Country Report

Transition pathways for Russia

August / 2024

Giannis Tolios, Panagiotis Fragkos, E3-Modelling

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

Key messages

- Russia is a signatory to the Paris Agreement, and has formalized its commitment to the international treaty, by ratifying it in 2019. Russia has also set a long-term target of net zero emissions by 2060.
- Russia is a fossil energy superpower, with the country being ranked in top places of oil, natural gas and coal production, and the Russian economy relying massively on hydrocarbon exports.
- The NDC and Long-term climate targets of Russia can be achieved, driven by the reduced use of fossil fuels combined with electrification of demand sectors, as well as the uptake of renewable energy sources and hydrogen. By implementing ambitious climate policies, Russia will be able to decarbonize its economy, and achieve the long-term target of net zero emissions by 2060.

Introduction and overview

In this report, we provide an overview of the climate policy of Russia (officially known as the Russian Federation), focusing specifically on its Nationally Determined Contributions (NDCs). Russia is the largest country in the world, with a total land area of approximately 17.1 million km^2, spanning the continents of Europe and Asia, and accounting for 11% of global land mass. Russia is a major fossil fuel producer and participates in various initiatives of the OPEC+ group, a coalition between OPEC member states, and other oil exporting countries. Russia is also a major geopolitical power that participates in BRICS and G20, while being a permanent member of the United Nations Security Council.

Key socio-economic figures and outlook

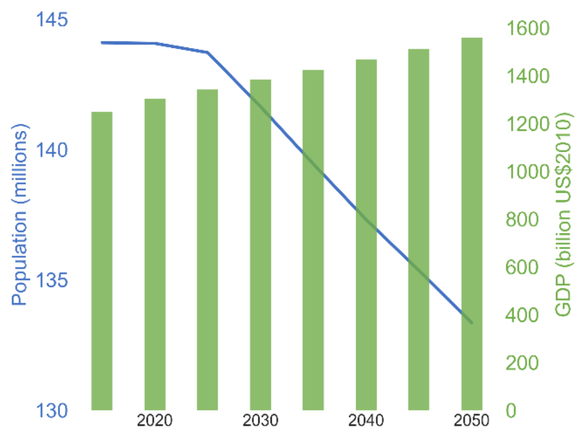

Figure 1: Russia's expected population and GDP development.

After the Soviet Union had been dissolved, Russia transitioned from a centrally planned to a mixed economic paradigm, gradually incorporating free market elements (Johanson, 2008). Russia is widely described as an energy superpower, with the country being ranked in top places of oil, coal and natural gas production, while also having significant reserves of those resources. Apart from the fossil fuel industry, other major sectors of the Russian economy include agriculture, defense industry, aerospace, and automotive industry. In February 2022, Russia invaded Ukraine, hence starting a military conflict that is ongoing to this day. Because of the invasion, western nations —including the USA and the EU— imposed sanctions on Russia, resulting to macroeconomic impacts such as inflation (Korhonen, 2023). The Russian GDP was approximately US '2010 1.3 trillion in 2020, and the economy is projected to grow at an average annual rate of 0.6%, thus reaching approximately 1.5 trillion dollars in 2050 (IEA, 2023). Russia's population is expected to drop from 144 million in 2020, to about 133 million in 2050, as the country is currently ranked in the 9th place worldwide on population (UN, 2022).

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

The Emission Situation of Russia in 2015

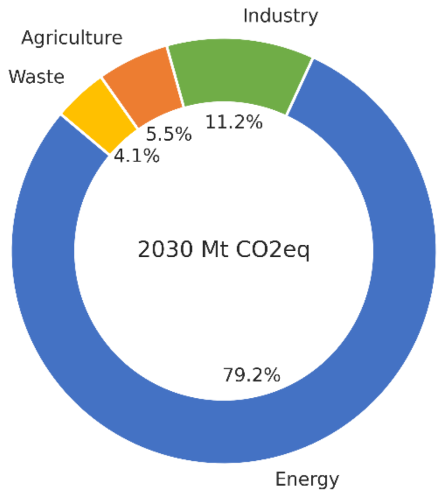

Figure 2: Russia's CO_2eq emissions by sector in 2015. Source: PIK.

When the Paris Agreement was adopted in 2015, total greenhouse gas (GHG) emissions of Russia were approximately 2030 MtCO_2eq, as seen in Figure 2. Russia is one of the top GHG emitting countries, with emissions that are comparable to India, Japan, Indonesia and Brazil. In 2015, most of those emissions came from the energy sector, amounting to 1610 MtCO_2eq, or a share of approximately 80%. Following next, the industry sector accounted for a share of 11.2%, while the agriculture sector accounted for a share of 5.5%, and the waste sector emitted 83.4 MtCO_2eq, accounting for 4.1% of total GHG emissions. It should also be noted that Russia is a major emitter of methane, mostly originating from the country's natural gas infrastructure, such as gas extraction facilities and leaking pipelines. Because of that, fugitive methane emissions amounted to approximately 420 MtCO_2eq in 2015. Exploring the energy sector in more detail, we see that electricity production was almost completely reliant on fossil fuels, including oil, gas and coal. Nuclear energy was also heavily used for electricity production. Considering renewable energy sources, hydropower was the most prominent, while the usage of solar, wind, geothermal and biomass was very low (BP, 2022). As a result of its high carbon intensity and dependence on fossil fuels, Russia has one of the highest emissions per capita rates globally, standing at about 14 tCO_2eq in 2015.

The Current State of GHG Emissions

After the Paris Agreement was adopted, Russian GHG emissions slightly fluctuated, while returning to the 2015 levels in 2022, with a minor redistribution of sectoral shares. While dropping a few percentage points, the energy sector remained the most prominent source of emissions, with a share of 76.2%, amounting to 1550 MtCO_2eq in 2022. The industry sector increased its share at 13%, or the equivalent amount of 265 MtCO_2eq. The emissions from the agriculture and waste sectors remained almost stable, at 5.9% and 4.9% respectively. Fugitive methane emissions increased to approximately 500 MtCO_2eq, further establishing the position of Russia as a major source of such emissions. Finally, the emissions per capita rate increased further to 15 tCO_2eq, as a result of Russia's declining population. Those statistics indicate that Russia has made negligible progress in reducing GHG emissions since the Paris Agreement, and officials must strive to implement more ambitious mitigation policies.

