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RUSSIA AND GLOBAL WARMING

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Analysis

The Danger of Climate Change for Russia – Expected Losses and Recommendations

By Alexey O. Kokorin and Inna G. Gritsevich, Moscow

Abstract

Global warming could significantly change the Russian climate, though it will affect different parts of the county in different ways. The impact will be especially strong on Russia's extensive permafrost and forests. Rising temperatures will also influence the economy and people's lifestyles. Among potential positive changes are reductions in the winter heating season and a longer growing season for Russian agriculture. But it is not clear that Russia will be able to take advantage of these benefits: the country will also face higher temperatures, shifting climate zones, more droughts, forest fires, and extreme weather phenomena. Many types of plants and animals will be threatened. Russia can help to limit the possible adverse consequences, but doing so will require skillful management and the introduction of a wide range of new policies.

Observed and Predicted Climate Changes

Recently published international reports and scientific articles make it possible to identify the consequences of climate change for various Russian regions and to address the three most important issues: the impact of climate change on energy, agriculture, and the permafrost zone, which occupies about 60 percent of the country's territory. On the basis of this information, it is possible to draw several macro-economic conclusions affecting Russia.

The increase in temperature, which is the main indicator of climate change, in the next 30 years for Russian territory in comparison with 2000, could reach 0.4-0.8 °C by 2010-2015 and exceed 1.5 °C by 2030. As in the past, the temperature increase will not be even across Russia's vast territory. Scientists predict different levels of increase in different parts of Russia: by 2015, temperature will likely rise 0.5 – 1.0 °C in Central Russia; 3-4 °C in Western Siberia; 2-3 °C in Yakutia; and 1-2 °C in the Far East. The winter temperature will increase on average 1 °C for most parts of Russia, but only 0.4 °C during the summer.

The amount of precipitation also will increase, especially during the cold period of the year. During the winter, it will rise 4-6 percent. The greatest increase will be in Eastern Siberia, 7-9 percent. As a result, in several regions ground water levels will rise, expanding the extent of the swamps. Because of hotter winter weather in many regions, by March, there will be 10-15 percent less snow accumulation, which could have a negative impact on the harvests. In the eastern parts of the country, from the Ural Mountains to the Far East, in contrast, there could be 2-4 percent more snow.

The change in the temperatures and precipitation amounts will also affect the flow of the rivers. In most northern regions in the European part of the country, flows will increase 60-90 percent in the winter and 20-50 percent in the summer. The overall annual flow into the Arctic Ocean will increase by 10-20 percent each year, and as much as 150-200 percent during the winter. In all of the southern regions of the country, the river flows will drop by 10-20 percent.

The lack of stability in climatic conditions will grow worse as the frequency and intensity of extreme phenomena increases. Between 1990 and 2005, the occurrence of such phenomena doubled for Russia from 150 to 300, according to the Russian meteorology service, Rosgidromet. Between 2000 and 2015, the number is expected to double again, from 300 to 600. The occurrence of floods will rise, particularly in the spring time. In the southern regions, water flows during catastrophic spring floods could exceed the average annual maximum by 5-7 times. The danger of floods due to heavy downpours will also increase, especially in mountain foothill areas, where they are often accompanied by destructive torrents and landslides.

Impact on the Permafrost and Forests

Climate change will have several negative consequences for the permafrost, particularly along its southern border (see the article by Roland Götz in this issue for more details). Additionally, the warmer air temperatures will increase the number of droughts and heat waves, causing further melting in the permafrost and other harmful consequences.

These changes will have negative consequences for the forests. For example, there could be a replacement of conifers with deciduous trees since the latter are less affected by climate change. If the warming of the northern taiga continues at the current rate, 0.4-0.5 °C a decade, the result will be an outbreak of epidemics in the forest and the spread of harmful parasites. Simultaneously, the steppe zone will shift to the north, and the forest-steppe will encroach on the forests. In the worst-case scenarios, the borders of these zones could shift north by 600-1,000 km. By less extreme predictions, the polar-tundra, forest tundra, and southern taiga-forest zones will shift north 200-350 km.

One likely consequence of climate change will be an increase in the number of forest fires. For much of the country, the fire watch season, with an increased danger of forest fires, will increase by 5-7 days.

The shifting of climatic zones and the destruction of the current ecological balance will have an impact on a wide variety of plants and animals. By the middle of the century, millions of geese, eider-ducks, stints, and other types of birds will lose up to 50 percent of their nesting areas, which could lead to a significant reduction in their populations. With an increase of 3-4 °C, the lemming population could drop 60 percent, which could disrupt the entire food chain of the tundra ecosystem, with a particular impact on the polar owls and foxes. The polar bear will also lose much of his living space.

Impact on the Economy and Life Styles

In the coming decades, the influence of climate change on the economy, living conditions and health of the Russian population will increase. In the majority of cases, this influence will be negative.

Among the positive impacts of climate change, however, most specialists list the reduction of the amount of time Russians will have to rely on heating. On average, they will need heaters 3-4 days a year less by 2015, and in the southern parts of Kamchatka, Sakhalin, and Primorsky Krai, the reduction will be as much as 5 days a year. By 2025, in most of Russia, the heating season will drop as much as 5 percent. In the southern parts of European Russia and in the north-east of the Far East, the length of the heating season will drop 10 percent. The resulting fuel savings will be 5-10 percent of current usage.

By the middle of the twenty-first century, the heating season in the central parts of Russia will be 5-10 percent shorter. In the southern regions of European Russia and in the northern regions of Siberia and the Far East, it will be 20 percent shorter. Since winter will be warmer, residents will use less fuel to maintain a comfortable temperature in their homes during the winter. Overall, by 2050, Russians could save as much as 10-20 percent of their current energy usage thanks to global warming.

Unfortunately, it is not clear if it will be possible to take advantage fully of this positive effect. The instability and variability of weather conditions during various parts of the year will generate negative short-term phenomena – unseasonable periods of anomalous heat and cold, frosts, strong winds, and snow storms. These occurrences will require additional use of energy.

