Report of the Standing Committee on Environmental Rights to the Presidential Council for Civil Society and Human Rights of the Russian Federation

The Green Turn

Climate change as a political and economic challenge: a unique opportunity for the Russian Federation to technologically transform and respect the environmental rights of its citizens

Climatescience.ru
Moscow
2021

Published by Ivan Zassoursky
Editor-in-Chief Angelina Davydova

The Green Turn/ I. I. Zassoursky—Climatescience.ru, 2021.—194 pages

This report, presented in a series of thematically-related scientific and expert articles, offers to look at the problem of climate change from multiple perspectives, with a primary focus on how climate change will affect Russia. This book is the first in the Russian language to focus on reassessing security risks to the Russian Federation from a human rights perspective while providing an overview of the scientific consensus on climate change and showing the trajectory of developing scientific discussion.

Translated from the Russian by Sasha Grafit

CONTENTS

SUMMARY OF THE REPORT

Early predictions about a new climatic reality were already being made by the Soviet scientific community in the second half of the 20th century: some calculations made in the 1970s by the great Soviet scientist M.I. Budyko are now being confirmed (Sections 1.1, 1.2). According to monitoring data, the concentration of carbon dioxide in the Earth's atmosphere is steadily increasing; in 2019, it reached a new high, which will most likely be exceeded in 2020 (Section 1.1). At the same time, permafrost degradation can lead to the release of additional volumes of methane—the second most important greenhouse gas—accelerating the processes of climate change, for which our civilization is largely unprepared (Section 1.4), and for which it will be unprepared unless it takes the "Green Turn".

A new state climate policy is a necessary condition for the technological transformation of the Russian economy. Russia is taking important steps in the field of climate protection. In September 2019, the Russian Federation joined the Paris Agreement and prepared a draft strategy (hereinafter referred to as the Strategy) for the long-term development of the Russian economy with low levels of greenhouse gas emissions until 2050. However, the draft Strategy and other strategic planning documents do not take into account the significant potential of the Russian Federation to reduce greenhouse gas emissions and do not allow for the necessary contribution required to keep the Earth's temperature rise within 1.5-2 and even 2.5 degrees (existing obligations on countries in the agreement will still lead to an increase of by 3-3.5 degrees by 2100). Moreover, there are currently attempts to weaken environmental legislation in Russia.

In order to achieve the goals of the Paris Agreement, such **a climate policy is needed that will provide conditions for technological transformation.** The basis of this policy should be to adopt a radically more ambitious national goal for 2030, one that delineates the efforts needed to meet the nationally determined contributions (NDCs) of the Paris Agreement and achieve the goal of carbon neutrality by mid-century. A condition of the NDC is the introduction of an accounting system aimed at reducing greenhouse gas emissions. The criterion for the success of this system should be a radical reduction in the energy consumed per unit of GDP (energy intensity) and the prioritization of renewable energy development.

Public demand is a prerequisite for a technological transformation toward climate-friendly and environmentally friendly technologies. Solving the transformation problem is impossible without providing high quality information to society and ensuring constructive interaction between politicians and scientists, which alone can be a ifficult task.

Nevertheless, there is already a serious demand from Russian society for a transformation toward environmentally friendly technologies and a more active climate agenda from the state. Polls by Russian Public Opinion Research Center (VTsIOM) and the National Energy Security Fund show that 43% of respondents believe that the fight against climate change should be carried out primarily by the state through the creation of a legislative framework that regulates the use of natural resources.

Unfortunately, creating public demand for environmental modernization runs into a number of problems caused, among other things, by the incomplete state of climate and environmental policy and propaganda by polluters. Often, public organizations and activists in the field of climate and environmental protection are persecuted for demanding technological modernization. Since 2012, the Russian Foreign Agent Law has resulted in 22 of 32 environmental NGOs being declared foreign agents and shut down. At the same time, there has been an increase in conflicts caused by environmental problems, resulting in street protests and direct clashes between local residents, builders, and private security companies (section 5.2). **Even public campaigns such as the ones to preserve green spaces in cities and the fight against wildfires must be considered as part of the policy to adapt to global climate change.**

In the education system, the topic of climate change has not yet received necessary attention. In the process of preparing this report, it turned out that only a very limited network of people in Russia has the sufficient competencies to understand the climate situation, and even fewer specialists are able to effectively communicate on this topic. To rule out worst-case scenarios and adapt to the inevitable impacts of climate change, we need to avoid panic (like the kind that arose during the pandemic) and ensure that everyone has access to verified scientific information. To solve this problem, it is necessary to establish international cooperation and absorb the competencies and skills that currently can only be offered by American universities.

In the field of science and education, it is necessary to put forth all necessary efforts to **stimulate academic exchange programs,**

educational study abroad programs, and joint programs (like the Lomonosov Moscow State University and the State University of New York at Albany already do) for personnel training and communication management in the context of the implementing measures to prevent the worst climate scenarios and to introduce the new climate policy in general. Support for the following areas is recommended:

- **prioritizing the climate agenda in the development of science and technology, developing climate management technologies by collecting greenhouse gases and supporting biodiversity, expanding the subjects and issues of research,** including using the mechanism of open competitions;
- aggregating research and data into the public domain, establishing a systematic method for monitoring greenhouse gases, glaciers and precipitation; maximizing access to knowledge and publishing open data on climate issues. Climate technologies must have no restrictions;
- **ensuring high-quality communication** within the scientific community, between researchers and practitioners and with society as a whole to achieve the most effective interactions between different actors, which will make the situation comprehensible to the population, and limit the possibility of spreading false information and misleading citizens, thereby **preventing panic**;
- **supporting the creation and launch of new scientific media, including those that combine the operating principles of traditional academic journals with social media**, as well as open competitions for the publication of works, which will help localize knowledge faster.

The new climate policy must include large-scale scientific studies of methane release in permafrost zones and from the continental shelves of the Global Ocean. Support is suggested for research into preventing large-scale emissions of methane in the event of permafrost degradation and the destabilization of oceanic methane hydrates. This unprecedented task requires international scientific and technological cooperation. Within the international climate agenda, it is in many ways Russia's responsibility to control the release of methane from the Arctic shelf and from permafrost, to ensure the conditions for the survival of Arctic ecosystems, and to prevent the extinctions of local animal species. **The development of methane collection and capture technologies must be quickly and decisively pursued.**

In international politics, Russia can become both a leader in certain technologies (for example, in the production of "green" hydrogen), and a leader in the formation of a new type of international relations aimed at overcoming national egoism in the matter of saving the climate. In the course of preparing this report, we discovered a US-USSR agreement, signed by Nixon and Podgorny, still valid in terms of legal mechanics, regarding the formation of an intergovernmental commission with bilateral working groups including Working Group VIII, which was chaired first by the academic Mikhail Budyko, and subsequently by the academic Yuri Izrael. We propose starting with the restoration of the climate working group, appointing Anna Romanovskaya, Director of the Izrael Institute of Global Climate and Ecology, as the head of the Russian delegation, which would emphasize continuity. The editor of this report, Angelina Davydova, could become the secretary of the working group.

Russia can expand the range of climate-friendly projects being implemented in the country by partnering with both developed and developing countries, for which it is necessary to transition away from the current strategy of situational response tactics to emerging climate risks while postponing specific, results-driven measures and toward **a consistent, proactive climate policy** corresponding to Russia's status within the framework of the international climate movement and the real state of affairs in its economy. This international policy could be directed toward the creation of a Russian greenhouse gas trading system and its integration with other international systems.

The time for the "green turn" has come, and this may be the era of a new political consensus. This turn can also be skipped, but, in this case, the price of that decision in an era of a global climate catastrophe would be the fragility of Russia as a state that will not be able to guarantee human rights in the near future.

In Russia, the rate of climate change exceeds the world average: between 1976 and 2019, the average annual air temperature in Russia increased 0.47°C every 10 years, which is two and a half times higher than the global temperature rise rate (Section 1.1). Examples of threatened entities that are naturally and culturally significant to our country include the ecosystem of Lake Baikal and the city of St. Petersburg (Section 1.3).

In St. Petersburg, the hydrologic network and the karst formation processes are at risk: both are particularly sensitive to a predicted rise in sea level, increases in the amount and intensity of precipitation, and increases in the proportion of liquid precipitation. Floods and shore-

line destruction for the coastal areas of the Kurortny district of St. Petersburg present an acute problem. According to model estimates, with the floodgates of the St. Petersburg dam closed, maximum water levels during floods in the Kurortny District increase by about 5–10%. The city's adaptation strategy will be developed as part of the next HRC climate report and is likely to become a model for other regions.

Infrastructure in permafrost areas, which comprise 65% of the territory of the Russian Federation, is also threatened (Section 1.4). Several abnormally warm and snowy winter seasons can provoke active thawing of permafrost. Even conservative climate models show that at least 25% of the infrastructure in Russia's northern cities could be destroyed by 2050. In Russia, direct annual damage from melting permafrost already reaches 150 billion rubles a year. At the same time, the reports of an Arctic scientific expedition indicate that the release of methane from the sea is increasing and may radically increase after the disappearance of multiyear ice as early as the 2020s or 2030s. Permafrost is the leading reservoir of organic matter, containing 1400–1800 bln metric tons of carbon. When the permafrost melts, bacteria convert this organic matter into carbon dioxide and methane. According to estimates, if global greenhouse gas emissions continue growing until the end of the century to reach 100 billion metric tons of CO_2-equivalent per year, then at the same time, 800 billion metric tons of CO_2-equivalent may enter the atmosphere from permafrost over the next 80 years. If the methane cannot be collected, we are essentially doomed.

An increase in the number of meteorological hazards as a consequence of climate change has a direct impact on the Russian economy. In recent years, monetary damage from dangerous climatic events grew by almost 3 times, and between 2014-18 it comprised ~30–60 billion rubles.

It should be noted that climate change brings economic benefits as well. But these benefits need to be considered in conjunction with other factors. For example, despite a lengthened agricultural growing season, and consequently, an increased bioclimatic potential yield in certain periods, under worst-case scenarios for Russia as a whole, *"the productivity of grain crops will decrease by 17.6% by the end of the century compared to the baseline period of 1981–2000."* A shorter household heating season and the resulting reduction in fossil fuel consumption is offset by the additional use of electrical energy for cooling during increasingly prolonged heat waves. For example, for the Southern Federal District, the energy consumption index in the cold season will decrease

by about 700°C/per day by 2060, and the energy consumption index in warm seasons will increase by 300°C/day.

Climate change affects all aspects of peoples' lives and threatens the full exercise of fundamental human rights. The consequences of climate change are already violating or leading to the **violation of the rights of citizens to life, a beneficial environment, the right to choose a place of residence, and access to food and clean water.**

Climate change, which leads to quality of life deterioration, also **creates additional challenges for the socio-political system.** As international experience shows, deteriorating climatic conditions can lead to **forced migrations which result in the aggravation of social conflicts** arising from subcultures and ethnic groups being compelled to integrate too rapidly in terms of historical time. Further inevitable deterioration of the environment will lead to an increase in migration flows from Central Asian countries, with Russia as their primary destination.

In addition to direct losses from climate change, there are **significant risks associated with the transformation of traditional global energy markets, upon which the Russian economy depends.** Many countries—economic partners of the Russian Federation—have declared a transition to a low-carbon economic model, leveraging the current situation of the COVID-19 coronavirus epidemic. Countries fulfilling their voluntary Paris Agreement commitments by 2030 will lead to a 20% (in material volume) decrease in Russian energy exports; by 2050, this will grow to a 25% decrease compared to the baseline scenario, in which the Paris Agreement is not adhered to.

Additional political risks result from the emergence of **economically depressed regions and single-industry mono-towns due to shifts in global market conditions from reduced consumption or rejection of fossil fuels.** For example, due to a declining pricing environment and a fall in global demand, the Kuznetsk coal basin may repeat the fate of such single-industry coal cities as Inta and Vorkuta.

Technological transformation is one of the key strategies for managing economic and political risks. The current climate change situation, as well as the preparations of other countries, requires a radical transformation of Russia's socio-economic development and the creation of new relations with foreign partners based on a dialogue regarding climate issues and technological modernization. Low-carbon transformation of the economy in the medium and long term will avoid or minimize future economic crises and political risks. Most importantly, this will protect the fundamental human rights of citizens, includ-

ing the right to a healthy environment while addressing real threats to national security and not habitual or imaginary ones.

This report was published in full on the website Naukaoklimate.rf / Climatescience.ru, created specifically for the preparation of a series of reports of the environmental commission on the climate. Thanks to the support of Clarivate Analytics, which owns the scientific platform Web of science, the world's largest open repository of high-quality scientific publications was created in the shortest possible timeframe. A significant portion of the report was first published in expanded form in the «journal» section of the site and peer reviewed during publication and during the editing process.

This report contains **two appendices:** an article about the academic Budyko and his forecast of warming, which has been accurate for the past 50 years, written by his student Andrey Lapenas; appendix 2 is the text of the Nixon-Podgorny agreement, which, due to the complex legal mechanics of its termination and the status of the Russian Federation as the legal successor of the USSR, remains valid and demands execution. Such requirements, especially in the context of this report's publication and publicity tour (translated into English and German from the Russian) may probably be the best way to interact with the new US administration, which is completely changing US policy on climate change.

Given the high risks of an apocalyptic scenario developing due to massive methane emissions from the Arctic and permafrost, **Russia can become a real leader in the fight against global warming and help eliminate the worst-case scenarios**, but this requires serious work, which, in fact, is continually being postponed until a later date, which in the current situation can be considered neither reasonable nor correct. That is why it is extremely important that the work contains prescriptions from Russian scientists on how to prevent permafrost thawing ("Impermanent permafrost" by N. Zimov) and how to capture methane ("Methane Capture Technology as a Necessary Tool in the Battle with Global Warming" by A.L. Gusev), containing an overview of possible technological solutions to this scientific and technological challenge. The solution to this problem can have a serious positive effect, which will be difficult to ensure if the necessary preparations are not made starting with high-quality, scientifically substantiated assessments of the risks of accelerating temperature growth and predicting the nature, type, and probability of catastrophic events of one kind or another.

ACKNOWLEDGMENTS

The Standing Committee on Environmental Rights to the Presidential Council for Civil Society and Human Rights of the Russian Federation thanks the authors and publishers of this report: Senior Researcher at the Biology Research Institute at the Irkutsk State University, laureate of the Russian Federation Prize in science and technology for young scientists, **D. S. Bedulina**, Ph. D. Bio; lecturer at the Department of Integrated International Ecological Problems and Wildlife Management, MGIMO, Ministry of Foreign Affairs of Russia, **E. A. Bliznetskaya**; General Director of the TATA Scientific and Technical Center, LLC and the Hydrogen Economics Institute, LLC, Editor-in-Chief of the Journal of Alternative Energy and Ecology, **A. L. Gusev**; Senior Lecturer at St. Petersburg State University and the European University at St. Petersburg, **A. V. Davydova**; Member of the Presidential Council for the Development of Civil Society and Human Rights, President of the Internet Publishers' Association, Advisor to the Rector of St. Petersburg State University, Head of the Department of New Media and Communication Theory of the Faculty of Journalism at the Moscow State University, publisher of Climatescience.ru, "Scientific Correspondent", Noosphere and "Private Correspondent", **I. I. Zassoursky**, Ph. D. Philol.; Researcher, Pacific Institute of Geography, Far Eastern Branch, Russian Academy of Sciences, **N. S. Zimov**; Researcher of the Geography Department at the Moscow State University, Associate Professor of the Geography and Geo-information Technologies Department at the Higher School of Economics, **Yu. S. Kuznetsova**; General Director of the "Goal Number Seven" Association, Senior Researcher at RANEPA, **T. A. Lanshina**, Ph. D. Econ.; Associate Professor, Department of Climatology and Environmental Monitoring, Institute of Earth Sciences, St. Petersburg State University, honorary scientist of the Hydro-meteorological Service, member of the Russian Geographic Society, **N. A. Lemeshko**, Ph. D. Clim.; Associate Professor, Department of World Economy, Faculty of Global Economics and International Affairs, Higher School of Economics, **I. A. Makarov**, Ph. D. Econ.; Head of the climate platform ClimateScience.ru., A.M. Pisarevskaya; Professor, chief researcher and head of the laboratory of the Institute for Economic Forecasting, Russian Academy of Sciences, 2007 Nobel Peace Prize laureate as a member of the Intergovernmental Group of Experts on Climate Change, **B. A. Revich**, M. D.,Ph. D.; Director of the Institute of Global Climate and Ecology, Corresponding Member

of the RAS, **A. A. Romanovskaya**, Ph. D. Bio.; Director of the Center for Environmental and Natural Resource Economics of the Higher School of Economics, **G. V. Safonov**, Ph. D. Econ.; Co-chairman of the Russian Socio-Ecological Union, director of the Friends of the Baltic Association, **O. N. Senova**; Co-chairman of the Russian Socio-Ecological Union, **V. V. Servetnik**; Full Member of the Russian Mineralogical Society, Full Member of the European Academy of Natural Sciences, Deputy Chairman of the Committee for Nature Management, Environmental Protection, and Environmental Safety of St. Petersburg, **I. A. Serebritskiy**, Ph. D. Geol.; General Director of the Information and Analytical Center "New Energy", **V. A. Sidorovich**, Ph. D. Econ.; Director of the Energy Policy Research Center of the European University at St. Petersburg, **M. A. Titov**; Faculty member of the Department of New Media and Communication Theory, Faculty of Journalism, Moscow State University, project coordinator of the Internet Publishers' Association, **N. D. Trishchenko**, Ph. D. Phil.; editor-in-chief of the Life-Inform news agency, **E. I. Usov**; Chairman of the Standing Commission on Environmental Rights of the HRC, **S. A. Tsyplenkov**; Senior Researcher at the Laboratory of Climate Theory of the A. M. Obukhov Institute of Atmospheric Physics at the Russian Academy of Sciences, science secretary of the Scientific Council of the Russian Academy of Sciences on the problems of the Earth's climate, **A. V. Chernokulsky**, Ph. D. Phys.; Director of the Greenpeace Projects Department, **V. A. Chuprov**, B. Ecol.; Associate Professor of the Institute of Design and Urban Studies, Head of the Laboratory for Sustainable Urban Development at ITMO University, Director of the ANO Institute for Sustainable Development Strategy, **I. A. Shmeleva**, Ph. D. Psych.; Head of the Greenpeace Climate Program, **V. M. Yablokov**; Head of the Greenpeace Forestry Program, **A. Yu. Yaroshenko**, Ph. D. Bio.

