Russia

Country Profile

1. Overview of Electricity Supply

Russia is the fourth largest generator of electricity, behind the US, China, and Japan. The system has a total electric generation capacity of about 228.7 gigawatts (GW), and in 2008 generated approximately 1,036 TWh of electric power. Since the collapse of the Soviet Union, electricity generation showed both a dramatic decline, (down 31 percent between 1990 and 1998), followed by a gradual recovery (up 25 percent between 1998 and 2008), showing almost a full recovery over the last decade. Similar to patterns in oil, natural gas, and coal, the economic slowdown which followed the Soviet Union's collapse also stunted electricity generation. Russia does not consume all of its electricity production and is a net exporter of electricity. Electricity demand within Russia decreases or increases largely as a function of its economic condition.

Roughly 68 percent of Russia's generation capacity is thermal plants, 21 percent hydro, 10 percent nuclear, and 1 percent from renewables such as wind and geothermal, and waste heat. About 16% of actual generation is from hydro, and 16% of it is from nuclear. A few generators in the far-eastern part of the country are not connected to the power grid. Russia was the first country to have an operating nuclear energy plant, and currently has 31 nuclear plants operating, with almost 22 GW of capacity. Half of the operating nuclear reactors are based on the same design as the Chernobyl plant, and many of the plants are nearing the end of their rated working lifetimes. However, Russia has plans to double nuclear output by 2020 and has over 8.7 GW of nuclear currently under construction, and an additional 28 GW planned.

Since the dissolution of the Soviet Union in the early 1990's, Russia has seen severe recession and economic boom in the space of a decade. The industrial landscape has changed significantly with the advent of competition, and extensive foreign investment. This changed has reached the energy sector, with restructuring efforts underway to privatize the industry, and pave the way for open wholesale electric competition. Efforts are also underway to integrate Russia's energy grid with that of Western Europe.

Despite the progress, the electric sector faces many of the same challenges as other eastern European countries, including uneconomic tariff structures, non-payment, and aging electric systems.

Russia's unique situation with its vast natural resources and its underdeveloped economy make it the world's leading energy exporter. Russia has the world's largest natural gas reserves, the second largest coal reserves, and the eighth largest oil reserves. Russia's exports make up an estimated 80% of Russia's foreign trade earnings. It is a major supplier to the European Union, countries of the former Soviet Union, as well as to China, Poland, Turkey and Finland. In country prices of energy are even lower than export prices. This has led to slow development of renewables, despite equally vast renewable resources.

Russia has some of the largest reserves of coal and natural gas in the world, leading to a low cost of energy and creating a challenging environment for the development of renewables. However, Russia also has great potential of renewable energy sources, largely due to its size and range of geographic features. The renewable potential is especially applicable in some of the more remote parts of Russia that are not connected to the grid. Transportation of fuel from energy rich portions of the country to these remote sectors can significantly increase the cost of fuel and energy. As a result, some remote territories spend more than half their budgets on fuel. Geothermal resources in the Far East or North Caucasus, or hydro from the many watersheds, or other renewables such as wind and solar energy could potentially serve remote populations and provide energy at competitive prices on the grid.

With some 10 million people not connected to the electricity grid, Russia also has huge potential markets for off-grid electricity systems based on renewable energy. In many isolated settlements, renewables can be the most economic, and perhaps even the only way to provide electricity and heat to consumers.

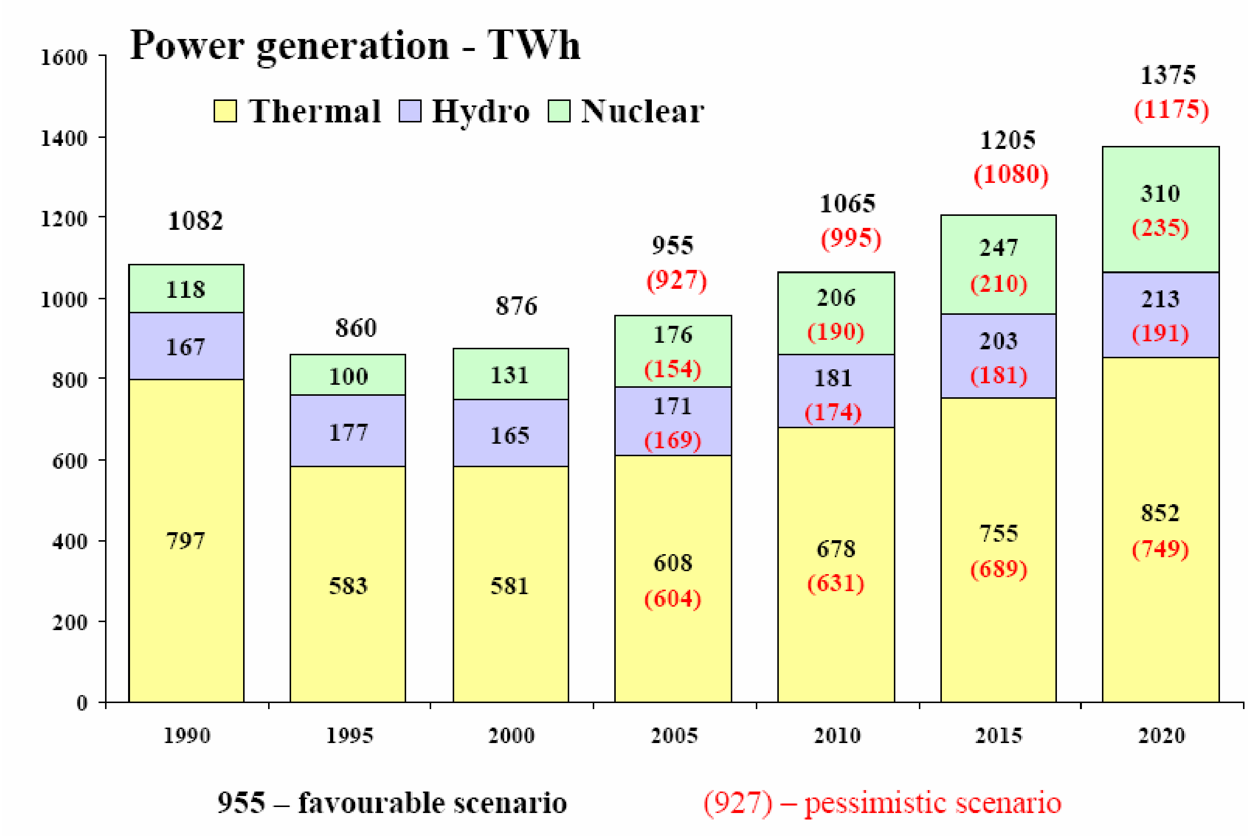
Demographical Information	
Population, millions (2009)	140.0
Land area, thousand sq km (2009)	17,100
Macroeconomic Information (2008)	
GDP, billion US$	2.23
Real GDP growth rate, percent	6.0
Foreign direct investment (net), million US$ (2007)	9,218
Electricity disposition, billion kWh (2006)	
Generation	964.21
Consumption	819.59
Exports	15.81
Imports	5.67
Generation capacity, GW (2005)	
Nuclear	23.24
Thermal	149.20
Hydro	45.84
Other renewables	0.09
Total	218.37