Thanks to changes in the Earth's soil due to the melting of the permafrost, increasing ground water levels, and overall warming and the rising number of extreme phenomena, the expected life-span for buildings is expected to drop. By 2015, it will be necessary to refurbish them twice as often as today. The threat that housing and other buildings will be destroyed is growing. There will be particular new pressures on pipes and with a change in the flow of rivers and the amount of ice, there will also be more pressure on pipes under ground. This pressure will lead to more frequent accidents, with oil spills and gas leaks, especially in the northern parts of the country, where most pipes are located.

If air temperatures rise 3-4 °C by 2050, the amount of permafrost will drop 12-15 percent and its southern border will move north-east by 150-200 km and the extent of the summer melting season will lengthen by 20-30 percent. Monitoring of the consequences from these changes will have to increase. Current studies show that more than a quarter of houses in the northern cities of Yakutsk, Vorkuta, and Tiksi, built in the 1950s to 1970s, could become uninhabitable in the next 10-20 years, and in Vorkuta, for example, the number of such inhabitable buildings could be 80 percent.

Some believe that climate change will have positive effects on Russian agriculture. The extent of farmable land will increase 150 percent. The frost-free growing season will expand by 10-20 days a year. The quality of the soil in the Black Earth region will improve. The extent of land for growing warm-climate crops will increase. However, the extent of droughts will increase across Russia. Thus, in the south-western European part of Russia, including the Don basin and other key areas for growing wheat, in the first quarter of the twenty-first century, there may be a significant reduction in water supplies. A further increase in droughts combined with increased economic activity could lead to serious water problems and a reduction of the harvest. In some areas, including Siberia and the North Caucasus, the drop in the grain harvest due to droughts could be as much as 20 percent and become critical for the economies of these regions. Accordingly, they will come to rely more heavily on irrigation and have to seek out crops that need less water.

The amount of water supplied to the population and the economy will have to increase. It will grow by 12-14 percent by 2015. However, there will be an increase in the inequality of its distribution across the territory of the country. The most hard-hit areas will be those that are heavily populated, which today are experiencing a shortage of water.

Across the country, there will be more particularly hot summer days and the extent of these heat waves will increase 1.1 to 1.5 times by 2015. Thanks to rising temperatures in urban areas, Russia can expect 4,000 to 28,800 more deaths per year. In the lower Volga and other southern regions, with hotter and drier weather, there could be water shortages and increased threats of cholera, rodent-borne diseases, and a variety of other health issues.

Macroeconomic Conclusions and Recommendations

The above discussion focuses only on the direct dangers facing Russia in the coming decades. In the longer term, the negative consequences could be much worse, especially if there are no reductions in the global production of greenhouse gases, which would make it possible to hold the temperature increase to two degrees. Economic losses could reach 5 percent or more of the economy.

Some believe that "with skillful management of the processes, several countries could avoid losses." This view holds that if climate change is held to 2 degrees, several northern countries, through skillful management, would actually see the size of their economies grow one percentage point faster.

But it is very important to understand here what "skillful" management means for Russia:

1. Timely adaptation of the economy to the new climatic conditions. State support for technologies of the future and stimulation of the private sector to introduce these innovations.
2. Achieving maximal benefits from "natural" energy and economic advantages: the presence of extensive natural gas reserves, great expanses for growing exportable bio-fuels, hydro-electricity for energy-intensive production, and reserves of fresh water.
3. Imposing a strict international regime to reduce the emission of greenhouse gases, supporting the price of emissions at a high level (20 euros for one ton of carbon dioxide), and limiting global climate change by 2050 to 2 degrees. Unfortunately, if the temperature rises 3-4 degrees, Russia will face losses that will be much larger than the costs of implementing a timely transfer to new energy technologies.

The emission of greenhouse gases in Russia has grown since 2000. However, the growth between 2000 and 2004 was only one-sixth the increase in GDP. At this level of growth, with the introduction of measures to save energy and increase efficiency, Russia could begin reducing greenhouse gas production to 30 percent less than 1990 emissions by 2020.

Now the members of the United Nations are negotiating over international obligations for reducing greenhouse gas emissions after 2012. In the long-term, energy pricing factors for the development of a market for carbon emissions should be the main area of discussion. The market might not include some of the countries that emit the most emissions, but it could be "stronger" in terms of the obligations and higher prices for the emissions that it imposes on its members. Those conditions would allow Russia to realize its comparative advantages and make a contribution to preserving the planet's climate.

Translated from Russian: Robert Orttung

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Analysis

Energy Savings in Russia – Political Challenges and Economic Potential

By Petra Opitz, Berlin

Abstract

Russia's economy is one of the most energy inefficient and carbon dioxide (CO_2) intensive in the world. Russia produces as much CO_2 per capita as Germany, yet the amount of energy consumed per unit of Russian gross domestic product (GDP), measured in purchasing power parity, is almost three times larger than in Germany. There are numerous ways that Russia could save energy, but currently the incentives are not right to encourage such savings. Although Russia's leaders talk about this problem, they will need political will to implement effective solutions.

Russian Energy Efficiency Lags Behind Western Standards

Russia's Energy Strategy until 2020, which was adopted in 2003, assumes a tripling of the GDP with only a 40 percent increase in energy consumption. Russia's leaders hope to achieve this goal by implementing technological and organizational energy-saving measures, as well as introducing structural changes in the economy.

These scenario planners estimated Russia's energy saving potential to be about 278 million tons of oil equivalent (Mtoe). This amount corresponds to 43 percent of Russia's primary energy consumption during 2004, or twice the current exports of natural gas to the European Union.

In fact, the assumptions of the Energy Strategy turned out to be too conservative for the period 2000–2004, underestimating Russia's real energy efficiency potential. Estimates for 2006 show that GDP growth until 2006 was much higher, 43.9 percent compared to 2000, than the forecasted 33.9 percent, but energy consumption was less than (2005) or equal to (2006) the forecast. Therefore, energy intensity decreased more (up to 23.3 percent compared to 2000) than assumed in the Energy Strategy to 2020 (about 17.7 percent). This achievement was mainly the result of a more rapid structural change of the GDP then previously expected. The share of the low energy intensive sectors has increased considerably more rapidly than the other sectors.