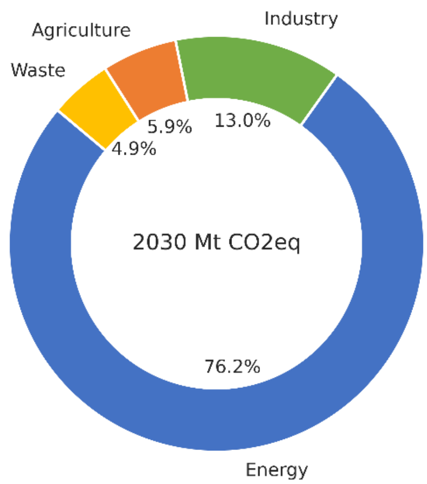

Figure 3: Russia's CO_2eq emissions by sector in 2022. Source: PIK

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

Nationally Determined Contributions of Russia

Russia is a signatory to the Paris Agreement, and has formalized its commitment to the international treaty, by ratifying it in 2019. Nationally determined contributions (NDCs) are commitments made by individual countries with the purpose of reducing GHG emissions, and achieving the global targets specified in the Paris Agreement (UNFCCC, 2015). The Russian government submitted its NDC document in November 2020, including specific details about their climate change mitigation plans and ambitions. The Russian NDC target is reducing GHG emissions by 2030 to 70 percent relative to the 1990 level, taking into account the maximum possible absorptive capacity of forests and other ecosystems, and subject to sustainable and balanced social economic development of the Russian Federation (Russia, 2020). In September 2022, Russian officials also submitted their "Strategy of socio-economic development of the Russian Federation with low greenhouse gas emissions by 2050" to the UNFCCC secretariat (Russia, 2022). This document includes the long-term climate strategy of Russia, and more specifically the target of achieving climate neutrality, i.e. net zero GHG emissions by 2060.

Description	NDC Target for 2030	Long-term Target
GHG Mitigation	Limiting GHG emissions to up to 70% compared to 1990 levels by 2030	Net zero GHG emissions by 2060
Absolute Emissions (excl. LULUCF)	Up to 2408 $MtCO_2eq$	not adequate information about the Long-term Russian strategy
Compare with 2010	20% above 2010 levels	100% reduction from 2010 levels

Table 1: Basic NDC information of Russia's NDC and long-term targets

The NDC document includes detailed information about the climate change mitigation plans of Russia, that are focused on energy efficiency improvements, renewable energy sources, protecting natural sinks of GHGs, and encouraging the reduction of GHG emissions with financial and tax incentives. In addition, a monitoring and reporting system for GHG emissions will be established, being in alignment with international standards. Apart from mitigation measures, the NDC document also focuses on adaptation, highlighting the impacts of climate change on natural ecosystems, socioeconomic development, as well as the living conditions and health of Russian citizens. Climate change adaptation will be accomplished by implementing a national action plan, that will prioritize specific actions for the adaptation of economic sectors and regions, based on their needs and vulnerabilities. Regarding the long-term target of net zero emissions, the Russian strategy relies heavily on carbon dioxide removal from the land use, land use change and forestry (LULUCF) sector, emphasizing the utilization of forests as natural sinks. Negative land-use-related emissions in Russia are projected to double, reaching approximately -1200 $MtCO_2eq$ in 2050. It should be noted that the Russian economy went through a prolonged economic crisis and recession after the Soviet Union collapsed, which resulted in large reductions of GHG emissions (Schiermeier, 2019). As a direct consequence, the Russian emissions were significantly higher in 1990 at approximately 3100 $MtCO_2eq$ compared to their current levels, meaning the NDC target can be accomplished with relatively small effort.

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

Additionally, independent experts have assessed the Russian NDC document, criticizing the lack of ambitious emissions reduction targets and characterizing the specified policies as “highly insufficient” and not compatible with the Paris Agreement goals (CAT, 2022).

Key Decarbonization Pathways

In this section, we explore the decarbonization pathways of Russia, based on the targets included in the NDC document and Russia’s long-term strategy, as well as expert analysis and modelling. We intend to evaluate the climate pledges of Russia, and assess their alignment with the Paris Agreement goals, i.e. the 1.5°C and 2°C global temperature increase limits. The scenarios used in the following analysis are based on detailed modelling using the EDS model and expert assessment of the Russian climate ambitions, along with information from the official policy documents. We have established a business as usual (BAU) scenario, taking into account the current climate policies and legislation being implemented in the Russian Federation. The NDC/LTT scenario is based on the targets and plans included in the NDC and long-term strategy documents, that have been submitted by Russian officials. Those scenarios were created using EDS (Fragkos et al, 2013), an energy system model that has been utilized in various climate policy studies and academic research (Fragkos, 2023).

Impact of Russian NDCs on Primary Energy Consumption

We begin the analysis by focusing on the scenario impact on Russian primary energy consumption. As seen in Figure 4, primary energy is projected to steadily increase in the BAU scenario, reaching approximately 33.3 EJ/year in 2050. The main drivers of this increase are economic growth and rising living standards for Russian citizens indicating the limited effectiveness of current Russian policies to curb energy consumption. In contrast, the NDC/LTT scenario projects that primary energy consumption will be mostly unchanged between 2020 and 2050 (due to enhanced energy efficiency and the uptake of more efficient technologies and fuels), with only minor fluctuations taking place. In the BAU scenario, primary energy is dominated by fossil fuels, with oil, gas and coal having a total share of 80% in the primary fuel mix, reflecting the lack of ambitious climate policies in Russia. Nuclear energy also has a significant share at 10%, as Russia has 11 nuclear power plants, operated by the state-owned Rosatom corporation, while there are plans for further expansion of nuclear power. Renewable energy sources are underutilized, with biomass, hydropower, solar and wind energy having a combined share of 10%. In the NDC/LTT scenario, fossil fuel usage drops significantly, with the share of fossil fuels at 62% in 2050, resulting from the imposition of climate policies to ensure that Russia meets its NDC and long-term climate targets. As emphasized in the Russian NDC document, renewable energy sources have a significantly higher uptake in this scenario, with a total share of 19% in the primary energy mix by 2050, while their implementation still faces significant barriers as illustrated by the very low progress in renewable energy projects so far in Russia.