Sources: CIA World Factbook, U.S. Energy Information Administration, United Nations Conference on Trade and Development.

Russia Country Summary Table

The following figure displays the estimated power generation for the Russian Federation until the year 2020.

Electricity Development
(Source: Ministry of Energy of the Russian Federation)



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2. Energy Policy, Barriers and Incentives

Russia's energy policy is mostly outlined in a document created in 2003 which plans out to 2020. Over the last decade, significant steps in an on-going privatization and de-monopolization process have taken place in the Russian energy sector. A key element of these reforms is the introduction of cost-based pricing. In particular, major progress has been made in the electricity sector reform process with the adoption of a package of laws in 2003.

Reform in other energy markets is also underway, though its pace differs from sector to sector. Domestic prices of oil and oil products are already close to international levels. Domestic gas prices, which are still much lower than export prices, are gradually rising and are expected to reach international levels in the future. Then, as the existing energy infrastructure expands, comparisons among different fuel sources and technologies will favor those renewable energy technologies that are currently competitive in many market applications.

Generally Russia has lacked policy in support of renewables. In January, 2009, Russia's energy policy included a mandate to increase energy from renewables to 4.5%, up from less than 1%, by the year 2020. In an energy system as large as

Russia's, this signifies a major increase in renewables, and would require an additional 22 GW of new renewables generation. Russia has also set targets to double nuclear production by 2020.

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3. Wind

In the 1930s Russia was the first in the world to start constructing utility-scale wind turbines. Studies of the wind potential were also done many years ago. However, due to financial difficulty and lack of policy, in the last several years development of the wind power industry has been slow. Currently, Russia only has a little over 20 MW of wind and new hasn't been built since 2002. More recently, the wind power industry in Russia has started gaining a little bit of traction. In 2008 the first wind turbine became grid connected in Murmansk. This pilot project is important because to the lack of policy that supports renewables, wind projects often have difficulty getting connected to the grid. Grid companies hesitate to connect renewables due to their intermittency. Plans to build a large-scale wind farm in the same region have also started.

The option of grid-connected wind power production may benefit from the existence of the unique extensive UPS. At the same time stand-alone wind power systems might be promising in the remote mountain and coastal regions which have large wind potential and are not connected to a grid. Western experience, policy, research, and technologies could act as a catalyst to accelerate the introduction of wind energy.

