mortality per 1000 live births

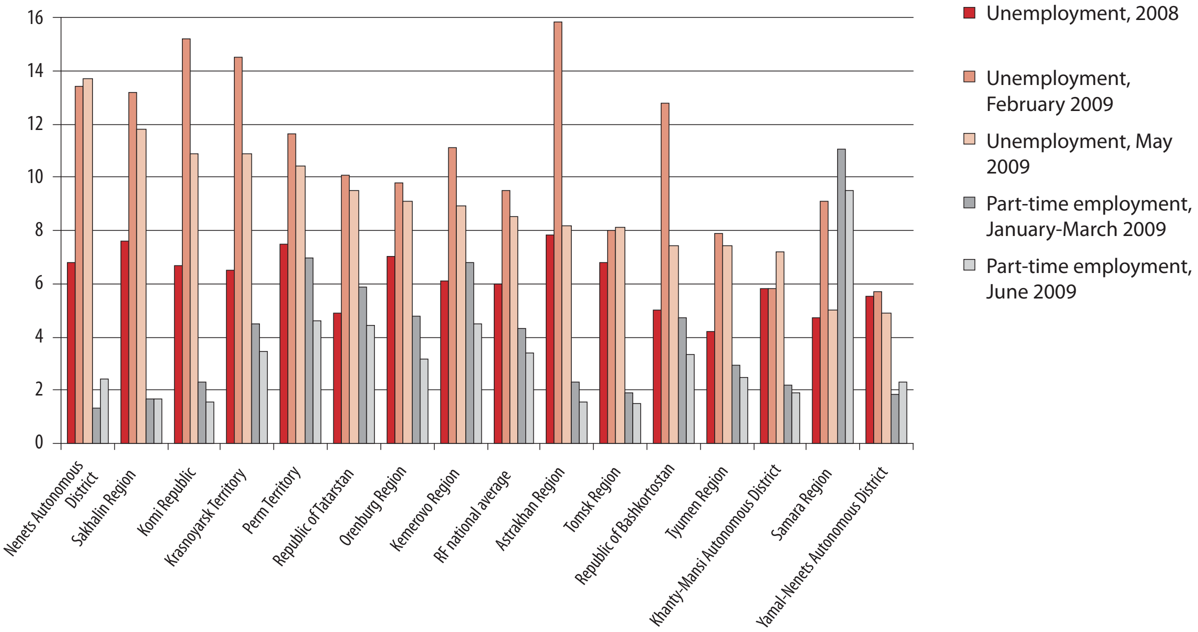


the Ministry for Regional Development predicts that negative difference between actual and expected budget earnings in 2009 will be largest in Tyumen Region (59%), Khanty-Mansi Autonomous District (38%), Republic of Tatarstan (25%), Perm Territory and Yamal-Nenets Autonomous District (20%), i.e. in all the leading oil & gas producing regions of the country. This will inevitably lead to reduction of social spending (purchases of new equipment for social purposes will be most affected), though local government has promised to maintain social payments and wages of employees in the budget sector.

The other main social consequence of the crisis is unemployment. Regions specializing in machine-building and metallurgy have been hardest hit, because these industries suffered most from the recession and because they are more labor-intensive. Highest rates of unemployment in early 2009 among fuel & energy regions were in Komi, Krasnoyarsk Territory, Astrakhan and Sakhalin Regions, and Nenets Autonomous District, all of which had unemployment rates above the national average (Figure 2.8). Quarterly surveys of regional labor markets are insufficiently accurate, but trends are clear. Firstly, the autonomous districts of Tyumen Region (Russia's largest oil & gas producers) have been able to avoid a surge of unemployment. Secondly, the situation in regions, which had higher unemployment rates even before the crisis, is now worse. Thirdly, in addition to job losses, there has been a growing tendency towards part-time employment, which is a form of concealed unemployment. The tougher the recession (e.g. in Samara and Kemerovo Regions, and in Perm Territory), the more frequently private businesses tried to reduce costs by switching their employees to part-time work. Employment issues came to a head in Q1 2009 and tension on the labor market had started to subside by the summer, albeit slowly. However, the improvement may be seasonal, in which case a new wave of unemployment should be expected in the fall of 2009.

Growth of unemployment and hidden unemployment should be accompanied by decline of personal incomes, but the decline has been minimal to date: in January-May 2009

Figure 2.8
Unemployment (ILO standards) as % of economically active population and part-time employment (those working part-time and temporarily laid off, % of average employee headcount)



average per capita household incomes were down by less than 1% y-o-y. Monthly regional statistics are not very precise and trend fluctuations are very large, so a final assessment will not be possible until full-year figures are available. However, comparison of salaries, consumer expenditures and development of retail trade turnover shows rapid shrinkage of consumption in oil &gas regions. The same is true in the Moscow and St. Petersburg agglomerations, and other regions with main cities that have more than a million inhabitants. People in these regions have adapted relatively quickly to 'crisis risks; and have changed their consumption behavior accordingly.

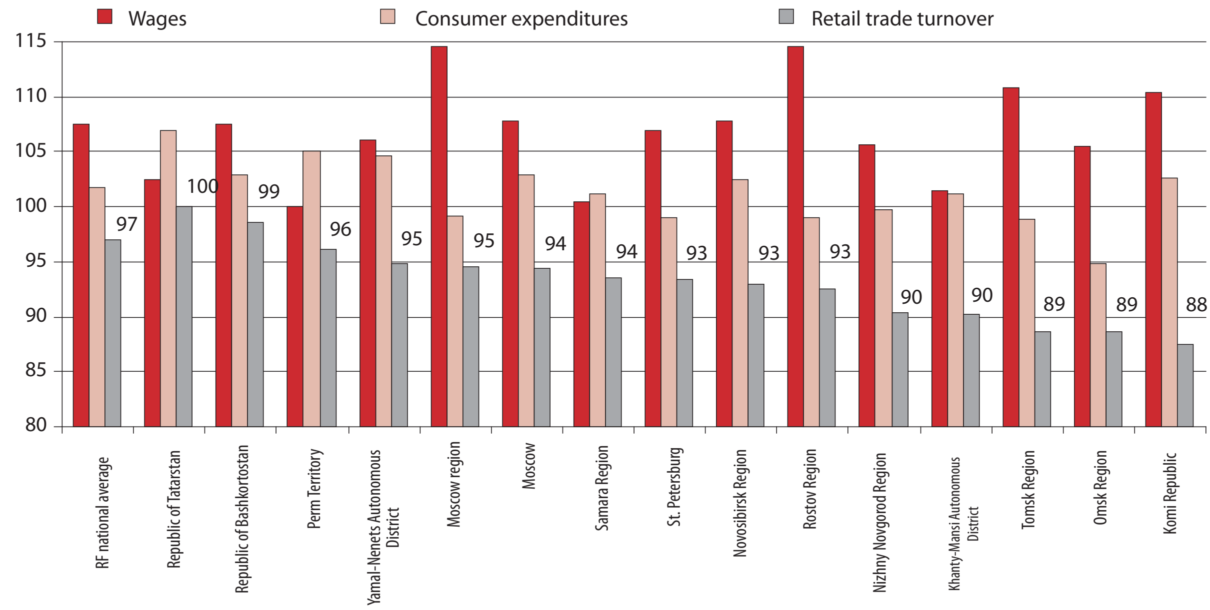
So less steep decline of industrial production in fuel industry regions did not spare them from social impact of the crisis. Budgets of these regions, together with budgets of regions specializing in metallurgy, suffered more than others. Half of fuel & energy regions reported sharp increases of unemployment. Companies are cutting costs and jobs are being lost both in the fuel sector itself and in auxiliary industries and services. However, it should be noted that, in regions with other industries in addition to fuel, the main contribution to unemployment, and especially to hidden unemployment (part-time work), came from other industries and not from fuel & energy.

2.5. Summary and recommendations

Is it possible for wealthy resource mining regions to lead human development? There is no clear answer. Only 2-3 oil & gas producing regions with the best fiscal capacity have financial resources for upgrading their social infrastructures. But these are northern regions with low population, where higher investments in social infrastructure are swallowed up by high costs of construction and operation of schools and hospitals. Besides, high fiscal capacity only creates advantages when expenditure priorities are correctly defined. Otherwise social problems pile up, as has happened with pre-school education. Rapid growth of budget revenues is not necessarily accompanied by rapid growth of social expenditures, and this is true not only in fuel & energy regions.

Sustained development of single-industry northern regions has to contend with

Figure 2.9
Wage trends (May 2009 vs. May 2008), consumer expenditures (May 2009 vs. May 2008) and retail trade turnover (H1 2009 vs. H1 2008) in several regions of the Russian Federation, %



various other long-term problems in addition to financing. These regions find it difficult to diversify their economies due to negative impact of rising prices, which lowers competitiveness of non-resource industries. Nevertheless, human development potential in these regions can be realized if more funding is combined with institutional modernization of the social environment, increasing efficiency of such investments.

There are much greater opportunities for human development in regions with diversified economies, large cities, more 'modernized' life style, and established networks of social services. But Russia's centralization means that these regions are strictly limited in their efforts by shortage of financial resources and of authority to act. The new crisis has once again demonstrated that the existing relationship between the center and the regions lacks stability and does not stimulate institutional modernization of more developed regions. In such regions the main vector of development, set by federal government, should be supplemented by competition between social practices, helping these regions to choose a path of development that will help them to attract and retain the most scarce of Russia's resources – people.

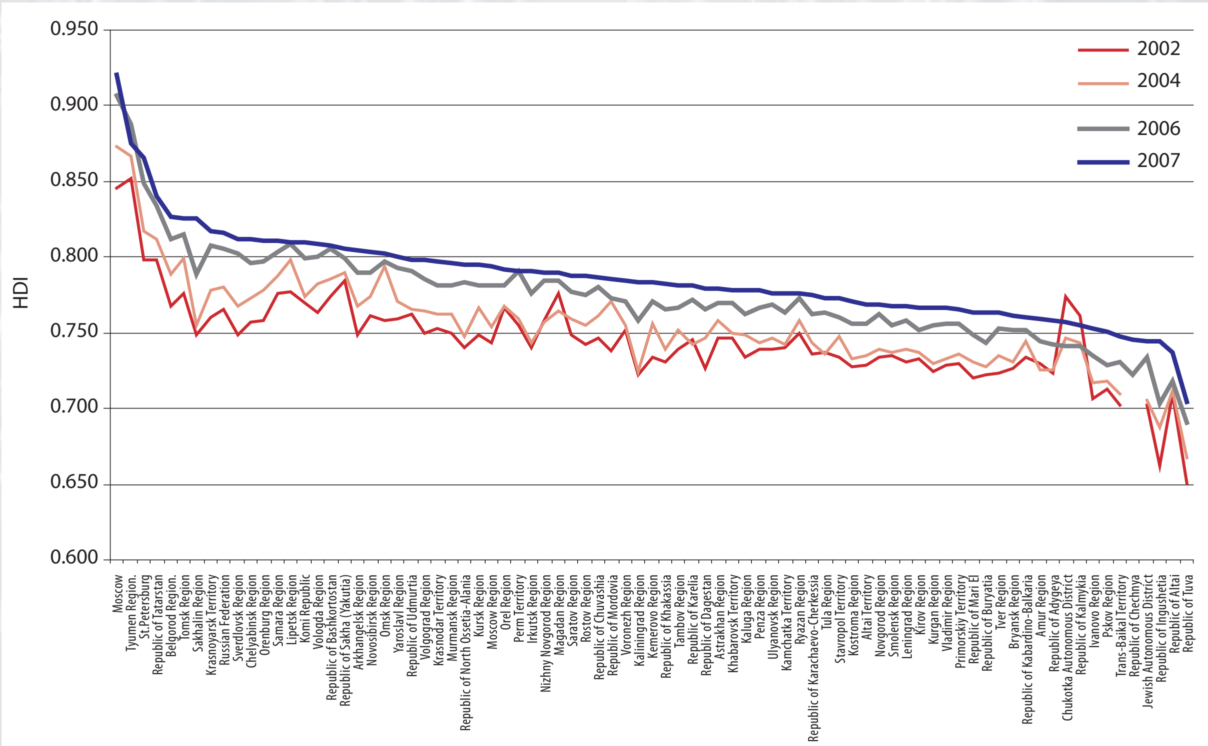
Box 2.1. Human Development Index

In 2007 over a quarter of Russia's regions (22 out of 80)[1] were rated as 'developed' in terms of the Human Development Index (HDI). The cut-off point for this group is a score of 0.800 (Table 2.1.1). In 2006 only half as many regions (12) were rated as developed. Russia's leading group of regions moved up the rankings due to the income index, whose contribution to the HDI became even greater. Almost half of this group consists of fuel & energy extraction regions (italicized). If regions specializing in crude oil processing are added, more than half of the group are fuel & energy regions. But fuel & energy industries are not alone in boosting regional HDI levels: regions that specialize in metallurgy enjoy the same advantages.

Moscow remains the runaway leader with HDI exceeding 0.900, far in advance of all other regions. Tyumen Region can no longer compete with the capital as it used to in the early 2000s, despite having highest per capita Gross Regional Product (GRP) thanks to its autonomous districts, which are the biggest oil & gas producers in Russia. The reason for this is that the formula for HDI calculation limits the maximum income level: after reaching USD 40,000 at Purchasing Power Parity (PPP) the income index becomes 1.00 and stops growing. Per capita indicators of GRP are much higher in Tyumen Region, but they do not add advantages, while the region is far behind Moscow by other HDI components. HDI of St.Petersburg is even farther back because its per capita GRP is twice smaller than Moscow. As was explained above, Moscow obtains these advantages because it hosts the head offices of Russia's largest corporations, primarily oil & gas corporations. Some big corporations are starting to relocate to St.Petersburg, which will definitely increase the income index in Russia's northern capital. Factually, though, the two federal cities are redistributing oil rent for their benefit.

Besides the growing number of high HDI regions there is also an encouraging trend of rising HDI in the most underdeveloped regions, especially in the republics of the North Caucasus (Figure 2.1.1). Even among the outsiders, there is no longer any region with HDI lower than 0.700. This positive trend

Figure 2.1.1
Regional HDI ratings



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[1] Except the Chukotka Autonomous District. The index is not calculated for other districts as they are included in the data for other regions.

is also associated with the fuel and energy sector. High oil & gas prices enriched the federal budget, which could therefore afford to increase funding of the least developed regions. It is doubtful that increasing financial transfers have been used efficiently and approaches to solving many social problems are clearly unsatisfactory, but growing GRP has enabled the outsider regions to increase their HDI ratings, at least nominally.

Rating of the regions is inadequate for evaluating human development potential, because Russia's regions vary tremendously in population, from 10.5 million down to 50,000 people. Population distribution across regions with different HDI ratings gives a more accurate picture (Figure 2.1.2). This form of assessment shows Russia's HDI progress even more clearly: in 2007 one third of Russia's population lived in high HDI regions, while the share just one year earlier was below 25%. In five years the number of people living in regions with low HDI (between 0.700 and 0.750) has decreased by 10 times and there are no longer any regions with ultra-low HDI (less than 0.700).

Overall 2007 was a successful year for human development in Russia. But it should be remembered that improvements were mainly due to increasing incomes, associated with price movements on international fuel and metal markets. The crisis that began in 2008 could upset this trend, due to falling prices on world markets. Life expectancy indicators also grew in 2007, particularly in the most problematic eastern regions, where longevity has been particularly low. More federal funding for health care, including implementation of the 'Health' national project, helped to improve the situation. However, from 2009 the financing system has been changed and responsibility for implementation of national projects has been transferred to regional administrations. Their fiscal capabilities are not equal to the task, particularly in the post-crisis environment.

Forecasts in an unstable environment are not reliable, but it is very likely that the sustained growth of regional HDI ratings seen in 2007 will not continue. That growth smelt too strongly of oil.

Figure 2.1.2
Breakdown of Russia's population between regions with different HDI ratings, %

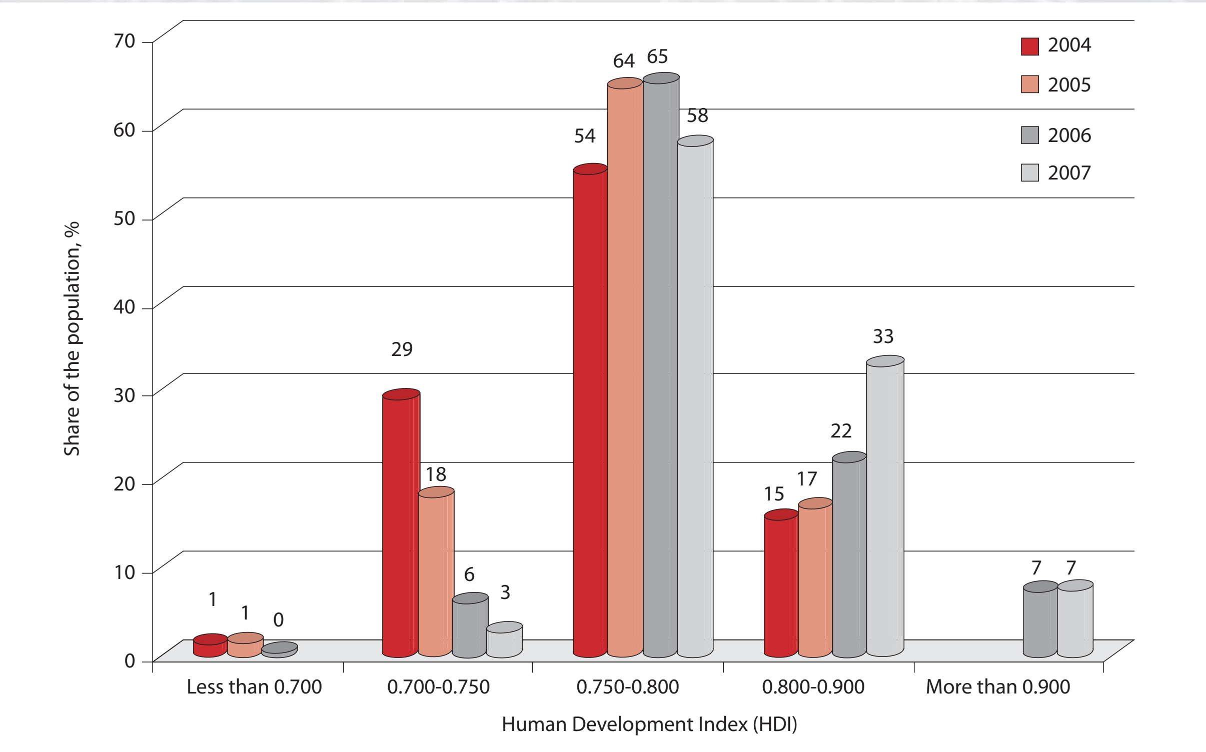


Table 2.1.1. HDI ratings in 2007

	GDP, USD at PPP	Income Index	Life Expec-tancy	Lifespan Index	Literacy, %	Students aged 7 - 24, %	Education Index	HDI	Rating
Russian Federation	**14737**	**0.833**	**67.51**	**0.709**	**99.4**	**0.735**	**0.908**	**0.817**	
Moscow	33603	0.971	72.5	0.792	99.8	1.000	0.999	0.920	1
Tyumen Region	49969	1.000	68.57	0.726	99.2	0.717	0.900	0.876	2
St.Petersburg	16817	0.855	69.86	0.748	99.8	0.988	0.995	0.866	3
Republic of Tatarstan	18080	0.867	69.44	0.741	99.0	0.756	0.912	0.840	4
Belgorod Region	13738	0.822	70.33	0.756	98.6	0.734	0.902	0.826	5
Tomsk Region	14892	0.835	67.68	0.711	98.9	0.814	0.931	0.826	6
Sakhalin Region	26657	0.932	64.48	0.658	99.4	0.669	0.886	0.825	7
Krasnoyarsk Territory	17758	0.864	66.58	0.693	99.0	0.706	0.895	0.818	8
Sverdlovsk Region	14190	0.827	67.5	0.708	99.2	0.720	0.901	0.812	9
Chelyabinsk Region	13664	0.821	67.14	0.702	99.1	0.752	0.911	0.811	10
Orenburg Region	15596	0.843	66.68	0.695	98.9	0.710	0.896	0.811	11
Samara Region	13097	0.814	67.19	0.703	99.2	0.762	0.915	0.811	12
Lipetsk Region	15373	0.840	67.31	0.705	98.4	0.683	0.884	0.810	13
Komi Republic	16228	0.849	65.83	0.681	99.2	0.710	0.898	0.809	14
Vologda Region	14611	0.832	66.96	0.699	98.8	0.713	0.896	0.809	15
Republic of Bashkortostan	12791	0.810	67.81	0.714	98.8	0.722	0.899	0.807	16
Republic of Sakha (Yakutia)	13629	0.820	66.17	0.686	99.0	0.754	0.911	0.806	17
Arkhangelsk Region	15149	0.838	66.27	0.688	99.2	0.681	0.888	0.805	18
Novosibirsk Region	10738	0.781	67.43	0.707	98.8	0.795	0.924	0.804	19
Omsk Region	12574	0.807	66.54	0.692	98.7	0.749	0.908	0.802	20
Yaroslavl Region	11745	0.795	67	0.700	99.2	0.735	0.906	0.801	21
Republic of Udmurtia	11973	0.799	66.59	0.693	99.0	0.732	0.904	0.799	22
Volgograd Region	10178	0.772	68.84	0.731	98.9	0.701	0.893	0.798	23
Krasnodar Territory	10003	0.769	69.25	0.738	99.0	0.676	0.885	0.797	24
Murmansk Region	13032	0.813	66.72	0.695	99.6	0.651	0.881	0.796	25
Republic of North Ossetia-Alania	7174	0.713	71.74	0.779	99.1	0.696	0.893	0.795	26
Kursk Region	9431	0.759	66.66	0.694	98.5	0.822	0.931	0.795	27
Moscow Region	13587	0.820	66.93	0.699	99.6	0.601	0.864	0.794	28
Orel Region	8969	0.750	67.23	0.704	98.9	0.787	0.922	0.792	29
Perm Territory	12804	0.810	65.23	0.671	98.9	0.702	0.893	0.791	30
Irkutsk Region	12267	0.803	64.9	0.665	99.1	0.730	0.904	0.791	31
Nizhny Novgorod Region	10744	0.781	65.58	0.676	98.9	0.761	0.913	0.790	32
Magadan Region	11549	0.793	63.57	0.643	99.6	0.810	0.934	0.790	33
Saratov Region	8710	0.746	68.01	0.717	99.2	0.720	0.901	0.788	34
Rostov Region	8288	0.737	68.38	0.723	99.1	0.727	0.903	0.788	35
Republic of Chuvashia	8580	0.743	67.39	0.707	99.0	0.752	0.911	0.787	36

Republic of Mordovia	8051	0.732	68.4	0.723	97.9	0.748	0.902	0.786	37
Voronezh Region	7800	0.727	67.52	0.709	98.3	0.787	0.918	0.785	38
Kaliningrad Region	10784	0.781	65.79	0.680	99.4	0.683	0.890	0.784	39
Kemerovo Region	13402	0.817	64.01	0.650	98.9	0.672	0.883	0.784	40
Republic of Khakassia	9404	0.758	66.19	0.687	98.8	0.732	0.903	0.782	41
Tambov Region	8343	0.738	67.9	0.715	98.1	0.712	0.891	0.782	42
Republic of Karelia	11437	0.791	65.12	0.669	99.2	0.664	0.883	0.781	43
Republic of Dagestan	5439	0.667	74.21	0.820	98.4	0.586	0.851	0.780	44
Astrakhan Region	8675	0.745	67.02	0.700	98.6	0.701	0.891	0.779	45
Khabarovsk Territory	9517	0.760	64.76	0.663	99.5	0.747	0.912	0.778	46
Kaluga Region	9255	0.756	66.64	0.694	99.2	0.673	0.886	0.778	47
Penza Region	7339	0.717	68.3	0.722	98.4	0.722	0.897	0.778	48
Ulyanovsk Region	8293	0.737	66.97	0.700	98.6	0.705	0.892	0.776	49
Kamchatka Territory	8862	0.748	66.15	0.686	99.7	0.687	0.894	0.776	50
Ryazan Region	8511	0.742	65.61	0.677	98.7	0.753	0.909	0.776	51
Republic of Karachaevo-Cherkessia	5892	0.680	71.28	0.771	98.4	0.651	0.873	0.775	52
Tula Region	9469	0.760	65.01	0.667	99.1	0.698	0.893	0.773	53
Stavropol Territory	6316	0.692	69.49	0.742	98.6	0.684	0.885	0.773	54
Kostroma Region	8650	0.744	66.27	0.688	98.8	0.666	0.881	0.771	55
Altai Territory	7491	0.720	67.22	0.704	98.2	0.683	0.882	0.769	56
Novgorod Region	10322	0.774	63.96	0.649	98.9	0.670	0.883	0.769	57
Smolensk Region	8646	0.744	64.46	0.658	98.9	0.726	0.901	0.768	58
Leningrad Region	14159	0.827	64.58	0.660	99.5	0.461	0.817	0.768	59
Kirov Region	6974	0.708	67.02	0.700	98.4	0.706	0.891	0.767	60
Kurgan Region	7141	0.712	66.66	0.694	98.4	0.708	0.892	0.766	61
Vladimir Region	8040	0.732	65.3	0.672	99.4	0.696	0.895	0.766	62
Primorskiy Territory	7930	0.730	65.11	0.669	99.5	0.705	0.898	0.766	63
Republic of Mari El	7412	0.719	66.16	0.686	98.8	0.685	0.887	0.764	64
Republic of Buryatia	8134	0.734	64.2	0.653	98.8	0.732	0.903	0.763	65
Tver Region	8858	0.748	63.99	0.650	99.1	0.689	0.890	0.763	66
Bryansk Region	7050	0.710	66.11	0.685	98.6	0.696	0.889	0.762	67
Republic of Kabardino-Balkaria	5173	0.659	71.18	0.770	98.8	0.582	0.853	0.760	68
Amur Region	8596	0.743	63.93	0.649	99.3	0.670	0.885	0.759	69
Republic of Adygeya	5325	0.663	68.77	0.730	98.7	0.674	0.883	0.759	70
Chukotka Autonomous District	15614	0.843	58.72	0.562	99.4	0.614	0.867	0.757	71
Republic of Kalmykia	5131	0.657	68.35	0.723	98.2	0.688	0.884	0.755	72
Ivanovo Region	5696	0.675	65.55	0.676	99.3	0.735	0.907	0.753	73
Pskov Region	7410	0.719	64.09	0.652	98.9	0.666	0.881	0.750	74
Trans-Baikal Territory	7969	0.731	63.01	0.634	98.8	0.659	0.878	0.748	75
Republic of Chechnya	3257	0.581	74.28	0.821	96.0	0.581	0.834	0.745	76
Jewish Autonomous District	8935	0.750	61.94	0.616	99.1	0.623	0.868	0.745	77
Republic of Ingushetia	2548	0.540	79	0.900	96.2	0.450	0.791	0.744	78
Republic of Altai	5617	0.672	64.33	0.656	98.3	0.682	0.883	0.737	79
Republic of Tuva	5022	0.654	59.16	0.569	99.1	0.691	0.891	0.705	80

Box 2.2. The energy sector and indigenous minorities of the Russian North

Current status of indigenous minorities in the Russian North

Large energy facilities which are already operating, under construction, or planned in northern Russia, Siberia and the Russian Far East are mostly located in areas, where small, indigenous minorities are engaged in traditional natural resource use. The energy projects affect these minorities and their environment.

In its report, 'Legal Support for Ethnological Audits as a Compulsory Condition for Development of Northern Territories', issued for parliamentary hearings in the Federation Council, the Council's Committee for Northern Territories and Indigenous Minorities has published the following conclusions of the Federal Real Estate Cadaster: "Since the 1930s the structure of natural resource use and concepts for development of northern territories have prioritized industrial development at the expense of traditional sectors, leading to pollution and environmental degradation over vast areas, causing disturbance and loss of the most valuable grazing and agricultural land ... Reindeer pastures have been particularly badly damaged … the ecological situation has been destabilized due to stress exerted by industrial facilities on reindeer pastures and hunting areas, amounting to as much as 40% of the territory where traditional natural resource use is practised."

Industrial development of the North, Siberia and the Far East has done much to change the local demographic situation, and experts are concerned about the current socio-economic and demographic status of native minorities.

These areas are inhabited by over 250,000 people representing 40 indigenous minorities, which are listed in the official register of indigenous small-numbered peoples of the North, Siberia and the Far East. Criteria for inclusion in the register are adherence to a traditional way of life and total ethnos size under 50,000 people.

Russia's northern territories, particularly rural areas, are also inhabited by descendants of larger Slavic and non-Slavic peoples, which have traditionally lived here, including the Komi, the Karels, Yakuts, Pomors and half-blood descendants of the first Russians, who came to these regions and have been living there now for over 300 years. These small nations and population groups are not registered as indigenous minorities, but in most cases they have a similar way of life and depend fully on the local environment, making their living from hunting, fishing, gathering and cultivation. Ethnographers estimate their total number at around one million people.

More than 75% of these peoples live in rural areas, and those who are in towns and cities maintain close ties with their families in the countryside, supplementing their incomes by traditional seasonal activities (hunting, fishing and gathering) in their places of origin. Around half of the population of northern territories breeds reindeer.

The way of life is self-supporting and relies on use of traditional natural resources. Unemployment among indigenous peoples rose by 8 times in the last decade of the 20th century compared with 3.5 times in Russia as a whole, and cash incomes are 2-3 times lower than the national average. The number of births in 2002 was only 69% of the 1995 level, while the mortality rate had risen by 35.5%. Average life expectancy of males among native minorities is 10-20 years lower than the national average at 45 years. The epidemiological and public health situation in these areas has significantly worsened, and tuberculosis and alcohol addiction rates are much higher than the national average.

The share of deaths from external causes (accidents, suicides, murders) is very high among northern peoples: in 1998–2001 it was 37%, compared with the Russian national average of 14% and much lower figures in developed countries (under 8% in Finland in the same period, 6% in the US in 1998, and even lower in other European countries). Current birth and mortality rates place indigenous minorities in a particularly high-risk group, and serious damage to the environments, on which they rely for their livelihood, could lead to their complete disappearance[1].

[1] D.D.Bogoyavlenskiy. Are the minorities of the North dying out?//Social studies, 2005, 8, pp.55-61. D.D. Bogoyavlenskiy. 2008 http://www.npa-arctic.ru /Documents /conferences/climat_19052008 /Presentations /19.05.08 /bogoyavlensky.pdf

Legislative control of impact audits for energy projects affecting traditional human habitat and habitat and way of life

Russian federal laws do not contain precise standards for assessing the impact of industrial projects on the traditional habitat and way of life of local minorities, or for compensating damage. The Federal Law, 'On guarantees of the rights of indigenous small-numbered peoples of the Russian Federation' (Article 1) introduces the notion of 'ethnological expert assessment', which is defined as 'assessment of the impact of changes in the natural habitat and socio-cultural environment of indigenous minorities on their ethnic development'. The same law, as well as some other Russian laws, gives indigenous minorities the right to take part in decision-making on issues concerning protection of their natural habitats and traditional way of life, as well as indemnification of losses incurred by them as a result of damage to their natural habitat (Article 8 of the abovementioned law). Theoretically, this is a good foundation for resolving the problem, but in reality, since local populations have no legal ownership rights to the land where they live, hunt, fish or breed reindeer, companies do not consider themselves obliged to obtain the approval of local inhabitants before proceeding with development projects. There is also an absence of stated procedures for conducting an 'ethnological expert assessment', assessment of specific damage to habitat and people who live by it, and mechanisms for use of any compensation.

At the regional level, only 5 out of 27 northern administrative regions with their own indigenous peoples have local laws that oblige industrial companies to negotiate with representatives of these peoples and obtain their approvals (Nenets, Yamal-Nenets and Khanty-Mansi Autonomous Districts, Republic of Sakha (Yakutia) and Sakhalin Region). In practice, lack of appropriate laws at federal level means that industrial corporations can challenge these regional provisions or dictate their own conditions. It is much simpler for large corporations to pay specified amounts of money to regional and local governments, or, in some cases, to make payments to organizations that represent indigenous minorities, than to negotiate and seek specific agreements with those peoples. Companies try to avoid active cooperation with native peoples on issues such as joint environmental monitoring of projects, joint resource management, design verification, and training and employment of local inhabitants.

Positive instances of energy companies cooperating with indigenous minority organizations have been the exception rather than the rule to date. Example are: agreements on social and economic assistance to communities and reindeer farms in the Nenets and Khanty-Mansi Autonomous Districts (made by the companies Northern Lights, Lukoil Komi, LUKoil Western Siberia); a tripartite agreement on cooperation between the administration of Yamal-Nenets Autonomous District, the indigenous minority organization 'Yamal – for our Descendants!' and the companies Gazprom, NOVATEK, Rosneft, Lukoil, TNK-BP; organization of the first environmental council in Yamal District; and implementation since 2006 of the Programme for Assistance to Indigenous Minorities in Sakhalin Region by representatives of local indigenous minorities together with Sakhalin Energy and the administration of Sakhalin Region. However, all of these initiatives have been put together by regional administrations, companies themselves and indigenous minority organizations, without federal government coordination. The same companies, which participate in these programmes, take a completely different stance in regions where regional government and minority organizations do not have a strong voice[2].

The issue of legitimate interaction between initiators of energy projects and local populations should be resolved at federal government level. Leadership from federal government is essential if

[2] O.A. Murashko (compilation). Environmental co-management of resource companies, local administrations and indigenous minorities, M. 2009

harmonious relationships, partnership and observance of the rights of indigenous minorities to their habitats and way of living are to become the rule. Obligations of the state and business towards indigenous minorities and local populations, during mineral extraction projects and construction of energy facilities in areas of traditional habitat and resource use, need to be stated in federal law, which should contain a proper mechanism for protecting small ethnic groups, their habitats and traditional lifestyles, in accordance with the Russian Constitution.

Climate change, the energy sector and indigenous minorities in the North of Russia

Researchers have found that the consequences of climate change[3] create additional threats to the traditional environment of native populations in the Russian North. These consequences could be particularly dangerous in areas around energy facilities. A state programme for preventative and adaptation measures is therefore needed in order to help indigenous and rural populations in northern regions to deal with anticipated climate change (Table 2.1.1).

Table 2.1.1

Anticipated climate change impacts	Impact on traditional way of life and natural resource use by indigenous peoples	Options for alternative employment and lifestyle modernization for indigenous peoples
Increase of load and accident risk on high-voltage power lines due to temperature fluctuations and increased frequency of dangerous weather phenomena. Soil movements in permafrost melting areas create risks for operation of buildings and facilities (including transportation infrastructure, such as roads and airfields) and trunk pipelines. More intense storms and coastal erosion, causing damage to coastal facilities and infrastructure, including oil terminals and pipelines. Increased access to new mineral resource deposits, encouraging arrival of new population in search of jobs.	Large reindeer herds, which are the main livelihood for half of the indigenous population, will be most affected. Reindeer herding is already under pressure as a result of more frequent ice-crust formation, which causes hunger and death. Damage to infrastructure in settlements and accidents at industrial facilities will further diminish lands where traditional resource use can be practiced, leading to impoverishment of the local population. Arrival of new migrants, drawn by new mineral resource exploitation could further marginalize the local population, narrowing the scope for traditional land-use practices (due to competition with new comers in hunting, etc.) and leading to changes in traditional lifestyle and diet.	Adaptation options: - Migration to areas not spoiled by industrialization and modernization of traditional occupations; - Development of deep processing for the products of traditional land-use practices; - Development of new businesses (folk art and marketing of traditional natural products). Attempts at urban assimilation of indigenous peoples will completely change their lifestyle and diet, and will cause stresses. Negative impact of industrialization on the local population could be minimized through prophylactic public health measures, adapting the education system to take account of specific features of indigenous minorities, and selection of areas where traditional lifestyles can be preserved.

[3] Assessment report on climate change and its consequences in the Russian Federation, Roshydromet, 2008. Climate change impact on the Russian Arctic: analysis and solutions. WWF Russia, M. 2008, p.28, www.unfccc.int

Chapter 3 Personal Incomes, the Energy Sector and the Crisis

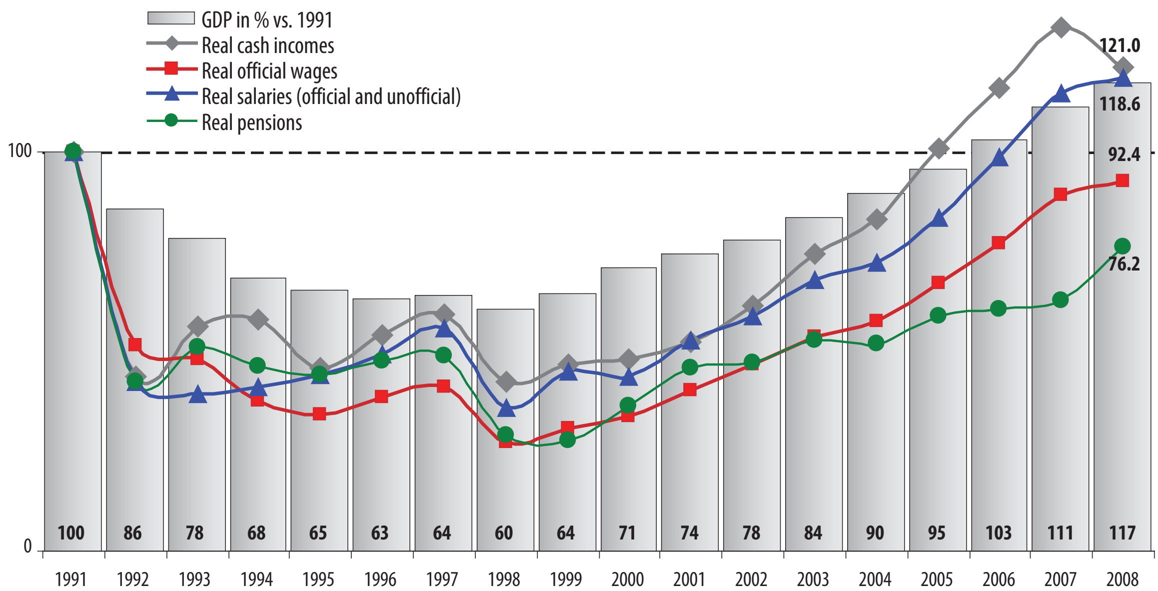
One of the three components of the Human Development Index (HDI) is calculated by assessing levels of income – mainly wage income of employees – and differences between income levels. So analysis of processes that determine income and employment trends is an integral part of any human development report. The present Report assesses main living standard indicators in the context of the continuing economic crisis and looks at main human development issues via impact of the energy sector on the economy and living conditions. This chapter, which deals with personal incomes, therefore offers estimates of how energy-related business influences levels of income and inequality in its distribution.

3.1. Incomes, employment and poverty at various stages of the economic cycle

Economies traditionally adapt to a crisis situation through reduction of incomes and business activity. However, each country works out its own adaptation model to cope with decline of GDP and industrial production, usually via reduction of the price or quantity of labor, as well as reduction of social expenditures and their restructuring in order to target the poorest members of society. How did the labor market and personal incomes react to the crisis and what levels of income security and employment had Russia attained on the eve of the crisis? Descriptive analysis of main living standard indicators, published by Rosstat (the Federal State Statistics Service), will help us find answers to these questions.

We begin by studying the evolution of income level and structure, with wages and pensions separated out (Figure 3.1). Russia's post-Soviet development has been characterized by volatility of per capita incomes, which have been pulled down periodically by economic and institutional crises. The first such crisis (in 1992) resulted in the deepest drop of real incomes. In the last years of the Soviet era personal income structure was much the same as in other

Figure 3.1
Development of incomes, salaries and pensions compared with 1991 (1991=100%), December data



Source: Authors' calculations based on official data provided by Rosstat.

countries, which have undergone industrial modernization and where household incomes depend mostly (80%) on wages. But the principal difference in Russia was absence of incomes from business and property. Incomes from these sources rose to 20% of all personal incomes in the first years of Russia's market economy and remain at that level now (Table 3.1). Access to these sources of income was the main positive effect of market transformations and led to acceptance of reforms despite double reduction of real incomes. Business activity was at its maximum at the beginning of market reforms, when it brought 16% of all personal incomes. During the economic growth period, relative weight of business incomes tended to shrink and be replaced by income from property, which were then heavily depreciated by the current crisis. Business and property incomes explain why total income growth exceeded wage increases during the first years of economic recovery.

There was a clear decline of real incomes in 2008 (Table 3.2). In December 2008 they were 88.4% of their level in December 2007, although the observable part of real wages even rose slightly (101.8% of the December 2007 level) and pensions rose considerably (109.5% to December 2007). So the fall in real incomes was due to significant reduction of unofficial wages, and of business and property incomes. This structure indicates that high-income groups were hardest hit in the first months of the crisis, mainly through loss of regular annual bonuses.

Pensions, despite their growth in real terms, remain lower than in the pre-reform period, and, in the crisis environment, initiatives to raise pensions will compete for financing with efforts to maintain employment and with targeted assistance for the poor. The correct diagnosis would be as follows: the way the crisis has affected Russia and the steps taken to overcome it reflect the fact that, in Russia, the problem of poverty aggravation is associated with low pensions. The outcome of this has already been seen at the political level: Russia is speeding up pension increases. But the problem, which is being tackled in this way, is not a consequence of the crisis: it is the problem of disproportions, which were ignored during the period of economic growth and have become acute in the conditions of high inflation, associated with the crisis. At the end of the period of main structural and institutional reforms (1992–1999) pensions, which are the main source of income for one third of Russia's households, had fallen more

Table 3.1
Evolution of personal cash incomes in Russia, %

	1980	1990	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Cash incomes, total	100	100	100	100	100	100	100	100	100	100	100	100
Wages	79.8	76.4	66.5	62.8	64.6	65.8	63.9	65.0	63.6	65.0	67.5	68.6
Social transfers	15.1	14.7	13.1	13.8	15.2	15.2	14.1	12.8	12.7	12.0	11.6	12.8
Property incomes	1.3	2.5	7.1	6.8	5.7	5.2	7.8	8.3	10.3	10.0	8.9	6.6
Incomes from business	2.2	3.7	12.4	15.4	12.6	11.9	12.0	11.7	11.4	11.1	10.0	10.0
Other incomes	1.6	2.7	0.9	1.2	1.9	1.9	2.2	2.2	2.0	1.9	2.0	2.0

Source: Social Situation and Living Standards in Russia, 2005, Statistical Digest/Rosstat – M, p.124; Russia in Numbers, 2009, Brief Statistical Digest/Rosstat – M, 2006, p.118 than any other sources of income – to 27.5% of their level in 1991. Relatively rapid increase of pensions during the years of economic growth (2000–2008) did not bring pensions back to the pre-reform level, although the pre-reform level of overall income was regained in 2005 and wage levels were restored in 2006. Retired people reacted to lower real pensions by finding employment and at present a quarter of all pensioners remain economically active. The state has compensated low pensions by increasing social assistance and benefits for pensioners: pensioners receive over 50% of all welfare payments and 70% of benefits in kind (mostly subsidies for transportation, medicines and housing & utilities). The priority given by the social security system to senior citizens limits availability of benefits to other groups with high poverty risks, e.g. families with children.

Development of income levels by months during the crisis period (Table 3.2) shows a measure of recovery from January 2009, which is surprising in the context of falling GDP and industrial production. Incomes were only lower y-o-y (i.e. than the same period of the previous year) in June 2009. This is hard to reconcile with the fact of the crisis, and closer study indicates that negative effects of the crisis on personal incomes are being postponed. Why were personal income levels maintained despite the fall of GDP? Mostly due to the following factors: near doubling of the minimum wage (since January 2009); wage reform (i.e. increase of wages) for those who are paid from the federal budget (also since January 2009); payment in January-March 2009 of bonuses, dividends and rewards for 2008, and faster growth of pensions. However, these factors could no longer support real personal incomes at higher y-o-y levels after June, and a process of y-o-y declines began.

Table 3.2
Average per capita personal incomes and real disposable cash incomes

Year	Month	Nominal cash incomes			Real disposable cash incomes	
		Rubles	%, y-o-y	%, m-o-m	%, y-o-y	%, m-o-m
2008	July	15674	124.5	102.2	105.9	101.4
	August	15979.6	126.0	102	107.6	102.1
	September	15946.7	123.6	99.8	105.2	98.4
	October	16059.6	122.3	100.7	103.5	98.5
	November	15543.4	109.6	96.8	93.9	97.1
	December	20586.9	104.4	132.5	88.4	129.4
2009	January	11178.8	104.6	54.3	92.2	53.8
	February	14973.6	115.7	134.0	102.3	134.5
	March	15761.6	116.9	105.3	103.4	103.0
	April	16909.6	114.2	107.3	101.4	106.8
	May	16078.4	111.0	95.1	100.3	95.2
	June	17648.6	115.1	109.8	98.8	103.4
	July	18188.1	116.0	103.1	94.6	97.0

Note: Real disposable cash incomes are incomes less obligatory payments and adjusted by the consumer price index.

Official wages stopped growing from February 2009, when effects of the previous year's bonuses ceased to be felt, and by July 2009 they had fallen to 94.8% of their level in June 2008 (Table 3.3). Real wages were and remain the principal means of covering living costs. At present about 65% of all households include people in employment: 30% of households have a single member in employment, 26% have two employed members and 6% have three or more[1].

Wide use of informal payment schemes is a characteristic feature of the Russian labor market. According to Rosstat[2], about 40% of wages are hidden from statistics. Not all of these wages are illegal, because statistics do not include wages of employees in small businesses. Based on official employment levels in small businesses and levels of official wage payments in such businesses, our expert assessments suggest that about half of unregistered wages represent illegal employment.

Another characteristic phenomenon in the Russian economy is wage arrears, which tend to grow exponentially in times of crisis, since payroll reduction is viewed as preferable to job cuts in a context of falling GDP. Wage arrears are on the increase in the current crisis, but so far the amounts and number of employees affected are incommensurable with previous crises. According to Rosstat official data, total wages overdue as of July 1, 2009 were around 2% of total registered payroll. In 1992–1993 this figure was about 20% and in 1998 it peaked at 150%[3].

Table 3.3
Average monthly nominal and real wages

Year	Month	Average monthly nominal wages			Real wages	
		Rubles	%, y-o-y	%, m-o-m	%, y-o-y	%, m-o-m
2008	July	17758	130.3	100.5	113.6	100.0
	August	17244	128.9	97.5	112.1	97.2
	September	17739	128.2	102.9	111.4	102.1
	October	17643	125.3	99.5	109.7	98.6
	November	17598	119.3	99.7	104.9	98.9
	December	21681	115.3	123.1	101.8	122.3
2009	January	17119	115.5	79.0	101.9	77.2
	February	17098	111.1	100.1	97.6	98.5
	March	18129	111.9	105.8	98.2	104.4
	April	18009	108.3	99.3	95.7	98.6
	May	18007	107.5	100.0	95.7	99.4
	June	19247	108.2	106.9	96.7	106.3
	July	18862	105.5	98.0	94.2	97.4

Source: Rosstat, www.gks.ru

[1] Author's calculations based on the data of the random National Survey of Well-being and Participation in Social Programmes (NOBUS), conducted by the State Statistics Committee (Goskomstat) of the Russian Federation in 2003 with 44,000 households selected.
[2] Social Situation and Living Standards in Russia, 2008. Statistical Digest/Rosstat – M; Russia in numbers, 2009, Brief Statistical Digest/Rosstat – M, 2009
[3] Zarabotnaya plata v Rossii: Evolyutsiya I differentsiatsiya (Salaries in Russia: Evolution and Differentiation). V.Gimpelson, R.Kapelyushnikov et al.; State University, High School of Economics – M, HSE Publishing House, 2007, p.61

Are wages now the main instrument for adapting the labor market to crisis conditions, and is the same adaptation model being used now as was used (in the opinion of R.Kapelyushnikov)[4], in previous crises? The current situation on the labor market differs from that of 1990s when employment declined more slowly than GDP. In the 2000s employment growth lagged far behind rise of GDP. T.Maleva and other specialists believe that two stages of the Russian labor market development have already been completed: (1) moderate decline of employment and sharp decline of wages (1991–1998); and (2) moderate recovery of employment and faster growth of wages (1999–2007)[5].