According to the Energy Strategy, in 2020 Russia's GDP should reach an energy intensity level of about 0.29 kgoe/USD (PPP) [kilograms of oil equivalent per dollar at purchasing power parity] (See Figure 1 on p. 7). If so, Russia's economy in 2020 would still be twice as energy intensive as today's EU average. Thus, Russia's gains in energy efficiency are more than anticipated, but far below what potentially could be achieved.

Enormous Potential for Energy Savings

Russia can realize much of its energy saving potential at low cost. According to Russian Ministry of Industry and Energy estimates, approximately 20 percent of the energy saving potential can be achieved for as little as \$20–\$50/t of coal equivalent.

A closer look at the structure of Russia's energy efficiency potential shows that the main opportunities for savings are within the energy sector and the communal services sector (see Figure 2 on p. 8).

Major efficiency potentials within the energy sector are:

- Reducing the amount of flared gas at Russian oil wells and converting this gas to energy. Estimates about the amount of gas flaring in Russia range from 15 to 42 billion cubic meters (bn m^3), creating between 43 and 124 million tons of CO_2.
- Cutting losses in natural gas transmission and distribution. Losses amounted to about 10 percent of the 656 bn m^3 transported in 2006, or approximately 65 bn m^3. Up to 20–25 bn m^3 of these losses could be prevented, according to World Bank estimates. Thus, about 3–4 percent of current natural gas production could be saved.
- Increasing the efficiency of oil refineries. About 50 mn t of oil could be saved annually if the processing depth of Russia's refineries reached 90 percent.
- Replacing outdated power stations with modern gas-steam turbines and gas turbines. An annual savings of about 50 bn m^3 of natural gas could be achieved.
- Improving the domestic heating system. Seventy percent of Russia's heating comes from centralized heat supply systems. Experts have identified the potential for huge energy savings in the heat generating process, particularly by replacing outdated boilers with combined heat and power generators

(CHP) and modernizing more than 48,000 small boilers with an efficiency factor of ≤ 30%. In addition, losses in the heat supply systems, which on average amount to 8.6 percent of the heat generated could be substantially reduced and the fuel mix in heat generation could be improved.

Additionally, Russian industry has an enormous potential for introducing greater energy savings. The energy efficiency of many technologies is still far below respective standards in Europe and even the US. For example, the energy intensity of technologies in the iron and steel sectors is about 0.31 toe/t in Russia compared to 0.17 toe/t in the US, 0.12 toe/t in Germany, and 0.1 toe/t in Japan. Also, in the chemical industry, non-metal primary industry, and food industry, the energy intensity is twice as high as in Germany. Russia's minimum energy efficiency requirements are below international standards. Convergence in this field would help to increase the international competitiveness of Russian products.

Nearly one third of Russia's ability to save energy lies in the communal and housing sector. Due to institutional barriers, such as ownership questions, tariffs, and metering/billing issues, this potential remains almost untapped. Establishing apartment owner communities, which would essentially amount to converting Russian apartments into condominiums, will help to establish the legal basis for financing investment into refurbishing existing buildings, where energy efficiency measures will be one important component. In terms of energy pricing, state subsidies remain in place and few politicians want to risk public ire in removing them. Finally, thanks to Soviet era practices, when there were no meters on individual apartments, it is very difficult to measure and charge for individual consumption and therefore hard to encourage individuals to save energy by raising prices. Russia has introduced a number of communal housing sectors reforms to address these problems, but the process is only moving forward slowly.

Obstacles to Reform

Why has Russia been so slow in taking advantage of its huge potential to improve energy efficiency? For example, Russia could save large amounts of natural gas, which would then be available for export. There should be interest in using this potential.

Many proposed projects seeking to reduce natural gas consumption for domestic heating by introducing individual meters into private households, making it possible to bill households for their real heat consumption, were not implemented. Although the legislation is in place for this reform, actual progress has been slow. The main problem is the institutional structure of the heating sector, which is dominated by badly regulated supply monopolies. At present, they have almost no incentive to save energy since they can easily transfer their huge energy losses to the final costumers.

For natural gas supplier monopolist Gazprom, there are low incentives for energy savings on the consumer side. Many experts assert that Gazprom could benefit from energy savings on Russia's domestic market, where it must sell gas at regulated prices that are much lower than world prices, by making available additional amounts of gas for export to foreign markets, where international prices prevail. In practice, however, the situation is much more complicated and interests are different. Currently, Gazprom has no need to receive additional amounts of natural gas for export, because current contracts are secured over the next several years. If external demand for gas goes up in the future, Gazprom certainly will calculate which gas potentials to exploit at least cost. If exploiting the energy saving potential of the internal Russian market costs less than exploring and developing new gas fields or buying gas from Turkmenistan, Gazprom would have greater incentives to focus on increasing efficiencies. While exploiting new fields is expected to be extremely expensive, Gazprom currently is able to acquire relatively cheap gas from Turkmenistan.

In addition, the Energy Strategy until 2020 assumes that the structure of Russia's domestic energy demand should be changed in favor of increasing the share of coal burned in the country in order to fulfill future obligations in natural gas exports. Pursuing this strategy would, of course, increase Russia's CO_2 emissions. If, instead, Russia could take advantage of greater energy savings, there would be no need to burn more coal.

In Europe, a strong desire to mitigate climate change and the Kyoto Protocol provide strong incentives for developing energy efficiency potentials. In Russia, such incentives have much less influence. According to the Kyoto Protocol, Russia must hold greenhouse gas (GHG) emissions to the level of 1990. At the beginning of the 1990s, the Russian economy contracted and GHG emissions dropped sharply. In parallel with the country's recent economic recovery, emissions started to rise again, but most likely Russia will be able to meet its quantitative Kyoto commitments easily without further domestic measures. In 2004 Russia's GHG emissions reached a level some 33 percent below its Kyoto commitments. Thus, it has a surplus of Assigned Amount of Emissions (AAUs) of about 1 billion metric tons carbon equivalent (mtce) until 2012.