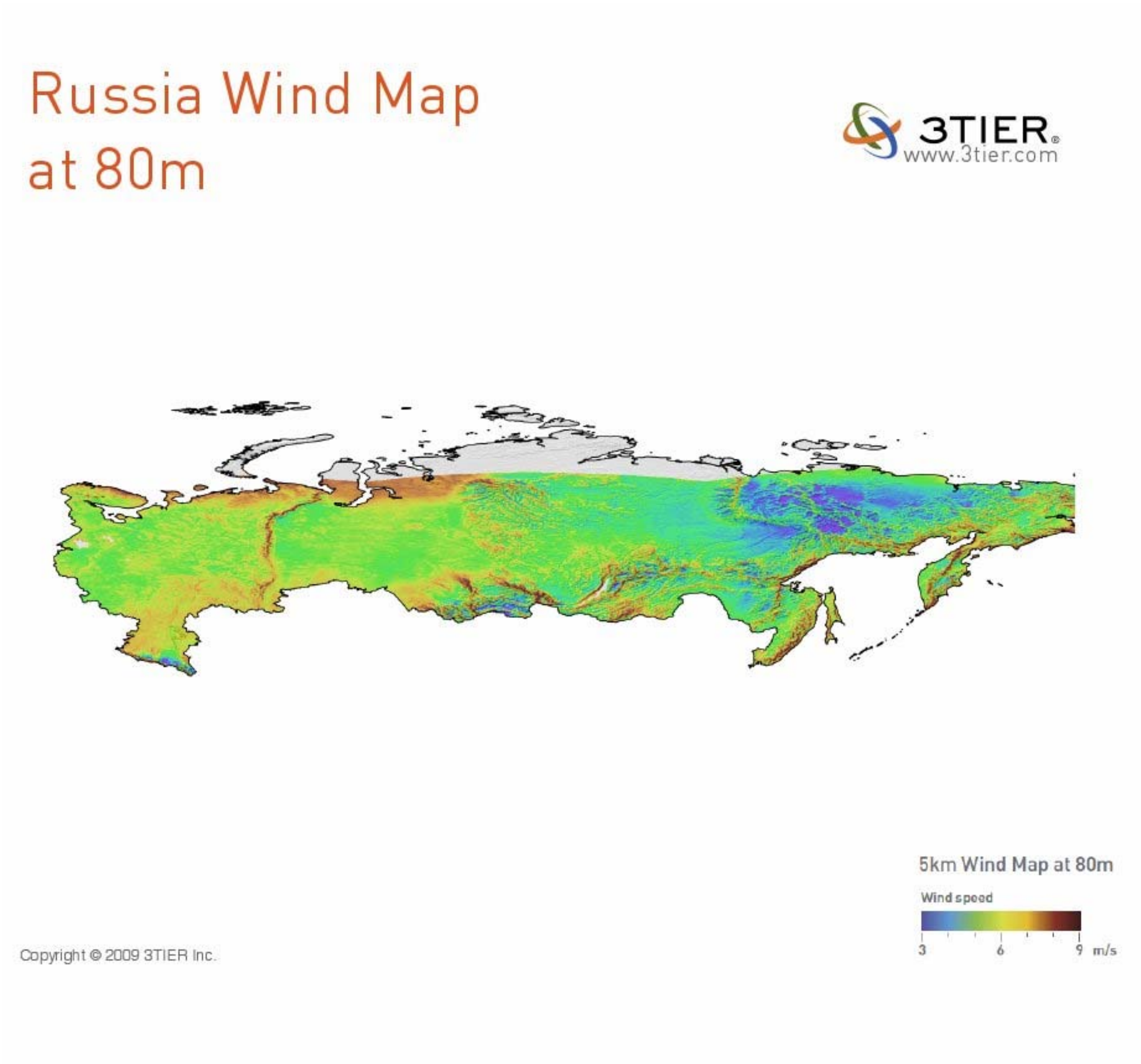
Russia is one of the largest countries in the world and is situated in different climatic zones, which result in high wind energy potential. Mostly the highest wind energy potential is concentrated along Russia Federation seacoasts, in the vast territories of steppes and in the mountains. The regions most favorable for wind energy use include the North of Russia and Far East.

According to the decision of the Council of Ministers of the USSR in 1989 all the research and design works in the renewable energy technologies were united on the State Scientific and Technological program Ecologically Clean Energy. The program included development of various wind turbine models 0.25 - 1'250 kW. Later the 30 kW and 1,250 kW models were abandoned due to lack of financing. The leading R&D organizations in the program were Vetroen and Yuzhnoe (both Science Production Associations), Hydroproject (Scientific Research Institute), Raduga (Design Office) and Energobalance-SoVENA.

Over most of Russia, wind speeds are greater in the daytime than at night, although this variation is much less pronounced in the winter. The annual variation in mean wind speed (i.e. the difference between the maximum and minimum mean daily speeds) is insignificant for most parts of Russia.

Several attempts have been made to estimate the exact potential of wind energy in Russia, beginning with the Wind Atlas published in the Soviet Union in the 1930s. More recently, have estimated gross wind potential at 26,000 million tones of coal equivalent, technical potential at 2,000 mtce, and economic potential at 10 mtce. According to analysis, about 30 percent of the economic potential of wind development is concentrated in the Far East, about 16 percent in West Siberia and another 16 percent in East Siberia.

Russia Wind Resource Map (Source: 3Tier)



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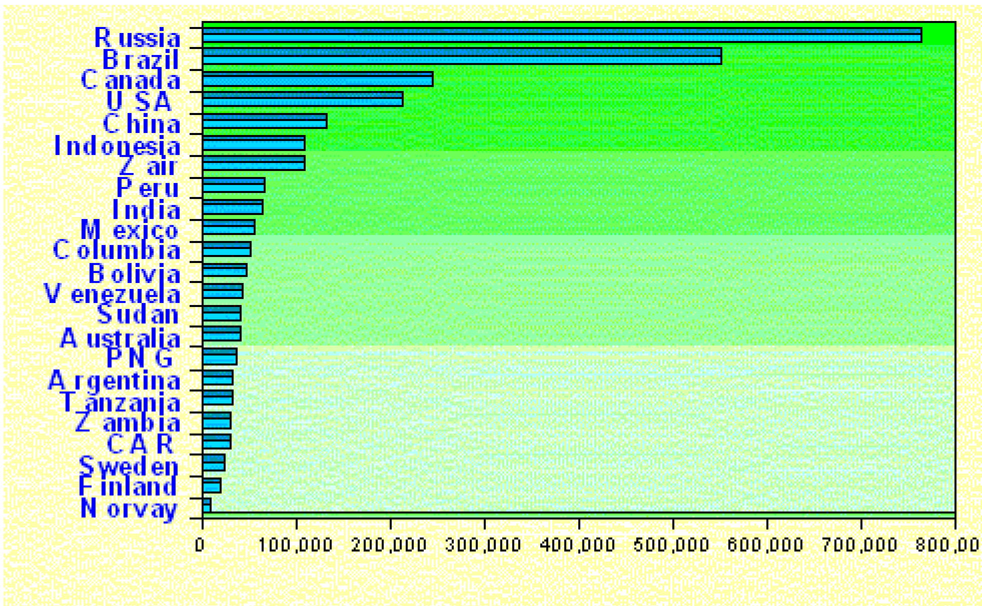
4. Biomass

Russia has about 22 percent of the world's forests located on its territory. Forests cover about 40 percent of the entire landmass, with the current annual allowable cut of 542 million m3. The largest forests are in the Siberian taiga, the Far East and the northern European territories. The forest industry is important for the Russian economy, and it is a large potential supplier and consumer of biomass (wood waste) products. At present, these products are only being minimally exploited. The technical potential of biomass is estimated at more than 50 Mtce.