The Standing Committee also expresses special gratitude to the Executive Secretary for the preparation of the report: Senior Lecturer at St. Petersburg State University and the European University in St. Petersburg, director of the "Bureau of Environmental Information", editor-in-chief of the journal "Ecology and the Law", Observer to the UN Talks on Climate Change Talks since 2008, **A. V. Davydova**.

The Standing Commission expresses its particular gratitude to the speakers and participants of the 69th special meeting of the Presidential Council for Civil Society and Human Rights of the Russian Federation on the topic of "Civil participation in ensuring environmental safety and climate preservation", where this report was presented, and especially thanks the Adviser to the President of the Russian Fed-

eration, Chairman of the Human Rights Council, **V.A. Fadeev**; Adviser to the President of the RF, Special Representative of the President of the RF on Climate Issues, **R. S. Edelgeriev**; Goodwill Ambassador of the United Nations Environment Program, **V. A. Fetisov**; Chairman of the HRC Commission on Historical Memory, **S. A. Karaganov,** for his help and support in organizing the special meeting.

We would also like to express our gratitude to the creators of the Naukaoklimate.ru / Climatescience.ru platform, a repository of over 77 thousand scientific articles on climate and ecology, created in partnership with Clarivate Analytics (operated by Web of Science). We would like to thank Vernsky: Advisor to the Director **Dmitry Siling**, Technical Director **Stanislav Lagun** and Lead Developer **Mikhail Volkov**. We would like to thank the Internet Publishers' Association and **Angelina Gorbunova**, the editor-in-chief of Chastny Korrespondent. for their contribution to making this report possible and full of vivid illustrations of scientific consensus in this field.

We would like to thank the Rector of St. Petersburg State University. **Nikolai Kropachev**, and **Elena** Vartanova, the Dean of the Faculty of Journalism of the Moscow State University, for their valuable support.

We express our gratitude to the Russian branch of Greenpeace for the organizational assistance in preparing the report.

We thank the President of Russia for the offer to work together, for the trust and the unique opportunity to present the Russian national report on climate, "The Green Turn: Climate change as a political and economic challenge: a unique opportunity to technologically transform the Russian Federation and respect the environmental rights of its citizens."

FOREWORD

Climate change has long since grown from an exclusively scientific concern into a political, economic, and social one—in Russia as well. At the 75th session of the UN General Assembly, Russian President Vladimir Putin identified climate change as one of the critical issues facing humanity: "The focus of our unified efforts, of course, should remain both environmental protection and climate change. Multilateral conventions, treaties and protocols within the UN framework have been fully justified. We call on all states to take a responsible approach to

their observance, especially in achieving the goals of the Paris Agreement“[1]

The question is how to make climate change not just a challenge to our time but also a stimulus for transitioning to a new social structure that allows for the continued existence of human civilization? **This report, presented in a series of thematically related scientific and expert articles, offers to look at the climate problem as a unique opportunity for the technological transformation of the country.**

We must be neither formally abstract nor cynical about the climate crisis: it is an existential challenge requiring humanity to join forces and invest massive resources into ensuring the survival of modern civilization. Climate change is now the main threat to national and global security, which contrasts with most of humanity's historical experience, when the source of danger, generally, was an enemy army. The present climate situation calls for rapid rethinking and urgent action on how to correctly communicate the problem to the public, improve communications between politicians and scientists, reduce emissions, and invest in technologies for monitoring and capturing greenhouse gases.

Anyone who reads this report will get an impression of the scale of the challenges ahead. Unfortunately, we are unprepared to address them today: to cope with the climate crisis, we need to carefully research all the possible methods of reducing emissions and accumulations of greenhouse gases, investigate the effects of positive feedback loops and stop them at the weak links. Finally, it is necessary to restore international cooperation, including bilateral relations with the United States in the field of climate research. Even in Soviet times, there was an intergovernmental commission, which included the famous Working Group VIII, comprised of the academicians Budyko and Izrael with Andrei Lapenas acting as secretary—his article on the accuracy of Mikhail Budyko's global warming forecasts (made 50 years ago!) adorns this report.

This is not just a challenge requiring vigilance and mobilization: preventing the worst effects of the climate crisis and adapting to its inevitable changes is also a game of timing. Urban studies can be conducted to the point of exhaustion, but without taking into account the climate problem, the effects of restorative measures will be too short lived, and resources will be irretrievably spent on that which is unnecessary at the expense of that which is critical. Devel-

[1] http://www.kremlin.ru/events/president/news/64074

opment plans for innovating prioritized technologies appear fragile and abstract if they ignore the problem of the survival of humankind as a species on planet Earth. The worst thing that can be done is to ignore real challenge in an attempt to maintain the status quo. Even compromises that may seem productive today may, in retrospect, appear as betrayals. Our current behavior corresponds neither to the scale of the challenge, nor to our capabilities of meeting it. Only through the awareness and analysis of the situation's nuances as well as the training of competent specialists can we come to an understanding of what we should do and how. To start, we have collected more than 77,000 climate-related scientific articles on *ClimateScience*, indexed by *Web of Science*. Unfortunately, in addition to accessing scientific information, there is also the challenge of organizing communications related to climate and ecology, for which we urgently need to train specialists.

As the experience of the pandemic shows, without well-organized communications, without open science and access to verified information, without societal awareness, it is impossible to develop a proper response and to implement it appropriately—society resists that which it does not understand. Therefore, the main task of the report and its related projects is to create a platform for this kind of open communication.

There is a scientific consensus that cannot be ignored, just as there are still scientific discussions that must be conducted properly, on the basis of evidence. Some may believe that climate problems are insignificant or are the result of an enemy conspiracy, but to think so is to deceive oneself—and ignoring reality rarely leads to positive outcomes. Conversely, by overcoming ignorance, fear, and despair, we can find the hope and resources necessary to change the situation. The time of doubts has passed, the moment of truth is approaching: the time when our country should take "The Green Turn". If this seems too extreme, it is appropriate to recall that we have had accurate calculations forecasting the current situation for 50 years. The thought of what will happen if we cannot turn the tide of events is terrifying. However, because it is already too late to prevent many consequences, it is thus necessary to prepare a strategy of adapting to the inevitable changes. To do this, we must take into account international experience and focus on the task of preparation by freeing resources from those areas where they can be reduced: for example, by stopping the development, production, and deployment of nuclear arsenals and new types of weapons of mass destruction, we can help

channel the army's resources to tackling real security threats instead of fictitious ones.

We hope this report will help us and make a united effort to change our priorities and to create a new vision for the future of our country.

1. Climate change is a destabilizing factor determining a new course of civilizational development

1.1 Relevant scientific evidence of the causes and the consequences of ongoing climate change

Causes of global climate change

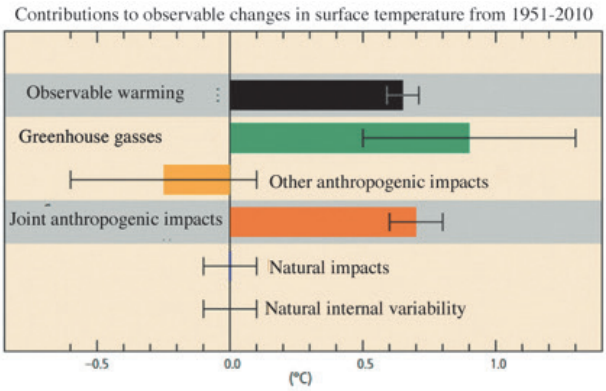
Evgeny Igorevich Usov

The Intergovernmental Panel on Climate Change (IPCC) was formed in 1988 at the initiative of the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) to study the causes and consequences of global climate change.[2] The IPCC includes 195 member countries, including Russia, whose representatives have worked with the group since its inception.

IPCC participants aim to obtain the most independent, objective knowledge about climate change by aggregating and evaluating data and results from scientific publications. The IPCC does not conduct scientific research but only analyzes and summarizes scientific information presented in peer-reviewed journals and scholarly monographs. The results of this work are presented in assessment reports issued every five to seven years. The fifth assessment report on climate change was released in 2014.

Before publication, an IPCC report undergoes a multi-stage peer review, in which the official representatives of the participating countries, scientists from international organizations, as well as experts who have interest and competence in such work, participate. Thus, 830 authors (including dozens of Russian specialists) participated in the preparation of the Fifth Assessment Report of the IPCC; approximately 142 thousand comments were received during the report review. Approval of the report's texts takes place on the basis of consensus at the plenary session of the IPCC. Thus, the results are as unbiased and independent as possible. The materials prepared by the IPCC indicate that climate change is now a reality for humankind, and it is now

[2] The Intergovernmental Panel on Climate Change. https://www.ipcc.ch/



necessary to adapt to its consequences while taking every possible measure to combat its causes.

The causal relationships of climate change and the contribution of various factors to the observed dynamics have been studied deeply. The ongoing changes in the Earth's climatic system cannot be explained solely by natural causes such as fluctuations in the Earth's orbit, changes in solar activity or volcanic eruptions.

The IPCC findings as well as the reports of various countries unambiguously indicate a significant human contribution to observed changes in the climate.[3] The human contributions include the burning of fossil fuels, animal husbandry, deforestation, marsh drainage, urban growth, and so on. These impacts have been studied since the 1970s, when the first estimates of future climate change were by the academic M. Budyko, and E. Fedorov, the head of the Hydro-meteorological Service. Now, real data are conforming to those academic forecasts.

An increase in the concentration of atmospheric greenhouse gases is recognized as a fundamental indicator of the problem. The main types of greenhouse gases are carbon dioxide, methane, and nitric oxide. Isotope analysis has been used to prove that the bulk of atmospheric CO_2 has come from the burning of fossil fuels: the significant increase in the content of the stable carbon isotope 12-C in the atmosphere can only be attributed to fossil fuels, as there are not other sources of such a large quantity of this isotope.

About half of the total anthropogenic emissions for the time period of 1750–2011 have occurred over the past 40 years.

---

[3] Climate Change, 2014 Synthesis Report, IPCC, Geneva, Switzerland, p.163 https://www.ipcc.ch/report/ar5/syr/

Climate change and Russia

Observational data indicate that Russia is among the countries where climate change is most clearly apparent.

According to the report "On the particulars of the climate in Russian Federation territory in 2019" written by the Federal Service for Hydro-meteorology and Environmental Monitoring of Russia (Roshydromet), the average growth rate of the average annual air temperature in Russia from 1976–2019 was 0.47°C / 10 years. This is more than two and a half times the rate of growth of global temperature over the same period, 0.18°C / 10 years, and more than one and a half times greater than the average rate of warming of Earth's surface temperature, 0.28°C / 10 years (estimates based on data from Hadley Center and the University of East Anglia). The average annual temperature of the Northern Polar Region grew at the fastest rate: 0.81°C / 10 years, which is 2.43°C over 30 years.

The obvious indicators of warming are the rapid decrease in Arctic ice cover, the increased thawing of permafrost, and a decrease in snow cover duration.

Data from Russian monitoring stations indicate an increase in CO_2 content in northern latitudes—on average 2.26 ppm / year. In 2019, another maximum was observed when the average annual value approached 414 ppm. The concentration of methane continues to increase, and 2019 was the fourth warmest year since 1936: the average annual temperature exceeded the norm by 2.07°C. [4]

Main conclusions:

1. Observed changes to the Earth's climate—both from global and regional perspectives—are caused by an increase in the concentrations of atmospheric greenhouse gases due to human economic activities.

2. Climate change is characterized not only by an increase in temperatures but also by negative trends in all components of the climate system: changes in the hydrological regime, sea ice cover, and increasing climate extremes.

3. The rise in temperature on Russian territory is associated primarily with an increase in the concentration of greenhouse gases.

---

[4] Roshydromet releases report on the particulars of the climate in the Russian Federation territory in 2019// Roshydromet, 03.12.2020 http://www. meteorf.ru/press/news/20626/

Overview of the impacts of climate change on Russia

Evgeny Igorevich Usov

Hazardous hydro-meteorological events have complex, multifaceted impacts on human society and exacerbate socio-economic, and socio-political problem. An analysis of the consequences of such phenomena and predictive estimates of future risks for Russia are presented in the 2017 Roshydromet report "On climatic risks to the Russian Federation".

According to the World Economic Forum (WEF), extreme weather events are one of the leading global risks, ahead of forced migration, natural disasters, and major terrorist attacks.[5] At the same time, up to 90% of economic losses at the largest scale are due to floods and deluges, strong winds, torrential rains, hail, and droughts. By comparison, volcanoes, tsunamis, and earthquakes account for only 10%.

This increase in the number and magnitude of extreme weather events is directly related to climate change, which is critically relevant for Russia, where, according to Roshydromet, climate warming occurred faster and more extensively than the global average.[6] Since the mid-1990s, in Russia, the number and intensity (destructiveness) of hazardous phenomena (HP)—which cause significant damage to the economy and the population—has been growing.[7] Annual damages from dangerous hydro-meteorological phenomena and unfavorable weather conditions in Russia range from 30–60 billion rubles per year.[8] In addition to direct economic damage, HPs are often accompanied by the loss of life.

---

[5] Global Risks Report 2017. http://reports.weforum.org/global-risks-2017/

[6] Report "On the particulars of the climate in Russian Federation territory in 2016", Moscow, 2017, p.70 http://cc.voeikovmgo.ru/images/dokumenty/2017/doc2016.pdf

[7] Report on the scientific methodology for developing adaptation strategies for climate change in the Russian Federation, Roshydromet, Climate Center Roshydromet, 2020

[8] Hydrometeorological security and sustainable development of the Russian economy for consumer demand: statistical analysis of dangerous weather conditions. Korshunov A. A. Shaimardanov M. Z. Shaimardanova I. L. Proceedings of the Russian Research Institute of Hydrometeorological Information — https://clck.ru/SFjAX

Wind

For all regions, except for Western Siberia, strong winds pose a serious danger. They are associated with 27% of emergency situations.[9] In the Central Black Earth economic regions, the maximum wind speed for the entire observation period of 2001 was noted as 28 m/s. Since 2008, abnormal winds have been observed annually in Moscow. These phenomena are almost impossible to predict and to effectively prepare for, so they cause the greatest damage. Energy, housing, municipal services, and transportation are the most vulnerable to strong winds.[10] Abnormal winds lead to significant economic damage, injuries, and loss of life.[11]

Precipitation

The share of extreme precipitation in the period from 1991–2018 accounted for more than 25% of the total number of major types of extreme weather events. Out of 580 weather cataclysms in 2015, 200 were associated with heavy precipitation, and they accounted for more than 55% of the economic damage from all HP.[12],[13] The catastrophic 2019 flood in Tulun and other settlements in the Irkutsk region was caused by abnormal atmospheric processes associated with climate change, and the likelihood of future recurrences is quite high. According to specialists from the Department of Meteorology and Near-Earth

---

[9] Report on the scientific methodology for developing adaptation strategies to climate change in the Russian Federation, Roshydromet, Climate Center Roshydromet, 2020, p.35

[10] Climatic risks and adaptation to climate change and variability in the technical sphere/N.V. Kobysheva, Akentieva E.M., Galyuk L.P..// St. Petersburg: "Kyrillitsa Publishing House", 2015 — 256 p. https://clck.ru/RsNGF

[11] Dangerous and unfavorable hydro-meteorological phenomena that have caused material and social damage on Russian territory/Shamin S.I., Bukhonova L.K., Sanina A.T.//http://meteo.ru/data/310-neblagopriyatnye-usloviya-pogody-nanjosshie-ekonomicheskie-poteri

[12] Dynamics of quantitative characteristics of extreme atmospheric precipitation in the territory of the Russian Federation. Putyrskiy V.E., Kukushkina, A.V. Environmental engineering, (3), 2019, 115-120. doi: 10.34677 / 1997-6011 / 2019-3-115-120

[13] Report on the scientific methodology for developing adaptation strategies to climate change in the Russian Federation, Roshydromet, Climate Center Roshydromet, 2020

Space Physics at Irkutsk State University, these processes manifested in the context of observed global and regional climate changes.[14]

Temperature

The number of days with abnormally high temperatures is growing throughout Russia— the frequency and intensity of heat waves is increasing. The heat wave of summer 2010 was marked by a record duration of anomalous temperature in Moscow: 53 days.[15] In addition to economic losses, this anomalous phenomenon also resulted in the loss of life. According to the United Nations Office for Disaster Risk Reduction (UNISDR), the 2010 heatwave in Russia was one of the top ten deadliest disasters on Earth over the past 20 years (seventh place in the top-38 disasters rating). According to the EM-DAT center, 55,736 people died in Russia as a result of the 2010 heat wave.[16] Increased environmental temperatures negatively affect the human nervous system and, in addition to a noticeable decrease in working capacity, can contribute to the growth of suicides.[17] Rising temperatures exacerbate food security issues and lead to drinking water shortages.

