Russia Chapter

pathways to
deep decarbonization

2014 report

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SciencesPo.

SUSTAINABLE DEVELOPMENT SOLUTIONS NETWORK
A GLOBAL INITIATIVE FOR THE UNITED NATIONS

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Preface

The Deep Decarbonization Pathways Project (DDPP) is a collaborative initiative, convened under the auspices of the Sustainable Development Solutions Network (SDSN) and the Institute for Sustainable Development and International Relations (IDDRI), to understand and show how individual countries can transition to a low-carbon economy and how the world can meet the internationally agreed target of limiting the increase in global mean surface temperature to less than 2 degrees Celsius (°C). Achieving the 2°C limit will require that global net emissions of greenhouse gases (GHG) approach zero by the second half of the century. This will require a profound transformation of energy systems by mid-century through steep declines in carbon intensity in all sectors of the economy, a transition we call "deep decarbonization."

Currently, the DDPP comprises 15 Country Research Partners composed of leading researchers and research institutions from countries representing 70% of global GHG emissions and different stages of development. Each Country Research Partner has developed pathway analysis for deep decarbonization, taking into account national socio-economic conditions, development aspirations, infrastructure stocks, resource endowments, and other relevant factors. The pathways developed by Country Research Partners formed the basis of the DDPP 2014 report: Pathways to Deep Decarbonization, which was developed for the UN Secretary-General Ban Ki-moon in support of the Climate Leaders' Summit at the United Nations on September 23, 2014. The report can be viewed at deepdecarbonization.org along with all of the country-specific chapters.

This chapter provides a detailed look at a single Country Research Partner's pathway analysis. The focus of this analysis has been to identify technically feasible pathways that are consistent with the objective of limiting the rise in global temperatures below 2°C. In a second—later—stage the Country Research Partner will refine the analysis of the technical potential, and also take a broader perspective by quantifying costs and benefits, estimating national and international finance requirements, mapping out domestic and global policy frameworks, and considering in more detail how the twin objectives of development and deep decarbonization can be met. This comprehensive analysis will form the basis of a report that will be completed in the first half of 2015 and submitted to the French Government, host of the 21st Conference of the Parties (COP-21) of the United Nations Framework Convention on Climate Change (UNFCCC).

We hope that the analysis outlined in this report chapter, and the ongoing analytical work conducted by the Country Research Team, will support national discussions on how to achieve deep decarbonization. Above all, we hope that the findings will be helpful to the Parties of the UNFCCC as they craft a strong agreement on climate change mitigation at the COP-21 in Paris in December 2015.

Contents

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1 Country profile

1.1 The national context for deep decarbonization and sustainable development

With the largest territory (17 billion km^2, of which 67% are on permafrost), the Russian Federation is endowed with very high fossil fuel reserves representing 34%, 12% and 20% of world deposits of natural gas, crude oil, and coal, respectively. The energy sector is logically dominated by fossils fuels, which are importantly used for exports (around 40% of the 1.7 billion tons of coal equivalent (tce) extracted natural gas, coal, and crude oil is exported).

The forest area covers 1.2 billion hectares and the agricultural land – mainly used for plowing, crops, forage production and livestock pastures – occupies 220 million hectares. Total waste production is approximately 4 billion tons per year, less than half of which being utilized or treated.

National production is structured around industrial production (30%), trade (20%), transport and communication (8%), agriculture (4%), construction (7%), services (31%). An important characteristic of the industrial sector is the rather high overall depreciation of industrial capital. Since more than 80% of assets are more than 20 years old across all carbon-intensive industries and sectors, industrial modernization is one of the high priorities for the national government. Similarly, since main investments were made in the 1960-1980s, the overall capacity structure of the power generation sector is quite old and almost all large units will exceed their expected service life and become obsolete in 10-20 years. Notably, in 2010, out of the 146GW thermal power and combined heat and power (CHP) plants, 91 GW were more than 30 years old and 46 were more than 40 years old. Another important specificity over recent years is the intense rise of the transportation sector, notably for private cars which have reached 38.8 millions units or 257 cars per 1,000 people in 2013.

The long-term strategic goals of economic development are stipulated in various official documents, such as the Concept of Socio-Economic Development by 2020,[1] Energy strategy–2030,[2] General Scheme of Electricity Units Allocation – 2030,[3] and others. The specific climate change mitigation policy objectives are provided in the Russian Climate Doctrine (2009),[4] Presidential Decree "On greenhouse gas emission reduction" (2013)[5] and its Implementation Plan adopted by Government (2014),[6] as well as the sectoral and industrial plans and programs (e.g. the energy efficiency improvement program, environmental policy, forestry, agricultural, and many others).

The main focus on longer-term development goals in Russia concern the economic growth, diversification of the economy, modernization of its technological base and infrastructure, increase of the share of innovative, knowledge-based sectors, improvement of environmental quality, and population wellbeing. The long-term targets for carbon emissions by 2050 have not been identified as yet, and the deep decarbonization strategy is still to be developed and adopted by Russia.

