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САХАЛИНСКАЯ ЭНЕРГИЯ
SAKHALIN ENERGY

ENVIRONMENTAL PROTECTION AT THE PRIGORODNOYE PRODUCTION COMPLEX

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Ph. D. Biology

INTERNATIONAL ENVIRONMENTAL COOPERATION

In the XXI century, the international community has been paying closer attention to the environmental protection issues, and a wide range of laws and declarations are passed to maintain the delicate balance between people and nature.

The modern system of international environmental protection began to form at the 1972 United Nations (UN) Conference in Stockholm. The environmental regulatory activities at national and international levels became more intensive after the event.

1992 saw the UN Conference on Environment and Development, also known as the Rio de Janeiro Earth Summit. It was attended by 108 heads of State or Government and more than 2400 representatives of non-governmental organisations. It was the largest environmental forum in the history of mankind. For the first time ever, the heads of states and governments of various countries agreed on how to address the most important global environmental problems. The Conference adopted the Agenda for XXI century (Agenda 21) on sustainable development, i.e. high quality of environment and sound economy for all the peoples of the world.

In 2000, the UN member states adopted the Millennium Development Goals (MDGs). One of those goals was to ensure environmental sustainability. Work on MDGs implementation was performed from 2000 till 2015. The countries participating in the MDG Programme found it successful and recognised the need for a new Agenda after 2015; for this reason, at the 2012 UN Conference on Sustainable Development it was decided to develop a set of Sustainable Development Goals (SDGs). SDGs are a system of global targets aimed at economic, social and environmental development issues planned for implementation by 2030.

On 30 April 2012, Dmitry Medvedev, President of the Russian Federation, recognising the importance of these goals, approved the 'Basic Principles of State Environmental Development Policy of the Russian Federation till 2030'. This document lists the governmental objectives in terms of environmental protection, as well as mechanisms for their implementation.

In May 2015, the Business and Climate Summit was held. The participants (over 130 countries including Russia) pledged to take the lead in decarbonising global economy, i.e. gradual transition to low-carbon fuels in the energy industry, and taking measures to reduce emissions.

In December 2015, the Climate Agreement was signed in Paris, which can be now regarded as historical. Before the conference, all 175 participant countries (the Russian Federation among them) accepted their national goals to reduce or restrict emissions of greenhouse gases for 2025–2030.

NATURAL GAS: ENVIRONMENTALLY FRIENDLY ENERGY SOURCE

From environmental point of view, natural gas is the cleanest natural fuel, since it generates much less harmful compounds rather than wood, coal, or oil when burning. Methane is the main component of natural gas, so its combustion products are carbon dioxide and moisture vapour. The same compounds are exhaled during breathing. At different natural gas fields, the content of methane can vary from 70 to 99%. Natural gas is not an isolated substance; it is a mix of various components. Normally, natural gas contains methane homologues[1]: ethane, propane, butane, and small quantities of heavier hydrocarbons. In addition, gas may contain nitrogen, carbon dioxide, and helium. Very often gas contains hydrogen sulphide or mercaptans, its organic derivatives.

Natural gas is odourless. So why can people smell it when there is a leak in an apartment? For the sake of our safety, household gas fuel contains odorants[2], special additives that can be felt immediately by human nose even in the tiniest concentration. Mercaptans are normally used for this purpose, because they are so malodorous that you cannot fail to notice it. Humans can smell this compound even in the amount of two trillionths of a gram!

Mercaptans occur in nature, too, mainly in proteins putrefaction products. Skunk's scent glands generate butyl mercaptan, which is one of the most malodorous substances existing in the nature.

[1] Homologues are substances of the same class, with similar composition, structure and properties, but differing by one or several groups.

[2] Odorants are substances added to gas for a specific odour.

Coal and oil consist of more complex organic compounds with larger volume of carbon, as well as more nitric and sulphurous components. This means that burning coal and oil generate more harmful emissions, including higher volumes of nitrogen oxides and sulphur dioxides. Moreover, when burning, coal and oil produce ash in the form of small particles that do not burn out and pollute the environment. On the contrary, burning natural gas generates smaller amounts of nitrogen oxides, sulphur dioxide, soot, and virtually no ash particles. Furthermore, the amount of greenhouse carbon dioxide emitted when burning natural gas is minimal; that is why natural gas is called 'green fuel'. If we compare natural gas to coal, the amount of carbon dioxide emitted into atmosphere from burning coal to produce one unit of energy is by 67% greater than that emitted from burning the same amount of natural gas.

Natural gas is primarily used as a source of energy. It easily enters into the chemical reaction of combustion. That is why it is typically used for generating electrical and thermal energy. Due to the benefits of natural gas as an energy source, over 90% of all produced gas is consumed as fuel at power plants, industrial enterprises, and in households. Fuel gas has distinct advantages when compared to oil and even more compared to coal: it has high calorific capacity; it can be delivered to any consumer through a system of gas pipelines; it leaves no ash when burning. Furthermore, gas can be used in producing fertilisers, fuels, paints, and many other products.

Liquefied natural gas is even more environmentally friendly, because it undergoes additional purification before liquefaction. After the impurities have been removed, natural gas is cooled down to its dew point temperature (-161.5°C) when it turns into a fluid called liquefied natural gas (LNG). When liquefied, the gas volume decreases 600 times; it is one of the main advantages of this technology, as it allows transporting LNG by sea, railway, and trucks.

SAKHALIN-2 PROJECT

Sakhalin Energy Investment Company Ltd. (Sakhalin Energy) is the operator of the Sakhalin-2 project; it conducts its activities in strict compliance with the environmental laws of the Russian Federation and takes into account international standards and best practices in the oil and gas industry.