Abnormal temperatures can force decreases in the output of power plant generators, while the energy consumption for cooling residential and industrial buildings grows. In this regard, the greatest weather and climatic risks exist in the seven regions of Russia with the highest density of nuclear and thermal power plants.[18]

Predicted reductions in the freeze-up period to 15–27 days coupled with a decrease in ice thickness by 20–40% in Siberian reservoirs creates serious risks for the delivery of vital cargo to remote areas.

---

[14] Anomaly, shifting toward constancy // Irkutsk State University. 07/01/2019. http://isu.ru/ru/news/newsitem. html?action=show&id=7268

[15] Heat waves on Russian territory as an environmental discomfort factor. Vinogradova V.V., Bulletin of the Russian Academy of Sciences. Geographic series. 2017; (4): p. 68 -77. https://doi.org/10.7868/S0373244417040065

[16] Poverty & Death: Disaster Mortality 1996-2015 // Centre for Research on the Epidemiology of Disasters. https://www.unisdr.org/ les/50589_creddisaster mortalityallfinalpdf.pdf

[17] Relationship between daily suicide counts and temperature in England and Wales./ Page, L. A., Hajat, S., Kovats, R. S. // The British journal of psychiatry: the journal of mental science, 191, 2007, 106–112. https://doi.org/10.1192/bjp.bp.106.031948

[18] Report on climate risks in Russian Federation territory—Roshydromet, Saint Petersburg, 2017

Sanitation and epidemiology

Under warming conditions, the habitats and activity of infectious diseases carriers—ticks, malaria mosquitoes, and rodents—expand. In Russia, an increase in instances of such diseases as hemorrhagic fever, borreliosis, Lyme's disease, and West Nile virus has been observed.[19]At air temperatures above 5°C, a one-degree increase in the average weekly temperature results in a 5–10% increase in the incidence of salmonellosis.[20]

Climate-driven migration

Climate change creates socio-economic stresses, which lead to hazardous, rapid mass-migration of groups leaving affected regions.

Degradation of permafrost

Climate change is causing the melting of permafrost, which occupies about 60% of Russia's territory. This process has a significant negative impact on roads, railways, bridges, tunnels, as well as commercial and residential infrastructure. Additionally, the efficiency of energy extraction decreases: when permafrost thaws, oil-producing wells are deformed, leading to a post-repair decrease in oil production of 10-20%. Pipelines carry their own particular risks. Hundreds of thousands of kilometers of oil and gas pipelines have been constructed in Russia. There are nearly 2,000 oil pipeline crossings over large and medium-sized rivers—pipelines that were designed and built in the last century without accounting for climatic hazards.

Impact of climate change on buildings and structures

Climatic anomalies not only negatively impact buildings and structures in the permafrost zone. Extreme weather conditions, increasing freeze-thaw cycles, increased precipitation intensity, changes in soil

---

[19] Identification of climatogenic changes./ Semenov S.M., Yasukevich, V.V., Gelver, E. S. // Moscow, Publishing Centre "Meteorology and Hydrology", 2006, 324 pp.,

[20] Climate Change and Projections of Temperature-Related Mortality/ Shaposhnikov, D., Revich. B. //In: Climate Change and Air Pollution. Akhtar, R., Palagiano, C. (eds), Springer Climate. Springer, Cham. 2018. https://doi.org/10.1007/978-3-319-61346-8_11.

conditions, and flooding all lead to the destruction of buildings and structures that were constructed without accounting for climate risks.

Impact of climate change on indigenous peoples

The multifaceted impacts of climate change are radically altering and even destroying the living conditions of entire populations, namely indigenous peoples who lead traditional ways of life. This is the most vulnerable part of the Russian population, whose existence directly depends on climatic conditions. Weather anomalies, a shift in seasonal changes in nature, melting of permafrost, etc., endanger their very survival.[21]

1.2. Soviet and Russian science on climate change

Developing a conception of global warming: studies in the USSR and Russia

Natalia Alexandrovna Lemeshko, Ph.D. Clim. Associate Professor, Department of Climatology and Environmental Monitoring, Institute of Earth Sciences, St. Petersburg State University, honorary scientist of the Hydro-meteorological Service, member of the Russian Geographic Society

In the USSR, the first works on climate change appeared in the 1960s and 70s. They were preceded by a large-scale project of calculating surface air temperature anomalies, directed by Mikhail Budyko (of the State Hydrological Institute, Voeikov Main Geophysical Observatory) and Professor Oleg Drozdov (Leningrad State University). Thus, average annual air temperatures in the northern hemisphere's extratropical zone were calculated for the first time; deviations from this average were used as a criterion for assessing changes in the state of the climate system. At present, this value is the main indicator of global climate change.

Although until the 1980s, anomalies were not entirely obvious in the context of natural climatic processes, studying them allowed Mikhail Budyko to conclude that the progression of global warming

[21] Socio-economic factors in the lives of reindeer herders in the Yamal-Nenets Autonomous Okrug http://magazine.arctic89.ru/wp-content/ uploads /2020/02/%D0% BD% D0% B2_4-19_a-2.pdf

was intensifying. Mikhail Budyko established the foundations of physical climatology and climate theory based on the laws and mechanisms of atmospheric solar energy flows in his 1971 monograph "Climate and Life" (Budyko, 1971).

In the late 1960s, under Mikhail Budyko's leadership, the energy-balance model was created, in which the climatic distribution of atmospheric surface layer temperatures was determined by the equilibrium between the absorbed solar radiation and the radiated longwave radiation. This relatively simple model was foundational to developing the physical theory of the climate, studying its mechanisms of change, assessing the role of anthropogenic factors, and examining the sensitivity of the climate to external influences.

To "isolate the anthropogenic indicator," Mikhail Budyko and his associates studied radiation fluxes during changes in atmospheric aerosol concentrations. The resultant data identified changes in atmospheric transparency as a primary natural climate-forming factor. (Budyko, 1971; Budyko, Pivovarova, 1967; Borzenkova, 1974).

The work of Soviet scientists made it possible to approach the creation of a semi-empirical model of modern climate change (Vinnikov and Groisman, 1979, 1982) and to estimate the contribution of growth in greenhouse gas concentration as an anthropogenic factor.

Pointed debates about the causes and trends of climate change continue to this day: opponents of the anthropogenic factor attempt to attribute observed changes to other reasons, particularly to natural fluctuations inherent to the climate system. Yet, Mikhail Budyko was the first Russian scientist to prove that the anthropogenic component—namely, the change in atmospheric gas composition due to the influx of carbon from burning fossil fuels—is the main cause of global warming. Mikhail Budyko and his colleagues showed, through their research, the contribution of greenhouse gases, including those of anthropogenic origin, to climate formation. "Atmospheric Carbon Dioxide and Climate" (Budyko, 1973); "The effect of increasing the amount of carbon dioxide in the atmosphere on the climate", (1982);"Forthcoming changes in the climate" (1991), and many other publications are devoted to this issue.

Studies by Soviet and Russian scientists have confirmed the heterogeneity of temperature anomalies caused by climate change. In addition to spatial differences, warming was revealed to be uneven in nature, with air temperature increases observable only in certain months and seasons of the year. This means that in some regions, for example, an increase in air temperature is recorded in the spring, while in others

a cooling is noted. In Russia, an increase in air temperature prevails during the winter and spring, while in summer the anomalies are not so great, which can lead to erroneous denials of the warming trend.

Regional features of climate change and changes in such parameters of the climate system as precipitation, atmospheric circulation, wind, river runoff, sea ice cover have been covered in dozens of Russian scientific publications.

Russian scientific research has made a significant contribution to the study of such factors as extreme temperatures, precipitation, wind, and hydrometeorological phenomena. Such studies have both theoretical and applied significance: in the context of global warming, increasing climate extremes are associated with an increase in dangerous hydrometeorological phenomena and an increased risk of natural disasters. In this regard, Russian scientific research pays a great deal of attention to the negative consequences of climate change and adaptive strategies. These studies are also fully applicable to the development of agriculture and to the maintenance of residential and industrial infrastructure in the permafrost zone.

As new data are obtained, including hydrometeorological observations, monitoring of greenhouse gas emissions, cryospheric processes, and many others, Russian scientists face new challenges.

One relatively new task has become the tracking methane emissions during permafrost degradation. This topic demands extensive study focused both on the problems of monitoring methane emissions as well as modeling future scenarios of massive methane releases.

The Intergovernmental Panel on Climate Change (IPCC) has been operating since 1988; Russian specialists actively participate in and contribute to the climate assessment reports issued every 5–6 years.

List of references

1 Climate and life / Budyko, M.I. 1971. // L., Gidrometeoizdat, 470 p.

2. The influence of volcanic eruptions on the incoming solar radiation to the Earth's surface / Budyko, M.I., Pivovarova, Z.I., 1967. // Meteorology and Hydrology, No 10, p. 3–7.

3. On the question of the possible effects of volcanic dust on radiatioactive and thermal conditions./ Borzenkova, I.I. 1974. // Proceedings of the MGO, no. 307, p. 36–42.

4. An empirical model of modern changes in the climate / Vinnikov, K.Ya., Groisman, P. Ya. 1979.//Meteorology and Hydrology, No 3, p. 25–36.

5. Empirical Research on climate sensitivity./ Vinnikov, K.Ya., Groisman, P.Ya. 1982. // USSR Academy of Sciences, Atmospheric and Oceanic Physics, vol. 18, no. 11, p. 1159–1169.

5. Atmospheric carbon dioxide and the climate/ Budyko, M.I. 1973 // L., Gidrometeoizdat, p. 32
6. The influence of an increase in the amount of carbon dioxide in the atmosphere on the climate. 1982. — Proceedings of the Soviet-American meeting on the study of the effect of increasing the amount of carbon dioxide in the atmosphere on the climate. Leningrad, June 1981. — L., Gidrometeoizdat, 56 p.
7. Forthcoming climate changes. 1991 / Ed. M.I. Budyko and M. McCracken. — L., Gidrometeoizdat, 272 p.
8. Forthcoming climate changes. 1991 / Ed. MI Budyko and M. McCracken. — L., Gidrometeoizdat, 272 p.

1.3. Climatic threats to natural and cultural heritage sites of outstanding value

Lake Baikal and climate change

Daria Sergeevna Bedulina, Ph.D. Bio., Senior Researcher at the Biology Research Institute at Irkutsk State University, laureate of the Russian Federation Prize in science and technology for young scientists

Climate change threatens destroy the ecosystems found at natural sites of outstanding value. In turn, such objects would lose their natural, aesthetic, recreational, and social values. Threats to Russian territories recognized as belonging to the heritage of all of humanity raise the greatest degree of concern. The UNESCO World Natural Heritage Site and one of the main symbols of Russia—Lake Baikal—is a particularly illustrative example of this risk. Currently, the unique ecosystem of the lake is experiencing a large-scale negative anthropogenic impact from poorly managed tourism, lack of treatment facilities, forest fires, and poaching. In this context, climate change threatens the lake's unique properties, which are beneficial to all of humanity.

Climate change leads to complex disturbances in the structure of biological communities and poses a threat to biodiversity [1, 2]. Freshwater ecosystems that are important to humankind are particularly susceptible to temperature changes. Recent studies have shown that the summer temperatures of the lake's surface waters increases at an average rate of 0.34°C per decade [4].

Lake Baikal was declared a UNESCO World Heritage Site for the singular nature of its ecosystem, which contains about 20% of global reserves of liquid fresh water [5] and is particularly susceptible to

the risk of biodiversity extinction during global climate change. To date, over 2500 species of animals inhabit the lake, 80% of which are highly specialized endemic species [6].

The ecosystem of Lake Baikal is located in one of the three regions of the world with the fastest climatic changes; the other two being the Antarctic Peninsula and northwest North America [7].

All three areas are characterized by long and cold winters. In the area of Lake Baikal, winter air temperatures drop to between –37 and –40°C; the lake is covered with ice from 4 to 5 months of the year [5]. Despite the enormous heat capacity of such a large reservoir, global warming has caused an increase in the average temperature of the surface water layer by 1.21°C over the past 50 years [8]. This has occurred in tandem with a simultaneous change in the lake's summer stratification [8]. Over a 100-year period, the maximum increase in average temperature (by 2.1–2.2 ° C) was recorded in December and January, while in August, September, and October the average temperature increase was only 0.1–0.5° C. The lake's ice regimen has changed significantly over the past 100 years of observations [10]. The ice-free period has increased by 16 days from 1868 to 1995 [8], which is twice the global average [11]. This is especially important for the ecosystem of Lake Baikal, since ice is probably its most important abiotic driver [8].

The aforementioned changes are already altering the structures and dynamics of phyto- and zooplankton: widespread increases in tiny, mobile phytoplankton species during the summer blooming, and reductions of sensitive endemic diatoms during the winter under-ice blooming [12]. Planktonic communities are important for the vertical energy flow in the lake, but the bulk of the lake's biodiversity is found in benthic communities [6]. The littoral and sublittoral zones are the most diverse in terms of the species composition of benthic organisms, which will be significantly influenced by unprecedented changes in the water temperature of the coastal areas of Lake Baikal.

Recent studies have shown that amphipod species dominant in the benthic communities of Lake Baikal are already susceptible to the negative impact of climatic change since temperatures in the littoral zone have exceeded critical physiological thresholds for key inhabitants. In the future, this can lead to migrations or even extinctions of certain species, on which the functioning of benthic ecosystems and the ecosystem of the lake as a whole depends [13].

Sources

1. Ecological and evolutionary responses to recent climate change / C. Parmesan // Annual Review of Ecology, Evolution, and Systematics. — 2006. — No 37. Pp. 637–669.
2. Climate, climate change and range boundaries / Thomas, C. D. // Diversity and Distributions. — 2010 . — 16 (3). — Pp. 488–495.
3. Biodiversity: climate change and the ecologist / Thuiller, W. // Nature. — 2007. — 448. — Pp. 550–552.
4. Rapid and highly variable warming of lake surface waters around the globe / O'Reilly, C. M. // Geophysical Research Letters. — 2015 . — 42 (24). — Pp. 10.773–10.781.
5. Lake Baikal: Evolution and Diversity Leiden / Kozhova, O. M., Izmest'eva, L. R. // Leiden: Backhuys Publishers, 1998. — 447 p.
6. Index of animal species inhabiting Lake Baikal and its catchment area / Timoshkin, O. A. et al. // Novosibirsk: Nauka, 2001. — Vol. 1, pp. 74–113.
7. Introduction. Antarctic ecology from genes to ecosystems: the impact of climate change and the importance of scale / Clarke, A., Johnston, N. M., Murphy, E. J., Rogers, A. D. // Philosophical Transactions of The Royal Society B Biological Sciences. — 2007. — 362. — Pp. 5–9.
8. Sixty years of environmental change in the world's largest freshwater lake — Lake Baikal, Siberia / Hampton, S. E., Izmest'eva, L. R., Moore, M. V., Katz S. L., Dennis, B., Silow, E. A. // Global Change Biology. — 14 (8). — Pp. 1947–1958.
9. The rise and fall of plankton: long-term changes in the vertical distribution of algae and grazers in Lake Baikal, Siberia / Hampton, S.E., Gray, D.K., Izmest'eva, L.R., Moore, M.V., Ozersky, T. // PloS one , 9 (2), e88920.
10. Trends in hydrological and hydrochemical processes in Lake Baikal under conditions of modern climate change / Shimaraev, M. N., Domysheva, V. M. // Climatic Change and Global Warming of Inland Waters. — Chichester: John Wiley & Sons Ltd., Chichester, 2012. — Pp. 43–66.
11. Historical trends in lake and river ice cover in the Northern Hemisphere / Magnuson, J. J. et al. // Science. —289 (5485). — Pp. 1743–1746.
12. Lake-wide physical and biological trends associated with warming in Lake Baikal / Izmest'eva, L. R. // Journal of Great Lakes Research. — 42 (1). — Pp. 6–17.
13. Lake Baikal amphipods under climate change: thermal constraints and ecological consequences / Jakob, L. // Ecosphere. — 2016 . — 7 (3).

Consequences of climate change for St. Petersburg[22]

Evgeny Igorevich Usov

The city of St. Petersburg is one of the most striking examples of a site of outstanding historical and cultural value that is negatively impacted by climate change. According to data from the Voeikov Main Geophysical Observatory, a complex of negative events resulting from increases in destructive weather, meteorological and hydrological phenomena — extreme daily precipitation amounts, floods, ice deposits, heat waves —threatens the objects of this city's cultural and historic heritage.

In St. Petersburg, a steady increase in average temperature and changes in precipitation cycles have been observed.

An alarming trend is a 40% increase in the number of days with heavy precipitation of more than 15 mm/day. Several records have been set in the past decade: in 2011 the snowiest winter in St. Petersburg's recorded history was observed, and in 2016, the city had its wettest summer.

Floods are one of the most notorious hazards in St. Petersburg. According to the North-West Administration for Hydrometeorology and

[22] The article was prepared based on information and analysis from: "St. Petersburg's experience in managing the adaptation to climate change and mitigating the anthropogenic impact on the climate system." http://www.infoeco.ru/index.php?id=8780

Figure: 1. Precipitation for the warm and cold periods of the year and in general for the year from 1881 to 2017.