1.2 GHG emissions: current levels, drivers, and past trends

Domestic energy consumption relies on fossil fuels, where natural gas, coal, and petroleum represent respectively 52%, 12%, and 35% of total demand. Electricity generation is mainly based on thermal power plants (68% of total production), and major alternatives include hydropower with 15% and nuclear with 16%. The share of renewable sources is negligible (below 1% of total primary energy production).

Russia's GHG emissions are dominated by CO_2 emissions, contributing to 73% of total GHG emissions (Figure 1a). These emissions essentially come from fossil fuel combustion, which amount to 1.5 Gt CO_2e (according to UNFCCC) or 65% of total GHG emissions. Other major sources of emissions include fugitive emissions from the energy sector (403 $MtCO_2e$, or 18%) and industrial processes (mineral products, chemical industry, metal production, production and consumption of halocarbons and SF6) (173 $MtCO_2e$, or 8%). The agriculture, waste, solvent, and other product use jointly account for 221 $MtCO_2e$ (10%).

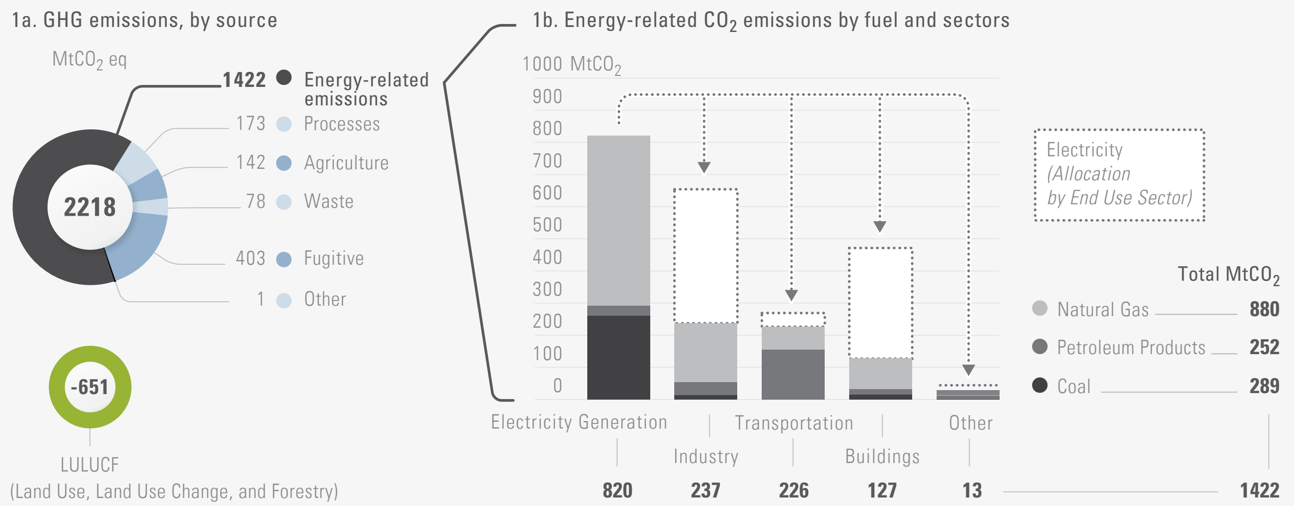
Carbon sinks (forestry and land use) play an important role in Russian carbon balance and are also of high political concern due to perception of the national forest as a source of global ecological gift. In 2010, the net carbon sequestration (in "managed forest") amounted to 651 $MtCO_2e$, "compensating" 29% of total national GHG emissions.

In this study, the main focus is on carbon emissions related to the Russian energy sector, covering primarily CO_2 emissions from electricity generation, industries, transport, buildings, and other sources. The share of these sources and related energy is described in Figure 1b.

1 http://www.economy.gov.ru/minec/activity/sections/strategicplanning/concept/
2 http://minenergo.gov.ru/aboutminen/energostrategy/
3 http://minenergo.gov.ru/press/min_news/3915.html
4 http://kremlin.ru/acts/6365
5 http://kremlin.ru/acts/19344
6 http://government.ru/media/files/41d4d0082f8b65aa993d.pdf