Sakhalin-2 is not only the largest integrated oil and gas project, but also one of the most complex oil and gas projects ever implemented in terms of engineering. The project involved the construction of modern infrastructure including three offshore platforms, the offshore pipeline system, the trans-Sakhalin pipeline system, the onshore processing facility (OPF), gas transfer terminals (for gas transfer, including for gasification of the Sakhalin Oblast), the oil export terminal (OET), and the first LNG plant in Russia.

ENVIRONMENTAL PROTECTION

Sakhalin Energy has been certified in accordance with ISO 14001 standard (International Organisation for Standardisation). ISO 14001 is acknowledged all over the world and can be applied to any company in any industry. This standard was developed by the International Organisation for Standardisation and is based on two principles: compliance with regulatory requirements and continuous improvement.

ISO 14001 certificate confirms that the company's environmental management system has been checked for compliance with the best practices covered by the standard. The document is issued by an independent certification authority to acknowledge that Sakhalin Energy is actively taking measures to minimise the impact of production processes on the environment.

Planning and conducting industrial environmental control, local environmental monitoring, and biodiversity conservation are the key aspects of the environmental management system. The company's environmental activities are based on the principles of risk management and environmental impacts mitigation according to the 'prevent − reduce − recover − compensate' hierarchy.

Industrial environmental control and local monitoring help assessing the impact of production facilities on the environment and develop measures for impact mitigation and rational resource use.

THE PRIGORODNOYE PRODUCTION COMPLEX

The Prigorodnoye production complex is one of the assets within Sakhalin-2 project operated by Sakhalin Energy; it includes the LNG plant and the OET.

The OET, as well as export pipeline and a tanker loading unit (TLU), are situated eastwards of the LNG plant; they have common control systems located at the central control room, and support systems located at the production complex site.

Oil is delivered to the OET from the Piltun-Astokhskoye field by the trans-Sakhalin pipeline system. At the OET, it is mixed with condensate from a gas fractionation unit. After mixing, the oil is transported to storage tanks, vertical cylindrical steel tanks with a floating roof. The capacity of tanks is about 95,000 cubic metres each. By a sub-sea pipeline, oil is supplied from the storage tanks to the TLU, which is located 4.8 kilometres away from the coast, and functions as a single-point mooring. Water depth in the TLU area is about 30 metres. The TLU can service oil tankers with a capacity from 40,000 to 150,000 cubic metres. Depending on the tanker capacity, loading operations last from 14 to 24 hours.

The LNG plant comprises two parallel production trains and general service facilities. The plant facilities layout allows for the plant expansion.

The production trains process and liquefy the gas delivered from the Lunskoye field. LNG is produced using the double mixed refrigerant technology developed by Shell. This technology is applied only at the Prigorodnoye production complex; it was designed specially for the Sakhalin LNG plant to ensure maximum LNG production during severe Sakhalin winters. Natural gas is cooled in two cycles: pre-cooling with mixed refrigerant, and in the main cycle. The novelty of this technology is in using a cycle with mixed refrigerant which is composed of light hydrocarbons, mainly ethane and propane mix. By varying its composition from winter to summer, it is possible to control LNG production volume, taking the advantage of cold climate.

The general service facilities of the Prigorodnoye production complex include nitrogen production units, water and wastewater treatment plants, flare unit, and gas turbine generators for electric power supply.

After liquefaction, LNG is stored in two tanks with the capacity of 100,000 cubic metres each. LNG is stored in the tanks until an LNG carrier arrives. LNG is loaded on the vessels via a special 805 metres long jetty. The depth at the jetty's mooring wall is 14 metres. The LNG jetty is designed for LNG carriers with a capacity from 18,000 to 145,000 cubic metres. Loading takes from 6 to 16 hours.

AIR QUALITY CONTROL

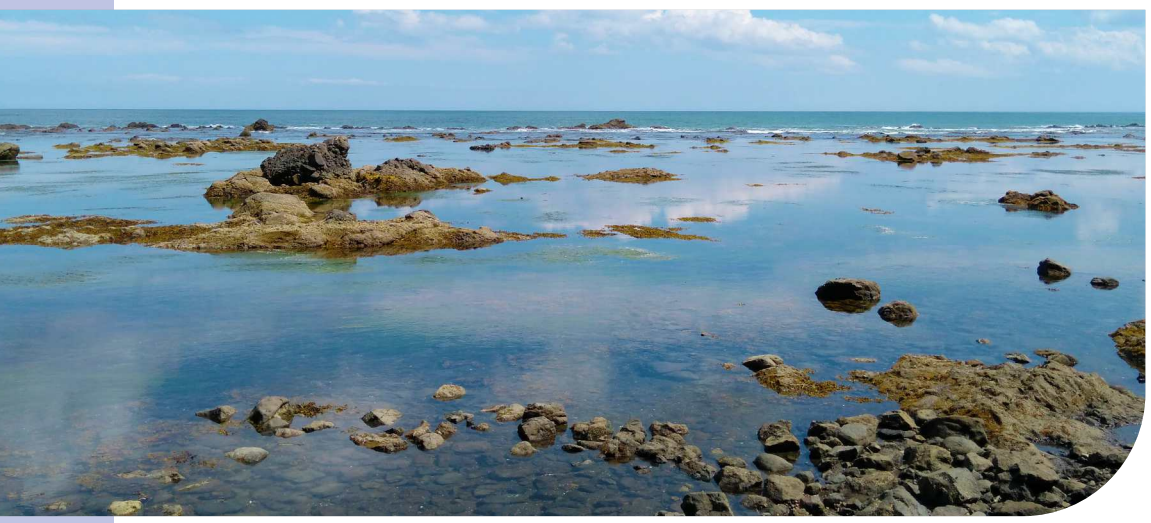
The main sources of atmosphere emissions at the Prigorodnoye production complex are a flare unit, gas turbines, an acid gas incineration unit, boilers, and standby diesel generators. The flare unit is an integral part of any oil and gas production facility. It is a kind of safety valve of the plant. Flame always burns on the flare unit (pilot burners). This means that the production complex is in normal operation. Average height of the flame in regular mode is 3-5 metres. Pilot burners ensure continuous ignition of gas on the top of the flare stack (flare tip) in case it is necessary to release gas from the process facilities. Gas is released in emergency situations or during commissioning, when it is necessary to reduce the pressure within the process facilities. In such cases, smoke emission and flame height change on the flare unit are possible. The reason for smoke emission is that there is not enough time for full combustion of gas components, since the gas is supplied to the flare unit under high pressure.