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

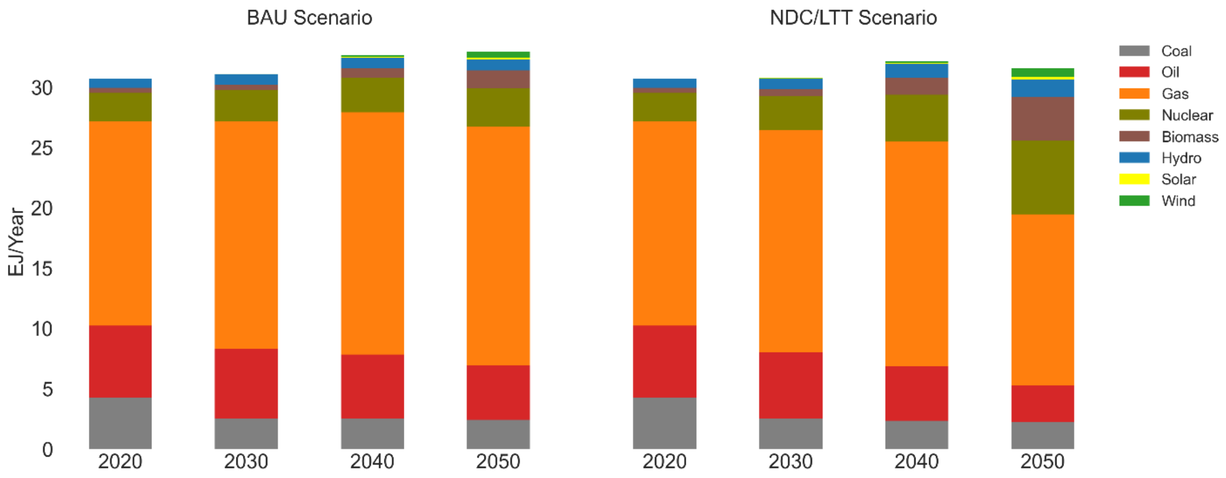

Figure 4: Primary energy consumption of Russia in the BAU and NDC/LTT Scenarios. Source: EDS Model

Sectoral System Transformations

In this section, we explore the sectoral transformations of the Russian economy as a result of the NDC/LTT scenario. Our analysis covers all the main energy demand and supply sectors, including industry, buildings, transportation, and electricity production. As seen in Figure 5, final energy consumption increases significantly in the BAU scenario by 2050, mostly driven by the growing economic activity and rising living standards combined with the lack of ambitious climate policies. In contrast, the NDC/LTT scenario projects only a marginal increase of final energy consumption, due to the energy efficiency improvements and the gradual uptake of more efficient energy forms and technologies (e.g. electric vehicles instead of conventional ICEs) that are planned in the Russian NDC document. It should also be noted that the projected decline of Russian population by 2050 also plays a significant role, by reducing future energy needs.

Industry

The Russian industry sector is largely dependent on fossil fuels, with the BAU scenario projecting a total share of 50% for fossil gases, liquids and solids in 2050. Electricity is also utilized in the same scenario, with a share of 21%, while other fuels (mostly steam and heat) have a share of 25% in the final energy mix and biomass solids account for 4%. In the NDC/LTT scenario, fossil fuel usage is reduced by 2050, with a total share of 40%, due to the more ambitious climate policies and the implementation of industrial transformation strategies. The electricity share of total final energy use in industries increases to 26%, with the purpose of replacing carbon intensive energy sources, and reducing GHG emissions. The use of biomass solids get a higher share of 6%, replacing the use of coal, while the use of hydrogen (accounting for 7.5% of industrial energy use in 2050) also emerges especially in the chemicals and in the steelmaking sectors.

Buildings

In the BAU scenario, the Russian buildings sector is heavily reliant on fossil fuels, with fossil gases and liquids having a total share of 65% in 2050, primarily used for space and water heating. Electricity usage is projected to increase in this scenario, having a share of 32% in 2050, but still the sector faces considerable challenges to be transformed as indicated by the limited use of clean energy sources for space and water heating in buildings. In the NDC/LTT

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

scenario, the use of fossil fuels is projected to decline as a result of climate policies and the implementation of sectoral transformation strategies and options, whereas electricity share increases to 38% by 2050 mostly driven by the enhanced uptake of heat pumps. This is a result of the combined efforts to reduce GHG emissions and electrify the buildings sector. In addition, sectoral energy consumption is 5% lower compared to BAU, because of improved energy efficiency standards, thermal insulation and the use of modern equipment and energy efficient appliances. Since 2016, Russian houses have been assigned an energy efficiency class, ranging from A++ to G, as ordered by the Russian Ministry of Construction. Newly constructed buildings are forbidden to have an efficiency class below B, thus reducing energy needs (Zagoruichyk, 2022).

Transportation

In the BAU scenario, the transport sector remains heavily reliant on fossil fuels, with liquids and gases accounting for 84% of the fuel mix in 2050. Electricity and biofuels are also utilized, with shares of 14% and 2% respectively (electricity mostly for in the extensive rail sector of Russia). In contrast, the NDC/LTT scenario projects a significant drop in fossil fuel usage, whereas electricity increases to 31% in 2050 driven by the massive uptake of electric vehicles showcasing the large transformational potential of the sector in case that ambitious policies and strategies are implemented. This is a result of conventional internal combustion engine (ICE) vehicles being gradually phased down, while sustainable technologies like electric vehicles (EV) are adopted. Furthermore, the share of biofuels is also increased to 5%, indicating the utilization of alternative fuels, like ethanol, biodiesel and others to reduce emissions from sectors where electrification is challenging (e.g. aviation, shipping).

