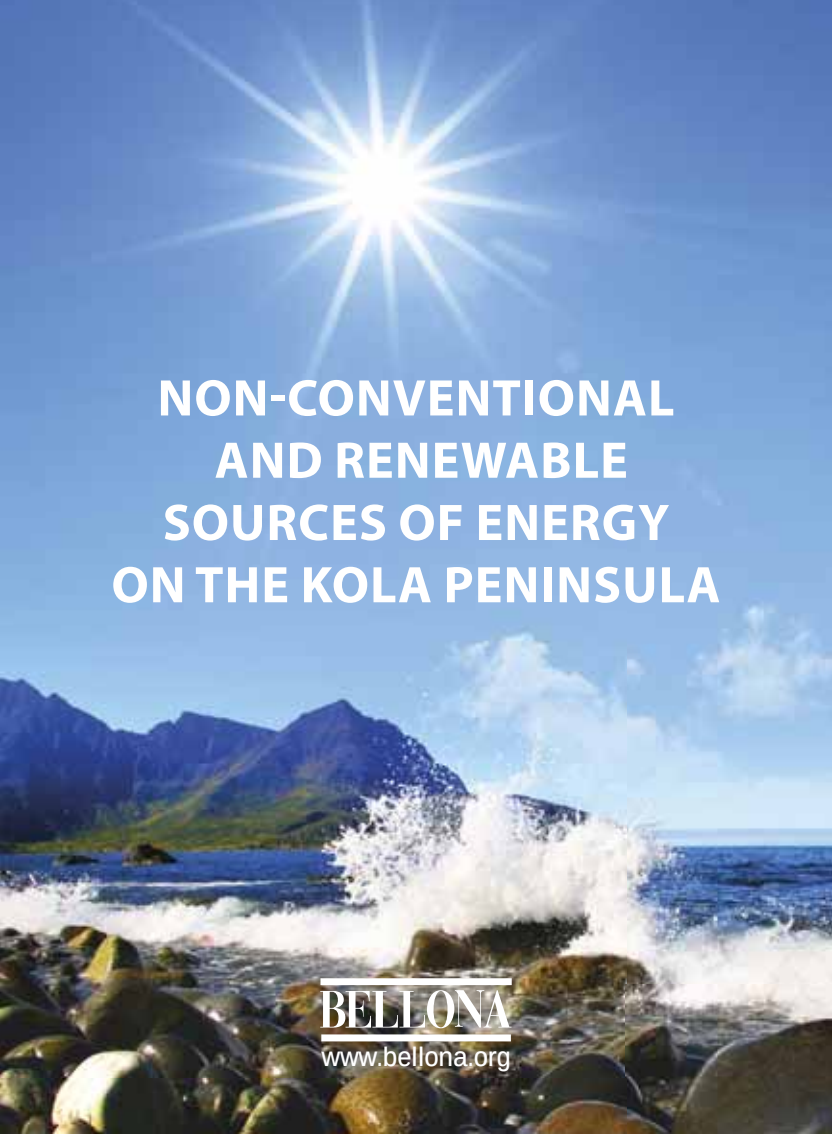
NON-CONVENTIONAL AND RENEWABLE SOURCES OF ENERGY ON THE KOLA PENINSULA



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WHAT IS IT ABOUT?

Renewable energy is the key to solving many of the world's environmental problems. The Bellona Foundation and Bellona Murmansk are working to promote development of clean renewable energy on the Kola Peninsula as a replacement to hazardous nuclear energy and polluting fossil fuels. In 2006 we commissioned scientists at the Kola Science Centre to conduct a comprehensive investigation of the potential for renewable energy on the Kola Peninsula.

This brochure provides summary information on six types of renewable resources that are prospective for the Kola Peninsula from this evaluation: bioenergy, wind energy, solar energy, tidal energy, small hydro energy and wave energy.