The agricultural sector is also important in Russia, accounting for 8 percent of GDP, and employing 11 percent of the labor force. It is also an important source of biomass resources. Still, the vast majority of Russia's agricultural resources are not being used at all. An estimated 850 million liters of biofuel could be produced on this land, although currently there is only one biofuel plant in the country.

Forests' Portrait of Russia on the Global Scale

Forested Area, mill.ha



Source: All-Russian Research and Information Centre for Forest Resources

Most of the energy created from biomass in Russia is used for heating purposes, and not power generation. Current biomass power plants include about 90 MW of generating capacity from refuse (unprocessed municipal solid waste), and about another 600 MW from burning peat. No additional biomass power plants are planned.

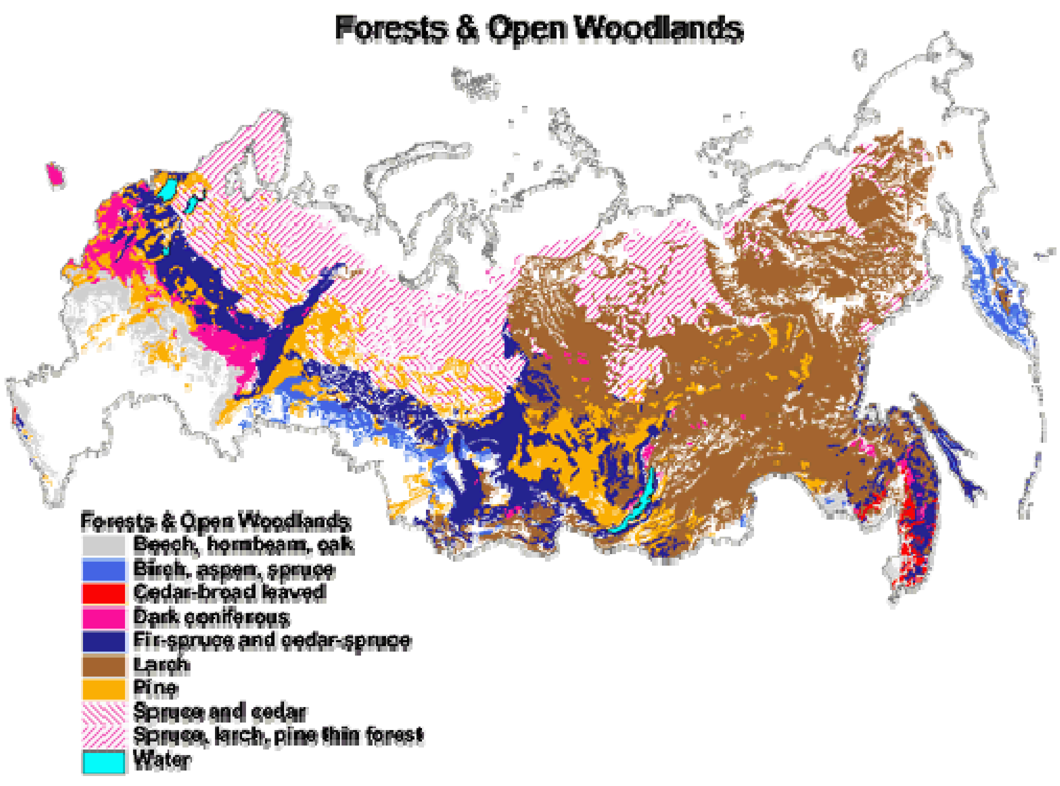
According to IEA statistics, Russia used 7.5 Mtoe of combustible renewables (biomass) and wastes in 1999, and 6.9 Mtoe in 2000. This figure is approximate, because there are no official statistics on traditional biomass use for heat and hot water production by individuals in the countryside. Strebkov estimates that individuals in rural areas use 30 Mtce (21 Mtoe) of wood each year, and people in semi-rural industrial settlements, meteorological and geological sites, and in the fishing industry use another 10 Mtce (7 Mtoe).

About 40 thermal power stations use biomass (mostly waste from the wood processing industry) along with other fuels. Biomass is also used as solid fuel in certain district heating boilers. A couple of the recent heating plants built were at sawmills, including a 24 MW plant for the Stora Enso sawmill, and 20 MW of power for the LDK Igirma LTD sawmill in Irkutusk. These plants both produce heat and do not feed electricity into the grid.

Russia has some 100 plants that convert biomass and agricultural wastes into biogas today. However, considering the vast organic waste resources that could be used for anaerobic digestion or landfill gas, there are no large scale biogas power plants in Russia. There are also no related projects planned. This is largely due to Russia's vast reserves of natural gas. A lot of surrounding countries depend on natural gas exports from Russia, and it is even less expensive in country.

Municipal and industrial wastes are utilized at large incineration plants. The city of Moscow has two incinerators, which provide many benefits: removing wastes, improving energy efficiency, improving sanitation and consequently the health of the population. The Ministry of Natural Resources is in the process of drafting a new law on municipal wastes. Currently, a wastewater sludge plant of about 3 MW is in planning.

As concern about reducing carbon emissions increases in surrounding countries, many countries are trying to reduce their dependency on Russian natural gas. Russia could use this as an opportunity to tap its vast unused resources in biomass, biofuels, and biogas as a new energy export. It already has much of the transportation infrastructure required for this in place.