Using Joint Implementation (JI) under the Kyoto Protocol could provide new incentives for investing in energy efficiency projects by providing co-financing from selling Estimated Ultimate Recoveries (EURs) created by the projects. Western companies are strongly interested in such projects. On May 30, 2007, the Russian government issued a decree on the national JI procedure, which now allows for implementing the JI mechanism in Russia. Despite this advance, at the project level, the incentives to reduce CO_2 emissions have much less impact on energy efficiency improvement in Russia than, for example, in the EU member states. In Russia, there are no binding caps for CO_2 emissions on companies. The implementation of Green Investment Schemes, i.e. foreign investment for the transfer of AAUs, could also bring economic benefit. It could push for technological modernization and increased competitiveness within Russian industry. To the extent that energy efficiency technologies become a driver for economic growth, create competitive advantages and new jobs, and attract investment into these sectors, they could help the Russian government reach its political goal of increasing the share of higher value added sectors in the overall GDP. Currently GDP growth is driven mainly by energy exports rather than more desirable technology fields.

Although President Putin and some other Russian leaders have stressed the issue of energy efficiency, in practice, a real policy push is needed to put in place a legal framework that provides energy efficiency incentives for the development of technologies that will improve energy efficiency in all sectors of the economy where there are such potentials. As Western practice shows, improving energy efficiency requires a strong political will to implement an adequate legal and economic framework.

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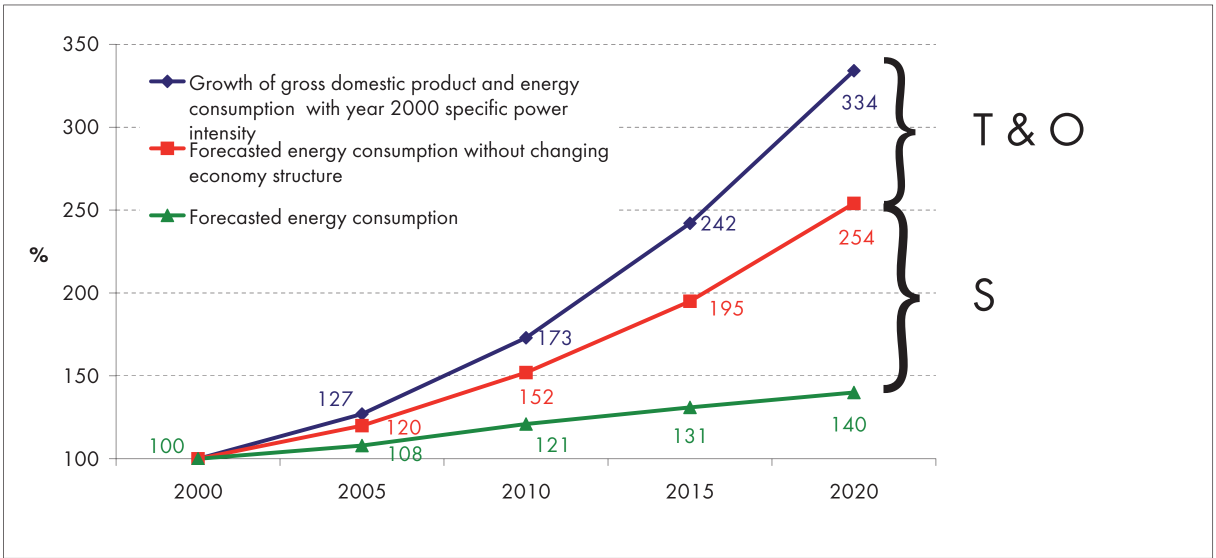
Dr. Petra Opitz serves as the Head of Department at the German Energy Agency.

Table 1. Key Indicators, 2004

	Russia	OECD Europe	USA	Germany
Primary energy consumption per capita (toe/capita)	4.46	3.50	7.91	4.22
Energy intensity of GDP (kgoe/USD (PPP))	0.49	0.16	0.22	0.16
CO^2 per capita (t CO^2/capita)	10.63	7.72	19.73	10.5
CO^2-Intensity of GDP (kg CO^2/USD (PPP))	1.17	0.35	0.54	0.43