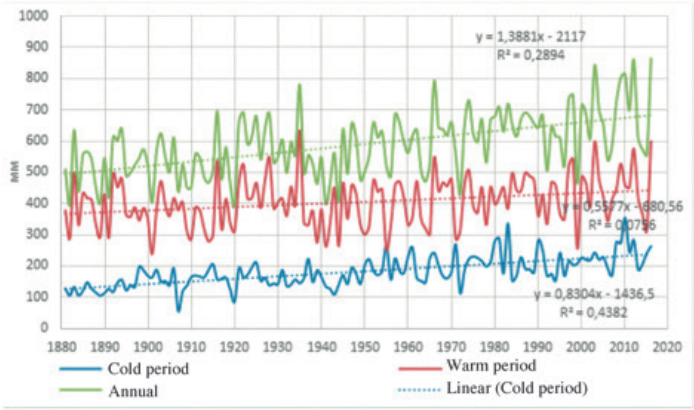
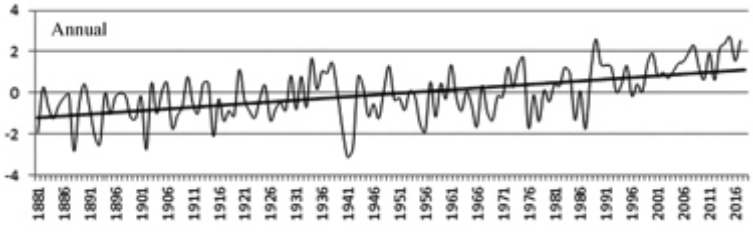


Figure: 2. Variation of average annual surface air temperature anomalies over time, averaged over the territory of St. Petersburg for 1961–2017. Anomalies are calculated as deviations from the mean temperature for 1961–1990. The straight line shows the linear trend from 1881–2017.



Environmental Monitoring, 75 floods occurred in the 18th century, 77 in the 19th century, and 138 in the 20th century. Existing observations from the 21st century suggest that the frequency of floods will increase.

The city's historical district is sufficiently protected from floods by a complex of protective structures, but a significant portion of St. Petersburg is located outside this protected zone, in the Kurortny district.

The number of winter floods, which are usually accompanied by storm conditions, has tripled. At the same time, the duration of the cold season in St. Petersburg is shortening. As a result, ice builds up in the Neva Bay much later than normal, and disappears earlier. In the absence of ice, storms contribute to progressive coastal wave erosion.

Photo Evgeny Usov

A series of storms destroyed almost 50% of the beach in the St. Petersburg's 300th Anniversary Park.

Photo Google Earth

More than 60% of the Kurortny District coastline suffers from wave erosion. The retreat of the coastline reaches up to 2 meters per year. Significant economic damage is inflicted as the most valuable recreational areas are lost.

Coastal protection structures have been created to protect the beaches: walls made of natural stone, concrete slopes, and block dumps. However, they have often led to the complete degradation of beaches, eliminating the recreational value of the coast.

In the 21st century, the expected rise in sea levels will bring the coastline erosion to critical levels. This process is also observed in multiple other waterways in St. Petersburg like rivers and canals. Every year, new changes are observed in the configuration, expansion, and deepening of erosional areas, which can cause adverse consequences for the urban population and economy.

Flooding in the city is caused not only by deluges, but also by unexpectedly concentrated precipitation (rain with an intensity of more than 7.2 mm for 20 minutes), which has become more frequent. In the past 30 years, such unpredictably intense rains have occurred

Photo Google Earth

almost every year. For example, in 2019, 16 cases of unexpected atmospheric precipitation were recorded. The increase in the amount of precipitation and its intensity creates an excessive load on the drainage systems, which can also lead to tragic outcomes. On June 16, 2016, on Savushkina street during a severe thunderstorm, a concrete hatch cover a square meter in size flew into the air from the buildup of water pressure in the manifold. Fortunately, there were no human casualties.[23]

Warming is accompanied by an increase in the temperature of water sources, which can cause critical technological safety issues; for example, in the cooling systems of thermal and nuclear power plants. In addition, the risk of infectious diseases increases. Adverse weather events like ice, “slanting rain”, “freezing rain”, alternating thaw and

[23] http://rusdtp.ru/page,1,2,49686-letayuschaya-plita-upala-na-mashinu-vpeterburge.html

frost cycles, contribute to the disruption and destruction of hydraulic structures and power supply lines.

Climate change can exacerbate the problem of karst bedrock sinkholes, which is relevant for the Krasnoselsky and Pushkinsky districts of St. Petersburg. Fluctuations in temperature, the number and intensity of precipitation, and a rise in sea level lead to changes in the regimen of groundwater and groundwater bodies, which increase the karst hazard—for the densely populated city of St. Petersburg, full of potentially dangerous objects, the consequences threatened are dire.

Another urgent problem for St. Petersburg is the spread of invasive plant and animal species, not only those carrying dangerous diseases. The Neva Bay and the Gulf of Finland, linked by shipping routes to many regions of the world, are a classic example of a system most likely to introduce invasive species. Species introduced from the ballast water of cargo ships, for example, can find ideal conditions for propagation due to climactic changes. In the Neva Bay and the eastern part of the Gulf of Finland, invasive, potentially toxic algae and cyanobacteria have been detected—the potential of their mass reproduction poses a critical threat.

Some researchers associate the catastrophic spread of Dutch elm disease in St. Petersburg with climate change. Due to warming, the vectors of this disease—elm sapwood—have seen an expanded range and shifted their borders northward up to the southern part of Finland.[24]

In 2017, "The Environment of St. Petersburg" magazine reported that, "from 1995 to 2014, about 70% of elms died in the Forestry University Park. Currently, old-age elms are dying en masse in the historic parks of St. Petersburg (Summer Garden, Ekaterininsky Garden, Mikhailovsky Garden, Aleksandrovsky Park, Tauride Garden, etc.). The Dutch disease also destroys elm saplings planted along streets in all parts of the city. About 800 outbreaks of Dutch disease were registered In 2016."

---

[24] Current state of elms in the arboretum of the Peter the Great Botanical Garden in the epiphytotic conditions of the Dutch elm disease. https: // cyberleninka.ru/article/n/sovremennoe-sostoyanie-vyazov-ulmus-l-ulmaceae- v-parke-dendrarii-botanicheskogo-sada-petra-velikogo-v-usloviyah-epitotii-gollandskoy /viewer

1.4. Permafrost degradation and associated risks

Impermanent permafrost

Nikita Sergeevich Zimov, Researcher, Pacific Institute of Geography FEB RAS (TIG FEB RAS)

More than 60% of Russian territory is located on permafrost. The thickness of this frozen layer can vary from several hundred centimeters to 1,300 meters. Since the middle of the last century, the Soviet Union has actively developed the northern territories and constructed significant infrastructure on frozen soils. In order to address these challenges, entire institutions were directed to develop construction rules and regulations that would make feasible the construction of sustainable infrastructure in dozens of cities.

However, as of the end of the 20th century, with the beginnings of climate change, the temperature in the Arctic has grown 2-3 times faster than the global average. [1]. A rise in permafrost temperature has followed the rise in air temperature. The average growth rate of temperatures is 0.3–1 degrees Celsius over 10 years [1], and in recent years, the rise in soil and permafrost temperatures has been accelerating [1]. After a series of warm and snowy winters, local processes of permafrost thawing were observed in the Arctic in 2017–2018 [2].

In many regions of Russia, ice comprises 50 percent or more of permafrost. As temperatures rise, the ice melts and soil sinking occurs. In this case, permafrost thaws at a catastrophic pace: ecosystems are destroyed, ravines, canyons, and thermokarst lakes are formed. Houses and roads built on permafrost collapse. This process can become self-reinforcing and would continue even if the climate were stabilized. The Batagaika crater exemplifies such destructive processes. Thus, even in the Arctic zone of continuous permafrost—where permafrost temperatures are currently in the range of -3 to -7 degrees Celsius—several abnormally warm and snowy winter seasons can provoke active permafrost thawing. Even conservative climate models predict that at least 25% of the infrastructure of the northern cities of Russia will be destroyed by 2050 [3].

Permafrost is the principal reservoir of organic matter, containing between 1400–1800 billion metric tons of carbon [4, 5]. When permafrost thaws, bacteria convert the organic matter into the greenhouse gasses carbon dioxide and methane. According to expert estimates, if humanity follows the scenario of growth in greenhouse gas emis-

sions (referred to by the IPCC as Representative Concentration Pathway "RCP" 8.5), then by the end of the 21st century, permafrost will release more than 200 billion metric tons of organic carbon in the form of greenhouse gases [6]. Annually, this would account for more than a 20% increase above current anthropogenic emissions. However, since this expert assessment, recent data indicate that the catastrophic nature of permafrost thawing will significantly increase the flow of greenhouse gases [7]. Additionally, the share of methane in total greenhouse gas emissions from permafrost has been insufficiently estimated [8]. When looking at the greenhouse effect in the context of the 21st century, methane is 33 times more potent a greenhouse gas than CO_2; if 10–20% of permafrost carbon were converted into methane, this would significantly accelerate global warming. Global warming, in turn, would further accelerate the melting of permafrost. It should also be borne in mind that heat is generated when organic matter decays, and in the case of microbial activity in strata rich with organic matter, the heat produced would be sufficient to thaw the underlying frozen layers, even in a stabilized climate [9].

Despite conservative forecasts and models expecting a systematic retreat of permafrost starting from its southern boundary, realistically, we can expect permafrost melting over large areas in the coming three decades, which will be accompanied by destruction of infrastructure and a significant flow of greenhouse gases into the atmosphere.

In this regard, it is necessary to develop and implement engineering solutions to stabilize the permafrost under existing infrastructure. When building new facilities, it is critical to take into account decreases in the bearing capacity of soils due to thawing permafrost.

Geo-engineering approaches to solving the issues of global warming deserve special attention. An example of such approaches is the "Pleistocene Park" re-wilding project. This scientific project aims to restore highly productive pasture ecosystems in the Arctic in order to influence the climate and permafrost temperature [10. The surfaces of northern pastures have been shown to reflect solar heat more effectively. Organic carbon accumulates better in soil, and animals, by trampling snow, allow for greater cooling of the permafrost [10].

Sources

1. The Arctic [in "State of the Climate in 2019"] / Richter-Menge, J., Matthew L., Druckenmiller et al. // Bull. Amer. Meteor. Soc. — 2020. — 101 (8). — Pp. 239–285. DOI: https://doi.org/10.1175/BAMS- D-20-0086.1.

2. Methane Emission in the Russian Permafrost Zone and Evaluation of Its Impact on Global Climate / Anisimov, O. A, Zimov, S. A., Volodin, E. M., Lavrov, S. A. // Russian Meteorology and Hydrology. — 2020. — Vol. 45, No. 5. — Pp. 377–385. DOI: 10.3103 / S106837392005009X.
3. Climate Change and Stability of Urban Infrastructure in the Russian Permafrost Regions: Prognostic Assessment Based on GCM Climate Projections / Shiklomanov, N. I., Streletskiy, D. A., Swales, T. B., Kokorev, V. A. // Geographical Review. — 2017. — Vol. 107: 1. — Pp. 125–142 DOI: https://doi.org/10.1111/gere.12214.
4. Soil organic carbon pools in the northern circumpolar permafrost region / Tarnocai, C., Canadell, J. G., G. Schuur, E. A.. Kuhry, P., Mazhitova, G., Zimov, S. // Global Biogeochemical Cycles. — Vol. 23, GB2023. — 11 p. DOI: 10.1029 / 2008GB003327.
5. Estimated stocks of circumpolar permafrost carbon with quantified uncertainty ranges and identified data gaps / Hugelius, G., Strauss, J., Zubrzycki, S., Harden, J. W. // Biogeosciences. — 2014 . — 11 (23). — Pp. 6573–6593. 10.5194 / bg-11-6573-2014. DOI: 10.5194 / bg-11-6573-2014.
6. Expert assessment of vulnerability of permafrost carbon to climate change / Shuur, E. A. G., Abbott, B. W. et al. // Climatic Change. — 2013. — 119. — Pp. 359–374. DOI: https://doi.org/10.1007/s10584-013-0730-7.
7. Permafrost collapse is accelerating carbon release / Turetsky, M. R. et al. // Nature. — 2019. — Vol. 569. — Pp. 32–34. DOI: https://doi.org/10.1038/d41586-019-01313-4.
8. 21st-century modeled permafrost carbon emissions accelerated by abrupt thaw beneath lakes / Anthony, K. W. et al. // Nature Communications. — 2018. — 9. — 11 p. DOI: 10.1038 / s41467-018-05738-9.
9. Vulnerability of permafrost carbon to global warming. Part I: model description and role of heat generated by organic matter decomposition / Khvorostyanov, D. V., Krinner, G., Ciais, P., Heimann, M., Zimov, S. A. // Tellus B: Chemical and Physical Meteorology. — 2008. — Vol. 60: 2. — Pp. 250–264. DOI: 10.1111 / j.1600-0889.2007.00333.x.
10. (2005). Pleistocene Park: Return of the Mammoth's Ecosystem / Zimov, S. A. // Science. — Vol. 308 Iss. 5723. — Pp. 796–798. DOI: 10.1126 / science.1113442.

Growing Climate Risks for the Russian Federation in the Coming Decade

Ivan Ivanovich Zassoursky, Ph.D. Philol., Chair of the New Media Studies and Communications Theory Department at the Moscow State University, founder of the Climatescience project, Chastniy Korrespondent (Private Reporter, Publication), Nauchniy Korrespondent (Scientific Reporter, Publication), The Federal Reserve of Knowledge Banks, The Noosphere Registry, and "The Way-to-Science" Competition, President of the Web-Publishers' Association

The possibility of an explosive permafrost methane release could lead to a climate catastrophe starting as early as the 2030s. Today's rapid rates of warming temperatures both globally and within the Russian territories generally correspond to the first forecasts of global climate changes predicted by Mikhail Ivanovich Budyko (M.I. Budyko, 1972). This forecast further predicts the complete disappearance of perennial Arctic sea ice by 2050 leaving only annual ice, which would cover most of the Arctic during the winters but melt quickly in the summers. Septembers in the Arctic would increasingly become iceless. Today, this forecast is confirmed by recent data from the Intergovernmental Panel on Climate Change (IPCC), which has recorded the rapid disappearance of Arctic perennial ice with satellite observations. Several possible IPCC scenarios—particularly ones premised on the highest levels of greenhouse gas emissions—predict the disappearance of the remaining ice between 2050–2100, if not sooner (Newton et al., 2016).

The above worst-case scenarios are predicted if atmospheric carbon dioxide levels continue to increase according to a "business as usual" trajectory of minimal emissions control, referred to by the IPCC as Representative Concentration Pathway (RCP) 8.5. To date, increases in atmospheric surface layer temperatures also correspond to this scenario, with some discussion about the accuracy of mathematical models, which differ mainly in the magnitude of surface air temperature sensitivity in response to a doubling of atmospheric CO_2. However, the spectrum of debate for this parameter varies between 1.8 and 5.6 degrees of warming (Zelinka et al., 2020). On Russian territory, this increase is predicted to be nearly 2.5 times the global average.

Recently, new information has appeared that was not available to M.I. Budyko and that was not analyzed in detail by the IPCC in 2014. First, a revision of the total estimates of methane reserves in permafrost set the current figures at 1670-1850 Gigametric tons (1 GT = 10^{15} grams, or a billion metric tons) of carbon (AMAP, 2017; 10, Schuur et al., 2015;

6, Lenton et al., 2019). Currently, between 2-3% of the carbon in permafrost is released as methane, but this is at risk of increasing. A one-time release of 10% of the total permafrost carbon into the atmosphere as methane would lead to an increase in the planet's greenhouse effect equivalent to a seven-to-eight-fold increase in the atmospheric concentration of CO_2. Of course, the effects of this would be relatively short-lived as the lifetime of methane in the atmosphere is about 12 years. However, there would be a sharp spike in surface air temperatures before the methane decomposed, the ocean absorbed the "extra" heat, and the climate system reached an equilibrium state. In this case, even hypothetically, one could expect average temperature increases of about 10 degrees, which, over millennia, would destabilize the ice sheets of Greenland and Antarctica. Simultaneously, this greenhouse effect could potentially contribute to Earth missing the next ice age. Then, for thousands of years, the Earth would have a climate similar to that of the Late Cretaceous period of about 65–100 million years ago.

Russian scientists are inclined to believe that the rate of methane input into the atmosphere will continue to increase with melting permafrost and Arctic warming as contributing factors (Anisimov et al., 2020). The same authors warn that, in the coming decades, methane emission from permafrost soils can equal or exceed the current total of anthropogenic atmospheric methane input. Moreover, some studies do not exclude the possibility of an "explosive" release of this greenhouse gas into the atmosphere (Turetsky et al., 2020). This year, the *Akademik Keldysh* research vessel expedition attracted a great deal of media attention after recording the initial releases of oceanic methane; full data from the expedition are expected when the ship returns to port. The Russian Federation methane monitoring system is limited to a few observation posts, among them Tiksi, and so far, methane measurements from that arctic location show only seasonal variations, with peaks lower than those from Novy Port station, which is located in a region of traditional gas production processes (Roshydromet, 2020). These observations and measurements are currently carried out on initiatives from foreign partners, but domestic funding for monitoring and research development is essential.

The most adverse hypothetical scenario adopted by UN experts is an explosive release of methane over 2% of the permafrost area in the Northern Hemisphere, which would lead to the same consequences as a gradual increase in the atmospheric concentration of carbon dioxide according IPCC RCP 8.5 (Turetsky et al. 2020). Unlike RCP 8.5, where an increase in temperature to 5 degrees Celsius is expected only by

2100, the hypothetical—very adverse—scenario of an explosive methane release could lead to the same greenhouse-induced temperature increase by 2030–2040.