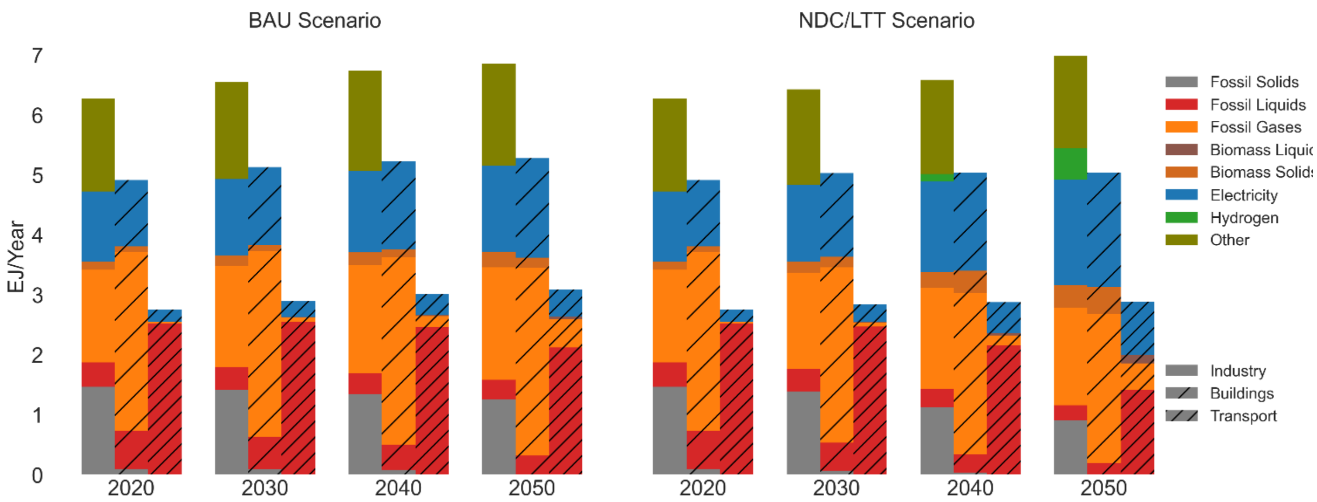

Figure 5: Final energy consumption of Russia by main sector and fuel in the BAU and NDC/LTT Scenarios. Source: EDS Model

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

Electricity Production

As seen in Figure 6, electricity production keeps increasing in both the BAU and NDC/LTT scenarios, albeit at a significantly higher rate in the latter scenario, with total production being approximately 30% higher in 2050 compared to BAU driven by the accelerated electrification of energy and mobility end-uses in the NDC/LTT scenario. In the BAU scenario, electricity production is largely dependent on fossil fuels, with gas and coal having a total share of 45% in 2050. This is a direct consequence of Russia having the world's largest natural gas reserves, therefore utilizing domestically produced, cheap gas for electricity production. Nuclear energy is also heavily used, accounting for about 20% of the power mix (close to current levels) as Russia prioritizes nuclear power as part of its current energy strategy. Hydropower is the major renewable energy source with a share of 18% in 2030, while biomass, solar and wind energy have limited adoption. In the NDC/LTT scenario, fossil fuel usage drops significantly, with a share of 23% in 2050 (most of this combined with CCS), because of the intensified efforts to reduce GHG emissions. It should also be noted that carbon capture and storage (CCS) will be utilized to reduce the carbon intensity of coal and gas power plants. Nuclear energy has a total share of 30% in 2050, highlighting Russian ambitions to increase nuclear capacity in the future (WNA, 2024) combined with the country's limited potential for renewable energy expansion, as the uptake of wind and solar is constrained due to limited resources. However, the large uptake of nuclear power comes with large economic and financial challenges, serious environmental threats and geopolitical impacts, especially in the current political context with the war in Ukraine. Finally, the combined RES uptake is significantly higher at 46% —with wind, hydro and biomass having significant contributions— as emphasized in the NDC document, and the Russian long-term climate strategy, focusing on the deployment of renewable energy sources.

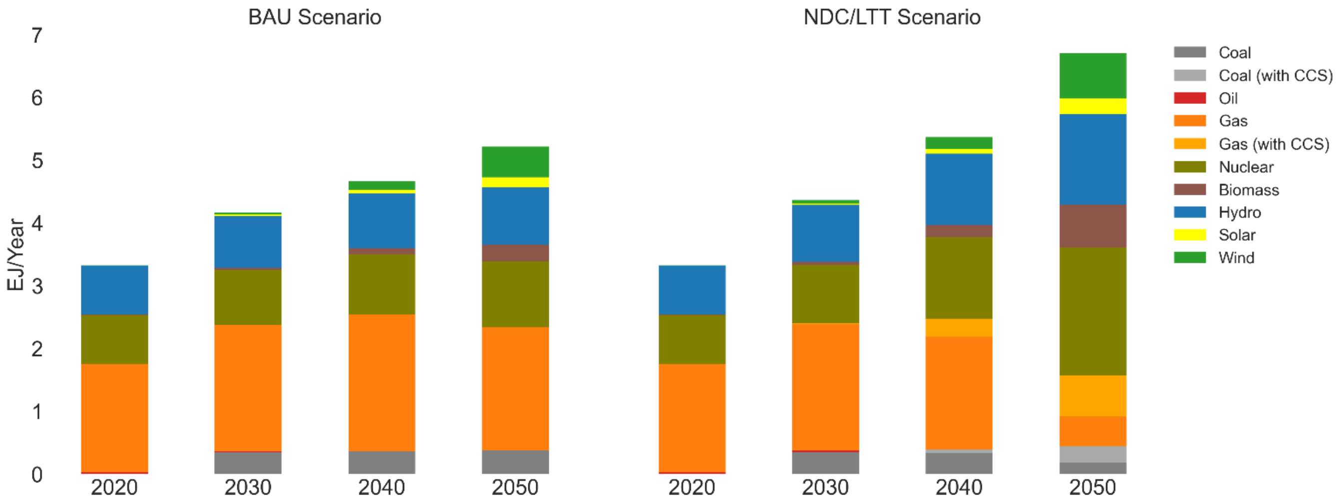

Figure 6: Electricity production of Russia by fuel in the BAU and NDC/LTT scenarios. Source: EDS Model