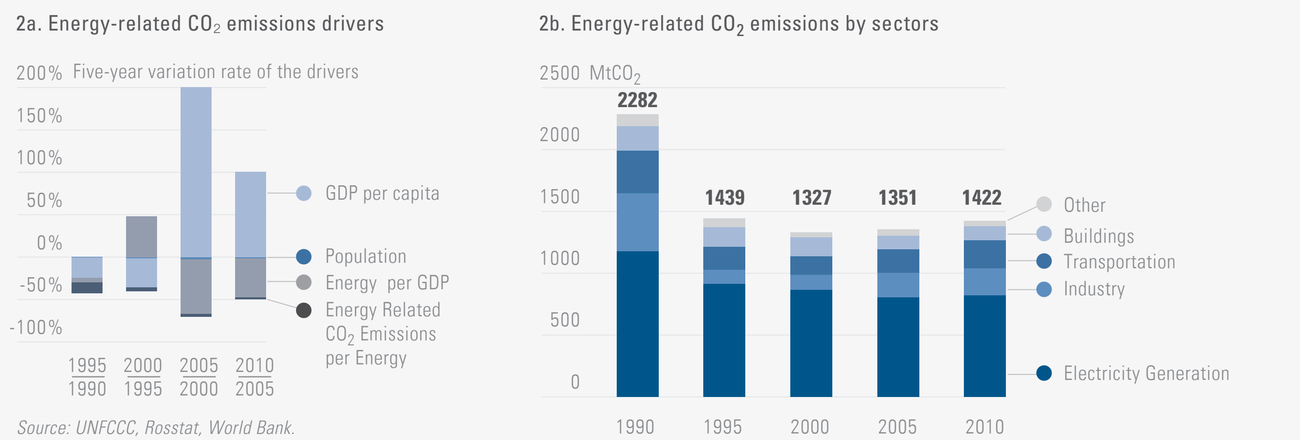
Total GHG without LULUCF emissions in Russia decreased by 31% over 1990-2011, from 3,352 to 2,321 $MtCO_2e$, with in particular a 38% decrease of energy-related CO_2 emissions over 1990-2010 (Figure 2), notably caused by dramatic drop of industrial production after the collapse of USSR in 1991. The 1999-2011 period was remarkable for Russia as it demonstrated clear decoupling of economic growth and carbon emissions (only 18% increase of emission for 96% GDP increase). The main drivers of this evolution include economic growth, structural changes in the economy, technological changes (modernization), fuel switch from coal to gas, growth of energy prices, and corresponding energy saving. Less but still important factors for carbon emission dynamics include transport and infrastructure development, waste management, agricultural production and forest policy (reforestation, forest management).

Figure 1. Decomposition of GHG and Energy CO_2 Emissions in 2010



Source: UNFCCC, IEA (IEA data source is used for decomposition when official UNFCCC information is not available.)

Figure 2. Decomposition of historical energy-related CO_2 Emissions, 1990 to 2010



Source: UNFCCC, Rosstat, World Bank.

2 National deep decarbonization pathways

2.1 Illustrative deep decarbonization pathway

2.1.1 High-level characterization

The illustrative scenario discusses the technical feasibility of a low-carbon economic development under assumptions on economic growth (notably, increase of steel and cement production, as well as increase of mobility) and patterns of development integrating a set of assumptions from official,[7] independent, and experts' visions and assumptions of Russian long-term economic development, technologies development reviews, and projections by the Russian and international organizations, as well as extensive expert consultations.

Then the scenario of economic development is simulated with technological model RU-TIMES with a decarbonization target set up at 1.67 t of CO_2 per capita in 2050. Uncertainties and robustness of conclusions are discussed in section 2.2 and 2.3.

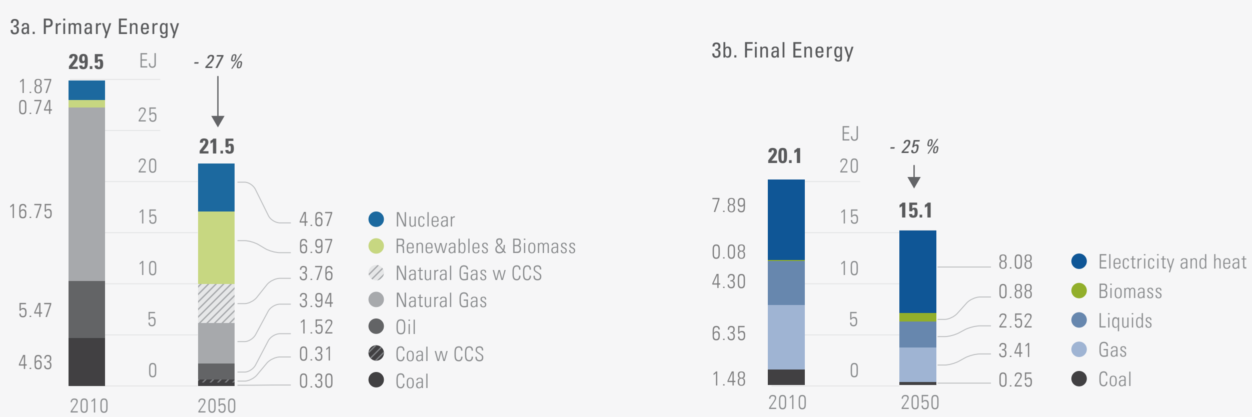
The scenario assumes a population decline from 142 to 120 million people in 2050 and the tripling of per capita GDP (Table 1). The simulation of total primary energy supply (TPES) and final energy demand are shown in Figure 3. The deep decarbonization results in a decline of TPES by 27% in 2050, with significant changes in the structure of energy production: total coal use drops to 2.8% (half of it with CCS); natural gas contributes 36% of TPES but almost half of it should use CCS; the share of oil should drop to 7.1%; renewables' share including biomass rises to 32.5%; and the share of nuclear can reach 21.8%.