It is not yet clear how the situation will develop in the current economic crisis, but a development framework can be sketched using the expert opinions of T.Maleva, V.Gimpelson, R.Kapelyushnikov, S.Roschin, T.Chetvernina and other leading labor market experts. In the current crisis the following factors seem to favor application of the 'traditional' Russian model, which maintains employment levels by reducing wages:

- Short duration of the crisis, which means that cost of dismissal will be higher than cost of retaining the workforce;
- Payroll flexibility (it is estimated that Russian payrolls can be lessened by 15-40% by withholding bonuses), which makes reduction of labor expenses through payroll reduction more legitimate and easier than dismissals;
- Failures of the legal environment, so that employees find it difficult to enforce their legal rights when companies withhold or reduce wages, and government is able to exert pressure on companies to stop them carrying out dismissals;
- High inflation rates, which depreciate the real value of wage arrears.

However, there are several other factors, which seem to work against successful application of the 'traditional' model in present circumstances:

- Fundamentally different nature of the current crisis, compared with previous crises (structural crisis in the early 1990s, cyclical crisis in 1998–1999);
- Cost of dismissals may be lower in the long run than cost of retaining labor;
- Raising of the wage floor: the monthly minimum wage was almost doubled from January 1, 2009 and now stands at 4330 rubles;
- Toughening of government policy on wage arrears and actual enforcement of this policy;
- Lower inflation as compared with previous crises: lower inflation increases debt risks for companies associated with delay in payment of wages;
- Restructuring of the informal labor market, including small-scale farming on private plots, which has switched from payment by exchange to cash payment, and disappearance of street markets, where people could sell their produce;
- Increased unemployment benefits and social support programmes for the unemployed.

Available statistics (Table 3.4) suggest that initial reaction of the labor market, when it became clear that the crisis would have major impact on Russia (October-December 2008), was 'non-traditional': real salaries continued to rise (though more slowly than in September) and unemployment also rose. But this initial reaction was short-lived. When it became clear in early 2009 that the crisis would not end quickly, characteristic Russian labor market mechanisms began to assert themselves.

[4] R.Kapelyushnikov, Rossiyskiy Rynok Truda: Adaptatsiya bez restrukturizatsii (Russian Labor Market: Adaptation without Restructuring)-M, HSE Publishing House, 2001; Survey of Russia's social policy: early 2000s, T.Maleva et al, Independent Institute for Social Policy – M, IISP, 2007; R.Kapelyushnikov, Konets Rossiyskoy modeli rynka truda? (Is this the end of the Russian labor market model?) A series of public lectures, Polit.ru, 2009. http://www.polit.ru/lectures/2009/04/23/kapeljushnikov.html.

[5] Survey of Russia's Social Policy: Early 2000s, T.Maleva et al, Independent Institute for Social Policy – M, IISP, 2007

Employers are making full use of the main underemployment mechanisms: part-time work and unpaid or partly paid vacations. By June 2009 as many as 1.2 million people were working part-time and a further 1.2 million were on unpaid or partly paid vacation. Current legislation limits scope for employers to impose part-time work or unpaid vacation on employees, so many employers have found new ways of using these mechanisms without formally violating the Labor Code. The most popular approach is preparation of agreements between employer and employee on part-time work (used for 52% of all part-time employment) or on unpaid/partly paid vacations (used for 73.3% of all applications by employees for unpaid vacation and proposals by employers of vacation with partial payment). So employers are seeking legal means to continue applying the Russian model of labor market flexibility, i.e. keep the workforce but cut the payroll.

Unemployment has a special place in the system of indicators that describe the labor market, but the unemployed only became a recognized group in Russia after the end of the Soviet period. Total unemployment, defined as the ratio of the unemployed to the total economically active population, peaked during the 1998 crisis and fell to its minimum in the last years of economic growth. Registered (official) unemployment in Russia is 3-4 times lower than real unemployment due to unattractiveness of unemployment benefit schemes and widespread unofficial employment.

Unemployment started to grow from the first days of the current crisis (Table 3.4) and

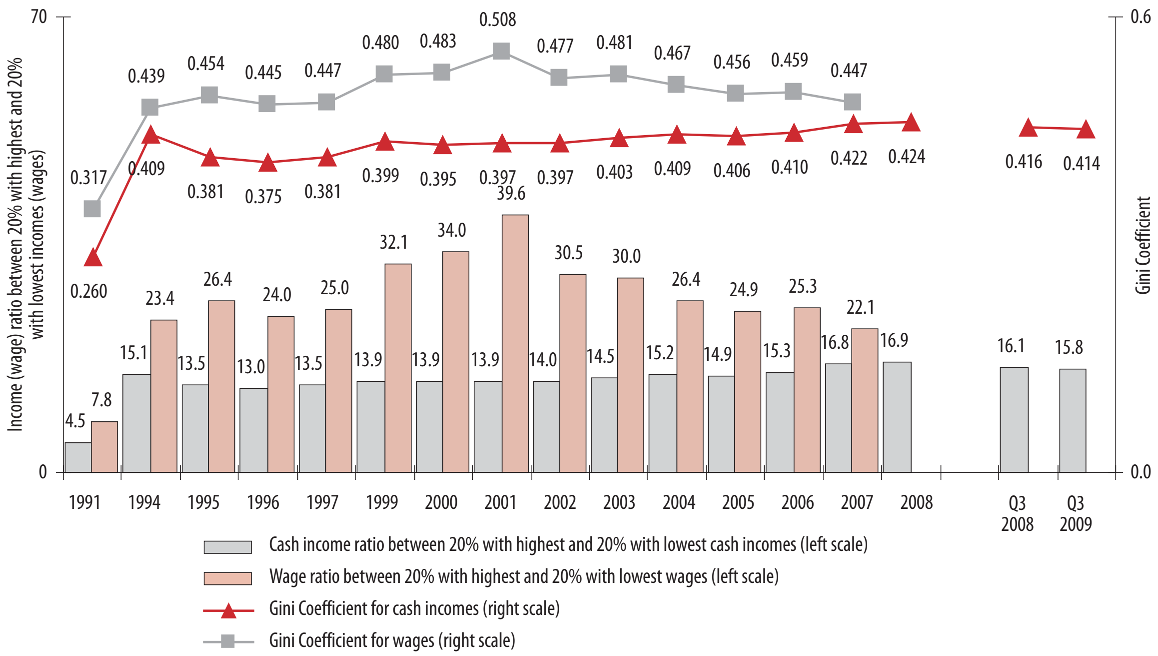
Table 3.4
Economically active population

Year	Month	Economically active population		Of which				Unemployment, %	Registered unemployed		Official unemployment, %
				Employed		Unemployed					
		mln.	%, y-o-y	mln.	%, y-o-y	mln.	%, y-o-y		mln.	%, y-o-y	
2008	July	76.3	100.9	72.0	100.9	4.3	100.4	5.7	1.3	89.4	1.7
	August	76.6	101.0	72.1	100.7	4.5	104.9	5.8	1.3	88.9	1.7
	September	76.4	101.0	71.6	100.4	4.7	111.4	6.2	1.2	88.2	1.6
	October	76.1	101.1	71.1	100.0	5.0	118.0	6.6	1.2	87.7	1.6
	November	75.9	101.1	70.6	99.7	5.3	124.6	7.0	1.3	87.1	1.7
	December	75.5	100.7	69.6	98.9	5.9	128.2	7.8	1.5	98.0	2.0
2009	January	75.1	100.3	68.6	98.2	6.5	131.2	8.7	1.7	110.1	2.3
	February	74.8	100.1	67.8	97.5	7.1	133.5	9.5	2.0	127.8	2.7
	March	75.2	100.1	68.3	97.3	6.9	140.4	9.2	2.2	141.9	2.9
	April	75.6	100.2	68.9	97.1	6.7	148.6	8.8	2.3	153.5	3.0
	May	76.0	100.3	69.5	97.0	6.5	158.4	8.5	2.2	158.3	2.9
	June	76.1	100.1	69.8	97.2	6.3	149.2	8.3	2.1	160.9	2.8
	July	76.3	100.0	70.0	97.3	6.3	144.9	8.3	2.1	163.0	2.8

comparison of month-on-month development of unemployment rates against the same periods in the previous year show that unemployment growth cannot be explained by seasonal fluctuations. Unemployment reached a local maximum in February 2009, and y-o-y increases peaked in May 2009. Registered unemployment entered a phase of explosive growth in early 2009 when levels of unemployment benefit were raised, and y-o-y rates of growth of registered and total unemployment became comparable in March. To date GDP and industrial production have fallen faster than unemployment has risen, but previous crises show that such a time lag is to be expected. The unemployment peak is still to come. Depending on economic and budget policies experts predict more tension on the labor market in the fall of 2009 and early 2010.

How have changing incomes, salaries and pensions affected income stratification in society? Inequality tripled during the structural crisis of 1992–1999, when real incomes were halved (Figure 3.2). The economic growth period saw steady growth of the Gini Index and of the ratio between incomes of the wealthiest 20% of the population and the poorest 20%. The main contributor to such inequality is wage differences: the ratio of the 20% best paid to 20% worst paid employees is 1.7 times larger than ratio between the highest and lowest 20% in terms of overall income (Figure 3.2). The wage ratio grew from 7.8 to 39.6 times from 1991 and 2001, but then fell sharply to 30.5 times. It should be noted that these statistics are only for large and medium-sized businesses, which account for half of all those in employment (54.3% in June 2009). What these statistics show, therefore, is that widening of the income gap from 2002 onwards was due to incomes from property, business activity, wages paid to employees of small businesses, and informal remuneration schemes. Available data on differentiation of observable wages suggest that salary differentiation was most affected by major redistributive processes within and between

Figure 3.2
Indicators of income and wage differentiation



Source: Social Situation and Living Standards in Russia, 2007. Statistical Digest/Rosstat – M; p.136; Social Situation and Living Standards in Russia, 2000. Statistical Digest/Goskomstat RF – M, p.130.

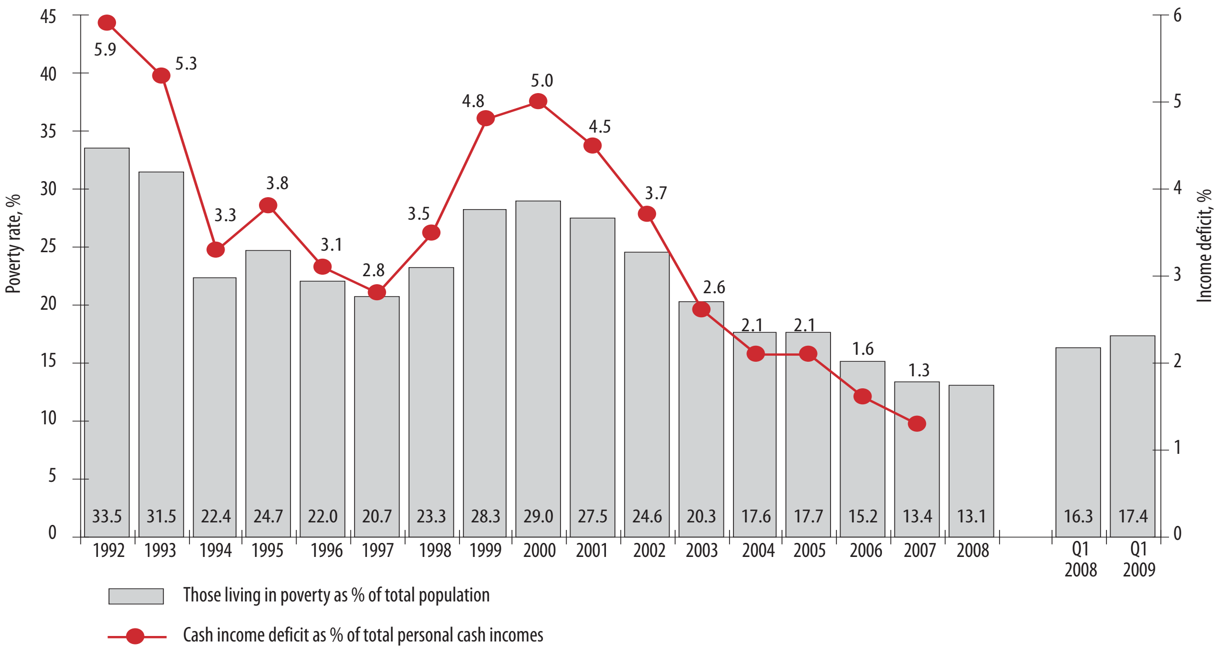
various sectors. Inter-sectoral payroll differentiation is determined both by distinctions in the economic status of various sectoral groups with differing economic significance and by differing competitiveness of their outputs. Raising of minimum wages and pensions led to growth in income levels of the poor, so that income difference narrowed in the third quarter of 2009, despite the crisis.

Changes in incomes and inequality have caused changes in the poverty rate (Figure 3.3), which has been subject to large fluctuations since market reforms began. In 1992, after price liberalization, one third of Russia's population qualified as poor. There was steady decline in the poverty rate after 2001 and it had declined by half in 2007 compared with 2000. The current crisis has already led to 0.9 p.p. growth of the poverty rate in Q1 2009 compared with Q1 2008, representing an increase in the number of poor people in Russia by 1.5 million.

It is highly important to identify which social groups are most vulnerable to the risk of poverty and tend to be particularly poor, and which groups make up the greatest share of the poor. Specifics of the 'poverty profile' for Russia are amply presented in the literature[6] and can be summarized as follows:

- Risk of poverty is twice higher than the national average for families with children (and for children as such, aged under 16). This risk of poverty increases in proportion to the number of children in the household, and single-parent families are more likely to be poor;
- Rural populations are more vulnerable to poverty;
- Pensioner households (either a single pensioner or couples) are twice less likely to be in poverty than the national average;

Figure 3.3
Poverty rate in Russia



Sources: Russia in Numbers. 2004; Statistical Digest / Federal Statistics Service, M, 2004; pp.99-100; Russia in Numbers. 2004; Statistical Digest / Federal Statistics Service, M, 2004; p. 100; Social Situation and Living Standards in Russia, 2007. Statistical Digest/Rosstat – M, 2007, p.144.

[6] (1) Poverty and Inequality in Russia: Correlation between Poverty and Inequality Indicators and the Method of Measuring Household Prosperity Indexes. Illustration based on NOBUS data / E.Teslyuk, L.Ovcharova. Gen. edit. R.Yemtsov – M, Alex, 2007, pp.17-19
(2) Incomes and Social Services: Inequality, Vulnerability, Poverty. Edited by L.Ovcharova, NISP – M, HSE Publishing House, 2005 – p.348
(3) Survey of Russia's Social Policy: Early 2000s, T.Maleva et al, Independent Institute for Social Policy – M, IISP, 2007

- The unemployed, people who are economically inactive, and recipients of social and disability welfare are at high risk of poverty;
- A large number of those who are poor are in employment.

Although the number of people in poverty has halved, the structure of poverty by main socio-demographic groups has remained unchanged. The biggest share of the poor are still people of working age, particularly young people: the share of the young people among the poor is larger than that in the overall population. The risk of being poor is also above average for children, while the elderly, by contrast, are 16.8% of the total population (2006 data), but represent only 13.1% of the poor (although their share has been growing in recent years). Growth in the share among the poor of people who are of working age but economically inactive offers indirect evidence of marginalization of that group of the population. Such a conclusion is confirmed by specialized research, which suggests that this group includes a large number of young males who are not studying, working or seeking employment[7]. Changes in the educational profile of the able-bodied poor show that the share of people with higher education has decreased from 20.7% in 2000 to 13.2% in 2006[8]. The objective reality in the present economic environment is that birth of a second child in families pushes consumer behavior towards that, which characterizes poverty.

3.2. Role of the energy sector in incomes and inequality

Economic activities related to the energy industry are traditionally well-paid, with low levels of labor-intensity. A picture of their contribution to personal incomes in Russia can be obtained from employment and wage indexes for businesses associated with energy production and transportation (Table 3.5). The statistics base, which is used, has figures for all sectors of the economy, but only covers large and medium-scale enterprises, leaving small businesses out of account. The base therefore covers 53% of all employees (as of June 2009) and 43% of total wages paid in the economy. Around 9.2 million employees of small businesses, 3.8 million self-employed, and about 7.2 million employees with indeterminate legal status are not included. But there are only about 50,000 people in these categories working in the energy sector, equal to just 3% of those working at large or medium-scale companies in the sector, and statistical reporting suggests that wages in small businesses related to power production and transportation are 1.5-2.0 times lower than wages at large and medium sized companies in the sector. So impact of the energy sector on the labor market and household living standards can be adequately studied though salaries and employment at large and medium-scale enterprises in the sector.

The average wage in all energy sector businesses as of June 2009 was 1.8 times higher than the national average wage. Highest wage levels were in pipeline transportation (3 times higher than the national average), and wages of pipeline workers increased by more than 1.5 times (159%) during the crisis period in real terms. In other energy industries nominal increase of wages failed to keep pace with 11.7% inflation in the period between June 2008 and June 2009, so that real wages decreased. Wage levels in June 2009 were 94% compared with a year earlier in the extraction industry; 93.3% in production of coke and oil

[7] Poverty and Well-being of Households in Leningrad Region. Based on random interviews with households in April 2005 – SPb., Celesta LLC, 2007 – p.288

[8] Social Situation and Living Standards in Russia. Statistical Digest/Goskomstat of Russia – M, 2001, p.144; Social Situation and Living Standards in Russia, 2007. Statistical Digest/Rosstat – M, 2007, p.149

products; 99.3% in production, transportation and distribution of electric power, steam, gas and hot water; and 97.7% in production and distribution of gas fuel. So the crisis had negative impact on wages of people employed in production and processing of crude oil, but did not affect wages in other energy segments, where wage levels even rose substantially in some cases.

The rate of job losses in the energy industry was lower than in the whole economy and there were even increases of employment in two sub-sectors: production and distribution of electric power, gas, steam and hot water; and pipeline transportation. However, reduction of head count in fuel extraction and also in production of coke and oil products was higher than the national average since the crisis began. So employment and wages in the oil sector were negatively affected by the crisis, but proved immune to it in other energy sectors, making overall employment and wage figures for the energy segment look better than for the economy as a whole.

The next question is how the situation in the energy sector affects personal incomes throughout the economy. There are a number of indexes for assessment of impact of the energy sector on employment, payroll, public incomes and inequality (Table 3.6). Energy-related business has limited importance for incomes and employment: only 2.5% of employees at large and medium-sized companies work in the power sector and they represent only 2.9% of the total payroll at all large and medium-sized Russian companies.

Table 3.5
Wages and employment in the energy sector

	Nominal monthly wages					Job turnover	
	Salaries in June 2009		Wages in H1 2009				
	Rubles	% vs. June 2008	Rubles	% vs. H1 2008	% vs. national average	Thousand	% vs. June 2008
Total	19247	108.2	17929	110.3	100	37643.8	96.2
Extraction of fuel resources	38141	105.0	38725	108.3	220	582.7	94.9
Production of coke and oil products	34022	104.1	37050	114.9	210	108.2	94.2
Production, transportation and distribution of electric power, natural gas, steam and hot water	30089	110.9	27865	112.7	155	676.7	101.3
Production and distribution of gas fuel	19926	109.2	19300	112.3	108	161.1	99.5
Pipeline transportation	60067	178.0	40897	123.3	230	188.2	101.3
Entire energy sector	35402	115.7	-	-	-	1716.9	98.4

Employment in the energy sector accounts for only 2% of total employment incomes, so importance of the energy sector for the labor market, incomes and wages is quite limited. Some experts believe that high salaries in the energy sector are the main reason for high differentiation in salaries and incomes, and it is true that, as of April 2009, 32.2% of energy sector employees were among the best-paid 10% in the economy as a whole. No other segment has such a high share of its employees among the economy's best-paid workers (the runners-up are financial operations, with 24.6%, and real estate including rental operations, with 16.4%). But this does not entail that income and wage differentials are determined by the energy sector, since the sector accounts for only 12.7% of all the best-paid 10% of employees in the economy. For comparison, real estate employees are 12.5% of the 10% best-paid, state administration and military security are 11.1%, transport and communications 10.6%, and financial organizations 7.6%. Education, health care and social services together take 13.6% of best-paid jobs, surpassing the share of energy. Also, the energy sector has relatively low intra-sectoral payroll differences: wages of the 10% best-paid employees in the sector are 12.5 times higher than those of the 10% of the least paid. In the financial segment this gap is 26.7 times, and it is 15 times in both education and health care. All that can be realistically said, therefore, is the opposite of what some experts think: the energy sector operates against income inequality by not making any large contribution to low-paid labor.

To summarize impact of the energy industry on incomes, employment and inequality: the segment provides a very limited number of jobs, most of which are well-paid. Due to its small number of employees and low intra-sectoral wage differentiation, the energy sector is not the driving force for sharp inequality in incomes. A large part of incomes generated in the sector is redistributed through the budget, other businesses associated with the energy sector, dividends, and social packages and bonuses, which are not counted in the monthly wage and income reckonings. The reasons for inequality are not to be sought in the resource-oriented economy as such, but in the existing system of state institutions for redistribution of incomes.

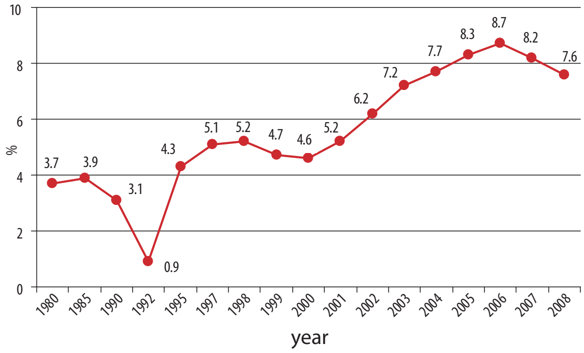
3.3. Household spending on housing utilities and social measures to mitigate price rises for such services and for electricity

As shown above, the link between trends in the energy sector and the standard of

Table 3.6
Impact of the energy sector on employment and inequality

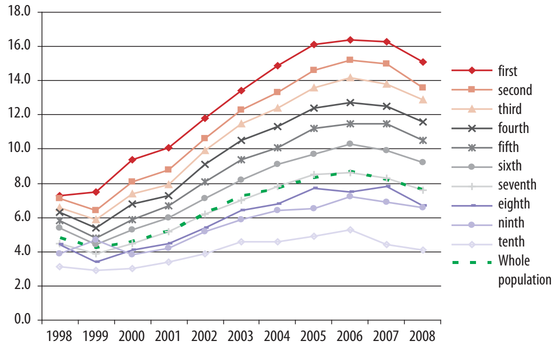
Indicator	Value
1. Share of energy sector employees in total numbers of employed, June 2009, %	2.5
2. Share of wages received by energy sector employees in total wages paid, June 2009, %	2.9
3. Share of wages received by energy sector employees in total personal incomes, June 2009, %	2.0
4. Share of energy sector employees, who are among the 10% best-paid employees in the economy, in all of the 10% best paid, April 2009, %	12.7

Figure 3.4
Housing utilities in overall consumer spending of Russian households, % (sampling survey of household budgets)



Source: Rosstat, www.gks.ru

Figure 3.5
Housing utility expenditures in overall consumer spending of Russian households by decile groups (decile breakdown by average per capita disposable income), %*



Source: Incomes, expenditures and consumption of households, based on random sampling of households (digests, 1999-2008)
**Note: Consumer expenditures of households in this decile group are taken as 100%*

living of Russian households is not to be sought in the field of employment and wages. The key interaction between households and the energy sector is via spending by the former on housing utilities (government sector rents, electricity, water and gas bills, which are usually charged monthly in a single itemized bill). We begin with some international comparisons, for which spending on housing utilities are grouped together with household spending on fuel. As of 2005[9] (the most recent year for which statistics are available) such expenditures were 9.4% of actual final consumption of Russian households, compared with 17.9% in Latvia, 17.3% in Italy, 15.0% in Hungary, 16.0% in USA, 15.3% in Great Britain and 19.2% in Sweden. So Russian household expenditures on housing utilities are rather low, even compared with countries where the per capita income level is similar. In countries with higher per capita income levels the shares of housing utilities expenditures are also high. This probably explains the poor technical, technological and institutional state of Russia's housing utilities sector. Even if Russia succeeds in overcoming negative effects due to high levels of corruption in this sector, it will be impossible to achieve a breakthrough in quality of housing utility services without larger payments by households. Increase in the share of household expenditures spent on housing utilities will also encourage the general public to rationalize their relationship with the state and business with respect to production of and payment for these services.

How has household spending on housing utilities developed? Available data are shown in Figure 3.4. They show that decline of personal incomes during structural reforms (1990–1995) was accompanied by reduction of the housing utilities share in total household expenditures. Low prices for housing utilities helped people to cope with fall of their incomes by nearly half, but lack of investment had negative impact on maintenance of the services. Starting from 1994 housing utilities prices skyrocketed. By 1995 their share in household budgets had returned to levels at the end of the Soviet period and the growth continued. Housing utility price growth paused for the 1998 crisis, but then resumed. The housing utility share in household budgets declined in the last two years of economic growth, but the current crisis is likely to reverse that trend.

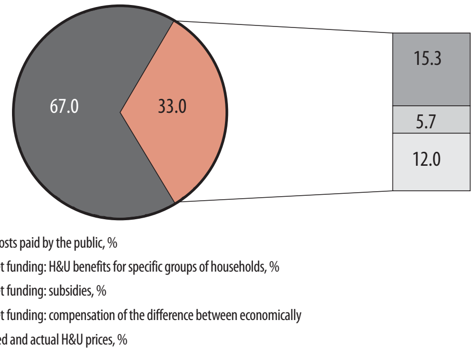
[9] Social Situation and Living Standards in Russia, 2008. Statistical Digest/Rosstat – M, 2008,p.482

The share of household expenditures taken by housing utilities varies greatly depending on income levels, living conditions and regional specifics (housing utility price formation and social security programmes of regional government). The share of housing utility expenditures in budgets of poor household are as much as double the average, even though housing conditions of the poor are usually worse than average and despite social programmes that aim at reducing the share of housing utilities in spending by such households (Figure 3.5). Regional differences in housing utility tariffs are also quite significant. In June 2008 the price of hot water for households was 23.52 rubles per person in the Republic of Ingushetia, while it was 544.01 rubles in Kamchatka Region, and 100 KWh of electric power in the Chukotka Autonomous District cost 345 rubles compared with 45 rubles in Irkutsk Region.

Faster growth of housing utility prices compared with incomes poses the biggest threat to budgets of single pensioners and single-parent families with children living in accommodation with full services, particularly in small towns, where housing utility prices are the highest. Our calculations show that average share of housing utility expenditures in budgets of such households is 15.5%.

It is important to grasp how household and government spending on housing utilities has been balanced in the past. Transition to market principles in provision of housing utility services required changes to institutional regulation of the sector. In the planned economy, housing utility pricing was merely symbolic and the wages of a Soviet employee were not designed to cover acquisition or maintenance of a dwelling, which was the responsibility of the state. Creation of a market economy meant that the huge gap between expenditures of households on housing utilities in the Soviet-era and their real cost had to be closed. By 1997 average regional and federal standards for coverage by households of housing utility costs were 38% and 35%, respectively, of the real costs of housing utilities. By 2005 the federal standard had been raised to 100% of 'economically justified' housing utility tariffs, but actual implementation has been slower. As of 2007 housing utility tariffs had reached 'economically justified' levels in 7 regions, while they were above 90% of the level in 48 regions, and below 90% in 30 regions. So the state is still subsidizing the housing utilities sector, and prices for households will have to rise faster than inflation in coming years in order to achieve 100% payment by households for the services they receive.

Figure 3.6
Sources and amounts of housing utility funding in 2007, %



Calculation basis: Statistics Digest No.9 (149), FSGS – M, 2008 pp.76-77; data taken from Rosstat website http://www.gks.ru/scripts/db_inet/dbinet.cgi?pl=1812003, accessible since January 16, 2009.

This transition requires social support programmes to be put in place for households, which cannot afford such extra costs. How do such programmes function in Russia? The latest available data are for 2007 when total housing utility payments by government were 260 billion rubles or 33% of the total cost of housing utilities (Figure 3.6), so that households were meeting two thirds of housing utility service costs out of their own pockets.

Budget funding for the housing utilities sector can be divided into two components:

1. Compensation of the difference between real costs of housing utilities and prices paid by households;

2. Benefits and subsidies, to assist housing utility payments by households.

In 2007 compensation of the difference between real housing utility costs and prices paid by households amounted to 12% of the total real cost of housing utilities or 36% of all budget funds allocated for the sector. This compensation represents subsidization of all households regardless of their incomes, but mostly benefits households, which enjoy better living conditions (i.e. wealthier households). However, compensation of the difference between real housing utility costs and prices paid by households has been declining in recent years and has ceased to be the main subsidization instrument. The biggest share of financial support for housing utilities is now in the form of direct assistance to individuals who meet certain criteria (various categories of disability, etc.) to help them meet their housing utility bills. In 2007 such assistance represented 15.3% of all housing utility costs (46.4% of all budget funds allocated for housing utilities). Other direct assistance, specifically to poor households, was only 5.7% of housing utility costs (17.3% of all budget expenditures on housing utilities).

It is worth giving a brief account of how direct assistance for payment of housing utilities operates in Russia. The country has had a programme of housing subsidies since 1994. According to the initial regulations, subsidies are provided to households whose justifiable housing bills exceed 22% of aggregate household income. The number of recipients rose to a peak of 15.2% in 2003, suggesting that every seventh household required social support. Research into

Table 3.7
Main parameters of social programmes related to housing utilities

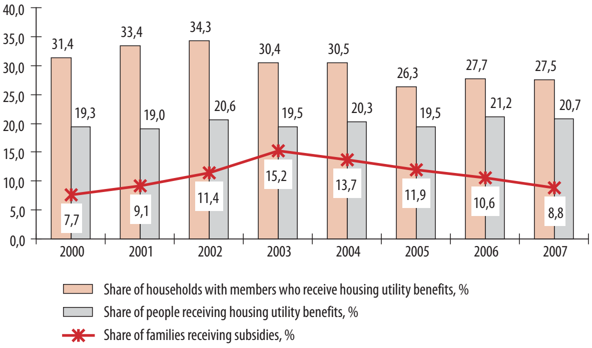
	2000	2001	2002	2003	2004	2005	2006	2007
Families receiving housing utility subsidies, thousands	3212.4	3963.4	5251.3	7092.6	6801.5	6063.6	5457.7	4560.9
% of all families	7.7	9.1	11.4	15.2	13.7	11.9	10.6	8.8
Average monthly subsidies per family, rubles	80	124	237	361	435	550	675	641
Number of people in households with members who receive housing utility benefits, thousands	46015.1	48810.7	49795.1	44011.7	43913.3	37615.6	39513.3	38846.4
Number of people, receiving housing utility benefits, thousands [sub-set of previous line]			29914	28151.5	29156.4	27860.3	30171.5	29416
Average monthly benefit support per recipient, rubles	32	47	67	98	126	178	216	259

Source: Calculations based on Rosstat data, Central Statistics Database, http://www.gks.ru/dbscripts/Cbsd/

subsidization practices in the regions[10] showed that without subsidies people would stop paying for housing utilities and the sector would have to be financed directly from the budget. Nevertheless, the programme has undergone constant modifications, regional standards for cost of services have become increasingly varied, and rules for provision of subsidies have become increasingly strict, so that the scale of subsidies has diminished in comparison with household expenditures. This can be seen from development of the average subsidy per family (Table 3.7). Since 2004 there has been a reduction of budget spending on housing subsidies for the poor and narrowing of the group of households, which are recipients. This has been obtained mainly by raising the allowable share of housing utility expenses in household budgets to the federal standard of 22% of aggregate family income, as well as by introduction of flexible regional standards for housing utility costs.

Secondly, there is a system of benefits, now called 'measures for social support with regard to payments for housing and communal services'. These are a legacy of the Soviet era and, unlike subsidies, their recipients are defined by falling under certain definitions (disability, etc.) and not on the basis of need. Previously the benefits were provided as discounts on housing utility tariffs. The discount was 100% of housing utility costs for people meeting certain definitions, while others (the most numerous group) received 50% discount, and other groups received less. Monetization of benefits, brought in by Federal Law No.123 in 2005, had little effect on the housing utility benefit system: some regulations on provision were altered (e.g. non-extension to other family members) and

Figure 3.7
Coverage of social support programmes related to housing utilities



Source: Calculations based on Rosstat data, Central Statistics Database, http://www.gks.ru/dbscripts/Cbsd/

there was partial monetization in certain regions, which led to reduction of the number of recipients (Figure 3.7).

What is the outlook for social support measures in the crisis context? As explained above, housing utility tariffs will continue to grow, so that larger amounts of social support will be necessary. The government is considering the possibility of giving federal subsidy entitlement to households, which spend over 15% of their income on housing utility, lowering the threshold from current 22%. But preliminary studies show that such a step would require 300 billion rubles of additional funding, which is unaffordable for the budget[11]. The threshold remains unchanged to date, although regional governments are free to set lower thresholds, covering the difference out of their own budgets. The system of housing utility benefits ('measures for social support…' described above) will be monetized, so that people who qualify for them will pay their housing utilities in full but will receive compensatory cash payments. In general,

[10] World Bank project, 'Improvement of targeted social assistance programmes and employment support to fight poverty', carried out in 2006-2007 by specialists from the Institute for Urban Economics (Moscow), Independent Institute for Social Policy (Moscow), and the Urban Institute (USA) in five regions of the Russian Federation: Tver, Tatarstan, Tomsk, Kalmykia and Karachaevo-Cherkessia. A.Ya.Burdyak, who worked on field studies in Tver and Kalmykia, analyzed the housing subsidies programme and efficiency of administrative spending.

[11] Interview with the Minister for Regional Development, Victor Basargin, Rossiyskaya Gazeta, Federal Issue, April 28, 2009 http://www.rg.ru/2009/04/28/basargin.html

affordability of rising prices for housing utilities will continue to be ensured through the system of social support.

Attraction of investments remains the key problem of the housing utility sector. Federal Law No.210, 'On basic principles for tariff regulation in housing and communal services', passed in 2004, took transparency and predictability as its guiding principles. But amendments to the Law in 2005 allowed federal regulation of housing utility tariff growth through limiting indexes in order to curb inflation, making housing utilities more dependent on the budget and swelling debts of housing utility providers. Positive changes in the sector slowed down in 2006 and the rate of breakdowns in the sector rose[12] (based on government statistics and calculations by S.Sivayev, the Institute for Urban Economics). Maintenance of the limiting indexes is the biggest obstacle to long-term direct and transparent tariff regulation and the start of full-scale investment programmes.

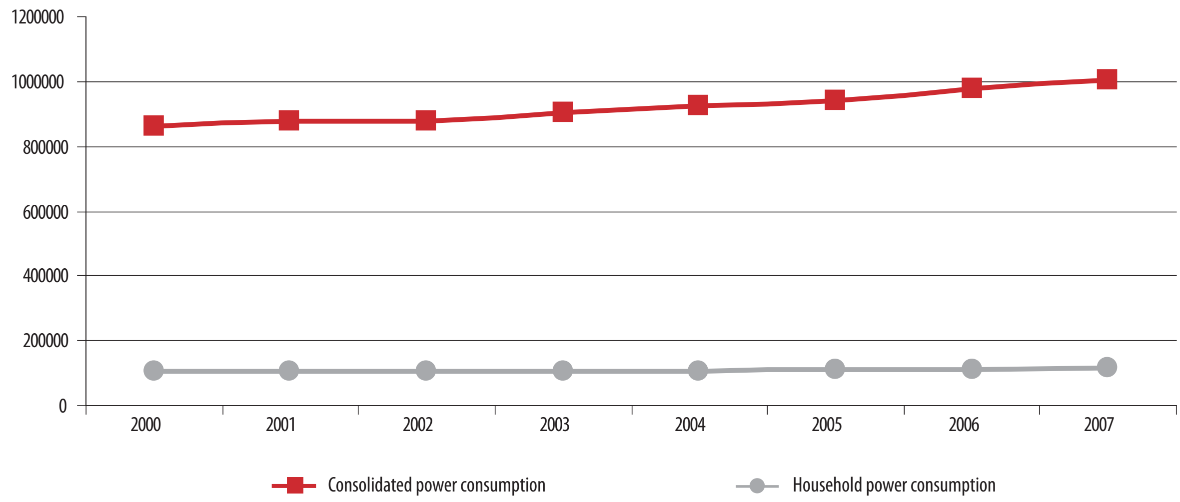
To conclude this review of household spending on housing utilities, the fact that Russians spend a relatively small share of their incomes on these services should entail scope for price growth. However, the real situation is that the existing system of housing utility payments already stretches personal income capacities.

3.4. Household consumption of electricity

What are the trends and what impact is the crisis likely to have on use of electricity in the household sector? Economic growth saw increase of overall power consumption in Russia by 16% from 2000 to 2007, while household use rose by only 9% in the same period (Figure 3.8). The share of power consumed by the household sector fell as a result from 12.3% in 2000–2001 to 11.5-11.6% in 2004–2007, so that growth of its power use in absolute terms looks insignificant.

Growth of personal incomes and changes in the structure of consumer expenditures have boosted the construction, retail, public catering and other service segments in Russia. Places where economic growth is concentrated now have a new lifestyle model, involving power-intensive recreation outside the home, so that differences

Figure 3.8
Annual power consumption by households, million KWh



Source: Calculated using National Energy Statistics

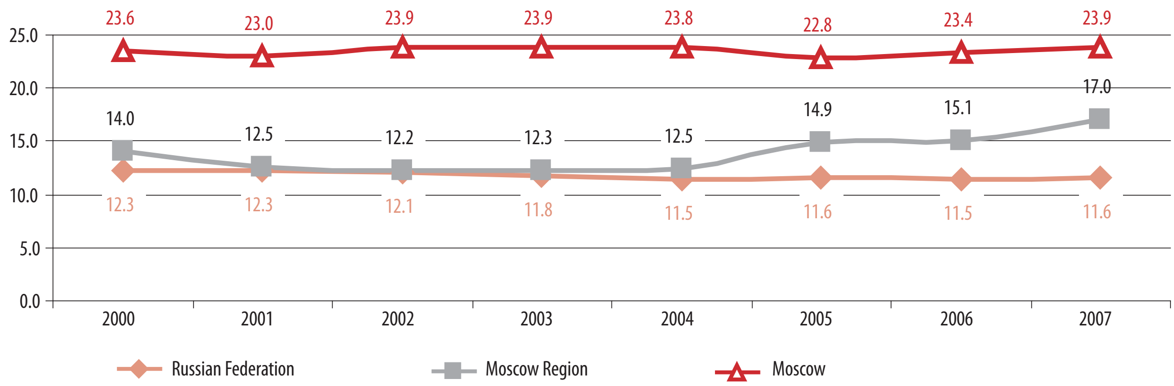
[12] Economy of the Transition period. Essays on economic policy of post-communist Russia. Economic growth 2000-2007 – M, Delo publishing house. Academy of National Economy, 2008.

in power use between regions now depend on economic development and household incomes as well as climate conditions. While the national average share of power use by households in 2000–2007 was 11.9%, figures for Moscow, St.Petersburg and Krasnodar Territory (where Black Sea resorts are concentrated) were much higher at 23.5%, 19.9% and 22.2%, respectively. The household share in Rostov region, which also has a Black Sea[13] coastline, was also high at 18.7%. These regions should be viewed as trendsetters, with service economies and high population density. By contrast, the lowest household shares in power use are in main raw-material regions of Siberia, where the economy is industry-focused: Krasnoyarsk Territory, 5.8%; Kemerovo Region, 7.3%; Irkutsk Region, 7.5%. The household power share is also low (8%) in Russia's main oil producing area, Tyumen Region with its autonomous districts. Large and relatively well-developed regions with diversified economies and regional capitals with over one million inhabitants are in a middle position, either equal to or slightly below the national average: Samara Region, 12%; Sverdlovsk Region, 10%; Chelyabinsk region, 9.8%; Republic of Tatarstan, 9.7%. Two regions in the European part of Russia, with cities of more than one million people and a mixture of initial processing[14] and import-substitution industries – Nizhny Novgorod and Volgograd – are on opposite sides of the national average with indicators of 13.1% and 9.3%, but are closer to the 'middle-class' regions. Moscow Region (13.8%) and Leningrad Region (9.8%) are in roughly the same situation.

Strong growth of power consumption by the housing sector makes installation of new generating capacity an urgent task in some regions. The share of power consumption by households in Moscow Region has risen from 12.2% to 17.0% (Figure 3.9), closely approaching the four regions, which have shown highest shares of households in total power (the cities of Moscow and St.Petersburg, Krasnodar Territory and Rostov Region). Peak loads related to household consumption are becoming a serious problem for these regions.

The trends, which emerged during the period of economic growth, will remain dominant. The 10% increase of household power tariffs planned for 2010 will raise the share of household spending on housing utilities in a context of declining real incomes, but the impact for low-income groups will be mitigated by social support. Better-off

Figure 3.9
Share of households in total power consumption in Moscow and Moscow Region



Source: Calculated using National Energy Statistics

[13] Classification of Russia's regions is in accordance with the Special Atlas of Russia's Regions, N.Zubarevich, http://atlas.socpol.ru/typology/index.shtml.
[14] Industries producing semi-products: metallurgy, chemistry, forestry and paper-milling.

households with modern, high-tech power consumption lifestyles will not drastically change their power consumption habits. Housing construction will continue, although social housing will be given priority in the crisis context, and more ample housing will continue to drive household demand for electric power. Decline of industrial production as a results of the crisis will also raise the share of households in overall power consumption.

3.5. Summary and recommendations

Summing up this analysis of incomes and employment in the context of energy sector development and the continuing economic crisis, we see a number of points with special importance for future economic transformation in Russia.

Firstly, rapid development of the resource-oriented economy, which provides the country's tax base and high incomes for a very small group of people, has not favored creation of enough 'good' jobs, which would offer an economic base for expansion of the middle class – the main driving force for evolutionary modernization. Rapid economic growth was accompanied by growth of income and salary inequality. Meanwhile, government attitude towards the labor market has been focused on the issue of unemployment, rather than on creation of efficient employment. So job quality and productivity have been left out of account and the self-regulating mechanism, by which improvement of education levels should produce good jobs, has not been operating effectively.

Secondly, deficits of goods and services, which had stimulated development of small business despite lack of access to credit, means of production, legal protection, etc., disappeared in the last years of economic growth. Absence of development banks, leasing and insurance companies, and other supports for small business turned jobs in the small-business sector into 'bad' jobs, geared towards survival rather than modernization and development.

A poor institutional environment and resource-oriented economy have been unable to produce educational, professional, and socio-demographic resources that could generate efficient, innovative employment – the type of employment, which would ensure that workers and their families can buy essential goods and meet their needs for housing, education and healthcare.

Old targets focused on greater prosperity need to be reformatted as new targets that aim to create an economy with diversified, effective employment, shifting emphasis from programmes of support for the unemployed and assistance for the poor to creation of development institutions, which could bear the major costs and risks of creating and operating 'good' jobs.

The study of prosperity (income) levels, which are one of the three components of the Human Development Index (HDI), through energy sector issues led us to an analysis of indexes, which determine the role and place of the energy sector both in generating household incomes and meeting the consumption needs of households.

The energy sector is the basis of Russia's resource-oriented economy, but incomes generated in this sector are only sufficient to:

- provide a high standard of living for its employees and promote the development of associated consumer markets;
- form the tax base for the country's budget, which guarantees a high standard of living for the bureaucracy and associated consumer markets;
- develop public support programmes in the form of small-scale per capita assistance to a large number of ordinary people. This supports a dialog between government and the broad general public, but efficient employment for the majority of people has no place in this scheme.

Electricity prices for households have risen faster than incomes, increasing the share of household expenditures on utilities, particularly among poor households. Rapid growth of urban agglomerations in a context of decline and, later, moderate growth of industrial production has increased the share of households in energy consumption, particularly consumption of electric power. Energy saving has therefore grown in importance, particularly for households. However, most energy wastage is beyond the control of households, and housing utility providers are the most wasteful part of the economy. Households in Russia actually consume less power per capita than in developed countries, despite very limited availability of power-saving technologies.

Box 3.1. Education for the power industry

Education of new specialists for the power engineering industry is of great significance for development of Russia's innovative economy. Creative engineers, developers and designers are the people who must bring advanced technologies to Russia's power industry and other industrial sectors to make them more competitive. Engineering universities are not only suppliers of human resources; they also develop new technologies, production processes and promising new segments in the power industry and other sectors.

We will first try to assess the scale and structure of training provided by the Russian higher education system to meet the needs of Russia's power engineering industry (Table 3.1.1). In the past decade the number of graduates with a degree in 'Power engineering and electrical equipment' (specialization No. 140000 in the higher education curriculum) has increased almost threefold in absolute terms, and the share of this subject in the total number of technical graduates has increased by 3%. However, power engineering has not been spared by the general decline in the share of engineering graduates among all graduates of the Russian higher education system. The share of power sector graduates in all higher-education graduates declined by 0.6 percentage points from 1995 to 2006.

Hardly any private universities offer courses in power engineering (just 0.6% of all graduates in the subject in 2006 were from private universities). However, the number of students majoring in power engineering at state high schools on a paid basis is steadily increasing, which testifies to popularity of the profession. The share of students with state scholarships majoring in power engineering and electrical equipment fell from 73% in 2003 to 57.7% in 2006.

So the trends revealed by analysis of structural changes in power engineering education at Russia's higher education schools are the same as for all engineering professions[15]:

- Steady increase in the absolute number of engineering students and graduates;

Table 3.1.1
Total graduates, engineering graduates, and graduates in power engineering and electrical equipment (PE), 1995-2006[16]

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Total graduates (thousand)	396	415	458	501	555	635	720	840	977	1077	1152	1255
PE share in total graduates, %	2.99	2.74	2.48	2.11	2.08	2.09	2.09	1.91	1.87	2.30	2.31	2.31
Total engineering graduates (thousand)	157	161	160	160	172	191	207	230	252	233	252	275
PE share in engineering graduates, %	7.55	7,08	7.07	6.62	6.70	6.97	7.27	6.98	7.25	10.61	10.57	10.54
PE graduates (thousand)	*11.8*	*11.4*	*11.3*	*10.6*	*11.5*	*13.3*	*15*	*16.1*	*18.3*	*24.8*	*26.7*	*29*

** Education in Russia:2007. Statistics Bulletin. M., GU-VHSE, 2007.*

[15] See.: I. Dezhina, I. Frumin. Engineering education in Russia and its link with innovative activities// From knowledge to wealth; integrating science and higher education for the development of Russia. M., 2006, p. 278-318. //
[16] It is noteworthy that prior to 2004 the Russian National Profession Classifier made a distinction between power engineering and electrical equipment, which were recorded as two different professions. The share of power engineering graduates in total graduates in both specializations rose from 59% to 63% in 1995-2003, and it can be assumed that this trend continued after 2003.

- Steady decrease in the percentage of engineering students and graduates in all higher-education students and graduates;
- Only state universities offer training in the field.