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

Greenhouse Gas Emissions

In this section, we analyze the CO_2 emission trajectories of the Russian energy sector, in the BAU and NDC/LTT scenarios. As seen in Figure 7, the BAU scenario projects an upward trend for CO_2 emissions, increasing from 1630 $MtCO_2$ in 2020, to approximately 1780 $MtCO_2$ in 2030, and peaking at 1850 $MtCO_2$ in 2040. Afterwards, emissions are projected to marginally drop to 1750 $MtCO_2$ in 2050. In the NDC/LTT scenario, the growth of CO_2 emissions decelerates this decade, in order to meet the Russian NDC target (CO_2 emissions stand at 1750 $MtCO_2$ in 2030); this is followed by an emissions reduction after 2030 to 1520 $MtCO_2$ in 2040. Afterwards, CO_2 emissions are projected to decline even more drastically, reaching 730 $MtCO_2$ in 2050. This is a result of the Russian ambition to achieve climate neutrality, i.e. net zero emissions by the year 2060, as well as the GHG reduction plans detailed in the NDC document. It should also be noted that independent experts have assessed that Russian climate pledges are not aligned with the Paris Agreement goal of limiting global mean temperature increase to 1.5°C by the end of the century and characterized them as “highly insufficient”.

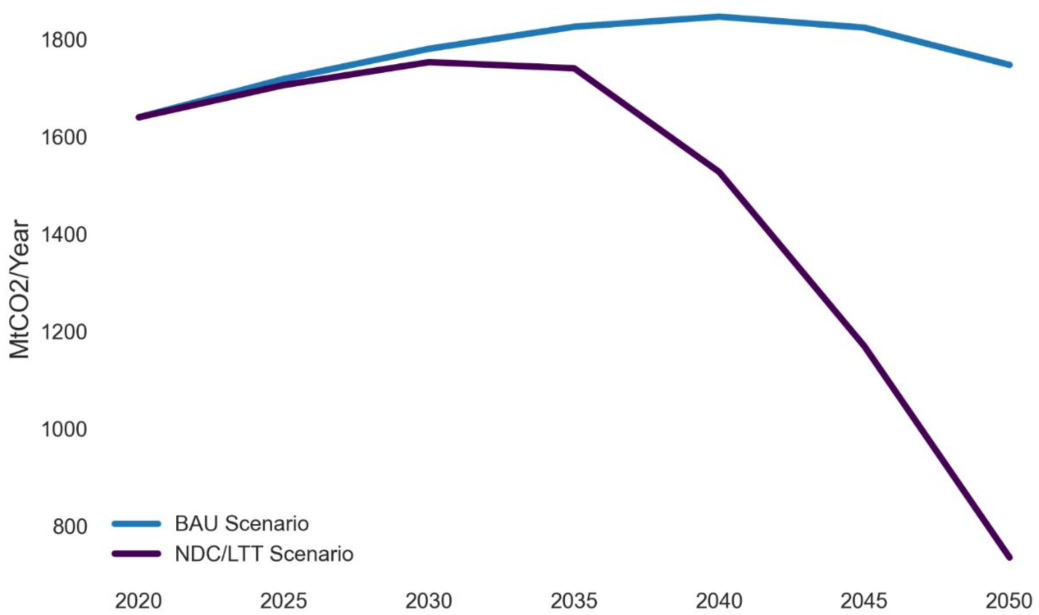

Figure 7: Annual CO_2 Emissions of the Russian energy sector in the BAU and NDC/LTT Scenarios. Source: EDS Model

Socioeconomic impacts of the Russian war on Ukraine and the trade sanctions

The Russian military invasion of Ukraine and the subsequent responses by different countries in the world, have led to several fundamental changes in national policies and international relations. In addition to increasing geopolitical tensions, sanctions enforced on Russia and its collaborators by Western countries have led to economic impacts

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

and soaring fossil energy prices in 2022, particularly for natural gas in Europe. The fossil energy embargo, energy price fluctuations and general increase in energy security risks have forced the EU to promptly change its fossil energy imports and rethink its short and medium-term energy security and climate strategy. In addition, the war has threatened Ukrainian grain production and transport, which has raised concerns about global food security and rising food prices (Ruta, 2022). According to Climate Action Tracker, the EU's investment in liquefied natural gas (LNG) infrastructure to replace Russian gas supplies could either increase the risk of fossil fuel lock-in - potentially leading to an additional global 1.9 Gt CO_2e per year in 2030 - or result in increased stranded assets (CAT, 2022). In this section, we aim to systematically assess the short-term (up to 2030) and medium-term (2050) implications of the Russian-Ukrainian war, both in terms of economic impacts (GDP, employment) due to trade restrictions, as well as the physical aspects (energy, emissions). We aim to assess how increased energy prices, could affect emissions and energy supply and demand trends as well as socio-economic developments in Russia and the EU. To achieve this, we use the advanced General Equilibrium model GEM-E3 to perform a detailed scenario assessment to quantify the socioeconomic impacts of the Russian war on Ukraine and the trade sanctions.

GEM-E3 is a detailed applied Computable General Equilibrium (CGE) model, simultaneously representing 46 countries/regions, including all EU countries individually and the G-20 economies globally. GEM-E3 covers the interactions between the economy, the energy system and the environment. It is a comprehensive model of the economy, covering the interlinkages between productive sectors, consumption, price formation of commodities, labor and capital, bilateral trade and investment dynamics. The model is dynamic, recursive over time, driven by accumulation of capital and equipment. The model features alternative market regimes, discrete representation of power producing technologies, equilibrium unemployment, energy efficiency standards, carbon pricing and formulates emission permits for GHGs. GEM-E3 can quantify the macro-economic, employment and distributional impacts of trade and climate policies.