At earlier LNG plants, so called cold vent was used: in emergency situations or during repair works, the gas was simply released directly into the atmosphere. As natural gas consists mainly of methane, ethane and propane, which are very light gases, they quickly rose to the upper atmosphere and formed an additional layer there. Greenhouse effect of methane released in such a manner is 25 times higher than during its combustion when carbon dioxide is generated. Moreover, under certain weather conditions, heavier components of natural gas can accumulate in terrain depressions and form potentially explosive clouds. State-of-the-art technology of gas flaring at the Prigorodnoye production complex is more environmentally friendly; as it is less harmful compared to non-ignited gas release in atmosphere, and it is safer because there is no risk of explosive clouds accumulating at the ground level.

The main emissions from flaring are carbon dioxide, carbon monoxide, nitrogen oxides, methane, soot, and water vapours. No heavy metals or toxic compounds are formed when natural gas is flared. Flaring does not affect the amount of oxygen in the atmospheric air. The height of the flare unit (125 metres) was specially designed for better dispersion of combustion products in the atmosphere. The flare unit employs a system of fuel gas supply to the flare tip and enhanced mixing of released gas with atmospheric air, which facilitates gas combustion in a low-soot mode. On the top of the flare burner, there are specially designed tips that ensure better combustion of natural gas and, consequently, lower content of carbon monoxide and nitrogen oxides in the emissions.

Gas turbines generate electric power for the production complex and actuate the main compressors in the process trains. They are situated both in the general service area and in the production trains.

The turbines are run on the natural gas supplied by the pipeline. They are equipped with special burners suppressing nitrogen oxidation, which reduces the emissions containing nitric compounds. Nitrogen oxides emission from standard gas turbines amount to 100-300 ppm (parts per million), while the burners suppressing nitrogen oxidation reduce this amount to 10-25 ppm.



Before liquefaction, natural gas is treated to remove acidic components and certain hydrocarbons, which are disposed at the acid gas incineration unit.

The boilers (water heaters) are run on fuel gas; however, the technology allows using diesel fuel as well (but only when fuel gas is unavailable). The boilers are used for heating administrative buildings and treatment plants. Standby diesel generators are used for supplying electric power to critical equipment in case of blackouts.

All process facilities at the Prigorodnoye production complex, including the flaring system, are operated in accordance with the design documentation and the permit for air emissions issued by the state authorities.

According to the "Industrial emissions control programme", Sakhalin Energy performs regular monitoring of the impact that the Prigorodnoye production complex has on the air quality. Samples are taken quarterly to control the air quality at the boundary of the sanitary protection zone, monthly under the flare monitoring and during warm season, on the territory of dacha plots located in the vicinity of the complex[3].

The results of monitoring show that the emission of pollutants during the Prigorodnoye production complex operation do not exceed the limits established for allowable impact on the air.

[3] From May till October monitoring is carried out at the Stroitel' dacha cooperative territory.

WATER QUALITY CONTROL

Sakhalin Energy strives to reduce water consumption for production purposes and to minimise environmental impact caused by wastewater discharge.

Using water for process equipment cooling can result in significant water consumption. For this reason, unlike many other similar plants, the Sakhalin LNG plant employs air cooling system.

The plant is supplied with water from an independent water supply system, which does not affect Korsakov municipal water supply system. Water is produced from four water wells located about six kilometres away from the production complex. The independent water supply system serves all the needs for potable, firefighting and service water.

Water used for household purposes at the production complex (cooking, washing up) is filtered and chlorinated.

Service water undergoes preliminary desalination and then is used for various production needs of the Prigorodnoye production complex, mainly for mechanisms' operation and cleaning. Desalination is a process of removing dissolved salts and mineral substances from water. The objective is to prevent scale build-up in the equipment operating with service water and at high temperatures.

All wastewaters from the Prigorodnoye production complex are purified at a wastewater treatment plant to required standards before they are discharged into Aniva Bay. There are four different systems for wastewater collection and treatment at the Prigorodnoye production complex:

1. Collection and treatment system for potentially contaminated storm water. The system is located on the territories where there is a potential risk of oil products spill, such as a refuelling station. Probability of such spill is very low; nevertheless, the system is in place. In case of oil products spill, contaminated water will be collected in special concrete pits. Next, truck tanks with vacuum pumps will pump the water from these pits and transport it to the treatment plant where oil products are removed from the storm water. There are several stages of wastewater treatment at this plant. Since oil products are lighter than water, they accumulate on the surface and form a film. The oil film is removed from water surface with special tools called skimmers, and then collected and disposed in accordance with the Russian Federation legislation.