Practically speaking, for the Russian Federation, an increase in global temperature by 5 degrees or more would be catastrophic in the fullest sense of the word. Most of the country's territory is located in the northern latitudes, and in the Arctic—where temperature increases would occur faster than in lower latitudes—the result would be an even greater magnitude of negative effects on infrastructure, including railways and pipelines. In addition to rising temperatures, the models predict increases in the frequency and duration of droughts in the central and southern regions of the country, which would also harm the agriculture in the southern regions of the Russian Federation (Roshydromet, 2017). A temperature increase in the boreal forest zone would lead to an increase in the area and frequency of mega-fires (fires with an area of more than 1,000 hectares), especially in the regions of Eastern Siberia (Natole et al., 2020). Positive effects of Arctic warming do include completely opening up the Northern Sea Route, allowing it to function year round. And increased Arctic precipitation during this warming would enhance the biological production of natural ecosystems, including forests, which could partially compensate for losses from fires. It should be borne in mind, however, that in the short term following the explosive release of methane, economic losses would manifest almost instantaneously, while the benefits (like forest growth) would be delayed. Additionally, the loss of perennial ice can lead to the collapse of Arctic ecosystems and the disappearance of their inhabitants.

The perspective of the global climatological community

This is a moment when the world climate community has come to a unified position regarding the causes of global warming resulting from human activity; however, there is still no consensus on the likelihood of an explosive methane release scenario as described above. This methane explosion coupled with an RCP 8.5 scenario, can be called the "Worst-case Scenario" for 2030, or, building on current terminology, RCP 8.5+. Indeed, as shown above, such a scenario could lead to a temperature rise of several degrees almost instantaneously, over just a few years. According to Andrei Lapenas, climatologist at the State University of New York, the classic RCP 8.5 scenario pales in comparison to

the catastrophic nature of the "Worst-Case Scenario" (RCP 8.5+), which includes the rapid release of methane into the atmosphere.

Recent fires have made imminent the question of the responsibilities a country bears for the processes taking place within its territories. However, it can be argued that the attractiveness of strategies to reduce emissions will be somewhat reduced in the near future due to collapsing oil prices on the global markets and the excessive supply of hydrocarbons. Judging by the volume of permafrost, Russia occupies an honorable first place in the list of most precarious jurisdictions from the perspective of climate change, and yet here, as in other countries, the monitoring of greenhouse gas releases is on too small a scale. We know very little about what happens to methane in swamp areas and in the vast arctic territories.

The following measures are proposed to determine the likelihood of an explosive warming scenario and to strengthen the position of the Russian Federation in world politics as the primary actor in the fight against global warming:

1. Intensive and urgent measures are needed to empirically determine the likelihood of a possible explosive release of methane from the permafrost, including the possible "response" from Arctic lakes and swamps. Such work cannot be carried out expediently using existing scientific resources. For example, it is necessary to increase the production of laboratory aircraft capable of conducting high-precision measurements of atmospheric methane over large areas. At present, there is (for the entire RF) one such aircraft—which, unfortunately, currently lacks flight capabilities—at the Institute of Atmospheric Optics in Tomsk. To monitor East Siberia alone, a minimum of 10 such aircraft equipped with modern measuring equipment are needed. However, even ten flying laboratories will probably not provide a real assessment, which would require ten thousand balloons or one million gravity-neutral drones equipped with the necessary equipment for continuous monitoring of methane released into the atmosphere. Deploying such a system would radically reverse the proliferation of forest fires. Of course, a parallel, several-fold increase in ground measurement of methane input into the atmosphere from the soil along the entire perimeter of the Russian sector of the Arctic would also be necessary.

Increasing the field staff of specialized institutes (Arctic and Antarctic Research Institute, State Hydrological Institute, Main Geophysical Observatory) would make this a possibility. A mega-grant model aimed at this specific problem could be used to invite leading scientists from

the global community to conduct such projects in the Russian Federation.

2. Data obtained from this research will help Russian scientists to provide the IPCC with relevant, up-to-date information.

3. Only radical improvements in research pursuits can mobilize the scientific community to solving a problem that is critical to humankind, and far more important even than the atomic project, for which an entire industry had to be created. In the near future, preventing the worst-case scenarios of climate disaster and adapting to its consequences will become an acute topic, which is why developing international cooperation is critical. Many representatives of the Budyko school of thought have become the luminaries of modern climatology.

4. It is necessary, within a compressed time frame, to strengthen national proposals for the real reduction of greenhouse gas emissions. Such measures are in development at the Yuri A. Izrael Institute of Global Climate and Ecology (IGCE), but the national government must learn to resist the seductive onslaught of private and state-owned businesses in the natural resources industries for whom cost savings on technological development is the main strategy for maintaining "stability" in the face rapidly changing conditions. Such short-term profits will result in colossal long-term losses for society. Strategic resistance and managerial irresponsibility is exacerbated by Russia's particular conditions, where national assets are managed by nominal owners, corrupt partnerships, and cartels—all inexcusable in the face of a climate catastrophe.

Russia's role as a "bulwark" in climate issues is enshrined in the symbolically numbered Executive Order No. 666, and formal compliance with the Paris Agreement requires the imminent imposition of restrictions on foreign markets, which is possible only through a brilliant and resolute strategy aimed at fulfilling the aforementioned objectives for reducing emissions and preventing the transformation of the climate crisis into a global natural disaster.

5. For Russia to take its rightful place in the fight against climate change, moving from a formal approach to taking real steps is required:

- Industry should not be an obstacle, but a key stakeholder in the process of reducing emissions, risks, and eliminating the consequences of methane release.
- Emission reduction should become a research and development priority and a key criterion for state financing of industrial and

technological modernization programs, as well as a criterion when considering economic stimulus measures.

Bibliography

1. Snow, Water, Ice and Permafrost in the Arctic // AMAP Report to the Arctic Council, chapter 4. — Oslo: 2017. — 269 pp. DOI: https://doi.org/10.1029/2002WR001512.
2. Inadvertent Climate Modification. Report of the Study of Man's Impact on Climate (SMIC) / A. L. Hammond. — Cambridge: M. I. T. Press, 1971. — 308 pp. DOI: https://doi.org/10.1126/ science.176.4030.38-a.
3. Emissions — the 'business as usual' story is misleading / Hausfather, Z., Peters, G. P. // Nature. — 2020. — 577. — Pp. 618–620. DOI: https://doi.org/10.1038/d41586-020-00177-3.
4. Emissions: world has four times the work or one-third of the time. New synthesis shows what a wasted decade means for the climate pact made in Paris / Höhne, N. et al. // Nature. — 2020. — 577. — Pp. 25–28.
5. Climate Change 2014: Synthesis Report / [Core Writing Team] Pachauri, R. K. and Meyer, L. A. (eds.)] // IPCC, Geneva, Switzerland. — 151 pp. — DOI:.https://doi.org/10.1017/CBO9781107415324.
6. Climate tipping points — too risky to bet against / Lenton, T. M., Rockström, J., Gaffney, O., Rahmstorf, S., Richardson, K., Steffen, W., Schellnhuber, H. J. // Nature.—2019. DOI: https://doi.org/10.1038/d41586-019035950.
7. Thermal Equilibrium of the Atmosphere with a Given Distribution of Relative Humidity / Manabe, S., Wetherald, R.T. // Journal of the Atmospheric Sciences. — 1967. — DOI: https://doi. org/10.1175/1520-0469(1967)024<0241:TEOTAW>2.0.CO;2.
8. Machine Learning Algorithms Identified Climate Warming as Principle Control of Forest Mega-Fires in East Siberia / Natole, M. Jr.,Ying, Y., Buyantuev, A., Stessin, M., Lapenas, A. // Global Biogeochemical Cycles (in preparation), 2020.
9. White Arctic vs. Blue Arctic: A case study of diverging stakeholder responses to environmental change / Newton, R., Pfirman, S., Schlosser, P., Tremblay, B., Murray, M., Pomerance, R. // Earth's Future. — 2016. — No 4. — Pp. 396–405. DOI: https://doi.org/10.1002/2016EF000356.
10. Climate change and the permafrost carbon feedback / Schuur, E. A. G. et al. // Nature, — 2015. — No 520. — Pp. 171–179. DOI: https://doi.org/10.1038/nature14338.
11. Causes of Higher Climate Sensitivity in CMIP6 Models. / Zelinka, M. D. et al. // Geophysical Research Letters. — 2020. DOI: https://doi.org/10.1029/2019GL085782.
12. Human Impact on Climate/ Budyko, I.M.— Hydrometeorology Press 1972. — P. 46.
13. 2019 Report on Climate Particulars in Russian Federation Territories / Federal Service for Hydrometeorology and Environmental Monitoring

of Russia —Moscow, 2020. — 97 pp. URL: http://www.meteorf.ru/press/releases/20628/.
14. 2016 Report on Climate Particulars in Russian Federation Territories / Federal Service for Hydrometeorology and Environmental Monitoring of Russia —Moscow, 2020. — 70 pp. URL: http://www.meteorf.ru/upload/pdf_download/Доклад2016.pdf.

1.5. Public Health Consequences

Assessment of the consequences of climatic changes on the health of citizens and the sanitary and epidemiological situation

Boris Alexandrovich Revich, Dr. Sci. Med., Professor, Chief Researcher and Head of the Laboratory of the Institute of Economic Forecasting of the Russian Academy of Sciences, 2007 Nobel Peace Prize laureate as a member of the Intergovernmental Group of Experts on Climate Change

1. Assessment of the public health consequences of climate change on the urban population. One of the primary consequences of climate change is an increase in the number of days with extremely high temperatures, an increase in the number of heat waves and periods of heavy precipitation. There is an increase not only in the number of such waves, but also in their duration. According to WHO estimates, climate change causes from 1 to 10% of deaths in older age groups in Europe, up to 150 thousand additional deaths worldwide, and adds 5.5 mln years of disability per annum: this is 0.3% of the total deaths and 0.4% of the total number of years of disability. The overall global economic cost of additional deaths from climate change ranges from USD6 billion to USD88 billion per year. The hot summer of 2010 led to fires and a sharp rise in mortality in the European part of Russia; in Moscow the excess number of cases reached 11 thousand. 40% of these were associated with abnormally high temperatures, 29% with exposure to polluted atmospheric air, and 31% with the confluence of these two factors. During this heat wave, the number of ambulance calls for strokes increased by 2.5 times, and by a factor of 5 for pneumonia. Periods of abnormal heat waves in the Russian territory are observed annually, in Siberia and the Far East as well.

2. Predictive assessments of the consequences of climate change in terms of deteriorating air quality and its impact on

health. In Russia, it is extremely difficult to assess the future prospects for air quality due to the heterogeneous nature of causal vectors. On the one hand, the further development of the coal industry has been declared, which may lead to increased air pollution, especially in Siberia; on the other hand, the federal "Clean Air" project is being implemented to reduce air pollution in 12 cities, with planned increases to the number cities that will receive special federal funding for national projects.

3. Predicting the public health consequences of climate change on the urban population. By 2050, the WHO expects a 1.0–1.5% increase in the number of deaths caused by climate warming in Europe—excepting the Nordic countries—in comparison to the beginning of the 21st century. In the cities of the Russian Arctic macro-region (Murmansk, Arkhangelsk and Yakutsk) by 2090–2099, a 3.2–4.5% decrease in winter mortality rates is expected when compared to 1990–1999.

4. Assessment of climate change consequences from the perspective of sanitation and epidemiology: impact on public health in permafrost areas. A gradual warming of the Arctic climate and anomalously hot summer weather lead to a gradual degradation of permafrost, which can lead to the degradation of anthrax cattle burial grounds. In 2014, an outbreak of anthrax occurred on the territory of the Yamalo-Nenets Autonomous Okrug. The potential destruction of anthrax cattle burial grounds in Yakutia and Taymyr Autonomous carry the highest risk to the population. Permafrost degradation also damages the foundations of buildings and infrastructures, including water supply and sewerage systems. Up to 1 million people may be critically in danger of water-borne infections and an increase in the number of intestinal infectious diseases.

In the Arctic, indigenous peoples comprise the most vulnerable demographic. Increases in anomalous weather events related to climate warming can lead to disruptions of traditional natural resource management and movement patterns. By limiting traditional methods of hunting, fishing and movement, the indigenous populations will be exposed to food insecurity. An increase in air temperature in traditional food storage areas can cause acute intestinal infections.

Permafrost melting, changes in snow cover distribution, and the earlier melting and later formation of river ice observed in recent years are disrupting the traditional migration routes of reindeer between winter and summer pastures. Changes in the migration routes of wild reindeer and their food sources coupled with a decrease

in marine animal numbers may reduce the traditional activities of the Arctic's minority indigenous populations. In a number of countries, adaptation measures have already been taken to relocate such peoples to special settlements. However, these kinds of relocations impose lifestyle changes, which lead to psychological stress, and subsequently very few indigenous people are able to return to the complex and thoughtful model of nomadic reindeer herding and cultural traditions.

5. Assessment of climate change consequences from the perspective of worsening sanitation and epidemiology: impact on public health. Climate warming has led to an increase in the incidence of climate-dependent infections. The number of cases of West Nile fever has increased significantly in the southern territories (Astrakhan and Volgograd regions); in the Volgograd, Rostov regions and Kalmykia, Crimean-Congo Hemorrhagic fever is on the rise—these diseases can migrate to the center of the European part of Russia. Breeding populations of mosquitoes—carriers of other fevers—have been found on the Black Sea coast. The lack of herd immunity to these diseases indicates that infections and mortality rates would be especially severe. Increasing desertification of the southern regions (Kalmykia, Stavropol Krai and others) may lead to an increase in the number of diseases transmitted through substandard water and food. Increases in desert dust mass transferred from desert and semi-desert territories to residential areas threaten air quality and can cause additional morbidity and mortality, especially in terms of cardiovascular and respiratory diseases.

In the European north, climate warming contributes to shifting the distribution boundaries of ixodid ticks—the primary carriers of tick-borne encephalitis—to the northeast, and the lengthening their active periods. In the Arkhangelsk region and the Komi Republic, tick-borne encephalitis has shifted northward. Further warming, threatens to expand the range of ticks—carriers of the tick-borne encephalitis virus—further north into the territory of the Republic of Karelia, the Arkhangelsk region, and the Komi Republic, as well as advance into Siberia and the Far East. Climate change in the Arctic also leads to changes in animal habitats and the resulting related risk of infections for humans from diseases such as rabies.

6. Assessment of the consequences of climate change for public health, accounting for the combinations of polluted atmospheric air and the COVID-19 virus. In 2020, an increase in the incidence and death from the virus in cities with the highest levels of air pollution has been proven in some cities in the USA, Italy, Spain, China

and other countries. This is due to the fact that the presence of high concentrations of fine particles suspended in atmospheric air promotes the transfer of viruses over longer distances from infection sources. Additionally, the particles decrease immunity and intensify the body's inflammatory response to the viral infection in the respiratory system.

Bibliography

1. Air Pollution and Covid-19: The Role of Particulate Matter in the Spread and Increase of Covid-19's Morbidity and Mortality / Comunian, S., Dongo, D. Milani, C., Palestini, P. // Int. J. Environ. Res. Public. Health. — 2020. — 17 (12). — 20 p. DOI: 10.3390/ijerph17124487.
2. COVID-19 as a factor influencing air pollution? / Dutheil, F., Baker, J., Navel, V. // Environmental Pollution. — 2020. — 263 (Part A). DOI: https://doi.org/10.1016/j.envpol.2020.114466.
3. COVID-19, City Lockdown, and Air Pollution: Evidence from China / Guojun, H., Pan, Y., Tanaka, T. // Nature Sustainability. — 2020. DOI: https://doi.org/10.1101/2020.03.29.20046649.
4. COVID-19 PM2.5 A national study on long-term exposure to air pollution and COVID-19 mortality in the United States [Electronic Resource] / Wu, X., Nethery, R.C., Sabath, B.M., Braun, D., Dominici, F. // URL: https://projects.iq.harvard.edu/ les/covid-pm/ les/pm_and_covid_mortality.pdf.
5. Association between short-term exposure to air pollution and COVID-19 infection: Evidence from China / Zhu, Y., Xie, J., Huang, F,, Cao, L. // Sci Total Environ. — 2020. — 727:138704. DOI: 10.1016/j.scitotenv.

2. Climate change: economic and political risks

2.1. Global low-carbon development trends and their impact on the Russian economy

Global low-carbon development trends and their impact on the Russian Federation: analysis of risks and opportunities for Russian hydrocarbon exports

Igor Aleksandrovich Makarov, Ph.D. Econ. Associate Professor at Higher School of Economics, Department of World Economy, Faculty of Global Economics and International Affairs.

Global efforts to reduce greenhouse gas emissions pose a challenge for countries that depend on the production and export of fossil fuels. Decarbonizing—the implementation of measures to switch to cleaner energy sources, energy conservation, and energy efficiency—lowers the demand for fossil fuels. In 2017, oil and gas were the source of about 40% of federal budget revenues in Russia, and they accounted for 70% of Russian exports.[25],[26] The "Strategy for Economic Security of the Russian Federation for the Period until 2030" states that, "the change in the structure of world demand for energy resources and the structure of their consumption, the development of energy-saving technologies and a decrease in material consumption, the development of 'green technologies' are among the challenges and threats to economic security.[27]

The Paris Agreement is a key instrument for coordinating the efforts multiple countries to reduce greenhouse gas emissions. Its parties have set national targets for emission reductions in the form of Nationally Determined Contributions (NDC)—targeted primarily for 2030. The list of the leading countries' contributions is shown in Table 1. It is assumed that every five years from 2023 onward, the NDCs will be revised with an eye towards greater rigor. Thus, if we forecast

[25] According to the RF Ministry of Finance.