Source: Land Resources of Russia

Biomass resource type	Total production	Production density
Total land area covered by	(avg. 2006–2007, km²)	(avg. 2006–2007, %)
Arable Land	1,215,740	7
Permanent Crops	17,955	0
Permanent Meadows and Pastures	921,060	5
Forest Area	8,086,465	47
Other Land	6,136,521	36
Inland Water	720,500	4
Primary crop production	(avg. 2006–2007, tonne)	(tonne /100 km²)
Total primary crops (rank among COO)	175,560,044 (28)	1,027 (3)
Top 10 primary crops		
Wheat	47,198,080	276
Potatoes	37,678,420	220
Sugar beet	29,930,615	175
Barley	16,908,330	99
Sunflower seed	6,204,680	36
Oats	5,143,635	30
Cabbages and other brassicas	4,063,620	24
Maize	3,810,900	22
Rye	3,437,675	20
Vegetables fresh nes	2,506,370	15
Animal units, number	(avg. 2006–2007, number)	(number / 100 km²)
Cattle	21,470,072	126
Poultry	360,525,500	2,109
Pigs	14,623,855	86
Equivalent animal units	30,924,869	181
Annual roundwood production	(2006–2007, m³)	(m³ / 100 km²)
Total	198,800,000	1163
Fuel	45,500,000	266
Industrial	153,300,000	897
Wood-based panels	9,387,500	55
	(2006–2007, tonne)	(tonne / 100 km²)
Paper and paperboard	7,496,500	44
Recovered paper	2,075,000	12

Source: Food and Agriculture Organization of the United Nations

Russia Biomass Resource Data

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5. Solar

In spite of general northern geographic location, Russia possesses considerable solar resources. Annually the solar radiation energy incident on its territory is equivalent to $18.7 \cdot 10^9$ GWh that exceeds significantly the power potential of any other available energy resources. Some areas of Russia receive more than 300 sunny days per year, and the cold temperatures also improve the efficiency of solar cells.

However, Russia lags behind leading countries in terms of development and production of solar collectors. The main reason for this is the lack of sufficient demand for such units, and given the lack of state programs of assistance, there is insufficient funding for research engineering in this field. Currently, Russia has no utility-scale solar power plants planned or in operation.

Although there is low domestic demand for solar energy, in the past couple of years the country has become increasingly interested in competing in the international market for producing solar products in order to boost its high-tech industry. The low cost of energy gives Russia an advantage in producing the electricity-intensive panels, and the labor costs are low as well. Plans for one of the world's largest thin-film plans have been announced, with 2011 to mark the start of production.

Russia has some experience from several years ago developing solar power for the space program. However, financing difficulty, lack of policy, and lack of local demand will make it challenging for Russia to successfully compete against more established solar producers.

In early 2009, Russia's energy plan included increasing generation from renewables up 4.5% from what is currently less than 1%. This may increase local demand for solar energy, which thus far has been low despite Russia's vast solar resources.

The technical potential of solar energy was estimated as $18.7 \cdot 10^6$ GWh, with an economic potential around $1 \cdot 10^5$ GWh per year in the national report "Role of renewable energy sources in energy strategy of Russia". The technical potential is equal to the solar energy incident into 0.1 percent of territory of the country, while the economic potential constitutes about 0.5 percent of technical potential.

The annual course of solar radiation, i.e. its incidence during a year, has quite considerable meaning for using the solar energy. Data on the total solar radiation incident on the horizontal surface and data on the direct solar radiation on a surface parallel to beams are presented below in Tables 1 and 2 correspondingly. They are given for five different points at the territory of Russia located in the different geographical and climatic zones of the country. Two areas, Sochi and Astrakhan are located in the southern part of European territory, while the other three are located in Asian territory: Kyzil is located in the southern part of Siberia, Mangut is in southern Transbaikalia and Vladivostok is in the Far East.

Location	Astrakhan	Sochi	Kyzil	Mangut	Vladivostok
Jan	137	152	127	187	247
Feb	202	211	225	285	323
Mar	371	347	454	485	488
Apr	528	458	556	572	519
May	690	599	680	692	612
Jun	737	737	706	665	538
Jul	719	743	683	605	513
Aug	651	647	585	569	480
Sep	477	485	429	436	456
Oct	301	345	273	321	364
Nov	144	190	143	206	250
Dec	94	131	101	148	206
Yearly	5051	5045	4962	5171	4996

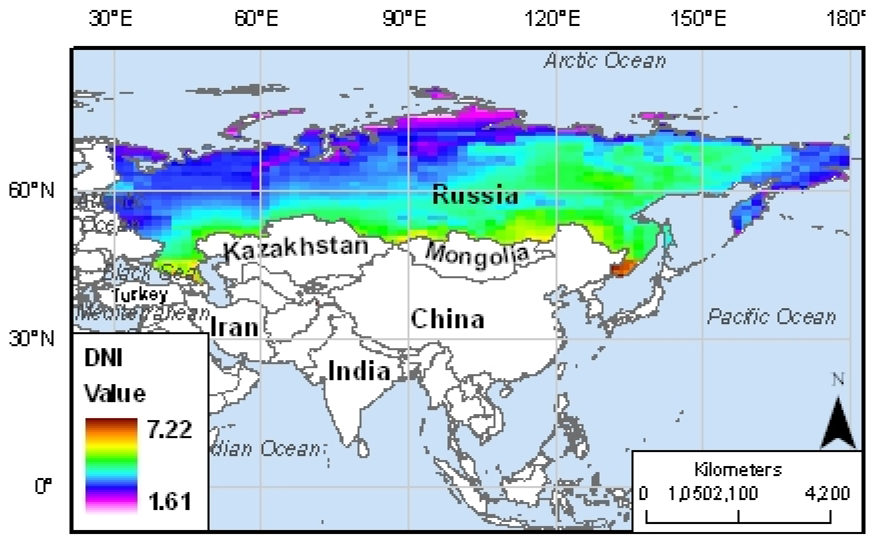
Total solar radiation incident on horizontal surface, MJ/m^2