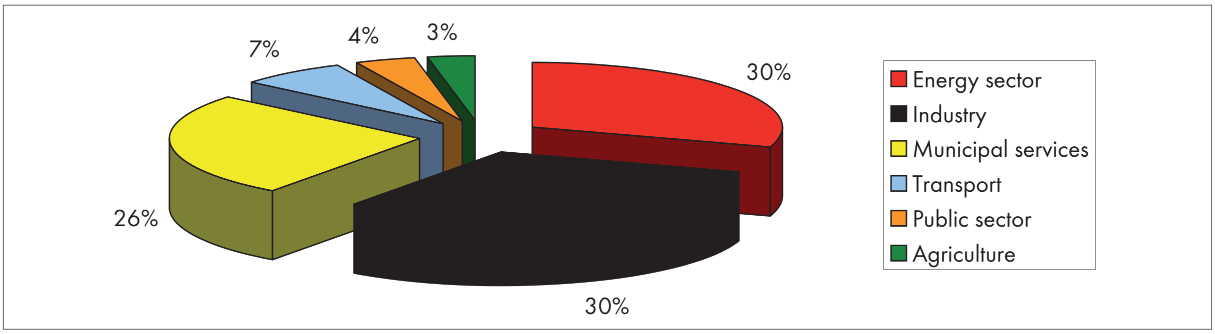
Source: IEA

Figure 1. Forecast of Increase in Russian Energy Consumption, 2000–2020



Source: Energy Strategy of Russia until 2020

Figure 2: Structure of Energy Efficiency Potential in Russia

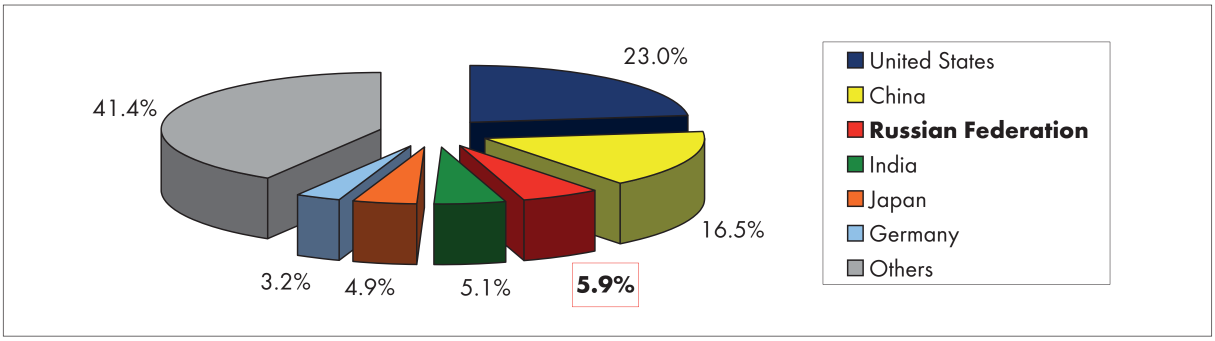


Source: Energy Strategy of Russia until 2020

Tables and Diagrams

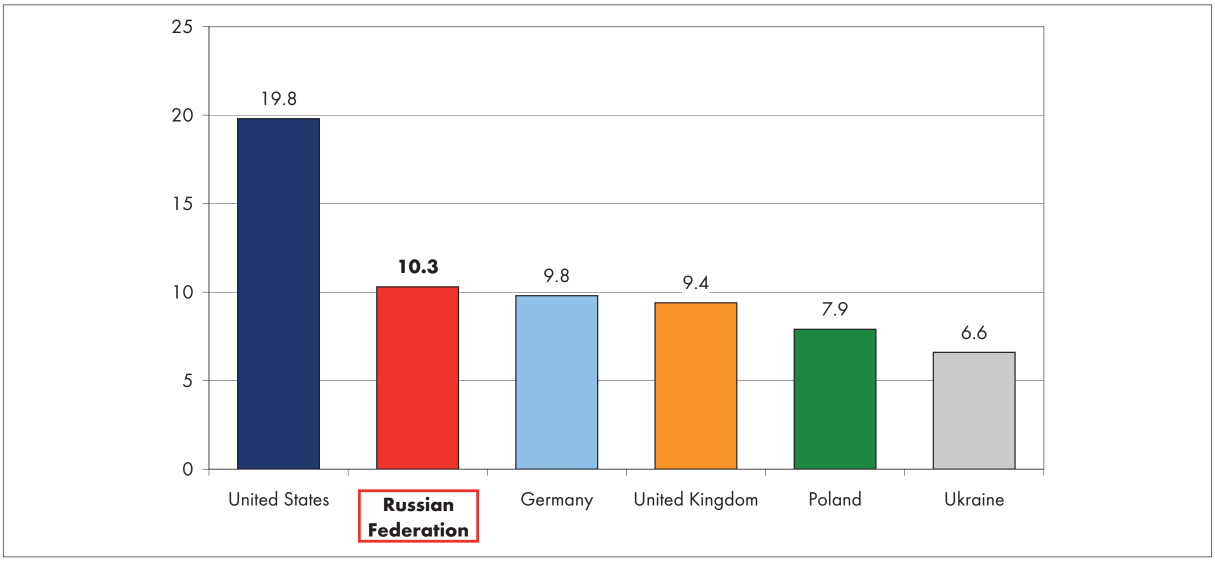
Russian CO_2 Emissions and Energy Consumption in International Perspective

Carbon Dioxide Emissions - Share of World Total (%)



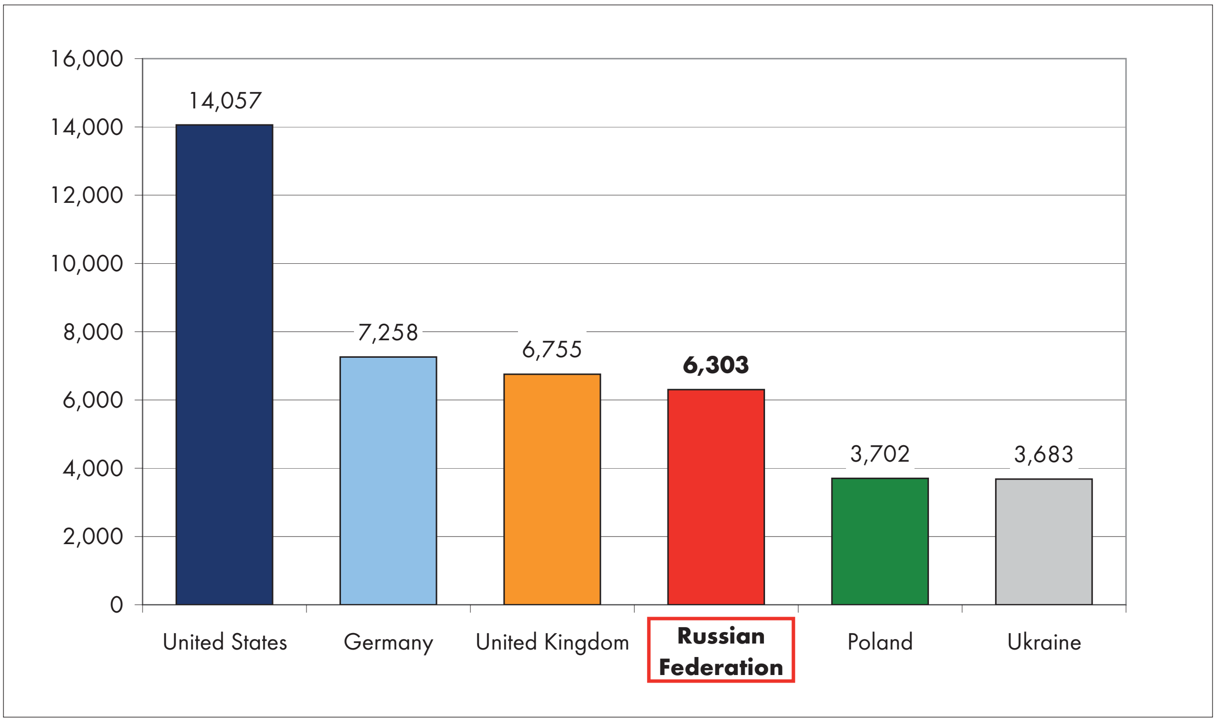
Source: Human Development Report 2006; http://hdr.undp.org/hdr2006/statistics/indicators/204.html

Carbon Dioxide Emissions - Per Capita (Metric Tons)