The final energy consumption (from 20.1 EJ[8] in 2010 to 15.1 EJ in 2050, Figure 3) in Russia should also be significantly transformed in the deep decarbonization scenario: coal use to be phased out to 1.6%; the share of gas to reach 22.5% of final energy consumption; total liquid fuel (including biofuels) to decline to 16.6%;

Table 1. Selected assumptions and results about the socio-economic and energy sector development for the deep decarbonization scenario in Russia

	2010	2020	2030	2040	2050
Population (millions)	142	137	132	126	120
GDP per capita (constant 2012 US$)	13,116	19,127	25,726	32,932	40,833

Figure 3. Energy Pathways, by source



while the share of biomass should reach 5.8% of TPES and electricity and heat 53.9% by 2050.

The scenario pinpoints a decline of energy-related CO_2 emissions from 1,422 Mt in 2010 (IEA estimate is 1577-1678 Mt) to 200 Mt in 2050. The share of renewables in energy balance moves up to 10% in 2050 (0% in 2010). The decomposition of energy-related CO_2 emissions drivers and their pillars show that the growth of GDP per capita drives CO_2 emission up but is offset by the following emissions abating drivers (Figure 4):

- The reduction of the use of primary energy per unit of GDP: the energy intensity of GDP must decline from 15.8 to 4.4 MJ/$;
- The decarbonization of energy production: in particular, the carbon intensity of electricity generation should decline from 392 to 14 gCO_2/kWh;
- The electrification of the economy: the share of electricity in total final energy consumption should increase from 13% to 34%;
- A declining population.

2.1.2 Sectoral characterization

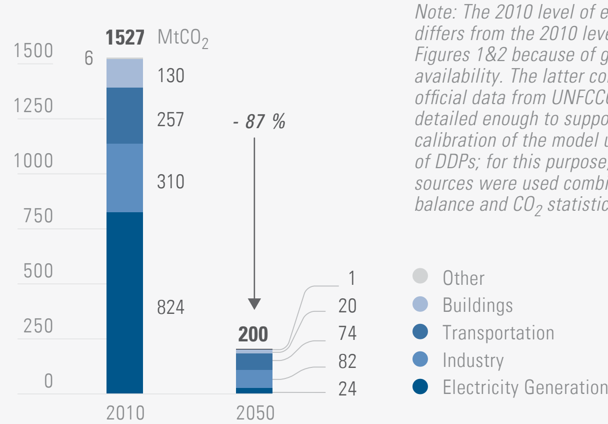
Electric power sector

The electric power sector is key in the decarbonization of the Russian economy. The Russian electric power sector has 700 power and combined heat and power (CHP) plants (over 5 MW of capacity). The total installed capacity accounts for 226.5 GW (in 2013), of which zero-emission capacities include 46 GW of hydro and 23 GW of nuclear power plants. The rest is covered by

7 Concept of the Long-Term Socio-Economic Development of Russian Federation (2008), Energy Strategy – 2030, industrial and sectoral programs of development (electric power sector, transport, metallurgy and others), IEA Technology Perspectives (2010, 2012, 2014), and others.

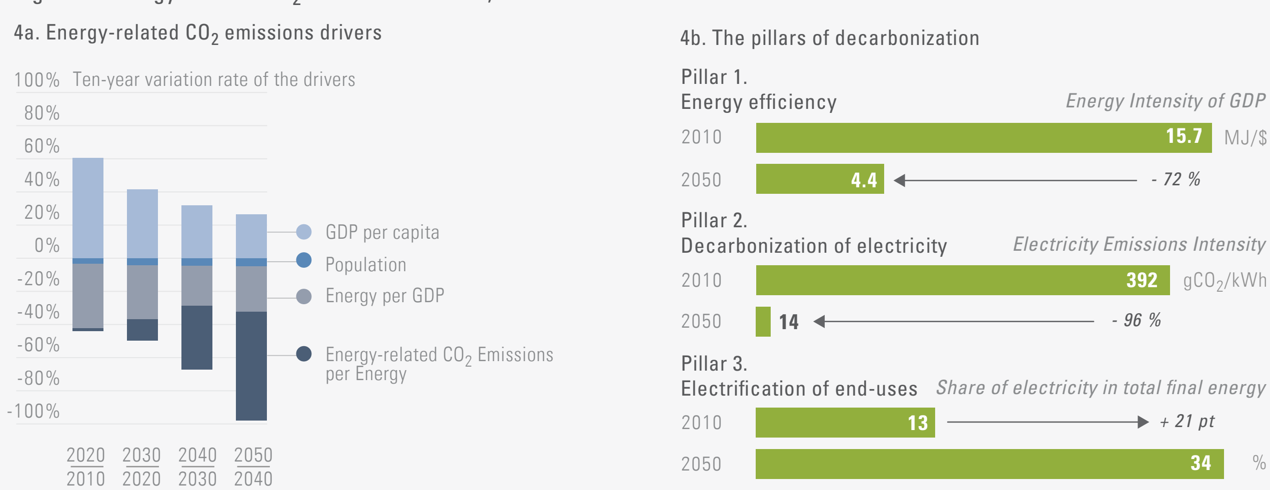
8 The estimate of the final consumption also includes energy used by blast furnance processes for iron production less transformed energy to blast furnance gases.