We develop three alternative scenarios that run up to 2050 and incorporate a high level of detail in climate and energy policies, including recent greenhouse gas emissions projections of the current policies scenario for major emitting countries (Dafnomilis et al., 2022). As the analysis requires a detailed representation of recent global developments, GEM-E3 has been calibrated with the most recent available data for the relevant variables, including (BP, 2022; IEA, 2022; IMF, 2022), which encompass the effects resulting from the war. The scenarios also account for all global and regional economic impacts resulting from the COVID pandemic, based on Dafnomilis et al. (2022). The key socio-economic and policy assumptions are harmonized based on SSP2 trajectories or similar (Riahi et al., 2017)), using the most recent current policies (Dafnomilis et al., 2022).

The Current Policies (CP) reference scenario includes all recent major climate policy updates and COVID epidemic socio-economic implications, including recent GDP recovery trends. However, it excludes implications resulting from the Ukraine war. Therefore, only pre-war GDP projections are included (i.e., the IMF projection from October 2021 (IMF, 2021)) and the 2022 fossil energy price peaks are excluded (i.e., the scenarios include price data up to and including 2021 based on BP (2022)).

The Ukraine scenario includes all assumptions from the CP scenario, complemented with the implications from the war. These implications include global and regional GDP effects, energy (and other) trade limitations, and short to medium-term increases in energy prices. The implemented energy trade restrictions require a full elimination of Russian fossil energy exports to the EU from 2023 onwards. Currently, the EU, the United States, United Kingdom

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

and Australia have a nearly full ban on direct fossil energy (gas, oil & coal) imports from Russia. Japan has reduced oil and coal imports by roughly 50%. Energy sanctions are assumed to be in place until 2027 (5 years after the start of the war). After that, import levels are assumed not to exceed 20% of 2020 levels, as a continuation of pre-war trade relations is assumed to be highly unlikely. Changes in energy prices due to trade restrictions are calibrated based on the most recent energy price data including the year 2022 (BP, 2022;).

Non-energy trade restrictions are simulated in GEM-E3 based on the current trade sanctions by product. Non-energy sanctions are assumed to be in place until 2027 (5 years after the war), with a gradual phase-out until 2040. Economic sanctions include the export ban of engineering, electronics, transport equipment, motor vehicles, communication and dual use products to Russia from Western countries, and the import ban of iron, steel, wood, cement and food from Russia to Western countries (see Table 2). The Ukraine_long scenario represents a prolonged war situation where (both energy and economic) trade sanctions will be in effect until 2050.

Import bans from Western countries to Russia on:	**Import bans from Russia to Western countries on:**
Metal Goods	Food, Drink & Tobacco
Mech. Engineering	Wood & Paper
Electronics	Non-Metallic Mineral Products
Elec. Eng. & Instrum.	Basic Metals
Motor Vehicles	Metal Goods
Other Transport Equipment	Manufacturing other
Manufacturing other	Land Transport
Land Transport	Water Transport
Water Transport	Air Transport
Air Transport	Computing Services
Communications	Professional Services
Computing Services	
Professional Services	

Table 2: Economic sanctions as implemented in GEM-E3 model in Ukraine and Ukraine_long scenarios

The macro-economic assessment with the GEM-E3 model shows that the energy and trade sanctions would have negative – but overall limited - impacts on economic activity (see Figure 8). The model projects small reductions in global GDP due to the war in 2025 (0.4%) and 2030 (0.2%), and an almost negligible reduction in global GDP (<0.03%) in 2050 as a result of the trade sanctions on energy and industrial products. The trend, small negative impacts that are almost fully reduced in 2050, occurs in all regions, except Russia, which will be most negatively affected, also in the longer term. Its GDP is projected to be reduced by about 4% in 2030 compared to the Baseline

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

scenario, due to declined fossil fuel exports to the EU and other OECD economies and the negative economic repercussions of trade sanctions in key sectors and products for Russian economy. If the sanctions are kept in place until 2050 (i.e., the 'Ukraine_long' scenario), GDP reduction in Russia is projected to increase towards 6% in 2050. GDP impacts are limited in the EU (-0.1%-0.4% in 2030), which can replace lost Russian gas with other sources (either domestic renewables and energy efficiency or imported gas from other regions) at relatively low costs.