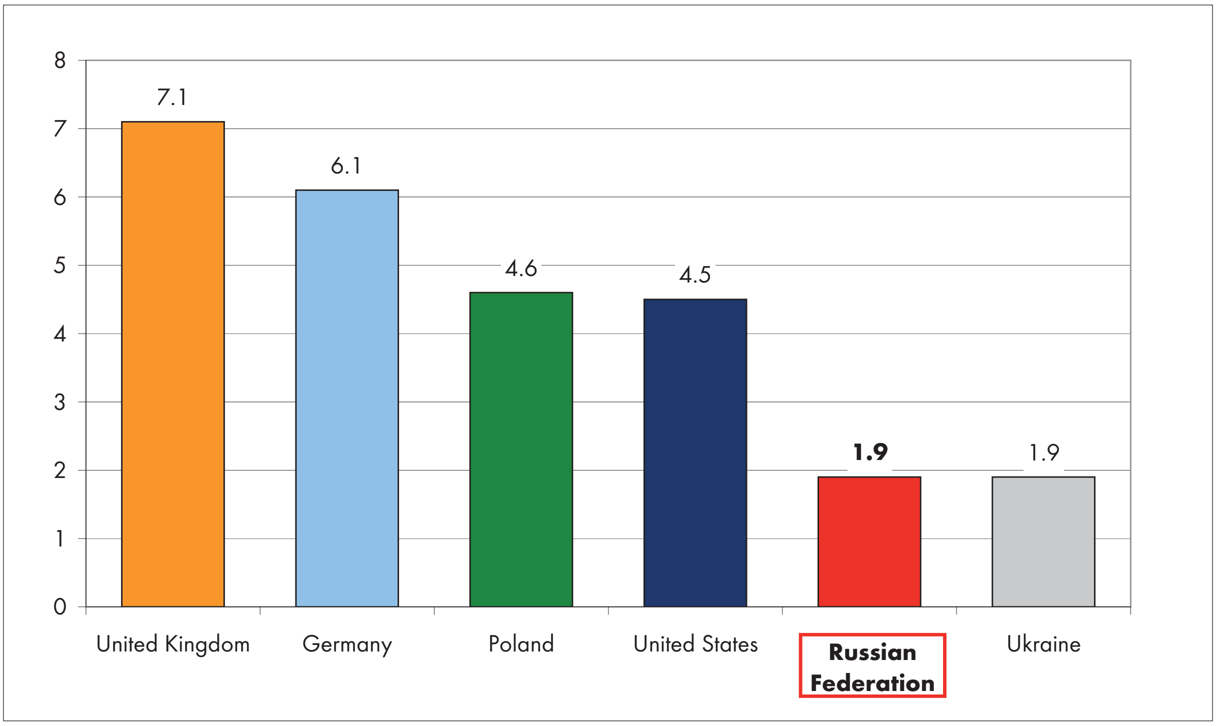
Source: Human Development Report 2006; http://hdr.undp.org/hdr2006/statistics/indicators/203.html

Electricity Consumption Per Capita (Kilowatt-Hours)



Source: Human Development Report 2006; http://hdr.undp.org/hdr2006/statistics/indicators/199.html

GDP Per Unit of Energy Use (2000 PPP US$ Per KG of Oil Equivalent)



Source: Human Development Report 2006; http://hdr.undp.org/hdr2006/statistics/indicators/201.html

Documentation

United Nations Framework Convention on Climate Change and Kyoto Protocol

United Nations Framework Convention on Climate Change (UNFCCC)

Over a decade ago, most countries joined an international treaty -- the United Nations Framework Convention on Climate Change (UNFCCC) -- to begin to consider what can be done to reduce global warming and to cope with whatever temperature increases are inevitable. Recently, a number of nations have approved an addition to the treaty: the Kyoto Protocol, which has more powerful (and legally binding) measures. The UNFCCC secretariat supports all institutions involved in the climate change process, particularly the Conference of the Parties, the subsidiary bodies and their staff.

The Provisions of the Kyoto Protocol and its Rulebook

The 1997 Kyoto Protocol shares the Convention's objective, principles and institutions, but significantly strengthens the Convention by committing Annex I Parties to individual, legally-binding targets to limit or reduce their greenhouse gas emissions. Only Parties to the Convention that have also become Parties to the Protocol (i.e by ratifying, accepting, approving, or acceding to it) will be bound by the Protocol's commitments. 173 Parties have ratified the Protocol to date. Of these, 35 countries and the EEC are required to reduce greenhouse gas emissions below levels specified for each of them in the treaty.

The individual targets for Annex I Parties are listed in the Kyoto Protocol's Annex B. These add up to a total cut in greenhouse-gas emissions of at least 5% from 1990 levels in the commitment period 2008-2012.

The Negotiation of the Kyoto Protocol and its Rulebook

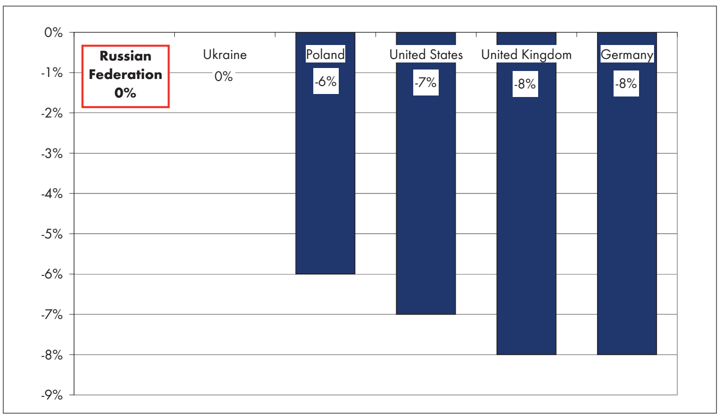
When they adopted the Convention, governments knew that its commitments would not be sufficient to seriously tackle climate change. At the Conference of the Parties 1 (COP) held in Berlin March/April 1995, in a decision known as the Berlin Mandate, Parties therefore launched a new round of talks to decide on stronger and more detailed commitments for industrialized countries. After two and a half years of intense negotiations, the Kyoto Protocol was adopted at COP 3 in Kyoto, Japan, on December 11, 1997.

