

Expert Report

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Expert: Mark Chernaik, a Ph.D. in biochemistry from Johns Hopkins University School of Public Health, in Baltimore, Maryland; and a J.D. from the University of Oregon School of Law; Staff Scientist with the Environmental Law Alliance Worldwide (ELAW) for 30 years; since 1992, the author of several hundred reports and affidavits for public interest lawyers in more than 60 countries. In June 2005 and February 2011, the European Court of Human Rights relied on his work to reach landmark decisions regarding the rights of individuals exposed to toxic substances.¹ He provided expert opinion before the National Environment Tribunal of Kenya in the landmark case of *Save Lamu & Others v. National Environmental Management Authority (NEMA) & Another* in which climate impacts of a proposed coal-fired power plant were a major issue. His opinions on environmental matters have been cited favorably in judgments of the Supreme Courts of India, Pakistan and Belize.² A major focus of his work is evaluating the climate impacts of proposed development projects, including quantifying their carbon footprints, and assessing whether such projects are consistent with the goals of the Paris Agreement of the United Nations Framework Convention on Climate Change. He studied Russian at the University of Massachusetts and is able to read materials published in Russian.

The present report is prepared upon the request of lawyers Dariana Gryaznova, Grigory Vaypan and Alexandra Suchkova.

1. The questions put to the expert:

- 1.1. Does Russia Experience Climate Change-Related Impacts To Health and Well Being Of Its Population?
- 1.2. What Are Russia's Historical And Current Greenhouse Gas (GHG) Emissions?
- 1.3. What Are Russia's Expected Future GHG Emissions Under Its Existing National Climate Change Policies, In Particular Under Decree Of The President Of The Russian Federation Of 4 November 2020 No. 666 "On The Reduction Of Greenhouse Gas Emissions" And The Strategy For The Socio-Economic Development Of The Russian Federation With A Low-Level Of Greenhouse Gas Emissions For The Period Until 2050 Approved By The Decree Of The Government Of The Russian Federation Of 29 October 2021 No. 3052-R?

¹ *Fadeyeva v. Russia* 55723/00 [2005] ECHR 376 (9 June 2005); *Dubetska v. Ukraine* 30499/03 [2011] ECHR (10 February 2011)].

² *M.C. Mehta v. Union of India*, 1999-(003)-CLJ 0361-SC; *Shehla Zia v. WAPDA*, PLD 1994 (SC) 693; *Belize Institute for Environmental Law (BELPO) v. Department of Environment (DOE)*, Supreme Court of Belize (30 June 2008) (Claim No. 302 of 2007)]

- 1.4. Is There Any Gap Between Russia’s Expected Future GHG Emissions And Emissions Necessary To Limit Global Warming To The Temperature Targets Of The Paris Agreement Under The United Nations Framework Convention On Climate Change?
- 1.5. To What Extent Does Russia Have To Reduce Its GHG Emissions To Comply With The Temperature Targets Of The Paris Agreement Under The United Nations Framework Convention On Climate Change? In Particular, To What Extent Does Russia Have To Reduce Its GHG Emissions (In %) By The End Of 2030 And 2050, Compared To 1990 Levels To Limit Global Warming To The Temperature Targets Of The Paris Agreement Under The United Nations Framework Convention On Climate Change?

2. Sources and Literature

- 2.1. Decree of the President of the Russian Federation of 4 November 2020 No. 666 “On the reduction of greenhouse gas emissions”
- 2.2. The Strategy for the Socio-economic Development of the Russian Federation with a Low-Level of Greenhouse Gas Emissions for the Period until 2050 approved by the Decree of the Government of the Russian Federation of 29 October 2021 No. 3052-r
- 2.3. Paris Agreement under the United Nations Framework Convention on Climate Change
- 2.4. Climate Change 2022: Impacts, Adaptation and Vulnerability. Working Group II Contribution to the IPCC Sixth Assessment Report
- 2.5. Climate Change 2022: Mitigation of Climate Change. Working Group III Contribution to the IPCC Sixth Assessment Report
- 2.6. Scientific publications, articles and documents referenced to in footnotes 1-45 of this report.

3. Research

3.1. Methodology

To arrive at my answers to the questions above, I researched the body of peer-reviewed scientific literature and government publications to attain all relevant published materials related to climate change and Russia, and applied my experience analysing published data to interpret their significance to the questions that were posed.

A “Fair-Share National Greenhouse Gas Reduction Target” is the **fair level of contribution of a country to the global effort in reducing greenhouse gas emissions so that global warming is held to a particular long-term temperature target**, such as the targets of Article 2 of the Paris Agreement. Fair-Share National Greenhouse Gas Reduction Targets are calculated by taking into

account published data regarding the following country-specific characteristics: Responsibility, Capability/Need, Equality, Equal Cumulative Per Capita Emissions, Responsibility/Capability/Need, Capability/Cost, and Staging/Timing of Emission Reductions.

A “Cost-Optimal Greenhouse Gas Reduction Target” is a modelled domestic GHG reduction pathway taking into consideration technological, socio-economic and policy assumptions aligned with global least-cost solutions to meet long-term temperature goals rather than an equitable distribution of burdens.

I determined that Russia’s Fair-Share National Greenhouse Gas Reduction Target for 2030 is a more preferable benchmark than Russia’s Cost-Optimal Greenhouse Gas Reduction Target for 2030 by determining that the former target included equitable principles in addition to cost that the latter target did not include.

3.2. Does Russia Experience Climate Change-Related Impacts to Health and Well Being of Its Population?

3.2.1. Severe Heatwaves

Yes. Climate change affects human health directly by causing periods of intense heat beyond which the human body can endure, especially among the elderly and infirm. According to a study published by scientists from Germany:

“Exposure of humans to extreme temperatures causes a considerable danger to health. The average human body temperature is defined as 36°C to 37.5°C. **A deviation of $\pm 3^{\circ}\text{C}$ can overexert the body’s compensation mechanisms and cause substantial damage, potentially leading to death. Population groups such as the elderly and people with chronic (respiratory) diseases have a particularly high risk of being affected by extreme temperatures due to exhaustion of predominantly cardiorespiratory compensatory mechanisms.**”³

In the Summer of 2010, a heatwave lasting 44 days, with 24-hour average temperatures ranging from 24°C to 31°C, blanketed large parts of Russia. The 2010 heatwave likely exceeded “500-year-long seasonal temperature records over approximately 50% of Europe.”⁴ According to data supplied by local sources to the Emergency Events Database (EM-DAT), the 2010 heatwave **directly caused 55,736 excess deaths in Russia.**⁵

Heatwaves also cause human deaths by increasing the levels of air pollutants and susceptibility to air pollution. A study published by scientists from the Institute of Economic Forecasting,

³ Brennenstuhl, H., Will, M., Ries, E., Mechler, K., Garbade, S., & Ries, M. (2021). Patterns of extreme temperature-related catastrophic events in Europe including the Russian Federation: a cross-sectional analysis of the Emergency Events Database. *BMJ open*, 11(6), e046359.

⁴ Barriopedro, D., Fischer, E. M., Luterbacher, J., Trigo, R. M., & García-Herrera, R. (2011). The hot summer of 2010: redrawing the temperature record map of Europe. *Science*, 332(6026), 220-224.

⁵ Brennenstuhl, H., Will, M., Ries, E., Mechler, K., Garbade, S., & Ries, M. (2021). Patterns of extreme temperature-related catastrophic events in Europe including the Russian Federation: a cross-sectional analysis of the Emergency Events Database. *BMJ open*, 11(6), e046359.

Russian Academy of Sciences, and the Institute of Demography, Higher School of Economics, Moscow, Russia, found that *in Moscow alone* during the 2010 heatwave there were: “close to 11,000 excess deaths from nonaccidental causes during this period, mainly among those older than 65 years.”⁶ These scientists concluded:

“In conclusion, our study shows major acute effects on mortality by high temperatures and air pollution during the prolonged 2010 heat wave in Moscow. Effects were seen among the working age population as well as the older population and for causes of death in addition to cardiovascular disease. Mortality related to the prolonged heat wave increased steeply during the first 2 weeks, after which the excess risk gradually tapered off. **Interaction between high temperatures and air pollution from wildfires added a substantial number of deaths.**”⁷

In June and July of 2021, another record-breaking heatwave has affected Russia, but the extent of its health impacts have yet to be fully quantified.⁸

3.2.2. Vector-Born Infectious Disease

Climate change also affects human health indirectly by increasing exposure to vector- and water-borne diseases like malaria, dengue fever, and *tick-borne encephalitis*.

