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.

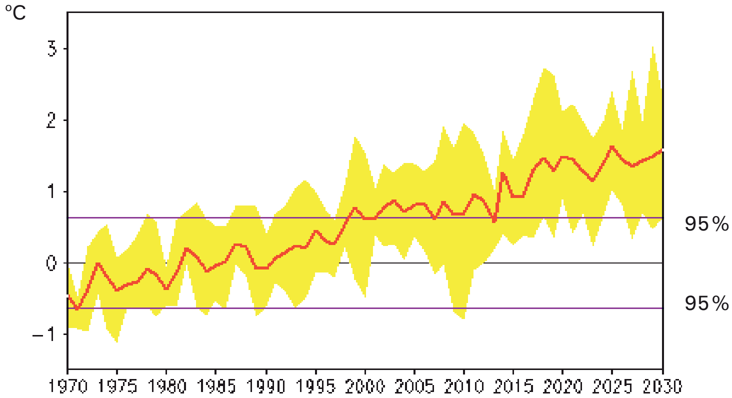
When the "active" layer melts in spring, the water cannot drain off because of the frozen ground below. The result is the formation of pools and lakes as habitats for plants that subsequently decompose. Because of the cold and wet climate, more humus is produced than can decompose, and peat is formed. 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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