The complete results of the scientific investigation are published in Bellona's report "Prospects for Development of Non-conventional and Renewable Sources of Energy on the Kola Peninsula" available free of charge at our website:

www.bellona.ru/reports/Energy_Kola_Peninsula/Kola_Peninsula_report

The drawings presented in this brochure were made by the pupils of the school No 21 (Murmansk, Russia).

painted by Bocharov Sergey (10 years old)

Windmill installation in Murmansk
(photo: Belllona)

WHAT IS RENEWABLE ENERGY?

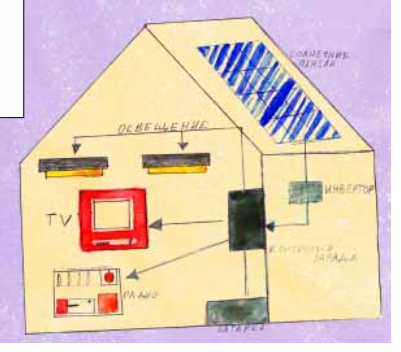
Renewable energy is energy which is produced and continually replenished from the earth's natural processes – such as the sun, wind, water, wave, ocean currents and vegetation as well as geothermal sources. Renewable energy is sustainable and inexhaustible; it is available in infinite supply and cannot be depleted. Renewable energy does not produce emissions that cause global warming. Renewable energy sources include solar, wind, hydro (with the exception of huge hydro electric accumulating stations), tidal, wave and bioenergy sources like plants, agricultural crops and livestock manure, wood and forest waste, and consumer household and food waste.

WHY SHOULD WE USE RENEWABLE ENERGY?

- Renewable energy sources are virtually unlimited as well as easily accessible and sustainable, and they do not deplete natural resources.
- Renewable energy produces no harmful CO_2 emissions in contrast to fossil fuels (oil, gas and coal) which pollute the environment, cause global warming and climate change, and damage ecosystems.
- Renewable energy produces no hazardous waste in contrast to nuclear energy which entails a threat to human health and security risks connected with its reprocessing, transportation and storage.
- Renewable energy can provide regional energy security, by ensuring a stable, reliable and locally available energy supply to remote areas, and protect connected customers from cut-offs.
- Renewable energy is a profitable sector capable of providing the basis for new employment opportunities, product export and financial income.

painted by Belyaeva Anastasiya
(9 years old)

painted by
Alekseeva Anastasiya
(9 years old)



painted by
Moiseeva Dar'ya
(10 years old)

BIOENERGY

Bioenergy is energy obtained from biomass. Biomass is organic material of biological origin and includes waste from forestry and woodworking industries (such as firewood, woodchips, bark, sawdust, powerwood, and power cultures), household and industrial waste, animal industry and poultry farming waste, crops and plants. By means of combustion or fermentation biomass can be used to produce heat or electricity, or converted to liquid or gas for use by the transport sector. Biofuel is any fuel that can be derived from a recently living organism or its byproduct. A differentiation is made between three types of biofuel: liquid (ethanol, methanol, biodiesel) solid (firewood, straw) and gaseous (biogas). Bioenergy is considered carbon neutral with regard to climate gasses because combustion of biomass does not emit more carbon dioxide to the atmosphere than was absorbed by the plant during its growth. On the Kola Peninsula, the most promising areas for utilisation of wood waste are small population points which receive electricity from local diesel electric stations and heat from community boilers. On farms and at poultry processing facilities animal wastes can be utilised to guarantee the facility's own power requirements.

Fact: Farm animal manure has a production capability (brutto usable biomass) of 200 kWh per ton. One cow produces 0.045 m^3 manure per day which yields approximately 15-18 m^3 manure per year. This corresponds to 0.8-1.2 m^3 biogas per day or approximately 4.7-7.1 kWh per day. 1 m^3 biogas can ensure the functioning of a 2 horse power engine for one hour, or replace 0.6 liters black oil (mazut).

Murmansk region: The possible yield of biogas at cattle breeding/diary farms and poultry processing facilities in the Murmansk region is 12-17 million m^3 per year; the potential technical resources of wood waste from the lumber and sawmill industry of the Murmansk region is nearly 1 TWh.