However, there are a number of important questions, the answers to which help to obtain an accurate picture of prospects for the power engineering industry in Russia:

1. Does the power industry really need 29,000 engineers every year?

2. Does the quality of education of these new engineers meet current and forecast needs of the industry?

There are serious questions marks over the quality of students, who are being prepared for careers in the power industry. Analysis of university admissions in 2009 shows that all types of engineering higher education in Russia are experiencing a serious crisis: up to 50% of those admitted to higher education schools had scored only three out of five for mathematics and physics in the five-point system, which is used to assess Russian school pupils (a score of three is equivalent to 'satisfactory' or a C-grade). It is unlikely that these students will be capable of acquiring the necessary professional competencies[17].

Power engineering and electrical equipment is currently among the most popular engineering specializations, attracting relatively strong applicants. The average school-leaving exam score of students applying successfully for state scholarships to study power engineering and electrical equipment is 64.1. However, the average score for applicants who obtain a scholarship in humanity subjects is 76.4, and in economics and management it is 71.4. Clearly, the best school leavers have limited interest in engineering professions[18].

As can be seen from the table, the quality of students admitted to study power industry specializations is as dubious as for other engineering professions. It should be noted that the minimum admission requirements at Moscow universities[19] correspond to a weak 3 (weak C-grade): a score of 48.1 in the school-leaving exam for a state scholarship and 42.7 for admission as a tuition paying student (Table 3.1.2).

There is much stratification both within single universities and between different universities. Comparing admission scores for state-funded places, the threshold for courses within the power engineering and electrical equipment group was 57, to study nuclear reactors and energy installations at MIFI, while the admission score to study nuclear and particle physics at the very same school was only 42. And the admission score for plasma power installations at MAI was just 33[20].

The higher education process itself is also riddled with problems. In the spring of 2009, research was carried out at a number of engineering universities across Russia to find out whether the

Table 3.1.2
Average score achieved at 2009 school-leaving exam among applicants to study power engineering and electrical equipment at Moscow and Siberian universities[21]

State scholarships available		State scholarship students				Tuition paying students			
		Average score		Admission score		Average score		Admission score	
Moscow	Siberia	Moscow	Siberia	Moscow	Siberia	Moscow	Siberia	Moscow	Siberia
2382	1040	64.1	68.8	48.1	58.9	53.6	49.9	42.7	41.7

[17] State exam and university admissions. Average score of applicants admitted to Moscow universities on the basis of state exam results, August 2009. M. GU-VHSE, 2009, page 12.
[18] State exam and university admissions. Average score of applicants admitted to Moscow universities on the basis of state exam results, August 2009. M. GU-VHSE, 2009, page 69.
[19] These include: Moscow N. Bauman State Technical University (MGTU), Moscow Power Engineering Institute (MEI), Moscow Physics-Engineering Institute (MIFI), Moscow State Institute of Steel and Alloys (MISIS), Moscow Aviation Institute (MAI), Moscow State Rail University (MIIT), Moscow A. Kosygin State Textile University, Moscow State Industry University, Moscow State Engineering Ecology University, Moscow State Applied Bio-Technology University.
[20] State exam and university admissions. Average score of applicants admitted to Moscow universities on the basis of state exam results, August 2009. M. GU-VHSE, 2009, pages 45-46.
[21] State exam and university admissions. Average score of applicants admitted to Moscow universities on the basis of state exam results, August 2009. M. GU-VHSE, 2009, page 73.

educational process met the demands of potential employers and students[22]. Power engineering was among the fields studied. The findings are quite disturbing. Almost a quarter of students nearing completion of their education said that they would like to adjust their specialization but could not do so, because the field they were majoring in is too narrowly defined and their schools provide no flexible mechanisms for changing specialization between admission and graduation. Some 80% of students said that all the courses in their study programme were mandatory.

The research also found that students are generally expected to be passive recipients of knowledge. According to the survey results, 95% of students nearing completion said that lectures were the primary mode of instruction, 20% said they never participated in a discussion or project working in a small group, and a third had never prepared their own presentations. In most cases the instructor was the primary source of information, with few students trying to search for information on their own. Only 20% of students surveyed had participated in projects of their instructors, 33% of the students nearing completion had never done projects of their own, 55% had not implemented projects as part of a group, 55% had not prepared any presentation on a completed project, 85% had never been involved in projects for real customers, 60% had never read books on their subject in a foreign language.

Results of the education process are verified mainly by oral and written examinations and through oral defence of course papers. Tests in class are used very seldom, while 60% of surveyed students had never had to write an essay.

Links between universities and potential employers are very limited. Some 63% of students nearing completion knew either very little or nothing at all about working conditions in Russian companies for graduates with their specialization (though 90% had been through some kind of work experience), and only 32% had been given any information about what to expect in their future jobs by their universities. Only 37% had met with representatives of their potential employers, while 15% said that they had never been introduced to any technical, economic, or corporate news of relevance to their profession. Finally, only 35.9% of graduates with engineering degrees (including those with degrees in power engineering) find work in their field after graduation[23].

Based on the above, we can justifiably state that:

- Engineering universities and engineering specializations have to a large extent lost their prestige in comparison with other types of higher education. They seem willing to accept low-quality students in order to fully use their intake quotas;
- Narrowly defined specializations and impossibility of fine-tuning individual trajectories lead to a situation where a significant part of the technologies taught at university are obsolete in comparison with what graduates will have to deal with once they enter the job market. Students themselves are often frustrated by the impossibility of tailoring the education, which they receive, to their individual preferences.
- The passive role assigned to students in the education process, lack of hands-on experience of working on projects alone or in groups or working for real customers, lack of demand for initiative, ambition and creativity, and lack of awareness of the international technological framework tends to make graduates incapable of innovation, and suited only for roles as technicians rather than engineers.

To conclude, we will try to point out the main respects, in which Russian technical higher education (including power engineering) has deteriorated, and propose some steps that need to be taken in order to rectify the situation.

[22] An integrated assessment of education standards for students approaching graduation and of employment by aerospace companies of graduates from specialized higher education schools. The research was carried out by United Aircraft Manufacturing Corporation as part of work to design a system for supporting education of students and employment of graduates in the aerospace industry. See also: Maria Dobryakova, Isak Froumin. Higher engineering education in Russia: incentives for real change // International Journal of Engineering Education. 2010, spring (forthcoming).
[23] V. Gimpelson, R. Kapelushnikov, T. Karabchuk, Z. Ryzhikova, T. Bilyak. Choosing a profession; what did they learn and where were they useful? M., GU-VHSE, 2009, page 18.

1. The number of graduates with engineering degrees far exceeds real demand in the economy. The situation is exacerbated by the fact that these large numbers are achieved by significantly lowering admission standards. There need to be far stricter admission thresholds, and state funding of tuition should be on a per student basis.

2. Universities are no longer making a clear distinction between creative engineers and simple technicians. Both spent the same amount of time studying and are often taught using the exact same programmes. The existing engineering professions, in which universities offer training (including power engineering professions), are often defined too narrowly. We believe that universities must shift as soon as possible to two-stage training, where the first stage offers very broad bachelor degrees (for those who plan to continue their education majoring in a narrower field) and applied bachelor degrees for technicians, and where the second stage offers master's degrees for creative engineers specializing in specific fields.

3. Engineering universities do not allow students to choose between courses. This reduces students' interest in the process of acquiring knowledge and their motivation to seek a job in their chosen field. The introduction of credits and modules based on ECTS, and transition to third-generation state standards will offer more scope for individualizing education, though it is difficult to predict how universities will make use of these new opportunities.

4. Education at most engineering universities is not organized in a way that makes students work alone and in groups, participating in their instructor's projects and in projects for real customers. Modernization of the education process along these lines is a crucial part of reform of the engineering education system, including power engineering.

5. A broad professional horizon is an essential part of the education of a future engineer. But at present the absolute majority of engineering students are only acquainted with Russian achievements in their field, and the focus is on theoretical knowledge, which does not always help students to develop the practical skills they will need in the present market. The situation is exacerbated by the fact that teachers themselves are often theoreticians, far removed from the practical challenges of the industry about which they teach and therefore barely able to navigate through the knowledge and competencies relevant to the modern economy. Until students know about the latest trends in their chosen field, not only in Russia but in the rest of the world, and until they start doing real-life projects during their studies, no sector of the economy will be supplied with personnel who can meet the challenges of innovative work.

6. To date interaction between universities and employers has failed to make the education process more relevant to the challenges of the contemporary economy and to ensure university-employer cooperation in preparing students for future jobs. Engineering universities must realise that they are a key element for implementation of state economic policy. Effective training of new specialists will only be possible if universities create appropriate information systems as well as formal and informal interfaces, through which their graduates can move more easily into the job market.

Burgeoning demand for energy in the late 20th and start of the 21st centuries has led to a dramatic increase in crude oil & gas production, which, in turn, led to increasing discharge of pollutants into the environment. Volumes of waste water created by the electricity industry have been growing since 2004, and atmospheric emissions from fuel-fired power stations is growing faster than their electricity output. Decline of pollution levels in the metallurgy and chemical industries has caused the share of the fuel & energy sector in overall pollution to rise by almost 10% in recent years. Share of the sector in total industrial pollution is 56%, including 58% of solid waste and 23% of waste water.

Problems from use of coal top the agenda when assessing environmental impacts of the fuel & energy sector. Current national structure of primary fuel use reflects the prolonged 'gas pause': the share of coal in the national fuel balance is only 18%, while that of oil is 21% and natural gas dominates with a share of 52%. Annual consumption of coal by the power industry is rising more slowly in Russia than in the rest of the world at present, but large increase in the share of coal in the national energy balance is expected, reflecting huge Russian deposits of coal, especially in the industrially developed Kuznetsky Coal Basin ('Kuzbass') in Kemerovo Region. The National Energy Strategy up to 2020, approved by the Russian government in 2003, calls for increase in the share of coal in the country's energy balance from 19% to 20%. Greater use of coal should be accompanied by application of new coal processing technologies, which will enable it to be burnt more efficiently. Coal, as the main alternative to natural gas, is the biggest feedstock in US and Chinese power generating (50% and 80% of all fuel-fired inputs, respectively), and its share in Poland is as high as 96%. Such intensive coal use is possible thanks to introduction and development of a number of environment-friendly and efficient coal combustion technologies.

Coal extraction in Russia is growing faster than had been expected and rose by over 20% between 2000 and 2008 (from 258 to 314 million tonnes). Further growth to 373-430 million tonnes is expected by 2020. Coal will be the main alternative to natural gas in the future, particularly in Siberia, where proximity of the Kuznetsky and Kansko-Achinsk coal basins reduces transport costs by several times. Development of the Yuzhno-Yakutsk basin in Eastern Siberia is also proceeding rapidly. Growth of coal extraction is partly driven by depletion of profitable natural gas deposits and high export value of gas.

Growing power production and planned increase of the share of coal in the national energy balance could aggravate public health and environmental problems. Consumption of coal by power stations grew by 2.7% in 2008 alone due to reduction in use of natural gas[1], and further large increases of coal burning are planned. It is too early to judge whether modern environmental requirements will be met, but WHO and European Commission directives ought to be taken into account as well as Russian environmental rules. Wide public discussion of the issues is desirable in regions affected by power-station emissions.

Russia's Energy Strategy makes development of clean coal combustion technologies a condition for increase of coal use by power stations and other industrial facilities. Transition from direct coal burning to use of coal-water fuel (CWF, made of various quality coals, including waste from coal concentration processes)[2] will be an important part of this process.

The Energy Strategy sets general indicators for development, but it does not contain specific targets for reduction of pollution, suggesting that commitment to clean technologies may be less than complete.

[1] I.S.Kozhukhovskiy, Situation Analysis and Development Forecast / Report presentation at the conference, The Power Industry – Risks and Growth Limits in Times of Recession – March 24th, 2009, http://www.e-apbe.ru/actions/09_03_24_Vedomosti_Kozhukhovsky.pps# .

[2] A.P.Starikov, V.D.Snizhko, The ways of solving environmental problems at a modern coal-mining facility / Ugol – 2008, No.9 – pp.66-67

As well as requiring better fuel combustion technologies, sustainable development of the energy sector also needs to take account of sustainable development capabilities and environmental capacity of specific geographical regions. Attention must be paid to the specific conditions, in which fuel oil and coal combustion is to be increased, including state of the environment and public health in locations, where investment projects are to be implemented. Top management of the recently dismantled power monopoly, Unified Energy Systems (UES) understood this: Anatoly Chubais the CEO of UES, referred to replacement of natural gas by fuel oil as "technological, economic and environmental barbarism"[3]. In 2006 increased burning of fuel oil led to increase of atmospheric emissions by 11%.

Environmental pollution occurs right along the chain from extraction, transportation, processing of fuel resources to production of heat and power. The victims are people living in small settlements adjacent to generating facilities, but also populations in cities, where emissions by the energy sector and industrial facilities are compounded by rapidly increasing traffic emissions.

4.1. Environmental pollution in areas of fuel resource extraction and transportation

Extraction of fuel resources is one of the main causes of atmospheric pollution, contributing 27.1% of all stationary emissions and exceeding emissions by the metallurgy sector[4]. Main sources of emissions in fuel extraction are in the Khanty-Mansi Autonomous District, Yamal-Nenets Autonomous District, Komi Republic, Kemerovo and Orenburg Regions (Table 4.1). Coal-mining cities and coal-burning industries are the leaders in solid atmospheric emissions: coal-mining Vorkuta (33,700 tonnes per year), Cherepetskaya power station in the town of Suvorov, Tula Region (33,500 tonnes per year). Vorkuta is also among the biggest emitters of hydrocarbons and volatile organic compounds, together with four cities in Kemerovo Region (Novokuznetsk, Mezhdurechensk, Leninsk-Kuznetsky and Prokopyevsk), and two cities in the Komi Republic (Ukhta and Inta).

4.1.1. Extraction and transportation of crude oil. Pollution of drinking water sources due to pipeline accidents

Russia's oil deposits are spread around the country: in the Baltic, Timan-Pechora, Barents-Karsk, Okhotsk, Caspian, Yenisei-Khatanga, North-Caucasus, Volga-Urals, Lena-Tunguska, Lena-Vilyui, West-Siberian, Anadyr-Navarin and other oil & gas provinces. Total length of oil pipelines owned by Transneft (the

Table 4.1
Total atmospheric emissions in extraction of fuel and energy resources, 2007

Territory	Emissions, thousand tonnes per year
Khanty-Mansi Autonomous District	2085
Kemerovo Region	798
Yamal-Nenets Autonomous District	789
Orenburg Region	453
Komi Republic	392
Tomsk Region	246
Samara Region	173
Nenets Autonomous District	136

[3] Environmental Aspects of Power Industry – Environmental Policy of RAO UES and its implementation – Conference speech, June 16th, 2007
[4] Annual digest of ambient air emissions in cities and districts of the Russian Federation in 2007, R&D Institute for ambient air protection, St Petersburg, 2008, 204 p.

oil pipeline monopolist) and its affiliated companies is 48,700 km (as of June 2006).

The threat of pollution exists at every stage of oil production, from geological surveying to field construction, accidents at construction sites, and during field development and transportation of crude oil. Pollution of drinking water sources by hydrocarbons poses a particularly serious threat to public health: if an oil well 'drowns', due to bad sealing or for other reasons, oil can penetrate water horizons used for drinking or bathing. Oil products have already been discovered in fresh water at the Samotlor oil field at depths of 180-200 meters, threatening the water supply for the city of Nizhnevartovsk[5,6], and the Voy-Vozh oil field has been found to affect quality of drinking water in underground water sources used for needs of the nearby town (oil products and phenols were detected)[7].

Many pipelines are in a poor state of repair. More than 38% of crude oil pipelines and 47% of oil product pipelines have been in operation for over 30 years, and a further 75% and 80%, respectively, are over 20 years old[8]. Data published 11 years ago showed 40,000 accidents at fields in Western Siberia alone[9] and it is natural to suppose that number of accidents will have risen as output levels increased in recent years. Oil field development in Khanty-Mansi Autonomous District has polluted 70-80,000 hectares of land[10], and the Vozeysky oil pipeline accident in the Komi Republic caused pollution over 60 km^2. Large quantities of hydrocarbons may have penetrated sources of drinking water as a result of these accidents.

It is almost impossible to find information regarding spillages on internet sites of oil companies, but media reports suggest numerous accidents involving oil pipelines. There are reports of average 1900 accidents each year at oil fields in Khanty-Mansi Autonomous District[11] where principal aquifers have been polluted by constant leakages[12]. The share of water samples in the District, which fail to meet sanitary norms, is as high as 53%[13]. The situation is comparable in Tomsk Region, where pipe corrosion and intensified development of oil fields have led to a spate of pipeline accidents. Soil and ground water are polluted by oil products and highly mineralized water; samples from northern rivers in Tomsk Region, where oil field development is concentrated, show levels of oil products and phenol exceeding maximal allowable concentration as well as presence of hydrogen sulfide and methane[14]. These toxins may also be present in drinking water. Until recently pollution of drinking water by oil products was not viewed by the medical community as a serious threat to health, but more detailed study has revealed a threat from strata water, which is also carried in oil pipelines, and consists of a mixture of calcium-chloride mineralized water with

[5] N.Ya,Krupinin, On environmental conditions in Nizhnevartovsk Region//Ways and means of reaching a balanced environmental and ecological development in oil producing regions of Western Siberia // NDI works, Vol.1, Nizhnevartovsk, 1995, pp22-29.

[6] I.V.Korabelnikov, A.I.Korabelnikov, Ecological and sanitary aspects of oil field drowning during oil extraction // Newsletter of the St Petersburg State Medical Academy -2005 – No.1(6) pp.83-85.

[7] State Report: On environmental conditions in the Komi Republic in 2000, Ministry of Natural Resources and Environment of the Komi Republic, RGUN-TSARIKS RK, Syktyvkar, 2001, p.195

[8] V.V.Bushuyev, A.A.Troitskiy, Russia's Power Strategy up to 2020 and reality. What next?, Teploenergetika, 2007, No.1, pp/2-8.

[9] N.M.Davydenko, Environmental problems of Russia's Northern oil & gas producing regions, Novosibirsk, Nauka, Siberian establishments of the Russian Academy of Science, 1998, p.224

[10] A.P.Sadov, P.P.Krechetov, S.S.Varuschenko, Environmental problems of hydorbarbon extraction enterprises // Environmental and industrial security, 2008, No.12, pp.116-119.

[11] Digest: Environment of Khanty-Mansi Autonomous District – Yugra, in 2003, Khanty-Mansiisk, 2004

[12] T.Ya.Kochina, G.I.Kushnikova, Pollution of geological environment with oil products - Environmental and medical impact // Hygiene and Sanitation, 2008, No.4, pp.23-26

[13] N.G.Kashapov, A.A.Kazachikhin, Hygienic assessment of water procurement in the Khanty-Mansi Autonomous District – Yugra// Hygiene and Sanitation, 2008, No.5, pp.32-34

[14] Environmental Monitoring. Environmental situation in the Tomsk Region in 2007, / Department of Natural Resources and Environmental Protection of Tomsk Region, OGU Oblcompriroda, Tomsk, Graphika, 2008, p.24

Box 4.1. The village of Kolva in Ussinsk District

A major pipeline accident in 1994 caused oil pollution of the river Kolva. Immediately after the accident oil concentration in the river was 0.15-0.40 mg/l, compared with maximum allowable 0.05 mg/l. Dangerously high levels of phenols and chlorides were also registered. A detailed medical study of children in the village of Kolva in 1997 found serious dysfunctions of urinary and gastrointestinal systems. The kidneys are particularly vulnerable to effect of polluted drinking water. The urine of children in the village also contained abnormally high levels of phenol, indicating oil product metabolism in the body. After the accident people in Kolva stopped eating fish, which provided vital nutrients (magnesium, phosphates, specific amino-acids and unsaturated fatty acids). Dietary imbalances and lack of plant products (vegetables, fruit, berries) weakened immunity levels. Statistics shows higher incidence of illnesses of the digestive system among both adults and children in Kolva, compared with populations in other parts of Usinsk District. High incidence of gastritis is specific to children in the village[15].

Contamination of the environment with oil products also impacts the traditional lifestyle of indigenous peoples, which is based on fishing. An oil tanker accident near the Osinki archipelago and the coast of the Onega peninsula in Arkhangelsk Region upset bio-resources in the White Sea. Impact on local fishing communities, which depend on these resources, has not been measured[16].

microelements (some of them toxic ones) and radioactive nuclides. Oil phenols, which penetrate drinking water, are particularly dangerous, since they can produce cancerous chlorine-organic compounds when such water it chlorinated.

There has been very little epidemiological research into impact of oil spills on sources of drinking water and public health in Russia, but research was carried out on impact of the Usinsk oil spill in the Komi Republic (Box. 4.1).

4.1.2. Coal extraction

Coal production in Russia plummeted in the 1990s, but output (including open-cast mining) has begun to recover since 2000. Discharge of untreated waste water into surface water bodies has increased by 83% and untreated atmospheric emissions are up by 62%[17]. Coal mining is concentrated in areas, which already face environmental difficulties due to operation of the country's largest metallurgy and chemical enterprises. Over 50% of Russia's coal is mined in Kemerovo Region (Kuzbass), and other large coal mining facilities are located in Krasnoyarsk Territory, Komi Republic, the Republic of Sakha (Yakutia) and some other regions.

Pollution in populated areas is due to operation of underground mines and open pits, and also to liquidation of unfeasible coal production facilities. Kemerovo, where coal mining is the dominant industry in eight cities, is the best-researched region. The atmosphere in Kemerovo's cities is polluted by particulate matter, and drinking water is contaminated by metals. Locally produced food has excessive concentrations of lead, cadmium, mercury, and arsenic. Comparative environmental analysis of Kemerovo's mining towns found highest levels of air pollution in Belovo, followed by Prokopyevsk and Osinniki, and then Kiselevsk, Berezovskiy, Leninsk-Kuznetskiy, Anzhero-Sudzhensk and Mezhdurechensk. Public health problems in these cities reflect adverse industrial factors and air pollution, which accounts for 5.8-14.3% of newly diagnosed

[15] B.A.Revich, Hot spots of chemical pollution and public health in Russia, M, The RF Public Chamber, 2007, p.192
[16] A.A.Nenashev, Environmental aspects of oil and oil product transportation in Arkhangelsk Region // Human Ecology, 2005, No.12, pp.37-41
[17] A.A.Kharitonovskiy, Yu.A.Tolchenkin, The status and primary vectors of environmental protection in the coal industry // Coal, 2008 No.2, pp56-59

Box 4.2. Ambient air pollution and public health in coal-mining cities of the Kemerovo Region

Prokopyevsk (population 213,200)[19] is a large coal mining center. It used to have 17 mines and 5 coal concentrate plants. The coal industry produces up to 82% of all emissions in the city. Ambient air within city limits has high concentrations of nitrogen dioxide (3 times the Russian legal limit); benzopyrene (3.8 times), and particulate matter (2.1 times)[20]. Children living in the worst polluted city district had an abnormally high rate of respiratory diseases. In Leninsk-Kuznetskiy (population 105,400) there is a proven excess of premature deliveries, fetal deaths, child health anomalies and infant disease compared with the regional average[21].

Pollution in Kemerovo's cites is also caused by dust rising from polluted soils, which makes land reclamation highly important. According to the regional Department of Natural Resources and Environment, there are more than 180,000 hectares of unreclaimed land in Kemerovo, which is 10 times more than the national average As much as 20-27% of all land in Kiselevsk and Prokopyevsk is unreclaimed. Coal mining companies sometime try to avoid responsibility for land reclamation.

illnesses and 4-19%[18] of mortality. Kemerovo Region saw a 19.4% increase rise in disease incidence and 19.7% increase in mortality in 1993–2006 (Box 4.2).

People living in mining cities have to cope with unemployment and labor market difficulties in addition to environmental pollution, raising stress levels and putting more pressure on public health.

Liquidation of underground mining facilities also endangers drinking water sources, and preventive steps were taken at 51 mines, which closed in 1994–1998, in order to protect water sources[22]. Technical wear of equipment, and inadequate repair and reconstruction work on waste treatment facilities leads to methane and carbon emissions from underground mine workings and rising levels of ground water[23].

Closure of unprofitable workings in Perm Territory, another Russian coal mining region, led to atmospheric pollution by mine dust and coal ash, as well as worsening of drinking water quality. Pollution in the region caused aggravation of bronchial asthma among children, forcing increased spending on treatment[24].

Owners of ageing coal-powered power stations are trying to reduce environmental impact by full or partial changeover to natural gas, which lowers emissions of solids, sulfphur and nitrogen dioxides, and lowers ash and slag waste, but this approach looks unpromising because increasing natural gas prices make gas-generated power uncompetitive. Investments to upgrade outdated facilities also lack feasibility as a way of solving environmental issues, due to short residual life periods. The proposal, instead, is that all fuel oil and coal-dust boilers, which are transferred to natural gas, should undergo work to reduce nitrogen oxide emissions. Such work (reduction of excessive air input, off-stoichiometric combustion, simplified two-stage combustion) does not require capital investments and, if properly executed, does not worsen boiler performance. Boilers that will

[18] V.A.Zenkov, Hygiene problems in Kuzbass mining towns, abstract of a thesis for a Doctor of Medicine degree, 2000, p.42
[19] Russia's Regions. Main social and economic indexes of Russian cities. 2008. Statistical Digest / Rosstat, M. 2008, 378 p.
[20] Report on the sanitary and epidemiological situation in Kemerovo Region in 2005, Kemerovo, 2006
[21] Yu.F.Kaznin, A.S.Krasnov, Health status of pregnant women and new-born children in cities with developed coal industry // Environmental issues of the development of Kuzbass coal deposits, Novokuznetsk, 1991, p.43.
[22] A.Ye.Agapov. Analysis of work during liquidation of unfeasible coal mines and open pits in 2008 // Coal, 2009, No.3, p.3-6.
[23] V.A.Zenkov, E.A.Lodza, Sanitary and epidemiological support for restructuring of the Kuzbass coal industry // Public health and human environment, 2001, No.9, pp. 32-34
[24] S.V.Farnosova, Hygiene assessment of the combined influence of social and industrial factors on contraction and course of child bronchial asthma (based on data from depressive coal mining regions in Perm Territory), abstract of a thesis for a Doctor of Medicine degree, Perm, 2008

continue to use solid fuel for a long period of time (mainly coal power stations in Siberia and eastern Russia) require a different approach. Choice of the reconstruction option should be based on the expected period of service[25]. Combustion of coal in fluidized-bed boilers will enable use of low-grade and high-ash coals. Improvement of fuel quality – enrichment, pelletizing and other approaches – is also an option.

Any project for construction or reconstruction of coal-fired power plants should be approached with great caution, taking maximum account of existing environmental conditions and proposed new environmental standards of WHO, the European Commission and other international organizations. Installation of coal-fired combined heat & power plants (CHPs) near cities has already elicited protests: planned construction of a CHP near Zheleznogorsk in Krasnoyarsk Territory is opposed by local people who fear pollution of air and underground water[26].

In the north-western Kaliningrad Region, local people have voted against construction of a CHP using coal from Kemerovo near the town of Svetly[27].

There is an investment program for transferring large fuel-fired condensing power plants (CPPs) and CHPs from coal to natural gas. The stations concerned are: Verkhnetagilskaya (generator #12), Kashirskaya (generator #3), Troitskaya, Serovskaya, and Kharanorskaya. However, planned changeovers of Shaturskaya-5, Ryazanskaya, Novo-Bogoslovskaya, and Verkhnetagilskaya from coal to gas have been delayed. Cherepetskaya, Novocherkasskaya, Astrakhanskaya, Omskaya stations will burn more coal and proposals have been made for construction of large coal-powered CPPS and CHPs in Murmansk, Tambov, Rostov, Volgograd, Sverdlovsk, Irkutsk, Kemerovo, Novosibirsk, Omsk, Tomsk, Sakhalin Regions, the Republics of Mordovia, Buryatia, and Udmurtia, Trans-Baikal and Khabarovsk Territories.

There is currently a freeze on construction of thermal power plants (TPPs, which are smaller coal-fired power stations), including the Medvezhyegorskaya, Novgorodskaya, Kaluzhskaya, Petrovskaya and Abagurskaya projects, in favor of expansion of existing TPPs (Smolenskaya, Reftinskaya, Yuzhno-Uralskaya and Kemerovo). This is undoubtedly positive from an environmental viewpoint. Commissioning of a coal-powered unit at an existing TPP takes 3-4 years, while construction of greenfield stations requires 5-8 years. So that mass development of coal-fired generation will not go ahead in Russia before 2020–2025 at the soonest. Application of modern coal combustion technologies may be feasible by that time.

4.1.3. Oil & gas pipelines and threats of highly dangerous infections due to climate warming in Arctic regions

Global warming, particularly in Arctic regions, brings a threat of deformation in permafrost zones. The total permafrost zone is expected to shrink by 10-12% in the coming 20-25 years and its border will move by 150-200 km to the north-west[28,29]. Risk of damage to infrastructure located in the permafrost zone has been assessed using a permafrost hazard index, which is highest in Chukotka, the coastal area of the Karsk Sea, in Novaya Zemlya and in the northern part of European Russia. Global warming creates a real risk of damage to burial

[25] A.G.Tumanovskiy, V.R.Kotler, Possible environmental solutions for heat & power plants // Teploenergetika, 2007, No.6, pp. 5-11
[26] www.eprussia.ru/epr/98/7259)/
[27] www.rambler.ru/news/0/0/11034505
[28] O.A.Anisimov, M.A.Byelolutskaya, Assessment of the impact of climate change and permafrost degradation on infrastructure in northern regions of Russia // Meteorology and Hydrology, 2002, No.6, pp. 15-22
[29] O.A.Anisimov, A.A.Velichko, P.F.Demchenko, A.V.Yeliseev, I.I.Mokhov, V.P.Nechayev, Climate change impact on the permafrost in the past, present and future // Atmosphere and Ocean Physics, 2004, No.1 (volume 38), pp. 25-39

Table 4.2
Main carcinogenic and non-carcinogenic substances in refinery emissions

Вещество	Impacts
Sulfur dioxide	Respiratory system, mortality
Nitrogen dioxide	Respiratory system, blood
Nitrogen oxide	Respiratory system, blood
Manganese and Manganese compounds	Respiratory system, central nervous system (CNS)
Kerosene	Liver
Saturated hydrocarbons C_{12}-C_{19} (per common hydrocarbons)	Respiratory system, organs of vision, liver, kidneys, CNS
Hydrogen sulfide	Respiratory system
Carcinogenic substances	**Impacts**
Benzol	Haemopoietic system
Soot	Respiratory system

areas for cattle, which died of anthrax. Construction of new or repair of old oil & gas pipelines close to such areas adds to the threat of infection of human populations. There are over 200 such areas in the Republic of Sakha (Yakutia) alone[30].

4.2. Oil & gas refining territories

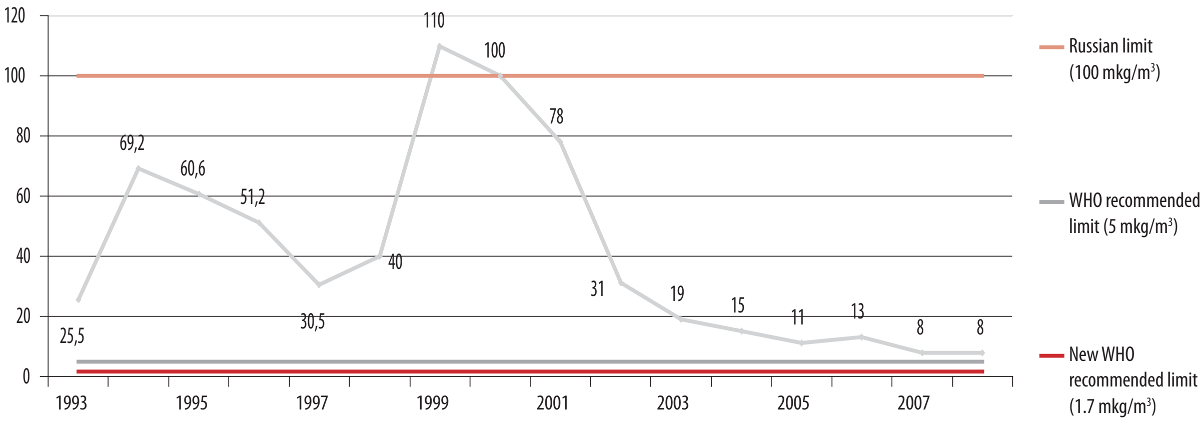
While coal extraction and processing are usually located next to each other, oil & gas fields are typically located thousands of kilometers away from the places where outputs are processed.

4.2.1. Oil Refineries – Impact on Public Health and Environment

Russia currently has 28 large oil refineries, over 80 small-scale refineries and 20 more small-scale facilities under construction. These refineries process crude oil into gasoline, kerosene, fuel oil, diesel and jet fuel. Many large refineries are located inside cities with high levels of pollution: Angarsk, Achinsk, Volgograd, Kirishi, Komsomolsk-on-Amur, Kstovo, Moscow, Nizhnekamsk, Novokuibyshevsk, Omsk, Rostov-on-Don, Ryazan, Syzran, Tomsk, Ufa, Khabarovsk, Yaroslavl, etc. These cities have other major sources of pollution in addition to oil refining.

The refining process has significant environmental impacts, and localities around

Figure 4.1
Average annual Benzol concentrations in ambient air, Omsk (Roshydromet station No.26), mkg/m³ [31]



[30] B.M.Kershengoltz et al., Dangerous infections in the Republic of Sakha (Yakutia) // Climate Change Impact on Public Health in the Russian Arctic, United Nations Office in the Russian Federation, 2008, pp. 24-25
[31] Atlas: Ambient air and public health in Omsk Region, Omsk, 2008

Box 4.3. Ambient air pollution and public health in Novokuibyshevsk

Novokuibyshevsk (Samara Region) is a city of 112,000 people with an oil refinery and a number of other petrochemical and chemical production facilities. The city has a centralized water supply system, fed by ground water. Depreciation of the municipal water pipeline system (150 km long in total) is 70%. The existing monitoring system does not provide adequate information on the state of ground water, particularly near sources of pollution, and it is impossible to forecast negative impacts on ground water, develop preventative actions, or localize and eliminate sources of pollution. Some water drawing facilities are located close to the refinery. Monitoring found significant quantities of oil products in ground water within the perimeter of the refinery, as well as in the townships of Russkiye Lipyagi and Chuvashskiye Lipyagi. Water for drinking and household use does not meet existing hygiene norms. Drilling, extraction, transportation and storage of crude oil generate oil and drilling sludge, and wastewaters from oil extraction and processing facilities penetrate ecosystems, polluting them with oil products and other chemical compounds. This has already led to salination and loss of soil fertility, and contamination of vegetation. Oil products have been detected in soils at allotments and in crops (onions, strawberries and oats) that are grown there. Oil product concentrations in soil in the city are up to 200 mkg/m^3 compared with provisional limits of 15 mkg/m^3 [32] set by the Natural Resources Ministry.

Risk assessment shows that the biggest carcinogenic threats are from atmospheric concentrations of 1.3 butadiene, benzol, formaldehyde, chloroform, acetaldehyde and some other substances, while the main non-carcinogenic threats are from nitrogen oxides, gasoline, etc[33]. Novokuibyshevsk is worse affected by diseases of the CNS, sensory, respiratory and digestive systems among children than other towns and cities in the Region and only 8.5% of children, who have been examined, were rated as healthy[34]. Child health abnormalities are due to other industries located in the city as well as impact of refining operations. Order No.295 of the State Environmental Committee (Goskomekologiya), dated May 25th, 1999, confirmed the Report of a State Environmental Commission, which rated Novokuibyshevsk as an environmental emergency area.

many of the facilities listed above have had serious pollution problems in the past. Emissions contain a wide range of toxic organic substances, the most hazardous of which are carcinogenic, including benzol, carbon dust, formaldehyde and benzopyrene (Table 4.2).

Benzol pollution in the atmosphere is very hard to estimate. The problem is that the detection method used by the Russian State Hydrometeorological Service (Roshydromet) has minimum sensitivity of 20 mkg/m^3, reflecting Russia's daily upper limit of 100 mkg/m^3 for benzol concentrations in air. However, the WHO recommends a much stricter annual norm of 5 mkg/m^3 and this may be further reduced to 1.7 mkg/m^3 due to the carcinogenic effect of benzol and acceptable risk criteria. This new recommendation is based on the individual risk of leukemia throughout life (70 years). The low concentrations, recommended by WHO, cannot be detected using methods available in Russia, but weather stations sometimes detect benzol concentrations as high as 290 mkg/m^3. Benzol concentrations are constantly monitored by 74 stations in 23 cities, but the results fail to show real pollution levels or to specify zones with hazardous levels of carcinogenic risk .

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[32] Atlas: Ambient air and public health in Omsk Region, Omsk, 2008
N.M.Tsunina, Hygiene assessment of the environment of the territorial industrial complex // Hygiene and Sanitation, 2002, No.4, pp.15-17
[33] Priorities in main environmental protection actions in Samara Region based on cost-efficiency of health risk reduction., M., 1999, 209p.
[34] G.A.Makovetskaya, T.Yu.Savirova, O.N.Gerasimova, The role of the environmental factor in child health // Environment and human health. Thesis at the 2nd practical science conference, Samara, 1995, pp.61-62

Box 4.4. Gas exploration and processing – public health risks

Astrakhan Region has large discovered reserves of natural gas with high content of hydrogen sulphide (H_2S), so the Astrakhan GPC produces sulphurous gas emissions. Gas pipeline accidents during initial stages of operation released untreated gas into the atmosphere, killing several workers. Releases of untreated gas sometimes still occur due to well blow outs. Gas and condensate processing at the GPC also produces pollutants. Concentrations of H_2S in air have fallen over time thanks to improvement of industrial processes, reduction of accidental emissions, commissioning of a Sulphren treatment unit and environmental measures. Children living near the GPC have development abnormalities, psycho-emotional problems, functional disorders of the cardiovascular system, visual system, CNS, ear, nose & throat, and are more prone to illness than children in a control area[35]. Local people used to complain of bad smells from sulfurous compounds in the atmosphere. Pollution levels around the GPC have been considerably reduced more recently.

Staff of the Orenburg Medical Academy have found acute toxicity from sulphurous compounds at the Orenburg gas condensate field (the largest in Russia) due to accidents at the field's processing plant or along pipelines. Schoolchildren who live in communities close to the extraction, primary processing, transportation and gas production area, and also near to the Orenburg Gas Processing Plant, suffer from external respiratory disorders, high arterial blood pressure, difficulties with concentration, and low scores on psycho-physiological and physical development indexes compared with other children living in Orenburg Region[36,37].

We will take monitoring data from Omsk, where several oil refineries are located, as an example of benzol pollution. Figure 4.1 shows benzol concentrations in ambient air of the city's northern district for the past 15 years. During that period the concentration has seriously exceeded WHO recommendations and this situation has not yet been fully rectified.

Oil refinery operations pollute the atmosphere, and they also affect ground water, soils, and crops. This is illustrated by data from Novokuibyshevsk (Box 4.3).

4.2.2. Impact of gas processing facilities on air quality and public health

The most comprehensive studies of environmental pollution by natural gas production and processing and its impact on public health have been carried out in Astrakhan and Orenburg Regions (Box 4.4). Children are most at risk. Installation of modern treatment technologies enables large reduction of emissions, as demonstrated by the Astrakhan Gas Processing Complex (GPC).

There have been several protests by locals against construction of liquefied natural gas (LNG) facilities due to concerns about possible accidents at the plants or spillages from LNG tankers at sea.

4.3 Public health risks related to power and heat generation

Electricity, gas, steam, heat, and hot water are all essential for household infrastructure in Russia. They are produced

[35] A.I.Plotnikova, Clinical and immunological specifics of child health in the area affected by the Astrakhan GPC, abstract of a thesis for a Doctor of Medicine degree, Orenburg, 1994

[36] V.M.Boev, S.V.Perepelkin, G.N.Zheludeva, N.P.Setko, L.A.Barkhatova, Hygiene aspects of air pollution by sulphur compounds // Hygiene and Sanitation, 1998, No.6, pp.17-19

[37] I.L.Karpenko, V.V.Utenina, N.D.Osadchaya, S.V.Perepelkin, V.V.Shkunov, Hygiene assessment of physical and psychophysiological development of children living in the area affected by emissions from the Orenburg Gas Extraction Complex// Hygiene and Sanitation, 1998, No.6, pp40-43

either by large power generating facilities (CPPs and CHPs), or by small boiler facilities, often located among residential buildings. In Russia coal is used by 143 thermal power plants (TPPs), while the number of small boiler-houses running on coal is unknown, but must run into tens of thousands. Public health risks from these operations are determined by many factors, but mainly depend on fuel type, height of chimney stacks, local climate, and proximity to residential areas. In Russia coal is used for power generating purposes mostly in Siberia and the Far East, often in territories with a strongly continental climate, which limits self-cleansing in the atmosphere (Table 4.3). In these conditions even small-scale emissions can cause air pollutants to accumulate and reach high concentrations. In Abakan, Barnaul, Blagoveshchensk, Gorno-Altaisk, Krasnoyarsk, Kyzyl, Chita, and Ulan-Ude up to 70% of all heat generating facilities use solid fuel and emissions by power-generating units account for 50-60% of all air pollution from stationary sources. The average concentration of solid particles in the air of cities in the eastern part of Russia is 30% higher than in European Russia (143 and 100 mkg/m^3, respectively).

Presence of coal-fired power plants with obsolete technologies in depressive regions with low HDI and high levels of air pollution (Table 4.3 and Appendix 4.1) adversely affects the social and economic situation. Six out of ten Russian regions with lowest HDI are mainly reliant on coal for fuel (Republic of Buryatia, Amur Region, Jewish Autonomous District, Trans-Baikal Territory, Altai and Tyva Republics) and life expectancy there does not exceed 60.9 years, which is 4.4 years lower than the national average.

The role of air pollution in mortality has been assessed in Ulan-Ude, where emissions by a coal-fired heat & power station have led to severe pollution of ambient air with solid particles. Researchers using risk assessment found that mortality associated with solid particle pollution was 17% of total mortality[38], while the national average is about 2%. According to Roshydromet data, approximately the same level of ambient air pollution is found in Chita, Blagoveshchensk, Magadan, Yuzhno-Sakhalinsk and some other Siberian and Far East cities.

Table 4.3
Fuel-fired power stations and boiler facilities of UES by the share of coal in fuel inputs (consumption of fuel equivalent as per Rosstat recording form RAS-T2), 2007

Share of coal in total fuel, %	Region
Up to 20	Vologda, Ivanovo, Kaliningrad, Kirov, Kurgan, Moscow, Ryazan, Tomsk Regions, Republic of Karelia, Komi Republic, Republic of Udmurtia
20-50	Arkhangelsk, Murmansk, Tula, Chelyabinsk, Sverdlovsk, Rostov Regions
Over 50	Amur, Irkutsk, Kemerovo, Magadan, Novosibirsk, Omsk, Sakhalin Regions, Altai, Trans-Baikal, Krasnoyarsk, Primorsky, Khabarovsk Territories, Chukotka Autonomous District, Republic of Buryatia, Republic of Sakha (Yakutia), Republic of Tyva, Khakassia

Russian coal-fired power units have relatively low capture, transportation, storage and utilization of carbon ash and slag, and relatively high pollutant emissions. Emissions of fine suspended solids and SO_2 by many Russian coal-fired generating units are about 10 times higher than at coal-fired power stations in the European Union[39]. Fine particles

[38] A.B.Boloshinov, L.V.Makarova, Assessment of the adequacy of industrial ambient air monitoring systems for the purpose of assessing public health risks / Assessment of health risks caused by adverse environmental conditions, experience, challenges and solutions. Records of the All-Russian practical science conference (October 23-25, 2002, Angarsk), part 1, p.79

[39] D.A.Krylov, E.D.Krylov, V.P.Putintseva, Estimates of ambient air emissions of SO2, NOx, solids and heavy metals from operation of coal-powered heat & power plants using coal from the Kuznetsk and Kansko-Achinsk basins // Nuclear Power Bulletin, 2005 No.4, pp. 32-36

(between 10 and 2.5 microns) are particularly hazardous to human health, and WHO is tightening limits on maximal allowable concentrations. Mortality from air pollution is usually associated with solid particles. A specialist in dust pathologies, B.T.Velichkovskiy (Member of the Russian Academy of Medical Science), dust particles make body cells required more oxygen, leading to 'respiratory explosion', but the extra oxygen consumed is used neither for energy, not for tectonic needs of the cells. Fine suspended solids inside the human body cause excessive production of chemically active free radicals, provoking aseptic inflammation of respiratory organs. Such inflammations cause chronic diseases of the respiratory organs, particularly among children and the elderly, including pulmonary hypertension or pulmonary heart conditions, and account for up to 80% of all deaths from broncho-pulmonary pathologies[40].

4.3.1. Large generating companies

Power generation facilities producing electricity and heat, which used to be incorporated in RAO UES, are now owned by a number of nationwide and territorial generation companies. In 2005 the Board of UES committed to implementing an environmental policy, which would reduce emissions and waste water discharges. However, the policy did not include any analysis of the environment and public health situation in areas where CPPs and CHPs are located, though the effect of emissions on public health depends to a large extent on microclimate, self-cleansing abilities of the atmosphere, presence of other hazardous industrial facilities, the social and economic situation, and some other factors specific to the location of each generating facility. As stated above, coal-fired generators represent the biggest threat to the environment and public health. Of all Russia's large CPPs, 16 are completely or partly coal-fired. Coal also represents nearly 100% of fuel inputs at Apatitskaya, Intinskaya, Vorkutinskaya-2, Severodvinskaya CHPs, Cherepetskaya CPP, and the experimental CHP in Rostov-on-Don. More than 30% of inputs are coal at Novocherkasskaya, Cherepovetskaya, Vorkutinskaya-1 and Kumertau CHPs, and also

Box 4.5. Cherepetskaya condensing power plant: ambient air quality and modernization plans

Cherepetskaya CPP, which burns high-quality coal from the Kuznetsk Basin (Kuzbass), is a source of ambient air pollution in the town of Suvorov (population 28,000) in Tula Region. The station's boilers emit carbon, sulphur and nitrogen oxides, a series of aromatic polycyclic hydrocarbons, vanadium pentoxide, coal ash, fuel-oil ash, which contain a number of microelements, some of which are toxic. Coal dust is emitted from coal delivery areas during loading-unloading procedures although the areas are equipped with aspiration traps. Design documentation for two new power generating units envisages up-to-date circulating fluidized-bed coal burning technologies, which dramatically reduce toxic pollution, as well as an electrostatic filtering unit with 99.7% efficiency rating and a flue-gas desulphurization (FGD) unit with a 90% efficiency rating. After its reconstruction, Cherepetskaya CPP will be the first generator in Russia to use the latest coal burning technology. It is unfortunate that the existing system of air quality monitoring fails to measure pollution by particularly toxic fine particles, but comparison of total concentration of particulate matter around the Plant with WHO[40] safety norms indicates that ambient air quality up to 4 km from the station is unsatisfactory.

[40] B.T.Velichkovskiy, Pathogenic impact of peak increases of mean daily concentrations of particulate matter in populated areas. Hygiene and Sanitation, 2002, No.6, pp. 14-16

[41] European air quality recommendations / Translation from English, M. Ves Mir Publishing House, 2004, 312p.