According to researchers principally with the Yakut Scientific Research Institute of Agriculture, in the Republic of Sakha, the long-term trend of “increasing annual temperatures and thawing permafrost have corresponded with the northward range expansion of tick-species in the Republic. Indigenous communities living in these remote areas may be severely affected by human and livestock diseases introduced by disease vectors like ticks.”⁹ These researchers ***found a 40-fold increase in the frequency of tick-bite cases between 2000 and 2018*** in the Republic of Sakha. About 25% of the ticks collected in this region were infected by pathogens causing Lyme disease or anaplasmosis in livestock. The researchers concluded:

“The warming climate in the Republic of Sakha corresponds with the increase of disease vectors in the region. We observed a clear northward spread and a general increase in reported tick bite cases in Sakha. Between 2000 and 2018, cases increased 40-fold. Additionally, cases were initially noted only in southern districts but by 2018 twenty-one districts had been affected, including Verkhoyanskiy—which is above the Arctic Circle. Our negative binomial regression model predicts that winter temperature, annual temperature, and Selyaninov’s hydrothermal coefficient are significantly and positively related to increases in tick-bite frequency in the Republic. We suggest that public health

⁶ Shaposhnikov, D., Revich, B., Bellander, T., Bedada, G. B., Bottai, M., Kharkova, T., ... & Pershagen, G. (2014). Mortality related to air pollution with the Moscow heat wave and wildfire of 2010. *Epidemiology* (Cambridge, Mass.), 25(3), 359.

⁷ *Ibid.*, at page 363.

⁸ Washington Post (23 June 2021) “Records crumble in Europe, Russia amid scorching heat wave: Moscow has its highest June temperature on record due to one of several heat domes baking the Northern Hemisphere.”

⁹ Vladimirov, L. N., Machaktyrov, G. N., Machaktyrova, V. A., Louw, A. S., Sahu, N., Yunus, A. P., & Avtar, R. (2021). Quantifying the Northward Spread of Ticks (Ixodida) as Climate Warms in Northern Russia. *Atmosphere*, 12(2), 233.

entities as well as agricultural organizations in the Republic of Sakha should continue to monitor the spread of tick-borne diseases, and consider possible interventions to reduce its impact on local health and livestock farming.”¹⁰

According to researchers principally with St. Petersburg Pasteur Institute, the Russian Academy of Sciences, and Umea University in Sweden, there is a strong relationship between tick-borne encephalitis (TBE) and air temperatures in the Komi Republic (RK) of Russia.¹¹ The researchers found the following:

“In 1998–2011 in RK a substantial growth of TBE virus (TBEV) prevalence both in questing and feeding ticks was observed. In 1992–2011 there was 23-fold growth of the tick-bite incidence rate in humans, a northward shift of the reported tick bites, and the season of tick bites increased from 4 to 6 months. In 1998–2011 there was more than 6-fold growth of average annual TBE incidence compared with 1970–1983 and 1984–1997 periods. This resulted both from the northward shift of TBE, and its growth in the south. In our view it was related to local climate change as both the average annual air temperature, and the air temperature during the tick activity season grew substantially. We revealed in RK a strong correlation between the change in the air temperature and that in TBE incidence.”¹²

The researchers concluded:

“The rise in TBE incidence in RK is related considerably to the expansion of the range of *Ixodes persulcatus*. The territory with reported TBE cases also expanded northward. Climate change is an important driver of TBE incidence rate growth.”¹³

According to researchers principally with St. Petersburg Pasteur Institute, the Russian Academy of Sciences, and the World Health Organization, there is a significant relationship between tick-borne encephalitis (TBE) in the Arkhangelsk Oblast (AO) and rising ambient temperatures.¹⁴ The researchers found the following:

“In last 10 years, there was nearly 50-fold rise in TBE incidence in AO when compared with 1980-1989. Probably, the increase both in mean annual air temperatures and temperatures during tick active season resulted in the northward expansion of *Ixodes Persulcatus*, main TBE virus vector. The Ixodid ticks expansion is confirmed both by the results of ticks flagging from the surface vegetation and by the tick bite incidence in the population of AO locations earlier free from ticks. Our mathematical (correlation and

¹⁰ Ibid., at page 13.

¹¹ Tokarevich, N., Tronin, A., Gnativ, B., Revich, B., Blinova, O., & Evengard, B. (2017). Impact of air temperature variation on the ixodid ticks habitat and tick-borne encephalitis incidence in the Russian Arctic: the case of the Komi Republic. *International journal of circumpolar health*, 76(1), 1298882

¹² Ibid., at page 1.

¹³ Ibid., at page 1.

¹⁴ Tokarevich, N. K., Tronin, A. A., Blinova, O. V., Buzinov, R. V., Boltenev, V. P., Yurasova, E. D., & Nurse, J. (2011). The impact of climate change on the expansion of *Ixodes persulcatus* habitat and the incidence of tick-borne encephalitis in the north of European Russia. *Global Health Action*, 4(1), 8448.

regression) analysis of available data revealed a distinct correlation between TBE incidence and the growth of mean annual air temperatures in AO in 1990-2009.”¹⁵

The researchers concluded:

“Not ruling out other factors, we conclude that climate change contributed much to the TBE incidence increase in AO.”¹⁶

3.2.3. Insect Outbreaks and Forest Fires

Yes. A recent report systematically analyzed: “the Russian Federation’s forest resources; their potential for carbon sequestration and contribution to the Paris Agreement targets; the impacts of climate change; and the risks associated with biotic and abiotic disturbances.”¹⁷ Chapter 3 of the report: (Climate Change in Russia – Past, Present and Future) describes the following extent of climate change in Russia:

“A spatial analysis of the annual temperature changes in Russia is presented in Figure 12. **The most rapid increase of temperature was observed in the Arctic regions of Siberia and the Far East, where the linear trend of temperature in 1976–2013 showed more than 0.8–1.0 °C warming per decade (Figure 12). This phenomenon is known at the global scale as “Arctic amplification” (Cohen et al., 2014).** Another hot spot of warming is the western part of European Russia, where trends were around 0.6 °C per decade. Minimal warming trends were observed in the southern part of Western Siberia (0.2–0.3 °C per decade).”¹⁸

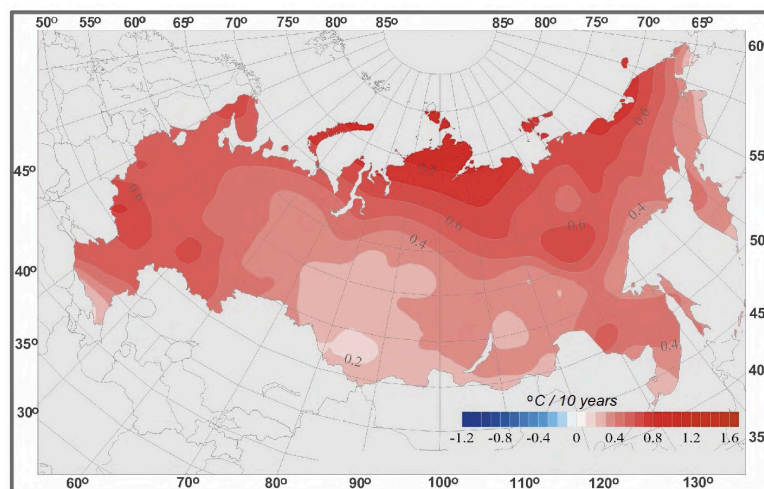


Figure 12. Trends of annual temperatures for 1976–2013 in Russian territory (change in temperature over the 42-year period, expressed as degree / 10 years). Source: Roshydromet, 2014.

¹⁵ Ibid., at page 1.

¹⁶ Ibid., at page 1.

¹⁷ Zamolodchikov, D., Shvidenko, A., Bartalev, S., Rulikova, E., Held, A., Valentini, R., & Linder, M. (2020). Russian forests and climate change.

¹⁸ Ibid., at pages 45-46.

Chapter 4 of the report (Climate change and Russian forests: impacts, vulnerability and adaptation needs) describes the following observed impacts of climate change on Russian forests, including outbreaks of damaging pests:

“4.1 Observed impacts of climate change ...

“The geographical distribution of many pests (cf. Chapter 2.2) is limited by low winter temperatures. **Temperature increase allows these pests to expand their area to the north and upslope. In line with observed warming, the outbreak zone of the Siberian silk moth (*Dendrolimus sibiricus*), one of the most dangerous boreal insect pests, shifted north. An outbreak in 2014 in cedar-fir stands of the Yenisei plain, damaged considerable forest areas north of the historical distribution area of Siberian silk moth (Kharuk et al., 2017b). Another example is the Sakhalin-fir bark beetle (*Polygraphus proximus*) which causes dieback of Siberian fir stands, affecting approximately 40% of forest area of the Tomsk oblast (Krivets et al., 2018; Debkov et al., 2019).**

“Over the 20th century, the frequency of droughts in Russia increased (Groisman et al., 2007) and in 2005–2008, massive dieback of pine and spruce stands occurred near the southern tree line (Allen et al., 2010). Large scale dieback of oak stands occurred in the Middle Volga region, with damages amplified through weather conditions that stimulated insect outbreaks in 1991–1994 (Yakovlev and Yakovlev, 1999). Decreasing soil moisture levels were a main cause of massive dieback of spruce stands in Arkhangelsk oblast in 1990–2000 (Aakala and Kuuluvainen, 2011). Similar dieback processes occurred in fir stands in the Krasnoyarsk kray since 2010, caused by an extreme drought followed by invasion of Sakhalin-fir bark beetle, which was not earlier observed in the region (Kharuk et al., 2019). ...