The second stage of treatment is fine impurities removal. This is done by pollutants sedimentation, i.e. water is left for settling. After some time, the pollutants start settling on the bottom.

The next stage of treatment is removing the finest suspended matter. After settling, water is exposed to electric current, which makes it bubble. Gas bubbles move from bottom to top and carry the remaining pollutants to the surface where they are collected with a skimmer.

2. The collection and treatment system for wastewater potentially contaminated with oil products is designed for collecting drainage water from the production train areas and parking lots. Water quality is monitored. If the presence of oil products is detected, the water is pumped to the process wastewater treatment plant to remove oil products. If there are no oil products in the wastewater, it is discharged to the oil-free wastewater collection system.

3. The oil-free wastewater collection system is a network of open drain ditches located in the areas free from oil products. Natural terrain makes the storm water flow through these ditches into the pond with water for fire-fighting needs. If necessary, this water can be used for firefighting, so the pond is always full. Excessive clean storm water is discharged into Aniva Bay.

4. Domestic wastewater treatment system is designed for collecting sewage wastewater from the main administration building, canteen and workshops located at the Prigorodnoye production complex. Wastewater is delivered to the treatment unit where it is fully purified using bacterial treatment and UV disinfection. Chlorine contained in the wastewater volatilises, and the residual chlorine is simply 'consumed' by organic compounds present in the water. Thus, chlorinated water is not discharged into Aniva Bay.

Wastewater quality is monitored monthly by both the laboratory of the Prigorodnoye production complex and third-party certified laboratories.

The laboratory of the Prigorodnoye production complex is certified in accordance with the Federal Law No. 412 'On Accreditation within the National Accreditation System' dated 28 December 2013. Competent personnel of the laboratory test the wastewater quality by a number of parameters, using advanced equipment. The test parameters include the following:

• Biochemical oxygen demand (BOD) is a natural water and wastewater quality index. It shows the quantity of organic matter that could be consumed by microorganisms present in water. For example, if BOD index of wastewater is high, it means that the water is dirty that may reduce the concentration of oxygen essential for aqueous flora and fauna. The efficiency of the wastewater treatment plant at the Prigorodnoye production complex in terms of this parameter is 95 to 99%. For instance, after treatment, the BOD of wastewater lies in the range from 0.665 mg/l to 2.11 mg/l, which is less than maximum permitted concentration of 3 mg/l. This means that there is no negative impact on the water bodies.

• Suspended particulates reflect water transparency. High concentrations of suspended particulates can pose direct mechanical impact on microorganisms, cause water turbidity, and obstruct light penetration. This inhibits photosynthesis in plants and has a negative effect on fish feeding. Background concentrations of suspended particulates in Aniva Bay before the Prigorodnoye production complex construction was 5.4 to 7 mg/dm³. Average values of actual concentration of suspended particulates after wastewater treatment do not exceed 1.9 mg/dm³.

• Hydrogen value, or pH value. Water is neutral when its pH value is equal to 7.0. For natural water, this value normally varies within the range of 5.0 to 8.5. Seawater pH exceeds 7.0 due to hydrocarbo-nates, and river water pH is less than 7.0 due to humic acids. This parameter is very important for aqueous flora and fauna. For instance, if seawater pH falls below 7.0, the growth of skeletons in marine organisms will be impeded, because carbonates deposition will be impossible. That is why all parameters of wastewater including pH index are strictly controlled. The pH value of the wastewater from the Prigorodnoye production complex is 6.5 to 8.5, which meets the requirements set for Aniva Bay.

The pattern of hydrochemical parameters content and distribution shows that Aniva Bay water area near the Prigorodnoye production complex can be categorised as clean water body with high concentration of oxygen dissolved in water.

Thanks to high efficiency of the treatment facilities at the Prigorodnoye production complex, the level of pollutants content in the purified wastewater is much lower than the maximum permitted concentration level set for Aniva Bay.

SOIL AND GROUNDWATER

Soil monitoring helps keep track of soil processes, detect potential accumulation of pollutants, identify causes of negative changes, and develop relevant measures to prevent or mitigate impacts. As early as at the pre-commissioning phase, when the flaring system was put into operation, background condition of soil and vegetation cover was assessed within the four kilometre zone around the LNG plant, and sites for further monitoring were set afterwards. Soil monitoring around the Prigorodnoye production complex began in 2008 and was performed by specialists from the Moscow State University named after M. V. Lomonosov. There are twelve permanent sampling sites in the vicinity of the complex, and seven sites on the territory of the Prigorodnoye production complex.

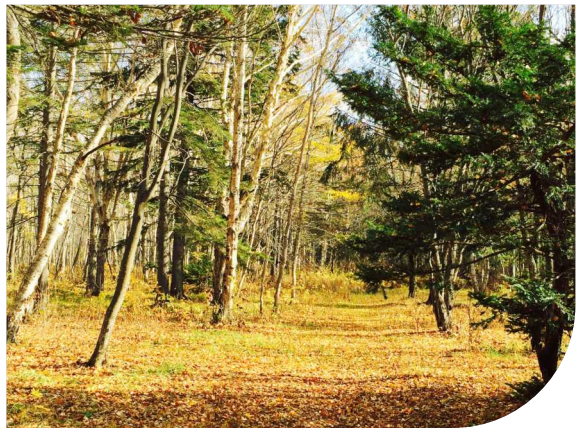
The monitoring sites within the four kilometre zone around the Prigorodnoye production complex are located on the territory of the State Forestry Fund. Environmental quality standards for this type of lands have not been developed[4] in the Sakhalin Oblast and in the Russian Federation. So far, only hygienic norms have been approved, which are applied to agricultural lands, residential areas, protected zones of potable water supply sources, sanatoria and resorts. Assessment methodologies for the above types of land involve sampling of topsoil, which is 20-25 centimetres thick. Although the soils around the production complex do not belong to any of the above categories, and there are no regional environmental standards, above hygienic standards are used as conventional assessment criteria.