Regional experience: In the settlement Verkhny Tulomsky (80 kilometers from Murmansk) 3000 inhabitants use heat produced by the community's district heating broiler which operates on wood sawdust, manufactured by an adjacent sawmill. This reduces emissions of pollutants from the boiler by 200 tons per year and economises on mazut (black oil) by 1000 tons annually. In addition, through the combustion of wood waste, the bioenergy facility decreases the harmful consequences otherwise inevitable from rotting sawdust – the acidification of soil and water, and the emission of methane. Furthermore, the ash by-product left over is used by local residents as an organic fertiliser to improve potato crop yields.

Bioheating station in Murmansk oblast (photo: Bellona)

Biogas station in Norway (photo: Bellona)

Wood pellets (photo: Bellona)

WIND ENERGY

Wind energy is the kinetic energy of air masses in the atmosphere. Different types of wind installations are used for the conversion of wind power into electricity. The most widespread wind instruments have winged wind wheels and a horizontal axis of rotation. The rotation of the wind wheel is created by a lifting force, which is formed by the flow of an air stream around the blade. As a result, the kinetic energy of the air steam flowing in the area swept aside by the blades is converted into mechanical rotational of the wind wheel. On the Kola Peninsula wind energy has three prospects; it can provide an electrical supply to remote decentralized users, supply heat in small cities and settlements in windy areas and be used on a large-scale in wind parks as part of a system-integrated centralised power supply system.

Fact: The work of a wind generator with a capacity of 1 MW for 20 years of operation enables a savings of approximately 29 thousand tons of coal or 92 thousand barrels of oil. A wind generator with a capacity of 1 MW reduces annual emissions into atmosphere by 1800 tons of CO_2, 9 tons of SO_2, 4 tons of nitrogen oxide.

Murmansk region: Technical wind resources on the Kola Peninsula are estimated at 360 TWh annually, which makes wind resources on the Kola Peninsula among the best in Europe. In the north along the Barents Sea coastline the wind speed measures 7–9 meters per second. Maximum wind speeds occur during the colder seasons and coincide with the seasonal peak in heat and electricity demand and consumption. Moreover, the winter wind maximum is in a counter-phase to annual river flow creating an opportunity for joint utilisation of wind and hydro resources in a complementary manner. Seventeen hydroelectric stations in the Murmansk region provide the possibility for accumulation of water in periods with active winds and release of this water in periods when the wind is calm. Wind installations can supplant 60%–70% of the fossil fuel imports used by decentralised settlements in the Murmansk region. The most promising sites for large-scale wind power development are in the vicinity of Dalniye Zelentsy and Teriberka, in the Hibiny Mountains, and along the Murmansk – St.Petersburg highway. Wind data shows that the presence of prevailing winds (that is, wind which blow from one predominate direction and have the greatest energy concentration) permits a compact and cost-efficient location of mulitiple wind turbines in wind parks with minimal interference or energy loss. There are currently plans underway to build the region's first large-scale windpark (200 MW) south of the Murmansk-Tumanny road in the vicinity of Teriberka.

Regional experience: In 2001 a single windmill (WINCON-200) with a capacity of 200 kW was erected next to the hotel “Ogny Murmanska” as an experimental pilot project to demonstrate the practical application of wind energy. Since that time the windmill has produced more than 1.5 million kWh of electricity. In April 2008 this windmill was officially connected to the local power grid and it is now integrated in the centralised power system.

painted by Averkin Alexandr (10 years old)

Windmill installation in Murmansk (photo: Belllona)