Figure 5. Energy-related CO_2 Emissions Pathway, by Sector, 2010 to 2050



Note: The 2010 level of emission in Figure 5 differs from the 2010 level reported in Figures 1&2 because of gaps in data availability. The latter corresponds to official data from UNFCCC, that are not detailed enough to support the full calibration of the model used in the analysis of DDPs; for this purpose, additional data sources were used combining IEA energy balance and CO_2 statistics.

Figure 4. Energy-related CO_2 Emissions Drivers, 2010 to 2050



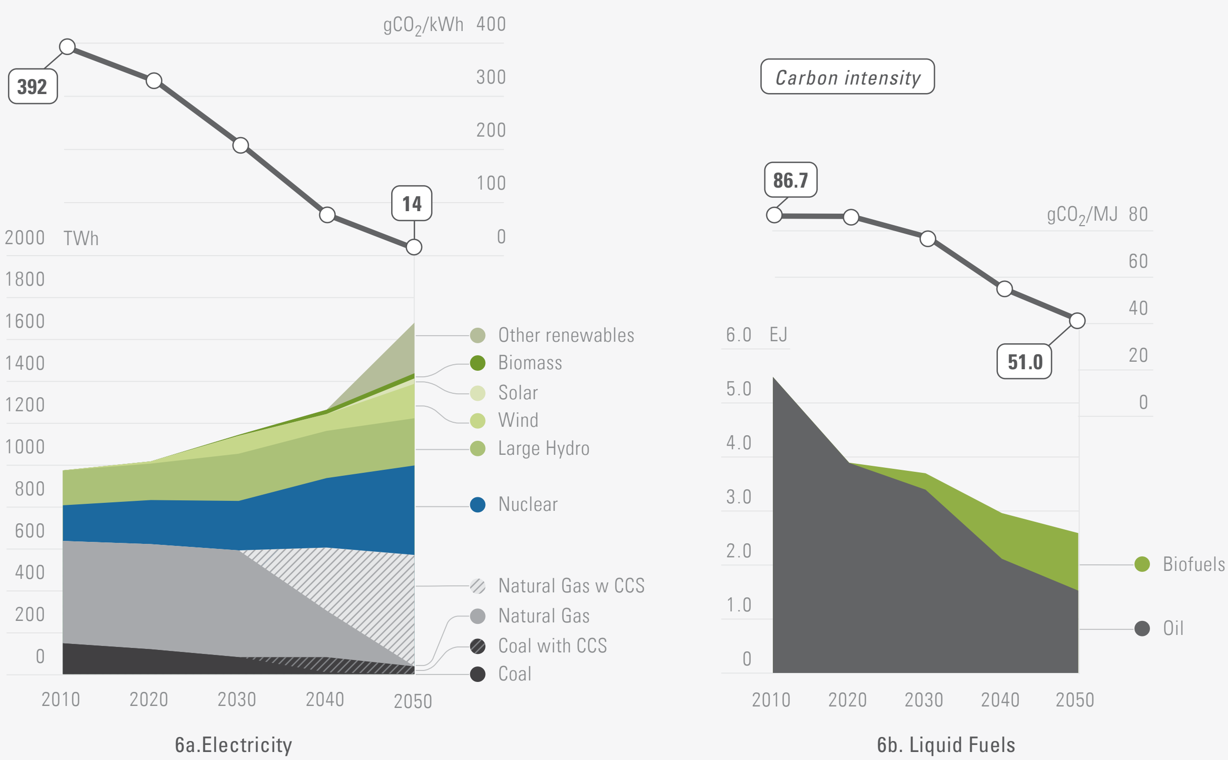
natural gas and coal-fired power plants. The forthcoming retirement of the majority of fossil-based power stations, made necessary by their obsolescence, creates both opportunities and challenges for the industry. The modernization will improve energy efficiency of the sector, which is far below best available technological options. The excessive capacities and slowly-growing demand limit opportunities for investment in the industry.

Several strategic developments can be envisaged to decarbonize the power industry, including growth of nuclear and large hydropower (already planned by the industry) as well as a growth of renewables' share in the energy mix. These renewables consist essentially in a progressive deployment of wind as well as of small hydro, tidal, and geothermal (the "other renewables category" in Figure 6a). However, with assumed CCS availability, the significant expansion of this latter category will be required only after 2040 to meet the low-carbon target (see discussion in section 2.3 in case of lower availability of CCS). The CCS technologies are assumed to be commercially available, and they will play an important role in the decarbonization strategy in the power sector in Russia beyond 2030. Almost all remaining thermal power plants (coal and natural gas fired) need to be equipped with CCS technology by 2050 to reach the deep decarbonization target (Figure 6).