[26] According to the Federal Customs Service.

[27] Executive Order of the President of the Russian Federation "The Strategy for Economic Security of the Russian Federation for the Period until 2030" dated May 13, 2017 No. 208.

the efforts of the world community to reduce greenhouse gas emissions for the coming decades, then we can consider the country-specific NDCs as the minimum level for the anticipated decarbonizing efforts.

Table 1. Declared Nationally Determined Contributions of Leading Countries Declared within the Paris Agreement. [28]

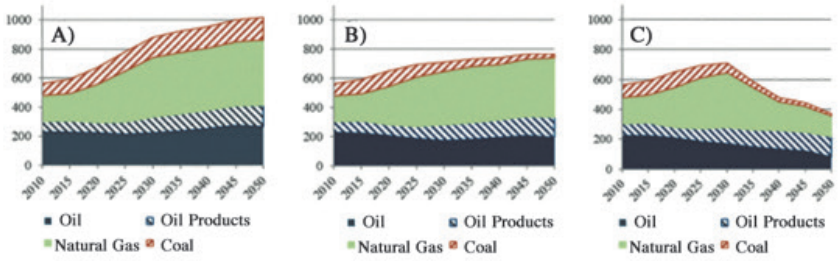
Country	Main Mitigation Pledge
China	Reach peak CO_2 emissions around 2030, lower CO_2 intensity of GDP 60-65%
USA	Reduce GHGs to 26-28% below 2005 levels by 2025 (exited Paris Agreement, with high likelihood of reentry)
EU	Reduce GHGs 40% below 1990 levels by 2030.
India	Reduce GHG intensity of GDP 33-35% below 2005 level by 2030.
Japan	Reduce GHGs 25% below 2005 levels by 2030.
Korea	Reduce GHGs 37% below BAU in 2030.
Canada	Reduce GHGs 30% below 2005 levels by 2030.
Brazil	Reduce GHGs 37% below 2005 levels by 2025
Mexico	Reduce GHGs 25% below BAU in 2030.
Indonesia	Reduce GHGs 29% below BAU in 2030.
Australia	Reduce GHGs 26-28% below 2005 levels by 2030

The parties to the Paris Agreement cannot fulfill their commitments to reduce emissions without reducing their consumption of fossil fuels. We can predict demand for Russian fossil fuels for 2030 and for 2050 by taking into account the achievement of country-specific goals set in the Paris Agreement under the following scenarios: [29]

[28] After Paris: Fiscal, macroeconomic, and financial implications of climate change/ Farid, M., Keen, M., Papaioannou, M., Parry, I., Pattillo, C., and Ter-Martirosyan, A.// IMF Staff Discussion, 2016, Note, 16(1).

[29] The MIT EPPA6 (Economic Projection and Policy Analysis) model version six, developed at the Massachusetts Institute of Technology (MIT), was used to simulate these scenarios.

Figure 1. Russian energy exports A) in the baseline scenario; B) in the "INDC" scenario; C) in the "2 degrees" scenario (million metric tons of oil equivalent)



1. Base Scenario, in which countries do not make any efforts to reduce emissions, avoiding the commitments that they declared in the Paris Agreement.
2. "INDC" (Intended Nationally Determined Contributions) Scenario, in which countries fulfill their national contributions declared in the Paris Agreement of 2015 by 2030. But, after 2030, no additional measures to reduce emissions by countries are undertaken.
3. The "2 degrees" Scenario, in which countries fully adhere to their national contributions until 2030, and then take significant additional measures to keep the temperature rise from going above 2°C by 2050.

Simulations based on these three scenarios show that countries adhering to their Paris Agreement commitments would have significant negative impact on Russian energy exports.[30] In the INDC scenario (Figure 1C), exports would drop 20% by 2030, and 25% below the baseline scenario—in which no country adheres to the Paris Agreement—by 2050. While in the baseline scenario (Figure 1A), the export of all energy carriers grows, in the INDC scenario, the export of coal sharply decreases (by factor of six compared to the baseline scenario by 2050), oil exports remain relatively stable, and exports of natural gas grow to nearly double by 2050, as compared to 2010. Exports of petroleum products and natural gas in the INDC scenario do grow, but this growth is slower than in the baseline scenario.

In the "2 degrees" scenario (Figure 1C), Russian exports of all types of fossil fuels decline significantly. Compared to the INDC scenario,

[30] Implications of the Paris Climate Agreement for the Russian economy/ Makarov, I. A., Chen, H., Paltsev, S. V. // Economic Issues, 2018, No. 4, pp. 76–94.

the export of petroleum products is reduced by a small amount, but the export of crude oil will almost halve by 2050. In the "2 degrees" scenario, Russian exports of coal are reduced by 65% and natural gas by 49%, compared to the INDC scenario.

Coal is the most vulnerable form of fuel in terms of emissions reduction measures. In the medium term, it is assumed that the demand for coal will decline globally. Thus, according to the IEA, if from 2000 to 2016 coal capacities in the world increased by 900 GW, then from 2017 to 2040 the expected increase is only 400 GW—mainly due to projects planned or started before the Paris Agreement.[31]

A phenomenon known as the "green paradox" arises with coal: coal producers, expecting difficult times in the future, are vigorously attempting to increase production and sales in the present, while coal is still in demand.[32] For investors, on the other hand, coal is becoming a toxic asset. They do not believe in the future of the coal industry and fear that investing in it could damage their image. The movement of diversification from the coal industry is gathering momentum, which has already been joined by thousands of institutional investors. More than two dozen countries have announced a move away from coal by 2030. The convergence of these two trends makes it so that we can expect somewhat of an increase in coal usage in the short term, followed by a rather sharp decline in the long term.[33]

The prospects for Russian coal exports will be determined by these same trends. In the INDC scenario, and even more so in the "2 degrees" scenario, a slight increase in the early 2020s will be followed by a significant decline. This applies to both the European and Asian markets, which are currently primary for Russian coal producers. These markets will see a gradual replacement of coal with renewable energy sources and natural gas (primarily in Asia), and sometimes with nuclear energy (China and Japan).

The situation is different with natural gas exports. EPPA predicts an increase in global natural gas consumption in the INDC scenario. Even in Europe, by 2050 there will be 25% increase, and in Asia it will be 60% above 2015 levels. For Russian natural gas, the INDC scenario does not pose serious problems, but in the "2 degrees" scenario,

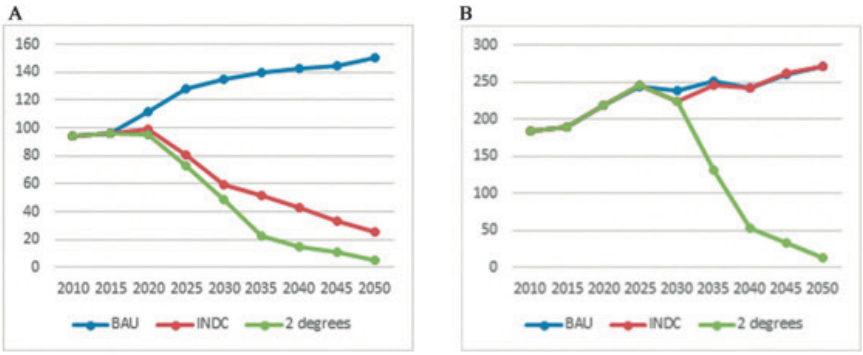
---

[31] EA. World Energy Outlook 2017. Paris, 2017.

[32] Kotlikoff L. J., Polbin A. and Zubarev A. Will the Paris Accord Accelerate Climate Change? (No. w22731) // National Bureau of Economic Research, 2016.

[33] Bauer N., McGlade C., Hilaire J. and Ekins P. Divestment prevails over the green paradox when anticipating strong future climate policies // Nature Climate Change, 2018, 8(2), p.130.

Figure 2. Export of Russian fossil fuels to Europe in different scenarios: 2A) coal, million tons; 2B) natural gas, billion cubic meters ("BAU" — Baseline scenario; "INDC" — INDC scenario based on NDCs of EU countries under the Paris Agreement; "2 degrees" scenario based on the goal of limiting global temperature growth of within 2°C)



the global consumption of natural gas is reduced due to the expanded use of renewable energy sources.

A specific consideration for the oil market is that demand is determined primarily by its use in the transportation sector, and not in the energy sector. Stimulated by the Paris Agreement, the climate policies of various countries include tightening standards for the combustion of motor fuel and the development of public transport systems. In developed countries, the growth in oil demand has practically stopped as a result. In developing countries, where the number of cars is still increasing, the demand for oil continues to grow.[34] Future developments in the oil market will be determined by new technological solutions, primarily electric vehicles.[35] However, it remains unclear when these solutions will be massively implemented.

The most rapid changes for Russian energy exports are expected in the EU market. If the countries of the European Union fulfill the goals declared in the Paris Agreement (reducing GHG emissions to 40% of January 1990 levels by 2030), Russian coal exports will decline by 55% and natural gas by 6% compared to the baseline scenario (Figure 2, INDC scenario). A 55% reduction in greenhouse emissions by 2030, which is currently being discussed in the EU, will lead to an even

[34] IEA, Oil Market Reports https://www.iea.org/oilmarketreport/omrpublic/
[35] Ibid.

greater decrease in Russian exports of fossil fuels. The EU "Green Deal", which assumes the achievement of zero net emissions by the middle of the 21st century, corresponds with the goal of limiting the rise in global temperature to no more than 2 degrees by the middle of the 21st century. This would mean an almost complete cessation of Russian fossil fuel exports to the EU countries by 2050 (Figure 2, scenario "2 degrees"). [36]

The EPPA, like any computable general equilibrium model, does not account for technological breakthroughs, so it does not show any revolutionary changes in the oil market. Thus, even the INDC scenario still assumes an increase in the export of Russian oil and petroleum products by 2050, although this growth is less rapid than in the baseline scenario. In the "2 degrees" scenario, the expected volumes of Russian oil and petroleum exports are one third lower than current values by 2050 and almost two times lower than baseline scenario values. However, when interpreting these scenarios, we must keep in mind that for oil, the main risks for manufacturers and exporters are scientific and technological progress, which are pegged as incremental and conservative in the model.

The simulation results show that in the INDC scenario, the average annual growth rate of Russian GDP will fall by 0.2–0.3 percentage points (p.p.) by 2030 as compared to the baseline scenario. Further tightening of global climate policy will cause an additional reduction in GDP growth rates of about 0.5 p.p. in the period from 2035 to 2050. Base period GDP values within a reasonable interval (from 1 to 3%) will not have a significant effect on these estimates.

The scenarios built in the model are not forecasts. The baseline scenario is actually unrealistic and is given only in order to compare the simulation results with the scenario of "what would have happened had there been no Paris Agreement". Rather, the INDC and the "2 degrees" scenarios should be considered as the lower and upper bounds for the range of realistic forecast estimates. From one perspective, it is highly likely that countries will meet their INDCs. Moreover, in 2023, contributions will be revised towards greater rigor—the EU countries have already revised a number of NDCs, for example. It is obvious that after 2030, the parties to the Paris Agreement will strengthen their climate policy measures. Thus, the described INDC scenario is actually an overly optimistic one for Russian energy exports.

On the other hand, the 2°C target is largely considered to be unfeasible, and this scenario may be too pessimistic for fossil fuel produc-

[36] Makarov I., Y. H.H. Chen and S. Paltsev Impacts of climate change policies worldwide on the Russian economy' // Climate Policy, 2020, 20(10), pp. 1242–1256.

ers. Real efforts to reduce emissions by 2050 will lie between these two options.

It should also be borne in mind that the model takes into account only gradual scientific and technological progress while ignoring the possibilities of technological breakthroughs (for example, in energy storage or transmission technologies that can give a powerful stimulus to the development of renewable energy sources, hydrogen energy, and electric vehicles). In general, such breakthroughs are not outside the realm of possibility given the huge investments that are being made into the research and development of clean technologies around the world.

Risks of maintaining the traditional economic structure and Russia's Green Deal

Tatiana Alexandrovna Lanshina, Ph.D. Econ. General Director of the "Goal Number Seven" Association, Senior Researcher at RANEPA

In 2019–2020 multiple major global economies either declared their intentions or formally adopted decisions to reduce greenhouse gas emissions to zero by 2050–2060. The list of countries that will move to carbon neutrality includes the EU, UK, China, Japan, and South Korea. Joe Biden, the current US President, included a clean electricity transition by 2035 and carbon neutrality by 2050 in his campaign platform. In the EU, the transition to carbon neutrality is part of a broader economic transformation program called the European Green Deal, adopted in December 2019. The shift to carbon neutrality and the implementation of Green Deals in the world's largest economies will bring about an unprecedented transformation of the global economy, which will place the green sector and renewable energy sources at the center of this system. These changes require a Russian response. Maintaining the traditional economic model—one that is centered on the extraction and export of fossil fuels—will reduce Russia's revenues, diminish its influence in the world, and inhibit its participation in global processes.

In September 2020, the Russian branch of Greenpeace, together with major business associations, environmental NGOs and experts, developed a framework program for reforming the Russian economy called the Green Deal of Russia.[37] This program sets for Russia

[37] Greenpeace (2020). Green Deal of Russia. URL: https://greenpeace.ru/wp-content/uploads/2020/11/%D0%97%D0%B5%D0%BB%D0%B5%D0%BD%D1%8B%D0%B9GC_A4_november_2020_002%D0%BF%D0%BF-1-1.pdf

the same goal that the largest economies have set or are aiming for: zero net greenhouse gas emissions by 2050.

As an interim goal, the Russian Green Deal proposes reducing greenhouse gas emissions to 40% of 1990 levels by 2030, taking into account land use, land-use change and forestry (LULUCF). It is proposed that that same goal be the first nationally defined contribution to the global response to climate change by 2030 under the Paris Agreement. Executive order No. 666 "On the reduction of greenhouse gas emissions" of the Russian President from November 4, 2020 calls for a reduction in emissions to 70% of 1990 levels by 2030, taking into account the maximum possible absorptive capacity of forests and other ecosystems. In 2018, greenhouse gas emissions in Russia, taking into account LULUCF, amounted to 52.4% of 1990 levels, so Russia actually plans to significantly increase its emissions.[38] This must be prevented.

The main source of greenhouse gases is the combustion of fossil fuels, which accounted for 79% of emissions in Russia in 2018.[39] This means that climate neutrality can be achieved primarily by abandoning traditional energy and replacing it with renewable energy sources and new low-carbon energy carriers such as green hydrogen.[40] The remaining emissions are shared between industrial processes (11%), agriculture (6%) and waste management (4%). Reducing greenhouse gas emissions in these sectors requires the introduction of the principles of a circular economy: an economy in which the generation of waste and the extraction of natural resources is minimized while the waste of some industries is the raw material for others.

Russia's Green Deal envisages a reduction in net greenhouse gas emissions to zero by 2050 through a full transition to (1) clean energy and (2) a circular economy, as well as through (3) offsetting emissions that cannot be avoided by natural sinks such as forests. The proposal

---

[38] Ecology and economics: dynamics of air pollution in the country on the eve of the ratification of the Paris Agreement (2019), Analytical Center under the Government of the Russian Federation. URL: https://ac.gov.ru/archive/files/publication/a/23713.pdf.

[39] (2020). National inventory of anthropogenic emissions by sources and removals by sinks of greenhouse gases not regulated by the Montreal Protocol for 1990–2018/ Romanovskaya et al. // URL: http://www.igce.ru/performance/publishing/reports/.

[40] Green hydrogen is hydrogen that is produced by water electrolysis using renewable energy sources.

suggests 12 quantitative and qualitative targets and 100 measures in these three areas.

The implications of a transition to clean energy by 2050 involve increasing the share of renewable energy sources to 100% in electricity generation, heating and cooling, and transport. Nuclear power, including controlled thermonuclear fusion, is not a suitable alternative due to its high cost, lengthy nuclear power plant construction time, increased risk of accidents, and the unresolved problem of radioactive waste. Carbon capture and storage technologies are also not considered to be an acceptable method for decarbonizing because they do not reduce emissions from fossil fuels to levels lower than those of renewable energy sources, because of their economic inefficiency, and because they cannot offset the significant environmental damage caused by oil, gas, and coal extraction. Another important goal in the field of clean energy is reducing the energy intensity of Russia's GDP which was 46% above the world average in 2018, to be on par with the world average.[41]

In terms of the circular economy, the following are required: a transition to carbon-neutral production of metals, cement, and concrete; a transition to carbon-neutral agriculture as well as the introduction of sustainable diets (containing more plant-based products than animal products); a 60% decrease in the volume of solid municipal waste per capita by 2050 compared to 2020 levels, as well as a minimum of 80% recycling level of generated waste. Reducing emissions from industrial processes is the most challenging task because carbon is involved in the chemical production processes of a number of materials and cannot always be replaced. Nevertheless, electric arc furnaces—with electricity from renewable energy sources—can be used for steel smelting, the content of carbon-intensive clinker in cement can be reduced with substitutes, the use of ammonia fertilizers in agriculture can be reduced through organic farming, etc.

In the realm of forest restoration and protection, the main qualitative achievement should be a transition away from developing remaining wild forests and towards plantation forestry and intensive forestry on previously reclaimed lands.