[4]As of the date of publication, 2017.

Soil monitoring comprises periodic observation of soil condition and chemical composition. Physical and chemical properties of soils, as well as concentrations of pollutants, are monitored. Based on the resulting data, current condition of soils can be assessed, and causes and sources of variations in the soil cover can be detected.

Samples are taken by 'envelope method', i.e. at five points − in the centre and on the corners of a sampling site. The samples are tested for the following quantitative parameters: acidity, grain-size composition, humus content, nitrate nitrogen, labile phosphorus and potassium, oil products, and benz(a)pyrene.

The results of monitoring in the Prigorodnoye production complex area show that the concentration of benz(a)pyrene (which is a key indicator of possible contamination) in the 0-25 centimetres soil layer is negligible (<0.005 mg/kg on average); it is at the lower limit of detection according to the method used in line with the GOST (specified value for topsoil is 0.02 mg/kg).



Groundwater monitoring is carried out at 16 monitoring wells at various depths. There are five wells outside the production complex fencing; two of them are on the eastern side, one on the northern side, and two on the western side; one well is located on the territory of Prigorodnoye port. The rest of the wells are located on the territory of the production complex.

Groundwater samples are taken from all wells two times a year, after snow melting in spring and after rain floods in autumn. Activities at wells including water level and temperature measurements, as well as wells cleaning and maintenance (if required), are performed by a contractor competent in hydrogeology. Water samples taken from the wells are delivered to a certified laboratory for testing. Based on the data obtained, the contractor prepares special reports describing the current condition of groundwater, variations and trends, as well as analysis of data compared with the previous years of monitoring.

The results of groundwater condition monitoring do not give any cause for concern; water level variations lie within the ranges of levels fixed in previous periods of monitoring; no extreme deviations have been detected. Chemical contamination has not been detected either. Generally, the groundwater situation can be described as stable, which is the evidence of efficient measures for soils and groundwater protection undertaken at the Prigorodnoye production complex.

FLORA AND VEGETATION

Vegetation is one of the most important components of biota, which determines the area appearance and plays a significant role in all natural processes. Vegetation prevents river banks and hill-side scouring as well as soil erosion; it affects the atmosphere, waterways, lakes and swamps, underground water, and wildlife. Plants are sensitive to environmental changes caused by both natural phenomena and human-induced impacts.

Background studies of flora (primarily, of protected species of plants, lichens and fungi), as well as plant communities, started at the Prigorodnoye production complex area as early as in 1990s with participation of specialists from Sakhalin Botanical Gardens of the Far-Eastern Branch of the Russian Academy of Science (FEB RAS), and were continued in early 2000s by researchers from the Far-Eastern State University (Vladivostok). During the background studies, 313 species of vascular plants relating to 215 genera and 80 families were found, which is 20.5% of the total number of species inhabiting Sakhalin Island.

Monitoring of plant communities is carried out annually within the frames of the industrial environmental control and local monitoring system of Sakhalin Energy. The main objective of monitoring is to assess current condition of flora and vegetation in the area potentially affected by the Prigorodnoye production complex. The monitoring is performed on permanent sample sites covering the most typical plant communities of this region. The sample sites are situated in five main directions (west, north-west, north, north-east, and east) one to four kilometres away from the Prigorodnoye production complex. Furthermore, there is a network of sample sites in dark coniferous forests where protected Sakhalin spruce is dominant; these sample sites are located on the territory of the Korsakov Spruce Forest natural monument, as well as outside it, at a considerable distance from the LNG plant (these are so called background, or reference sample sites). There are a total of 21 sample sites in the area. The sample sites are used to monitor the species composition and structure of plant communities, plant development phases, and the condition of rare and protected species populations. Generally, the diversity at the sample sites fully reflects the natural diversity of vegetation cover in the study area.

The protected species observed in the vicinity of the Prigorodnoye production complex include woody plants such as Sakhalin spruce, Japanese yew, Japanese angelica tree; herbaceous flowering plants such as Aralia cordata, Liparis sakhalinensis Nakai, woodland peony (Paeonia obovata), Trillium tschonoskii, large-flowered cypripedium (Cypripedium macranthos); and lichens such as lungwort (Lobaria pulmonaria) and Menegazzia terebrata.

Studies of locations of protected vascular plant species show that they are in good condition, and the integrity of these areas is not damaged. Some epiphytic lichens, including protected species, are affected to some extent, which has been originally caused by microclimate disturbance (stronger light and wind, dusting due to soil exposure) in the period of the company's assets construction. On the other hand, almost all of the sample sites showed rudiment young thalluses[5] alongside with the older thalluses, which indicates the restoration of the lichen cover.

The results of monitoring are indicative of species composition stability on the sample sites in the vicinity of the production complex. Insignificant variations in the number of trees in some areas are caused by natural factors, such as dying of old trees and transfer of trees from the undergrowth to the adult layer. Subordinate layers, i.e. shrubs, dwarf shrubs, and herbs, remain in good condition. Species composition of layers has not changed on any sample sites.