SOLAR ENERGY

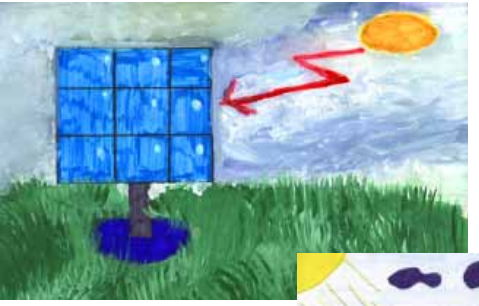
Solar energy is solar radiation from the sun. Solar energy can be transformed into thermal power or electrical energy. There are several methods of obtaining electricity and heat from solar rays. Electrical power can be obtained with the aid of photovoltaic cells which are usually made of crystalline silicon which produces an electric current in the presence of sunlight. Thermal power can be generated by active solar energy whereby a surface collector, such as a mirror or metal plate, absorbs solar radiation and converts it into hot air or hot water for heating, or by passive solar energy that uses the basic building elements and construction to capture natural heat and light from the sun without mechanical processes. Both heat and electricity can be generated by means of a concentrated solar power (CSP) system. CSP uses a system of mirrors or lenses to concentrate solar radiation and achieve higher temperatures. The collectors may be large flat mirrors, curved mirror solar troughs or solar dishes which concentrate solar radiation at a receiver containing a fluid which is heated and used to turn a steam generator or a turbine that converts heat into electricity. Solar energy can be used to heat water, cook food, power district heating systems for residential and commercial buildings, generate electricity, or disinfect and desalinate water.

Fact: Solar resources are the most abundant of all renewable energy sources. Approximately 30% of the suns rays are reflected back into the atmosphere and another 20% is absorbed by clouds and oceans. As a result only 50% of solar radiation reaches the earth's surface, but this is equivalent to all the energy produced by approximately 170 million of the world's most powerful electrical power stations. The sum total of solar energy arriving on the surface of the Earth for a week exceeds the energy of all global reserves of oil, gas, coal and uranium. In fact, the solar radiation received on the earth's surface in just one day exceeds all the energy needs of the entire planet for one year.

Murmansk region: Solar energy resources are the most considerable of renewable energy sources on the Kola Peninsula (11 000 TWh), however direct sunlight is reduced up to 60–70% due to the characteristic cloudiness of the region. The greatest obstacle to the development of solar energy on the Kola Peninsula is the absence of solar activity during the winter when energy demands on the part of consumers are the greatest. Fortunately, peak wind

and solar resources are in antiphase with one another; they occur in different seasons. This factor makes it possible to substitute the one resource with the other when they are used jointly. On the Kola Peninsula the most prospective applications for solar energy are to develop it as a local energy supply for remote settlements, which are dependent on fossil fuels that are both difficult and expensive to import, as well as for southern regions with a high technical potential. A promising site for development of solar energy is in the vicinity of the village of Umba (population 6500 people) where solar radiation is comparable to data in the Swedish town Inglestad where a solar heating station supplies heat to 52 homes.

Regional experience: Since 1998, a joint Russian-Norwegian project has successfully removed decaying radioactive strontium batteries in lighthouses located along the northern coastline of the Kola Peninsula and replaced them with solar panels.



painted by
Volkova Olga
(10 years old)

painted by
Micshenko Artem
(11 years old)

TIDAL ENERGY

Tidal energy is the conversion of energy produced by sea level changes into electricity. Sea and ocean tides are the periodic fluctuations in sea level caused by the gravitational forces of the Moon and the Sun in relation to the Earth. There are two methods of utilising tidal energy; one way is to use the kinetic energy of the tidal current as it rises and falls, the other is to build a dam or barrage and use the potential energy of the difference in tidal height between high and low tide. Tidal energy is converted to electricity in a tidal electric station by means of a turbine-generator system. Tidal stations are situated at the mouth of sea and ocean bays. At high tide water passes through turbines filling a basin behind a dam and the turbine produces electrical energy. At low tide water again passes through the turbine on its way back out to sea and the turbine again produces electrical energy. The most important indicators of the energy potential of a tide are the height of the tide and the area of the tidal basin.

Fact: A tidal power plant has an expected operative lifespan of 75 to 100 years which is more than double that of conventional fossil fuel or nuclear power plants. A special characteristic of tidal energy is its predictability; it is invariable throughout the month and independent of water level throughout the year, despite variations within a 24 hour cycle. In Russia, it is possible to generate 270 TWh of electricity annually by means of tidal energy which is sufficient to cover more than one-fourth of current energy consumption in the country.