According to this chapter of the report, such impacts are projected to intensify:

“4.2 Projected impacts

“4.2.2 Projected changes in forest disturbances

“Recent dramatic fire seasons and insect outbreaks (cf Chapter 2.2) have demonstrated the important role forest disturbances might play for future forests (Seidl et al., 2017). Direct climatic effects appear for example when warmer temperatures reduce fuel moisture and thus increase fire risk, while indirect effects occur for example when climate-induced changes in vegetation composition or productivity increase fuel availability or flammability. Especially boreal forests are likely to face stronger effects of direct and indirect disturbances (Seidl et al., 2017). Uncertainties about future changes in precipitation remain large and these matter: While under warmer and wetter conditions both drought and fire activity might be partly reduced depending on local conditions, warmer and drier conditions will clearly increase the risk of fire, drought and insect outbreaks in European and Asian forests. Future projections of changing disturbance risk in Russia are rare and usually only consider fire danger. Sherstyukov and Sherstyukov

(2014) analysed how fire danger expressed through the Nesterov index changes across an ensemble of 31 climate models following RCP4.5 and RCP8.5. **The length of the season with fire danger increases by 10 to 20 days throughout the country for the period 2041–2060 compared to 1980–2000 and at the end of the century (2080–2090) at least an additional 20 fire risk days (and locally up to 50 days) were projected for the European part of Russia, West Siberia, and the south and mid-latitudes of East Siberia.** Recent simulations by a regional climate model ensemble confirmed the general increase in fire risk under climate change but found that especially under RCP4.5 climatic fire risk could partly decrease regionally in Central Siberia because of increasing precipitation levels (Torzhkov et al., 2019).

“In combination, climate change-induced shifts in species ranges and forest disturbances could affect forest dynamics and functioning more than indicated by individual assessments. The boreal forests of the northern hemisphere have been identified as a tipping element in the global climate system (Lenton et al., 2008). **Strong, drought-driven tree mortality interacting with increasing insect and fire disturbances may further increase the susceptibility of forests to large-scale dieback under global warming levels above 3°C global warming (Lenton et al., 2008; Schellnhuber et al., 2016). It is unclear whether the projected disturbance dynamics assessed in this chapter interact at a scale that could result in irreversible forest loss. However, they clearly reach beyond past experiences with increasing risk of unprecedented adverse impacts on forests.**”¹⁹

Recently published evidence in the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6) affirms the risk of increased frequency and severity of wildfires in Russia. The Working Group II report of the IPCC AR6 states:

“Climate change, human activity and lightning determine increase of wildfire severity and area burned in North Asia (high detection, medium-to-low attribution to climate change). In North Asia, the extent of fire affected areas in boreal forest can be millions hectares in a single extreme fire year (Duane et al., 2021) and has nearly doubled between 1970 and 1990 (Brazhnik et al., 2017). During recent decades, number, area and frequency of forest fires increased in Putorana Plateau, north of Central Siberia; in larch-dominated forests of Central Siberia; and in Siberian forests as a whole. This increase is in line with increase of the average annual air temperature, air temperature anomalies, droughts and the length of fire season (Ponomarev et al., 2016; Kharuk and Ponomarev, 2017; Pospelova et al., 2017).”²⁰

“Under regional projections for North Asia, warmer climate will increase forest fire severity by the late 21st century (medium confidence). For south taiga in Tuva Republic, central Siberia, in a warmer climate, both the annual area burned and fire intensity will increase by 2100. For middle taiga in Irkutsk Region, the annual area burned and the crown: ground fire fraction will increase by late 21st century against historical (1960-1990) estimate. This moves forest composition toward greater contribution of

¹⁹ Ibid., at pages 56-57.

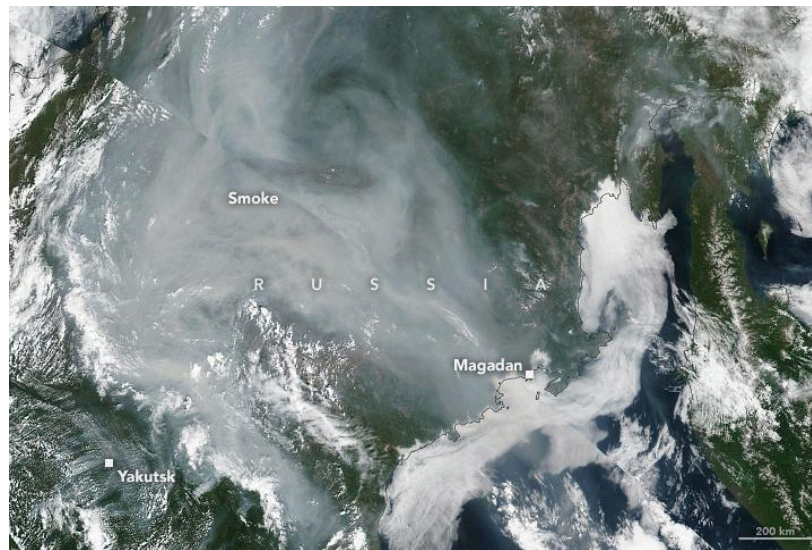
²⁰ IPCC (February 2022) IPCC WGII Sixth Assessment Report, at page 10-23.

hardwoods (*Betula* spp., *Populus* spp.) (Brazhnik et al., 2017). This shifting was also proved by observations in the Northern Mongolia, where boreal forest fires likely promote the relative dominance of *B. platyphylla* and threaten the existence of the evergreen conifers, *Picea obovata*, and *Pinus sibirica* (Otoda et al., 2013). For Tuva Republic, warming ambient temperatures increase the potential evapotranspiration demands on vegetation, but if no concurrent increase in precipitation occurs, vegetation becomes stressed and either dies from temperature-based drought stress or more easily succumbs to mortality from insects, fire, pathogens, or wind throw (Brazhnik et al., 2017).”²¹

3.2.4. The Extent and Significance of the 2021 Wildfires in Northeastern Siberia

Wildfires in July 2021 provide evidence that fire activity induced by climate change will intensify in Russia. According to the National Aeronautics and Space Administration (NASA) Earth Observatory:

“Following record-breaking heat and drought in northeastern Russia, hundreds of intense wildfires are now burning through taiga forests in Siberia.

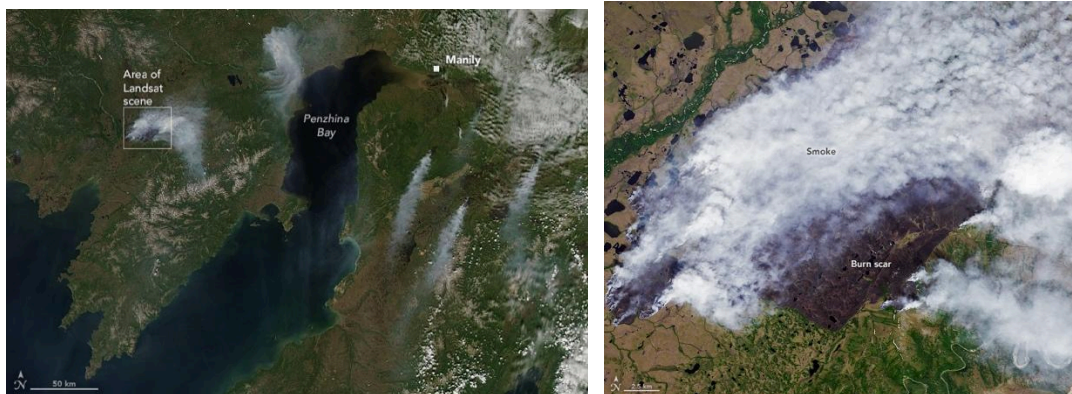


“The Visible Infrared Imaging Radiometer Suite (VIIRS) on Suomi NPP acquired this natural-color image of large clouds of smoke enveloping the Republic of Sakha (Yakutia) on July 5, 2021. Satellite data indicates that several small fires burned intermittently in the area for weeks, but several exploded in size during the last week of June.