Box 4.6. A city at risk

Novocherkassk (population 177,000) was rated by the State Environmental Expertise Committee as an environmental problem zone in 2000. The city climate is characterized by frequent periods without wind and long-lasting fogs, aggravated by temperature inversions, making Novocherkassk particularly susceptible to air pollution. Mean annual concentrations of the main pollutants – formaldehyde, particulate matter, benzopyrene – have exceeded Russian maximal allowable concentration by 3.0, 1.2 and 10.1 times, respectively. Maximum short-term concentrations were higher than allowable levels by 8.2 times for CO, 5.4 times for NO_2, 3.9 times for H_2S and formaldehyde, 4.4 times for particulate matter, and 2.9 times for SO_2 and phenol. The highest registered mean monthly concentration of benzopyrene was 35.2 times higher than the permitted maximum[42].

Emissions by Novocherkassk Power Plant will decline to some extent thanks to introduction of circulated fluidized-bed coal burning technology. Impact of polluted air on public health in the city is combined with high levels of water pollution due to merger of the Severniy Donets river with the Don river upstream from collectors, which supply the city with water: the Severniy Donets is polluted by discharges from chemical facilities in Ukraine. Water supplied to households is treated with chlorine and presence of carcinogenic chlorine compounds is above allowable concentration.

at the Ryazan and Kashira-4 CPPs. Emissions at several CPPs rose in 2008.

Environment quality in areas where these plants are located varies significantly. In some cases (Novocherkasskaya, Rostov-on-Don, Ryazanskaya, Tom-Usinskaya) emissions are declining thanks to use of coal with lower sulphur and ash content, improvement of ash traps, and introduction of fluidized-bed combustion technology. This technology will also be used in two new power units to be built at the Cherepetskaya Plant (Box 4.5).

Most large generating plants are located near small settlements and high stacks send emissions far away from local communities, but a number of plants are located inside cities, where negative impact from power generating is often combined with pollution by other local industrial facilities, including pollution of drinking water. This has long been the case at Novocherkassk (Rostov Region), where high levels of pollution from particles and carcinogenic benzopyrene are caused by a CPP and by the world's largest electrode plant (Box 4.6).

Unlike CPPs, CHPs are usually located inside towns or cities and therefore pose a greater threat to local populations than the former (Appendix 4.1). Most coal-fired CHPs are located in the Urals, Sverdlovsk and Chelyabinsk Regions, as well as in Kemerovo Region, Perm Territory, Irkutsk, Chita Regions and some other regions of Siberia and the Far East. CHP-22 (Dzerzhinskiy, Moscow Region) still uses coal, but installation of new electrostatic filters, which trap of up to 99% of some pollutants, reconstruction of the coal storage area (now underway) and a number of other environmental measures have significantly reduced the plant's threat to public health. NO_2 remains the main toxin in Plant emissions, but high levels of this compound are mostly localized outside residential areas.

CHP-9 in Perm used to burn coal, but was switched to natural gas due to the threat posed to a city district. A court has ordered reduction of emissions at the Kemerovskaya CHP.

4.3.2. Health risks from coal burning in cities

The share of coal in the fuel balance of small heat & power generating facilities,

[42] State Environmental Expertise Committee Report, February 22, 2000

operated by housing utilities, is only 13%, but heat & power plants and boiler facilities are often located adjacent to residential areas, causing a health risk. More of these facilities may now be switched from natural gas to coal. The most detailed research into impact of such decisions on the environment and public health has been carried out in the city of Novgorod, which is currently supplied by CHP-20 and by municipal and industrial boiler facilities. Increase of the share of coal in the city's energy balance, including coal burning at the CHP would greatly increase air pollution risks. Mortality caused by particulate matter (PM_{10}) and SO_2 emissions could almost double; disturbances of the lower respiratory passages among children would triple and bronchitis among children would rise by 15%; incidence of acute bronchial asthma would rise by 35%, and carcinogenic risks due to soot emissions would be 30% higher than at present. The authors therefore believe that the proposed investment project for reconstruction of the municipal heating system and changeover of CHP-20 to coal is hazardous for the local population[43]. Implementation of this dangerous project has currently been postponed.

Researchers of the Krzhizhanovskiy Energy Institute and the Kurchatov Institute (Russian Scientific Center) have carried out comparative analysis of health risks from emissions produced by burning various types of coal[44]. Economic damage caused by such emissions was estimated for several TPPs in European Russia (Kashira, Ryazan, Shatura). Impact is shown in volume terms as units of specific pollutants (1 kg or 1 tonne) and per unit of generated power (1 KWh or 1 MWp.a.). Impacts were calculated based on specific emission indexes shown in Table 4.4.

Table 4.4
Emissions of TPPs using various types of coal (g/KWh)[45,46]

TPP	Coal	Ash, total	SO_2	NO_x **	Solids
Operating	Moscow brown	240	54	2.2	10.0
	Donetsk hard coal	100	22.0	2.8	4.0
	Kansko-Achinsk brown	30	2.6	1.5	1.2
	Ekibastuz	250…420	11.5	3.6	10.0…17.0
	Kuznetsk hard coal	80	3.3	2.5…3.7	0.8…3.3***
Planned*	Kuznetsk hard coal	80	0.7	2.0	0.4…0.8

** Technical requirements for new TPPs*
*** For comparison: emissions of gas-fired TPPs are 0.4g/KWh*
****Particle trapping index (96-99%)*

[43] S.L.Avaliani, V.A.savin, A.A.Golub et al. Additional benefits from implementation of the Kyoto Protocol. Velikiy Novgorod // Climate Changes – the Russian View / Chief Author V.I.Danilov-Danilyan, M., TEIS, 2003, pp.355-381

[44] M.A.Kulikov, E.I.Gavrilov, V.F.Demin, I.E.Zakharchenko, Health risks caused by power plant emissions // Teploenergetika, 2009 No.1, pp.71-76

[45] V.F.Demin, A.P.Vasilyev, D.A.Krylov, Procedures and methods of comparative assessment of environmental risks from various methods of electric power generation // The challenges of assessing surface and ground water pollution by the fuel & energy sector: coll. of sci. pap. / OJSC Gazprom; VNIIGAZ LLC, M., 2001, pp135-145

[46] D.A.Krylov, E.D.Krylov, V.P.Putintseva, Estimates of ambient air emissions of SO_2, NO_x, solids and heavy metals from operation of coal-fired heat & power plants using coal from the Kuznetsk and Kansko-Achinsk basins // Nuclear Power Bulletin, 2005 No.4, pp. 32-36

In order to assess impact of these emissions on public health the authors used economic impact parameters from materials of the Coordination Council of the Russian Ministry for Atomic Energy, which are used for risk assessment in the nuclear sector[47] (Table 4.5).

As shown in Table 4.6 economic impact from coal burning is quite high compared with impact from gas burning. Commissioning of new coal-fired generating facilities will increase the negative impact on public health.

The authors of this interesting research conclude that public health impact from planned new coal-fired TPPs is 2.5 times lower than that of units that are already operating, but much higher than impact of gas-fired stations (Table 4.7).

4.3.3. The hydropower sector

The hydro-electric sector is traditionally regarded as the most acceptable source of power generating as regards impact on public health. However, health risks from construction of giant water dams have been little studied. Such construction projects cause high levels of stress among local people, who must choose whether to live next to the facility or move away. Such stress must have impact on health. There is also a danger of migration by infected animals and discharge of toxic chemical substances and industrial waste.

Table 4.5
Economic parameters of risk assessment

Health risk	Impact unit	Cost per impact unit, rubles
Reduction of life expectancy	1 man-year	600.000
Chronic bronchitis	1 disease	1.500.000
Days lost due to illness	1 day	1.000

4.4. Summary and recommendations

Development of the energy sector in Russia must take account of both the existing situation in various regions and new environmental directives of WHO, EU and other international organizations. Many fuel production and power generating facilities are

Table 4.6
Mean specific values of public health impact per tonne of pollutants[44]

Pollutant	Mean specific impact in natural units, g									Mean specific impact β, 10^3 rubles/tonne.		
	Life expectancy loss			Chronic bronchitis, $N_{illnesses}$ / m.t.			Morbidity rate, N_{days}/ m.t.					
	MR	CR	OR	MR	CR	OR	MR	CR	OR	MR	CR	OR
Particles	0.08	0.03	0.026	0.020	0.010	0.006	8.5	3.0	3.0	90	36	25
NO_x	0.16	0.07	0.018	0.037	0.020	0.004	19.0	7.0	2.1	170	80	19
SO_2	0.11	0.04	0.013	0.025	0.012	0.003	13.0	5.0	1.4	120	47	13

$N_{illnesses}$ – number of chronic bronchitis cases; N_{days} – number of days lost to illness; MR – Moscow Region; CR – Central Russia; OR – Omsk Region

[47] I.L.Abalkina, V.F.Demin, S.I.Ivanov et al., Economic parameters of risk assessment for calculating damage to public health due to various hazards // Risk assessment challenges, 2005, Vol.2, No.2, pp 132-138

Table 4.7
Mean values of public health impact, Rubles/KWh[44]

Pollutant	Plants in Moscow Region		Plants in Central Russia	
	Operating	Planned	Operating	Planned
Powered by Kuzbass coal				
Solids	0.30	0.05	0.12	0.008
NOx	0.50	0.33	0.24	0.160
SO_2	0.40	0.08	0.16	0.034
Total	1.20	0.56	0.52	0.202
Powered by natural gas				
NOx	0.07	-	0.03	-

located in populated areas with high levels of pollution and some are in locations, which have been declared environmental emergency zones. In the past human populations were concentrated along rivers, in favorable environmental conditions. Nowadays, however, Russia exploits vast fuel deposits, and the country is covered by a network of oil & gas pipelines, so that the working population often lives and works in inhospitable areas.

It is hard to obtain accurate information about levels of pollution in areas where the fuel & energy industry is mainly concentrated. The archaic system used by Roshydromet does not allow measurement of ambient air quality in accordance with parameters used by developed countries or recommended by WHO. There are no hygiene norms for ambient air concentrations of particularly hazardous fine particles, but even if such norms are adopted by the relevant government agency (Rospotrebnadzor) only Moscow and St.Petersburg have a system, which can carry out such measurements. There is almost no information on concentrations of oil products, phenols and other toxic substances in drinking water in areas where oil spillages and pipeline accidents have occurred. The situation is no better as regards measurement of ambient air pollution with carcinogenic benzol: existing methods of measurement are not precise enough.

Assessment of fuel & energy sector impacts on public health is a difficult task. Our estimate is that air pollution accounts for up to 3% of mortality in the urban population, of which 15-20% is contributed by the fuel and energy sector. In some areas, where air pollution is high due to presence of coal-fired power generators, that share could be as high as 30-40% of all mortality due to air pollution. Changeover to coal of CHPs, which have short stacks and are located inside residential areas, is unacceptable unless up-to-date coal burning technologies are used.

More efficient coal burning and reduction of its impact on the environment and public health are increasingly important. The share of coal in Russia's fuel balance is expected to rise significantly in the near future due to large coal deposits, particularly in the heavily industrialized Kuzbass. Increased importance of coal in the country's power industry must be accompanied by introduction of new, environmentally friendly technologies.

Future development of the fuel & energy sector must take account of social and economic conditions of the Russian population. Sector growth depends on modernization of power generation facilities through safer fuel combustion technologies and with due account of sustainable development and environmental capacity of adjacent territories. Projects for increase of fuel oil or coal burning must consider specific environmental conditions and public health in the towns or cities concerned. Compliance with new international environmental standards (and not only Russian standards) for populated areas should become obligatory. Wide-scale public discussion of environmental issues in areas affected by power plant emissions is also required.

Health risk assessment and risk management plans should become prerequisites for any decisions to expand the fuel and energy sector. Construction and/or expansion decisions, which lack the required environmental substantiation, could lead to further worsening of living conditions and public health.

Chapter 5 Energy-efficient Russia

5.1. A more productive energy sector is a precondition for human development

Energy efficiency in the economy can be measured by various indicators: energy intensity of GDP (energy consumed per unit of GDP); energy productivity (GDP per unit of energy consumed); or an energy efficiency index (a special complex index measuring energy intensity changes due to improved efficiency in specific sectors of the economy and distinguishing the contribution of each to structural changes).

Energy intensity of GDP is the most commonly used indicator, but the most telling is energy productivity, which is similar to labor productivity. It goes up when energy consumption for providing a specific energy service is reduced, e.g. a compact luminescent lamp consumes 4-6 times less energy per unit of luminous flux than an incandescent lamp, and a Russian stove consumes 3-4 times less fuel per heat unit than an open fireplace.

Increase of energy efficiency means lower energy intensity of GDP and higher energy productivity. Reduction of energy intensity can be achieved by technological improvement (re-equipping), changes in the load parameters of industrial equipment, and by structural shifts in the economy, i.e. changes in the share of segments with different energy intensities due to their development at different speeds. The energy efficiency index is rarely used due to complexity of its calculation, but it shows the role of the technology factor more vividly.

There are three laws of transformation for the energy base of human development: the law of relative stability of the share of energy supply expenditures for all end-users in gross product or GDP (exceeding threshold limits of this share causes economic slowdown); the law of growth in quality of energy used; and (following from these first two laws) the law of improved energy efficiency or of improved energy productivity. Human development has for centuries been accompanied by increase of energy productivity. In the last century and a half this indicator has risen by about 1% every year[1] and even faster in the recent past.

5.2. Russia is now a leader by rate of reduction of energy intensity, but it is still one of the most energy intensive countries in the world

Energy intensity of Russian GDP fell by almost 5% each year in 2000–2008, which is much faster than in many other countries. But energy intensity of Russia's GDP in 2006 was still 2.5 times higher than the world average and 2.5-3.5 times higher than in developed countries (Figure 5.1)[2].

High energy intensity of Russian GDP is not the price paid for a cold climate, but the legacy of a centrally planned economy, which is still lingering after 17 years. It is interesting to note that energy efficiency in Tsarist Russia was 3.5 times higher than in Germany, 3 times higher than in France and Japan, 4.4 times higher than in the UK and USA and 3.5 times higher than the world average.

Four fifths of growth in demand for energy in 2000–2007 was met by rising energy efficiency. Structural changes in the economy and growing utilization of production capacities in the process of 'recovery growth' were important factors in reduction of energy intensity. Transition to investment growth in 2005–2007 greatly reduced input from these factors. Introduction of new technologies has only given 1% annual reduction of energy intensity, which is comparable with the results

[1] In the USA and Great Britain in 1850-2005 energy intensity of GDP declined by about 1% annually and in France by 0.5%, in Canada in 1920-2005 it declined by 0.7% annually. In 155 years energy productivity in the USA has risen by 5 times and in the UK by 4.6 times.

[2] Russia's CENEf (Center for Energy Efficiency) estimates that energy intensity of Russian GDP declined by 4.5% in 2008, but the decline may slow down to 2-3% per year during the economic crisis in 2009-2010

achieved in developed countries. So Russia has not been able to significantly reduce its technology gap with developed countries since 1990. The speed of technology upgrading needs to rise by 2-2.5 times in order to reduce the energy efficiency gap.

Resource support by the federal government in 1992–2008 for improvement of energy efficiency was completely inadequate for the challenges faced. Some steps for greater energy efficiency were taken after passing of Federal Law No.35, 'On energy saving', dated April 3, 1996. But the issue of energy efficiency received less and less attention after the 1998 crisis and government policy was reduced to fragmentary actions. The administrative reform of 2004 almost completely excluded energy efficiency from the scope of responsibilities of the federal government. Current statutes governing functions of federal executive bodies only mention energy efficiency as a responsibility of the Ministry of Economic Development. Some positive examples of federal government action in this field are: changing heat technology standards in construction (2003) and implementation of an energy efficiency programme by the Ministry of Education in 1999–2005.

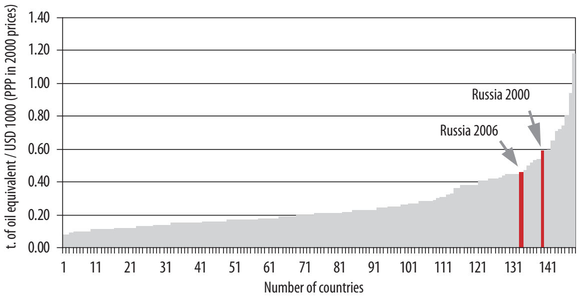
Enduring energy intensity of Russia's economy entails major risks:

- Lower energy security and slower economic growth;
- Threat to Russia's geopolitical role as an energy supplier on international markets (Figure 5.2);
- Difficulties in implementation of national projects;
- Inability of Russian industry to compete internationally;
- Faster inflation;
- Increasing burden of housing utility costs on municipal, regional and federal budgets, reducing their financial stability;
- Obstacles to overcoming poverty;
- Threats to the environment.

Russia's future prosperity depends on reduction of energy intensity. So the attitude of federal government towards energy efficiency needs drastic revision. There needs to be a new federal law on energy saving and efficiency as well as a system of legal acts to ensure implementation. The federal government must develop and implement a policy for greater energy efficiency. The government should create an integrated system to manage the process of energy efficiency, assigning responsibilities and ensuring efficient interaction between federal, regional and local executive government, businesses and the general public.

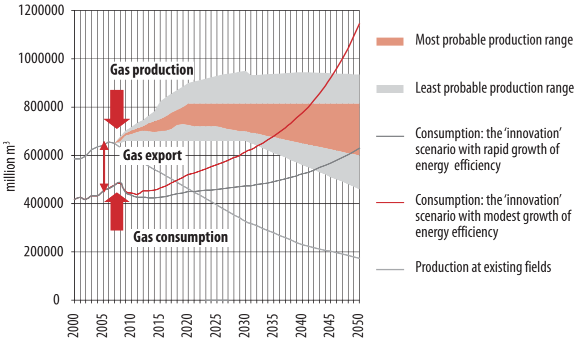
Almost the sole means of managing energy efficiency, available to the federal government in recent years, has been energy prices. A much wider range of instruments is needed, including design of a state programme for increasing energy efficiency, and setting of

Figure 5.1
Energy intensity of Russian GDP compared with other countries in 2000 and 2006



Source: Calculations based on IEA data

Figure 5.2
The 'gas scissors': forecast extraction and consumption of natural gas up to 2050



Source: Calculated by CENEf

targets for regional and municipal energy efficiency programmes. There should be a system of mandatory requirements for energy efficiency of equipment, buildings and facilities, and proper metering of energy production, transportation and consumption. Mechanisms of support for energy efficiency activities should be designed, as should a procedure and criteria for subsidizing regional and local budgets in order to promote their energy efficiency programmes. The state could also provide methodological and educational support, as well as energy efficiency training for employees.

Energy consumption statistics require improvement through creation of unified fuel & energy balances at both national and regional levels, and a multi-level system of indicators is needed to assess performance of federal, regional, and local government as well as business in raising energy efficiency.

Russia's regions have been pioneers in many aspects of energy efficiency. Laws on energy efficiency have been enacted in 43 regions, many regions have medium-term energy saving programmes, 75 regions have funds and agencies working on energy saving and 53 regions have imposed construction standards, which include energy efficiency and energy saving requirements. Moscow and the Republic of Tatarstan have led the way, but there has been much less progress in some other regions. Lack of interest in energy efficiency from federal government in recent years has had negative effect on regional initiatives.

Reduction of budget spending for provision of energy to northern territories is an important objective. A programme is required for modernization of energy supply systems and integration of renewables in remote areas in order to create a sustainable, economically and environmentally efficient, and reliable energy supply system in such areas.

A package of priority measures for increasing energy efficiency of regional economies should be designed and enacted as soon as possible, as should energy efficiency programmes at regional level, with specific objectives for each economic sector and specification of main mechanisms, actions and resources for each task. These programmes should include specific sub-sections: on reduction of budget sector expenditures through energy efficiency measures; on use of metering of energy consumption; on interaction and coordination of regional energy efficiency activities with similar programmes of local government, large resident corporations, and government-regulated organizations; and on mechanisms for assisting small and medium-sized business to reduce energy costs in operation of existing facilities and design of new projects.

5.3. Russia can reduce energy consumption by 45%

Estimates suggest that Russia could improve its energy efficiency by 45% compared with 2005 (Figures 5.3 and 5.4). Technological progress makes the resource for increasing energy efficiency renewable. Full use of the potential for electrical energy savings could reduce consumption by 340 billion KWh, or by 36% from the 2005 level. More efficient use of thermal energy and reduction of losses in heating networks could save up to 844 million GCal, or 53% of heat use in 2005. Reducing energy intensity of the Russian economy would also be equivalent to giving the country a natural gas field bigger than any, which it actually possesses. Potential for reducing natural gas consumption is now 240 billion m^3, or 55% of the consumption level in 2005, much exceeding gas exports by Russia in 2005–2008.

The capital investments needed to fully utilize energy efficiency potential are USD 324-357 billion, while investments needed for development of the fuel & energy sector are estimated at over USD 1 trillion. Gain of a single unit of energy through expansion of production requires 2-6 times more capital investment on average than gain of the same unit of energy by increasing energy efficiency. In many cases energy efficiency gains do not require any investments at all.

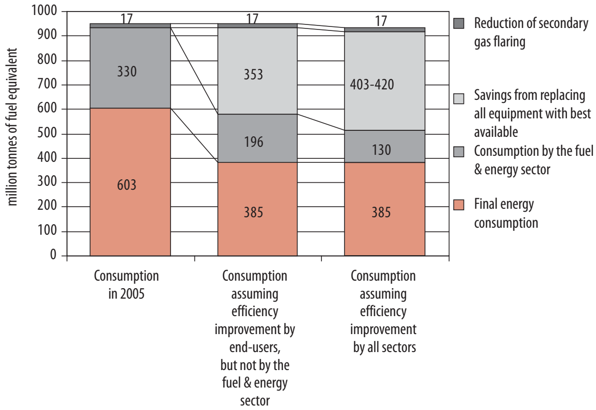
If Russia exported all of the oil, gas and oil products, which it would save by realizing its energy efficiency potential, the country would obtain additional annual revenues of USD 80-90 billion, as well as keeping GHG emissions well below the threshold level of 1990 until 2050, even assuming strong economic growth.

Energy saving potential is like oil deposits: they may be huge, but they are of no use until wells are drilled and a field is constructed. The obstacles to energy efficiency in Russia can be divided into four groups:

1) Lack of motivation;
2) Lack of information;
3) Lack of funding and long-term investments;
4) Lack of organization and coordination.

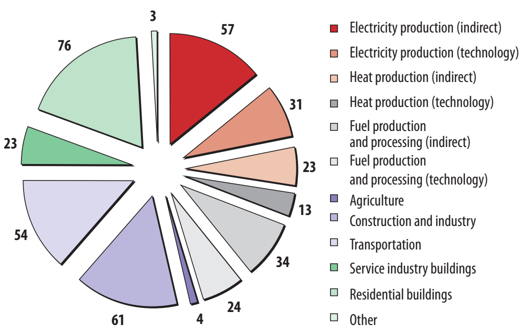
Strong government policy is needed to overcome these obstacles, and the time has come to move from words to deeds. Energy efficiency must be made the priority of energy strategy and must be viewed as the main contribution of the energy sector to economic growth.

Figure 5.3
Potential for energy efficiency improvement in Russia



Source: CENEf estimate for the World Bank

Figure 5.4
Breakdown of Russia's energy efficiency potential (million tonnes of fuel equivalent)



Source: CENEf estimation for the World Bank

5.4. National energy efficiency targets

Russian Presidential Decree No.889, 'On measures to improve energy and environmental efficiency of Russia's economy' (June 4, 2008) sets a goal of reducing energy intensity of GDP by 40% in 2020 compared with 2007, i.e. reducing energy intensity of GDP by 4% each year. This is a higher rate than Russia is achieving at present.

The national objective for energy efficiency could be summarized in quantitative terms as follows: reduce energy intensity of GDP by 40% in 2020 compared with 2007; and save about 1000 million tonnes of fuel equivalent in an economic development scenario based on innovation. Any more ambitious targets for 2020 are unrealistic. The savings would be equal to the whole of Russia's production of primary energy in 2008. Achievement of this goal will require creation of a specialized 'energy efficiency industry' in Russia.

Reduction of energy intensity of Russia's GDP by 40% in 2007–2020 would require total elimination of the gap between energy intensity of industries producing main goods and services in Russia and globally, or implementation of a tougher schedule for energy tariff increases from 2012 than is now envisaged by the innovation scenario: inflation-adjusted tariffs would have to rise by at least 13% annually until 2020.

Regional energy efficiency policy should focus on reduction of energy intensity of gross regional products. A multi-level system of indicators for all energy consumption sectors would enable control, analysis and monitoring of the process both nationwide and at regional level.

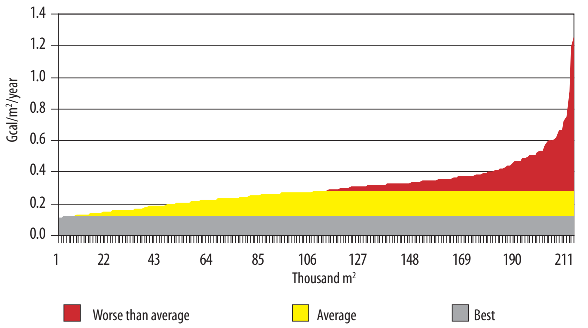
5.5. The government should set an example: improving energy efficiency in the budget sector

The budget sector (education, health, armed forces, etc., but not state-owned companies) is fairly energy intensive: it consumes about 40 million tonnes of fuel equivalent annually or 4% of national energy consumption. Utility expenditures of all Russian budget-funded organizations exceeded 180 billion rubles in 2007 and estimates for 2009 are over 260 billion rubles. These expenditures are 2% of the consolidated budget and 5-10% of regional and local budgets. High energy consumption in the budget sector is caused by depreciation of most facilities, which need major repair work. Lack of metering and control equipment means that budgets often pay for utilities, which they either did not receive or did not need.

Steps to install energy-saving management at budget-funded facilities began in 1999 with introduction of limits on electricity use. However, the system was abandoned in 2004. Energy saving potential in the budget sector is 15 million tonnes of fuel equivalent, or 38% of current consumption, as shown by the yellow and red lines in Figure 5.5.

Russia already has considerable experience of raising energy efficiency of budget-funded facilities, but an unwieldy procedure for accumulating budget funds, that have been saved, makes it hard to use the savings for modernization of those same facilities. In order to create motivation, owners of these facilities (federal, regional and local

Figure 5.5
Rating of educational facilities in Ekaterinburg by specific heat consumption for space heating



Source: CENEf based on data of the Fuel and Energy Authority of the Ekaterinburg Regional Administration

Table 5.1
Targets for reducing fuel and electricity intensity of GDP in the Concept for Long-term Social and Economic Development of the Russian Federation up to 2020, and estimates up to 2030 (%)

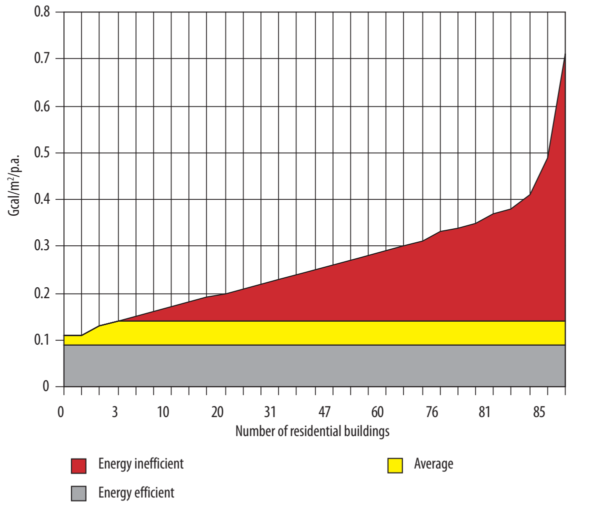
	Scenario	2007	2012	2020	Reduction in 2007-2020	2030	Reduction in 2007-2030
Energy intensity of GDP	Inertia	100.0	83.7	70.6	29.4	59.2	40.8
	Energy and raw materials	100.0	83.1	67.0	33.0	53.6	46.4
	Innovation	100.0	82.4	59.6	40.4	42.1	57.9
Electrical energy intensity of GDP	Inertia	100.0	88.1	81.4	18.6	77.1	22.9
	Energy and raw materials	100.0	88.7	80.1	19.9	70.7	29.3
	Innovation	100.0	87.9	72.5	27.5	56.5	43.5

Sources: Presidential Decree No.889 (June 4, 2008), 'On measures to improve energy and environmental efficiency of Russia's economy', and the Memorandum, ' On scenarios for long-term social and economic development of the Russian Federation', (Ministry of Economic Development, July 2008).

government) should set targets and goals for energy efficiency, basing payments for consumed, produced and supplied energy on metering data. The government should support creation and development of partnerships between the state and private businesses to install professional management of budget-funded real estate.

Part of the budget funds saved by increasing energy efficiency should remain with the budget organization, which achieved the savings. Business proposals to supply energy equipment should be assessed with respect to operating costs throughout service life.

Figure 5.6
Rating of 86 high-rise residential buildings in Moscow equipped with heat meters by specific heat consumption for space heating



Source: Calculated by CENEf based on the data of A.Naumov, Assessment of heat consumption for heating and ventilation purposes in residential areas, AVOK No.8, 2007

5.6. Raising energy efficiency in the housing sector

Energy use per 1m^2 of residential space was almost unchanged in 2000–2007. Measures to standardize energy consumption in new housing projects reduced the amount of energy used for heating by 35-45% in new buildings compared with old ones. Walls and roofs of residential buildings have degraded due to inadequate repair over time. Measurements for household apartments show that Russians consume 40-60% less hot water than envisaged by official standards, i.e. the same amount as in the EC or Japan.

Household energy consumption has been determined by two opposite trends: increasing energy efficiency of large imported household appliances (refrigerators, washing machines, etc.) has amounted to 'imported energy efficiency'; but a growing number of small household appliances (computers, air conditioners etc.) has canceled out the savings due to efficiency of large equipment.

The energy saving potential of Russia's residential buildings exceeds 76 million tonnes of fuel equivalent, or 55% of their total energy consumption (see the yellow and red zones in Figure 5.6). If energy saving potential is calculated using the 'passive building' concept, the figure increases by 36 million tonnes of fuel equivalent. Analysis has shown that reduction of relative heat consumption by new buildings does not increase construction costs.

Some 11 billion KWh could be saved each year merely by replacing 450 million incandescent lamps now used by the housing sector with luminescent lamps. That is only slightly less than annual energy consumption in Lipetsk Region. Replacing old refrigerators with modern models would save at least 10 billion KWh. The total saving together with replacement of lamps would equal annual output of the Kalininskaya Nuclear Power Plant.

In order to reach the national target, residential energy use per m^2 needs to decline by 22% before 2020. To achieve this the government should enhance current rules for energy efficiency in new buildings, requiring further improvements in energy efficiency of buildings. New technology and production should be developed to enable construction of comfortable and energy efficient housing, which uses two or more times less primary energy. Russian construction standards should be adjusted to match best international practice.

Volumes of major repair work on residential buildings declined by four times in 2007 compared with 1990 and by almost seven times compared with 1970. In the 1970s–1980s major repairs were carried out on 3% of total housing stock each year, but the indicators had fallen to 1.2% by 1990 and to a mere 0.2% in 2007. This is an unacceptably low level, which fails to improve average specifications of the entire housing stock, and only partially compensates degradation of the heat insulation qualities of buildings. The major repair rate should be raised to 3-4%, and relative energy use for heating should be reduced by at least 30% after such repairs. The Housing Utilities Reform Fund should make allocation of federal budget funds for major residential repair conditional on installation of metering equipment and minimum 30% reduction of relative energy consumption after repairs are completed. Ageing buildings, which require 2-3 times more energy than the housing average and 3-5 times more energy than new buildings, should be demolished and replaced.

The government should organize monitoring and energy efficiency rating of residential buildings using special 'energy passports'. Incentives could be created for energy saving in the housing sector through standard, 'result-oriented' contracts for residential building management. At the same time households need to learn to manage the management companies: whatever the procedure for selecting the management company, it should not be entrusted with all building management functions, ensuring that households are in charge of the company and not the reverse. Managing companies could act as energy service companies, selling specific levels of 'comfort' (i.e. specific temperature, humidity, lighting, elevator services, etc.) to households, rather than volumes of energy resources. Savings on utilities from improved energy efficiency of new and repaired houses should either be paid to households or used for more upgrading work on residential buildings. This requires that metering instruments should be installed and used for fair billing of utilities.

Availability of information is another key factor for correct energy efficiency decisions. Markings on household appliances and insulation materials will help consumers to make the right choice.

Efficient use of energy depends on basic training in relevant methods. Libraries of best practice are needed, offering lists of managerial solutions. There should also be a network of energy efficiency consulting centers to help households make energy choices. The media must be responsible for encouraging people to adopt new energy-efficient behavior. 'Energy-saving days' could be held at national and regional levels.

Those on low incomes suffer most from low energy efficiency, and these people need special help. Provision of such help will also reduce subsidies and welfare now paid to help low-income families pay for utilities. The 'Warm House' and 'Cheap Light' programmes should be implemented in all households and communities located in isolated northern regions of the country.

5.7. Improving energy efficiency of heating systems

In over a century of development Russia's heating supply system has grown to become the largest in the world. In 2006 Russia accounted for 44% of world production of centralized heat. Centralized heating takes 320 million tonnes of fuel equivalent or 33% of all primary energy consumed in Russia, which is equals to total consumption of primary energy in such countries as Great Britain and South Korea. The heating market is one of the largest single-product markets in Russia. Despite this, Russia does not have a federal management institution or uniform development policy for its heating networks. In 2007 government budgets at all levels spent 99 billion rubles on household sector heating.

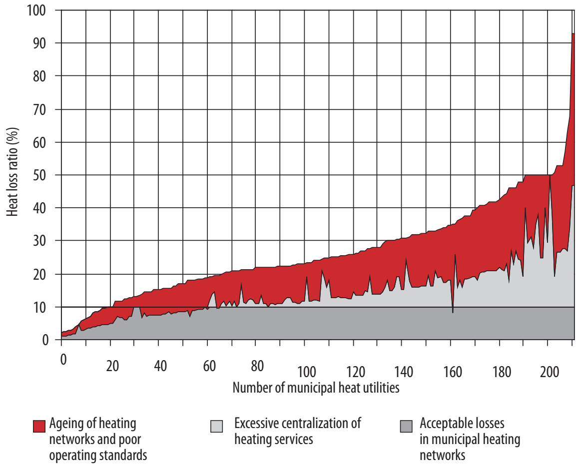
Consumption of heat did not rise in 2000–2008 despite the growth of Russian GDP, although it stabilized after the fall of the 1990s. Increased demand for heating due to new housing construction compensated reduction of heat consumption by existing users, as metering instruments and heat-saving measures became more widespread. Contrary to trends in the rest of the world, Russia's CHPs saw a reduction in their share of the heat market.

Efficiency of heat production and distribution changed little in 2000–2007. Production costs of many small boiler facilities are much higher than recommended levels. Relative consumption of electricity for production and transportation of heat is also above recommended levels at many such facilities. Losses in 70% of heating networks (mostly small networks) are 20-60% (Figure 5.7). However, Russia has improved its heating system efficiency in recent years by use of new technologies, and this trend needs to be continued.

Potential efficiency increases in heat utilization and transportation are estimated at 840 million Gcal, which is 58% of total consumption of heat produced by centralized systems. Potential improvements to production efficiency at boiler houses are estimated at 15 million tonnes of fuel equivalent or 8.4% of 2005 consumption. Heat load of 70% of Russia's heating networks is beyond the range of highly efficient operation and even beyond acceptable efficiency limits. These systems require full or partial decentralization. Potential for cutting heat losses in networks by decentralization, upgrading and heat saving by consumers is 212 million Gcal. Efficiency of heat production and utilization needs to be greatly increased in order to achieve national energy efficiency goals.

Compulsory inclusion of energy efficiency targets in all development

Figure 5.7
Rating of 230 Russian heat utilities by distribution losses



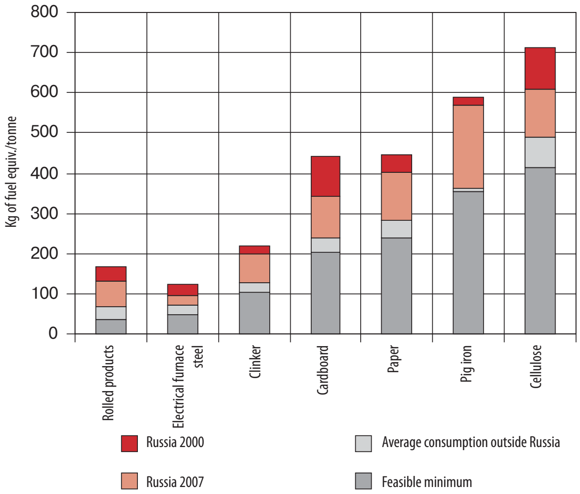
Source: CENEf

programmes for household utilities could be a good way of increasing efficiency of heating systems. Movement towards energy efficiency will also require: development of municipal energy and heating plans; modeling of the heating market and implementation of models, which encourage competition; changing the principles of heating network management through different planning approaches; organization of heat energy accounting through meter installation; changing operating methods of municipal heating networks by conversion of municipally owned enterprises into private businesses; a more efficient tariff system; and creation of 'smart' heating systems.

5.8. Raising energy efficiency in industry

In 2007 processing industries consumed 44% of all energy used in Russia. Primary energy intensity of industrial production (per GDP unit) fell by 35% in 2000–2007, and end-user intensity in industry was down by 39%. But, despite these trends, growth of energy consumption in Russia in recent years has been largely due to industry. Energy intensity of several industrial commodities has decreased more slowly than

Figure 5.8
Gap in energy intensity of specific types of products in Russia, compared with international best practice



Source: CENEf

overall energy intensity of industry (the indicator has remained the same or even increased for some commodities). Changing energy intensity of many goods was determined by change in production capacity load. However, improvements were achieved thanks to equipment and technology upgrades at some enterprises.

Despite reduction of energy intensity in 2000–2007 Russian industry still uses much more energy than world leaders, with serious impact on competitiveness (Figure 5.8). Contracts with energy suppliers place all the risks with industrial consumers, who must often pay for 'unused' energy.

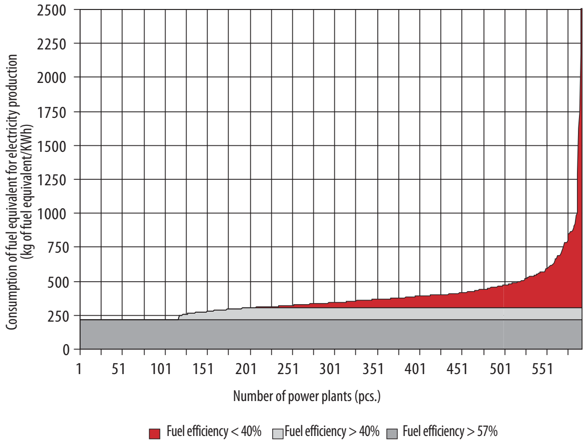
The national target for reducing energy intensity of GDP requires reduction of energy intensity of Russia's industry by at least 33% by 2020. Potential for increasing energy efficiency in industry (not including the fuel & energy sector) is estimated at 59 million tonnes of fuel equivalent. Including own needs and losses in the fuel & energy sector the figure rises to 138 million tonnes of fuel equivalent, which is more than annual energy consumption in Poland, Holland or Turkey. Energy-intensive sectors represent 42% of potential energy savings in processing industries and 20% of total energy saving potential in final consumption sectors.

Cooperation between the state and leading Russian industrial enterprises could significantly speed up realization of energy saving potential and neutralize negative effect from rapid growth in the share of energy costs. Russia has almost no experience of partnerships between government and the private sector in energy efficiency, but there is plenty of international experience. Voluntary agreements between government and corporations to increase energy efficiency and reduce GHG emissions or pollution are desirable, as well as mechanisms for coordinating government energy efficiency policy with cost cutting programmes of large national corporations, including agreements on energy efficiency targets.

Assistance to industrial companies during the crisis should be made conditional on their having an energy efficiency plan. Businesses need help in integrating energy efficiency goals into existing standards and management systems. The chief energy engineer at an industrial facility should also become an energy manager, capable of handling a wide range of both technical and economic issues. Energy management standards should be developed and introduced at Russian industrial enterprises.

Industrial systems engineered with regard to energy efficiency criteria are more durable, increase overall productivity and reduce energy costs. A special information campaign will help Russian businesses to determine and utilize their energy efficiency potential. Energy management and energy audit manuals will be needed, current practices, which sometimes penalize employees for saving energy, must be changed, and contracts for energy supply to industry should be modified. Part of the savings should be used to provide incentives to the chief energy engineer in his work and to further promote energy saving. Development of standardized banking technologies to finance energy efficiency

Figure 5.9
Generation efficiency rating of Russian thermal power plants in 2007



Source: CENEf

enhancement is also important. Energy service business in industry should be supported, and partnership between business and technical universities for development of energy saving programmes should be promoted.

The government could provide funding for enterprises, which invest in energy efficiency programmes. Saving of one million tonnes of fuel equivalent in industry requires 6-9 times less funding than expansion of fuel production to produce the same amount. Saving of one million tonnes of fuel equivalent in industry saves the same amount of fuel equivalent throughout the national economy, as well as releasing extra quantities of exportable oil &gas. These factors are sufficient reason for official support to be lent to energy efficiency programmes in industry.

Support could be in the form of partial compensation of loan interest, or federal budget subsidies for projects reducing consumption of natural gas, thermal or electric energy by installation of efficient equipment or use of secondary energy resources. Special funding packages could be used to implement model projects for promoting energy efficiency at industrial facilities with minimal risks: replacement of electric motors, lighting systems, ventilation, water and steam supply networks, refrigeration equipment, upgrading of compressed air systems, etc. Other instruments include tax and customs preferences, guarantees, accelerated depreciation of energy efficient equipment, and investment tax credits.

5.9. Increasing efficiency in the electricity segment

Energy losses at power stations in production of electric and heat energy account for 15-16% of all primary energy losses. In 2000–2007 the fuel efficiency coefficient at Russia's power stations declined from 58% to 56%, mostly because of shrinkage in the share of CHPs on the heat market. The average coefficient at Russian stations in 2000–2007 was 36-37% (Figure 5.9) and fuel consumption per 1 KWh of electric energy during the same period declined by only 1.5%. Only 1.5% of all energy generated in Russia met the IEA's upper efficiency limit, while 7% of all Russian electricity was generated at stations whose productivity indexes were below 30% and 2 billion KWh was generated at stations with indexes below 20%. Average energy consumption for heat production at power stations has decreased slightly from 156 kg of fuel equivalent per tonne in 2000 to 154 kg in 2007. Losses in energy grids in 2007 were 105 billion KWh or 10.5% of all energy consumption.

Potential for increase of energy efficiency in production of electric energy at the 2005 output level is 64 million tonnes of fuel equivalent. This figure would increase to 133 million tonnes if all consumers implemented the energy savings, of which they are capable. Russia needs to invest USD 106 billion to increase energy efficiency of its fuel-fired power stations.

Attainment of the national goal of reducing energy intensity of GDP requires reduction of fuel consumption at Russian power stations by at least 11% to 286 g of fuel equivalent/KWh by the year 2020. Requirements for minimal levels of energy efficiency need to be include in investment and production programmes of energy suppliers and of government-regulated organizations. Minimum fuel efficiency requirements for new power stations should be included in investment contracts: the minimum level for gas-fired stations should be raised to 60% by 2015–2020, and the minimum for new coal-fired stations should be 48%. The share of Russian heat output supplied by fuel-fired power stations should rise to 44% in 2006–2010 and 51% in 2020, while losses in electricity grids should be reduced to 7-8%.

Government tariff policy in the past few years has helped to promote energy efficiency, but there is still room for improvement of pricing processes to stimulate energy saving, and introduction of a carbon tax or a tax on harmful emissions is worth considering. Anticipated tariffs in 2010 will raise the 'market' share in energy efficiency potential to 70%, and future introduction of heavy penalties for emissions or of a carbon tax could raise the share to 92%. Energy tariffs should increase together with the ability of consumers to pay, and this ratio should be set in a way that encourages energy efficiency. There needs to be improvement of forecasting procedures for estimating future energy balances, taking account of expected outcomes of energy saving activities, as well as improvement of modeling of energy markets and relationships between market players. Tariff plans should offer economic motivation for raising of energy efficiency.

Long-term tariff regulation parameters should enable inclusion of mandatory energy saving activities and actions for increasing energy efficiency of consumers in investment budgets, as well as allowing government-regulated consumers to use the savings achieved by their energy saving activities over a period of at least five years.

It is important to assess possibility and advisability of introducing increased emission taxes and a carbon tax. Funds raised from such taxes and from sales of GHG emission quotas, including those received as 'green investments' could be used to finance government actions for increasing energy and environmental efficiency.

A part of energy suppliers' investment programmes should be supported through buying out of inefficient energy capacity and extra energy from consumers. The situation where the main task of the energy supplier is to sell as much energy as possible needs to be replaced by a situation where the main goal is to provide essential energy services (comfort, lighting, transport, etc.). Such a system could use so-called 'white certificates', proving certain energy saving achievements and based on existing practices such as the emissions market or the 'green certificate' system, which are used in an increasing number of countries. Buying of electric capacity from inefficient consumers (which use it during peak periods for lighting or electrical heating) would cost only USD 20-60 per KW, while construction of new generating capacity would theoretically cost USD 700-1,500 per KW, but, in actual Russian conditions, would cost USD 2,000-4,500 per KW, i.e. a hundred times more.

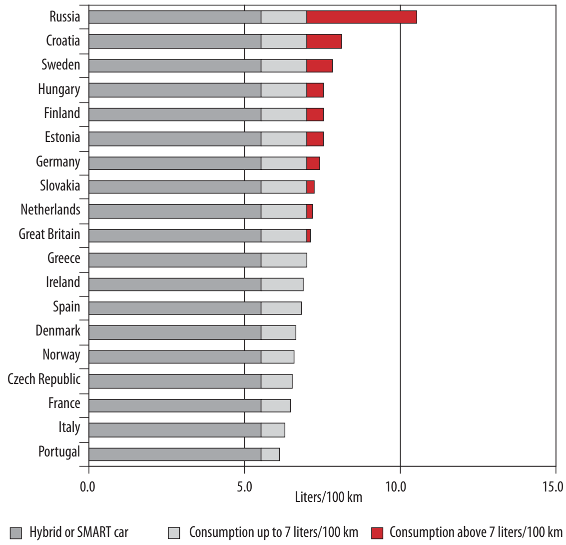
It is important to improve the energy supply system to remote regions. Although diesel power stations in remote areas produce relatively small quantities of electricity, this is the most expensive energy in the world and significant budget subsidies have to be spent on it. A programme of modernization and integration of diesel power stations with renewable energy sources is highly important for minimizing budget expenditures at all levels and ensuring a sustainable, effective and reliable energy supply.

5.10. Energy efficiency in Russian transport networks

Transport was in second place after industry by increase of energy consumption in 2000–2007. The share of privately owned automobiles in total passenger transport has sharply increased, which has greatly reduced energy efficiency of the transport system. Some transport companies, including JSC Russian Railways, are implementing energy saving technologies. But unit energy costs in many transport sectors grew in 2000–2007. This was true for pipeline transport of oil & oil products, electric traction on railroads, subway trains, streetcars, trolley buses, as well as diesel traction. Achievement of national energy targets will require significant reduction of energy intensity in the transport segment.