Despite attempts undertaken over the past decade to diversify the Russian economy, the fuel and energy complex still plays a major role. According to the World Bank, in 2018, fossil fuel rents accounted

---

[41] State report on energy conservation and energy efficiency in the Russian Federation // Ministry of Economic Development, 2019. URL: https://www.economy.gov.ru/material/le/d81b29821e3d3f5 a8929c84d808de81d/energyeciency2019.pdf.

for about 14% of Russia's GDP, and fuel provided 52% of the country's total merchandise exports.[42] In 2018, the share of oil and gas revenues in the federal budget was 46%, and 29% in 2019.[43] The pandemic has had a dramatically negative impact on the Russian energy sector. In April-May of 2020, Russian oil and gas revenues decreased by 43% compared to the same period in 2019; in the period from January to May, the decline was 30.1%.[44] It is obvious that the issues of energy sector development are essentially issues of the entire Russian economy's development, which require decisive action.

Agriculture and climate change in Russia

Georgy Vladimirovich Safonov, Ph.D. Econ. Director of the Center for Environmental Economics and Natural Resources at the Higher School of Economics

Climatic changes are already having a negative impact on agricultural production in Russia. Forecasts for 2050 and beyond provide extremely alarming results: Russia's climate will change much more rapidly than it has over the past 100–150 years. This will cause an increase in surface temperatures, a change in precipitation cycles, and an increase in the frequency of dangerous hydrometeorological phenomena—floods, droughts, heat "waves", cold waves, atypical frosts during the growing season, etc.

The first manifestations of climate change have already been felt by Russian agriculture: in 2010 and 2012, large-scale droughts led to a sharp decline in grain production in the country (by 33% and 25%, respectively), increases in grain crop prices, and an increase in the debt of agro-industrial enterprises.[45] Total damages from the drop in grain yield alone amounted to more than 300 billion rubles for these

---

[42] World Bank (2020b). DataBank. URL: https://data.worldbank.org/indicator/.

[43] Ministry of Finance of Russia (2020). Brief on the execution of the federal budget URL: https://minfin.gov.ru/ru/statistics/fedbud/ execute /? Id_65 = 80041-yezhegodnaya_informatsiya_ob_ispolnenii_federalnogo_byudzhetadannye_s_1_yanvarya_2006_g. #.

[44] World Bank (2020c). Russia: recession and growth under the shadow of pandemic. URL: https://openknowledge.worldbank.org/bitstream/handle/10986/34219/Russia-Recession-and-Growth-Under-the-Shadow-of-a-Pandemic.pdf?sequence=4&isAllowed=y.

[45] Results of the year: grain collapse // Agroinvestor. — 2012. — URL: https: // www.agroinvestor.ru/analytics/article/15155-itogi-goda-zernovoy-kollaps/

years.[46] The consequences fell mainly on the poor as most of the damage was compensated by rising bread prices.

Climate change knows no boundaries. During the droughts, almost all the leading regions of grain production in Russia suffered. But the damage was not only sustained by domestic agro-industrialists. In 2010, grain production declined in Europe, USA, Canada, Australia and other countries—the world's grain stocks decreased by 25% leading to a rise in prices on the world market.[47]

Are the country's agricultural enterprises ready for the challenges of climate change? Current technical, energy and financial resources are clearly insufficient for the sustainable development of agriculture in Russia in a changing climate. The expenses of enterprises in the industry are growing, and the financial situation of more than 30% of large and medium-sized agricultural enterprises is unstable, the technical base is shrinking, and the social situation in the countryside is deteriorating. In such conditions, these enterprises can hardly be expected to effectively resist the adverse effects of climate change on their own.

In the absence of adequate preemptive measures to adapt agriculture to climate change, the expected annual economic damage from climate-related crop decreases in Russia is estimated at USD3.5 billion by 2020 and more than USD3.9 billion by 2050.[48]

Adaptation measures vary significantly across the regions of the country. In the Altai Territory, wind and water soil erosion, drought, atypical frosts and snowfall during the growing season, and other climatic anomalies are evident. Agricultural producers in Altai are suffering massive losses from a decreased crop yields, and most importantly, the renewed possibility of "black" dust storms threatens to destroy the fertile layer in the steppe territories of the region, where the main grain-producing regions are located. The Voronezh Region is one of the few regions that managed to withstand the droughts of 2010 and 2012 due to competent policies and measures. But, if additional

---

[46] Economic analysis of the impact of climate change on agriculture in Russia: national and regional aspects/ Safonov, G.V., Safonova, Yu. A. // Oxford: Oxfam House, 2013. — URL: https://grow.oxfam.ru/attach_les/le_public_1028.pdf.

[47] The impact of natural hazards and disasters on agriculture, food security and nutrition // FAO. — 2015. — URL: http://www.fao.org/3/a-i5128e.pdf

[48] According to the All-Union Agricultural Research Institute, the decrease in the climate-dependent yield of grain crops in 2020 will amount to 11.9 million metric tons, and in 2050 — 17% or 13.4 million metric tons of grain. Estimates of economic damage are given at average grain prices in 2012.

adaptation measures are not taken, climate aridization and significant reductions in crop yields can be expected by 2020. The climate-related damage to the production of grain crops, in the Voronezh region, may amount to between USD46 million and USD114 million in 2020.[49]

Adaptation measures should be systemic and comprehensive: they must also be integrated with the agricultural development strategy and the national climate policy. It is necessary to account not only for the direct impact of weather and climatic factors on agricultural production (crop yield), but also for the risks associated with the impact of climate change on transportation infrastructure, energy facilities, processing facilities, society, etc.

It is estimated that the annual cost of adapting global agriculture to climate change is close to USD7 billion, at least 200 million of which must be invested into Europe and Central Asia, including Russia.[50]

The State Program for the Development of Agriculture and Regulation of Agricultural Products, Raw Materials, and Food Markets for 2013-2020 (approved by Russian Government Resolution No. 717 dated July 14, 2012) provides approximately USD15.3 billion for measures to reduce risks to agricultural producers, land reclamation, introduction of new crops, and the like. Adaptation measures could be carried out within the framework of this program, as well as measures to implement the Climate Doctrine and the National Plan for Adaptation to Climate Change, adopted in December 2019. Sectorial strategies, including those in the agriculture sector, should be developed by the 3rd quarter of 2021, and by the 4th quarter of 2022 the constituent entities of the Russian Federation should have regional adaptation strategies prepared.

---

[49] According to the General Information Report for 2010 on the Joint Research Program of the Interstate Council for Hydrometeorology of the CIS countries for the period 2006–2010.

[50] Climate Change. Impact on Agriculture and Costs of Adaptation // International Food Policy Research Institute. — 2009. — URL: http://ebrary.ifpri.org/utils/getle/collection/p15738coll2/id/130648/lename/130821.pdf.

2.2. Coal regions and prospects for the reduction of the coal market

Single-industry coal regions and the possibility of their equitable energy transition

Tatiana Alexandrovna Lanshina, Ph.D. Econ. General Director of the "Goal Number Seven" Association, Senior Researcher at RANEPA

The Russian coal industry has recently been experiencing a crisis. In Kuzbass, where 60% of Russian coal is mined, production decreased by 2% in 2019.[51] Although small, this is the first decline in 20 years; it was caused by low export prices and supply difficulties. The regional budget of the Kemerovo region for 2020 will be executed with a 16.5% deficit.[52] Earlier, in 2017 and 2018, Kuzbass experienced a budget surplus, and in 2019 it had slight deficit (0.6% of expenditures).[53]

However, the largest problems for the Russian coal industry are still ahead. In recent years, exports have been the primary growth driver, and now more than half of Russian coal goes abroad. The main consumer so far has been Europe (Germany, Ukraine, Poland, the Netherlands), with the remainder going east. In December 2019, the EU made a formal decision to move towards carbon neutrality (zero net greenhouse gas emissions) by 2050, which means that fossil fuels will essentially be phased out. In the Netherlands, the last coal-fired power plant will close by the end of 2029—Germany's, no later than 2038. Poland plans to reduce the share of coal generation from 74% in 2019 to 11–28% by 2040.[54]

---

[51] Kuzbass Government Administration (2020). In 2019, Kuzbass coal miners produced 250.1 million metric metric tons of coal. URL: https://ako.ru/news/detail/v-2019-godu-ugolshchiki-kuzbassa-dobyli-250-1-millionov-tonn-kamennogo-uglya-.

[52] Interfax (2020a). Revenues and expenditures of the Kuzbass budget increased by 2%, the deficit remained within 17% of expenditures. URL: https: // www.interfax-russia.ru/siberia/main/dohody-i-rashody-byudzheta-kemerovskoy-oblasti- uvelicheny-na-2-de cit-ostalsya-v-predelah-17-rashodov.

[53] Interfax (2020b). Kemerovo region in 2019 fulfilled the budget with a deficit of 0.6% of expenditures. URL: https://www.interfax-russia.ru/siberia/main/kemerovskaya-oblast-v-2019g-ispolnila-byudzhet-s-deficitom-0-6-ot-rashodov.

[54] Financial Times (2020). Poland plans $ 40bn nuclear push to cut reliance on coal. URL: https://www.ft.com/content/1ed55036-24b0-4734-9901-76133cfd3c3b.

Russia intends to redirect European exports to Asia, but this requires increasing the capacities of the BAM and Transsib railroads. For many years already, the Russian Railways Company has been transporting export coal at a rate several times cheaper than that for metals, oil, and other goods. In 2019, coal provided 20.8% of revenue and 30% of load for Russian Railways.[55] Essentially, other industries and the state will be forced to subsidize coal exports and transportation. Thus, in the Program for the Development of the Coal Industry of Russia until 2035, 80 billion rubles were allocated for the development of railways from the National Welfare Fund; 46.6 billion rubles were allocated or the development of port infrastructure from the federal budget. Meanwhile, all Russian coal companies are private.

In 2019, the largest Asian consumers of Russian coal were China, Japan, and South Korea—they accounted for 13%, 11.8% and 9.8% of exports, respectively.[56] In 2019, China developed a plan to merge the five largest coal generation companies with the aim of reducing their capacities by a third.[57] In 2020, the share of coal generation in China decreased from 70% in January to 60% in July.[58] In September of 2020, China announced its intention to become carbon neutral by 2060. In the summer of 2020, South Korea began developing a Green New Deal as a crisis-prevention policy focused on the development of renewable energy sources and other green industries by 2030. In October 2020, President Moon Jae-in announced his intention to move towards carbon neutrality by 2050. South Korea has repeatedly been forced to shut down its coal-fired power plants due to severe air pollution.[59] In September 2020, South Korea announced plans to close

---

[55] Vedomosti (2020). Coal miners cannot fulfill the instructions of the government. URL: https://www.vedomosti.ru/business/articles/2020/03/03/824384- ugolschiki-vipolnit.

[56] PWC (2020). Breaking trends: what the future holds for Russian coal exports. URL: https://www.pwc.ru/ru/industries/mining-andmetals/na-slome-trendov-kakoe-budushchee-zhdet-rossijskij-ugolnyj-eksport.pdf.

[57] Reuters (2019). UPDATE 1-China to slash coal- red power capacity at big utilities by merging assets -document. URL: https://www.reuters.com/article/china-coal-debt/update-1-china-to-slash-coal-fired-power-capacity-at-big-utilities-by-merging-assetsdocument-idUSL4N28C1Y9.

[58] IEA (2020c). Covid-19 impact on electricity. URL: https://www.iea.org/reports/covid-19-impact-on-electricity.

[59] CNN (2019). South Korea is shutting down a quarter of its coal generators this winter to tackle air pollution. URL: https://edition.cnn.com/2019/11/29/asia/south-korea-coal-plants-pollution-intl-hnk/index.html.

10 coal-fired power plants by 2022 and another 20 by 2034.[60] Japan may soon make a formal decision on the transition to climate neutrality by 2050.[61]

Among all Asian countries, Russia can now only hope to increase its coal exports to India. However, in 2019, only 3.7% of Russian export coal was sent there, and India's needs for coal are currently being met by Australia and Indonesia, which occupy the first and second places in global coal export (Russia is in third place). Additionally, during the pandemic in India, as in China, there was a substitution of renewable energy sources for coal generation, and coal's share decreased from more than 75% in January to almost 60% in September 2020.[62]

Coal prospects in the Russian domestic market are also limited. Even the Program for the Development of the Coal Industry for the Period up to 2035 admits this: "In the context of the redistribution of the fuel balance in favor of cheaper and more environmentally friendly gas fuel, the consumption of coal products practically does not increase in the domestic market." Moreover, according to available estimates, by the end of this decade it will become more expensive to operate all coal-fired power plants in Russia than to build new power plants based on renewable energy sources with energy storage facilities.[63]

Coal has long been considered the cheapest source of energy. Recently, however, thanks to the development of technologies, the cost of solar and wind generation has been rapidly decreasing and has already dropped below that of coal. According to a study by the Rocky Mountain Institute, Sierra Club and Carbon Tracker, it is now economically more profitable to close 39% of the world's coal-fired power plants and build renewable power plants with energy storage instead.

---

[60] The Korea Herald (2020). Moon vows to shut down 30 more coal plants to bring cleaner air and battle climate change. URL: http://www.koreaherald.com/view.php? Ud = 20200908000676.

[61] Japan Times (2020). Suga to declare Japan will go carbon neutral by 2050 in policy speech. URL: https://www.japantimes.co.jp/news/2020/10/22/national/suga-carbon-neutral-2050 /.

[62] IEA (2020c). Covid -19 impact on electricity. URL: https://www.iea.org/reports/ covid-19-impact-on-electricity.

[63] Rocky Mountain Institute, Sierra Club, Carbon Tracker (2020). How to Retire Early. Making Accelerated Coal Phaseout Feasible and Just. URL: http://rmi.org/wp-content/uploads/2020/06/How-to-retire-early-June-2020.pdf.

The share of non-competitive coal-fired power plants will reach 60% in 2022 and 73% in 2025.[64]

Despite these trends, in June 2020, Russia approved the Coal Industry Development Program for the period up to 2035. In the document, the growth in demand for coal in foreign markets is forecasted to increase 7-15% up from 2018 levels by 2035. Exports to the east are expected to increase by 2-2.5 times; in the west, demand is expected to decrease by 37% if the conservative scenario is implemented, and increase by 18% in the optimistic scenario. In total, the strategy expects coal export volumes to grow by 22–86% compared to 2018 levels. Coal production is expected to increase from 439.3 million metric tons in 2018 to 485-668 million metric tons in 2035 (a 10-52% increase). The same planned production and export volumes are indicated in the Energy Strategy of Russia until 2035, approved in June.

Coal enterprises are often city forming and can be vital to local economies. So, in 2018, coal mining accounted for 38.2% of the gross regional product of the Kemerovo region.[65] But the role of coal in the entire Russian economy should not be overestimated. In 2018, coal rent accounted for 0.5% of Russian GDP, while oil rent accounted for 10%, and gas rent for 3.7%.[66]

In order to avoid the coming economic decline and the inevitable social explosion in the coal mining regions, primarily in the Kemerovo Region, developing a strategy for equitable energy transition is necessary. A fair energy transition is generally understood to mean a transformation that takes into account the social, environmental and economic aspects of the transition to a 100% renewable energy system. In this transition, the state provides support to the regions where coalmines are being closed and to the employees of these mines.

Coal regions are characterized by single industry or mono-specialization, in which a significant part of the population depends on the coal industry; the development of alternative industries is complicated by the unattractiveness of the territories (from an investment standpoint) due to the undesirable environmental situation. To

---

[64] Rocky Mountain Institute, Sierra Club, Carbon Tracker (2020). How to Retire Early. Making Accelerated Coal Phaseout Feasible and Just. URL: http://rmi.org/wp-content/uploads/2020/06/How-to-retire-early-June-2020.pdf.

[65] Administration of the Government of Kuzbass (2020). Explanatory note to the forecast of socio-economic development of the Kemerovo region for 2020 and for the planning period until 2024. URL: https://ako.ru/deyatelnost/strategicheskoe-planirovanie-kemerovskoy-oblasti-.php.

[66] World Bank (2020b). DataBank. URL: https://data.worldbank.org/indicator/.

improve the environment in these regions, it is necessary to implement the measures proposed in the "Ecodefense!" report of October 2020:[67]

- a complete ban on the transfer of agricultural land for coal mining;
- ensuring that coal companies comply with the sanitary protection zone standards;
- banning the sale of coal mines unless the buyer's ability to carry out reclamation has been assessed;
- carrying out a comprehensive and complete assessment of the environmental situation in the region;
- introducing coal company liabilities for damage caused;
- banning mining and handling of coal within settlement boundaries.

The adoption of these measures will help create conditions for the development of traditional activities, like agriculture, for the Kemerovo Region and other coal regions. Additionally, attention should be paid to small and medium-sized businesses in coal regions. In Kuzbass there are only 111 small and medium-sized enterprises (SMEs) per ten thousand people, while the average for Russia is 181. The development of SMEs will increase the economic activity of the population and create new jobs. In some parts of the Kemerovo region, developing a tourism industry is possible, and the general development of the service sector, which is currently underdeveloped, has potential. The existing production base can be reoriented toward consumer goods production. Renewable energy, including both generation and production of equipment, is also a potential avenue. Most pressing is the need to invest in the development of human capital and retraining of former employees of coal enterprises.

[67] Eco-protection! (2020). Downward race. URL: https: //ecdru.files. wordpress.com/2020/10/race-to-the-bottom1.pdf.

2.3. Climate change and migration processes

Climate migrations

Yulia Sergeevna Kuznetsova, Researcher of the Geography Department at the Moscow State University, Associate Professor of the Geography and Geo-information Technologies Department at the Higher School of Economics

Unfavorable environmental conditions and natural disasters have always been a common cause of internal and external migrations.[68] However, in the modern world, the problem of migrations associated with global climate change is becoming increasingly important.