“According to Sakha’s emergencies ministry, **more than 250 fires were burning across roughly 5720 square kilometers (2,210 square miles) of land on July 5—an area about twice the size of Luxembourg.** While regional authorities report extinguishing dozens of fires per day, they call the situation “difficult” and will likely be battling large

²¹ Ibid, at page 10-26.

fires for weeks. Thick smoke has occasionally enveloped Yakutsk, the largest city (population 312,000) in Sakha, and other settlements in the region.



“The second image, acquired by the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA’s Aqua satellite, shows more distinct plumes from five large fires burning around Penzhina Bay (northwest of the Kamchatka Peninsula). The third image, from the Operational Land Imager (OLI) on Landsat 8, shows a detailed view of one of the fires on July 4.

“This is the second consecutive July that intense heat and wildfires have ravaged this region. In 2020, fires raged in Yakutia for much of July and August. Siberia wildlands also burned extensively in 2001, 2005, and 2013, according to a summary of the 2020 Siberian fire season authored by researchers from George Mason University and Siberian Federal University. An international group of scientists recently published a study noting that the prolonged heat waves in Siberia in 2020 would have been "almost impossible" without the influence of human-induced climate change.”²²

3.2.5. The Extent of Permafrost Thawing in Russia

A study, published in 2020 by scientists with the Institute of the Earth’s Cryosphere of Tyumen Scientific Center of Siberian Branch of Russian Academy of Sciences, Tyumen State University, and George Washington University, interprets long-term climate, and permafrost monitoring data at seven sites representative of diverse climatic and environmental conditions in the western Russian Arctic.²³ The study found that the Mean Annual Average Temperature increased from a low of 0.05 °C per year (at Nadym) to a high of 0.07 °C per year (at Cape Bolvansky and Marre-Sale). All seven stations displayed increasing precipitation trends from 1 to 3 millimeters per year since 1970. According to the study:

“ all seven sites examined show evidence of rapid permafrost degradation.”

²² National Aeronautics and Space Administration Earth Observatory (July 2021) “Fires Scorch the Sakha Republic.” Available at: <https://earthobservatory.nasa.gov/images/148537/fires-scorch-the-sakha-republic>

²³ Vasiliev, A. A., Drozdov, D. S., Gravis, A. G., Malkova, G. V., Nyland, K. E., & Streletskiy, D. A. (2020). Permafrost degradation in the Western Russian Arctic. *Environmental Research Letters*, 15(4), 045001.

The study found that mean annual ground temperatures increased from 0.03 to 0.06 °C per year at depths of 10-12 meters in the continuous permafrost zone, and that the permafrost table was lowered at all sites, up to 8 meters in the discontinuous permafrost zone.

The thawing of permafrost in Russia is predicted to accelerate under foreseeable climate scenarios. A study, published in 2019 by scientists with Lomonosov Moscow State University, the Russian Academy of Sciences, Moscow State Technical University, and Vrije Universiteit Amsterdam, used climatic and permafrost models combined with a field monitoring dataset to predict how permafrost within the Eastern Chukotka coastal area would change under various IPCC climate change scenarios.²⁴ The study predicts that the thawed layer of permafrost will be 6–13% thicker than current values under the RCP 2.6 climate scenario, and 43–87% thicker under RCP 8.5 climate scenario. This process will be accompanied by subsidence of 0.4–3.7 centimeters per year. Total lowering of the permafrost table by the end of the century will be from 150 to 310 cm.

3.2.6. The Extent of Increased Anthrax Risk in Russia Because of Permafrost Thawing

When permafrost melts, it can release virulent pathogens, such as anthrax spores, that have been frozen for centuries. A study, published in 2020 by scientists with the Institute of Polar Sciences, Consiglio Nazionale delle Ricerche, Politecnico di Milano, and the University of Venice, used a new epidemiological model for anthrax transmission that is specifically tailored to the Arctic environmental conditions to describe transmission dynamics, including also herding practices (e.g. seasonal grazing) and the role of the active layer over permafrost acting as a long-term storage of spores that could be viable for disease transmission during thawing periods.²⁵ Using the model, the study found that:

“... the temporal variability of grazing and active layer thawing may influence the dynamics of anthrax disease and, specifically, favor sustained pathogen transmission. Particularly warm years, favoring deep active layers, are shown to be associated with an increased risk of anthrax outbreaks, and may also foster infections in the following years. Our results enable preliminary insights into measures (e.g. changes in herding practice) that may be adopted to decrease the risk of infection and lay the basis to possibly establish optimal procedures for preventing transmission; furthermore, they elicit the need of further investigations and observation campaigns focused on anthrax dynamics in the Arctic environment.”

The study concluded:

“The results presented in our study suggest that, subject to conducive environmental conditions, seasonal thawing may indeed lead to an increased risk of disease outbreaks and sustained transmission in Arctic regions. Likewise, prolonged periods of warming temperatures, which have become more frequent in recent years, may favor the

²⁴ Maslakov, A., Shabanova, N., Zamolodchikov, D., Volobuev, V., & Kraev, G. (2019). Permafrost degradation within eastern chukotka calm sites in the 21st century based on CMIP5 climate models. *Geosciences*, 9(5), 232.

²⁵ Stella, E., Mari, L., Gabrieli, J., Barbante, C., & Bertuzzo, E. (2020). Permafrost dynamics and the risk of anthrax transmission: a modelling study. *Scientific reports*, 10(1), 1-12.

re-emergence of stored spores, which, in addition to freshly released spores, may set breeding ground for future infections, increasing the probability of endemic dynamics if no measures are taken to prevent transmission and environmental contamination.”

3.2.7. The Extent of Increased Landslide Risk in Russia Because of Permafrost Thawing

When permafrost thaw, the land becomes more susceptible to sudden and catastrophic movement of soil, rocks, mud and debris down hillslopes. A study published in 2019 by scientists principally with Colorado State University, reviews data about how climate change is altering the prevalence and severity of landslides in permafrost regions. The study concludes:

“Based on the altered hydrology ... vegetation ... and physical properties of annually thawed soils and bedrock ... it is likely that the dynamic equilibrium states of landsliding will be fundamentally altered after permafrost thaws. We predict that landslides will be driven primarily by atmospheric input of moisture and freeze-thaw fracturing rather than responding to disconnected and perched groundwater, melting permafrost ice, and a plane of weakness between ground ice and the active layer. ...

“These changes to the landslide occurrence and the physical properties of subsurface materials can pose serious geotechnical challenges for human communities and the environment. ... Where thermal perturbation occurs on hillslopes, even where the slope angle is low (10–20°), landsliding is likely to become more frequent ... and on a broader spatial distribution ...

“First, fundamental changes to landslide regimes will alter the timing and/or magnitude of hillslope connection to surface water. Permafrost related landslides are capable of displacing large volumes of hillslope sediment, nutrients, and soil downslope, altering the physical and ecological structure of affected hillslopes ...

“Lastly, increased landslide frequency amplifies hazards to people and infrastructure Climate and permafrost-induced landslide hazards are likely to fundamentally alter the safety and economic stability of human populations in permafrost terrain”

3.2.8. The Extent of Impacts to Infrastructure in Russia Because of Permafrost Thawing

A study published in 2019 by scientists principally with George Washington University and the Russian Academy of Sciences, used an ensemble of climate projections: “to estimate the cost of buildings and infrastructure affected by permafrost degradation by mid-21st century under RCP8.5 scenario” in Russia.²⁶ The study found that:

“... the total value of fixed assets on permafrost was estimated at 248.6 bln USD. Projected climatic changes will affect 20% of structures and 19% of infrastructure assets, costing 16.7 bln USD and 67.7 bln USD respectively to mitigate. The total cost of

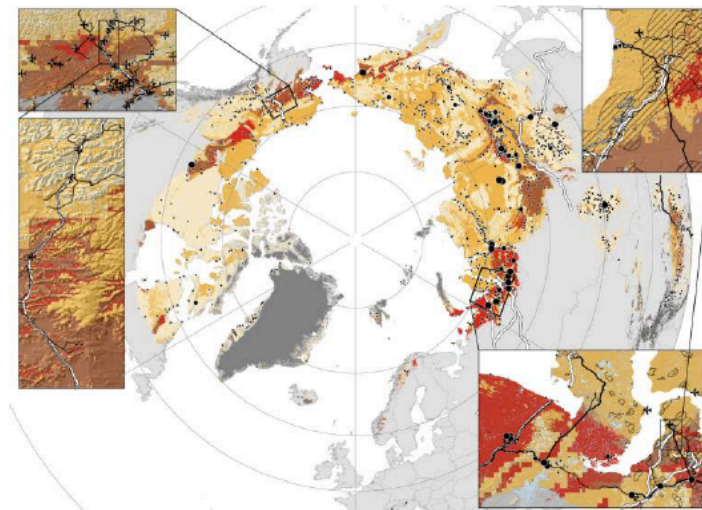
²⁶ Streletskiy, D. A., Suter, L. J., Shiklomanov, N. I., Porfiriev, B. N., & Eliseev, D. O. (2019). Assessment of climate change impacts on buildings, structures and infrastructure in the Russian regions on permafrost. *Environmental Research Letters*, 14(2), 025003.

residential real estate on permafrost was estimated at 52.6 bln USD, with buildings affected by significant permafrost degradation by the mid-21st century.”