Russia could reduce energy consumption in the transportation segment by 55 million tonnes of fuel equivalent, representing 28% of all energy consumed by transport in 2005, through the following steps: improvement of the database and data collection methods for energy consumption by transport; integrated planning of transport operations; improving the quality of public transport services and providing better opportunities for multimodal public transport (i.e. combining private and public transport within a single trip); introduction of a tax on purchase of private cars with large engines; providing incentives to drivers who buy energy-efficient vehicles; further strengthening of efficiency standards for fuel and emissions; introduction of fuel efficiency markings for automobiles; encouraging changes in behavior; introduction of utilization schemes for old vehicles; more rapid renewal of the vehicles on Russian roads through financial stimulation for utilization of old automobiles; and development of energy saving technologies.

Figure 5.10
Comparison of specific fuel consumption by new gasoline-fired passenger automobiles sold in 2006-2007



Source: ODYSSEE database for all countries, except Russia. Russian data provided by CENEf

5.11. Summary and recommendations

Russia is a world leader in reducing energy intensity of GDP, but still remains one of the most energy-inefficient countries. Reduction of energy intensity was mostly caused by structural factors and the technological gap with developed countries remains. This gap cannot be allowed to remain indefinitely if Russia means to approach the levels of prosperity of developed countries in a context of increasing global competition and depletion of resources, which could maintain the country's orientation to resource exports. The only way forward, therefore, is via a dramatic increase in productivity, including energy efficiency.

Potential for energy efficiency improvements in Russia is greater than in almost any other country in the world, amounting to 45% of all energy consumption. This potential is the main energy resource for future economic growth. However, until now the federal government has been sluggish in promoting energy saving activity, failing to encourage best use of this resource.

Russia's goals for increasing energy efficiency of the national economy are: to reduce GDP energy intensity by 40% in 2020 compared with the level in 2007; and to achieve energy savings of around 1000 million tonnes of conditional fuel. These are realistic goals, but they require development and implementation of a wide range of energy saving measures, including:

- Creation of an integrated energy efficiency management system;
- Enactment of legal measures, defining mechanisms of state regulation;
- Creation of a system for statistical monitoring and registration of energy efficiency levels in all industrial sectors, together with informational and educational systems to support energy saving activities;
- Implementation of regional and local energy efficiency programmes, as well as programmes for increasing energy efficiency of state and municipal organizations, as well as of government-regulated entities;
- Creation of necessary and sufficient conditions for partnership between the state and private businesses in targeted energy efficiency agreements for energy intensive sectors, and in implementation of reproducible energy saving projects;
- Creation of a budget funding system to stimulate energy saving projects, development of renewable energy sources and environment-friendly production technologies;
- Creation of a tariff policy, capable of promoting energy saving;
- Stimulating R&D work in environment-friendly technologies;
- Creation of new behavioral and motivational stereotypes for rational and environmentally conscientious utilization of energy and natural resources by the general public.

Box 5.1. Programme of the Ministry of Education and Science of the Russian Federation: 'Integrated Solutions for Saving Energy and Resources to Promote Innovative Development in Various Sectors of the Economy'

Russia's largest consumers of energy in the federal government sector are the Ministry of Defence, the Ministry of Education and Science, the Federal Penitentiary Service of the Ministry of Justice, the Ministry of Healthcare and Social Development, and the Ministry of Internal Affairs. The largest government sector consumers at regional and local level are educational and healthcare facilities.

Spending by budget-financed organizations on utilities in 2007 exceeded 180 billion roubles and the figure for 2009 is expected to be in excess of 260 billion roubles. The share of utilities in total expenses of the budget system is 2%, but as much as 5-10% of regional and local budgets have to be allocated for utilities. In 2009 almost 8 billion roubles were spent on energy supplies for and maintenance of Russia's budget-financed facilities (including those in local government ownership). In order to cover these expenditures Russia has to export at least 45 million tonnes of oil each year at a price of USD 50 per barrel or 65 billion cubic metres of natural gas (assuming that half of revenues from oil & gas export are taken by the budget).

At least 500 billion roubles would be needed to modernize all of Russia's budget-funded facilities, including measures to make their use of utilities more efficient. The budget system is unable to allocate such a sum for this purpose. However, the amount of money needed for such modernization could be significantly reduced if mechanisms were implemented, by which the savings would be used to finance the modernisation. Strain on the budget could also be reduced through partnerships between state organizations and private firms, by which part of the financing costs would be met by the private sector.

Russia has considerable experience in improving the energy efficiency of budget-financed facilities. Measures by the Ministry of Education and Science (prior to 2004 the Ministry of Education) are particularly worthy of note, and represent the first and so far the only consistent policy effort by a Russian government ministry to improve the energy efficiency of institutions under its control.

In 1999 the Ministry of Education developed and implemented a five-year energy saving programme to create a system for effective management of energy use at educational institutions. Under this programme, an infrastructure for implementing a single energy-saving policy at all educational institutions across Russia was created on the basis of leading universities. The emphasis was on specific energy-saving measures at federal educational institutions.

In 2000–2005 more than 1000 educational institutions in various regions of Russia, including the cities of Moscow and St.Petersburg, implemented the programme, by which energy consumers established business accounting systems, began introducing equipment and mechanisms for regulating heat consumption, and developed and implemented integrated low-cost measures for reducing energy losses at higher education and vocational training facilities. An automated research and information system was created for accounting and control over energy consumption at educational institutions, which were under the control of the Ministry of Education (more recently through the Ministry's subsidiary organisation, the Federal Agency for Education).

Energy certification of facilities owned by educational institutions in 2000–2005 as well as systematization of energy consumption accounting and analysis, installation of energy saving equipment and more efficient energy use enabled the education sector to reduce its energy consumption, achieve savings in energy consumption per student, and save considerable amounts of money by paying less for electricity and heat. Educational institutions were given only one year to achieve payback of funds, which had been provided in order to implement the energy-saving programme. A regional statistics collection network was set up to monitor actual consumption of and payments for electricity and heat by educational institutions. This made it possible to calculate average energy consumption per student and compare the declared energy consumption limits with actual consumption. Prototypes of new equipment and technologies were developed to help reduce consumption of electricity, heat and natural gas by educational institutions.

The Ministry of Education and Science has developed a further target programme, to be implemented in 2009–2010, which aims to develop integrated solutions to saving energy and resources for innovative development in various sectors of the economy. The programme, which is backed by Presidential Decree No. 889, 'On measures to improve the energy and environmental efficiency of the Russian economy' (June 4, 2008), is part of a larger federal target programme for development of education in 2006–2010, approved by the Russian government in its Resolution No. 803 of December 23, 2005 (based on a decision by the Science Coordination Council of the Ministry of Education and Science). The 2009–2010 programme is intended to mobilize the know-how of scientific organizations, higher education institutes and specialized private companies in order to improve energy efficiency of buildings and structures, which are the responsibility of organizations that are subject to the Federal Education Agency.

The programme is to be partly financed by non-budget funds provided by educational institutions themselves at a ratio of 1 rouble from the budget to at least 1 non-budget rouble. The programme is unique in its breadth of approach, spanning the whole range of energy-saving measures, from energy consumption research, estimate of the energy savings, which are achievable for educational institutions, to developing infrastructure for implementation of energy-saving projects and monitoring of results.

In 2009 a package of measures was developed for energy saving and greater energy efficiency at educational institutions reporting to the Federal Education Agency. These measures are being financed by the Federal Programme for Development of Education in 2006–2010. They target four main areas:

1. Developing a programme of specific energy-saving measures to be implemented by educational institutions in 2010;

2. Developing modern laws and regulations to help save energy and improve energy efficiency;

3. Establishing organizational structures (regional energy-saving centers) at leading universities to provide informational, methodological and educational support for energy-saving measures;

4. Creating a system for training and retraining of personnel in energy-saving and improvement of energy efficiency.

The goal of the first item on the list is to develop a set of measures that will give energy savings of up to 25% in buildings and structures run by educational institutions, which report to the Federal Education Agency, reducing utility bills (including those paid from the federal budget) while improving energy efficiency, and maintaining sufficient comfort levels inside buildings and structures without increasing their environmental footprint. Such energy saving measures include:

- Modernizing internal and external lighting systems, introducing energy-saving and up-to-date lighting equipment.
- Upgrading the heat supply system in lecture halls and dormitories.
- Purchasing automated systems for monitoring and managing fuel &energy consumption and putting them into operation.
- Installing energy efficient windows and walls to reduce heat loss from buildings;
- Modernizing energy consumption systems by optimizing consumer loads, introducing frequency drives and automatic regulation of ventilation and air conditioning units;
- Purchasing and installing metres on cold water, hot water and natural gas supply systems;
- Purchasing autonomous generators for educational institutions located in areas with frequent power outages.

The second area focuses on developing and testing energy audit methods for educational institutions, refining standard energy-saving measures, and developing economic mechanisms for educational institutions that would allow them to stimulate energy saving and refinance some of their energy-saving costs using the money saved through reduction of energy consumption. Regulations should be developed on use of performance contracts and revolving funds by educational institutions.

The goal in the third area is to set up a network of energy saving centres at the country's leading universities to carry out R&D and provide educational and informational support on issues related to fuel & energy efficiency. Completion of infrastructure projects will enable progress to a system of energy-service companies with links to energy-saving centers at major universities. These energy-service companies will then provide integrated energy-saving services (energy audit, preparation of draft business plans, financing and implementation of energy-saving measures).

The goal in the fourth area is to create a system for training and professional development of professors and instructors (as well as technicians of the engineering services of educational institutions) to develop their understanding of efficient fuel & energy use.

A total of 16 universities, 4 regional energy-saving centers and 7 R&D enterprises participated in implementation of the programme in 2009, and 100 higher education institutions in 7 of Russia's federal districts underwent energy audits. Each of these institutions was given an energy certificate and recommended a set of energy-saving actions. An integrated programme of energy-saving actions for higher education institutions reporting to the Federal Education Agency was developed with a budget of 1195.7 million roubles for 2010. Implementation of these energy-saving actions will enable educational institutions to achieve annual savings of 382.1 million roubles from reduced energy consumption.

A network of energy-saving centers was established in all of the seven federal districts, based on 36 leading universities. The following universities were assigned the role of coordinating implementation of energy-saving programmes in the federal districts: Pacific Economic University, Irkutsk State Technical University, Ural State Technical University, Nizhny Novgorod State Technical University, Moscow Power Engineering Institute (Technical University), St.Petersburg State Energy University, and North Caucasus State Technical University.

A new industry methodology for conducting energy audits of educational institutions was developed and published. This methodology was sent to 500 higher education schools. A methodology manual on saving energy in buildings and structures was prepared. It contains recommendations on how to implement standard energy-saving actions at budget-funded facilities, including educational institutions.

The coordinating universities set up a system for energy-efficiency training and retraining of technicians at other higher-education energy-saving centers and for engineers working in their maintenance departments. Curricula and training programmes were developed for undergraduate and graduate students as well as professional development programmes for instructors, all focusing on efficient use of energy resources. In the third and fourth quarters of 2009, some 350 people from 86 higher education schools in Russia received energy-saving training.

In July through October 2009, seminars were held at the coordinating universities in federal districts to share experience of developing and implementing energy-saving programs at educational institutions. A national conference on energy saving at educational institutions was held at R.E. Alexeev Nizhniy Novgorod State Technical University on October 28 and 29, 2009. The conference was attended by representatives of higher-education schools from 38 regions of Russia.

These projects in 2009 cost a total of 93.2 million roubles and created the conditions for successful implementation in 2010 of an integrated energy-saving action programme at the 100 educational institutions, which underwent energy audits and for which energy-saving programmes were developed.

Box 5.2. Opportunities for use of carbon market instruments to raise power efficiency of the Russian economy

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) is an international environmental agreement, in which Russia has a claim to global leadership. Russia is successfully implementing the institutional requirements of the Protocol and is far ahead of its quantitative commitments with regard to GHG emissions in 2008–2012.

Between 1990 and 1999 GHG emissions fell in all segments of the Russian economy due to decline of economic activity. There was some growth of emissions in both production and consumption segments during the period of economic growth from 2000 to 2008, but overall GHG emissions in 2008 were still 34% lower than in 1990.

Russia has more reserves for reducing emissions with only modest expenditures in the near future than any other developed country. This could attract massive domestic and foreign investments in development of the energy sector, metallurgy, housing utilities, forestry and other sectors, through the establishment of workable national procedures for approval and registration of joint implementation projects described in Chapter 6 of the Kyoto Protocol. Russia has a great deal to gain from implementation of the latest technologies in power production and utilization and views the carbon market as an instrument for attracting such technologies and know-how into the Russian economy. As of November 2009 over 100 joint implementation projects have been prepared in Russia. These projects have the potential for reducing emissions by over 200 m.t. in CO_2 equivalent between 2008 and 2012.

Another way of attracting much-needed investments is the utilization of 'green' investment scheme (GIS), which was first proposed by the Russian delegation at the 6th Conference of Parties UNFCCC (Hague) in 2000. GIS is an innovative financial mechanism, based on a voluntary country's obligation to reinvest income from sales of national quotas in support of energy efficiency and renewable energy development projects.

Experts estimate that the unused portion of Russia's GHG emissions in the first budget period of the Kyoto Protocol (2008–2012) could amount to about 5-6 billion m.t. in CO_2 equivalent, depending on economic development rates and energy saving scenarios. Clearly, there will not be sufficient demand to absorb such a large volume in the first budget period and, even in the most optimistic scenario, Russia will only be able to sell a small portion of its reserve through the GIS. However, this could be enough to stimulate significant foreign investments.

Environmental protection expenditures in Russia are less than 0.5% of GDP, which is less than in other developed countries. Implementation of the GIS could catalyze an increase of environmental investments in both the state and private sectors. GIS in Russia could become the locomotive for deep modernization of the environment management system, providing additional economic advantages and institutional innovations.

In 2010 we anticipate preparation of a number of pilot GIS operations, based on the Government Directive No.884-r, dated June 27, 2009, which calls on the Ministry of Economic Development, the Ministry for Foreign Affairs and Sberbank (the national savings bank) to hold negotiations with relevant national authorities of interested countries on participation in GHG emissions trading projects. This Directive assigns Sberbank as the authorized organization for implementing pilot GHG trading projects in pursuance of Article 17 of the Kyoto Protocol.

Section 13 of Article 3 of the Kyoto Protocol offers the possibility of carrying over unused emissions quotas from the first budget period to subsequent budget periods. Russia, Ukraine, Poland and other Eastern and Central European countries will have a significant surplus of GHG emission quotas in the first budget period and would like these surplus emissions to be carried over. However, the procedure for registering and carrying over the accumulated surplus of national quotas to subsequent periods could become a stumbling block in the negotiations, as it affects the interests of all main groups of countries.

Russia's unused GHG emission quotas could not only be used as an additional instrument for extensive development, but as a resource to help finance transition of the main sectors of Russia's economy to energy-saving and resource-saving development. It also seems practical to explore the possibility of creating an international financial mechanism for using national quota reserves to ensure that developed countries assume and fulfill additional obligations. The idea would be possible waiver by Russia and the Ukraine of their right to use a large portion of their forecast reserve to increase their quotas in the subsequent period, in exchange for guaranteed amounts of financing for GHG emission reduction projects. These reductions could be fully accounted, or accounted at a certain discount, by these countries when they assume quantitative commitments for reductions in the next period. At the same time the United States, Canada and other countries with relatively high emission reduction costs could use the mechanism in order to assume tougher reduction commitments while keeping their expenditures within limits. The idea of exchanging quota reserves for environmental investments could be included in the new international agreement on climate change for the period after 2012.

Increasing numbers of experts are of the opinion that Russia needs to start work on a national GHGs cap-and-trade system, which should be compatible with international carbon market systems. The target is to create incentives for businesses to reduce emissions and to increase energy efficiency by flexible and cost-efficient methods.

A regional carbon market has been in operations in the EU since 2005, and most leading countries (the USA, Japan, Australia, New Zealand) are also preparing to introduce national carbon markets. The EU is calling for creation of a global carbon market among OECD members by 2015.

The Copenhagen Accord includes a pledge by developed countries to provide USD 30 billion to developing countries in 2010–2012 for preparation and adaptation to global climate change. Russia, as a member of the G8, has declared its readiness to be a donor. It is worth considering the stance taken by Poland, which plans to make the level of its donations depend on the amount of income it receives from selling a part of its national GHG emissions quotas.

The immediate task is to determine the priorities, forms and mechanisms of Russia's financial input to the new global financial climate initiatives. There may be scope for partner countries, which require Russian aid, to use Russian donor assistance. Russia could propose a financial aid programme to help Trans-Caucasian and Central Asian countries adapt to and cushion the impact of global climate change. A regional carbon market initiative could also be considered.

Chapter 6 Opportunities for Renewable Sources of Energy

6.1. Changing structure of the global energy balance

The International Energy Agency (IEA) has defined several key vectors for operation of the world energy sector in order to meet goals of sustainable development: more efficient use of energy resources; reducing energy intensity of the world economy; ensuring energy security; and also creation of a new viable and independent renewable power industry that can play a key role in making the fuel sector more environment friendly and in increasing the share of clean energy in the global fuel & energy balance.

The IEA forecast shows a global shift of the energy balance towards greater energy efficiency, large-scale use of renewable energy sources, development of advanced CO_2 capture technologies, and changeover of the transport industry to new types of fuel. These changes will help to diversify national fuel & energy sectors and reduce emission of greenhouse gases.

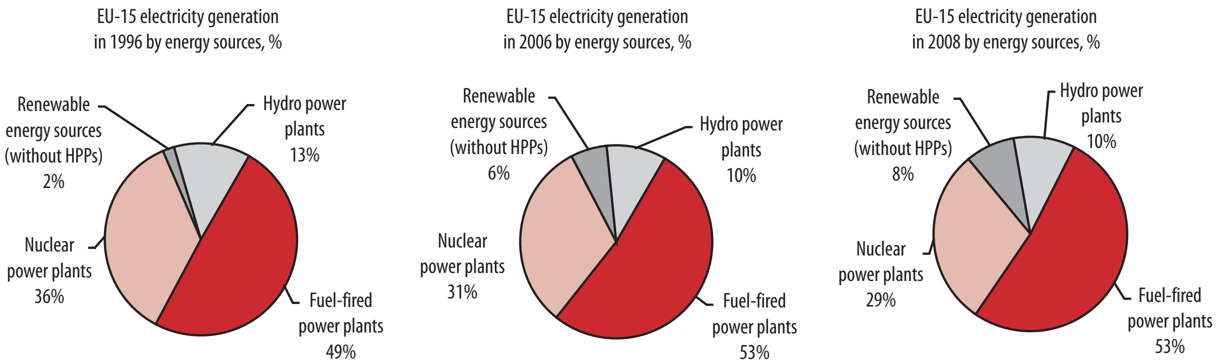
Renewable energy is the energy generated from natural resources such as sunlight, wind, water (including wastewater), tides and wave power of oceans, seas and rivers. It also includes geothermal energy obtained from natural subterranean heat sources and low-grade heat energy that comes from the earth, air and water, using a special transfer medium. Another renewable on the energy menu is biomass, which is primarily plant matter grown to produce heat. For example, forest residues (such as dead trees) may be used as biomass. Biomass also includes waste from consumption and production, but not hydrocarbon waste materials from various manufacturing and power/heating facilities. Renewable energy technologies are also used to utilize biogases such as pit gas and landfill gas.

Heightened interest in renewables is connected with ever growing energy consumption and the need to reduce emissions of greenhouse gases. Fossil fuels are non-renewable. They are limited in supply and will one day be depleted. The production and use of fossil fuels raise environmental concerns. So production of energy using renewables is an increasingly attractive option.

Developed countries have been joined by developing nations, such as China and India, in intensive development of renewables. These two countries boast the fastest growing markets for renewable energy in the world.

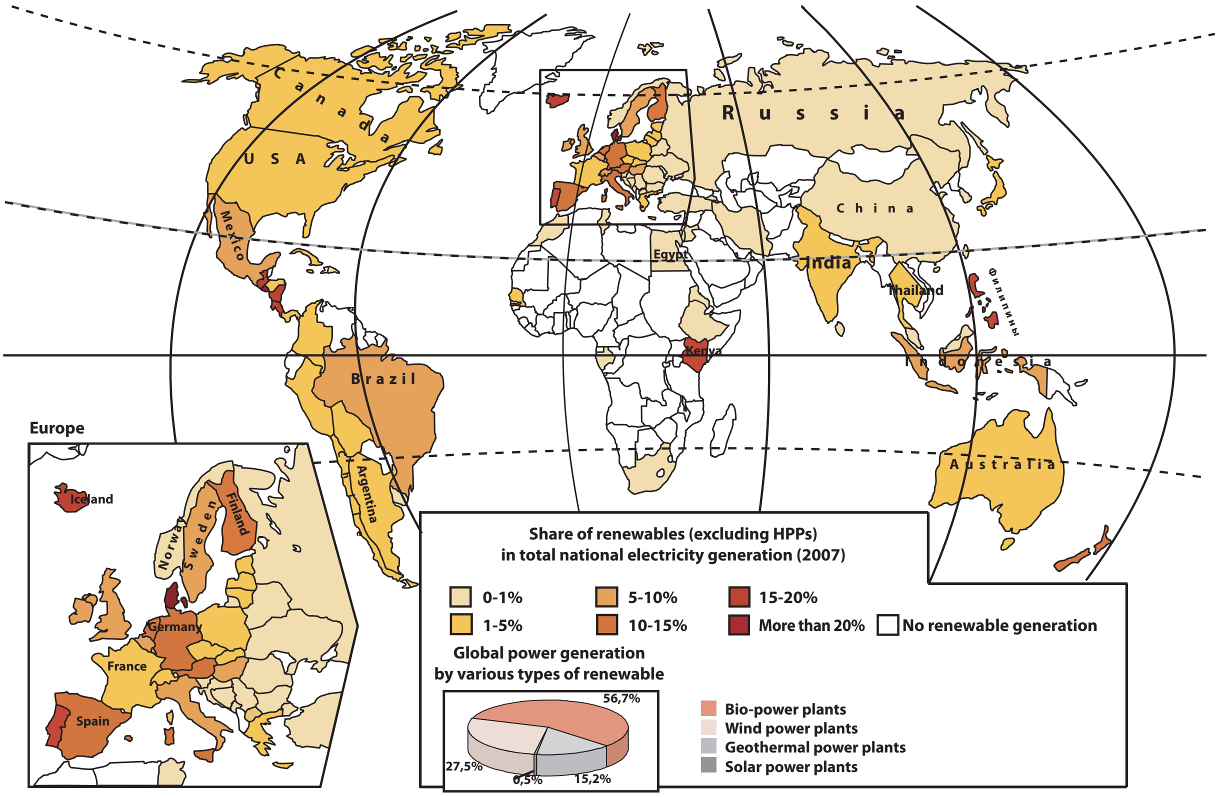
The share of renewable electricity (without hydro-generating) in gross electricity consumption in countries of the European Community (EU-15) grew by 4 percentage points in 10 years (Figure 6.1), representing electricity output of 130 TWh. The market share of renewables has topped 2% in the last two years (2006–2008), showing the substantial increase in total renewable electricity generation in western European countries. In some countries the renewable energy share in gross electricity consumption exceeds 10% (Iceland and Denmark, 29%; Portugal, 18%; Philippines, 17%; Spain, Finland and Germany, more than 12%;

Figure 6.1



Data provided by Energy Information Association

Figure 6.2
Share of electricity generated from renewables (excluding HPPs) in total electricity generation by countries (2008)



Source: Data of the Energy Information Association

Austria, 11%; the Netherlands, more than 10%). Brazil and Mexico are also rapidly developing domestic renewable sources of energy, the share of which in their electricity generation (excluding hydro-generating) exceeds 4% (Figure 6.2).

World electricity generation from renewable energy resources (excluding hydro capacities above 25MW) is heavily dominated by biomass power plants (56%). These are installations burning a variety of biomass, including forestry and agricultural waste, solid domestic waste, biogas and biofuels, landfill gas, etc. The wide variety of different types of biomass means that this resource is available in every country to a greater of lesser extent.

Wind power accounts for nearly 28% of all the electricity generated from renewables. Wind installations are most popular in developed western European countries and several US states. India and China have entered the top five countries by total installed wind capacity in recent years[1].

The share of geothermal in renewable electricity production is about 15%. Usable geothermal resources are site-specific. Solar energy provides less than 1% of the world's renewable electricity generation. The low share reflects high cost of solar power equipment and materials.

Different renewables play more or less important roles in various countries. Denmark is the world leader for wind power. Biomass is one of the most important renewable energy sources in Germany, followed by photovoltaic solar installations. Iceland and the Philippines

[1] As of 2007, Germany had the biggest installed wind power capacity, overtaking the USA. Spain is in third place, followed by China, India and various western European countries (link reference: http://www.gwec.net/fileadmin/documents/PressReleases/PR_stats_annex_table_2nd_feb_final_final.pdf)

are among countries now producing most electricity from geothermal sources.

Energy security and environmental balance in economic growth are priorities for Russia today, and renewable energy technologies are one way of achieving progress towards these goals.

6.2. The strategic significance of renewable energy in Russia

The reasons for development of renewable energy worldwide go beyond the goal of reducing greenhouse gases. By using renewables Russia and other countries will be able to improve their energy balances and move towards a new stage of civilization characterized by 'minimum use of carbon-based fuels', creating new impulses for industrial development. The world is attempting to build a new low-carbon economy.

According to Leonid Vaisberger[2], a country is defined by the type of business, in which it specializes. A country, which produces relatively simple products, finds itself in a more primitive environment and experiences slower growth compared with countries that move forward to more sophisticated products. Russia's major problem is that the country is 'stuck' at the stage of raw material exports, and is therefore becoming 'stuck' with low-grade technology, leading to stagnation. In high-tech industries, all participants add their value and thereby obtain profit. High-tech industry presupposes more equal income distribution than the process of exporting locally produced raw materials.

Power industry development using renewable energy technologies requires production and maintenance of high-tech equipment and materials. So renewable energy generation facilitates diversification of the Russian economy and, in particular, of the fuel & energy sector.

In addition to economic aspects, it is important to analyze social benefits of implementing renewable energy projects in Russia, the most prominent of which are new employment opportunities and higher standards of living.

The official unemployment rate in Russia topped 6% in 2008 with the highest rates observed in the Southern Federal District and regions of Siberia and the Far East. Unemployment is most acute in rural areas, which account for nearly half of the country's unemployed, although the rural population is only 26% of the country's total population.

Renewable energy will create additional employment, as renewable technology is more labor intensive (calculated per unit of output). Workforce will be required at every stage of the process, from research &development and testing to manufacturing, installation of equipment and plant operation and maintenance[3]. The biggest potential for job creation is use of biomass, which could help the employment situation in agriculture and forestry (Table 6.1).

Income inequality is one of the most acute social problems in Russia. Rural incomes are much lower than in cities, and living conditions in rural areas are much worse than in urban areas. Electricity supply is unreliable in many rural districts (a number of rural settlements have no electricity and many households lack access to a centralized water supply), so that daily tasks such as cleaning the house, laundry, washing the dishes, cooking, etc., require much time and effort.

Renewable technologies can enhance the quality of life for rural people, since these technologies are the most efficient way, and often the only way, of ensuring a dependable electricity supply. Electrification gives light, use of electric appliances (reducing time spent on household tasks), access to communications (radio, television, telephone, Internet) and modern medical assistance. Rural electrification can also facilitate water supply and increase the efficiency of agriculture.

[2] Internet TV, Channel 5, 'Open Studio' program, "Is Russia addicted to raw materials?" (Interview)
[3] With the exception of small hydro power plants and solar photovoltaic cells, which create the maximum of additional jobs at the R&D and construction stage, but require minimum workforce for operation and maintenance.

One of the major benefits of renewable energy is that it reduces greenhouse gas emissions, by reducing combustion of fossil fuels.

The Russian energy sector, particularly the electricity generating sub-sector, is responsible for the biggest share of man-made greenhouse gas emissions in the country (60% and 25% respectively). Most emissions are generated by burning of fossil fuels such as oil, natural gas and associated gas, coal, peat and oil shale, and their derivatives. The Russian energy sector is also responsible for particulate emissions from extraction, storage, transportation, processing and consumption of oil, gas and coal, as well as emissions from gas flaring and other combustions of fuels without useful application of the energy produced.

Most renewable energy systems only contribute to GHG emissions during their construction and produce zero or very little CO_2 emissions during their operation. Open-loop geothermal systems and biomass are exceptions to this rule, but technologies that use biomass can be regarded as 'neutral' in terms of carbon dioxide emissions, since the CO_2 produced by biomass burning was previously absorbed during the plant's life cycle. Emissions by open-loop geothermal systems are tens of times less than emissions from a traditional power station for the same amount of energy produced.

Atmospheric concentrations of harmful substances are highest in big cities with high population density. This has negative impact on public health (particularly child health) since the majority of the Russian population lives in cities and towns.

Energy production from renewable energy sources can make a significant contribution to development of high-tech engineering and creation of jobs in Russia's regions. Increased use of renewables in Russia would help to reduce unemployment, improve living conditions, and stop the outflow of population from rural areas, and from northern and eastern regions of the country. Development of renewable forms of energy in Russia would avert further environmental degradation and promote and protect public health and welfare.

Table 6.1
Employment levels using various electricity generating technologies (jobs/mW)

Technology	Construction stage	Operational stage
Wind power plants	2.6	0.2
Geothermal power plants	4.0	1.7
Solar photovoltaic cells	7.2	0.1
Solar thermal panel	5.7	0.2
Biomass (average)	3.7	2.3
Natural gas technology	1.0	0.1

Source: Heavner B., Churchill S., Renewables work (2002): Job Growth from Renewable Energy Development in California

Closing the gap with other countries in large-scale development of renewable is a political challenge of the utmost importance if Russia is to maintain its status as a world power and play a significant role in solving the world's energy problems.

6.3. The current situation and outlook for development of renewables in Russia

Russia has enormous potential for renewables, but their current share in total electricity production is as little as 0.9%. There are no statistics available for the amounts of heat produced using renewables, but some experts estimate that it is about 4% of the total.

'Technical' potential for generation in Russia using renewables (i.e. the amount of generation, which is theoretically possible using existing renewable technologies to the utmost) has been estimated at 24 billion tonnes of fuel equivalent per year (not including potential of large rivers), which is over 20 times more than Russia's annual domestic primary energy consumption. The 'economic' potential of renewable energy (i.e. the amount of generation, which is commercially feasible, taking account of costs for renewable and fossil fuel generating, etc.) depends on several factors: current state of the economy; cost, availability and quality of fossil fuel energy resources; electricity and heating prices in the country and its regions; distribution of technology capabilities between regions; etc. Potential changes with time and should be specifically assessed as part of preparation and implementation of specific programmes and projects for renewable energy. At present the economic potential is about 300 tonnes of fuel equivalent per year (which is 30% of annual primary energy consumption in Russia).

There are several reasons for very limited use of renewables in Russia at present: high capital costs of renewable energy plants; lack of specific mechanisms of state funding and support, and need for highly skilled staff; and lack of information about availability and economic potential of renewables among government, business and the general public.

Abundance of fossil fuels and surplus generating capacity in Russia might be added to the factors, which discourage development of renewables.

There are many opportunities for efficient use of renewables in Russia today. Russia is rich in sources of renewable energy, which could be harnessed using modern technologies. In particular, renewable sources could be used for non-grid electricity supplies and as local energy sources for heating.

Practically all Russian regions have at least one or two forms of renewable energy that are commercially viable, and most regions have several forms. These resources include: small rivers, agriculture and forestry waste, peat deposits, wind and solar resources and low-grade heat energy of the earth. In some cases, renewable energy is more cost-effective than use of fossil fuels (when supply of the latter is costly and unreliable).

About 10 million people in Russia are not connected to electricity grids and are currently served by stand-alone generating systems using either diesel fuel or gasoline. Nearly half of these diesel and gasoline systems are unreliable because of fuel delivery problems and/or high fuel costs. Remote northern and Far East regions are supplied with fuel by rail or road, and sometimes by helicopter. Some areas receive winter supplies by sea or river during the summer as water routes in Russia are only navigable during limited periods. Fuel deliveries are therefore unreliable and expensive.

Non-grid electricity supplies using renewable energy have proved to be cost-efficient in many countries, since they dispense with (often high) costs of creating transmission lines. In Russia a number of solutions could be efficient: hybrid wind-and-diesel systems, biomass boilers, and small hydro power plants, could all be competitive in comparison with conventional technologies using fossil fuels.

Heat and hot water could also be provided to households using renewables. Specific opportunities are as follows:

- Direct use of geothermal energy for heating of buildings, hot water production, temperature control in greenhouses, crop drying, etc., is commercially viable in Kamchatka, the North Caucasus and other regions with large geothermal resources;
- Changeover of district boiler facilities from fuel, delivered over large distances, to biomass boilers (using local agriculture and forestry waste);
- Use of solar collectors would be efficient in southern regions of Russia.

Heat pump technology, which is widely used in many countries, deserves special attention. It enables conversion of renewable low-grade heat into heat, which is usable for heating of premises, with a conversion rate of 4-6 or more. Examples of low-grade heat sources include: purified water from aeration plants in large cities, which has temperature of 16-22°C; circulating water used in turbine condensers at power stations, which has average year-round temperature of 12-25°C; warm water in abandoned coal mines; geothermal waters; sea water on the Black Sea coast and other water bodies; outdoor air; rocks and soil; solar installations and energy recovery systems. The strategic goal should be to manufacture heat pumps in Russia, and create the regulatory and engineering support, which could enable large-scale application of these technologies in coming years.

In many countries renewable energy technologies (photoelectric solar elements, small wind turbines, etc.) have also proven to be more cost-effective than conventional energy sources in certain industrial applications. The number of such applications is growing and includes: marine/river transport; cathodic protection of pipelines and well heads; power for off-shore oil and gas platforms; power for telecommunications; and many other applications. The list of renewable energy applications in industry is long and is being constantly added to. As well as generating electricity in specific circumstances at relatively lower costs, industrial use of renewable creates a new market for renewable energy, stimulating faster development of innovative technologies for non-standard uses.

Russia has considerable potential for industrial applications of renewable energy, but its current use is extremely limited. Renewable energy should be used in Russia to reduce environmental load in cities and towns with environmental problems, as well as in recreation and resort areas and specially protected natural sites. Use of renewables should be a key aspect of innovation-based development in Russian science, technology and the power sector.

Russian technologies in the field of renewable energy are already comparable to foreign technologies in their construction and function. Russia has enormous experience in the construction and use of small hydropower plants (less than 25 MW capacity), and technology levels in tidal and geothermal energy are ahead of the EU and US. But western countries are ahead of Russia in development of wind turbines, solar cells and heat pumps.

Most Russian technologies are at the R&D or testing stage, while similar western technologies have already been commercialized to a greater or lesser extent, enabling production of electricity with a huge price discount to traditional generating. If Russia can develop a viable domestic market for renewable energy technologies based on the considerable technical and scientific experience, which it already has, this would kick-start large-scale renewable generating.

The cost issue is the most crucial factor for development of renewable energy. The two main indicators, which determine efficiency, are initial cost of building renewable power plants and cost of electricity produced by these plants.

Per unit capital costs, as well as cost of electricity generation, is significantly lower for power plants, which use traditional sources of energy, than for renewable energy power plants.

Cost of electricity produced using renewables consists mainly (92%) of capital investments, while operating costs of renewable energy installations is much lower than that of fuel-fired or nuclear plants, and their 'fuel' is free. Costs of electricity production using renewables are not sensitive to fluctuations on energy markets.

Share of the fuel component in the sale price of electricity produced at coal-fired plants is 36% and it is as high as 64% for gas-fired plants. Sustained rise of prices for fossil fuels (particularly oil) is bound to make renewable energy increasingly competitive, as the cost of electricity produced from renewable energy sources will approach the cost of electricity from conventional power plants. Since renewable energy is environment-friendly and has other advantages over conventional power, there is bound to be increasing demand for 'clean electricity' in developed countries over coming years, and renewable energy will become fully competitive in many countries.

However, it is not hard to grasp why investors are skeptical and reluctant to invest in development of alternative energies. They cannot see the sense of investing heavily in relatively expensive facilities, future prospects for which are not entirely clear, when investments in fuel-fired and nuclear power plants offer guaranteed returns. However, there are many examples of economic breakthroughs by new generating technologies[4]. Also, Russia can draw on the experience of the EU, US and other countries, where government grants to renewable energy companies make their projects profitable.

In western European countries and some US states certain types of renewable energy are already fully competitive with conventional fuels. Electricity generating cost at wind-power installations has now fallen to 4 euro-cents per kilowatt-hour thanks to implementation of large-scale projects, technology improvements, and more efficient manufacturing.

As shown in Figure 6.3, the cost of electricity produced from renewable energy resources in Russia is significantly higher than in countries with mature renewable energy industries. The cost gap between electricity produced from renewable sources and from fossil fuels is also much bigger in Russia than in Western Europe and the US.

6.4. Examples of renewables best practice in Russia

The Russian government is keen to accelerate renewable energy development, targeting increase of the renewable share in electricity production from 0.9% to 4.5% by 2020. Development of renewable energy is an expensive project, but essential in the current context.

Renewable energy needs regulatory support from government, and since heat and power production is now almost entirely privately-owned, implementation of renewable energy projects should be based on private-public partnerships.

There are a number of successfully operating renewable energy facilities in Russia, which can serve as a basis for further development of the sector.

The 0.4 MW Kislogubskaya Tidal Power Plant has been operating since 1968 in the Kola Peninsula. Construction and testing of the plant helped to advance tidal energy technologies (Box 6.1).

Technology and design that has proven to be effective at the Kislogubskaya Plant will be used to create future tidal plants (Severnaya Plant in Dolgaya Bay, as well as the Mezenskaya and Tugurskaya Plants).

Russia also has experience, technology and locally designed equipment for production of geothermal energy. In 1999 the Verkhne-Mutnovskaya Geothermal Power Plant was commissioned with 12 MW installed capacity. The main advantage of this industrial scale pilot plant is that the thermal cycle enables environment-friendly use of the geothermal carrier, avoiding direct contact with the environment through use of air condensers and an ecologically clean cycle for geothermal fluid utilization.

Binary cycle geothermal power plants are also an interesting option (Box 6.2).

Box 6.1. Tidal power plants

Capital costs for construction of a tidal power plant consist mainly of cost of the dam. The Kislogubskaya Tidal Power Plant made first-ever use of the floating caissons method: reinforced concrete sections of the dam were made on the shore and towed to their final location at sea. This method enables large savings on construction costs, and is now recognized worldwide as the best way of building dams for tidal power plants.

Hydro turbine equipment is the other main cost component for a tidal power plant. The Kislogubskaya plant uses an orthogonal unit with the axis of turbine rotation perpendicular to the water flow. The turbine always rotates in the same direction regardless of the direction of the water flow.

Simple design and low metal requirements per unit of the structure made it possible to reduce costs, and manufacturing and installation time by nearly half.

[4] Average cost of 1 KW of installed capacity at US nuclear power plants which came on-stream in the mid-1980s was USD 3500-4000, while the cost for nuclear power plants about to be commissioned now will not exceed USD 1500 per KW (according to manufacturers).

Design and construction of geothermal power plants helped to accomplish a number of practical and scientific tasks. Such plants now supply 30% of energy generated by the central energy system on the Kamchatka Peninsula. The plants have helped to improve energy supply in Kamchatka, which used to be heavily dependent on expensive deliveries of fuel oil.

6.5. The way forward: regulatory and financial support for development of renewable energy in Russia

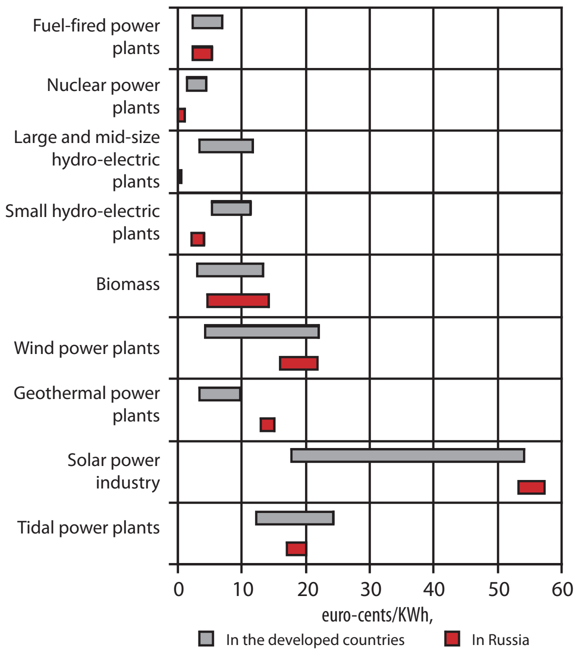
Many developed countries have adopted long-term programmes to meet global challenges by gradual increase of renewables in total energy production. These countries have also enacted laws to ensure implementation of their programmes.

On January 23, 2008, the European Commission proposed a plan to achieve the 2020 target for reducing CO_2 emissions by promoting rational, large-scale use of renewables. The proposals set the following objectives for the Commission up to 2020:

- to achieve 20% renewable energy in total EU energy consumption;
- to lower CO_2 emissions by 20% compared with 1990;
- to reach a minimum of 10% biofuels in overall fuel consumption.

Figure 6.3

Electricity production costs in developed countries and in Russia (2007)



Source: Data of the International Energy Agency, CJSC Energy Forecasting Agency, OJSC RusHydro

The Russian government has been paying more attention to development of

Box 6.2. Geothermal power plants

Most geothermal areas contain water at medium temperatures (below 200°C), which can be used to extract energy at binary-cycle power plants. Hot geothermal water and a secondary fluid with a much lower boiling point than water pass through a heat exchanger. Heat from the geothermal water causes the secondary fluid to flash to vapor, which then drives turbines. Because this is a closed-loop system, there are almost zero atmospheric emissions. Moderate-temperature water is by far the most abundant geothermal resource and most geothermal power plants in the future will be binary-cycle plants.

Binary-cycle plants are built using innovative modular construction. The turbine generators, electrical equipment, control panel, etc., are assembled as modules by the manufacturer, and shipped to the site, reducing construction times and simplifying the construction process in harsh climatic conditions.

Highly efficient technologies are used to remove water and other substances from the geothermal heat carrier, ensuring that steam has the required qualities when it passes through the turbines (moisture at the outlet from the separator should not exceed 0.1%). Emission of geothermal gases into the atmosphere is minimal, making geothermal power stations environment-friendly.

renewable energy in recent years. In November 2007 President Vladimir Putin signed the Federal Law, 'On the electric power industry' (Federal Law No. 250), which introduced the concept of renewable energy sources, and outlined key support and development measures for renewable energy.

The Federal Law was followed by a set of regulations to support renewable energy technology and markets. The first document signed by the Russian government in 2009 was the Resolution, 'Main directions of state policy for improvement of electrical energy efficiency up to 2020 through use of renewables'. The Resolution sets targets for production of electricity using renewable energy sources: the share of renewables is to be raised fivefold to 4.5% by the end of 2020.

These are very optimistic targets for Russia, which would require commissioning of 22 GW of new generating capacity by 2020 (equal to about two-thirds of total capacity of all thermal power plants in the Central Federal District). But the targets seem modest in comparison with western Europe: Germany alone had more than 22 GW of wind power capacity in 2007.

The Concept for Long-Term Socio-Economic Development of the Russian Federation until 2020 also has renewable targets. The Concept calls for increase of renewable electricity generation (excluding hydro power stations over 25 MW) from 8 billion KWh in 2008 to 80 billion KWh by 2020.

The Russian government has also approved an Energy Strategy until 2030, which foresees renewable electricity output of at least 80-100 billion KWh by that time.

However, despite the activities of government and other interested parties, there has been no significant progress in renewable energy development in Russia during recent years.

The process is hampered by delays in adoption of regulations that would define specific mechanisms for promoting renewable energy: premiums in the sale price of renewable energy; compensation of costs for renewable generators in obtaining connection to the grid; etc.

If Russia is to achieve its renewable energy output targets, work must be carried out for design and improvement of the regulatory framework.

Required measures include development of a national policy for renewable energy development and specific practical steps to ensure its implementation.

6.6. Conclusion

1. Power generation using renewables cannot yet fully replace traditional generating in Russia, which has one of the largest fossil fuel endowments of any country in the world. But an optimal combination of renewable and traditional generating in specific areas of the country has great potential for improving the social, economic and environmental situation.

2. In Russia, as in other countries, renewable energy needs strong government support, at least in the initial stages of its development. What is needed is not only direct support, but a system of measures for reduction of carbon dioxide emissions, improvement of energy efficiency and increased use of renewables.

3. Policy targets for the share of renewables in Russia's energy mix must be set at a level, which guarantees lower CO_2 emissions and meets energy efficiency goals. This is the only way for Russia to built a strong, diverse and efficient energy sector and economy.

4. Government support is obviously essential for development of renewable energy in Russia, but Russian society also has to play a part in this development. The starting point for progress towards clean energy is the desire of ordinary people to live in a clean environment and to ensure the health of their families. Great things come from small beginnings, and the future of our country depends on all of us. The changeover to sustainable development has to start by instilling a sense of responsibility for the environment among the young generation of Russians.

Box 6.3. Prospects for nuclear power

Nuclear power is not a renewable source of energy, and yet it is often viewed as an alternative to traditional energy generation technologies based on burning of fossil fuels. Economic development, increased competition in markets for energy resources, global climate change and a number of other problems have led to a renaissance of nuclear power worldwide. The presidential blog, maintained by Russian President Dmitry Medvedev, notes that 'a decision has been taken to gradually increase the share of renewable energy sources in Russia's overall energy production. The share of nuclear power will increase to 25% by 2030'[5].

Safety is the most important lesson

In the 1970s it appeared that nothing could stop the relentless advance of nuclear power across the world. It was forecast that by 1990 the total capacity of the USSR's nuclear power stations would reach 110 GW, while the world's total nuclear capacity would exceed 1000 GW (with the US alone having 530 GW)[6]. The nuclear power development programme adopted by the USSR in 1980 targeted 100 GW total capacity of the country's nuclear power stations by 1990. This seemingly unstoppable advance was interrupted by two major accidents: the Three Mile Island incident in the US in 1979 and the Chernobyl catastrophe in the USSR in 1986.

As a result by 1990 not only had the growth forecasts for nuclear power generation failed to materialize, but the whole future of the industry was in question. Some countries went so far as to start closing down their existing nuclear power stations and others decided not to build new ones.

However, the attitude towards nuclear power gradually has changed once again. Many countries found that they simply could not do without nuclear generating, which already produced a very high percentage of their electrical power, and the accidents had the salutary effect of making safety paramount in development and operation of nuclear reactors, helping to make them more acceptable to public opinion.

A great deal has been done:

- Huge amounts of money were invested in programmes to improve the safety of and modernize first-generation nuclear reactors;
- More attention was paid to the whole production cycle used by the nuclear industry, including the decommissioning of nuclear reactors and disposal of nuclear waste;
- Safety requirements began to be regulated at international as well as national level.

The economics of nuclear power stations have undergone significant changes since the 1980s. In the past, one obvious advantage of nuclear power generation was low operating costs compared with power stations using fossil fuels, since a reactor can continue to work for years on very little fuel. However, once oil prices had stabilised the heavy safety overheads associated with use of nuclear power essentially wiped out the competitive advantage derived from extremely low fuel consumption. Nuclear power stations then had to compete with other electricity producers on a level playing field and, if anything, nuclear power was now at a disadvantage as it faced generally negative public perception.

For a decade the world's nuclear industry tried to adjust to the new reality, find its place and create new opportunities for growth. Eventually these attempts began to pay off. Only a few years ago, most of the demand for new nuclear power stations was in countries with fast growing economies, such as China and India, but today developed nations are also on the verge of a nuclear renaissance.

Environmental priorities played a major role in changing the attitude towards nuclear power: because of global climate changes the option of simply increasing the capacity of fossil fuel power plants is no longer acceptable, at least not in Europe. Another factor has been the difficult situation on fossil fuel markets in recent years.