Murmansk region: The technical resources of tidal energy in the Murmansk region are estimated at 2 TWh. Prospective sites for construction of tidal stations of average capacity in the region are Dolgaya Bay, Drozdovka Bay, Ivanovskaya Bay and Gremikha. Another prospective site is a large aquatory at the Lumbovsky Gulf where the average tide is 4.2 meters. There are currently plans to build an 800 MW tidal power plant, named the Kolskaya tidal power plant, in Dolgaya Bay near Teriberka.

Regional experience: In the 1960s, the Kislagubskaya tidal electric station (400 kW) was built in Kislaya Bay as an experimental project. In 2006, an experimental metal floating power unit with a capacity of 1500 kW, in which was installed an orthogonal hydro-aggregate with a driving wheel 5 meters in diameter, was manufactured by the Sevmash factory in Archangelsk region. At the present time a new power unit is being tested under natural conditions. Although this project pursues only scientific purposes, the modernised tidal electric station will produce 350 000 kWh per year.

Kislogubskaya tidal electric station on the Kola Peninsula (photo: JSC Malaya Mezhenskaya TPP)

SMALL HYDRO ENERGY

Hydro energy is the kinetic energy of a river stream. Small hydro electric stations are installations which transform the energy of stream flow into electricity utilising turbines without requiring the construction of dams and water intakes with pressure head pipelines. Small hydroelectric stations are usually defined as hydroelectric stations with a relatively small capacity of less than 20 to 30 MW constructed primarily for isolated consumer groups at their own expense and using their own workforce. Even smaller installations classified as mini or micro power plants (with installed capacity under 1000 kW and 100 kW respectively) can be constructed for single consumers. For the Russian North hydropower stations of 3 MW to 5 MW are most prospective due to low population density. On the Kola Peninsula, the consumer groups which could benefit from the application of small hydro power include agricultural cooperatives, small industrial enterprises, farms and some large enterprises with low energy consumption.

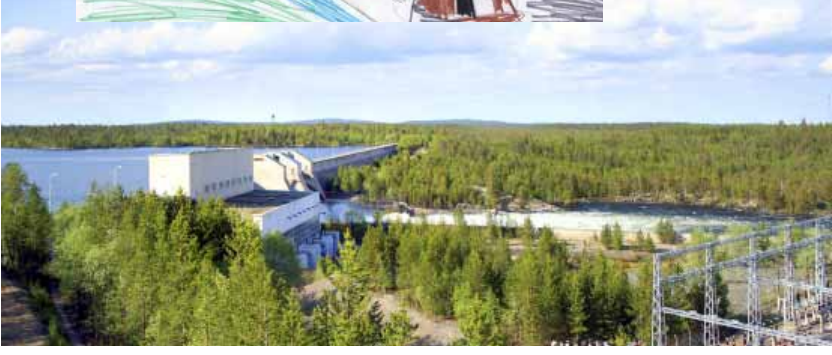
Fact: Small hydro power stations have minimal environmental impact in contrast to large hydro power complexes which require dams and reservoirs that have a negative effect on the environment. According to estimations by specialists, it is possible to generate approximately 500 TWh of electricity annually in Russia in small hydro electric stations with the means currently available.

Murmansk region: The technical resources of small hydro energy on the Kola Peninsula are estimated at 4.4 TWh annually. Even if one excludes from consideration the rivers which have considerable significance for the fishing economy, there are many small rivers in the region which are prospective from the point of view of small hydro power development: the Pirenga River, the Bolshaya Olenka River, the Ura River, the Zapadnaya Litsa River, the Titovka River, the Tumcha River, and the Umba River. In addition, construction of salmon stairs on rivers in conjunction with hydropower development can minimise negative environmental impact. Restrictions on construction of large hydroelectric power stations, as well as the progress made in the automation and remote control of hydroelectric stations, make development of small hydro power attractive. In addition, at the present time the centralised electrical supply does not include approximately 80–100 settlements and individual objects. Three isolated settlements are prime candidates for the application of small hydro power: Krasnschelye, Chavanga and Chapoma, as well as the military border guard camp – Svetly. Supplying these settlements with fuel is particularly difficult due to the absence of roads. Hydro energy can be used as

a supplementary energy source to diesel stations in periods of drought and as a reserve in emergencies.