A study, published in 2018 by scientists with the University of Oulu, University of Helsinki, Finnish Meteorological Institute, University of Oslo, University of Alaska Fairbanks, the Russian Academy of Science, Michigan State University, and Northern Michigan University, used forecasts of the ground thermal regime, a consensus of three geohazard indices, and infrastructure data products to quantify infrastructure elements potentially at risk owing to climate change. The researchers focused on current infrastructure fundamental to Arctic communities and economic activity, including residential (settlements and buildings), transportation (roads, railways and airports) and industrial facilities (pipelines and industrial areas). The study found the following:

“... by 2050 3.6 million people, which constitutes about three quarters of the current population in the Northern Hemisphere permafrost area, may be affected by damage to infrastructure associated with permafrost thaw A substantial proportion of the fundamental human infrastructure is potentially under risk: 48–87% (mean = 69%) of the current pan-Arctic infrastructure is located in areas where near-surface permafrost is projected to thaw by mid-century The potential risk to railways appears to be especially high, as for example 470 km of the Qinghai–Tibet Railway and 280 km of the world’s northernmost railway, the Obskaya–Bovanenkovo railway ... may occur in the areas of thawing permafrost. The figures for residential infrastructure and pipelines are also high There are currently more than 1200 settlements (ca. 40 with population more than 5000) in the zone where permafrost thaw is likely.”

The study include figures of Pan-Arctic infrastructure hazard map with close-ups from central Alaska and northwestern parts of the Russian Arctic (see below).



3.3. Russia's Historical Greenhouse Gas (GHG) Emissions

According to data compiled by the Global Carbon Project, from its inception as a nation until 2019, **Russia has emitted 113.88 billion tons of CO₂-equivalents**, comprising roughly 6% of global CO₂-eq emissions since the beginning of the industrial era.²⁷

This makes Russia the **fourth-most responsible** entity for climate change, behind third-most China (200 billion tons of CO₂-equivalents, 12.7% of global cumulative emissions); and ahead of fifth-most Japan (62 billion tons of CO₂-equivalents, 4% of global cumulative emissions).²⁸

3.4. Russia's Fair-Share National Greenhouse Gas Reduction Target for 2030 In Order to Attain the Long-Term Temperature Goals of the Paris Agreement

Earlier this year, in 2021, researchers with the University of Oxford, the NewClimate Institute, Wageningen University, and Climate Analytics published a study that uses a synthesis framework of applying principles of international law for developing country-level assessments of fair national greenhouse gas reduction targets for countries of the world in order to ensure that aggregate global emissions remain below the Long-Term Temperature Goals (LTTGs) of the Paris Agreement: namely; 1) below 1.8°C with 66% probability; and 2) below 1.5°C in 2100 and a peak below 1.7°C, both with 66% probability.²⁹

These researchers relied on literature-based country-specific information about: 1) Cumulative historical GHG emissions as an indicator of a country's historical responsibility; 2) GDP per capita or the Human Development Index as an indicator of a country's capability to reduce emissions; 3) Equal per capita emissions and equal cumulative per capita emissions as an indicator of how the principle of equality should determine a country's fair national greenhouse gas reduction target; and 4) a 'common but differentiated convergence' approach as an indicator of country's stage to begin a transition toward equal per capita emissions. Using data for each category described above, the researchers applied a cumulative distribution function to calculate a fair-share range for a country's emissions in 2030 that would attain the LTTGs of the Paris Agreement.

For Russia, the researchers determined that its fair national greenhouse gas reduction target in 2030 in order to ensure that aggregate global emissions remain below 1.5°C in 2100 with 66% probability ***should be no more than 36% of its emissions in 2010***.³⁰ According to the Climate Action Tracker, the fair national greenhouse gas reduction target for Russia for 2030 is 968

²⁷ According to data compiled by the Global Carbon Project, from its inception as a nation until 2019, Russia has emitted 113.88 billion tons of CO₂-equivalents, comprising roughly 6% of global CO₂-eq emissions since the beginning of the industrial era.

²⁸ Ibid.

²⁹ Rajamani, L., Jeffery, L., Höhne, N., Hans, F., Glass, A., Ganti, G., & Geiges, A. (2021). National 'fair shares' in reducing greenhouse gas emissions within the principled framework of international environmental law. *Climate Policy*, 21(8), 983-1004.

³⁰ Ibid. at Figure 5 on page 997.

million tons of CO₂eq (excluding LULUCF), and 157 million tons of CO₂eq for 2050 (excluding LULUCF).³¹

3.5. **Russia's Cost-Optimal Greenhouse Gas Reduction Target for 2030 In Order to Attain the Long-Term Temperature Goals of the Paris Agreement and How Does This Compare to Expected Future Greenhouse Gas Emissions Under Russia's Existing National Climate Change Policies**

In 2020, scientists from 22 institutions³² published an analysis showing how implementation of current climate change policies of major nations leaves large emission gaps by 2030 compared with optimal pathways to implement the temperature targets of well-below 2 °C and 1.5 °C of the Paris Agreement under the United Nations Framework Convention on Climate Change.³³ This international consortium of scientists described their work as follows:

“The aim of this article is to fill this knowledge gap and **to provide insights into the impact of national policies in comparison to emission pathways consistent with the NDCs and overall goals of the Paris Agreement.** Consequently, we divide the total emissions gap between national policies and well below 2 °C pathways into an implementation gap referring to the difference between the impact of national policies and the NDCs, and an ambition gap referring to the difference between the impact of the NDCs and well below 2 °C emission pathways. The results are presented for seven large economies and the world. The analysis was done by first establishing a list of high-impact policies for each G20 economy selected from a detailed open-access policy database, and translating these to input parameters for integrated assessment models. Subsequently, the model results allowed to assess the direct impact of these policies, as well as their interactions.”

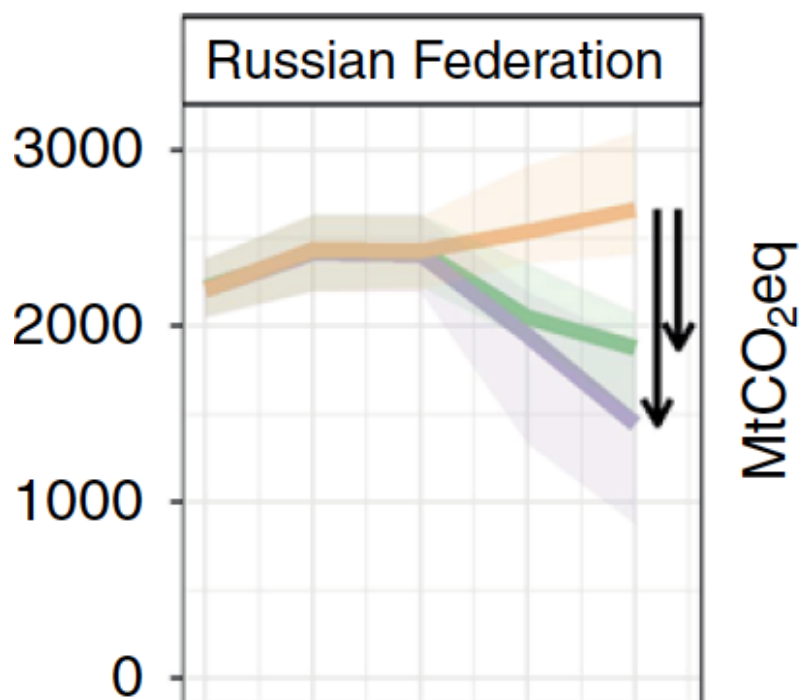
In particular, these scientists found that there is a **large implementation gap** between emissions Russia is expected to emit between now and 2030 under national climate change policies it has so far adopted (orange line); and emissions Russia would emit if it shared with the rest of the

³¹ See data at: https://climateactiontracker.org/documents/991/CAT_AssessmentData_RUS_2011-10.xlsx

³² Copernicus Institute of Sustainable Development, Utrecht University; PBL Netherlands Environmental Assessment Agency; Potsdam Institute for Climate Impact Research (PIK); Environmental Systems Analysis Group, Wageningen University; NewClimate Institute, Clever Strasse 13–15, 50668 Cologne, Germany; International Institute for Applied Systems Analysis (IIASA Austria; Global Energy Systems, Technische Universität Berlin; European Commission, Joint Research Centre, Seville, Spain; RFF-CMCC European Institute on Economics and the Environment (EIEE), Centro Euro-Mediterraneo sui Cambiamenti Climatici, Milan, Italy; Climate Analytics, Berlin, Germany; Kyoto University; E3M-Lab, Institute of Communication and Computer Systems, National Technical University of Athens, Athens, Greece. 13Research Institute of Innovative Technology for the Earth, Kyoto, Japan. COPPE, Universidade Federal do Rio de Janeiro, Brazil. Grantham Institute, Imperial College London, Exhibition Road, London, UK. Institute of Energy, Environment and Economy, Tsinghua University, Beijing, China. Joint Global Change Research Institute, Pacific Northwest National Laboratory, 5825 University Research Court, Suite 3500, College Park, USA; Energy Research Institute, National Development and Reform Commission, China; The Energy & Resources Institute (TERI), India Habitat Center, New Delhi, India; National Research University Higher School of Economics (HSE), Moscow, Russian; Indian Institute of Management-Ahmedabad, Public Systems Group, Vastrapur, Ahmedabad, Gujarat, India; National Institute for Environmental Studies, Ibaraki, Japan.