Today nuclear power stations generate 17% of all electricity produced in the world; their total design capacity is 372 GW, of which more than half is located in just three countries: the US, France and

[5] www.kremlin.ru
[6] Nuclear Power. Expert Development Estimates. Kurchatov Institute, 1949-2008. Moscow, IZDAT, 2008, page 29.

Japan (100, 63 and 47 GW respectively). The number of new nuclear power stations currently under construction is quite modest, but plans for future construction are ambitious. Nuclear stations in China currently have total capacity of 9 GW, but this should increase to at least 40 GW by 2020 and possibly to a much higher level of 70 GW.

Bad heritage problems

Some of the problems the industry has to deal with today have to do with the past rather than the future. The principal nuclear powers, particularly the US and Russia, are burdened with a negative nuclear heritage from the Cold War arms race, while the heritage problem for atomic power generation as such concerns handling of spent nuclear fuel and radioactive waste. In practice, until the late 1980s, the nuclear industry put off resolution of this issue: spent fuel and radioactive waste was allowed to accumulate without organisational, technical or economic solutions for permanent storage.

In recent years many nations have passed appropriate laws, introduced necessary financial mechanisms and begun implementing programmes to build facilities for recycling spent nuclear fuel and radioactive waste. Today these issues are being given top priority, and not only by national legislation: on September 5, 1997 a diplomatic conference of the International Atomic Energy Agency in Vienna sealed the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, which imposes a number of obligations on the nations that ratified it. Russia ratified this Convention in 2005.

Russia is taking practical steps to deal with its nuclear heritage as part of the federal target programme, 'Ensuring nuclear and radioactive safety in 2008 and the period until 2015'. The programme calls for creation of infrastructure for handling spent nuclear fuel and radioactive waste from thermal reactors, and appropriate legislation is also being developed, most importantly a new federal law on handling of radioactive waste, a draft version of which has already been prepared. The main goal of this law is to create financial mechanisms for handling radioactive waste on a long-term basis and to take inventory of waste that has accumulated so far, where it is stored, and the conditions of storage, so that decisions can be made about what to do with it in the future.

Long-term challenges

The design of modern reactors anticipates very long service lives, of 50-60 years. However, what has to be taken into account is not only the period, during which a reactor will be in use, but also its decommissioning, construction of facilities for safe disposal of radioactive waste, creation of a closed fuel loop and a financial system to support all these activities for years to come.

Nuclear power is a knowledge-intensive and high technology industry. Generating electricity using reactors running on thermal neutrons is now a standardized industrial technique and in this sense it is an 'old' technology, even though it can be classed as high-tech. Further refinement of this technology, primarily to optimize its economic and physical parameters, has its limits. The fuel reserve for thermal-neutron reactors is restricted by limited reserves of Uranium 235. Such reactors only use 1% of the uranium and as a consequence they by-produce significant quantities of underused nuclear fuel. The handling of spent nuclear fuel significantly increase the cost of the fuel cycle of a nuclear power station.

While looking for solutions to its medium-term problems, the nuclear power industry must also think about its long-term prospects. Development and adoption of a new technology in the nuclear industry takes a very long time, sometimes several decades. In effect, therefore, the introduction of new nuclear technology can span several generations, making it impossible to tell which of the new ideas proposed today will be in demand in decades to come.

Set to grow

For Russia to sustain its current level of power generation, it has to launch new capacity to replace the power stations that are going offline. At present 40% of the country's total power generating capacity consists of out-dated equipment at fuel-fired power stations. By 2020, 57% of these stations will have exceeded their design service life.

Russia's nuclear power industry has 31 power generating units with total capacity of 23 GW and currently generates 16% of all electric power consumed in the country. In European Russia the share of nuclear power is almost twice higher, at 30%. The design service life of the power generating units is 30 years. Even though in the original design it was expected that this service life could be extended by 10-20 years, Russia has to build new capacity simply because, sooner or later, the older nuclear reactors will have to be decommissioned.

However, Russia is on an economic growth trajectory, which will have to be supported by increase of power generation, and the power generation solutions need to be implemented long before demand for more power rises. New facilities cannot be built quickly from scratch for purely technical reasons, let alone other considerations. In the nuclear industry it takes a minimum of between five and six years to complete a single power generating unit after the site has already been surveyed and prepared (the preparatory stage can also take years). So the sort of nuclear power industry we will have in 10-20 years is to a large extent determined by decisions we took yesterday and are taking now.

Russia's energy strategy up to 2020 is based on a number of basic scenarios describing the country's social and economic development in years to come. The official energy strategy assumes that the fuel-energy balance will need to be optimized and that increase in the country's demand for electricity will best be met by creating additional nuclear power capacity, primarily in European Russia. The amount of electricity generated by nuclear power stations must grow from 130 billion kilowatt hours in 2000 to 300 billion kilowatt hour in 2020 in the best case economic-growth scenario and to 220 kilowatt hours if a more moderate scenario plays out. This means that the capacity of nuclear power stations will have to double while the share of nuclear power in total electricity production will increase to 23%.

One of the main principles of the official government plan for deployment of electric power facilities up to 2020 is maximum possible increase in the share of facilities not dependent on fossil fuels, i.e. nuclear and hydro-electric power stations.

Development of nuclear power would be impossible without the following prerequisites:

- Availability of appropriate designs and technologies;
- Acceptable levels of safety;
- Nuclear power stations must have certain environmental advantages over power generation using fossil fuel.

Russia is currently building nine nuclear power generation units at home and abroad. The backbone of the country's nuclear power development in the coming decade will be the new standard power generating unit using a VVER-1200 (AES-2006) reactor.

New technologies

Russian President Dmitry Medvedev has included improvement of nuclear technologies among the country's five main technology development priorities[7]. Thanks to large-scale research carried out in the past, Russia has all the necessary tools for creating a new nuclear technology.

The new technology must meet several key requirements, as follows:

- it must be safe;
- it must be competitive with other technologies;
- it must not be reliant on limited fuel reserves;
- it must be environment friendly;
- it must help solve nuclear non-proliferation tasks.

All these requirements are met by new technologies based on use of fast reactors in a closed fuel loop.

Fast reactors, also known as fast neutron reactors, represent a strategic innovation in the nuclear energy sector. Five countries (Russia, France, Japan, India and China) have achieved most significant results in development of this technology, and Russia is leading the way thanks to completion of the Beloyarsk nuclear power station,

[7] Dmitry Medvedev: 'Forward, Russia!'. September 10, 2009.

which is the world's first and only power station using a BN-600 fast neutron reactor. The next step in development the fast neutron technology is the BN-800 reactor, which is now being built at Beloyarsk and will use mixed oxide fuel: a blend of plutonium and depleted uranium (so-called MOX fuel), which can be made from depleted plutonium by-produced at thermal neutron reactors. A facility for making MOX fuel is being built simultaneously with the BN-800 reactor, and both are scheduled for launch in 2014.

The idea of MOX fuel is not new: this fuel is currently used by a number of nuclear power stations in Europe, primarily in France. Its advantages are that it uses more energy-efficient plutonium and resolves the problems of disposal. Fast reactors can use the same fuel multiple times, creating a closed fuel loop and resolving two important issues:

- Providing the nuclear power industry with long-term fuel supplies;
- Reducing the amount of radioactive waste that has to be disposed of, and consequently the cost of disposal.

Fast reactors with a sodium heat-carrier are not the only recent innovation in the industry. Designs are now being developed for fast reactors that use liquefied heavy metals (lead and bismuth-lead). The primary importance of this technology is its potential application: today's nuclear power stations are very large facilities, but reactors using heavy metals are designed for use in small- to medium-scale power stations, which can deployed in remote areas or regions where large power stations are simply not needed. Various alternative fuels for fast reactors are also being looked at, and projects are in hand to use nuclear reactors for non-electric purposes, such as water desalination.

Research needs to be diversified to maintain the industry's innovative potential and create a 'production line' of reactor and fuel technologies at different stages of preparedness for industrial use. These are the aims of the federal target programme, 'New Generation Nuclear Power Technologies for 2010–2015 and through 2020', designed to create a technological platform for nuclear power stations based on closed nuclear fuel loops with fast reactors, which would meet the country's increasing demand for energy resources and increase the efficiency of natural uranium and spent nuclear fuel utilisation.

Shortage of specialists

The current nuclear renaissance has made it clear to all developed nations that the nuclear industry needs to preserve and develop its human resources. In the recent past, negative public perception and unclear prospects made jobs in the nuclear power industry and nuclear science less prestigious and promising. As a result the industry has lost nearly a generation of engineers and specialists, who chose not to pursue careers in the nuclear industry.

Nearly all countries have felt this human resource drain in the nuclear sector and begun to implement more aggressive programmes to attract and train new staff. India and China have already managed to significantly improve their human resource capacity in nuclear engineering. Russia also suffered the full impact of nuclear stagnation, exacerbated by cuts in military and research programmes. The crisis of the 1990s also made a negative contribution. All of Russia's engineering professions have experienced shortages of trained staff, so that engineering positions in many industries, including nuclear, still have to be filled with older employees. If new nuclear technologies are to be developed and new power stations are to be built, the industry needs a long-term supply of skilled human resources.

Transfer of knowledge from one generation of technicians to the next is a prerequisite for preserving and developing any high-tech industry, and there is a risk that the ageing generation of specialists in the nuclear industry will disappear, leaving few heirs. Attention is therefore being focused, as a matter of urgency, on training of new specialists and creation of a system that will attract and retain young engineers in the nuclear sector, thanks to adequate opportunities for social and professional development.

Conclusion

The world's nuclear power sector is driven by a handful of nations from the elite nuclear club, which have the resources necessary to carry out R&D and implement pilot projects. These same countries dominate the international market for nuclear technologies. They shoulder the burden of sector development expenses and determine the direction, in which the rest of the world will move with respect to nuclear power.

Clearly, the nuclear sector faces a number of problems today, which no single nation can resolve alone. For this reason there is much discussion of the need to create an effective system for international cooperation in order to seek solutions that can benefit all countries. Nuclear fusion is one example of such cooperation. Other issues under discussion include establishment of international uranium enrichment centers, or centers for producing and recycling nuclear fuel. Such centers will strengthen nuclear non-proliferation while ensuring that all nations have equal access to nuclear power generation technologies.

Today Russia is implementing an integrated state nuclear power policy that aims to solve problems stemming from negative heritage and to create new technologies. Russia is one of few countries that has done research and implemented projects in practically all branches of nuclear science and can offer solutions for a broad range of questions related to nuclear power, from production and recycling of nuclear fuel to new reactor technologies. By preserving and developing this innovative potential, Russia can become a leader in the nuclear power sector and significantly improve its positions in the international market for nuclear technologies.

Chapter 7 The Energy Industry and Environmental Sustainability

Russia's energy sector is the foundation of the country's economy, but it is also the main cause of pollution and environmental degradation. The consequences of fuel & energy sector development for the environment are still insufficiently studied, both as regards the 'old' energy industries, which have prevailed during four decades of rapid sector growth, and as regards alternative forms of energy provision for the needs of the economy.

Production, transportation, and use of oil, natural gas, and coal on the scale seen today are inevitably associated with colossal adverse effect on the environment – 'colossal' in terms of the size of the impact, its depth (in the literal and figurative senses) and its extent. Debates over the acceptability, in principle, of risks related to nuclear power are still continuing; nearly all hydropower projects provoke objections on environmental grounds; and even renewable energy projects, which are supported by the majority of environmentalists, are criticized by other 'greens' for the impact they will have on the environment (wind farms are unsightly and lethal to unsuspecting birds; the process of manufacturing solar cells and their disposal after use have negative effects; and there is growing concern that biofuels are not as environmentally friendly as we would like them to be, especially those from crops and forestry; etc.).

Table 7.1
Fixed source emission rates, thousand tonnes[1]

	Years							
	1996	1999	2000	2001	2002	2003	2004	2007
RUSSIAN FEDERATION	**20274**	**18540**	**18820**	**19124**	**19481**	**19829**	**20491**	**20491**
Industry	16661	14704	15222	15492	15842	15875	16733	*
Oil extraction	1309	1329	1619	2119	3113	3227	4195	3706
Gas industry	542	456	501	476	537	591	651	508
Coal industry	596	560	604	786	819	764	757	1063
Power industry	4748	3935	3857	3656	3353	3447	3258	2924
Oil-refining industry	850	748	736	679	621	594	581	795
Chemical and petrochemical industry	413	415	427	437	428	403	408	393
Iron and steel industry	2535	2330	2396	2268	2223	2178	2203	*
Non-ferrous metallurgy industry	3598	3312	3477	3405	3297	3262	3287	*
Machine building and metal working industry	602	454	433	433	370	356	340	*
Woodworking industry and * Pulp and paper industry	434	367	379	372	332	309	304	*
Housing utilities	658	943	981	999	1058	1078	991	*
Agriculture		111	121	133	126	127	119	101
Transportation	2370	2394	2062	2055	2005	2175	2137	*
incl. pipelines in general use	2024	2111	1797	1787	1720	1890	1826	1850

** No official data*

[1] The 2000 Russia's National Environmental Report, M., The National Center for Environmental Programs (Gosecocenter), 2001, 562 p; The 2003 Russia's National Environmental Report, M., The National Center for Environmental Programs (Gosecocenter), 2004, 446 p; The 2004 Russia's National Environmental Report, M., ANO The Center for International Projects, 2005, 493 p; The 2006 Russia's National Environmental Report, M., ANO The Center for International Projects, 2007, 500 p.

7.1. Impact of the fuel & energy sector on the environment: atmospheric emissions

The fuel industry, especially oil production, is the absolute leader among energy sector branches by the level of adverse environmental effects arising from its operations. In 2004 the fuel industry took first place by volume of atmospheric emissions among 12 industries identified by the standard classification of the Federal Service of State Statistics (Rosstat), and it still occupies first place today, which is an unprecedented phenomenon for any country with a diversified economy. Table 7.1 shows air pollution by fixed sources in 1996–2007 and gives an impression of the energy sector's contribution. In 2004, the fuel, power-engineering, and oil-refining industries accounted for more than 54% of industrial pollutant emissions into the atmosphere, compared with 48% in 1996 and 2000.

In the 1990s, Russian atmospheric emissions by the overall economy and by industry were on the decrease, and no branch of the economy or industry showed any significant increase of emissions in any year. There was an abrupt change at the turn of the century, and emissions grew steadily in 2000–2006. Table 7.1 shows that this increase was due mainly to the fuel industry, especially oil production, while other sectors either continued to reduce emissions or kept them roughly constant. The large increase in oil production (31.7% in physical terms) during 2000–2004 is not sufficient to explain the enormous jump in emissions, which was more than threefold. Initially (in 2000–2001), attempts were made to explain the leap by improvement of the measurement system, which looked strange in the context of factual breakdown of the Russian environmental control system in those years and almost complete halting of environmental monitoring of polluters, previously carried out by territorial agencies of the Russian State Committee for Environmental Protection (Goskomgeologiya). In 2002 it became evident that worsening of adverse environmental effects from oil production was due primarily to ever increasing amounts of secondary gas flaring, which reflected disregard of environmental issues by most oil companies.

Unfortunately, there is no official information, which would enable us to continue the series for all sectors in 2005 and subsequent years: from 2005 the content and form of provision of information about environmental impact due to the economy in National Reports on the State of the Environment in the Russian

Table 7.2
Air pollutant emission changes in main sectors, 1999-2007 (thousand tonnes and %)

Industries	Years			Growth rates			
	1999	2004	2007	(3)-(2)	(5)/(2),%	(4)-(2)	(7)/(2),%
Industry	14704	16733	*	2029	14		
Oil extraction	1329	4195	3706	2866	216	2377	179
Coal industry	560	757	1063	197	35	503	90
Gas industry	456	651	508	195	43	52	11
Power industry	3936	3258	2924	-678	-17	-1012	-26
Oil-refining industry	748	581	795	-167	-22	47	6
Non-ferrous metallurgy industry	3312	3287	*	-25	-1		
Iron and steel industry	2330	2203	*	-127	-5	-	-

** No official data*

Table 7.3
Volumes of wastewater discharge into surface water, million cubic meters[2]

Industries	Years						
	1996	1999	2000	2001	2002	2003	2004
RUSSIAN FEDERATION	**22414**	**20657**	**20291**	**19773**	**19767**	**18961**	**18535**
Industry	7444	6445	6514	6352	6176	5852	16733
Oil extraction	4.7	4.3	7.0	3.7	4.2	3.0	3.7
Gas industry	5.9	3.2	10.3	11.5	11.6	11.7	10.7
Coal industry	658	396	380	432	395	372	414
Power industry	1073	995	946	860	768	791	685
Oil refining industry	228	164	153	159	145	133	210
Chemical and petrochemical industry	1363	1249	1280	1184	1303	1246	1126
Iron and steel industry	705	699	755	752	686	628	610
Machine building and metalworking	641	597	510	484	473	456	446
Non-ferrous metallurgy industry	483	364	393	439	421	420	443
Housing utilities	12072	12082	12133	11869	12206	11573	11432
Agriculture	2574	1769	1408	1315	1190	1360	1283

Table 7.4
Volume of wastewater discharge into surface water by economic activities, million cubic meters[3]

Type of economic activity	Years		
	2005	2006	2007
Russian Federation, total	**17727**	**17489**	**17176**
Crude oil and natural gas production and related services	40.7	54.7	42.8
Extraction of hard coal, lignite and peat	441	398	444
Production, transmission and distribution of electricity, gas, steam and hot water	816	826	893
Chemical production, rubber and plastic product manufacturing	897	855	704
Agriculture, hunting and related service activities	1033	1136	1039

Federation were changed. In the newer reports the national economy is no longer viewed as a set of industries. Instead, the data represent the environmental impact of specific economic activities. Excerpts from these reports, grouped in order to harmonize as far as possible with the structure of Table 1, are represented in the last column. In 2006 emissions from oil production decreased by 12% in comparison with the previous year due to introduction by several companies of facilities for collection and utilization of secondary gas. However, emissions growth resumed in the next year, matching the rate of extraction growth. Table 7.2 presents data on growth of atmospheric emissions by industry in general and by seven major polluting industries in 1996–2007.

7.2. Environmental impact of the fuel & energy sector: wastewater discharge

Volumes of wastewater and solid waste are insignificant at oil & gas production

[2] See Appendix 1
[3] Russia National Environmental Report, 2007, M., ANO The Center for International Projects, 2008, 504 p.

Table 7.5
Solid waste from production and consumption, million tonnes[4]

Industries	Годы		
	2002	2003	2004
THE RUSSIAN FEDERATION	**2035**	**2614**	**2635**
Industry	1989	2571	2599
Oil extraction	0.9	1.4	0.6
Gas industry	0.3	0.3	0.1
Coal industry	1054	1243	1443
Power industry	57	73	58
Oil-refining industry	1.6	0.9	1.0
Chemical and petrochemical industry	116	120	133
Iron and steel industry	398	478	429
Non-ferrous metallurgy industry	251	425	459
Housing utilities	7.8	17	15
Agriculture	8.3	15	13
Other sectors	30	11	8.4

Table 7.6
Production and consumption waste by economic activities, million tonnes[6]

Type of economic activity	Years[5]	
	2006	2007
Russian Federation, total	**3519**	**3899**
Fossil fuel extraction	1732	1636
Production and distribution of electricity, gas and water	73.5	70.8
Chemicals production, rubber and plastic products manufacturing	44.8	46.3
Metallurgy and fabricated metal product manufacturing	190	145
Construction	17.8	62.8
Agriculture, hunting and forestry	17.3	26.6
Wholesale and retail trade, repair of motor vehicles, motorcycles, and personal and household goods	143	311
Real estate operations, rental and service provision	50.9	386.3

enterprises but very significant in the coal industry (particularly for solid waste). Unfortunately, official statistics are incomplete and inconsistent. The National Report on the State of the Environment in the Russian Federation in 2000 contains information on generation of industrial toxic waste, which is classified by hazards rather than sources, but lacks data on generation of production and consumption waste (over a five-year period from 1996 to 2000), while the National Report for 2004 lacks the former information but shows the latter (for a three-year period from 2002 to 2004).

Environmental impact of the fuel sector (oil, gas and coal industries) compared with some branches of industry and the national economy (other major contributors to water pollution and solid waste) is presented by Table 7.3.

Further trends in wastewater discharge (2005–2006) for fuel sector industries are presented in Table 7.4, but in a different group compared with Table 7.3, which, naturally, makes it impossible to make a direct comparison. However, these data indicate that while the trend in the overall economy was towards slow decline of wastewater discharge

[4] Russia National Environmental Report, 2004, M., ANO The Center for International Projects, 2005, 493 p.
[5] The data for 2005 is not included in the National reports (and in industrial reports as well).
[6] Russia National Environmental Report, 2006, M., ANO The Center for International Projects, 2008, 504 p.

(by about 1-2% per year, except in 2005, when the decline exceeded 4%), the fuel & energy sector saw fluctuations between years when wastewater discharge declined and years when it increased. There is no convincing explanation for these fluctuations, which gives reason to doubt accuracy of data presented in National Reports on the State of the Environment in the Russian Federation.

7.3. Environmental impact of the fuel & energy industry: solid waste generation

Table 7.5 presents data on solid waste for 2002–2004. Data for 2006–2007 are shown in Table 7.6 (in a different grouping, as already noted).

The coal industry is responsible for the largest amount of solid waste, which continues to grow at a rate of 16-18% annually. Such rates are not justified by growth of output (about 2%) or worsening coal quality, which could only account for 1-2% of the growth at most. Volumes of solid waste generated by oil & gas extraction and transportation pose little or no risk to the environment.

Many of the indicators presented in National Reports on the State of the Environment in the Russian Federation, especially in the last seven of them, require explanations, which the reports do not give. There is a principle of 'environmental hazard', which operates in the opposite way to the presumption of innocence in criminal law, and which is often used in procedures of environmental expertise (audit), environmental impact assessment, etc. All doubts about the veracity of data in the official sources should be treated in accordance with this principle, i.e. it should be assumed that the actual situation is certainly not better than such data suggest.

7.4. Impact of the fuel & energy sector on the environment: disturbance of land

There is no doubt that oil producers could have produced the same quantities of oil without disturbing such huge tracts of land (Table 7.7[7]) through more efficient location and exploitation of wells, improvement of reservoir networks, use of better pipes, and (particularly) better construction and assembly work during installation of trunk pipelines and reservoir systems. About 100,000 wells had been drilled by the mid–1990s in Khanty-Mansi Autonomous District alone [On the State…], a large part of which did not recoup their costs due to mistakes in operation or choice of location. Table 7.7 shows that the fuel industry, oil & gas pipeline construction, and oil & gas geological prospecting taken together accounted for 60% of the land, which was disturbed in 2004, and these industries represented as much as 72% of the total in 2007! However, these industries, which are the wealthiest in the national economy and Russia's main foreign currency earners, accounted for less than 50% of land reclamation in 2004 and less than 60% in 2007. Land reclamation by the oil industry in 2004 was only 74% of land disturbed in the same year (the ratio for the gas industry was less than 57%), and only 45% in 2007. This is further proof of disregard for environmental problems by the majority of fuel companies. By contrast the coal and electric power industries have fulfilled their land reclamation responsibilities. This is partly due to pressure from public environmental organizations, local authorities and the general public, since the coal and electricity industries (unlike oil & gas) are located in densely populated areas. However, growing indifference on the part of government towards environmental issues has led to a negative trend: in 2007 the coal and

[7] The first data on disturbed and reclaimed lands appeared in the 2004 National Report. The transition from grouping land disturbance data by industry to grouping it by type of business was not made in the 2005 National Report, therefore a uniform table for 2004-2007 cannot be made. Nevertheless, it seems sufficient to give data only for the starting and finishing parts of that period.

Table 7.7
Areas of disturbed and reclaimed lands in 2004[8]

Industry	Disturbed land		Total area of disturbed land, end of period		Reclaimed land	
	2004	2007	2004	2007	2004	2007
Russia	**58 219**	**46 165**	**892 419**	**919 034**	**52 175**	**29 480**
Oil extraction	22 372	23 447	94 134	114 373	16 453	10 632
Gas industry	6 449	2 811	81 975	84 283	3 641	3 430
Coal industry	1 338	1 637	103 622	105 555	2 494	1 160
Geological prospecting	4 019	2 425	26 976	29 441	3 700	2 114
Peat industry	53	11	59 063	57 254	752	525
Oil and gas pipeline construction	1 859	3 027	10 708	13 853	1 466	868
Power industry	414	263	26 845	26 848	1 066	36
Iron and steel industry	645	221	51 197	51 500	232	42
Non-ferrous metallurgy	17 600	6 923	108 360	107 116	16 785	6 392
Chemical and petrochemical Industry	120	5	10 035	9 009	554	160
Construction materials industry	845	666	49 281	49 242	865	364
Railway construction	247	185	4 357	4 469	387	63
Road construction	1 020	696	20 092	19 677	1 568	655
Agriculture	274	542	121 756	115 922	912	415
Forestry	99	1 560	66 233	64 384	179	1 862
Construction relating to water bodies and improvement work	70	175	10 301	10 628	24	28
Other industries	795	1 571	47 494	55 480	1 097	734

power industries disturbed more land than they reclaimed (though the gas industry met its land reclamation responsibilities in that year).

As can be seen, the fuel & energy industry ranks first among all economic sectors by the land area, which it disturbs.

7.5. Impact of the fuel & energy sector on the environment: oil spills

There are almost no official statistics in Russia on oil spills due to blow-outs and other accidents on trunk oil pipelines and at reservoir systems in oil-producing areas. So the oil industry escapes negative attention, which it might otherwise attract.

Some impression of the frequency and scale of oil spills can be gathered from fragmentary information in the media, relating to particular regions and years[9] [Fundamentals of ..., 1989; Mazur, 1995; Problems of Geography ..., 1996; Solntseva, 1998]. The periodical 'Neft Rossii' ('Russian Oil') has reported that 545 accidents occurred on trunk pipelines alone between 1992 and 2001 and there was no trend towards reduction of the average number of accidents

[8] Russia National Environmental Report, 2004. M., ANO The Center for International Projects, 2005, 493 p; Russia National Environmental Report, 2007. M.

[9] For example, the average annual oil product content in the Okhinka River (Sakhalin) in 2000 was 368 times higher than the official limit and the maximum recorded concentration was 640 times above the limit The Russia National Environmental Report, 2000.

per year (50-60). In 2001, there were 42,000 instances of leaks from field pipelines, resulting in spillage of at least 65000 m^3 of oil and strata water [Russian Oil, 2003, № 1; № 2][10]. According to Neva-Ladoga Water Authority, there were at least 35 oil spills each year in the city of St.Petersburg and Leningrad Region due to shipping accidents in 1999–2003 [Barenboim, 2005][11]. Six major oil spills amounting to 42,290 tonnes of crude oil (and, on one case, combustion of the spillage) were officially registered in 1993–2001 on pipelines in Irkutsk Region operated by Transneft (the national pipeline monopoly) between Krasnoyarsk and Irkutsk and Omsk and Irkutsk (reported in letter No. 4-9-758, dated August 23, 2002, from the Irkutsk Regional Branch of the Ministry of Natural Resources of the Russian Federation) [cited in 'Green World', 2006])[12].

Impact of oil spillages from pipelines are essentially disregarded in accounting of disturbed land. This seems to be because most spillages occur in 'undeveloped' areas – areas, which have not been put to any (or to minimal) use in the economy. Local impact of spillages are often eliminated (though not completely) by spring floods within a year or a few years without the pipeline owner or emergency or environmental services taking any action. The fact that nearly every spillage of oil or oil products entails contamination of water bodies is not taken into account by official statistics on adverse environmental impacts, because such contamination does not come under any of the statistical headings: 'atmospheric pollutant emissions', 'waste water discharge', 'waste formation', 'land disturbance', 'radiation contamination', 'electromagnetic radiation', 'noise', and 'vibration'. The hydro-ecological sub-system of environmental monitoring shows that oil contamination of water bodies ranks fourth by volume among types of water pollution (after suspended solids, phosphorus, and iron compounds). Discharges of oil products and effluent from oil operations were 5600, 6600, 3700, 4600 and 3100 tonnes in respective year from 2003 until 2007, and oil industry pollution is the main type of pollution in many of Russia's rivers lakes and (particularly) reservoirs)[13]. The sources of pollution in specific cases (and therefore the responsible parties) are rarely identified, mainly because there is no national system for monitoring chief sources of oil pollution and no information on the shares of different economic sectors in pollution of water bodies. However, the figures adduced above leave no doubt that the share of oil production and pipeline transport in pollution is very high. Minor leakage from underwater pipelines (due to the high rate of wear, which is typical of most Russian trunk pipelines) makes a steady contribution to water contamination. One example is an underwater pipeline across the Sura River, which flows into the Cheboksary Reservoir, where a leak was detected by accident in the course of prospecting work [Barenboim, 2005][14]. But shares of the processing industry and the transportation sector (mainly water and road transport) in pollution of water bodies are also large.

To conclude, therefore, official data on oil spills and related environmental damage to soil, terrestrial ecosystems, ecotones and water bodies are lacking or are highly inadequate , but there is no doubt that such damage is very large.

7.6. Impact of the fuel & energy sector on the environment: pressure on ecosystems

The outcome of economic impacts on ecosystems depends on both the degree and

[10] Oil of Russia, 2003, No.1, pp.104-107; Oil of Russia, 2003, No.2, pp.84-88.
[11] G.M.Barenboym, Tha Main Scientific and Practical Results of GTsVM Operation and their Development Perspectives, M, 2006, 34 p.;
[12] Quote: "Green World", 2006, No.2 (471), p.13.
[13] For example, the average annual oil product content in the Okhinka River (Sakhalin) in 2000 was 368 times higher than the official limit and the maximum recorded concentration was 640 times above the limit The Russia National Environmental Report, 2000, M., The National Center for Environmental Programs (Gosecocenter), M, The National Center for Environmental Programs (Gosecocenter).
[14] Quote: G.M.Barenboym, Works.

nature of the impact (atmospheric emissions, wastewater discharge, solid waste disposal, land disturbance, etc.), as well as specific features of the ecosystems, which are affected (scale and quality of land reclamation is also important). Russia has enormous geography (17 million sq. km.) and encompasses a great variety of climate zones and an even greater variety of ecosystems. Hydrocarbon production is carried out all over the country as well as offshore, affecting terrestrial and marine ecosystems, but is located mainly in northern areas: southern tundra, forest tundra, and taiga. Major increase of oil & gas production is also to be expected in the near future on the offshore continental shelf. Atmospheric emissions by the fuel & energy sector are carried over vast distances. It has been established that sulfur dioxide (SO_2) and nitrogen oxides (NO_x), which are the primary causes of acid rain, can travel up to 4000 km from their source. Many lakes, including Lake Baikal, absorb more pollutants from the air than from discharge water.

Carrying of air pollutants over large distances makes it difficult to estimate their quantitative impact on ecosystems. Mixture of pollutants from various sources (industries) in the atmosphere adds to the difficulties. So, our ability to determine the share attributable to each type of source is limited to relatively simple cases. Satisfactory results can be achieved in modeling of air pollution by one or two industrial sources, but accurate estimates for three sources are not yet possible.

Methods of observation from a distance allow identification of impact zones, where ecosystems are under pressure from a specific pollutant source, and fuel & energy enterprises figure frequently among such polluters. Most such enterprises are located in undeveloped areas, in the 'wilderness', and this makes it much easier to identify facilities, which are having major impact on their close surroundings. This is also true for pollution of coastal areas and water bodies by leaks from pipelines. High-resolution satellite images are available, but they cost money and they need to be supplemented by integrated ground-based observations, which also require significant investment, especially in remote areas. Analysis techniques for distance monitoring data now exist, which can identify the source of close impact and track the spread of oil pollution ('spots') in water bodies (seas, lakes, reservoirs, rivers, canals). Wide implementation of these techniques is hampered by shortage of monitoring information and of money to pay for its collection. The biggest obstacles to progress, however, is the absence of any authority in Russia committed to carrying out these tasks (the Ministry of Natural Resources and Ecology of the Russian Federation is principally focused on maximizing natural resource extraction and not on preventing environmental damage or addressing other environmental concerns). Meanwhile, for want of monitoring, assessment and forecasts of fuel & energy impact on ecosystems, and for want of estimates of the economic damage arising from these impacts, there is a risk that Russia's biggest 'bread-winning' sector could become the destroyer of Russia's natural environment, and, consequently, the destroyer of its economy.

In order to maintain the current level of oil production in Russia, it will be necessary to expand the geography of production and to discover and develop new oil deposits, particularly in eastern Siberia and offshore. The same is true for the gas industry. The coal industry will open new mines adjacent to existing facilities. If per unit indicators of environmental impact (emission, discharge and solid waste per unit of production or transportation of raw materials) remain at current levels, there will be more pressure on ecosystems, which are already suffering large impacts. Russia is currently a global environmental donor, since overall impact of Russia's economy on the environment is less than the useful yield of Russian ecosystems for sustaining the global ecological balance. Russian boreal forests and wetlands (where most of the country's fuel & energy enterprises are located) are important carbon sinks. But Russia could lose this role if it allows the unfettered fuel & energy expansion, which we have just described, to continue.

7.7. Impact of the fuel & energy industry on the environment: concluding remarks

In the sections above, we have discussed main environmental impacts of the energy sector (mainly the fuel industry, but to a lesser extent, electric power generating and power engineering). There has not been room for discussion of other dangerous environmental impacts from uranium ore mining and enrichment [OECD ..., 1999; Proceedings ..., 2003][15], production of fuel elements for nuclear power plants, and operation of NPPs themselves (see, in particular, [Yablokov, 1997] for environmental concerns about nuclear power)[16]. We have also had to omit analysis of the environmental implications of oil & gas production on the continental shelf, construction and operation of oil & gas pipelines on the sea-bed, (see [Patin, 2001; Aibulatov, 2005])[17], environmental problems related to renewable geo-energy, etc. The 2009 Sayano–Shushenskaya hydroelectric accident has also raised new concerns about safety in the hydro-electricity industry. Environmental concerns related to this sub-sector have traditionally included flooding of land to create artificial reservoirs, coastal flooding, shallow water propagation with sharp deterioration of water quality, abrasion, local climate change, etc.), But Sayano-Shushenskaya raises serious concerns about equipment dangers, which seem to have been underestimated. These problems undoubtedly require large-scale monograph study, similar to electricity sector research in the mid–1990s [Lyalikov et al, 1995][18].

Every country in the world will continue to need considerable amounts of energy, including fossil fuels and their derivatives, for the foreseeable future. The question is how much will be needed, taking account of environmental factors, energy substitution, import potential and, especially, pricing (not only for energy, but for everything produced or used by energy-consuming industries). Progress of science and technology lowers energy intensity in all sectors, but to varying degrees and limits. Negative impact of extractive enterprises on the environment is inevitable and no technologies can reduce it beyond an objective limit. More difficult mining and extraction conditions tend to raise this limit, and that entails a principle of diminishing returns in environmental impact reduction: increasingly difficult production conditions in Russia, as the most accessible resources are depleted, will makes it increasingly difficult to minimize environmental impacts as time goes on.

In manufacturing industries that process materials, which have already been removed from natural systems, there is at least a theoretical possibility of reducing environmental impact to zero, though with two significant reservations: firstly, such possibility only concerns the production process and not what then happen to the manufactured product; secondly, heat pollution, which obviously has some non-zero low limit, is not taken into consideration. With these two limitations, technological progress should steadily reduce negative impact of the manufacturing sector on the environment.

The function of the extractive industries (not only mining, but also forestry, agriculture, fisheries, hunting, etc.) is extraction of natural substances from the environment and, whatever the extraction method, there will be some insuperable limit to reduction of negative impact from this process, regardless of any technological advances. This is a principle difference between the raw material sector and manufacturing industries.

[15] E.g. see: OECD Environmental Activities in Uranium Mining Milling. A Joint Report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency. 1999. 230 p.; Proceedings of International Conference Uranium Geochemistry 2003: Uranium Deposits – Natural Analogs – Environment. Wien, 2003. 380 p.

[16] The environmentalists' claims to the nuclear power segment are found in the following book: A.V.Yablokov, Nuclear Mythology: Environmentalist's View of Atomic Energy, M, Nauka, 1997, 272 p.

[17] See: S.A.Patin, Oil and the Continental Shelf Environment, M, VNIRO, 2001, 247 p.; N.A.Aybulatov, Russia's Activities in the Coastal Area and Environmental Issues, M., 2005, 364 p.

[18] Such an investigation was done in mid 1990-s only for a single sector of the Fuel and Energy Complex – electric power industry. See: G.N.Lyalik, S.G.Kostina, L.N.Shapiro, E.I.Pustovoyt, Electric Power Industry and the Nature: Environmental Issues of Electric Power Industry, M, Energoatomizdat, 1995, 352 p.

Further, the economic cost of environmental impacts is rising at an accelerating rate, and will continue to do. This factor and increase of impacts on the environment due to increasingly difficult extraction conditions (particularly in Russia), will widen the gap between extraction and processing in reduction of environmental impacts (this phenomenon has already been noted in analysis of structural tendencies in the economy of various countries, though it has often been left unexplained).

Conclusions about the grave environmental impact of Russian fuel & energy producers and converters are evident, despite incompleteness of our survey and superficial nature of our analysis. Impacts from the fuel & energy sector are large and (what is of more concern) they are growing. There have been overall improvements in the environmental performance of electricity generating and oil refining, but any improvements on the part of oil, gas and coal producers have been on minor counts. It is beyond question that reduction of fuel &energy production would have positive environmental effects. The question is whether such reduction can be achieved without undermining industrial output and through economically acceptable means. To answer this question, we need to briefly review how the energy produced by the fuel & energy industry is used in the Russian economy.

7.8. The connection between cold climate and energy consumption in Russia

After analyzing the impact of Russia's fuel & energy industry on the environment, it would be natural to pose the opposite question, and to investigate impact of the environment on energy production and consumption. However, such an investigation, if carried out in full, would take us far beyond the scope of this Report. We will therefore limit the discussion to impact of the climate on energy consumption in the housing utility sector.

Energy intensity of Russian housing utilities is catastrophically high, and that is the result of a careless, irresponsible attitude, rather than of Russia's severe climate as such. The 'energy concern index' (it might also be called an 'energy savings index') proposed by [Danilov, Shchelokov, 2002][19] is of considerable interest with respect to energy use in housing utilities and also in other sectors. The index definition and its method of calculation, as well as its values for several countries are presented in Table 7.8.

Like any other 'designed' index, the energy concern index cannot pretend to offer an accurate description of reality: in particular, it ignores the structure of the housing stock, as well as some other factors. But it undoubtedly gives an insight into the scale of wasteful energy

Table 7.8
The energy concern index, data for the beginning of 1990

Country	Climate severity index		Heat insulation production		Energy concern index: (5) compared with the USA
	Total	Compared with the USA	m^3 per thousand residents per year	same, with allowance for climate severity index: (4) / (3)	
USA	2700	1	500	500	1
Sweden	4020	1.49	600	403	0.8
Finland	4120	1.52	420	276	0.55
Russia	5000	1.85	90	48.6	0.1

See Appendix 19 with amendments

[19] N.I. Danilov, Ya.M. Schelokov, The Power Saving Encyclopedia, Ekaterinburg, Sokrat Publishing House, 2002, 352p.

practices in Russia's housing utilities sector, which are usually attributed to harsh climatic conditions.

If the energy concern index in Russia is 5.5-8 times lower than that of our Nordic neighbors, it is unsurprising that unit heat use for heating residential buildings in Russia (500–600 kWh/m^2 per year) is several times higher than in Sweden or Finland (135 kWh/m^2 per year), where climatic conditions are similar to the average in Russia (averaging is carried out with adjustment for population density, and not simply over the country's territory). Table 7.8 shows heat insulation of all premises (not only housing), as gross output of heat insulation corresponds to population size, rather than to floor area of particular premises. Severe climate is often cited to excuse higher energy costs in Russia. Russia is a northern country and much heating will be required, even with the best possible housing utility system. But the issue is the extent, to which higher energy consumption is due to climate, and the extent, to which it is due to other, quite unrelated circumstances. Estimates have shown that the climate factor can only be used to justify 25% excess of energy intensity in Russian GDP compared with western Europe (even if the need for air conditioning is left out)[20].

Energy intensity of Russian GDP at the start of the 21st century was 3.1 times higher than in the European Union (prior to the admission of new members, i.e. with 15 member countries). Maintenance of a relatively acceptable economic situation in the country was only possible thanks to large-scale export of oil and natural gas at relatively high prices. This makes the Russian economy extremely unstable and over-dependent on the state of global fuel markets. These discrepancies have become apparent since the 2008 global financial and economic crisis. Russian products cannot be competitive in the world market when their manufacture is so energy intensive. Only industries making semi-products from domestic raw materials (low-level metallurgy, mineral fertilizers, timber) can keep afloat thanks to disproportions between global and domestic energy prices. These factors cast a shadow on the long-term outlook. Long-term economic problems could only be addressed by efficient deployment of resources obtained in years when the market environment was highly favorable. But trends in energy intensity of GDP in 2000–2007 show that the potential is not being used adequately. Some reduction of the energy intensity index since 2000 is insufficient and much less than observed in the West after 1974.

These points are, essentially, platitudes, and are cited here to emphasize that Russia's long-term economic interests by no means conflict with its environmental interests: both necessitate reducing the power intensity of GDP through energy saving and increased energy efficiency. The modernization needed for energy saving would simultaneously yield considerable economic benefits, because new equipment is not just more energy efficient, but more economical overall and more reliable, enabling manufacture of better-quality products in better conditions of work, where staff can make fuller use of their professional skills. The latter aspect is particularly important, since current production technologies in Russia often fail to match the educational attainment level of industrial employees, entailing inefficient use of labor resources and negative social consequences.

7.9. Social and economic consequences of hypertrophic development of the fuel & energy sector

As shown in previous chapters, development of fuel & energy without regard for environmental concerns will have serious negative impact on the environment. If existing

[20] The United States spend more power for air conditioning than Russia for heating. This is partly due to the climate but partly is a result of the power wasting attitude. It is worth noting that Table 8 takes into consideration only the 'harshness' of the climate, but other aspects of a climate can also be unfavorable . Other negative climate aspects are also found in Russia, but they are less vivid and systematic in inhabited areas.

trends continued the damage would approach catastrophic levels. However, full significance of these consequences can only be grasped in conjunction with other processes, initiated, supported and intensified by hypertrophic development of the fuel & energy sector. We list all of the relevant factors (Box 7.1) without going into detail (such detail can be found in previous chapters of this Report and in other publications: [Danilov-Danilyan, 2001, 2003], etc.)[21].

It is easy to see that the points listed in Box 7.1 are interlinked. The first five refer mainly to negative economic consequences of hypertrophic development of the raw materials sector, while the other four emphasize social consequences of this process. The trends, which have been described, can undermine human development, creative social practices, and the strengthening of civil society.

7.10. Energy and environmental malaise and ways of overcoming it

The current state of Russian energy production, characterized by unacceptably high and increasing adverse impacts of the fuel & energy industry on the environment and squandering of energy in the economy, could be qualified as 'energy and environmental malaise'. We have described how this situation has come about, but a few more important aspects are worth pointing out.

The 'big money' to be made from oil discourages the development of long-range interests among business groups, particularly those dealing directly with oil. Their focus on maximum gains while market conditions are highly favorable is understandable: they would have to make much greater efforts in order to obtain many times smaller profits if world fuel prices were lower, so it is important to seize the opportunity while it is there. But this approach entails disregard for environmental protection, sustainable use of mineral resources, technological innovation, and energy and resource saving. There was no time or need for such details in the mid–2000s environment of super-profits from record oil prices (even a price of about USD 70 dollars per barrel triggers disregard for nature conservation, which drops out of account completely at higher price levels). Individual and clannish interests of oil magnates diverge radically from national interests. And artificially low domestic energy prices, which, essentially, result from exorbitant world prices, undermine progress to energy saving in power-consuming industries.

State regulation of oil production (and of mineral resource use in general) is inefficient: licensing commitments have token status and are not properly enforced; tax issues have been left unresolved; distribution of resource rent does not meet long-term national interests or the interests of the fuel & energy sector itself; and a search for 'direct' methods of rent expropriation lead to economic deadlock (see [Danilov-Danilyan, 2004])[22]; the government is not implementing any amortization policy, but has washed its hands of the major challenges of capital repair and renovation (unlike the situation in developed countries, where these issues are given equal priority with tax collection).

It is hard to expect resolution of environmental problems if the government has no environmental policy: since abolition in 2000 of the Russian State Committee for Environmental Protection (Goskomgeologiya), there have been almost no attempts to define and start consistent implementation of such a policy. Approval by the government in 2002 of the Russian Environmental Doctrine has had no practical consequences and no other documents related to environmental policy have been issued since 2000. The economic

[21] E.g. see: V.I.Danilov-Danilyan, The Run for the Market: 10 Years Later, M., MNEPU, 2001, 232p.; V.I.Danilov-Danilyan, Power Efficiency-the Key Route of Russia's Economic Development // Economic Issues of Environmental management on the Fringe of the XXI-st Century, M., TEIS, 2003, pp.580-593.

[22] See: V.I.Danilov-Danilyan, The Natural Resource Rent and Utilization of Natural resources // Economics and Mathematic Methods, 2004, vol.40, No.3, pp.3-15.

Box 7.1. Negative consequences of excessive growth of the fuel & energy sector

1) Investment efficiency in the raw material sector (as a function of production time or production volume) is declining, due to objective worsening of production conditions.

2) Emphasis on raw material development will inevitably lead to further deformation of the sectoral structure of the economy (and export), due to lack of adequate funding for development of high-tech industries.

3) Export of raw materials, particularly energy, is unreliable as a source of budget revenue (through taxes and duties) because of large and unpredictable volatility of international prices (some forecasters predict that oil prices will come down to USD 9 dollars per barrel in a few years in comparable prices, while others expect levels in excess of USD 200 dollars). To combine an energy based economy with relative stability a country needs huge foreign exchange reserves per capita (as in Kuwait and the other main OPEC countries). Russia has never had such reserves and cannot expect to accumulate them in the future.

4) Because it dominates the economy, the raw materials industry has no competitors: it is in a monopoly position as taxpayer, supplier of the country's budget income, and in other related respects. This favors large-scale corruption, but it also creates unfavorable conditions for development of the raw material sector itself: lacking economically efficient competitors, the sector loses interest in its own improvement; the wage levels of its management are too high to leave scope for incentives, etc.. This is a specific type of monopoly, but like any other monopoly it represents a threat both for the economy and (ultimately) also for the monopolist.

5) Science and technology have limited importance in the raw material sector. They do, of course, play a role (any company, which fails to use modern technologies, falls behind), but they are not paramount, as they are in the high-tech sector.

6) The raw materials sector is less accessible for small business than any other sector. The share of small business in the Russian economy is minimal in comparison with any developed country and this imbalance needs to be corrected, but it cannot be easily corrected due to raw material dominance.

7) Investment distribution between regions corresponds to geographical distribution of raw material industries, favoring regions with rich mineral endowments, but these tend to have unfavorable climates, small populations, and undeveloped and expensive infrastructure, so they are bound to suffer economic decline after depletion of their raw material resources or reduction of demand for the resources. Meanwhile, densely populated and otherwise promising regions are neglected by investors (as are non-raw material industries).

8) Work conditions in the extractive industry are particularly tough, even when the most advanced technologies are being applied, offering few prospects for personal development, and climatic and other negative factors specific to Russian resource regions add to his effect. Many oil wells are near the Arctic circle or beyond it, and the context of rigs, oil and gas pipelines, mines and quarries, does not help employees and their family members to benefit from the human development opportunities that are available in the 21st century.