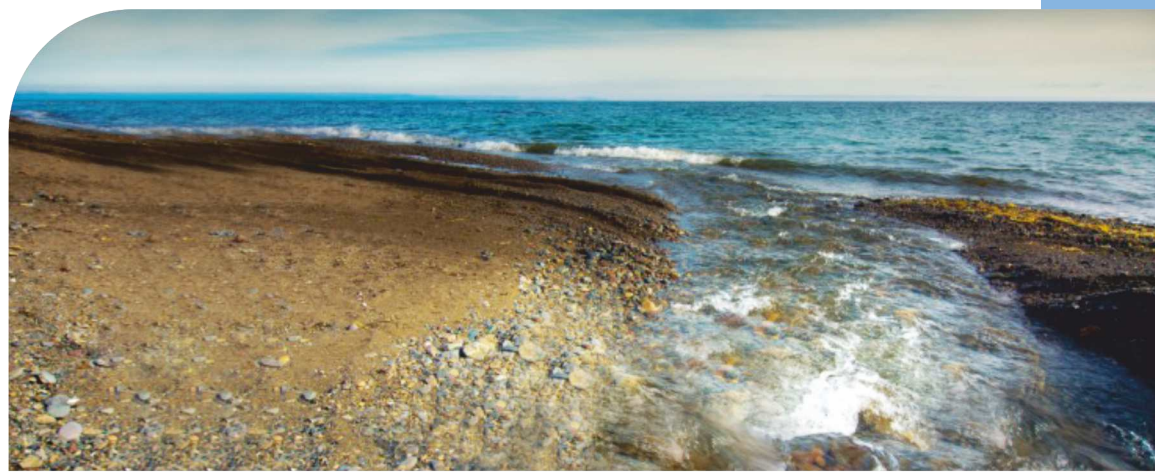
[5] Thalluses (from Greek thallos, meaning “young branch”) are bodies of plants not divided into organs, e.g. algae, fungi, lichens, and some mosses.

RIVER ECOSYSTEMS

Environmental monitoring of river ecosystems is a part of comprehensive environmental monitoring of watercourses in the area potentially affected by the Prigorodnoye production complex. The monitoring is performed with participation of specialists from the Sakhalin Research Institute of Fisheries and Oceanography (SakhNIRO), which has been assessing the humpback salmon resources, forecasting potential yield, and recording the catching since 1947.

The objective of this study is to assess the condition of spawning grounds and reproduction of Pacific salmons, as well as the quality of surface water and bottom sediments in the Mereya River and the Goluboy Brook during the Prigorodnoye production complex operations. Studying bottom sediments is very important in terms of river bed formation and its change over time. According to bottom sediments analysis, the bank of the Mereya River in this area is relatively stable, and the composition of bottom sediments is homogeneous.

The Goluboy Brook flows on the territory of the complex and divides it into 'oil' and 'gas' parts with the green protection zone; it is a kind of landmark of the Prigorodnoye production complex. The brook is about six kilometres long; it springs from the western slope of the Yunona mountain ridge and flows into Aniva Bay 15 kilometres eastwards of Korsakov. Ichthyic fauna of the brook is represented by typical species, such as humpback salmon, cherry salmon, East Siberian char, Dolly varden char, rainbow smelt, Pacific redfin, etc.



When the construction of the Prigorodnoye production complex started, the part of the brook located on the territory of the complex became a poaching-free zone.

Generally, the environmental monitoring of the Mereya River and the Goluboy Brook did not reveal any effect of the Prigorodnoye production complex on the quality of surface water, its flora or fauna. From the start of construction in 2003 till present, Pacific salmon continue entering the Mereya River and the Goluboy Brook for spawning. Furthermore, the location of the Goluboy Brook in the protected area which is not accessible for poachers has contributed to steady indicators for both humpback salmon arrival for spawning and the subsequent fry migration, which is confirmed by the results of monitoring performed by SakhNIRO.

MARINE ECOSYSTEMS

Sakhalin Energy performs comprehensive environmental monitoring in the area of the production complex offshore facilities located in Prigorodnoye port water area in Aniva Bay. The water area adjacent to the plant is studied by specialists from SakhNIRO, RosHydroMet (Agency on Hydrometeorology and Environmental Monitoring) departments, the Institute of Marine Biology of FEB RAS, etc. The studies are focused on wastewater discharge areas and places where oil tankers and gas carriers moor, i.e. the TLU and the LNG jetty. The comprehensive monitoring programme includes visual observations of sea surface, as well as sampling of water, bottom sediments, and biota. The latter is a community of plant, animal and microorganism species inhabiting a particular water area.

Concentrations of pollutants measured in the sea water are consistent with the concentrations that had been identified before the beginning of the production complex operations; their average values are considerably lower than the maximum permissible concentrations.

The underwater world of Aniva Bay coastal area is rich in terms of both composition and the number of marine inhabitants. Species composition and quantitative characteristics of phyto-, zoo-, and ichthyoplankton (organisms passively carried by sea currents) in Aniva Bay near the Prigorodnoye production complex are typical of the Far-Eastern seas. Since the port water area is open, there were no specific features found in the structure and distribution of plankton organisms.

The data on species composition and quantitative distribution of macrobenthos (organisms larger than 2 mm inhabiting the bottom) in the Prigorodnoye production complex area also correspond to the materials obtained by different researchers in previous years. Two bottom communities have been identified in the studied water area; one of them is represented by bivalved molluscs and large polychaetes. The other community is represented by large holothurias, sipunculoids, sea urchins, and bivalved molluscs.

Distribution of bottom communities has a mosaic pattern and depends on characteristic distribution of depths and types of bottom sediments. The mosaic pattern ensures more complete and efficient use of different types of habitats, as well as food resources.

Within the period of the Prigorodnoye production complex operation, no significant changes in the species composition, quantities or structures, or in the distribution of plankton and bottom communities have been found in the studied area of Aniva Bay.