The complexity of the negotiations, however, meant that considerable "unfinished business" remained even after the Kyoto Protocol itself was adopted. The Protocol sketched out the basic features of its "mechanisms" and compliance system, for example, but did not explain the all-important rules of how they would operate. Although 84 countries signed the Protocol, indicating that they intended to ratify it, many were reluctant to actually do so and bring the Protocol into force before having a clearer picture of the treaty's rulebook. A new round of negotiations was therefore launched to flesh out the Kyoto Protocol's rulebook, conducted in parallel with negotiations on ongoing issues under the Convention. This round finally culminated at COP 7 with the adoption of the Marrakesh Accords, setting out detailed rules for the implementation of the Kyoto Protocol. The Kyoto Protocol entered into force on February 16, 2005.

Source:

United Nations Framework Convention on Climate Change, http://unfccc.int/essential_background/items/2877.php *and* http://unfccc.int/kyoto_protocol/items/2830.php

Quantified Emission Limitation or Reduction Commitment (until 2012) (% of base year of period; 1990 for most countries)



Source: United Nations Framework Convention on Climate Change: Kyoto Protocol to the United Nations Framework Convention on Climate Change, http://unfccc.int/essential_background/kyoto_protocol/items/1678.php

Analysis

Russia and Global Warming – Implications for the Energy Industry

By Roland Götz, Berlin

Abstract

Climate change could make it more expensive to extract oil and natural gas from current and future sites in Russia. The melting of the permafrost, in particular, will impose a wide variety of costs. Many of these consequences are already being felt in Alaska. However, as long as oil and natural gas prices remain high, these projects will remain profitable.

Siberian Extraction Fields Moving North and East

The main Russian oil and natural gas extraction fields are currently in the northern part of Western Siberia. Because the deposits there are largely depleted, new oil and gas fields must be developed. New reserves are located in the northern coastal areas of Siberia and in the east of the country. In the future, natural gas will mostly be extracted on the Yamal Peninsula, offshore in the Barents Sea (Shtokman Field), and the Kara Sea, as well as in Eastern Siberia and in the Far East, on the Sakhalin Peninsula.

The distances for transporting resources from the new production zones to the consumer centers in Western Russia and Europe will be greater than for current production. Additionally, extraction and overhead costs will also increase because of the extreme climate with long and frigidly cold winters and the difficult hydrological conditions in the future production areas.

Russia has already invested enormous technical and financial effort into the current oil and gas extraction facilities, as well as pipeline construction in the Western Siberian taiga, since large swathes of that area are covered by swamps. Trains, roads, industrial facilities, and even entire settlements had to be constructed on sand foundations. The expansion of natural gas extraction to the tundra north of the taiga creates additional problems because that area is covered by permafrost.

Permafrost

Permafrost is permanently frozen ground varying in depth between several meters and several hundred meters, depending on air and ground temperatures and the properties of the soil. In Siberia, permafrost soil can be found reaching down to several thousand meters. The top, or "active" layer, thaws in spring and summer to a depth of between several centimeters and several meters, and then freezes again.

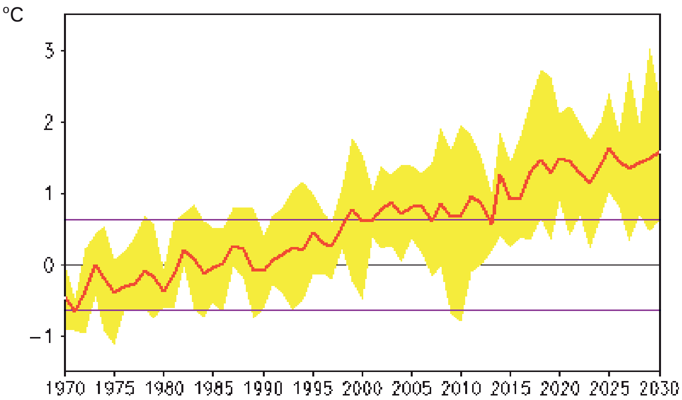
When the "active" layer melts in spring, the water cannot drain off because of the frozen ground below. The result is the formation of pools and lakes as habitats for plants that subsequently decompose. Because of the cold and wet climate, more humus is produced than can decompose, and peat is formed. Therefore, the permafrost soil in Siberia consists mainly of frozen peat soil containing ice deposits. When this ground ice melts, ground depressions are formed. The result is a hilly landscape known as thermokarst. Water aggregates in the hollow depressions, and lakes are formed.

During the summer, part of the organic material in the thawed ground is converted by microorganisms into methane and carbon dioxide, and these greenhouse gases are released into the atmosphere. All of these effects are reinforced and accelerated by global warming, speeding up the process.

Global Warming and the Thawing of the Permafrost

The temperature of the ground in Russia is rising at an accelerating rate. It rose by 0.4 °C just between 1990 and 2000, while the overall increase in the previous 100 years had been 1 °C. Russian officials expect a further increase by 2030, as described in Figure 1.

*Figure 1: Average Increase of Ground-Level Air Temperature in Russia by 2030, Compared to 1971-2000.**



** Surface air temperature rise in Russia computed with a group of models up to 2030, relative to the reference value of 1971–2000, based on computations made by the Voeikov Main Geophysical Observatory. The range of the different models included in the group is described by the yellow region, which comprises 75 percent of the average model values. A 95 percent confidence interval of temperature changes averaged over the group of models is specified by two horizontal lines.*

Source: Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet), Strategic Forecast of Climate Change in the Russian Federation 2010–2015 and Its Impact on Sectors of the Russian Economy (Moscow 2005), <www.meteorf.ru/en_default.aspx>.

Since the 1980s, temperatures in different parts of Siberia have risen between several tenths of a degree and two degrees. The result is that the permafrost thaws to increasingly deeper levels during the summer, and the thickness of the "active" layer grows. Thaw periods begin earlier in the year and end later. Plant growth is boosted and the volume of greenhouse gas emissions increases.

The melting of the snow cover and the spread of dark water patches accelerate the thaw of the permafrost. In winter, conversely, the ground freezes more slowly because the water serves as an insulating layer. The outcome is a self-reinforcing process of permafrost thawing. In the southern permafrost regions, the permafrost soil finally vanishes completely, the ground dries out, and the permafrost border moves further north.