9) Very high concentration of money is typical of the raw material sector, so dominance of the sector in the economy encourages creation of an oligarchy and extreme wealth inequality.

mechanism of environmental protection is effectively defunct, and even the generally accepted principle, by which 'the polluter pays', is not adequately embodied in law since adoption of a new Federal Law, 'On environmental protection' (2003). The roles of state environmental impact assessment and environmental oversight have been minimized: 200-300 federal environmental inspectors – helped (or hindered) in some, but not all, regions – cannot possibly exercise environmental control functions in a country of 17 million sq. km.

What the government needs to do in order to break out of the current energy and environmental malaise is so self-evident that we will not spend much time here spelling it out.

Measures to improve energy saving and energy efficiency should embrace all levels of the national economy. This involves a change in the country's sectoral structure, prioritizing development of sectors, which are less energy intensive. This process has been underway since the 1990s, but it has been slow and uneven, with development concentrated in the service sector. Within sectors the emphasis should be on changeover to new products, whose production or consumption requires low power inputs (for example, energy-efficient light bulbs instead of conventional incandescent lamps), deeper processing of raw materials, especially in oil refining, metallurgy, woodworking, etc. In many cases this approach requires radical reconstruction of operating plants and construction of new ones. In the oil industry, the challenge should be to minimize flaring of secondary gas to match standards of the world's best oil companies. The most effective steps at company level are for installation of equipment, which can make the same or similar products with less energy (for example, replacement of open-hearth furnaces by oxygen steel-making converters or electric furnaces). At the 'people' level, a large effect can be obtained by proper organization in the workplace and in daily life, and by following elementary rules of energy economy.

The experience of all developed countries gives a clear indication of the huge energy-saving reserves, which Russia has at its disposal. Use of this potential will invigorate the national economy and radically reduce adverse effects of the economy on the environment.

7.11. Conclusions and suggestions

The present situation in the Russian energy sector, characterized by unacceptably high and steadily growing negative impacts on the environment combined with squandering of energy in the economy, amounts to an energy and environmental malaise. The impact of the fuel & energy sector on the environment is unacceptably high. Continuation of existing trends will lead to large-scale disruption of ecological balances, massive pressure on ecosystems, and disappearance of Russia's role as a global environmental donor.

In order to avoid such a scenario and to accelerate transition to environmentally sustainable development Russia needs to:

- dramatically enhance its environmental system, ensuring its independence from the government system for natural resource management;
- develop efficient state environmental policy and vigilantly control its consistent implementation;
- enact regulations on more efficient use of energy and take steps to combat squandering of energy. Such regulations should be supported by a system of penalties for non-compliance and failure to take appropriate measures;
- ensure safety and security of all aspects of the energy sector, and of the national economy as a whole, through government initiatives (based on legislation), which ensure that depreciated equipment is repaired, decommissioned and replaced in a timely fashion;
- take practical action to restructure the economy through increase in the share of processing and high-tech industries.

Box 7.2. Environmental sustainability of Russian cities

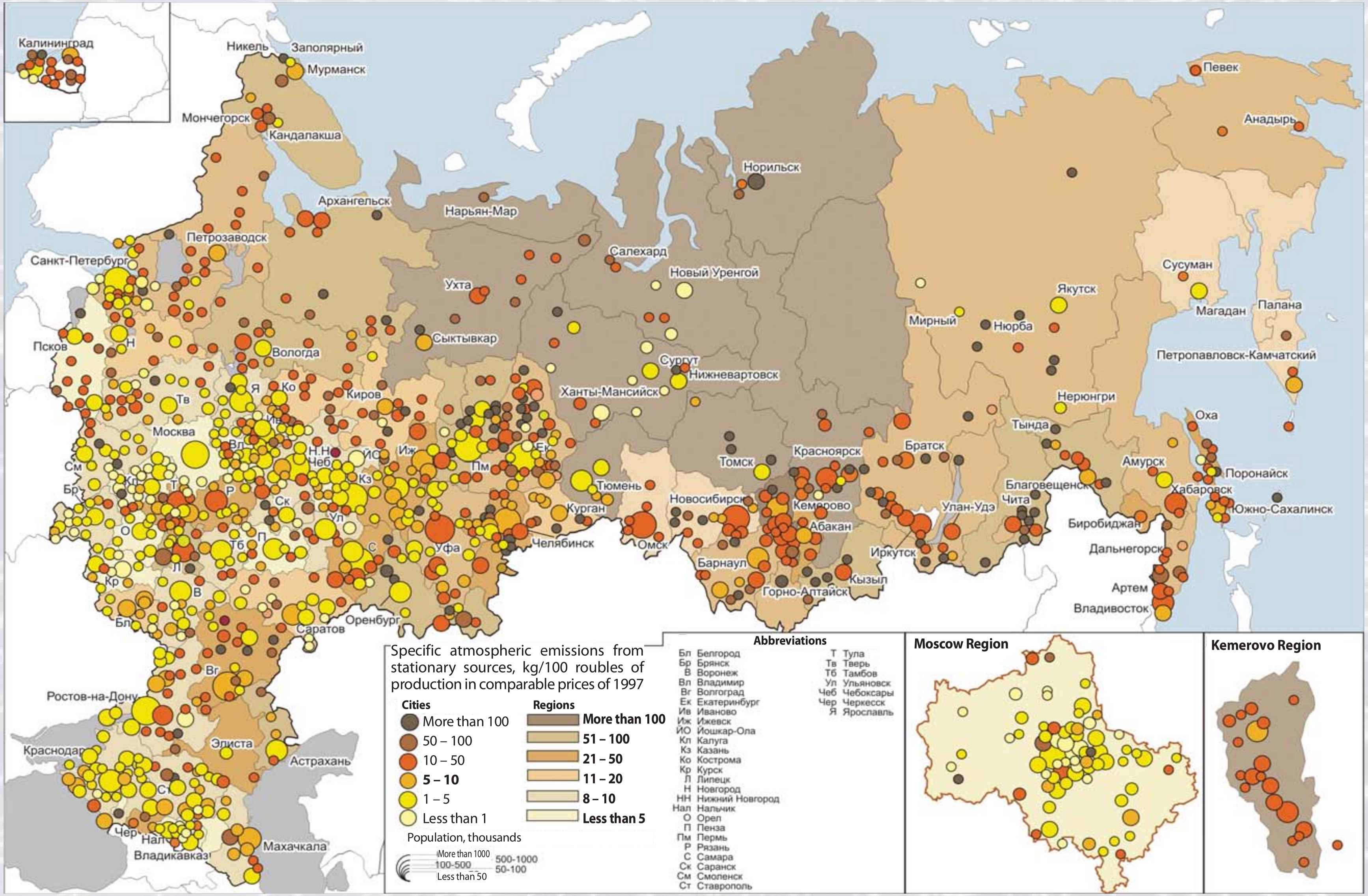
The environmental situation in a city, particularly its air quality, is of prime importance for the well-being of its inhabitants. Out of 56 Russian cities where emissions in 1990 exceeded 100 thousand m.t.p.a., only 25 still had high levels of pollution by 2008. These include major production centers for copper, nickel and some other non-ferrous metals, where the environmental situation is of great concern: Norilsk (Krasnoyarsk Region), Monchegorsk and Zapolyarniy (Murmansk Region), Mednogorsk (Orenburg Region), Bratsk and Krasnoyarsk. Norilsk has been the biggest source of atmospheric emissions in Russia in recent decades, with volumes between 2.540 million tonnes (in 1987) and 1.957 million tonnes (2008). The technologies used cause Norilsk to give off large quantities of flue gases containing sulphur dioxide which is not used for production of sulphuric acid. However, although annual emissions at Norilsk are 17 times higher than at Monchegorsk, annual indexes show the city's air to be somewhat cleaner. This is explained by a natural ventilation effect, which is much greater in the Norilsk area. Frequent and strong winds in the Taimyr peninsula, especially in winter, make the climate extremely harsh, but they also save Norilsk from becoming an environmental disaster area. Emission volumes depend on technical and economic factors (industrial layout of the area, scale of production, existence of treatment facilities and other types of environmental protection infrastructure), but self-purification is a purely natural characteristic of the local environment, determined by geographical location, ambient air circulation, specific climate, terrain, soils, vegetation and other natural features. These features can affect environmental conditions in the area around an industrial site to a greater degree than emission volumes.

The top 10 emission leaders include such metallurgical centers as Novokuznetsk, Lipetsk, Cherepovets, Magnitogorsk, Nizhny Tagil, Orsk, Chelyabinsk and Kachkanar. They are followed by large centers with coal-fired power generating, such as Troitsk in Chelyabinsk Region, petrochemical and oil refining industries (Omsk, Angarsk, Ufa) and areas where oil extraction is just beginning (Strezhevoy in Tomsk Region). The economic growth period that ended in 2008 saw reduction of emissions in all of the above-mentioned industrial centers, except Omsk, Novosibirsk and Angarsk, and this has led to decrease in specific pollution values (per unit of production in comparable prices).

Analysis of specific pollution figures and their progress in 974 towns and cities with total population of 92.4 million (97% of the total urban population in Russia) helps to determine main pollution trends. Differences between cities by specific pollution levels due to stationary sources are as great as 1000 times. Values are lowest in machine-building, light and food industry centers in European Russia, but they increase further north and east. There are less than 20 cities east of the Ural mountains, which have relatively low specific emissions (less than 5 kg/1000 roubles of industrial production in comparable prices, while the average national value is 31 kg). These include more than 10 oil & gas producing centers in the northern part of Tyumen Region, the diamond producing centre of Mirny, and Yakutsk, which has almost no industry and generates its electricity from natural gas, unlike most cities in Siberia and the Far East. On average, specific emissions in northern and eastern cities where coal accounts for most of power generation are respectively 3.5 or 1.4 times higher than in cities where power is generated from gas or fuel oil. Geographical location, climate and coal burning are the main reasons for increased levels of anthropogenic pollution in these areas (Figure 7.2.1).

It is generally believed that type of industrial specialization determines levels of pollution in cities, but this is not necessarily true, since several cities are relatively clean despite hosting potentially dirty industries. Generally, differences between industries are less marked than differences within the same industry. Oil extraction, which is potentially the most polluting fuel & energy sub-sector, has cities with very low emissions (0.4-0.5 kg/1000 roubles), for instance Kogalym, Langepas, Pyt'-Yakh and Megion in Khanty-Mansi Autonomous District, though Khanty-Mansi also has two towns (Pokachi and Beloyarskiy), where specific emissions are 70-80 kg/1000 roubles of production, even though the production company at Pokachi –

Figure 7.2.1
Specific atmospheric emissions in cities and regions of the Russian Federation (kg/1000 roubles of production in comparable prices, 2007)



Pokachevheftegaz – uses 88% of its secondary gas (flaring of secondary gas is often the main source of pollution from oil production). Some old oil production centers, such as Frolovo (Volgograd Region) and Pokhvistnevo (Samara Region) have specific emissions that are considerably higher at 130-170 kg/1000 roubles.

The gas sector causes large amounts of atmospheric pollution, both in extraction operations and at compressor stations. Production at compressor stations is modest in money terms (even though their overall emissions are comparable with the those from all stationary industrial sources in Moscow), so specific emissions are hundreds of kg/1000 roubles (at such locations as Myshkin and Sosnogorsk). Coal enrichment plants are the major polluters in the coal industry and specific emissions in areas where low-quality hard or brown coal is produced (Nazarovo, Kopeysk, Kumertau, Emanzhelinsk, Nyurba, Gremyachinsk) are 5-10 times higher than in areas where high-quality coals are mined (Borodinskiy, Berezovskiy).

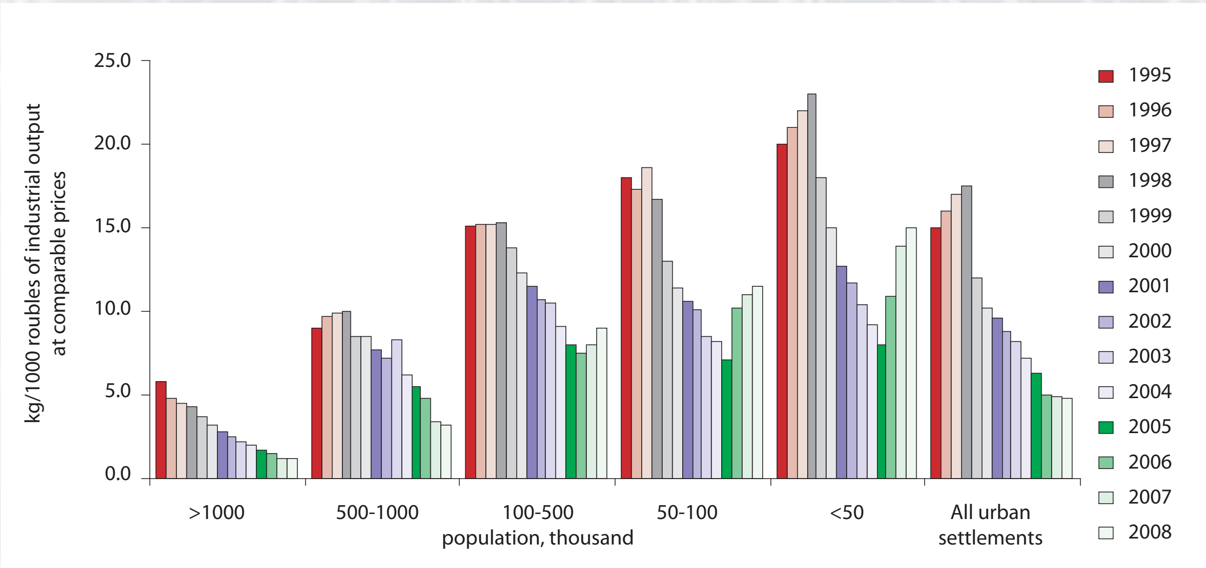
Thermal power production is associated with high specific emissions in nearly all parts of the country. Indicators depend on various factors, including capacity and type of power station, age of equipment and, crucially, the type of fuel used. Highest specific emissions (more than 100 kg/1000 roubles) are from coal-fired power stations with obsolete equipment (Suvorov, Myski, Verkhniy Tagil). Levels at new stations, which work on natural gas, are much lower at 10-12 kg/1000 roubles (Volgorechensk, Dobryanka).

Size of urban settlement is a more significant determinant of pollution than industrial specialization. Specific emission values in most cities are in inverse proportion to their population: the larger the city, the more likely it is to be included in the 'sustainable' group. Creation of production facilities in small towns could thus be viewed as tending to increase pollution impacts This contributes to formation of 'industrial poverty' areas, which combine poor infrastructure (including environmental infrastructure), inadequate purification facilities, lack of a skilled labor market and lack of incentives, which could attract qualified specialists.

Trends in specific emission data are particularly informative. They show negative changes in the structure of pollution by territories and are useful in forecasting alterations in environmental impact.

Pollution volumes declined more slowly than production volumes in the economic crisis years of the 1990s. Emissions in 1999 were 58.3% of their level in 1990, exceeding indexes for GDP and industrial production. Waste water discharge and solid waste declined even more slowly. As a result, specific emissions (pollution volume to

Figure 7.2.2
Specific emission trends in urban settlements with different populations, 1995-2008



money value of industrial output) continued to grow until the end of the 1990s in all types of towns and cities, except those with populations in excess of one million.

Specific emissions fell in all towns and cities when economic growth began (Figure 7.2.2). More prosperous businesses carried out reconstruction, and some of the oldest and most polluting businesses had closed down during the crisis period. The share of cities where specific emissions continued to rise came down from 50% in 1998 to 28% in 2000. These were mostly towns, accounting for just 5% of the country's urban population (the only exceptions were the cities of Nizhnevartovsk and Novy Urengoy).

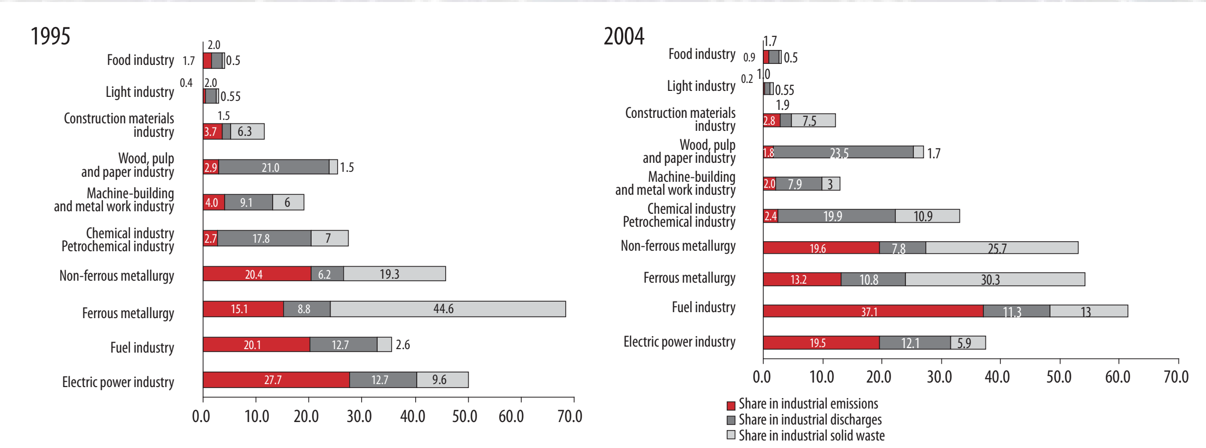
However, the negative specific pollution trends of the 1990s were not reversed because economic growth made it necessary to meet electricity demand by using some of the oldest generating capacity, and a growing deficit of natural gas forced power stations to burn more polluting coal and fuel oil. As a result, specific emissions grew in towns and cities where they were already too high (10-100 times the national average). A widening gap between specific pollution indicators of the country's towns and cities was a hallmark of Russia's newfound economic growth.

Most of the increase in gross and, particularly, specific pollution during the period of economic growth was due to obsolete power generating units. Old coal-fired boilers were re-commissioned in 20 cities in response to economic growth and the share of natural gas in generating in these cities declined by between 7% and 39%, mostly in favor of coal. Maximum reduction of the share of gas was in Sverdlovsk Region at the Serovskaya, Verkhnetagilkaya and Nizhneturinskaya CPPs and the Kamensk-Uralskiy CHP.

Specific emissions have declined in towns and cities where gas has either completely replaced coal in power generating (this is the case in Vladimir and Tomsk) or has partially done so (Ivanovo, Novosibirsk, Smolensk, Izhevsk etc.). The same is true in cities with combined gas and fuel oil power stations, which were switched to gas in 1998–2000 (Penza, Kuznetsk (in the Penza Region), Dzerzhinsk, Nizhny Novgorod, Ufa). This reflects overcoming of the situation in the 1990s, when regions tended to switch to locally produced fuel, even when it was more expensive.

Widening of the pollution gap between different territories was also driven by rapid increase in pollution from the oil extraction sector, which accounts for a third of all ambient air pollution in Russia (Figure 7.2.3). Khanty-Mansi Autonomous District doubled its emissions in 1998–2003 to become the biggest atmospheric polluter in Russia (this title was held by Krasnoyarsk Territory for decades previously). Oil production in the Autonomous District rose by 37% over the five years and emissions from stationary sources rose by 2.1 times. Record oil prices led to development of new oil fields in Russia and maximal use of older and less-efficient wells, giving further impetus to gross and specific pollution levels in oil production centers

Figure 7.2.3
The average impact index (share of each industry in each type of pollution) in 1995-2004.



where the level of pollution was already too high. Pollution growth exceeded growth of production at the oldest fields (those in development for over 35 years accounted for over 80% of all emissions) and at newly commissioned sites due to flaring of secondary and natural oil gas. Specific emissions at both the oldest fields (Frolovo in Volgograd Region, Pokhvistnevo in Samara Region) and the newest (sites in Khanty-Mansi and near the town of Strezhevoy in Tomsk Region) exceeded 100 kg/1000 roubles. The lowest rate of pollution growth was at 20-30 year-old extraction sites around Surgut, Kogalym and Langepas. These areas have a relatively lower level of pollution due to specifics of gas content in the oil-bearing strata, oil field area and well numbers, and Soviet-vintage infrastructure for utilization of waste. High rates of specific pollution are also characteristic of gas production centers (both extraction areas and locations of compressor station).

The situation is different in the oil refining industry, where there have been a number of positive trends since the mid–1990s. The growing number of cars on Russia's roads and creation of vertically integrated oil companies helped refineries to operate at full capacity, and investments were made to modernize facilities and increase the share of more expensive products in overall output. As a result, emissions per 1000 roubles of industrial output declined by nearly 10 times (from 40-54 to 4.8-16 kg) in cities where oil refineries were the only source of pollution (Kirishi, Kstovo, Novokuibyshevsk, Syzran, Tuapse). Reduction of pollution, though to a smaller extent (from 3-9 to 2.3-6.9 kg/1000 roubles of production), was also recorded in cities where oil refineries were not the only, but the major source of pollution (Yaroslavl, Ufa, Perm, Saratov, Volgograd, Omsk, Khabarovsk). However, specific emissions per million tonnes of primary refining output have only halved, and this is true both for towns and cities which previously had low pollution levels, such as Tuapse (5.5 kg/m.t. of oil) and for towns and cities with average levels, such as Komsomolsk-on-Amur (10.2 kg/m.t.) or high levels, such as Ukhta (41 kg/m.t.). Rates of pollution reduction slowed down as early as 2002, because further progress would require much greater investment.

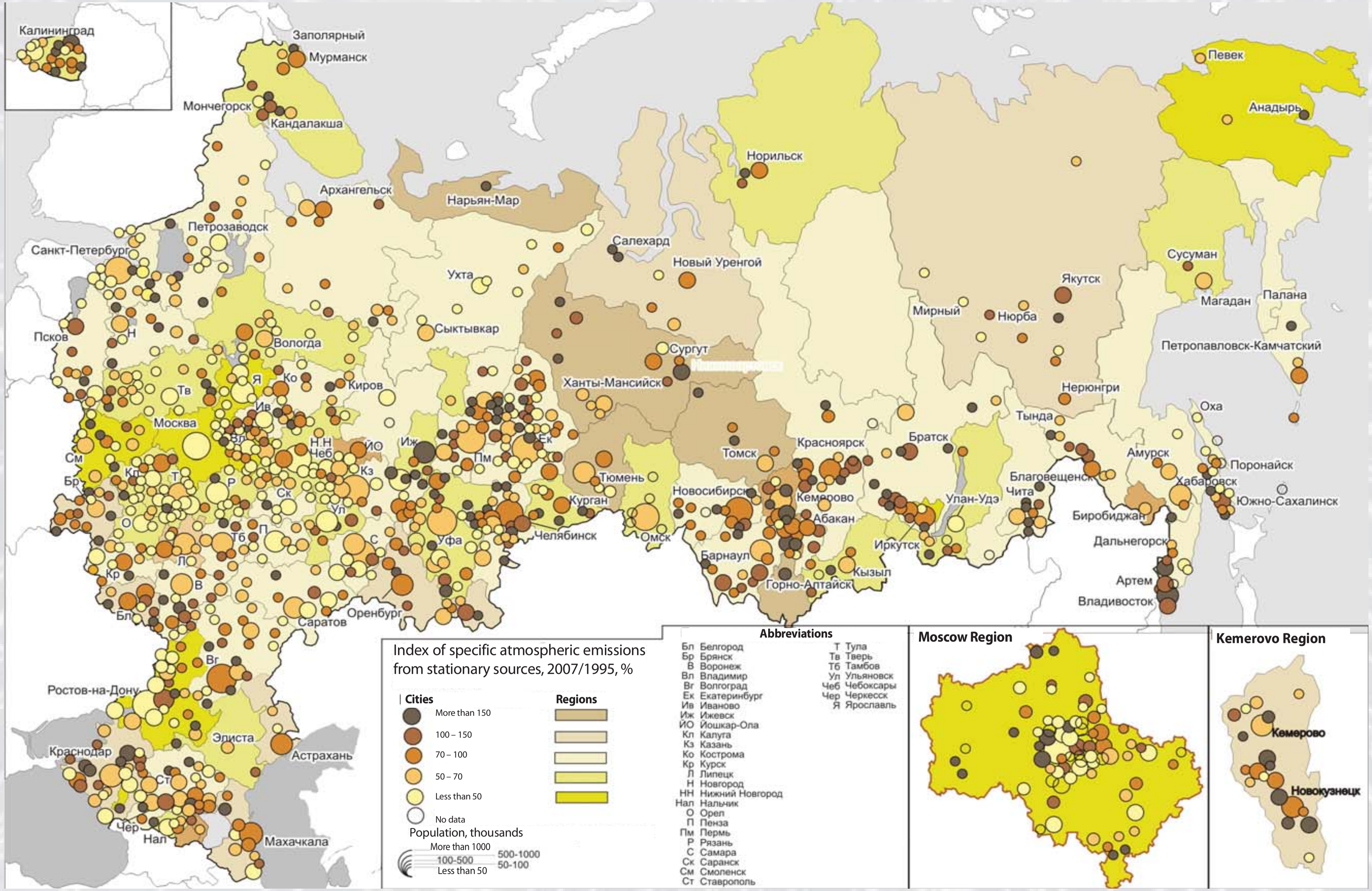
The first stage of Russia's economic growth did not lead to large-scale negative environmental impacts. However, the mechanism of compensational growth, based mostly on re-commissioning of idle facilities and commissioning of low-efficiency hydrocarbon fields, has led to an increase in specific and gross environmental pressure in towns where pollution levels were already high. Operation of obsolete assets led to increase in pollution levels, mostly in small cities and towns, which account for nine of out of ten urban settlements where specific pollution figures grew in 1998–2002.

Rates of growth in the oil & gas industry and of investments by large companies have slowed down since summer 2004, and positive effects from sector restructuring and investments have been mainly exhausted. Rate of growth of investments in environmental protection equipment declined from 2004 (in comparable prices) and there was a decline of environmental investments in 2007, with emission control being the hardest hit (84% reduction of investments compared with the previous year).

Even though specific emissions continue to decline nationwide, the share of towns and cities where they are growing has returned to levels of the 1990s (47% of towns and cities, with 35.4% of the population). Several large regional centers (over 50,000 inhabitants) with heavy industry or coal-fired power stations were among the 495 towns and cities where environmental parameters worsened in 2007 (the large centers in question were Izhevsk, Vladivostok, Chelyabinsk, Novosibirsk, Krasnoyarsk and Volgograd (Figure 7.2.4)). The pollution gap between large and small urban settlements started to narrow in 2007, but only due to this worsening of the situation in large cities.

Energy and fuel intensity in the economy may well increase in the context of the latest crisis. Electricity generation declined in the transition crisis of 1990–1998, but specific emissions grew in 89% of Russian towns and cities, reflecting environmental inefficiency of many Russian power stations. When in 2006 power consumption rose by 4.2% and production of thermal power plants by 5.2%

Figure 7.2.4
Trends in specific atmospheric emissions in cities and regions of the Russian Federation (kg/1000 roubles of production in comparable prices, 1995-2007)



compared with 2005, the absolute emissions growth was 11%. According to the recently dismantled electricity monopoly, RAO UES, about 80% of the extra emissions in 2006 were from five CPPs: Troitskaya, Reftinskaya, Novocherkasskaya, Kashirskaya and Kirishskaya. It will not be possible to reduce overall impact of anthropogenic pollution in towns and cities without large-scale replacement of obsolete assets. Generators took less advantage than other economic sectors of the potential for efficiency improvement offered by the 1990s transition crisis. The latest crisis gives the Russian power industry a second chance to eliminate its oldest and most polluting assets.

Chapter 8 The Energy Industry and Sustainable Development Indicators

8.1. In search of a new development dimension

The global economic crisis has shown once again that traditional development indicators need to be adjusted. Humanity has been held hostage to economic and financial indicators, which often ignore or distort real economic, social and environmental processes. The crisis happened because distorting financial and economic mirrors had been used in decision-making processes.

The most widely used economic measure in the world – GDP – is a prime example of an indicator, which is inappropriate in a sustainable development perspective. Most countries (Russia included) still measure their development achievements by the yardstick of GDP. But growth of GDP thanks to the resource (energy) sector can prove unsustainable for countries with social problems and large natural resource endowment, of which Russia is a typical example. Many leading Russian experts are agreed that most of GDP growth up to the present has been caused by a favorable external environment, and primarily by high oil prices[1]. So high GDP indicators have been mainly based on depletion of natural resources and transformation of the Russian economy into an energy and raw materials appendage of the global economy. The depth of the current crisis in Russia can be mainly explained by the fact that Russia has fallen into the 'energy and raw materials' trap. The GDP indicator fails to reflect major social problems, and it can grow even in a context of growth of income inequality, disease, mortality, etc.

Before the crisis, progress and growth in the world and in Russia were usually identified with GDP growth and maximization of profit, financial flows and other financial indicators, while the quality of growth and its costs (social and environmental) were mostly ignored.

However, the need to develop new indicators for social and economic progress has been long recognized by the world community. New conceptual and methodological approaches to measurement of social and economic progress appeared as early as the end of 1980s and beginning of 1990s, offering alternatives to the traditional indicators GDP, GNP and per capita income. The role of the UN in this process deserves to be stressed. The conceptual approaches and specific indicators, which were developed under the UN aegis, have made a huge contribution to the theory and practice of human development, offering new priorities for humanity. Two new theories – human development and sustainable development – have made the biggest contribution. Both were forged within UN structures and were supported by all members of the Organization, which has given them official international status. It is very important that these conceptual approaches have been reinforced by specific indicators, of which the best known are the Human Development Index (HDI), Millennium Development Goals, and System of Sustained Development Indicators. Creation of the Human Development Index (HDI) in the 1980s was specifically intended as a counterweight to GDP.

Other international organizations (the World Bank, Organization for Economic Cooperation and Development, European Community, World Wildlife Fund, etc.) have also participated in this work. The World Bank created the Index of Adjusted Net Savings, which reflects the social, energy and environmental aspects of development in a more adequate way. Most developed countries now have their own system of sustained development indicators.

If the Russian Government wants to achieve its long-term social and economic

[1] See, for example, A.G. Aganbegyan 'Necessary Conditions for the Future Growth of Russia' in the book -Transitional Economies in the Postindustrial World: Challenges of the Decade (materials of the international conference). M.: Institute for the Economy in Transition, Academy of National Economy under the Government of the Russian Federation, 2006, pages 148-150.

development targets, starting from the crisis period, it needs to prioritize human development, movement away from the energy and raw material economy, and structural transformation in order to create an innovative and socially-oriented development model. This has nothing to do with chasing quantitative ratings, whether they are value indicators (GDP, etc) or physical volumes (output of oil, gas, metals, etc). The accent in the new economy must be on qualitative and not quantitative development.

8.2. Types of energy indicators

The energy factor is widely reflected in sustainable development indicators, because sustainable development depends on due attention to economic, social and environmental aspects, all of which have much to do with energy[2]. Two approaches are most widely used in both theory and in practice. The first is to construct an integrated (aggregate) indicator (index), which enables judgment of the level of sustainability of social and economic development. The aggregation usually relies on three groups of indicators: economic, social and environmental. The second approach involves construction of a system of indicators, each of which reflects different aspects of sustained development. The aspects chosen are most usually economic, environmental, social and institutional. This is the approach used by UN sustainability indicators.

The energy factor has priority in all the approaches, as seen most clearly in ubiquitous use of the energy intensity index. It is important to grasp that division of the indicators into economic, environmental, and social is relative. Some indicators can reflect several aspects of sustainability, and this is apparent from the example of energy intensity, which is included in different groups of indicators by the UN, World Bank, Organization for Economic Cooperation and Development (OECD) and various countries: economic (reflecting efficiency of energy resource utilization in the economy); environmental (the level of pollution and greenhouse gas emissions); and social (since the volume and content of emissions has impact on human health).

Energy intensity is basic to global systems of sustainability indicators and to the systems used by specific countries. It is a key indicator for Russia, helping to gauge sustainability of its energy sector and of the country as a whole. As such, it should be included in programmes, strategies, concepts and projects at both federal and regional levels.

The following energy intensity indicators are most commonly used at the macroeconomic level:

- energy intensity of GDP as regards consumption of energy resources;
- energy intensity of GDP as regards production of energy resources (the proportion between primary energy production and GDP);
- energy efficiency (often identified as the reverse indicator of energy intensity);
- specific indicators of energy intensity of GDP (electric intensity, heat intensity, oil intensity, coal intensity, gas intensity of GDP) etc.

In Russia's case it is important to distinguish between two energy intensity indicators: intensity in terms of domestic consumption of energy as a share of GDP, and intensity in terms of the share of energy production in GDP. The consumption indicator is the classic and most widely used indicator. But it clearly fails to take account of many economic, environmental and social consequences of the extraction and production of energy for export, since (all else

[2] The indicators of sustainable development are studied in details in the monograph by S.N.Bobylev, N.V. Zubarevich, S.V.Solovyova, Y.S. Vlasov. 'The Indicators of Sustainable Development: Economy, Society, Nature'/ under the editorship of S.N. Bobylev. M.: MAX Press, 2008.

being equal) it only reflects that part of negative impacts on the environment and public health, which are conditioned by the process of energy consumption, so that it can only be a partial indicator of dependence of the Russian economy on energy exports and pressure of the energy sector on the environment and society (Chapter 1). The main reason why energy intensity by consumption is the dominant indicator worldwide is that most countries do not have sufficient energy resources of their own, so that energy intensity in terms of production is of little concern to them.

Energy production as a share of total production is a much more important measure for Russia because volumes of natural resources brought into economic use, both to meet domestic needs and for export, give an indirect indication of levels of pressure on the environment and public health.

The degree to which the two indicators differ can be clearly seen in Table 8.1. Levels of Russian energy intensity in terms of consumption are three times higher than in developed countries, but differences in energy intensity in terms of production are much more drastic: the difference between Russia and the European Community is 11 times, and the divergence with Japan is more than 30 times (see also Table 1.3 in Chapter 1). The two indicators could move in different directions: energy intensity in terms of consumption may decline, reflecting positive structural shifts in the economy, but in case of dramatic growth of energy resource extraction energy intensity in terms of production is likely to grow, reinforcing Russia's orientation to energy and resource exports. The long-run target should be to dramatically reduce energy intensity in terms of production by increasing energy efficiency and GDP while holding back rates of growth of primary energy extraction, i.e. by greater use of intensive growth factors. This course will not affect the country's export potential because, as mentioned in earlier chapters of this Report, relatively simply energy-saving measures could reduce domestic energy consumption by half, i.e. Russia has enormous 'hidden export' potential.

Table 8.1
GDP energy intensity in terms of energy consumption and production in different countries (1990, 2000 and 2008*)

Country	1990		2000		2008		2008/1990 (%)		2008/2000 (%)	
	1	2	1	2	1	2	1	2	1	2
Great Britain	0.156	0.174	0.130	0.178	0.102	0.096	65	55	79	54
Germany	0.171	0.108	0.131	0.064	0.113	0.059	66	55	86	92
France	0.154	0.089	0.147	0.086	0.132	0.078	86	88	90	91
USA	0.246	0.234	0.209	0.172	0.175	0.145	71	62	84	84
Canada	0.331	0.418	0.301	0.427	0.275	0.395	83	95	91	93
Japan	0.134	0.026	0.141	0.033	0.126	0.025	94	96	89	76
Norway	0.287	1.057	0.234	1.397	0.194	1.121	68	106	83	80
Russia	**0.460**	**0.840**	**0.496**	**0.943**	**0.324**	**0.767**	**70**	**91**	**65**	**81**
China	0.549	0.451	0.288	0.206	0.274	0.179	50	40	95	87
India	0.176	0.206	0.169	0.152	0.138	0.112	78	54	82	74
Brazil	0.115	0.107	0.133	0.119	0.125	0.138	109	129	94	116
Ukraine	0.643	0.297	0.741	0.385	0.423	0.246	66	83	57	64

Sources: World Bank (World Development Indicators Online Database), BP Statistical Review of World Energy June 2009; International Energy Agency (IEA World Energy Statistics and Balances - Energy Balances of Non-OECD Countries - Economic Indicators Vol. 2009 release 01)

* 2007 for the energy intensity in terms of production

1 – energy consumption intensity (m.t. of oil equivalent / thousand USD in 2005 by PPP)

2 – energy production intensity (m.t. of oil equivalent / thousand USD in 2000 by PPP)

Energy intensity in terms of production helps to raise energy awareness among decision makers and society, and should be recommended as a priority indicator in long-term national programmes and development strategies.

Both indicators of energy intensity in Russia have shown strong positive trends in the last decade, particularly in the early 2000s, when consumption intensity declined by 35% and production intensity by 19% (Table 8.1). These are among the best results in the world. But must faster decline of consumption intensity compared with production energy reflects major growth of Russia's energy export dependence (Figure 8.1). The relationship between the two indexes was the reverse in EU countries. It should also be realized that Russia has already used its potential for structural improvement of energy intensity, but the gap between Russian energy intensity and that of developed countries remains huge in absolute terms.

Energy intensity of separate parts of the economy is also important: specific sectors, industry, transport, housing utilities, and efficiency of fuel use in electricity generation all deserve to be distinguished. The last indicator is defined as fuel expenditure in electricity production at various types of power station, and is particularly important, since it reflects developments in the biggest fuel consuming industry.

Reduction of all types of energy intensity will be a vital link in the chain, which will pull the Russian economy towards sustainable growth.

8.3. Measuring the energy factor in systems of indicators

Multi-functionality of energy intensity as an indicator of sustainable development is evident in the Millennium Development Goals

Figure 8.1
Trends in energy intensity by consumption and production (primary energy production to GDP ratio), for Russia and EU-27 (1990 = 100%)

Source: World Bank (World Development Indicators Online Database), British Petroleum (BP Statistical Review of World Energy June 2009), International Energy Agency (IEA World Energy Statistics and Balances - Energy Balances of Non-OECD Countries - Economic Indicators Vol 2009 release 01)

(MDGs), issued by the UN in 2000. The MDGs are well-designed and relatively simple to use, setting out goals, tasks for achieving them, and relevant indicators. The mission of Goal 7 in this system is to ensure environmental sustainability both globally and in specific countries[3] (Table 8.2). Adapted for Russia, Goal 7 proposes three tasks and eight indicators, focusing on the need to solve two major problems for environmental sustainability:

- to reduce human impact on the environment and depletion of natural resources;
- to improve the environmental conditions for human development, reducing environmental threats to human safety, health and quality of life;

The importance of solving the second problem, connected with human development and improvement of the ecological conditions for human life and health, should be emphasized. This problem is often omitted when issues of sustainable development focus on environmental protection and utilization of natural resources.

In the MDG system energy intensity is referred to Goal 7, dealing with environmental sustainability and, specifically, to Task 1, which is to include principles of sustainable development in national strategies and programmes, and prevent wastage of natural resources (Table 8.2). In this context, energy intensity acts as an environmental-economic indicator.

Other key indicators of sustainable development are also closely connected with trends in energy intensity. Emissions of carbon dioxide, volumes of which depend mainly on the energy industry (Indicator No.4 in Table 8.2) are at the center of attention in issues of global climate change and ratification by Russia of the Kyoto Protocol. At present more than 72% of GHG emissions in Russia are due to burning of fossil fuels[4].

The index of numbers of people living in severely polluted cities has great importance for Russia and also depends on the energy industry (Indicator No.5 in Table 8.2). The energy sector and its products make a decisive contribution to air pollution, accounting for about half of all pollution from stationary sources plus emissions from combustion of car fuel. Addressing this problem has high priority for Russia, particularly in big cities with high pollution levels (there are 135 such cities with total population of about 60 million)[5]. The

Table 8.2
Goal 7 of the MDG, 'Securing Environmental Sustainability', tasks and indexes

Tasks of MDG 7 for Russia	Progress Indicators for Russia	Values
Task 1. Include principles of sustainable development in national strategies and programmes and prevent wastage of natural resources	1. Percentage of territory covered by forest 2. Percentage of territory, which is protected in order to maintain biodiversity of the land surface environment **3. Energy intensity** 4. Emissions of carbon dioxide (m.t.) 5. Number of people living in severely polluted cities (million)	45.4 2.4 0.324 2478 58
Task 2. Provide the population with pure drinking water	6. The share of residential areas provided with mains water (urban and rural)	Urban – 100% Rural – 30%
Task 3. Improve housing conditions	7. Share of residential areas with sewerage (urban, rural) 8. The share of slums and housing in dangerous disrepair	Urban – 98% Rural – 5% 3.2%

[3] This goal and its indicators are studied in detail by the author in the Chapter, 'Securing Environmental Sustainability' in the UN Human Development Report for Russia from 2005 (under general editorship of S.N.Bobylev and A.L. Alexandrova. M.: UNDP, 2005).
[4] The bulletin, 'Environmental Protection in Russia'. M.: Rosstat, 2008
[5] State Report, 'On Condition and Protection of the Environment in the Russian Federation in 2007'. M.: RF Ministry of Natural Resources, 2007

Concept for Long-term Socio-economic Development of the Russian Federation up to 2020 sets the following targets for this aspect of human development:

- fivefold reduction of the number of cities with high and very high levels of pollution;
- fourfold reduction of the number of people living in unfavorable environmental conditions.

The area of territories in Russia, which are protected in order to maintain biodiversity (Indicator No.2), also depends to a significant extent on the energy industry and its infrastructure. At present the majority of protected areas are in northern and eastern regions of the country where there are also huge deposits of energy resources, development of which will involve large-scale infrastructure creation: oil & gas pipelines, electricity transmission lines, railways and roads, etc. Development of the energy industry in these regions may therefore have negative impact on protected territories, biodiversity, forests and wetlands. Extensive development of the energy industry in north-eastern regions could undermine the role of Russia as a global environmental donor, diminishing the potential role of its ecosystems for humanity. A good example of a positive approach to solving such problems is the government's decision to move the route of a planned trunk pipeline away from Lake Baikal, which has unique environmental importance. Initial plans would have run the pipeline along the Lake shore.

The energy factor plays an important for achievement of MDG 7 tasks to provide pure drinking water and improve housing conditions (Indicators No. 6, 7, 8), which are highly important for human potential development. Provision of pure water, decent housing and sewerage will require considerable energy consumption in the housing utility sector.

The energy factor is well reflected in the system of indicators developed by the World Bank, which are published annually in the Bank's 'Indicators of Global Development'[6] And include six main energy indexes (Table 8.3.) The macro ratio to GDP used by the World Bank is not energy intensity, but the index of energy efficiency, which shows the opposite relationship. The system also has three structural indicators, connected with biomass, fuel combustion, and hydro-electricity. Russia produces almost 30% less GDP per unit of consumed energy than East European or Central Asian countries and 2.3 times less compared with countries that have higher income levels. The share of energy produced from biomass and waste is 2-3 times less in Russia than in the latter countries. Per capita electric power consumption is much higher in Russia than in East European and Central Asian countries (by more than a third), but much lower than the same index for rich countries (by 1.7 times). The share of electricity produced from fossil fuels is approximately the same: about two thirds of total production.

Constructive approaches to development of energy indicators have been proposed by the UN Economic Commission for Europe (ECE UN), including a special study for the transition economies of Eastern Europe, the Caucasus and Central Asia[7]. The approach is based on differentiation of indicators, using a system of 'driving force – pressure – state – impact – reaction'. ECE UN suggested four basic energy indicators: 1) final energy consumption (overall and by final consumers); 2) total energy consumption (overall and by major fuel types); 3) energy intensity; and 4) energy consumption using renewable sources. The first and second indicators relate to driving forces, and the third and the fourth to reactions.

Rates of GHG emissions are associated with energy indicators. For example, the World Bank considers CO_2 emissions per GDP unit and per capita, and growth of these indicators since 1990.

[6] World Development Indicators 2008. World Bank, Washington DC, 2008

[7] Environmental rates and estimative reports based on them. Eastern Europe, Caucasus and Central Asia. UNECE, New York, Geneva, 2007.

8.4. The energy factor in integral indicators

The energy factor is reflected in many integral indicators: its components are taken into account both directly and indirectly when statistical data are aggregated into single indexes. In particular, energy resources are reflected well in the Adjusted Net Savings Index, and the energy factor is indirectly reflected in the Human Development Index via prosperity (income) levels (see Chapters 2 and 3 and Box 2.1 on the Human Development Index) and life expectancy (influence of the energy sector on health, see Chapter 4).

The Index of Adjusted Net Savings (sometimes referred to as genuine (domestic) savings), which was developed and is widely used by the World Bank[8], is probably the best-suited to reflect energy aspects, and also has the advantages of a good statistical database and potential to be calculated at country and regional levels. Estimates of adjusted net savings take more account of human potential, and energy and environmental factors than traditional macroeconomic indexes. The importance of measuring these savings when implementing a sustainable development policy is clear: consistently negative indicators reflect formation of an unsustainable development path, which will lead to decline of prosperity.

The standard system of national accounts assumes that only investments in fixed capital represent investments in future prosperity of society. The expanded interpretation used by adjusted net savings includes natural and human capital alongside fixed capital as determinants of national wealth. From this point of view depletion of non-renewable natural resources (primarily, energy resources) and excessive utilization of renewable natural resources diminish national wealth. Investments in public education add to human capital. Current education expenditures are equivalent to investments, reflecting a definition of human capital/potential based on a broad concept of domestic investments. Investments in human resources are not treated as unproductive consumption, but as investments that will ensure future growth of national wealth. A country, which reinvests income from extraction of non-renewable natural resources in development of human

Table 8.3
Energy indicators

Indicators	Russia	East Europe and Central Asia	Countries with high income level
GDP per unit of energy use (2005 PPP $/kg oil equivalent)	2.6	3.3	6.0
Energy use per capita (kg oil equivalent)	4517	2826	5498
Energy from biomass products and waste (% of total)	1.1	2.2	3.2
Electric power consumption per capita (kWh)	5785	3633	9760
Electricity generated using fossil fuel (% of total)	65.8	66.1	62.5
Electricity generated by hydropower (% of total)	18.2	17.5	11.5

Source: World Development Indicators 2008. World Bank, Washington DC, 2008

[8] Where is the Wealth of Nations? Measuring Capital for the 21st Century. World Bank, Washington DC, 2006; World Development Indicators 2008. World Bank, Washington DC, 2008

Table 8.4
Breakdown of the Adjusted Net Savings Index

National accounting aggregates	Amount (in % of GNP)	
	Countries with high income	Russia
Gross saving (% of GNI)	19.9	30.7
Consumption of fixed capital (% of GNI)	13.0	7.0
Education expenditure (% of GNI)	4.7	3.5
Energy depletion (% of GNI)	1.5	37.5
Mineral depletion (% of GNI)	0.2	1.9
Net forest depletion (% of GNI)	0.0	0
CO_2 damage (% of GNI)	0.3	1.4
Particular emission damage (% of GNI)	0.3	0.3
Adjusted net savings (% of GNI)	9.3	-13.8

Source: World Development Indicators 2008. World Bank, Washington DC, 2008

Table 8.5
Adjusted Net Savings Indexes in specific countries

Country	Adjusted net savings	Country	Adjusted net savings
Japan	15.8	EU	12.0
Germany	12.1	Russia	- 13.8
France	11.4	Czech Republic	14.7
Great Britain	6.9	Poland	7.8
Canada	5.4	Ukraine	4.1
USA	4.1	China	36.1
Norway	9.2	India	20.6

Source: World Development Indicators 2008. World Bank, Washington DC, 2008

capital by raising educational levels accumulates savings and ensures sustainable development.

The Adjusted Net Savings Index takes particular account of the energy factor by adjusting the traditional gross savings index to reflect depletion of energy resources (Table 8.4), and by applying indicators of CO_2 and particular emissions to record impact of the energy industry on human health and environmental pollution.