³³ Roelfsema, M., van Soest, H. L., Harmsen, M., van Vuuren, D. P., Bertram, C., den Elzen, M., ... & Vishwanathan, S. S. (2020). Taking stock of national climate policies to evaluate implementation of the Paris Agreement. *Nature communications*, 11(1), 1-12.

world in reducing CO₂eq emissions by cost-optimal implementation of reduction measures with the lowest overall mitigation costs to meet the Paris Agreement goal of well-below 2° C (green line) and 1.5° C (purple line).³⁴



For the period 2020-2030, the year-by-year difference (∂) in Russia's expected CO₂ emissions under national climate change policies it has adopted versus CO₂ emissions under cost-optimal implementation of reduction measures to meet the Paris Agreement goal of well-below 2° C and 1.5° C is indicated in the table below.

	GHG emissions, million metric tons CO ₂ eq										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
National policies	2430.1	2451.1	2472.2	2493.3	2514.3	2535.4	2560.6	2585.7	2610.9	2636.1	2661.2
2C	1	8	5	2	9	6	2	8	5	1	7
1.5C	2426.9	2351.3	2275.6	2200.0	2124.3	2048.7	2015.0	1981.3	1947.6	1914.0	1880.3
	7	2	7	1	6	1	4	6	9	1	4
	2409.9	2317.9	2225.9	2133.9	2041.8	1949.8	1848.9	1748.0	1647.1	1546.2	1445.3
	8	5	3	0	8	5	5	6	6	7	7
∂ national policies versus 2 C Paris goal	3.14	99.86	196.58	293.31	390.03	486.75	545.59	604.42	663.26	722.09	780.93
∂ national policies versus 1.5 C Paris goal	20.13	133.23	246.32	359.42	472.51	585.61	711.67	837.73	963.78	1089.84	1215.90

Thus, for the period of 2021-2030:

³⁴ Ibid., at figure 3. A cost-optimal greenhouse gas reduction target for 2050 for Russia was not calculated.

- The **cumulative CO₂eq implementation gap** for Russia between existing national climate change policies and CO₂ emissions under cost-optimal implementation of reduction measures to meet the Paris Agreement goal of well-below 2° C is **4780 million metric tons CO₂eq**;
- The **cumulative CO₂eq implementation gap** for Russia between existing national climate change policies and CO₂ emissions under cost-optimal implementation of reduction measures to meet the Paris Agreement goal of 1.5° C is **6615 million metric tons CO₂eq**.

Note that these gaps are between Russia's CO₂ emissions under existing national climate change policies and CO₂ emissions under cost-optimal implementation (least-cost pathway) of reduction measures to meet the Paris Agreement temperature goals. Russia's fair-share greenhouse gas emissions are much lower than its cost-optimal greenhouse gas emissions. Experts in international environmental law emphasize that the least-cost pathway for a country is not a relevant considering a country's fair-share CO₂ emissions reduction pathway. According to Rajamani, L., et al. (2021):

“While identifying a least cost pathway may be a relevant consideration in choosing between alternative means of implementing national fair shares, it is not a relevant consideration in determining fair shares. As some scholars argue, imposing a least cost solution in a highly unequal world is ‘inherently unjust’ (Dooley et al., 2021). The precautionary principle requires measures to be taken, even in the absence of full scientific certainty, and these measures need to deliver ‘global benefits at the lowest possible cost’ (United Nations, 1992b, Article 3.4). In the context of climate change, there is overwhelming scientific certainty (IPCC, 2018b), and in any case, as discussed below, the precautionary principle is opposed to a simple cost–benefit analysis. Cost may, however, play a role in operationalizing and implementing fair shares, and the principle of cooperation, discussed below, supports for instance, market-based approaches to emissions reductions that lower the global costs of mitigation.”³⁵

3.6. **The Human Costs of the Difference Between Russia's Expected Future Greenhouse Gas Emissions and Its Cost-Optimal Emissions Reduction Target**

In July of 2021, the number of expected deaths caused by the emission of one additional metric ton of CO₂ was estimated by research conducted at the Columbia University School of International and Public Affairs. The study states the following:

“In this study, we create an extension to DICE-2016 called DICE-EMR (Dynamic Integrated Climate-Economy Model with an Endogenous Mortality Response). We construct an additional reduced-form mortality damage function that projects the effect of climate change on the mortality rate using estimates from studies chosen from an interdisciplinary systematic research synthesis of the scholarly literature (see “Methods”

³⁵ Rajamani, L., Jeffery, L., Höhne, N., Hans, F., Glass, A., Ganti, G., & Geiges, A. (2021). National ‘fair shares’ in reducing greenhouse gas emissions within the principled framework of international environmental law. *Climate Policy*, 21(8), 983-1004.

section for details). We use DICE-EMR to produce a new metric that avoids some of the limitations of the SCC: the mortality cost of carbon (MCC). The 2020 MCC is the number of expected temperature related excess deaths globally from 2020 to 2100 caused by the emission of one additional metric ton of carbon-dioxide equivalent emissions in 2020. We find that in the DICE baseline scenario that results in 4.1 °C warming above preindustrial temperatures by 2100, the 2020 MCC is 2.26×10^{-4} lives per metric ton in the central estimate, which implies that adding 4,434 metric tons of carbon dioxide in 2020 ... causes one excess death globally in expectation between 2020 and 2100.”³⁶

“We find that optimal climate policy in DICE-EMR, however, involves large immediate emissions reductions and full decarbonization by 2050. This results in 2.4 °C warming by 2100.

“If the world undertakes the optimal emissions path in DICEEMR and restrains global average temperatures to 2.4 °C, we largely avoid the temperatures where marginal increases in temperature resulting from a marginal emission today are most damaging. Therefore, the SCC and the MCC are highly sensitive to future climate policy. On the optimal emissions path the 2020 MCC drops by 53% from 2.26×10^{-4} lives per metric ton in the baseline emissions scenario to 1.07×10^{-4} lives per metric ton (see Table 1). This implies that under DICE-EMR’s optimal climate policy, adding (reducing) 9,318 tons of carbon dioxide— equivalent to the lifetime emissions of 7.3 average Americans—causes (reduces) one excess death globally between 2020 and 2100. It also implies that adding (reducing) 1,276 metric tons of carbon dioxide in 2020 ... causes (reduces) 0.14 excess deaths between 2020 and 2100 in expectation on the optimal emissions path”³⁷

Table 1 2020 mortality cost of carbon (MCC).			
	Low mortality estimate (<10th percentile)	Central mortality estimate	High mortality estimate (>90th percentile)
Baseline emissions scenario (4.1 °C warming by 2100)	-1.71×10^{-4}	2.26×10^{-4}	6.78×10^{-4}
Optimal emissions scenario (2.4 °C warming by 2100)	-2.16×10^{-4}	1.07×10^{-4}	5.22×10^{-4}
DICE-EMR projects that an additional metric ton of carbon dioxide emitted in 2020 causes 2.26×10^{-4} excess deaths from 2020 to 2100 in the central estimate in the baseline emissions scenario and 1.07×10^{-4} excess deaths in the central estimate in the optimal emissions scenario.			

This analysis allows us to calculate the mortality costs associated with Russia’s implementation gaps. For example, if the world undertakes the optimal emissions path and restrains global average temperatures to 2.4 °C by 2100, then for the period 2021-2030:

- Russia’s **cumulative CO₂eq implementation gap** between existing national climate change policies and CO₂ emissions under cost-optimal implementation of reduction measures to meet the goal of well-below 2 °C would cause 513,000 excess deaths.³⁸

³⁶ Ibid., at page

³⁷ Ibid., at page 4.