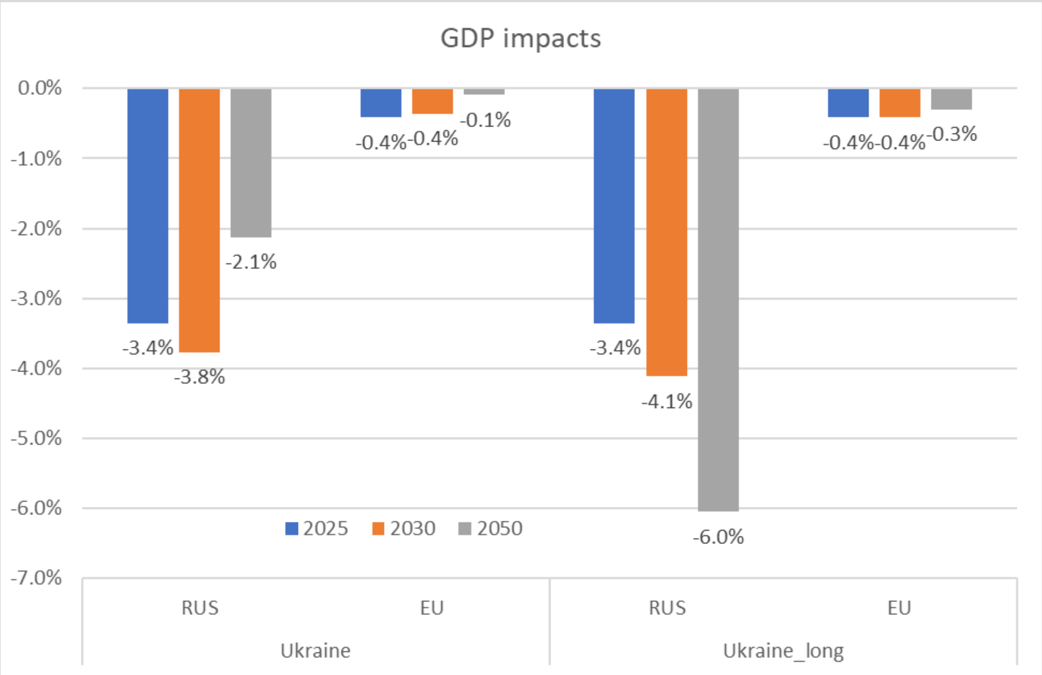

Figure 8: GDP impacts of the alternative trade sanction scenarios in the EU and Russia compared to a Baseline scenario

The (small) regional economic impacts show that there will be regional 'winners' and 'losers' (Figure 9). This is in line with findings by the World Bank (Ruta, 2022). While all energy importing countries are negatively affected, the sanctions will indirectly benefit major non-Russia hydrocarbon exporters (e.g., Norway-Rest EU, other energy producers (notably Saudi Arabia)) that benefit from increased fossil export revenues to the OECD economies as thy substitute reduce Russian fossil fuel exports. Overall, the impacts on employment closely follow the GDP impact patterns in major countries and regions.

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

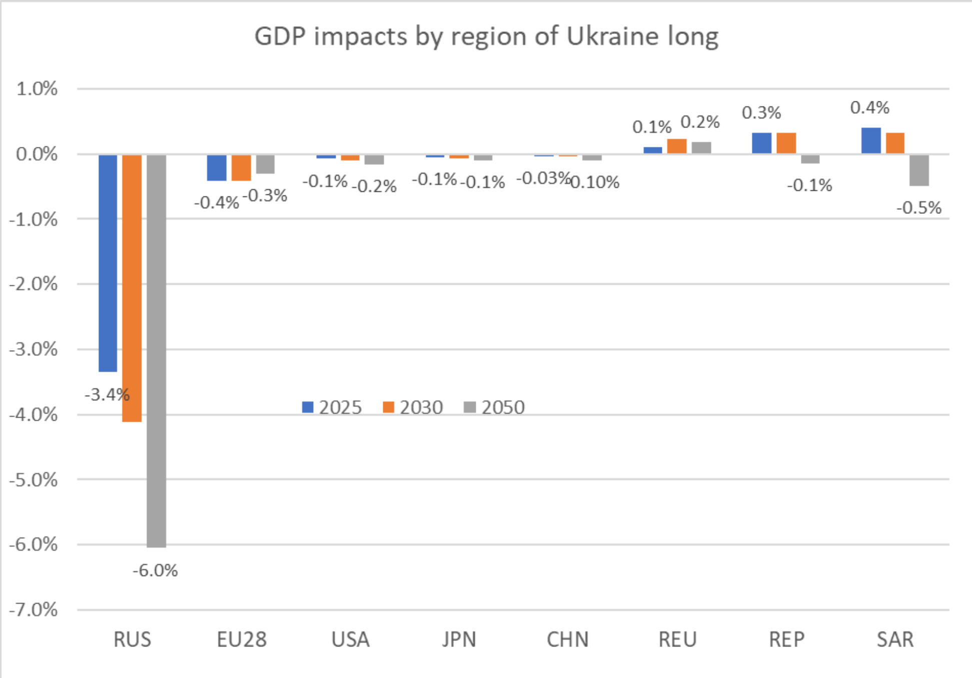

Figure 9: GDP impacts of the Ukraine_long scenario by region[1]

The model results show that, in response to the war, there is a shift from fossil fuels (notably natural gas) to renewable energy, in both 2030 and 2050, both in the EU and globally. This trend is in line with existing literature (Hartvig et al., 2023; IEA, 2022c; Liu et al., 2023). The most significant shift is projected to occur in 2030, with a global 2% reduction in primary fossil energy, 6% increase in primary (non-bio) renewables and 3% reduction in CO_2 emissions. The effects are relatively similar in the EU (in 2030: 4% reduced fossil energy consumption, 2% additional renewables, and 3% less CO_2 emissions). The model consistently shows a reduction of fossil primary energy use in the Ukraine scenario in both target years, both globally (in 2030: 20 EJ (4%), in 2050: 11 EJ (2%)) and in the EU (in 2030: 1.5 EJ (4%), in 2050: 0.5 EJ (2%)). The fossil reductions almost fully comprise reduced natural gas use, due to the higher price increases than oil and gas and regional supply dependencies. In the GEM-E3 model, gas substitution by coal leads to a relatively limited global increase in coal use in the Ukraine scenario, while oil also faces a small consumption decline globally. In all cases, the net reduction of fossil fuels is partly substituted by zero-carbon alternatives (mostly non-biomass renewables).

Overall, the study shows that the Russian military aggression against Ukraine and the following imposed fossil energy and other trade sanctions on industrial products, are projected to lead to a short and medium term shift from fossil fuel to renewable energy, mostly induced by the increased energy prices. GEM-E3 shows worldwide and EU-regional reduction of natural gas use, compared to a no-war reference scenario. The prolonged reduction in natural gas use in the EU is projected to lead to 12% lowered investments in gas infrastructure in the power sector, in the 2025-2050 period. Globally, the effect is smaller (6%), due to less dependence on Russian gas. The reduced investment could be fully counteracted or surpassed by additional LNG investments to replace Russian gas. Finally,

[1] EU28= the current 27 Member States of the EU + the UK, JPN= Japan, USA= the United States of America, CHN= China, REU= Rest of Europe (e.g. Norway), REP= Rest of major energy producers (mostly including Middle East and North African countries), SAR= Saudi Arabia, RUS= Russia

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

the war is found to have modest impacts on global GDP and employment, apart from Russia that faces large fossil export revenue reduction and severe impacts from trade sanctions, in line with earlier research. However, there are clear regional 'winners and losers', with non-Russian fossil fuel producing countries profiting from higher energy prices and exports to Europe, opposed to energy importing countries economically harmed by higher energy prices. We find that in the medium term, Europe can easily find substitution for Russian products (including fossil fuels) and thus it would face limited negative macro-economic effects.