Location	Astrakhan	Sochi	Kyzil	Mangut	Vladivostok
Jan	183	209	183	441	437
Feb	244	221	267	525	461
Mar	363	325	506	645	535
Apr	489	378	549	572	433
May	651	494	658	657	478
Jun	728	647	673	596	341
Jul	723	691	648	556	326
Aug	689	634	617	583	361
Sep	569	528	557	560	487
Oct	392	436	383	550	495
Nov	194	271	194	425	423
Dec	114	178	128	351	383
Yearly	5339	5012	5363	6461	5160

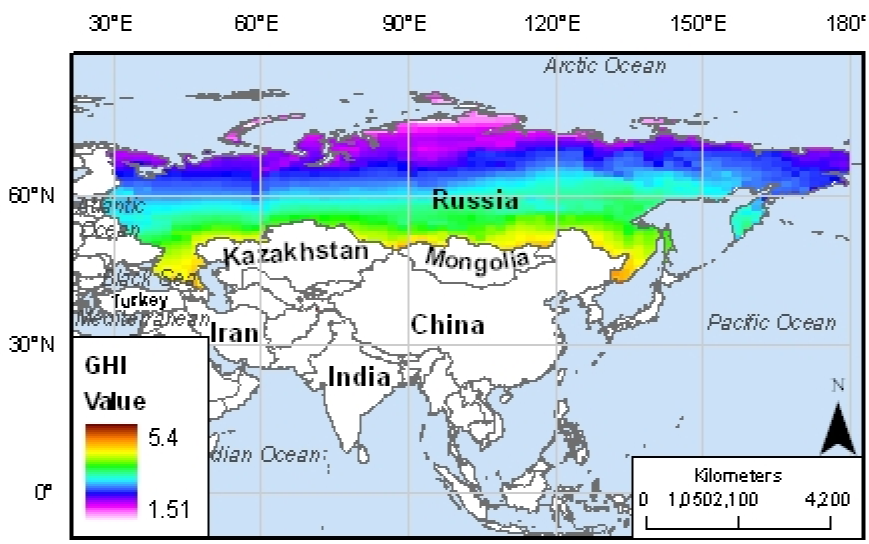
Direct solar radiation incident on surface normal to sunlight beams, MJ/m^2

A map displaying the direct normal insolation and global horizontal irradiance is below. As shown, the country does not have a significant amount of solar resource.

Russia Solar Direct Normal Insolation (Source: NASA)



Russia Solar Global Horizontal Irradiance (Source: NASA)



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6. Geothermal

Russia possesses vast geothermal resources, and over 3,000 wells have been drilled to take advantage. At present the geothermal energy is used in Russian Federation both for heat supply and electricity production. Their first two geothermal power plants were operating in 1966, and they were the first to use the single-flash binary cycle design.

In Russia, almost half of energy use goes toward heating. Direct use of geothermal can offer significant resource to provide this energy, potentially up to 30% (IGA, 2005), and this has been the predominant use of geothermal energy in Russia. Direct utilization of thermal water with temperature 30–100 °C for heating and hot water supply of buildings, for agricultural needs (heating of green houses and cattle raising farms), for fish breeding, in local industry, in balneology and for swimming pools takes place mainly at the Northern Caucasia (Krasnodar and Stavropol Territories, Republic Dagestan, Adygei Region, Karachai-Cherkessia) an at Far East (peninsula Kamchatka, Kuriles). Locally the thermal water is also used in the separate settlements of Western Siberia, near Lake Baikal, in Magadan and Chukot regions and at Sakhalin. Even within Lake Baikal, geothermal heat has been noticed to be breaking through thick ice in two specific locations, despite the depth of the lake. At Kamchatka there are the experimental plants for using thermal water in combination with heat pumps.

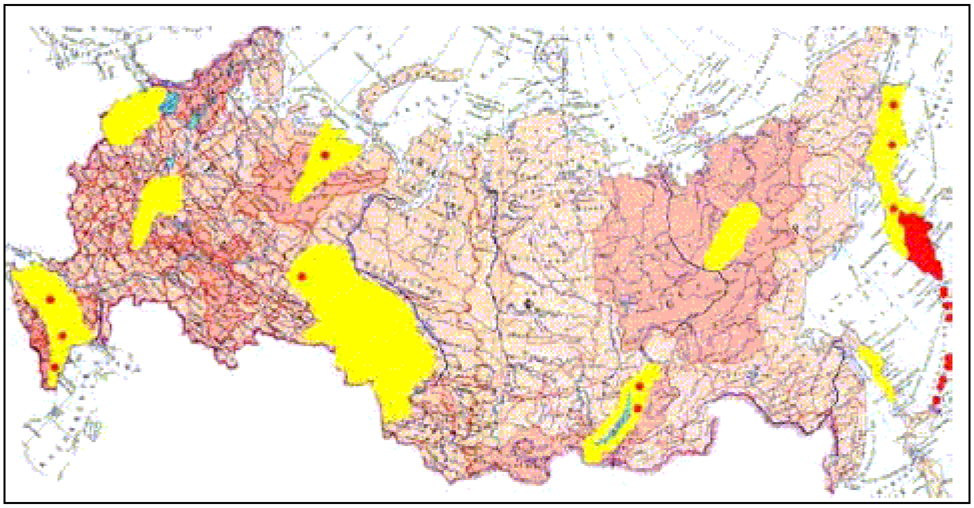
Use of geothermal to produce electrical power in Russia is also significant, and has been growing continuously. There are currently somewhere between 92-129 MW of geothermal power plants operating, and about 55 MW of planned additional capacity (UDI, June 2009 and EBRD Project database).