Transportation

It is expected that the recent trends of fast-growing mobility demand continues, leading to a 133% rise of passenger transportation by 2050 and an increase of light duty vehicles (LDV) and air transport.

Figure 6. Energy Supply Pathways, by Resource



The reasons for this growth include growing GDP per capita, expansion of the loan market, and a shift from public transport to private light duty vehicles (LDVs). The low-carbon technological options in the LDV sector include liquefied petroleum gas (LPG) engines in the mid-term and expansion of biofuel use in the long run with updating LDV to the best available technologies. Electric vehicles will likely experience delayed expansion in Russia due to tough (cold) climate conditions, unless the technology improves; plug-in hybrids with internal combustion engines on LPG or biofuel may be more competitive.

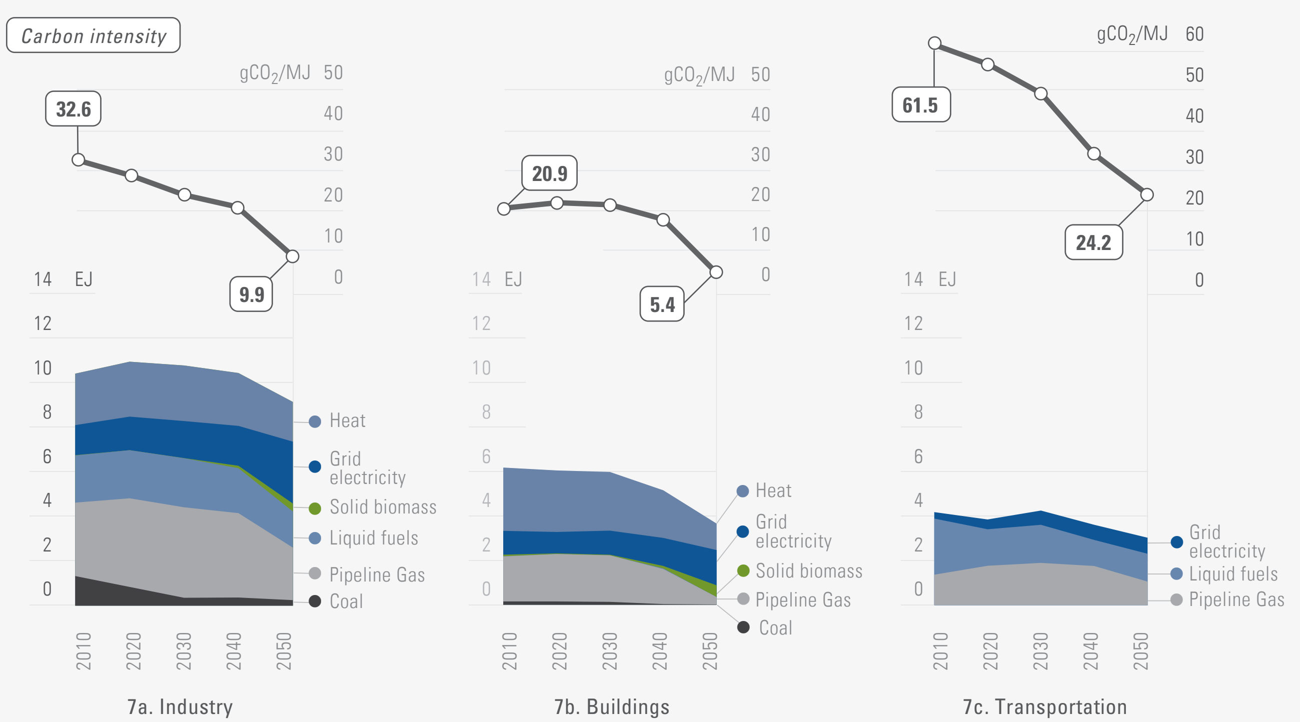
Another challenge is limiting emissions from air transportation, which will notably be permitted by the introduction of biofuels.

The freight transportation (rise from 2,372 to 4,250 billion t*km in 2050) can be decarbonized at relatively low costs. The heavy-duty vehicles (HDVs) could use LPG and liquefied natural gas (LNG) in medium-term. In the long-term, biofuels would be the primary option.

The biggest polluter in transport sector will be pipeline transport. There seem to be no alternative to the use of natural gas as fuel to transport natural gas via pipelines. So the amounts of consumed natural gas will be defined by the domestic natural gas consumption and exports via pipelines.

With all the decarbonization measures applied, emissions of the transport sector in 2050 can reach 73.5 $MtCO_2$. In final energy consumption, the share of electricity will move up from 7% in 2010 to 24% in 2050, with fall of oil products from 60% in 2010 to 6%, and increase of biofuels up to 35%.

Figure 7. Energy Use Pathways for Each Sector, by Fuel, 2010 – 2050



Note: Carbon intensity shown in Figure 7 for each sector includes only direct end-use emissions and excludes indirect emissions related to electricity or hydrogen production.