Regional experience: Russia has decades of experience in the exploitation of hydro power for electricity. In the Murmansk region during the 1950s there were around 10 small hydroelectric stations ensuring the electricity supply of remote settlements and villages.

painted by Bibarsova Alvina (10 years old)



Hydro power station on the Kola Peninsula

WAVE ENERGY

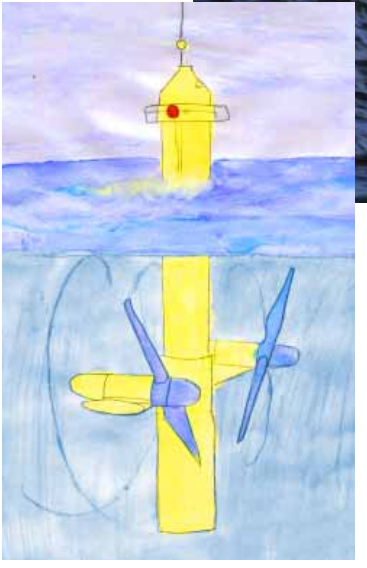
Wave energy is the harnessing of wave power and its conversion into electricity. Wave power is dependent on wave height and speed, wave length and density. Wave power stations can be built either offshore, near the coastline, or onshore and many types of wave conversion techniques exist worldwide. Regardless of the type of wave installation, at the heart of its operation is the utilisation of water speed, or changes in angle of the slope of the wave surface, or changes in wave pressure. All wave installations consist of a working body (floats, water wheels, turbines), a power converter (piston pumps, chain transfers) and a mounting system. The Kola Peninsula has over 1 000 kilometres of coastline providing numerous opportunities for development of wave power plants.

Fact: Wave energy has one of the highest efficiency rates of any non-traditional energy source, but it is also one of the most expensive forms of renewable energy to develop and its practical utilisation is particularly complex in regions with extreme weather conditions. A wave energy station covering 20 km^2 could theoretically produce 10 TWh per year. Worldwide wave energy potential is 2 000 TWh annually, or approximately 10% of global electricity consumption.

Murmansk region: Wide water expanses and strong frequent winds produce powerful ocean waves. Along the Barents Sea coast waves are twice as high in the winter, when energy demands are greatest, as during the summer. The average wave energy potential along the Barents Sea coast is approximately 22–29 kW per meter, a figure comparable to the neighbouring coastal region of Norway. Using a 60% efficiency rate as a basis, the total technical resources of wave energy from a 10 kilometre coastal strip on the Kola Peninsula are estimated at 1.2 TWh along the Barents Sea coast and 0.4 TWh along the White Sea coast annually. The most promising sites for development of wave energy are along the Barents Sea coast where there is a significant distance across the ocean over which wave energy can accumulate.

Regional experience: There are currently no wave stations in operation on the Kola Peninsula. However, electricity has been produced by wave energy as early as 1985 in Toftestallen, Norway where two pilot wave plants were built. The world's first commercial wave energy station was constructed in the 1990s on the basis of successful operation of a small research wave station at Islay Island, Scotland.

photo: Bellona



painted by
Moiseeva Dar'ya (10 years old)

FROM POLLUTION TO SOLUTION
Bellona's role

The Bellona Foundation is an international environmental NGO based in Norway. Founded in 1986 as a direct action protest group, Bellona has developed into a recognised technology and solutions-oriented organisation with offices in Oslo, Brussels, Murmansk, St. Petersburg and Washington DC. Altogether, some 60 engineers, ecologists, nuclear physicists, economists, lawyers, political scientists and journalists work at Bellona.

Bellona endeavours to identify and implement sustainable solutions to the world's most pressing environmental problems. These include the fight against global warming, the environmental impact of the oil and gas industry in Europe and Russia, and the cleanup after the legacy of the Cold War in Russia.

In all of its pursuits, Bellona understands that it is important to cooperate with scientific, business and political leaders to find more ecologically sound methods of operation. Bellona strongly believes that through such cooperation new solutions to environmental problems can be found and implemented.