Key messages for the next NDCs

Our analysis indicates that the NDC target of Russia can be achieved with relatively limited effort by 2030 as the emissions reduction goal is not ambitious. So, our study shows that the next Russian NDC should include a more ambitious emissions reduction target for 2030/2035 to pave the way towards the long-term transformation required to achieve net-zero emissions by mid-century. By implementing drastic climate policies as part of its next NDC, Russia will be able to decarbonize its economy, reduce its reliance on fossil fuels, diversify its energy mix, and also achieve the long-term target of net zero GHG emissions by 2060. This will be accomplished by the accelerated development of renewable energy sources, electrification of energy end-uses, and energy efficiency improvements, combined with the emergence of novel technologies (including hydrogen and CCS) to decarbonize hard to abate sectors. An important challenge that Russia needs to overcome on its pathway towards decarbonization concerns the limitations in renewable energy potential, especially for solar PV. In order to effectively decarbonize its power generation sector, Russia needs to significantly upscale other low- and zero-carbon options, including nuclear power, biomass and Carbon Capture and Storage; however all these options face several socio-political, financial, and environmental challenges that should be dealt with to ensure their efficient implementation in the country.

Russia is a major exporter of oil, gas and coal, thus having significant financial interests in the fossil fuel industry, and a strong incentive against decarbonization. Furthermore, it has been argued that climate change will have some benefits for Russia, e.g. by making energy resources accessible, due to the melting Arctic ice pack (Bergmann, 2024). Apart from any potential benefits, it must be emphasized that Russia is vulnerable to the effects of climate change. For example, Russian agriculture will be severely impacted by droughts, thus decreasing production, and having potential consequences on global food security (Javeline et al, 2023). The frequency of extreme weather events in Russia has also increased alarmingly, with heatwaves and floods threatening the health of citizens. Therefore, Russia must raise its climate policy ambitions, and submit an updated NDC document, with significantly strengthened GHG emissions reduction targets for 2030. Furthermore, Russian officials must phase out fossil fuels in the upcoming decades, and rapidly increase the uptake of renewable energy sources and energy efficiency. This will ensure a prosperous future for the Russian people, and the rest of humanity, in alignment with the Paris Agreement goal of 1.5°C temperature increase limit.

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

References

Bergmann, M. (2024). *Arctic Energy Security.* Center for Strategic and International Studies.

BP, (2022) BP Statistical Review of World Energy June 2022, http://www.bp.com/statisticalreview.

CAT (2022) Climate Action Tracker | Warming Projections Global Update - November 2022.

CAT (2022, November). *Russian Federation*. Retrieved from Climate Action Tracker: https://climateactiontracker.org/countries/russian-federation/

Dafnomilis, I., Chen, H.-H., den Elzen, M., Fragkos, P., Chewpreecha, U., van Soest, H., Fragkiadakis, K., Karkatsoulis, P., Paroussos, L., de Boer, H.-S., Daioglou, V., Edelenbosch, O., Kiss-Dobronyi, B., van Vuuren, D.P. (2022) Targeted Green Recovery Measures in a Post-COVID-19 World Enable the Energy Transition. Frontiers in Climate 4

Debra Javeline, R. O. (2023). Russia in a changing climate. *WIREs Climate Change*.

Fragkos, P. (2013). Model-based analysis of the future strategies for the MENA energy system. *Energy Strategy Reviews*.

Fragkos, P. (2023). Assessing the energy system impacts of Morocco's nationally determined contribution and low-emission pathways. *Energy Strategy Reviews*.

Fragkos, P., Fragkiadakis, K. (2022) Analyzing the Macro-Economic and Employment Implications of Ambitious Mitigation Pathways and Carbon Pricing. Frontiers in Climate 4

IEA (2023). *World Energy Outlook.*

IEA (2022) World Energy Balances 2022. https://www.iea.org/data-and-statistics/data-product/world-energy-balances.

IMF, (2022b) World Economic Outlook Database October 2022. https://www.imf.org/en/Publications/WEO/weo-database/2022/October

Johanson, M. (2008). Institutions, exchange and trust: A study of the Russian transition to a market economy. *Journal of International Management*.

Korhonen, I. (2023, June). *Sanctions against Russia: what have been the effects so far?* Retrieved from Economics OBservatory: https://www.economicsobservatory.com/sanctions-against-russia-what-have-been-the-effects-so-far

OPEC. (2023). *Annual Statistical Bulletin.*

Russia. (2020, November). Nationally Determined Contribution.

Russia. (2022, September). Strategy of socio-economic development of the Russian Federation with low greenhouse gas emissions until 2050.

Ruta, M., (2022) Worldbank study. Ruta, Michele (ed.). 2022. The Impact of the War in Ukraine on Global Trade and Investment. © Washington, DC. http://hdl.handle.net/10986/37359 License: CC BY 3.0 IGO.

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

Schiermeier, Q. (2019). Soviet Union's collapse led to massive drop in carbon emissions. *Nature*.

UN. (2022). *World Population Prospects.*

UNFCCC. (2015, December). Paris Agreement. *Report of the conference of the parties to the United Nations framework convention on climate change*.

WNA. (2024, March). *Nuclear Power in Russia*. Retrieved from World Nuclear Association: https://world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power

Zagoruichyk, A. (2022, September). *The Carbon Brief Profile: Russia*. Retrieved from Carbon Brief: https://www.carbonbrief.org/the-carbon-brief-profile-russia/

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

NDC ASPECTS

COUNTRY REPORT

Transition pathways for Russia

Corresponding Author

Panagiotis Fragkos
fragkos@e3modelling.com

PARTICIPANTS

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866