The thawing of Siberia's peat bogs, which has been happening for several years at an unexpectedly rapid pace, not only releases the carbon-dioxide that is captured inside of them, but also changes the soil composition. This process creates thermokarst, resulting in depressed areas and lake formation. The ground thaws to deeper levels and remains unfrozen longer than before.

Effects on the Economy

Researchers are already studying the effects of global warming, and specifically the thawing permafrost throughout the arctic region, on living conditions and the economy in Siberia. However, the public largely ignored these investigations for a long time – a situation that has only recently begun to change. It was not until 2005, when Judith Marquand (University of Oxford/England) and Sergey Kirpotin (University of Tomsk/Russia) reported on the increasing thaw of the permafrost soil in Siberia, that the issue began to receive broader media coverage. Independently, the Russian state's Federal Hydrometeorology and Environmental Observation Service (Roshydromet) in 2005 presented a "Strategic Forecast of Climate Change in the Russian Federation 2010–2015 and Its Impact on Sectors of the Russian Economy." It is the first report by a respected Russian institution to acknowledge the dangers from climate change by 2015 for human settlements, infrastructure, and the economy.

According to this report, some of the key current extraction areas for natural gas in Western Siberia and the future natural gas production regions on the Yamal Peninsula will be affected by thawing permafrost soil. The period during which the frozen ground can be traversed by vehicles will be reduced, making the development of new extraction areas more difficult. Buildings, traffic routes, and industrial facilities that are not anchored to sufficiently strong foundations will be threatened as the shifting ground endangers their structural stability. Likewise, oil and gas pipelines operating at high pressure could suffer damage. Pipelines and other oil and gas extraction facilities will require repairs more often. Pipelines constructed before 1990 are particularly likely to suffer disruptions. In the Arctic Ocean, the danger of icebergs will increase, threatening not only shipping, but also oil and gas drilling rigs. High waves and storms will occur more frequently, impeding shipping and therefore maritime supply lines.

Consequences

In order to minimize the consequences of the shrinking Siberian permafrost for the Russian economy, especially the energy industry, the existing infrastructure, such as mining facilities, pipelines, compressor stations, storage tanks, auxiliary buildings, and the roads and railways leading to the oil and gas fields, will need to be moored more firmly in the ground than is currently the case. New extraction and pipeline projects must be designed and built accordingly.

Pipelines can either be supported by struts driven into the frozen ground or designed as subterranean conduits. In the latter case, however, they must be insulated to avoid any further underground thaws. In both cases, the melting permafrost layer problem complicates construction plans. Investments for the projects in question will be higher than originally projected. Since the period in which ice roads can be traversed during the winter will be shorter, supplies will increasingly need to be flown in by aircraft. The builders of the Trans-Alaska Pipeline System have already had to contend with this problem. A 2003 study prepared by the U.S. Global Change Research Program (USGCRP) examining the consequences of climate change in Alaska state that:

> "Building on permafrost can incur a significant cost because it requires that structures be stabilized in permanently frozen ground below the active layer, and that they limit their heat transfer to the ground, usually by elevating them on piles. For example, to prevent thawing of permafrost from transport of heated oil in the Trans-Alaska pipeline, 400 miles of pipeline were elevated on thermosyphon piles (to keep the ground frozen), at an additional cost of $800 million. The pipeline was completed at a cost of $7 billion because of ice-rich permafrost along the route. This figure

> is eight times the estimated cost of installing the traditional in-ground pipeline.
> Breaks in the pipeline and other repair costs due to melting permafrost could become even more significant in the future. The near-term risk of disruption to operations of the Trans-Alaska pipeline is judged to be small, although costly increases in maintenance due to increased ground instability are likely. The pipeline's support structures are designed for specific ranges of ground temperatures, and are subject to heaving or collapse if the permafrost thaws. Replacing them, if required, would cost about $2 million per mile.
> Thawing of ice-rich discontinuous permafrost has already damaged houses, roads, airports, pipelines, and military installations; required costly road replacements and increased maintenance expenditures for pipelines and other infrastructure; and increased landscape erosion, slope instabilities and landslides. Because of melting permafrost, buildings already have been abandoned, including homes, a radio transmitter site near Fairbanks, and a hospital at Kotzebue, to name a few. The impact on subsistence communities has also been seen, is expected to increase, and is difficult to quantify in dollars. Alaska's warming climate has, for example, thawed traditional ice cellars in several northern villages, rendering them useless.
> Present costs of thaw-related damage to structures and infrastructure in Alaska have been estimated at about $35 million per year, of which repair of permafrost-damaged roads is the largest component. Longer seasonal thaw of the active layer could disrupt petroleum exploration and extraction and increase associated environmental damage in the tundra, by shortening the season for minimal-impact operations on ice roads and pads."

There may be some advantages from climate change to the Russian energy industry. Global warming will further reduce the freezing of the northern seas and will make maritime routes more easily navigable with and without icebreakers. It is likely that the northern sea route from the Atlantic to the Pacific will be ice-free for part of the year, and eventually all year round. This would allow oil and liquefied natural gas to be transported by tanker from the northern coasts of Russia west- or eastwards. Only short pipelines to the northern ports will be required, while the up to 5,000-km pipelines running from Western Siberia to Europe may not be overhauled after the end of their life cycle.

Nevertheless, the thaw of the permafrost ground is likely to increase the costs of natural gas and oil extraction in the very parts of Siberia where extraction is already expensive today. Since the price of natural gas in Europe is linked to the price of oil, and not to the extraction costs for gas, however, consumers will not notice the changing prices.

Should the price of oil, and therefore the price of natural gas in the European market, remain high, planned major projects for natural gas extraction in Russia will remain profitable and will proceed. However, Gazprom will exert even greater pressure to raise its gas prices to the European levels both domestically and in transactions with CIS customers.

As predictions regarding the outcomes of global warming remain uncertain at this point, the future amount of thawing in the permafrost layer can only be forecast to a limited extent. Both acceleration and delays of this process are possible. Should the consequences outlined above for Russia be confirmed, however, many more capital investments will be required to maintain or increase oil and natural gas extraction. Such expenditures will be forthcoming as long as oil and related natural gas prices remain at high levels.

Translated from German by Christopher Findlay

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About the Russian Analytical Digest

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