According to the Institute of Volcanology, Far East branch of Russian Academy of Sciences, the geothermal resources near Kamchatka are good enough to fully supply it with electric power and heat for more than 100 years. Besides the high temperature Mutnovskoe field with capacity of 300 MW(e) located in the south of Kamchatka, there are known rich geothermal resources at Koshelevskoe, Bolshe Bannoe and Kireunskoe (in the north) fields. In total these fields may produce about 2,000 MW(e).

The heat potential of Kamchatka's geothermal waters is estimated at 5,000 MW(therm). Also at Chukotka there are significant geothermal resources, part of which has been already discovered and may be effectively used for supplying power to nearby cities and settlements. The Kuril Islands are rich in geothermal resources as well. They can produce enough electric and thermal power to supply the region for 100-200 years.

The Iturup island features newly discovered biphase heat-transfer fluid resources the capacity of which 30 MWe is enough to meet the energy needs of the whole island. The southern island Kunashir has geothermal heat reserves that are being used for electric power and heat supply of Yzhno-Kurilsk. The subsoil of the northern island Paramushir is underexplored, yet is known to contain good resources of geothermal water of 70-95°C. The Northern Caucasus has well studied geothermal resources with temperatures ranging from 70 to 180°C °C at depths of 300 to 5000 m. Local geothermal waters are used for heat and hot water supply for a long time already.

Geothermal Map of Russia



Thermal water fields with proven resources

Field	Thermal water temperature, °C	Proven resources, thousand m^3/h	TDS, g/l
Kabinskoye (Krasnodar Territory)	100	6	15
Mostovkoye (Krasnodar Territory)	75	12	1-2
Cherkesskoye (Stavropol Territory)	60	5	1-5
Khankalskoye (Chechen Republic)	90-100	10	1-3
Kizlyarskoye (Republic Dagestan)	90-100	10	8-10
Vakhachkaninskoye (Republic Dagestan)	60-80	11	1-10
Tobolskoye (Western Siberia)	70	20	17
Omskoye (Western Siberia)	65	1	25
Ush-Beldirskoyr (Republic Altai)	80	1	0.4
Pitatekevskoye (Republic Buryatiya)	65	1.5	1
Goryachinskoye (Republic Buryatiya)	65	1.5	0.5
Kuldurskoye (Khabarovsk Territory)	70	1.7	0.5
Talskoye (Magadan region)	90	1.2	0.5
Esso (Kamchatka region)	75-80	19	1
Paratunskoye (Kamchatka region)	70-90	46	1-2
Reidovskoye (Iturup, Kuril Islands)	70	1	1-3
Poyarkovskoye (Sakhalin)	70	10	3-5

Proven fields of steam-water mixture and high-temperature brines

Field	Temperature, °C	Proven resources, MWe	TDS, g/l
Mutnovskoye (Kamchatka region)	250	200	0.5
Pauzhetskoye (Kamchatka region)	180	11	3.5
Nizhnekoshelevskoye (Kamchatka region)	250	90	1-2
Okeanskoye (Iturup, Kuril Islands)	180	25	1-2
Goriachi Plyazh (Kunashir, Kuril Islands)	180	3	5-10
Neftekumskoye (Stavropol Territory, Dagestan)	150-170	100	80-100

Many of these resources have already been developed or have plans for development or expansion.

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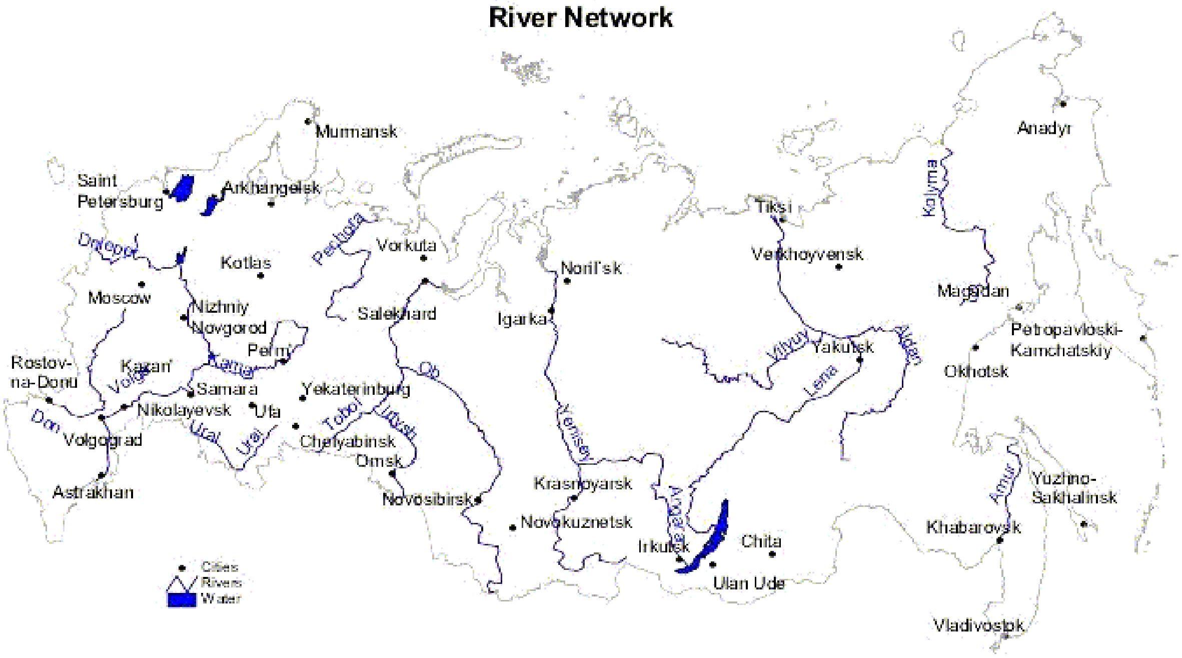
7. Hydroelectric

Hydropower is one of Russia's greatest energy resources, making up about 21% of total current generating capacity, although it only accounts for about 16% of production. Russia is currently the world's fifth largest producer of hydropower, at about 167 TWh/yr (BP Statistical Review of World Energy, 2009), and only about 18% of its hydropower potential has been developed.