³⁸ 4780 million metric tons CO₂eq x 1 death/9318 tons CO₂eq

- Russia's **cumulative CO₂eq implementation gap** between existing national climate change policies and CO₂ emissions under cost-optimal implementation of reduction measures to meet the goal of 1.5 °C would cause 710,000 excess deaths.³⁹

Note that Russia's fair national greenhouse gas reduction target for 2030 is 724 million tons of CO₂eq (excluding LULUCF), which is far less than its cost-optimal emissions reduction target for 2030 of 1445 million tons of CO₂eq (excluding LULUCF). Therefore, the human mortality costs of the difference between Russia's continuation of its national climate change policies and a pathway that aligns with Russia's fair national greenhouse gas reduction target for 2030 is far higher than the difference between Russia's continuation of its national climate change policies and a pathway that aligns with Russia's cost-optimal emissions reduction target for 2030.

3.7. Assessment of Russia's "Strategy for the Socio-economic Development of the Russian Federation with a Low-Level of Greenhouse Gas Emissions for the Period until 2050" (Стратегия социально-экономического развития Российской Федерации с низким уровнем выбросов парниковых газов до 2050 года, утв. Распоряжением Правительства РФ от 29.10.2021 № 3052-р)⁴⁰

On October 29th, 2021, the Government of the Russian Federation issued a decree containing a new Strategy for the Socio-economic Development of the Russian Federation with a Low-Level of Greenhouse Gas Emissions for the Period until 2050.⁴¹

As shown below in the following Table of Indicators, Russia's new strategy would not result in significant GHG reductions. In fact, the new strategy envisions GHG emissions **rising** from 2119 million tons of CO₂eq in 2019 to 2212 million tons of CO₂eq in 2030, and remaining at high levels (1830 million tons of CO₂eq) in 2050.

ПОКАЗАТЕЛИ массы выбросов и поглощений парниковых газов			
(млн. тонн эквивалента углекислого газа)			
Наименование показателя	Факт - 2019 год	План - 2030 год	План - 2050 год
Инерционный сценарий			
Выбросы парниковых газов	2119	2253	2521
Поглощения	-535	-535	-535
Нетто-выбросы	1584	1718	1986
Целевой (интенсивный) сценарий			
Выбросы парниковых газов	2119	2212	1830
Поглощения	-535	-539	-1200
Нетто-выбросы	1584	1673	630

³⁹ 6615 million metric tons CO₂eq x 1 death/9318 tons CO₂eq

⁴⁰ <http://publication.pravo.gov.ru/Document/View/0001202111010022>

⁴¹ Стратегия социально-экономического развития Российской Федерации с низким уровнем выбросов парниковых газов до 2050 года. Available at: <http://publication.pravo.gov.ru/Document/View/0001202111010022>

Furthermore, as the Table of Indicators shows, Russia's proposed transition to low-level of greenhouse gas emissions for the period until 2050 relies heavily on carbon dioxide removal (поглощения). In fact, **63%** of the proposed drop in net emissions from 1673 million tons of CO₂eq in 2030 to 630 million tons of CO₂eq in 2030 **consists of carbon dioxide removal**.

There are two reasons why such a heavy reliance on carbon dioxide removal for meeting proposed GHG reduction targets is inappropriate.

First, technologies and methods for large-scale carbon-dioxide removal are unproven and uncertain. With respect to the role of carbon dioxide removal in limiting global warming, the IPCC has concluded the following:

“The Role of Carbon Dioxide Removal (CDR)

“All analysed pathways limiting warming to 1.5°C with no or limited overshoot use CDR to some extent to neutralize emissions from sources for which no mitigation measures have been identified and, in most cases, also to achieve net negative emissions to return global warming to 1.5°C following a peak (high confidence). The longer the delay in reducing CO₂ emissions towards zero, the larger the likelihood of exceeding 1.5°C, and the heavier the implied reliance on net negative emissions after mid-century to return warming to 1.5°C (high confidence). The faster reduction of net CO₂ emissions in 1.5°C compared to 2°C pathways is predominantly achieved by measures that result in less CO₂ being produced and emitted, and only to a smaller degree through additional CDR. Limitations on the speed, scale and societal acceptability of CDR deployment also limit the conceivable extent of temperature overshoot. Limits to our understanding of how the carbon cycle responds to net negative emissions increase the uncertainty about the effectiveness of CDR to decline temperatures after a peak entail clear risks.

“CDR deployed at scale is unproven, and reliance on such technology is a major risk in the ability to limit warming to 1.5°C. CDR is needed less in pathways with particularly strong emphasis on energy efficiency and low demand. The scale and type of CDR deployment varies widely across 1.5°C pathways, with different consequences for achieving sustainable development objectives (high confidence).”⁴²

In fact, the Strategy for the Socio-economic Development of the Russian Federation with a Low-Level of Greenhouse Gas Emissions for the Period until 2050 does not specify what measures it would employ to attain the substantial levels of carbon dioxide removal it relies on.

Second, delaying GHG reductions, as Russia proposes, increases the quantity of carbon dioxide removal required to compensate for such delay. A study published earlier this year concludes:

⁴² Rogelj, J., D. Shindell, K. Jiang, S. Fifita, P. Forster, V. Ginzburg, C. Handa, H. Kheshgi, S. Kobayashi, E. Kriegler, L. Mundaca, R. Séférian, and M.V. Vilariño, 2018: “Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty” at page 96.

*“We illustrate how delaying near-term mitigation affects the CDR responsibilities of major emitters: raising emission levels in 2030 by one gigatonne generates about 20–70 additional gigatonnes of CDR responsibility over this century.”*⁴³ That is, if Russia were to emit 2000 million metric tons of CO₂ in 2030 rather than 1000 million metric tons of CO₂ in 2030, then Russia would need to commit to an additional removal of 20,000–70,000 million metric tons of CO₂ over the following 70 years to compensate for such delay.

Recently published evidence in the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6) affirms the principle that greenhouse gas emissions must peak soon and reduce rapidly with limited reliance on carbon dioxide removal to avert catastrophic climate change. The Working Group III report of the IPCC AR6 states:

“C.1 Global GHG emissions are projected to peak between 2020 and at the latest before 2025 in global modelled pathways that limit warming to 1.5°C (>50%) with no or limited overshoot and in those that limit warming to 2°C (>67%) and assume immediate action. [Table SPM footnote [#9], FOOTNOTE 38] In both types of modelled pathways, rapid and deep GHG emissions reductions follow throughout 2030, 2040 and 2050 (high confidence). Without a strengthening of policies beyond those that are implemented by the end of 2020, GHG emissions are projected to rise beyond 2025, leading to a median global warming of 3.2 [2.2 to 3.5] °C by 2100.

“C.2.2 Modelled global pathways that limit warming to 1.5°C (>50%) with no or limited overshoot involve more rapid and deeper near-term GHG emissions reductions through to 2030, and are projected to have less net negative CO₂ emissions and less carbon dioxide removal (CDR) in the longer term, than pathways that return warming to 1.5°C (>50%) after a high overshoot (C2 category). Modelled pathways that limit warming to 2°C (>67%) have on average lower net negative CO₂ emissions compared to pathways that limit warming to 1.5°C (>50%) with no or limited overshoot and pathways that return warming to 1.5°C (>50%) after a high overshoot (C1 and C2 categories respectively). Modelled pathways that return warming to 1.5°C (>50%) after a high overshoot (C2 category) show near-term GHG emissions reductions similar to pathways that limit warming to 2°C (>67%) (C3 category). For a given peak global warming level, greater and more rapid near-term GHG emissions reductions are associated with later net zero CO₂ dates. (high confidence) (Table SPM.1).”⁴⁴

Third, the carbon dioxide removal rate of 1200 million tons of CO₂eq in 2050, is beyond theoretical capacity of all land management changes in Russia to mitigate greenhouse gas emissions, which capacity is estimated at only 545–940 million tons of CO₂eq per year.⁴⁵

⁴³ Fyson, C. L., Baur, S., Gidden, M., & Schleussner, C. F. (2020). Fair-share carbon dioxide removal increases major emitter responsibility. *Nature Climate Change*, 10(9), 836–841