Buildings

The residential buildings in Russia contain huge potential for energy efficiency improvements. The heating system in Russia is historically highly centralized, with around 75% of heat being supplied by district boiler houses and combined heat and power boilers (CHPs). The overall losses in the heat supply system are over 50%.

The considered scenario assumes 30% growth of living space area per person, from 23 m^2 per capita to 30 m^2 per capita in 2050, as a catch-up with average living space per person for European countries (which is around 35-45 m^2 per capita). The decline of population over 2010-2050 however limits the expansion of total residential surface.

The deep decarbonization pathway requires tapping the existing reserves in energy efficiency improvement of buildings and overall residential heating systems. The scenario assumes a drop in energy consumption of buildings by 6 times to the level of 60 kWh / m^2 /year by 2050 (this is still a conservative estimate, compared to the best practice estimated around 15 kWh/m^2/year). The fuel mix structure should also be significantly changed with notable increases in biomass, electrification, and wide use of geo-heat pumps for heating.

The commercial and residential buildings have to follow the same strategy of energy efficiency growth, with additional electrification where possible and reduction of fossil energy consumption. Figure 7b shows total energy balance of the residential and commercial sectors, consistent with the deep decarbonization target.

Industry

Industrial output of energy intensive industries (iron and steel, non-ferrous metals, chemicals and petrochemicals, mining, and cement) is assumed to grow significantly over the next four decades, by 26% for steel production (from 66 Mt to 83 Mt), by 41% for cement (from 49 Mt to 69 Mt), and by 10% in other energy intensive industries. Important energy efficiency gains and changes in the energy mix are then necessary to make this significant growth compatible with limitations of associated emissions. The largest energy consumer in industry is integrated iron and steel (IIS) production. Since 1990, the IIS industry showed significant energy efficiency improvement that resulted in more than 20% reduction in carbon intensity of steel production due to retrofit and replacement of fixed capital. Further improvement, as expected, will lead to 33% additional energy efficiency, mainly due to the adoption of blast-furnace gas recycling technologies, which will increase carbon intensity of the steel production to EU level. However, for deeper reductions, further energy efficiency improvement technologies should be considered, such as direct reduced iron (DRI) on natural gas with potential to reduce CO_2 emissions up to 20-30% (with decarbonized electricity).

Processes of other energy-intensive industries are very diverse, and a moderate decarbonization potential of the remaining industries is considered, mainly by means of electrification of the industries from 14% to 34%, and a 6% energy efficiency growth from 2010 to 2050. The total fuel mix structure of industry and other remaining sectors (agriculture, forestry, fishing) consistent with the deep decarbonization scenario is presented in Figure 7a.

Agriculture, land use and forestry

The land use and forestry sector (LULUCF) is a very important source of carbon emissions and abatement in Russia. Since 1990, the net carbon sequestration in LULUCF increased up to 628 $MtCO_2$ due to relatively low levels of logging, low shares of over-matured wood, and other factors. However, the carbon net sink in Russian forests is expected to decline, and the net sink will become negative (emissions will exceed sequestration) by the mid-2040s[9] due to an increasing share of over-matured forest, expansion of forest fires and diseases, insufficient adaptation policies and measures, etc.

In order to keep and enhance the carbon sequestra-

9 http://unfccc.int/files/national_reports/annex_i_natcom/submitted_natcom/application/pdf/6nc_rus_final.pdf

tion capacity of Russian forests, as a large source of CO_2 absorption from the atmosphere, substantial enhancement and strengthening of climate change policy in the forest sector is required, including international cooperation in scientific, forest monitoring, forest fire and disease control measures, investment, and technological support.

2.2 Assumptions

The major technological conditions for reaching deep decarbonization in Russia include:

1. Pursue aggressive end use efficiency across all sectors;
2. Electrify where possible, and use gas where not possible to electrify;
3. Decarbonize the power sector by increasing the use of renewables, nuclear, hydropower plants, and maximize efficiency of thermal power and CHP plants;
4. Methane leakage, especially in extraction, storage, and transportation of natural gas is not covered by the scenario but will require substantial reduction;
5. Deep decarbonization of industrial production (e.g. metallurgy, cement, chemicals, and other);
6. Decarbonization of transport sector via electrification, biofuel use, etc.;
7. Energy efficiency improvement of all type of buildings;
8. Use of carbon capture and storage (CCS);
9. Utilization of huge biomass fuel potential, as well as other renewable energy sources; and
10. Large-scale heat production using heat pumps and energy saving in residential and commercial sectors.

2.3 Alternative pathways and pathway robustness

The most critical technological assumption in the analysis is CCS availability, biofuels potential, and scope of application of geothermal heat pumps for district heating. Although CCS has been tested in pilot projects around the world, the technology is not commercial yet, and it is uncertain if it will be available under competitive costs in Russia. With significant resources of biomass, costs and feasibility of biofuels production depend on many factors, including location, type of bio-resource, process of development, and competitiveness of the technology. In case one of these technological assumptions cannot be realized, alternative low-carbon strategies should be considered. If CCS is not available, renewables might be used instead. The current scenario is quite conservative for renewable energy in electricity production (about 25% in total generation) versus other countries, where renewable energy may reach more than 80%. Though Russia has relatively lower potential for mainstream solar and wind power, there is more than significant potential of tidal and hydro energy. A higher share of nuclear power is another alternative. Electrification of transport can be an alternative to biofuels. Higher energy efficiency improvements of buildings can reduce demand for heat and geo-heat pumps.