The main merit of the Adjusted Net Savings Index is that it offers a single method of calculation for the whole world and for specific countries, using official national statistics, updated annually and published in 'World Development Indicators' (the main statistical digest of the World Bank) or in other World Bank statistical materials. This Index is already used by several countries as an official macroeconomic indicator.

Calculations published by the World Bank and based on adjusted net savings (genuine savings) for all the countries show a dramatic difference between traditional economic indicators and those adjusted for environmental factors. In Russia economic growth (in the traditional understanding) has been accompanied by depletion of natural capital and environmental degradation, and adjustment to reflect these factors turns the traditional economic indicators negative. Russia's Index of Adjusted Net Savings has been negative in recent years, despite growth of GDP. It is important to take this fact into account during the crisis and in the search for ways of overcoming it. For example, 2006 was a highly successful year for the Russian economy judged in traditional economic terms: GDP growth amounted to 7.4%. But the Adjusted Net Savings Index was negative (-13.8%), mainly due to depletion of natural resources (Table 8.4)

Comparison of adjusted net savings in Russia and some other countries of the world is also telling. The Index level in developed countries is 9.3% (Table 8.4). Adjusted net savings for various countries (developed, developing and with transition economies) are presented in Table 8.5, and are positive in all cases except for Russia. Negative value of adjusted net savings in Russia cannot be explained only by dramatic depletion of natural capital (primarily energy resources), since international experience shows that countries with large and depleting natural capital can compensate the depletion by increase of savings, education spending, etc. Norway, Canada, the USA and Great Britain have positive Adjusted Net Savings Indexes (Table 8.5), and the figure for Norway is as high as 9.2%.

The Adjusted Net Savings Index has several defects, but its importance is in giving an aggregate estimate of sustainable development and showing the need to compensate depletion of natural capital through increase of investments in human and physical capital.

The Index shows the need for dramatic increase of energy efficiency in Russia, which would raise the country's Index score by raising productivity and putting limits on extensive, low-margin extraction of energy resources. It is also advisable for a country to have a special fund or funds ('fund of future generations') such as exist in Norway, the USA some oil-producing countries, which accumulate fixed contributions from extraction of finite fuel and energy resources to secure future economic growth. Russia set up such a fund – the Stabilization Fund – in 2007. It was subsequently decided, as part of the transition to a three-year budget cycle, to divide the Stabilization Fund into the Reserve Fund and the National Wealth Fund. The Reserve Fund is meant to play a stabilizing role for the Russian budget when oil prices decline, and the National Wealth Fund was earmarked as a fund of future generations. Unfortunately, most of the money accumulated has been quickly spent on stabilization of the social and economic situation in the country since onset of the crisis.

Calculations based on the adjusted net savings approach have been carried out in a few Russian regions, including coal mining Kemerovo Region[9]. Both the energy factor and the human factor had major impact when calculating the Index for this Region, which suffers from environmentally determined public health problems. Illness due to water and air pollution cause loss of up to 12% of GRP (Table 8.6). Depletion of resources by coal mining also reduces adjusted net savings in Kemerovo to a large extent. As a result, the Adjusted Net Savings Index for Kemerovo Region was around -10% in 2001–2005, despite significant growth of GRP (Box 8.1).

Popular integral indicators that take account of the energy factor include: Environmentally Adjusted Net Domestic Product, developed by the UN for national accounts; the 'Ecological Footprint' used by the WWF; and the Environmental Sustainability Index, constructed by specialists from Yale and Columbia Universities. The Ecological Footprint (EF) index, measuring pressure on the natural environment, which appears in regular reports of the World Wildlife Fund, is particularly functional. The EF index measures energy consumption in terms of the area necessary for absorption of respective CO_2 emissions and consumption of food and materials by people in terms of biologically productive land and sea areas, which are needed for production of these resources and absorption of the waste produced. The EF of one person

Box 8.1. Adjusted Net Savings Index for Kemerovo Region

There is huge divergence between traditional economic indicators for Kemerovo Region and calculations based on adjusted net savings, which take account of social and environmental aspects (Table 8.6). Depletion of the Regions' natural resources and environmental pollution are large enough problems to turn strongly positive traditional indexes negative when adjusted savings are calculated. Despite strong growth of GRP in 2001-2005, corrected net savings in Kemerovo Region were about -10%, signifying powerful 'anti-sustainable development' trends. The regional economy is currently living at the expense of future generations, through depletion of energy resources, depopulation and short life expectancy, and accumulated environmental damage in the form of polluted or disturbed land as well as degradation of ecosystems.

[9] Mekush G.E. Environmental Policy and Sustainable Development. M.: Max Press, 2007

Table 8.6
Breakdown of the Adjusted Net Savings Index for Kemerovo Region

Indicators / Years	2001	2002	2003	2004	2005
GRP, RUB billion	116.3	144.6	177.7	251.8	264.4
Gross saving, % GRP	20.9	18.2	20.8	25.9	26.3
Net regional savings, % GRP	13.5	12.6	14.3	19.4	19.8
Depletion of energy sources, % GRP	10.8	11.0	11.2	15.3	15.5
Damage from CO_2 emission, % GRP	1.2	1.2	1.3	1.5	1.8
GRP losses due to impact of pollution on public health, %	11.0	10.8	11.0	11.9	11.6
Adjusted net savings, % GRP	-9.5	-10.4	-9.2	-9.0	-10.0

from a developed country is 4 times higher than that of a person from a country with low per capita income[10]. The EF for an average US citizen is 9.6 hectares of biologically productive area, while for an Indian citizen it is only 0.8 hectares. The environmental deficit is particularly high in the USA (-4.8 hectares per capita), Great Britain (-4.0), Japan (-3.6) and Italy (-3.1). There is also an environmental deficit in such densely populated countries as China (-0.9) and India (-0.4). By contrast, some other countries have an environmental reserve: Russia (2.5), Brazil (7.8) and Canada (6.9).

8.5. Information and institutional support for the indicators

International experience shows that limitations and barriers to development of energy indicators and measures of sustainability are mainly due to a lack of necessary economic, social and environmental information. This lack is partly objective, but it is also partly due to commercial confidentiality (which is widespread in most energy companies).

A paradoxical situation has arisen where many key indicators of sustainable development are used in national development documents, but are not published in official data books, putting obstacles in the way of their use for decision making at all levels and transmission of information to the general public. For example, the index of energy intensity is present in the Concept for Long-term Development of the Russian Federation up to 2020, in the Russian Presidential Decree on energy and environmental efficiency improvement (2008), in energy strategies and programmes. But index trends over years are not included in Rosstat documents, making proper analysis impossible. There is a similar paradox with respect to regional GHG emissions. Another important indicator, of the number of people living in highly polluted areas, is not published outside the Ministry of Natural Resources.

The following indicators need to be included in state statistics and made available to the general public as a matter of urgency, so that they can be used in decision making processes at all levels:

- various forms of energy intensity (electric intensity, segment energy intensity, etc.);
- indexes of disturbance and reclamation of land by the energy sector;
- GHG emissions (per region);
- number of people living in polluted areas;
- reclamation, etc.

There have been instances recently of institutional support for greater use of energy indicators and measures of energy efficiency, at both federal and regional levels. A system of energy efficiency indicators has been developed as part of a programme led by the Ministry of Education and Science, 'Complex solutions for energy efficiency problems and efficient use of

[10] Living Planet Report 2006. WWF.

Box 8.2. Energy efficiency indicators used by the Federal Education Agency

The Federal Education Agency (a branch of the Ministry of Education and Science) is carrying out a programme to monitor energy use by educational establishments. A system of energy efficiency indicators has been devised by analysis of statistics on energy use at 120 educational institutions subordinated to the Federal Agency, covering 1200 buildings over a period of five years by types of energy and building types.

The indicators use relative rates of fuel & energy consumption, as follows:

- in natural volumes (by building type):
  - electric energy, KWh per sq.m. and per student p.a.;
  - thermal energy for heating and hot water supply (purchased and in-house production) per sq.m. and per student p.a.;
  - boiler and furnace fuels (by type) for internal energy sources (gas and coal boiler-houses), tonnes (cubic meters) per 1 Gcal;
  - cold water, cubic meters per student, p.a.;
  - natural gas for dormitories, cubic meters per person p.a.
- in standard units: all energy types are interconnected by conversion to tonnes of fuel equivalent, which provides a universal indicator for all of the institutions and their buildings.
- in value terms: roubles per sq.m. per student.

The system of energy efficiency indicators is confirmed by calculations made for specific educational institutions, split by type and group of institutions in the form of tables per type of fuel and energy resources and per group of standard buildings.

The energy efficiency indicators were used to develop a system of annualized statistical accounting. Recommendations have been prepared for using the energy accounting system and indicators throughout the system of education establishments controlled by the Ministry of Education and Science.

resources for innovative development of economic sectors' (Box 8.2).

The most advanced and inclusive regional system of sustainable development indicators has been developed in Tomsk Region, where the indicators are used in various fields, primarily for strategic planning, with institutional support from the Tomsk Regional Administration. Sustainability indicators are used for design of economic programmes and regional development strategy (Box 8.3).

The Independent Environmental Rating Agency has developed an energy efficiency rating of Russian regions based on calculation of energy efficiency of GRPs (Box 8.4).

8.6. Conclusions and recommendations

The global economic crisis has shown the need for changes to traditional development indicators. Macro-economic indicators often ignore or distort real economic, social and environmental processes. The two most common approaches in theory and in practice of sustainability measurement are creation of an integral (aggregate) indicator (index) and development of a system of indicators, each reflecting a separate aspect of sustainability.

The energy factor is widely represented among sustainable development indexes, that are used by international organizations and by national governments, and which include: indexes attached to Goal 7 of the UN Millennium Development Goals, World Bank energy indicators, adjusted net savings, and the ecological footprint. Energy intensity has a key place in all these, offering measures, which are economic (efficiency of energy resource use in the economy), environmental (the relation of energy to levels of pollution and GHG emission); and social (the scale and content of energy sector emissions have impact on public health).

Energy intensity is a key indicator for Russia, characterizing development sustainability

Box 8.3. System of sustained development indicators for Tomsk Region

The system of sustainable development indicators for Tomsk Region was developed in 2003 as part of the international project, 'Development of indicators for estimation of sustainability of economic and social reforms in the Russian Federation'. The system has been constantly refined since its creation, main indicators have been monitored, and a bulletin, 'Sustained development indicators in Tomsk Region' is published regularly[11], serving to inform government and the general public.

Such institutional support for development and application of indicators is unique for Russia. The chief editor of the bulletin is the Governor of Tomsk Region, V.M. Cress, and other editors are the First Deputy Governor, O.V. Kozlovskaya, and the Head of the Department of Natural Resources and Environmental Protection in Tomsk Region, A.M. Adam. The high status accorded to the indicators helps them to serve as a real instrument for monitoring and assessment of social-economic development in the Region and the environmental situation.

The indicators are used primarily for strategic planning, helping to design strategic targets for social and economic development. Three quarters of the sustainability indicators are used in the Tomsk Regional Development Strategy up to 2020 and the Program of Social and Economic Development of Tomsk Region in 2006-2010 (developed by Tomsk Regional Administration in 2005).

Tomsk Region uses a complex system, combining three types of sustained growth indicators: economic, social, and environmental. Indicators have been ranked according to their priority and regional specifics as 'key' or 'basic', 'additional' and 'specific'.

The system consists of 38 indicators in total, of which 12 key, 21 additional and 5 specific. The most important key indicator is energy intensity. Integrated (aggregate) indicators are also used: HDI, adjusted net savings, and natural capital. Relative indicators are widely used, mainly to measure environmental intensity.

of the country in general and of its energy segment in particular. Energy intensity has a claim to be the principal national development index for Russia and should play a role in programmes, strategies, concepts, and projects at federal and regional levels.

The Adjusted Net Savings Index is particularly constructive, with a good statistical database and calculability at both national and regional levels. Compared with traditional macro-economic indicators, adjusted net savings achieve wider recognition of the factors of human potential, energy and the environment. Such adjustment radically changes assessments of development sustainability for Russia. By taking account of energy resource depletion, the Index shows negative results, despite GDP growth in the first decade of the 21st century, demonstrating the urgency of compensating depletion of natural capital through growth of investments in human and physical capital, radical growth of energy efficiency, and accumulation of natural resource revenues in 'funds of future generations'.

The country and its regions now have experience of using different indicators and there is much potential for their adaptation to take more account of energy factors. Main energy indicators need to be included in official statistical publications at federal and regional levels, so that they can be more widely used in decision-making processes. This refers particularly to energy intensity and its specific varieties, GHG emissions by regions, and numbers of people living in polluted areas.

[10] Indicators of Sustainable Development in Tomsk Region. Edition 3/under the editorship of V.M.Cress. Tomsk: 'Pechatnaya Manufactura' Publishing House, 2007.

Box 8.4. Energy efficiency rating of Russian regions

The energy efficiency rating for Russia's regions was based on indicators showing energy efficiency of GRP (gross regional product) as calculated by the Independent Environmental Rating Agency (ANO NERA), which was set up by the International Socio-Environmental Association (MSOES). In 2009 ANO NERA and MSOES sent requests to all regional governors to provide information for the environmental and energy efficiency rating. Information for calculating the rating was provided by the heads of 77 of the country's constituent regions.

A preliminary estimate for GRP in 2008 was used. The estimate was based on trends in industrial and agricultural production, construction and other industries in 2007-2008. Before GRP values for various regions can be used to correctly compare efficiency of their economies, differences between sources of GRP in the different regions need to be taken into account. In regions where natural resources are extracted a large share of GRP comes from rent, primarily from natural gas and oil outputs, which has nothing to do with production efficiency (the reason why the rent is taken away as taxes).

Since several regions did not fill in their questionnaires and questionnaires returned by some other regions were not filled in properly, a control array of data on energy consumption had to be created. The problem was exacerbated by the fact that Russian official statistics do not calculate a unified energy balance by regions on a regular basis, so that, for the purpose of the ratings, ANO NERA had to produce its own estimates for consumption of all types of fuel (not including oil used by oil refineries in the refining process). Regressive analysis methods were used to establish dependence of fuel consumption on electricity consumption in regions with different types of energy systems. If a region was a net importer of electricity, the amount of imports was converted into tonnes of conditional fuel and added to the amount of internal fuel consumption. If a region was a net exporter of electricity and the electricity it exported was produced by thermal power plants, then the estimated amount of fuel consumed by the region was reduced by the amount of electricity exported to other regions, since this energy is used outside the region.

The energy consumption data provided by heads of regional administrations were compared with the data in the control array and average deviation of the regional data from the data in the federal array was determined. This average deviation was used as a criterion for discarding unreliable data. If the difference between the control array and the data provided by a region was greater than the average, then only the data of the control array were used. If the difference was significantly less than the average deviation, then the data provided by the regional administration were used. In instances between these two extremes, the mean of the control array and regional data was used.

Method for calculating GRP energy efficiency indicators

1. Energy consumption in 2008 per million roubles of GRP.

Estimated total energy consumption in each region, converted to tonnes of conditional fuel, is divided by estimated GRP less net taxes.

To make it easier to compare indicators for various regions, the estimate for each region is divided by average energy intensity of GRP for all Russia's regions. The result, expressed in percent, shows how much more or less energy is consumed in each region per million roubles of output compared with average energy intensity of GRP for all regions.

2. Trend in consumption of primary energy per unit of GRP in the period after 2000 (2008/2000).

3. Trend in consumption of primary energy per unit of GRP in one year (2008/2007).

It should be noted that calculation of relative energy consumption per unit of GRP did not use the monetary value of GRP but relied instead on changes in output of key industries, which are measured by Rosstat in natural units. For this purpose GRP of each region had to be divided by change in natural output (2008/2000 and 2008/2007). The result shows change in consumption of energy per unit of GRP in 2008 prices.

Table 8.4.1
GRP energy efficiency ratings of Russia's regions

Rating	Constituency	Energy intensity of GRP (% of Russian average), 2008	Change in energy intensity of GRP in 8 years (2008-2000 +/- %)	Change in energy intensity of GRP in one year (2008-2007 +/- %)
1	Rostov Region	72.2	-49.6	-15.4
2	Tver Region	78.9	-47.8	-21.8
3	Kaluga Region	87.9	-51.2	-28.4
4	Tambov Region	80.4	-48.4	-14.8
5	Amur Region	100.4	-60.6	-17.7
6	St.Petersburg	33.1	-42.5	-11.9
7	Chuvashia	67.3	-49.9	-8.9
8	Chukotka	48.7	-56.4	-5.0
9	Orel Region	85.5	-43.4	-9.8
10	AdygeiAutonomous Region	89.1	-43.9	-9.9
11	Bryansk Region	100.7	-38.6	-15.7
12	Arkhangelsk Region	100.6	-49.2	-9.5
13	Mariy-El	77.2	-37.0	-10.3
14	Pskov Region	89.9	-38.3	-9.6
15	Kalmykia	69.7	-24.9	-14.6
16	Leningrad Region	129.7	-44.2	-12.1
17	Sakhalin Region	38.6	-54.0	+12.3
18	Bashkortostan	117.8	-46.7	-8.2
19	Mordovia	150.0	-48.2	-14.6
20	Omsk Region	105.2	-49.0	-3.0
21	Tula Region	144.0	-45.5	-14.1
22	Kabardino-Balkaria	112.7	-41.8	-6.8
23	Stavropol Territory	147.4	-42.2	-14.8
24	Kaliningrad Region	60.7	-30.7	-5.6
25	Moscow Region	80.4	-28.1	-9.5
26	Magadan Region	130.8	-46.8	-6.0
27	Belgorod Region	125.2	-34.8	-15.4
28	Krasnodar Territory	84.8	-27.0	-8.6
29	Saratov Region	129.3	-36.1	-11.8
30	Yakutia-Sakha	84.6	-34.7	-2.7
31	Tatarstan	76.4	-32.6	-1.3
32	Orenburg Region	121.7	-37.5	-5.7
33	North Ossetia-Alania	187.4	-42.3	-10.6
34	Volgograd Region	124.0	-34.1	-9.9
35	Kurgan Region	131.6	-39.2	-5.9
36	Tyumen Region	87.9	-36.7	-0.3
37	Samara Region	99.8	-25.8	-7.1
38	Moscow	12.2	-26.6	+2.8
39	Jewish Autonomous Region	66.4	-37.2	+17.3
40	Novosibirsk Region	98.6	-38.2	+2.9

41	Penza Region	116.0	-35.2	-4.5
42	Altai	117.6	-41.4	-0.2
43	Voronezh Region	202.3	-37.1	-13.6
44	Kursk Region	86.2	-17.9	-5.5
45	Lipetsk Region	149.8	-36.8	-6.5
46	Kamchatka Region	81.9	-12.4	-5.4
47	Ulyanovsk Region	132.9	-32.7	-5.7
48	Khanty-Mansi Autonomous District	65.5	+10.3	-0.5
49	Khabarovsk Territory	75.2	-31.4	+13.0
50	Nizhniy Novgorod Region	120.7	-33.9	-1.5
51	Karelia	68.7	-9.0	+1.5
52	Ivanovo Region	158.4	-37.8	-1.9
53	Yaroslavl Region	117.5	-32.3	-0.3
54	Karachaevo-Cherkessia	139.4	-41.1	+3.9
55	Dagestan	101.6	-34.9	+12.8
56	Vladimir Region	133.7	-25.4	-4.6
57	Ryazan Region	133.8	-30.6	-2.7
58	Republic of Udmurtia	105.9	-10.5	-1.6
59	Primorie Territory	114.4	-14.7	-0.6
60	Kirov Region	130.4	-15.9	-4.1
61	Vologda Region	170.0	-22.4	-5.9
62	Komi Republic	105.2	-12.7	+1.2
63	Irkutsk Region	221.1	-36.2	-0.5
64	Nenets Autonomous District	31.1	+56.0	+22.7
65	Perm Territory	121.9	+0.5	-3.2
66	Chelyabinsk Region	157.2	-32.3	+0.8
67	Tomsk Region	91.3	+9.0	+6.3
68	Buryatia	118.7	-21.6	+7.0
69	Sverdlovsk Region	158.4	-34.8	+6.2
70	Altai Territory	172.2	-35.1	+10.4
71	Trans-Baikal Territory	132.4	-24.0	+9.8
72	Novgorod Region	167.1	-18.7	+1.2
73	Krasnoyarsk Territory	154.5	-23.1	+4.5
74	Republic of Tyva	109.5	-4.8	+21.9
75	Smolensk Region	140.6	-14.9	+5.2
76	Murmansk Region	153.4	-6.4	+2.2
77	Kemerovo Region	170.4	-19.0	+4.6
78	Kostroma Region	199.6	-15.5	+4.4
79	Ingushetia	265.2	-17.2	+13.2
80	Khakassia	254.4	+34.7	+3.5
81	Astrakhan Region	281.1	-16.6	+20.5
82	Yamalo-Nenets Autonomous District	184.0	+15.3	+28.3
83	Chechnya	364.3	+31.6	+36.8

Resulting estimates for energy intensity of GRP

The biggest geographical grouping in Russia with high energy consumption per unit of production is Central Siberia, a region stretching from Chita to Kemerovo and including Altai Territory, in the south, and extending to Yamal-Nenets District, in the north. These regions use huge amounts of energy for production of coal, aluminum, nickel and natural gas (high energy use in the natural gas industry is mainly at compressor stations on gas pipelines). By contrast, regions, which produce oil, and also timber regions (mainly the north-west taiga zone) turn out to be very energy efficient in the current system of prices and tariffs. All of the eastern Urals is very energy intensive, as might have been expected. Regions with lowest energy efficiency in the west of the country are clustered around the central Caucasus and form a cross-shape in the centre of European Russia (Figure 8.4.1)

Trends in energy consumption per unit of GRP

In the period following 2000, energy consumption grew or fell only slightly in regions that produce oil and natural gas, with the exception of the southern Urals. In the rest of the country energy consumption during the growth years formed a mosaic pattern, suggesting that causes of change in energy consumption were different in each region.

However, in the first year of the crisis there was a clear break: the energy intensity map for 2008 (Figure 8.4.2) shows reductions across the whole of the European-Urals agrarian zone without exception.

Figure 8.4.1
Energy consumption per million roubles of GRP (without net taxes) in 2008 (% of the average for Russia)

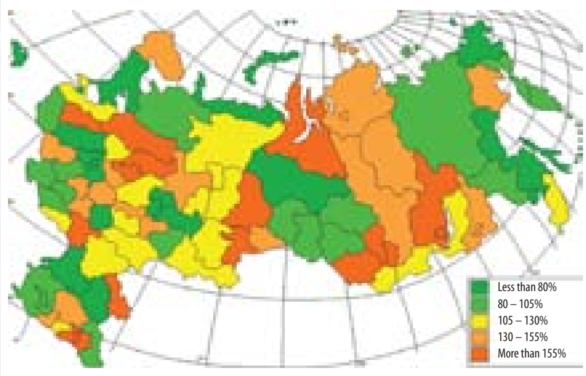
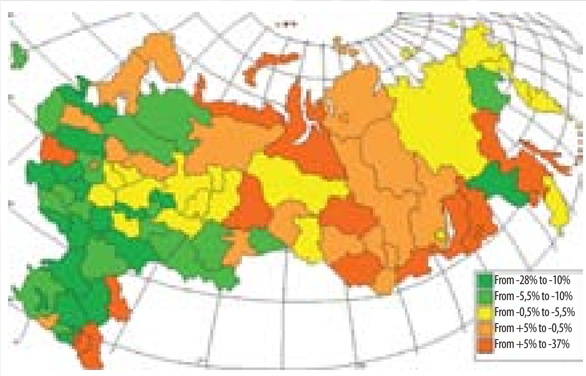


Figure 8.4.2
Changes in energy consumption per unit of GRP in 2008 +/- % of 2007



However, the industrial centers of Siberia and the North West not only stopped increasing their energy efficiency but saw an increase in energy intensity of GRP.

Combined criteria of high energy efficiency of GRP and improving trends indicate three clear regional winners, which are Rostov, Tver and Kaluga (Table 8.4.1).

Table 1.1. GDP energy intensity of some national and supranational economies, 1990-2008, t. oil equiv / thousand USD 2005 by PPP

Country/Region	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
EC-27	0.170	0.168	0.164	0.164	0.158	0.158	0.160	0.154	0.151	0.147	0.143	0.142	0.139	0.139	0.137	0.135	0.130	0.124	0.122
Great Britain	0.156	0.162	0.160	0.158	0.150	0.146	0.149	0.142	0.138	0.133	0.130	0.128	0.123	0.121	0.118	0.116	0.111	0.104	0.102
Germany	0.171	0.158	0.153	0.153	0.148	0.146	0.149	0.144	0.140	0.134	0.131	0.132	0.129	0.130	0.128	0.125	0.123	0.113	0.113
Italy	0.114	0.115	0.114	0.113	0.110	0.112	0.111	0.110	0.111	0.113	0.111	0.109	0.108	0.111	0.112	0.111	0.108	0.105	0.105
France	0.154	0.161	0.161	0.162	0.156	0.157	0.161	0.155	0.154	0.151	0.147	0.147	0.144	0.144	0.143	0.140	0.136	0.131	0.132
USA	0.246	0.246	0.242	0.241	0.236	0.235	0.234	0.226	0.218	0.212	0.209	0.203	0.203	0.198	0.195	0.189	0.182	0.182	0.175
Canada	0.331	0.342	0.348	0.348	0.344	0.340	0.347	0.335	0.315	0.306	0.301	0.292	0.288	0.291	0.285	0.285	0.275	0.273	0.275
Russia	**0.460**	**0.478**	**0.533**	**0.547**	**0.570**	**0.566**	**0.568**	**0.530**	**0.559**	**0.531**	**0.496**	**0.469**	**0.458**	**0.429**	**0.406**	**0.379**	**0.371**	**0.345**	**0.324**
Japan	0.134	0.135	0.135	0.136	0.140	0.141	0.140	0.140	0.141	0.142	0.141	0.140	0.139	0.137	0.136	0.134	0.131	0.127	0.126
Norway	0.287	0.259	0.263	0.264	0.245	0.249	0.216	0.217	0.217	0.219	0.234	0.205	0.212	0.187	0.183	0.206	0.185	0.194	0.194
China	0.549	0.528	0.482	0.454	0.425	0.412	0.394	0.359	0.318	0.301	0.288	0.275	0.266	0.281	0.297	0.296	0.290	0.278	0.274
India	0.176	0.184	0.184	0.180	0.178	0.180	0.178	0.177	0.174	0.167	0.169	0.161	0.162	0.153	0.154	0.148	0.141	0.140	0.138
Brazil	0.115	0.117	0.122	0.120	0.119	0.120	0.124	0.127	0.132	0.135	0.133	0.129	0.128	0.128	0.126	0.126	0.125	0.127	0.125
Korea	0.185	0.190	0.202	0.208	0.208	0.208	0.215	0.225	0.223	0.222	0.217	0.214	0.209	0.210	0.206	0.205	0.197	0.194	0.194
Mexico	0.121	0.121	0.119	0.119	0.121	0.125	0.128	0.124	0.124	0.119	0.116	0.116	0.116	0.120	0.118	0.118	0.118	0.117	0.119
Argentina	0.178	0.161	0.152	0.150	0.146	0.157	0.159	0.146	0.147	0.150	0.155	0.159	0.168	0.167	0.161	0.158	0.154	0.148	0.141
South Africa	0.327	0.328	0.326	0.331	0.340	0.349	0.352	0.353	0.350	0.339	0.327	0.315	0.315	0.322	0.323	0.300	0.290	0.288	0.291
Australia	0.216	0.217	0.220	0.219	0.219	0.216	0.214	0.211	0.206	0.199	0.192	0.194	0.193	0.186	0.184	0.183	0.185	0.179	0.166
Saudi Arabia	0.256	0.251	0.236	0.242	0.263	0.255	0.259	0.258	0.265	0.270	0.277	0.287	0.297	0.294	0.298	0.300	0.304	0.312	0.320
Indonesia	0.136	0.137	0.139	0.137	0.135	0.133	0.133	0.136	0.154	0.167	0.167	0.170	0.172	0.166	0.165	0.168	0.153	0.149	0.148
Ukraine	0.643	0.640	0.623	0.612	0.680	0.726	0.771	0.781	0.767	0.784	0.741	0.675	0.633	0.579	0.544	0.525	0.484	0.442	0.423

Source: World Bank (World Development Indicators Online Database), BP Statistical Review of World Energy June 2009

Table 1.2. Russian GDP energy intensity

Source:	Unit:	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Estimate of the Institute for Energy and Finance based on data from BP and World Bank	t. oil equiv.. / thousand USD 2005 (PPP)	0.460	0.478	0.533	0.547	0.570	0.566	0.568	0.530	0.559	0.531	0.496	0.469	0.458	0.429	0.406	0.379	0.371	0.345	0.324
IEA	t. oil equiv.. / thousand USD 2000 (PPP)	0.571	0.593	0.63	0.657	0.657	0.659	0.678	0.639	0.659	0.643	0.595	0.573	0.544	0.525	0.491	0.471	0.452	0.419	н.д.

Source: World Bank (World Development Indicators Online Database), BP Statistical Review of World Energy June 2009, IEA (IEA World Energy Statistics and Balances - Energy Balances of Non-OECD Countries - Economic Indicators Vol 2009 release 01)

Table 1.3. Primary Power Production to GDP Ratio for Selected National and Supranational Economies, 1990 – 2008, t. oil equiv./thousand USD 2000 (PPP)

Country/Region	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
World	0.264	0.261	0.257	0.253	0.248	0.245	0.242	0.235	0.232	0.223	0.219	0.216	0.212	0.212	0.211	0.208	0.202	0.194	н.д.
OECD	0.162	0.162	0.160	0.158	0.158	0.157	0.156	0.152	0.149	0.143	0.139	0.139	0.136	0.132	0.129	0.125	0.122	0.118	0.118
Countries outside OECD	0.440	0.431	0.423	0.412	0.397	0.388	0.377	0.365	0.362	0.348	0.340	0.330	0.321	0.321	0.317	0.310	0.297	0.279	н.д.
EC - 27	0.110	0.109	0.107	0.107	0.105	0.105	0.106	0.102	0.097	0.094	0.090	0.088	0.086	0.084	0.082	0.077	0.073	0.069	н.д.
Great Britain	0.174	0.182	0.182	0.185	0.195	0.199	0.202	0.195	0.191	0.191	0.178	0.167	0.161	0.150	0.133	0.118	0.105	0.096	0.090
Germany	0.108	0.093	0.088	0.082	0.077	0.075	0.074	0.072	0.067	0.066	0.064	0.062	0.062	0.063	0.063	0.062	0.060	0.059	0.057
Italy	0.020	0.021	0.021	0.022	0.023	0.022	0.023	0.022	0.022	0.021	0.019	0.018	0.018	0.019	0.019	0.018	0.018	0.017	0.017
France	0.089	0.094	0.094	0.100	0.095	0.096	0.098	0.094	0.089	0.087	0.086	0.085	0.086	0.086	0.084	0.083	0.081	0.078	0.078
USA	0.234	0.233	0.226	0.214	0.214	0.208	0.204	0.195	0.188	0.178	0.172	0.173	0.166	0.159	0.155	0.149	0.147	0.145	0.148
Canada	0.418	0.445	0.455	0.477	0.488	0.489	0.495	0.483	0.465	0.439	0.427	0.424	0.420	0.414	0.414	0.406	0.403	0.395	0.385
Japan	0.026	0.027	0.027	0.029	0.030	0.032	0.032	0.033	0.035	0.033	0.033	0.032	0.030	0.025	0.028	0.029	0.029	0.025	0.024
Norway	1.057	1.128	1.219	1.252	1.308	1.362	1.457	1.419	1.337	1.334	1.397	1.355	1.387	1.376	1.301	1.242	1.171	1.121	1.087
Former USSR	0.700	0.703	0.754	0.788	0.846	0.869	0.898	0.855	0.890	0.874	0.836	0.813	0.801	0.793	0.766	0.744	0.707	0.666	н.д.
Russia	**0.840**	**0.832**	**0.905**	**0.927**	**0.994**	**1.008**	**1.044**	**0.996**	**1.060**	**1.020**	**0.943**	**0.924**	**0.916**	**0.913**	**0.892**	**0.867**	**0.822**	**0.767**	**н.д.**
China	0.451	0.418	0.374	0.340	0.318	0.309	0.290	0.265	0.245	0.223	0.206	0.196	0.193	0.197	0.203	0.200	0.191	0.179	н.д.
India	0.206	0.211	0.203	0.196	0.190	0.185	0.175	0.174	0.163	0.155	0.152	0.147	0.145	0.139	0.132	0.125	0.118	0.112	н.д.
Brazil	0.107	0.106	0.107	0.103	0.102	0.099	0.103	0.106	0.112	0.119	0.119	0.121	0.130	0.136	0.132	0.137	0.140	0.138	н.д.
Australia	0.427	0.452	0.450	0.439	0.417	0.431	0.421	0.427	0.437	0.415	0.447	0.460	0.454	0.436	0.432	0.437	0.423	0.434	0.425
Argentina	0.169	0.156	0.151	0.149	0.154	0.170	0.174	0.173	0.171	0.178	0.184	0.198	0.214	0.204	0.184	0.164	0.155	0.141	н.д.
Indonesia	0.429	0.429	0.411	0.391	0.395	0.370	0.361	0.353	0.395	0.425	0.393	0.389	0.379	0.378	0.368	0.366	0.389	0.391	н.д.
Korea	0.053	0.047	0.041	0.038	0.034	0.034	0.034	0.034	0.042	0.043	0.042	0.041	0.041	0.043	0.041	0.045	0.043	0.040	0.041
Mexico	0.276	0.275	0.265	0.264	0.253	0.266	0.267	0.262	0.255	0.241	0.229	0.234	0.232	0.241	0.242	0.240	0.226	0.215	0.198
Saudi Arabia	1.726	1.989	1.957	1.935	1.883	1.889	1.846	1.797	1.803	1.679	1.721	1.671	1.669	1.743	1.712	1.705	1.636	1.528	н.д.
Ukraine	0.297	0.283	0.296	0.310	0.350	0.372	0.373	0.390	0.397	0.403	0.385	0.352	0.337	0.318	0.287	0.282	0.269	0.246	н.д.
South Africa	0.356	0.367	0.369	0.390	0.394	0.401	0.385	0.398	0.401	0.392	0.378	0.366	0.350	0.362	0.355	0.340	0.321	0.309	н.д.
OPEC	1.330	1.317	1.344	1.410	1.420	1.426	1.420	1.431	1.448	1.395	1.420	1.376	1.305	1.309	1.299	1.287	1.240	1.169	н.д.

Source: IEA (IEA World Energy Statistics and Balances - Energy Balances of OECD Countries - Economic Indicators Vol 2009 release 01, IEA World Energy Statistics and Balances - Energy Balances of Non-OECD Countries - Economic Indicators Vol 2009 release 01)

Table 1.4. Primary Power Production to GDP Ratio for Russia, 1990 – 2007, t. oil equiv./thousand USD 2000 (PPP)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Primary Power Production to GDP Ratio	0.840	0.832	0.905	0.927	0.994	1.008	1.044	0.996	1.060	1.020	0.943	0.924	0.916	0.913	0.892	0.867	0.822	0.767

Source: IEA (IEA World Energy Statistics and Balances - Energy Balances of Non-OECD Countries - Economic Indicators Vol 2009 release 01)

Table 4.1
Russian coal-fired power plants and socio-environmental indicators for their surrounding areas

Territory	Coal-fired CPP/CHP	Share of coal-fired heating sources, % *	Population, thousand**	HDI in 2006 /ranking ***	Level of ambient air pollution in 2006/2007, Roshydromet data ****
Central Federal District					
Vladimir Region				0.756/60	
Vladimir	Vladimirskaya CHP-2	11.7	339.5		High
Voronezh Region				0.771/40	
Voronezh	Voronezhskaya CHP-2	3.2	839.9		High
Ivanovo Region				0.735/73	
Ivanovo	Ivanovskaya CHP-2,3	16.9	406.5		Insufficient data
Kostroma Region				0.756/59	
Kostroma	Kostromskaya CHP-1,2	1.7	271.7		High
Kursk Region				0.781/30	
Kursk	Kurskaya CHP-1	3.8	408.1		High
Moscow Region				0.781/31	
Dzerzhinskiy	Dzerzhinskaya CHP-22		44.3		Fairly high
Kashira	Kashirskaya CPP 4*****		39.5		No data
Stupino	Stupinskaya CHP		66.4		No data
Shatura	Shaturskaya CPP		31.2		No data
Ryazan Region				0.773/38	
Ryazan		1.9	510.8		Very high
Novomichurinsk	Ryazanskaya CPP		20.0		Not monitored
Smolensk Region				0.755/62	
Smolensk		4.9	316.5		Fairly high
Ozerniy town	Smolenskaya CPP*****		6.0		Not monitored
Verkhnedneprovskiy town	Dorogobuzhskaya CHP		13.5		Not monitored
Tver Region				0.753/63	
Tver	Tverskaya CHP-3		407.3		Not stated. But monitored
Tula Region				0.763/50	
Tula		0.7	500.0		High
Suvorov	Cherepetskaya CPP*****		19.9		Not monitored
Alexin	Alexinskaya CHP		65.4		Not monitored
Yaroslavl Region				0.793/18	
Yaroslavl	Yaroslavskaya CHP-2	13.6	605.2		High

North-Western Federal District					
Komi Republic				0.799/13	
Syktyvkar		27.7	246.3		High
Vorkuta	Vorkutinskaya CHP-1,2		116.9		High
Inta	Intinskaya CHP		35.2		No data
Arkhangelsk Region				0.789/22	
Arkhangelsk		73.0	354.7		High
Severodvinsk	Severodvinskaya CHP-1		191.4		No data
Vologda Region				0.800/12	
Vologda		3.3	286.2		Fairly high
Kaduy town	Cherepovetskaya CPP*****		17.8		No data
Leningrad Region				0.758/55	
Kirovsk	Dubrovskaya CHP 8*****		23.4		Not monitored
Murmansk Region				0.782/28	
Murmansk	Murmanskaya CHP	12.5	314.8		Low
Murmashi town	Apatitskaya CHP		15.6		Not monitored
Novgorod Region				0.762/53	
Velikiy Novgorod	Novgorodskaya CHP-20		216.2		Fairly high
Pskov Region				0.729/76	
Pskov		11.4	194.2		Fairly high
Dedovichi town	Pskovskaya CPP*****		9.6		Not monitored
St. Petersburg	Pervomayskaya CHP	17.3	4568.1	0.848/3	High
Southern Federal District					
Rostov Region				0.775/36	
Rostov-on-Don		6.9	1048.7		High
Novocherkassk	Novocherkasskaya CPP*****		177.0		Not stated, in 2000 the city was rated as an environmental emergency area

Volga Federal District					
Republic of Bashkortostan				0.805/9	
Ufa		2.7	1021.5		High
Salavat	Salavatskaya CHP		155.9		High
Kumertau	Kymertausskaya CHP		62.4		No data
Republic of Tatarstan				0.834/4	
Kazan	Kazanskaya CHP-2	1.4		1120.2	Very high
Udmurt Republic				0.791/19	
Izhevsk	Izhevskaya CHP-2	26.5		613.3	High
Kirov Region				0.752/64	
Kirov	Kirovskaya CHP-3,4,5	43.2		486.3	High
Perm Territory				0.790/20	
Perm		6.7	987.2		High
Chaikovskiy	Chaikovskaya CHP-18*****		82.9		Not stated
Krasnokamsk	Zakamskaya CHP-5		52.6		Not stated
Dobryanka	Permskaya CPP		35.8		Not monitored
Yayva township	Yayvinskaya CPP		2.1		Not monitored
Samara Region				0.803/10	
Samara		5.7	1135.4		High
Togliatti	Togliattinskaya CHP		705.5		High
Urals Federal District					
Sverdlovsk Region				0.802/11	
Ekaterinburg	Sverdlovskaya CHP	15.3	1323.0		Very high
Krasnoturyinsk	Bogoslovskaya CHP		61.7		Very high
Atryomovskiy	Artemovskaya CHP		33.3		Not monitored
Kamensk-Uralskiy	Krasnogorskaya CHP		181.0		Environmental emergency area
Serov	Serovskaya CPP*****		98.5		Not stated
Verkhniy Tagil	Verkhnetagilskaya CPP		12.3		No data
Nizhnyaya Tura	Nizhneturinskaya CPP*****		22.8		No data
Asbest	Reftinskaya CHP*****		71.3		Not monitored
Chelyabinsk Region				0.796/17	
Chelyabinsk	Chelyabinskaya CHP-1,2	19.0	1092.5		Very high
Ozersk	Argayashskaya CHP		86.9		Not monitored
Troitsk	Troitskaya CPP*****		82.4		Not monitored
Yuzhnouralsk	Yuzhnouralskaya CPP*****		38.5		Not monitored
Magnitogorsk	Magnitogorskaya CHP		409.0		Very high

Siberian Federal District					
Republic of Buryatia				0.744/69	
Ulan-Ude	Ulan-Udenskaya CHP-1,2 Timlyuyskaya CHP	91.1	340.8		Very high
Gusinoozersk	Gusinoozerskaya CPP*****		24.1		Not monitored
Republic of Tyva				0.691/80	
Kyzil	Kyzilskaya CHP	100.0	108.1		High
Republic of Khakassia				0.765/48	
Abakan	Abakanskaya CHP	93.3	163.2		High
Altai Territory				0.756/58	
Barnaul	Barnaulskaya CHP-1,2 Barnaulskaya CHP 3*****	72.9	597.2		High
Rubtsovsk	Rubtsovskaya CHP		156.2		Not monitored
Biysk	Biyskaya CHP		221.4		Not monitored
Krasnoyarsk Territory				0.807/8	
Krasnoyarsk	Krasnoyarskaya CHP 1***** Krasnoyarskaya CHP-2	72.5	936.4		Very high
Turs township		62.5	5.5		Not monitored
Sharypovo	Berezovskaya CPP 1*****		38.5		Not monitored
Zelenogorsk	Krasnoyarskaya CPP-2		68.5		Not monitored
Kansk	Kanskaya CHP		99.0		Not monitored
Minusinsk	Minusinskaya CHP		66.8		No data
Nazarovo	Nazarovskaya CPP		53.6		Not monitored
Sosnovoborsk	Sosnovoborskaya CHP (renamed Krasnoyarskaya CHP-4)		30.1		Not monitored
Irkutsk Region				0.776/35	
Irkutsk	Irkutskaya CPP	56,6	575.8		Very high
Baikalsk	Baikalskaya CHP		15.0		No data
Markova township	Novo-Irkutskaya CHP		7.0		Not monitored
Angarsk	Angarskaya CHP-9***** Angarskaya CHP-10 Irkutskaya CPP-10		242.5		Not stated
Cheremkhovo	Cheremkhovskaya CHP		54.3		No data
Sayansk	Novo-Ziminskaya CHP*****		44.0		Not monitored
Ust-Ilimsk	Ust-Ilimskaya CHP		98.0		Not monitored
Kemerovo Region				0.771/41	
Kemerovo	Kemerovvskaya CPP Kemerovskaya CHP Novo-Kemerovskaya CHP	73,2	520.0		High
Novokuznetsk	Zapadno-Sibirskaya CHP Kuznetskaya CHP		562.2		High

Belovo	Belovskaya CPP		75.8		Not monitored
Myski	Tom-Usinskaya CPP*****		41.9		Not monitored
Kaltan	Yuzhno-Kuzbasskaya CPP*****		24.8		Not monitored
Novosibirsk Region				0.790/21	
Novosibirsk	Novosibirskaya CHP 2,3,4,5	64.2	1390.5		High
Omsk Region				0.798/15	
Omsk	Omskaya CHP-4,5	14.3	1131.1		High
Tomsk Region				0.815/5	
Tomsk	Tomskaya CHP-3*****	40.0	516.1		Very high
Seversk	Severskaya CHP		107.1		Not data
Trans-Baikal Territory				0.730/75	
Chita	Chitinskaya CHP-1,2	75.0	306.1		Very high
Sherlovaya Gora township	Sherlovogorskaya CHP		14.4		Not monitored
Yasnogorsk township	Kharanorskaya CPP*****		9.2		Not monitored
Priargunsk township	Priargunskaya CHP		8.1		Not monitored
Agin-Buryat Autonomous District					
Aginskoye township		100.0	13.9		Not monitored

Far Eastern Federal District					
Republic of Sakha (Yakutia)				0.799/14	
Yakutsk		6.6	255.8		High
Nyeryungri	Nieryungrinskaya CPP		64.4		No data
Chulman township	Chulmanskaya CHP (incorporated in Neryungrinskaya CPP)		10.4		Not monitored
Primorye Territory				0.756/57	
Vladivostok	Vladivostokskaya CHP-1,2	49.4	605.4		High
Artem	Atremovskaya CHP		111.9		Low
Luchegorsk township	Primorskaya CPP*****		22.0		Not monitored
Khabarovsk Territory				0.770/42	
Khabarovsk	Khabarovskaya CHP-3	58.3	577.3		High
Amursk	Amurskaya CHP		46.1		No data
Komsomolsk-on-Amur	Komsomolskaya CHP-1,2		272.4		High
Maiskiy township	Maiskaya CPP		3.0[1]		Not monitored
Amur Region				0.744/68	
Blagoveschensk	Blagoveschenskaya CHP	70.7	207.3		Very high
Kamchatka Territory				0.763/49	
Petropavlovsk-Kamchatskiy	Kamchatskaya CHP-1,2	50.9	194.9		High
Magadan Region				0.785/25	
Magadan	Magadanskaya CHP	14.3	107.1		Very high
Myaoondzha	Arkagalinskaya CPP		2.1 (2002 r.)		Not monitored
Sakhalin Region				0.788/23	
Yuzhno-Sakhalinsk	Yuzhno-Sakhalinskaya CHP	31.3	173.8		Very high
Lermontovka village	Sakhalinskaya CPP		4.6 (2003)		Not monitored
Jewish Autonomous Region				0.734/74	
Birobidzhan	Birobidzhanskaya CHP	100.0	75.1		High
Chukotka Autonomous District				0.741/72	
Anadyr	Anadyrskaya CHP	50.0	11.8		No data
Pevek	Chaunskaya CHP		4.4		No data
Egvekinot township	Egvekinotskaya CPP Egvekinotskaya CHP		2.4		Not monitored

** according to the State Statistics reporting form TaST as of the end of 2006 for all types of property*
*** Russia's regions. Main social and economic indices of cities - 2008. Stat. Digest / Rosstat – M., 2008. – 375p. (http://www.gks.ru/bgd/regl/B08_14t/Main.htm), also on data taken from http://www.mojgorod.ru, http://www.migratio.ru, http://ru.wikipedia.org*
**** The 2009 National Human Development Report - M., 2009.*
***** Annual emissions digest of Russia's urban and rural areas, 2007; The R&D Institute for Ambient Air Protection, St.Petersburg, 2008. – 204p.; Annual Digest of Ambient Air Pollution in Russian Cities, 2006. The A.I.Voyeykov Leading Geophysical Observatory of Roshydromet. St.Petersburg, 2008. – 208p.*
****** CHP, where coal-fired generation will be increased by 2020. Construction proposals for expansion of Smolenskaya, Reftinskaya, Yuzhno-Uralskaya CPPs are not available. (I.S.Kozhukhovskiy. Situational analysis and forecast, http://www.e-apbe.ru/actions/09_03_24_Vedomosti_Kozhukhovsky.pps# - material taken on july 07th, 2009.)*

[1] *http://bereg.in/index/0-5*

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