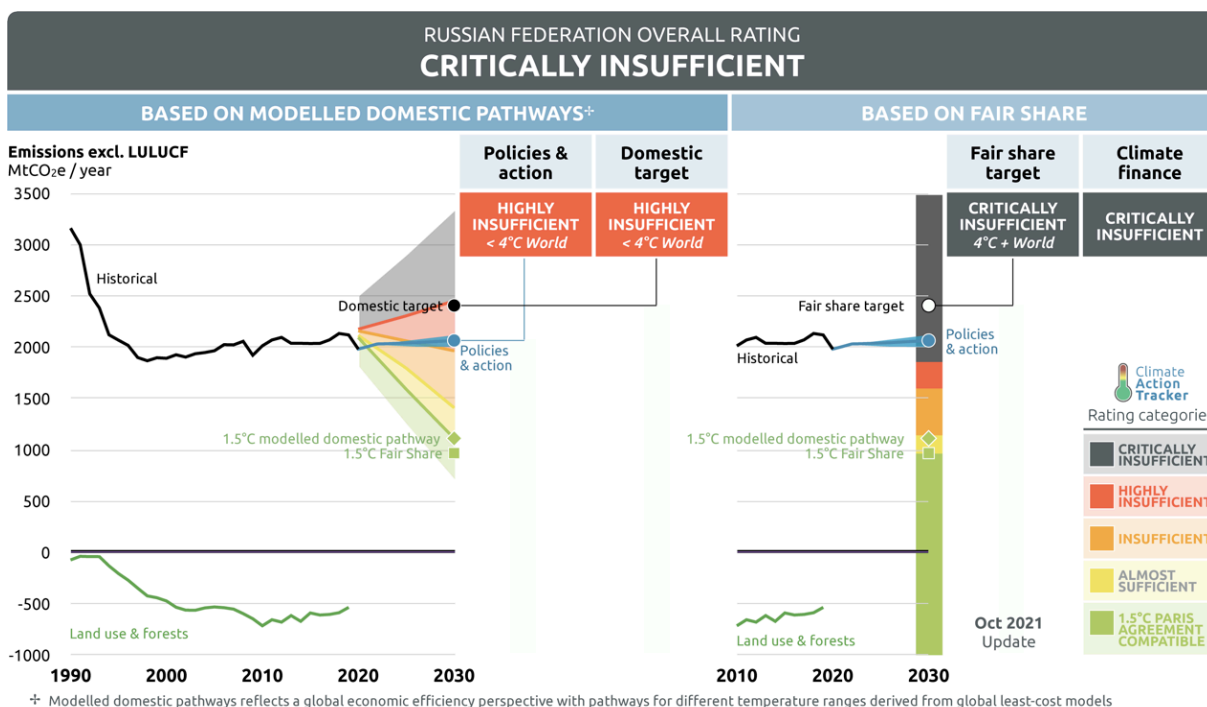
⁴⁴ IPCC (February 2022) IPCC WGII Sixth Assessment Report, Summary for Policymakers, at pages SPM 21 and 31.

⁴⁵ Romanovskaya, A. A., Korotkov, V. N., Polumieva, P. D., Trunov, A. A., Vertyankina, V. Y., & Karaban, R. T. (2020). Greenhouse gas fluxes and mitigation potential for managed lands in the Russian Federation. *Mitigation and Adaptation Strategies for Global Change*, 25(4), 661–687.

Presumably, Russia is aware of the substantial barriers and risks of its heavy reliance on carbon-dioxide removal for meeting the proposed GHG reduction targets of its new strategy. Its decision nonetheless to rely heavily on carbon-dioxide removal is further evidence that Russia is not serious about taking actions that would succeed in attaining the temperature targets of the Paris Agreement.

3.8. How Russia's Fair-Share National Greenhouse Gas Reduction Target for 2030, Russia's Cost-Optimal Emissions Reduction Target for 2030 and Russia's Expected Future Greenhouse Gas Emissions in 2030 Compare to Russia's Greenhouse Gas Emissions in 1990

It is estimated that Russia's GHG emissions in 1990 (excluding LULUCF) was **3159 million tons of CO₂eq per year**.⁴⁶ In the period of 1991-1995, Russia's GHG emissions fell rapidly because of a phase-out of inefficient industrial production following the end of the Soviet Union.⁴⁷ Climate Action Tracker *illustrates* Russia's historical GHG emissions in comparison to Russia's Fair-Share National Greenhouse Gas Reduction Target for 2030, Russia's Cost-Optimal Emissions Reduction Target for 2030 and Russia's Future Greenhouse Gas Emissions in 2030 (based on existing policies & actions and domestic targets) in the following manner.⁴⁸



Note that Russia's Future Greenhouse Gas Emissions in 2030 (based on existing policies & actions and domestic targets) aligns with a temperature increase by 2100 of 4 °C compared to the pre-industrial global average temperature, which is twice the goal of the Paris Agreement

⁴⁶ Data available at: https://climateactiontracker.org/documents/991/CAT_AssessmentData_RUS_2011-10.xlsx

⁴⁷ Schiermeier, Q. (2019). Soviet Union's collapse led to massive drop in carbon emissions. *Nature*.

⁴⁸ Illustration available at: https://climateactiontracker.org/media/images/CAT_2021-10_Graph_SplitSummary_Russia.original.png

limiting global warming to well below 2 °C, preferably to 1.5 °C, compared to pre-industrial levels.

4. Conclusions

1. Russia experiences climate change-related impacts to health because of severe heatwaves. A severe heatwave in Russia in 2010 caused more than 50,000 premature deaths. A severe heatwave in Russia in 2021 exceeded all-time maximum temperature records for Moscow, St. Petersburg, and in cities and towns in Siberia above the Arctic Circle.
2. Russia experiences climate change-related impacts to health because of increased incidence of vector-borne infectious diseases. In recent decades, the incidence of tick-borne disease, including encephalitis, has increased by several multiples in the Republic of Sakha, the Komi Republic, and Arkhangelsk Oblast because of rising ambient temperatures.
3. Russia experiences climate change-related impacts to forests because of insect outbreaks and wildfires. For example, approximately 40% of Siberian Fir in the forests of the Tomsk Oblast have been lost to Sakhalin-fir bark beetle (*Polygraphus proximus*) because of rising ambient temperatures. In July of 2021, in the Republic of Sakha, wildfires destroyed roughly 5720 square kilometers (2,210 square miles) of forests in one day alone.
4. Russia is experiencing extensive thawing of permafrost. At representative sites, mean annual ground temperatures increased from 0.03 to 0.06 °C per year at depths of 10-12 meters in the continuous permafrost zone, and the permafrost table has lowered, up to 8 meters in the discontinuous permafrost zone. As a consequence, Russia is predicted to suffer increased exposure to the bacteria that causes anthrax disease, increased prevalence and severity of landslides in permafrost regions, and damage to infrastructure in permafrost areas that will cost billions of dollars (USD).
5. If Russia and other countries do not align their climate policies with pathways consistent with the LTTGs of the Paris Agreement, then in my opinion climate change-related impacts to health, forests, and Russia's permafrost table will be far more severe than such impacts observed to date.
6. Historically, Russia has emitted 113.88 billion tons of CO₂-equivalents, comprising roughly 6% of global CO₂-eq emissions since the beginning of the industrial era, making Russia the fourth-most responsible entity in the world for climate change.
7. Russia's Fair-Share national greenhouse gas reduction target for 2030 in order to attain the long-term temperature goal of the Paris Agreement of below 1.5°C in 2100 and a peak below 1.7 °C, both with 66% probability, is 968 million tons of CO₂eq (excluding LULUCF), which is 31% of its emissions in 1990.

8. Russia's cost-optimal greenhouse gas reduction target for 2030 in order to attain the 1.5 °C long-term temperature target of the Paris Agreement is 1445 million tons of CO₂eq, which is 46% of its emissions in 1990.
9. Russia's Fair-Share national greenhouse gas reduction target for 2050 is 157 million tons of CO₂eq, which is 5 % of its emissions in 1990.
10. If Russia remains on the pathway of its existing national climate change policies rather than implementing cost-optimal measures to meet the goal of 1.5 °C, then doing so might cause 710,000 excess deaths worldwide.
11. Russia's "New Strategy for the Socio-economic Development of the Russian Federation with a Low-Level of Greenhouse Gas Emissions for the Period until 2050" would allow CO₂eq emissions to rise from 2119 million tons of CO₂eq in 2019 to 2212 million tons of CO₂eq in 2030. These emissions would align Russia with a temperature increase by 2100 of 4 °C compared to the pre-industrial global average temperature, twice the goal of the Paris Agreement limiting global warming to well below 2 °C, preferably to 1.5 °C, compared to pre-industrial levels.
12. Russia's proposed transition to low-level of greenhouse gas emissions under the new strategy relies heavily on carbon dioxide removal (CDR), despite the warning from the IPCC that CDR deployed at scale is unproven, and reliance on such technology is a major risk in the ability to limit warming to 1.5°C.

IN WITNESS WHEREOF, I hereunto affix my signature this ____ day of _____ 2022 at Eugene, Oregon, U.S.A.

Dr. Mark Chernaik Ph.D.

Affiant

SUBSCRIBED and **SWORN** to before me this _____ 2022 at _____, after affiant presented as competent evidence of his identity.