2.4 Additional measures and deeper pathways

Though the discussed scenario already has an ambitious target, additional measures could be envisaged to trigger deeper emission reductions notably through further electrification of industry, transport, final use sectors, and energy efficiency improvement. In particular, under specific conditions to be investigated more precisely, the following measures could be envisaged:

- Maximizing production of renewable electricity, harvesting tidal energy, hydro-power;
- Maximizing energy efficiency of buildings;
- Application of CCS in industry, including cement and iron and steel;
- Combination of biomass energy with CCS;
- Hydrogen-based technologies where possible, including transportation and steel production; and
- Optimizing public transportation, reducing number of trips, switching from private cars to public transport, and from air-transport to trains.

2.5 Challenges, opportunities and enabling conditions

The deep decarbonization of Russian economy will require significant efforts from government, businesses, and citizens. Rearrangement of the national economy in favor of low-carbon production technologies and a much less traditional use of fossil fuels will require dramatic changes in strategic planning, technological innovations, environmental regulation, low-carbon energy production technologies, relevant transport standards and infrastructure, household behavioral changes and, certainly, strong political will.

Evidently, Russia has an enormous potential for deep decarbonization. It has the necessary natural capital and territory, technological and scientific potential, and financial resources. The biggest challenge though is to channel the political will and business efforts towards the deep decarbonization pathway. In the current context, when the major share of Russia's industrial capital assets are depreciated and require renovation and modernization, it is a great opportunity for starting the new capital investment cycle based on the deep decarbonization platform. Russia can also play a significant role in exporting clean (carbon free) energy and products to neighboring countries, based on the implementation of large-scale projects on tidal energy generation in the North-West and Far East of Russia (with unique natural conditions), production of the second generation liquid and solid biofuels. The competitiveness of the new types of energy will be unlocked by emission reduction targets around the world.

Obviously, the international "decarbonization regime" would play an extremely important role in Russia's mitigation efforts, both in terms of scale and speed of changes required. Involvement of Russia in international initiatives would be crucial, including technological cooperation, implementation of investment projects (e.g. using Russian renewable energy sources, new generation nuclear power projects, etc.), global carbon pricing mechanisms, forest carbon sequestration and adaptation mechanisms (LULUCF, REDD+), scientific research on low-carbon development, etc.

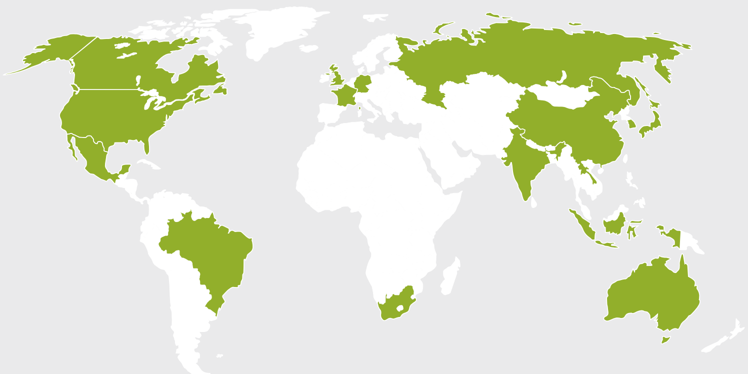
These long-term cooperation frameworks need to be provided in the new climate change agreement with active participation of all major-emitting countries, as well as other international agreements under the UN, WTO, and others.

2.6 Near-term priorities

Near-term priorities for the Russian deep decarbonization pathway should include:

- Establishment of the information basis for emission management (monitoring, verification, and reporting on the source level);
- Development and introduction of the GHG emission regulation system (providing incentives for emission reduction, project-based, cap-and-trade schemes, etc.);
- Strengthening the current decarbonization efforts (gasification programs, energy efficiency, renewable energy use, energy saving, decarbonization of transport, cement, chemical, metal production, etc.);
- Enhancing R&D in and implementation of breakthrough technologies (e.g. biofuels, electrification of transport and infrastructure, CCS, new generation nuclear power plants, etc.); and
- Improvement of the adaptation/mitigation policies and measures in forestry and agriculture, supporting carbon sequestration capacities.

These efforts will allow continuing decoupling GDP growth and GHG emission trends and will facilitate finding new solutions to deep decarbonization in Russia. Partly, these measures correspond to the activities approved in the Governmental Action Plan on reduction of GHG emissions (adopted on February 4, 2014) and other decisions. However, the deep decarbonization approach will require significant adjustments in strategic planning of the economic development, technological, and institutional changes aimed at the creation of climate-neutral Russia.



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