SAFETY OF HYDROCARBONS TRANSPORTATION AND BALLAST WATER MONITORING

Natural gas liquefied within the Sakhalin-2 project is transported by special vessels, or LNG carriers. LNG carriers are built in accordance with the latest requirements for safety in the LNG industry, and meet the most stringent international and national maritime standards. Within the Sakhalin-2 project, LNG is transported either by buyers' vessels or by LNG carriers built specially for the project and chartered on a long-term basis.

Oil is transported by oil tankers chartered by the company on a long-term basis. Oil is loaded from the TLU located in Prigorodnoye port.

All oil tankers and LNG carriers have double hulls, which nearly eliminates the probability of environmental damage in case the vessel's outer hull is damaged.

The vessels are equipped with the latest state-of-the-art facilities ensuring reliable and safe navigation; this is not the only measure taken to minimise risks during hydrocarbons transportation within the Sakhalin-2 project. The vessels employed for the project comply with all industrial and environmental safety requirements.

Prigorodnoye port applies a full range of measures aimed at port operations safety. For instance, there are four powerful ice-strengthened sea tugs in Prigorodnoye port, which ensure safe mooring operations for tankers and LNG carriers. Both oil and LNG terminals are equipped with electronically controlled automatic shutdown systems to stop loading operations in case of emergency. This way, the probability of oil spills is brought down to a minimum.

Based on Sakhalin Energy's experience gained over the years of the Sakhalin-2 project implementation, competence of its contractors, high requirements for vessels transporting oil and LNG, it is fair to say that the company has taken all possible measures to prevent Aniva Bay contamination.

The monitoring programmes carried out by Sakhalin Energy include monitoring of ballast water from tankers, as well as plankton and benthos monitoring in the littoral communities of Aniva Bay near the Prigorodnoye production complex. This programme was purposely developed to prevent negative impact on the ecosystem of Aniva Bay.

Every year, over 200 oil tankers and LNG carriers arrive at Prigorodnoye port from various worldwide ports (Japan, South Korea, China, Taiwan, etc.). International experience shows that the ballast water taken in those ports may contain dangerous invasive (alien, unusual in this region) plants and animal species.

Ballast water is loaded on a tanker in a port of departure in order to maintain vessel's navigability (vessel trimming and stabilisation) when cruising to a port of destination. Ballast water is very important for vessel's safety and stability. When hydrocarbons are loaded on a tanker, the ballast water is discharged in the port area.

Sakhalin Energy has developed the ballast water management system. First, all tankers transporting cargoes from Prigorodnoye port have separate tanks for ballast water, which fully prevents its contamination with oil products. Second, according to the approved rules, all tankers must change their ballast water in the open sea on the way to Prigorodnoye port. Changing ballast water in the open sea is an efficient measure to prevent alien species invasion. To control the compliance with this requirement, each vessel is subject to documentary inspection. In addition, express test of physical and chemical parameters of ballast water is performed, and discharge in Prigorodnoye port is permitted only after the confirmation of reballasting. From April till November, when the risk of invasive species drift and adaptation is especially high, samples of phyto- and zooplankton are taken from each vessel for analysis, including for the presence of potentially dangerous species.

The results of perennial monitoring indicate that there are no dangerous invasive species in the ballast water of tankers entering Prigorodnoye port. This means that the company's internal regulations are duly followed, and the requirements of the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM) are observed. This Convention was developed by the International Maritime Organization and put into effect in February 2004. The Russian Federation joined the International Convention in 2012.

The environmental monitoring aimed at the assessment of flora and fauna condition in the coastal zone of Aniva Bay has been conducted since 2007. It includes sampling and analysis of phyto- and zooplankton, ichthyoplankton, seabed organisms, fouling from berthing facilities; their species diversity, seasonal variations in abundance and biomass, and spatial distribution over the surveyed water area are investigated.

Thanks to the perennial monitoring of Aniva Bay, the researchers could study its flora and fauna more extensively. Over 600 species of phytoplankton, over 90 forms of zooplankton, about 40 species of ichthyoplankton, and 160 benthic species have been identified. New species of plants and animals have been found and identified, which had not been registered in the bay before, but can be related to the category of local inhabitants by their biogeographical and ecological characteristics. No alien species have been observed in the water area of Prigorodnoye port. The monitoring results prove that the current control measures are highly efficient.

BIRDS



Monitoring studies of ornithofauna have been carried out at all phases of the Sakhalin-2 project and include registration of birds both on the land plot and in the adjacent sea area within 4–6 kilometres from the Prigorodnoye production complex boundaries. To obtain high-quality data from ornithofauna surveys, it is essential to meet the following conditions: works should be carried out only within certain time covering the short nesting period (May – June); registration methodology should be followed; and ornithologists should be highly competent.

So far, 127 species of birds have been registered in the Prigorodnoye production complex area, with 23 protected species among them. The following rare species listed in the federal and regional Red Books were observed in the area of the Prigorodnoye production complex: Japanese snipe, white-tailed eagle, Japanese lesser sparrow hawk, reed bunting, Temminck's cormorant, mandarin duck, and others.

Japanese snipe, a typical inhabitant of open spaces, plays an important role in the ornithocomplexes around the Prigorodnoye production complex. This species was chosen as a basic monitoring object, because it is the only abundant species in this territory listed in the Red Book of Russia and in the Red Book of Sakhalin.