Russia's largest power plant, with a total generating capacity of over 6,400 MW, is hydroelectric. However, this power plant suffered a major failure in 2009 destroying two of the plants ten turbines, and seriously damaged a third turbine, which will take several years to reconstruct. Russia has numerous other large and mid-sized hydroelectric power plants, totaling over 47.6 GW in capacity.

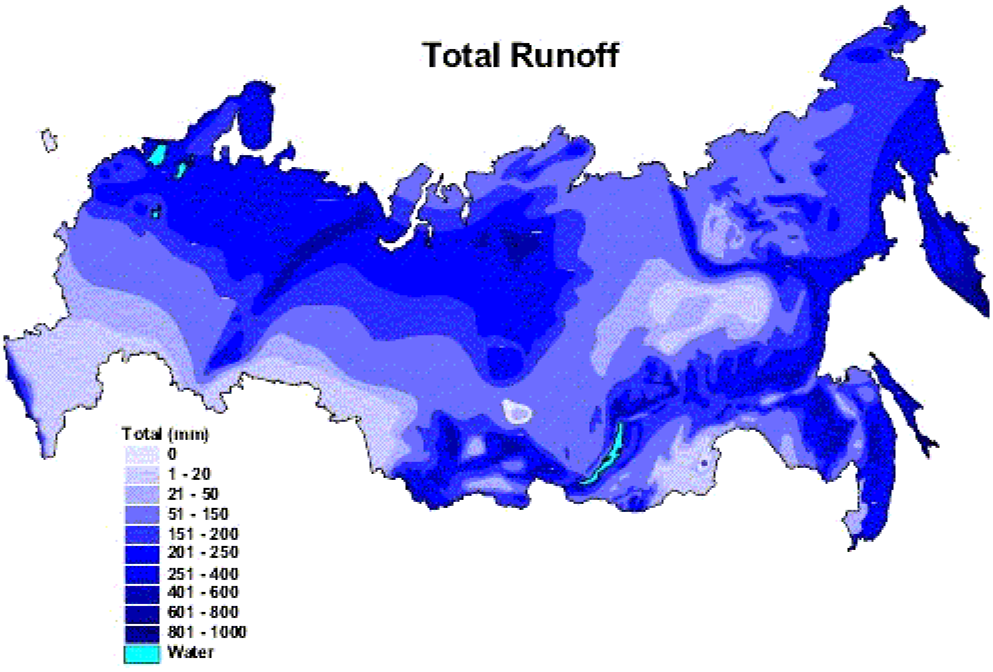
The total hydropower technical potential in Russia is estimated to be about 2,400 billion kWh per year, the majority of which is based on medium and large rivers. The economic potential for this resource is about 850 billion kWh per year. There is also significant hydro potential on the smaller rivers in Russia.

Most of the potential hydropower resources are located in Central and Eastern Siberia and in the Far East. The North Caucasus and the western part of the Urals also have good hydropower potential. The Far East and Eastern Siberia combined account for more than 80 percent of hydropower potential, and could produce about 450-600 billion kWh per year.



Source: Land Resources of Russia

The extent of developed economically feasible resources Russia is not uniform. In the European part 43.2 percent of economically feasible resources have been developed, which is similar to developed countries, while in Siberia and the Far East this figure is not large and accounts for 15.2 percent. Russia continues to actively develop its hydropower resources with over 5 GW of additional hydro capacity currently under construction, and over 8 GW in planning.



Source: Land Resources of Russia

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8. Ocean Energy

Russia has an interest in ocean energy, both from renewable sources as well as oil and gas located under the ocean floor. It is involved in detailed marine surveying and mapping.

Most of Russia's tidal power is dissipated in the Arctic regions, in particular the White Sea is considered to have a great amount of potential. In the Mezen Bay, the difference between low tide and high tide is greater than 20 feet.

Russia had its first tidal power plant, the Kislogubskaya, in 1968 in Kislaya Bay (Barents Sea), with a capacity of about 400 kW. This well-known tidal plant is still one of the few in the world, although that is rapidly changing. The plant has operated successfully despite extreme environmental conditions, being built in Arctic ocean water. In 2006, a new construction on a new generator for the station was completed.

In 2007, a 1.5 MW tidal power plant by Gidro OGK began operation as a pilot project in the same bay. If successful, the company plans on replacing it with a 10 GW of generating capacity, and potentially building several more GW in other Russian bays. Other companies have discussed building tidal power as well. RusHydro, Russia's leading hydropower developer, completed a feasibility study for a plant in 2009 and plans to construct a pilot plant which will take three years and may lead to additional development. Sevmash is planning on completing the construction of another plant, the Kolskaya plant, in the Dolgaya bayplant in 2010.

In Russia's "Maritime Doctrine of the Russian Federation 2020", Russia lists its long term goals as including "development of technology generation of electric energy from tidal phenomena, coastal winds and wind-driven waves, the water temperature gradient, thermal energy and flow, as well as thermal caloric biomass of algae."

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9. Relevant Links

Please see webpage for relevant links.

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10. References

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11. Country Contacts

Contacts made in the preparation of this assessment are gratefully thanked for their contribution to this report. Please see webpage for contacts listing.

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