In April 2008 Bellona established the Northwest Russia Renewable Energy Forum as a permanent arena for all stakeholders interested in developing ecologically clean and sustainable sources of energy in Northwest Russia. Within the context of the Forum participants discuss possibilities, obstacles and mechanisms related to renewable energy development and work towards implementation of renewable energy in the region. For more information about Bellona visit our website **www.bellona.ru**, **www.bellona.org** or **www.bellona.no**.

SUPPORT BELLONA'S WORK

Help us develop clean renewable energy sources in Northwest Russia.

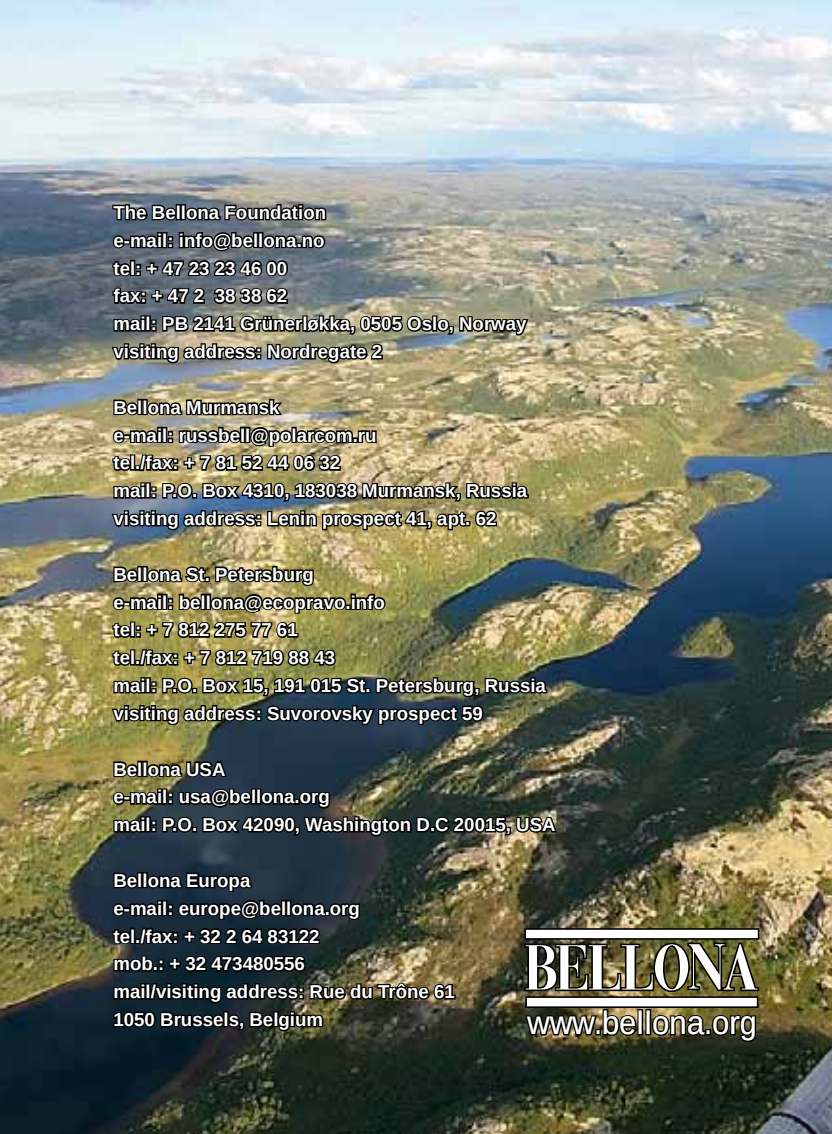
Give a donation at **www.bellona.no**, **www.bellona.ru** or **www.bellona.org** or send an e-mail to members@bellona.no if you want to become a member of our organisation.

Thank you for your support!

painted by
Montik Sergey (10 years old)

painted by
Borovkova Anna
(10 years old)

painted by
Gorlov Vladislav (10 years old)



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