Japanese snipe can be hardly not noticed when, having arrived in the middle of May, the males start courting in the nesting areas: they rise to some height and then swoop down, with their tail feathers producing a drumming sound. Due to good noticeability of Japanese snipe, it is possible to quickly detect virtually all nesting pairs in the study area. The results of perennial monitoring of this species showed a positive upward trend in its abundance, which is explained by the fact that new meadow areas appropriate for nesting have appeared after construction and reinstatement works at the Prigorodnoye production complex were completed. The birds started to occupy the territories which they had not used before. Preservation of the Goluboy Brook floodplain on the territory of the complex also facilitated preservation of Japanese snipe's habitats, as its nesting areas include grassy meadows in the lower course of the brook.

Composition of bird species observed around the production complex is quite rich. In adjacent territory, forest birds have been registered, such as tits, nuthatches, warblers, woodpeckers, thrushes, and buntings. Meadows are inhabited by sky lark, Shrenk's warbler, and stonechat. During tidal fall, the coastal area and the Mereya Lake located in the coastal lagoon in the Mereya River mouth are used by aquatic and semiaquatic birds for rest and feeding. In shallow water areas, one can often see a common heron watching out for prey. Various species of sandpipers also feed there, and during migration periods, these areas serve as stopover resting places for river ducks, such as teals, mallards, pintails, etc.

New engineering facilities have attracted the birds who actively use buildings and structures for nesting or safe rest. Tree sparrows, fork-tailed swifts, and black-backed wagtails make their nests in the plant buildings. Berthing facilities turned out to be attractive for marine birds. In summer, cormorants and black-tailed gulls rest on loading units. During migration period, this area is occupied by gatherings of kittiwakes, slaty-backed and common gulls. In the water area adjacent to the sea coast one can observe migrating grebes, loons, guillemots, auklets, harlequin ducks, long-tailed ducks, scoters, and black scoters.

Ornithofauna was compared at different phases of the Sakhalin-2 project, and the results showed that the area of the Prigorodnoye production complex is still used as a resting place by migratory marine, aquatic, and semiaquatic birds.

SMALL MAMMALS

Small land mammals including mouse-like rodents (mice, voles) and insectivores (shrews) play an important role in natural ecosystems. They are the main food objects for many predators and birds of prey (foxes, sables, minks, owls, hawks, etc.). People consider them primarily as crop pests and carriers of dangerous zoonotic diseases.

Unlike other mammals, rodents and shrews have high reproduction rates; they are able to quickly increase their abundance in the end of reproduction season; they are notable for perennial cyclic fluctuations in abundance, as well as for complete change of population within a year, which makes them a convenient object of environmental studies. Response of small mammals to pollutions from industrial facilities consists in community restructuring, lower reproduction rate, and variations in external morphological parameters.

Monitoring of small mammals has been implemented in the area of the Prigorodnoye production complex since 2008. Monitoring sites are set in the eastern, western, and northern directions, a kilometre away from the production complex (potentially affected zone), and 3 to 6 kilometres away (reference sites).

Within a few years, five species of rodents and six species of shrews were found on the monitoring territory.

The most abundant species, which form the basic population of small mammals, are northern red-backed vole, grey-sided vole, long-clawed shrew, and Laxmann's shrew. As for rare and scarce species, least Siberian shrew, long-tailed birch mouse, and Shikotan vole have been observed on the sites.

The analysis of abundance, community structures, sex and age composition, reproductive status, and general vital activities of small mammals on the test and reference sites has not revealed any obvious deviations from normal.

ANIMAL HOSPITAL

Pursuant to its commitments on biodiversity conservation and best international practices, Sakhalin Energy has been supporting the programme of personnel training in wildlife rehabilitation, in particular, oiled birds rescue, since 2005. This programme was developed in cooperation with the International Fund for Animal Welfare and the International Bird Rescue Research Centre, with a focus on specifics of flora and fauna in severe climate of Sakhalin. About three hundred people have passed the training since the programme was initiated. Apart from the company's employees, they included representatives of other organisations, for example, specialists from the Centre of Rescue and Ecological Operations, contractors' personnel, students of the Sakhalin State University, veterinarians, and other stakeholders. At the same time, the equipment necessary for both animals and birds scaring, and for the future Wildlife Rehabilitation Centre was purchased.

In 2011, Russia's first Wildlife Rehabilitation Centre was opened at the Prigorodnoye production complex. It is a mobile facility which is deployed to provide aid to animals contaminated with oil or oil products. It can house 1,000 birds at a time. Up to 70 birds can be treated at the Centre in one day. The equipment for the mobilisation is always available on the territory of the plant.

The Rehabilitation Centre includes the following stations:

• animal intake station where a qualified team of veterinarians examine animals, do required tests, and develop a rehabilitation plan;

• animal washing station with three washing tables and up to five rinsing tables;

• intensive care station provided with all necessary equipment for animal treatment, as well as for feeding especially weak individuals;

• stabilisation station, which is a room for animals equipped with infra-red heating lamps and equipment for drying animals after washing and rinsing;

• pools for birds, which are used for birds' feathers waterproofing;

• aviaries where shallow pools can be installed for animals if necessary.

Sakhalin Energy is well aware of the fact that isolated activities for biodiversity conservation might be insufficient for achieving the goals and solving problems. That is why the company's trained specialists are ready to provide aid to oiled animals in any emergency situation using the mobile equipment of the Wildlife Rehabilitation Centre.

CONCLUSION

Biodiversity conservation and environmental protection of the region where Sakhalin Energy performs its business activities is one of the top priorities of the company. The principle of environmental responsibility is an integral part of the company's corporate policy. The aspects of environmental impact control and the results of industrial environmental control and monitoring are covered in detail in the annual Sustainable Development Reports, the company’s scientific and research publications, and on the company's website.

All of us are shaping the future. Sakhalin Energy is aware of its responsibility and actively cooperates with Russian and international organisations to preserve the island's unique flora and fauna.