Climatic reasons for migration can be divided into two groups: climatic processes (rising sea levels, salinization of lands, melting of glaciers and permafrost, increasing scarcity of water resources) and climatic phenomena (floods, hurricanes, breakthroughs of periglacial lakes, etc.). Climatic processes develop over a long period of time and completely change the environment, gradually making it inconvenient or unsuitable for habitation. Migration flows from such territories can be prolonged, but are, as far as we know, irreversible. Migrations associated with climatic phenomena—predominantly disasters—can be temporary. Of course, each specific event's relation to climate change requires special research, but it is already evident that the frequency, intensity, spatial coverage, duration of weather and climatic extremes are all changing, the risk of unpredictable catastrophic events is growing, and, simultaneously, the number of potential climate migrants increases.[69]

---

[68] Environmental Change and Migration in History. Global environment. A Journal of History and Natural and Social Sciences. N. 9 — 2012. Special Issue by The Rachel Carson Center. https://www.academia.edu/7702914/Environmental_ Change_and_Migration_in_History

[69] Changes in climate extremes and their impacts on the natural physical environment. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation/ Seneviratne, S.I., Nicholls, N., Easterling, D., Goodess, C.M., Kanae, S., Kossin, J., Luo, Y., Marengo, J., McInnes, K., Rahimi, M., Reichstein, M., Sorteberg, A., Vera, C., and Zhang, X. 2012// [Field, C.B., Barros, V., Stocker, T.F., Qin, D. Dokken, D.J., Ebi, K.L., Mastrandrea, M.D., Mach, K.J., Plattner, G.K., Allen, S.K., Tignor, M., and Midgley, P.M. (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 109-230.

According to the International Disaster Base (EM-DAT) 6457 catastrophic natural events occurred worldwide for the period from 1995–2014—all directly or indirectly related to weather and climate (more than 90% of all natural disasters)—of which, on average, 335 events took place annually in the period from 2005 to 2014, up 14% from1995–2004 levels and almost twice the 1985-1994 average. [70] According to the UN, the total damage from climatic disasters in 1995–2014 amounted to between $250–300 billion. [71]

17.2 million people moved due to natural disasters in 2018, according to the International Center for Monitoring Internal Displacement; in 2019 that number reached 24.9 million, of which only about 1 million people were forced to migrate due to earthquakes and volcanic eruptions, while the remaining 23.9 million relocated due to weather-related (floods, hurricanes, droughts, etc.). [72], [73] In the first half of 2020 alone, natural disasters displaced 9.8 million people and remained a leading factor in internal migration worldwide. [74]According to the World Bank, by 2050, climate change will lead to the forced migration of more than 143 million people in just three regions of the planet: Tropical Africa, South Asia and Latin America. [75] In global forecasts, the most commonly cited figure is 200 million people displaced due to

---

[70] EM-DAT. The International Disaster Database. https://www.emdat.be/

[71] The human cost of weather related disasters 1995-2015. The report of Center for Research on the Epidemiology of Disasters (CRED) and The United Nations Occupation for Disaster Risk Reduction (UNISDR). https://www.unisdr.org/les/46796_cop21weatherdisastersreport2015.pdf

[72] Global report on Internal Displacement 2019). Internal displacement monitoring center (iDMC). https://www.internal-displacement.org/global-report/grid2019/

[73] Global report on Internal Displacement 2020. Internal displacement monitoring center (iDMC). https://www.internal-displacement.org/global-report/grid2020/

[74] Environmental migration. Migration data portal (accessed: 27 Oct. 2020) https://migrationdataportal.org/themes/environmental_migration

[75] Groundswell: Preparing for Internal Climate Migration / Rigaud, K. K., de Sherbinin, A., Jones, B.; Bergmann, J., Clement, V., Ober, K,, Schewe, J., Adamo, S., McCusker, B., Heuser, S., Midgley, A. 2018. // World Bank, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/29461 License: CC BY 3.0 IGO.

climate by 2050.[76] But other estimates predict ranges from 25 million to 1 billion people displaced by 2050.[77]

The three types of territories most vulnerable to climate change are coasts and islands, arid regions, and mountainous territories.[78] Each type of terrain has its own set of processes and phenomena associated with global climate change that provoke population migration. Populated regions of permafrost, from which migration can increase due to intensifying permafrost soil melting, deserve particular attention as well.[79]

The key geographic trend in the dynamics of world migrations to date is the following: as the global climate changes, the intensity of migration from Asia, Africa, the Middle East, Central, and South America increases toward regions more favorable from an economic and climatic point of view: Europe, North America, and Russia.[80] In addition, the outflow from rural to urban areas will increase in all countries of the world, since agriculture is more vulnerable to climate change.[81]

Currently, for Russia, the two most relevant types of climatic migrations are internal migration flows from areas with an unfavorable climate and immigration from neighboring states that are most vulnerable to global warming.

---

[76] MRS No. 31 — Migration and Climate Change (2008). Report by International Organization for Migration, prepared by Oli Brown. https://publications.iom.int/books/mrs-ndeg31-migration-and-climate-change

[77] MRS No. 31 — Migration and Climate Change (2008) Report by International Organization for Migration, prepared by Oli Brown. https://publications.iom.int/books/mrs-ndeg31-migration-and-climate-change

[78] Migration and Global Environmental Change (2011). Final Project Report. The Government Office for Science, London

[79] IPCC, 2019. Special Report on the Oceans and Cryosphere in a Changing Climate. https://www.ipcc.ch/srocc/

[80] The impact of environmental and climatic migration on global demographic processes/ Lukyanets, A.S., Moiseeva, E.M. //Article in the collection: "National demographic priorities: new approaches, trends" Ser. "Demography. Sociology. Economy." Edited by Ryazantsev S.V., Rostovskaya T.K .. Moscow, 2019. https://www.elibrary.ru/item.asp?id=38496185

[81] Migration and Global Environmental Change (2011). Final Project Report. The Government Office for Science, London. https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/,les/unpd-cm10201202-11-1116-migration-and-global-environmental-change.pdf

Climactically driven internal migration flows in Russia are still relatively small. In 2018, migration due to natural and climatic reasons accounted for 0.3% of the total number of all migrants (a total of about 11,500 people over the age of 14, with more than 48% being young people).[82] Population outflows predominantly come from Siberia, the Far East, and the Arctic North; inflow occurs mainly into the Central region of Russia, the Krasnodar Territory, and the Republic of Crimea. Natural and climatic conditions are traditionally one of the key factors of Russian Arctic migration, and in the context of global climate change, the northern regions are becoming one of the most vulnerable territories of Russia as the availability of water, food, medical assistance, and traditional economic opportunities are threatened.[83],[84] According to a survey on migration processes in the Arctic zone by the Center for Social and Political Research (an autonomous, non-profit organization), 22.6% of respondents identified problems of climate and ecology as a primary reason for the outflow of residents from the Russian Arctic zone.[85],[86]

Immigration flows into the Russian Federation are mainly associated with populations from Central Asia. In terms of climate change vulnerability calculated by the World Bank, Tajikistan ranks first among all countries of Eastern Europe and Central Asia, with Kyrgyzstan in

---

[82] The contribution of Russian youth to migration caused by environmental and climatic reasons/ Lukyanets A.S. //Article in collection: "State youth policy: national projects 2019-2024. in youth social development", Materials from the All-Russian Scientific and Practical Conference, 2020. https://www.elibrary.ru/item. asp? id = 42791565

[83] The paradox of population migration in the Russian Arctic: factors and barriers/ Shelomentsev A.G., Voronina, L.V., Tskhanova, A.V., Smirennikova, E.V. // Electronic scientific journal "Management of Economic Systems". Demography (117) UEKS, 11/2018. http://uecs.ru/uecs-117-112018/item/5218-2018-11-26-10-43-30

[84] Demographic processes, dynamics of labor resources and health risks of the population of the European Arctic zone of Russia/ Revich, B.A., Kharkov, T.L., Kvasha, E.A., Bogoyavlensky, D.D., Korovkin, A.G., Korolev, I.B. // Moscow, Lenand publishing house. 2016.304 p. https://www.elibrary.ru/item.asp?id=24196798

[85] Autonomous non-profit organization Center for Public Policy Research. http://anocopi.ru/

[86] Results of a sociological survey by ANO TsOPI "Migration processes in the Arctic zone of the Russian Federation in the XXI century: regional and external mobility", 2018. http://anocopi.ru/media/filer_public/6a/61/6a61b23e-14cd-40f6-b357-cd54c28e5bac/itogi_sotsoprosa_arktika.pdf

third place, Uzbekistan in sixth, and Turkmenistan in seventh.[87] Statistically, floods, droughts and extreme temperatures cause the most severe damage to these populations.[88] Intensive glacier melting in the mountains of Central Asia threatens the availability of clean freshwater in the coming years.[89] All of this leads to increasing migration flows, so far mainly from water-dependent agricultural regions.[90] The inevitable further deterioration of environmental conditions will lead to increases in migration flows from Central Asian countries, with the Russian Federation as a primary destination.[91]

Climatic factors of migration usually act as part of a multifaceted complex with socio-economic conditions, thus quantitative migration forecasts for individual regions—including for Russia—range widely. A number of researchers indicate that climatic factors are underestimated as migratory causes, especially in the context of long-term environmental changes.[92]

Determining the point at which climate change begins to pose an immediate threat to life remains a distinct and still unsolved problem. This leads to legal discussions on the need to introduce a special legal

---

[87] World Bank. 2012. Adapting to Climate Change in Europe and Central Asia: Lessons from Recent Experiences and Suggested Future Directions. Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/16090 License: CC BY 3.0 IGO.

[88] Economic and social consequences in the countries of Central Asia/ Lukyanets, A., Ryazantsev, S., Moiseeva, E., Manshin, R. // Central Asia and the Caucasus, Russian Edition. Volume 23, Issue 2, 2020.http://xn-h1aauh.xn-p1ai/wp-content/uploads/2020/06/cacR.2.20_13-pp.160-176.pdf

[89] Glaciers are retreating. Millions rely on their water/ Fountain, H. and Solomon, B. C. //NY Times interactive publ., 2016. https://www.nytimes.com/interactive/2019/04/17/climate/melting-glaciers-globally.html

[90] Mountains under pressure: Climate, hunger and migration. FAO review, 2017. http://www.fao.org/3/i8159en/I8159EN.pdf

[91] Economic and social consequences in the countries of Central Asia/ Lukyanets A., Ryazantsev S., Moiseeva E., Manshin, R. // Central Asia and the Caucasus, Russian Edition. Volume 23, Issue 2, 2020.http://xn-h1aauh.xn-plai/wp-content/uploads/2020/06/cacR.2.20_13-pp.160-176.pdf

[92] The impact of environmental and climatic migration on global demographic processes/ Lukyanets, A.S., Moiseeva, E.M. //Article in the collection: "National demographic priorities: new approaches, trends" Ser. "Demography. Sociology. Economy." Edited by Ryazantsev, S.V., Rostovskaya, T.K. Moscow, 2019. https://www.elibrary.ru/item.asp?id=38496185

status for “climate refugees” as well as disputes that arise at the intersection of the concepts of “climate migrant” and “climate refugee”.

Refugee status has been enshrined in the UN Geneva Convention Since 1951, according to which a refugee is or fears becoming a victim of persecution and cannot depend on the protection of their home country.[93] The Global Compact on Refugees approved by the UN General Assembly in 2018, states that, “climate, environmental degradation and natural disasters increasingly interact with the drivers of refugee movements.”[94] In 2009, the term “climate refugee” was included and then removed from the UN documentation due to objections from one of the parties.[95]The International Organization for Migration usually uses the expression “environmental migrant”, a term which is not endowed with a generally recognized legal status.[96]

Migrant rights are included in the preamble to the Paris Agreement within the UN Framework Convention on Climate Change, which Russia signed in 2016 and ratified in 2019.[97] Since 2015, an operational group on climactic migratory movements (Task Force on Displacement) has been working under the terms of this convention.[98] In 2018, the Warsaw International Mechanism for Loss and Damage associated with Climate Change, serving as the conference of the Parties to the Paris Agreement, published the Task Force’s “Guidelines for integrated approaches to prevent, minimize and address loss and

---

[93] Convention relating to the Status of Refugees, adopted on July 28, 1951 in accordance with UN General Assembly Resolution 429 (V) of December 14, 1950 https://www.un.org/ru/documents/decl_conv/conventions/refugees.shtml

[94] The Global Compact on Refugees, The UN Refugee Agency, affirmed on 17 Dec. 2018 by the UN General Assembly. https://www.unhcr.org/the-global-compact-on-refugees.html

[95] Recommendations for integrated approaches to avert, mini,ize and address displacement related to the adverse impacts of climate change. Platform on Disaster Displacement (PDD). The Warsaw International mechanism for loss and damage associated with climate change impacts. Task Force on Displacement. Activity II.3. Final report, 2018. https://unfccc.int/sites/default/les/resource/WIM%20TFD%20II.3%20Output.pdf

[96] Migration, Environment and Climate Change Evidence for Policy (MECLEP). Glossary. Implemented by IOM, 2014. https://publications.iom.int/system/les/pdf/meclep_glossary_en.pdf?language=en

[97] The Paris Agreement. United Nations Climate Change. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

[98] Task Force on Displacement. Summary of the process. United Nations Climate Change. https://unfccc.int/wim-excom/sub-groups/TFD#eq-2

damage associated with the adverse impacts of climate change."[99] In the text of the final report, the rights of internal and external migrants are mentioned alongside the rights of refugees. In 2019, the results of a briefing by the European Parliament were published in the form of the Climate Refugee Concept, which formulated possible approaches to solving the legal problems of climate migrants and climate refugees.[100]

It is worth noting that climatic factors, overlapping with region-specific socio-economic and political situations can, in some cases, provoke a struggle for resources, act as a trigger for armed conflicts, and play a significant role in creating of flows of "real" refugees. According to the former UN Secretary General, the environmental crisis, resulting in part from climate change, is at the heart of the military conflict in Darfur, Sudan.[101] Global warming is also seen as one of the key causes of the war in Syria. The international expert community recognizes that the future risk of such conflicts will only grow with the intensification of climate change,

Despite the fact that there is still no unambiguous legal regulation for the problem of climate migrants and climate refugees, the world community does recognize the issue of climate-driven migration. The problem is extremely topical and certainly deserves attention and further study in the Russian Federation at the scientific, political, and administrative levels.

---

[99] Recommendations for integrated approaches to avert, mini,ize and address displacement related to the adverse impacts of climate change. Platform on Disaster Displacement (PDD). The Warsaw International mechanism for loss and damage associated with climate change impacts. Task Force on Displacement. Activity II.3. Final report, 2018. https://unfccc.int/sites/default/les/resource/WIM%20TFD%20II.3%20Output.pdf

[100] The concept of climate refugee: towards a possible de nition. European parliament Briefing, May 2018. https://www.europarl.europa.eu/RegData/etudes/BRIE/2018/621893/EPRS_BRI(2018)621893_EN.pdf

[101] Ban Ki-moon. A climate culprit in Darfur. United Nations Secretary-General via the Washington Post (US). 16 June 2007. https://www.un.org/sg/en/content/sg/articles/2007-06-16/climate-culprit-darfur

3. Managing economic and political risks through technological transformation: successful examples of such transformation

3.1. Renewable energy development and energy efficiency as economic and political risk management methods

Development of renewable energy sources in the Russian Federation: the current situation and recommendations

Tatiana Alexandrovna Lanshina, Ph.D. Econ. General Director of the "Goal Number Seven" Association, Senior Researcher at RANEPA

Since 2013, in Russia, renewable energy sources (RES) having a capacity of more than 25 MW—with the exception of hydroelectric power plants (HPPs)—are incentivized in the wholesale electricity, capacity, and retail electricity markets through state regulation of the electric power sector.[102] Also, in the near future, support is expected for micro-generation from grid-connected renewable energy sources.

Until now, RES power plants in Russia were mainly built on the wholesale electricity and capacity markets. The Orenburg, Astrakhan, Rostov and Ulyanovsk regions became leaders in terms of commissioning volume. From 2014 to the first quarter of 2020, RES power plants with a total capacity of 1.5 GW— this is equivalent to 0.7% of installed capacity and 0.2% of generation—were built for the wholesale market.[103]

By 2025, 5.8 GW of renewable energy power plants or less than 2.5% of total installed capacity will be built in this sector, which

[102] Large hydropower plants are currently not considered the preferred RES, since their construction is associated with significant negative consequences for the environment. For this reason, these large-scale hydroelectric power plants will not be taken into account subsequently in this report.

[103] Association for Development of Renewable Energy Sources (ADRES) (2020). Renewable energy market in Russia: current status and development prospects. URL: https://rreda.ru/information-bulletin-2020.

will provide less than 1.2% of generation.[104] In 2020, the process of confirming the extension of support for renewable energy sources in the wholesale electricity and capacity market until 2035 will be completed. With the most favorable development of events, by 2035 the share of renewable energy facilities in the wholesale market will be about 5% of the total installed capacity and 2–2.5% of generation.

Until recently, investors in retail markets did not have enough guarantees of return on investment, which is why the volume of commissioned renewable energy projects in this segment is only about 300 MW. In August 2020, by Russian Government Resolution No. 1298, the mechanism for supporting renewable energy sources in retail markets was improved: in particular, grid companies were required to conclude energy purchase agreements with winners immediately after bidding results were announced, and not after the construction of the power plant; additionally, a decision was made to set the price for renewable energy based on the price in the investor's application and not according to regulated rates. Nevertheless, renewable energy source development in retail markets is limited: electricity generation by renewable-energy-generating facilities in retail markets cannot exceed 5% of network losses (power lost during distribution). Thus, the capacity potential of renewable energy sources in retail electricity markets is 3 GW or slightly more than 1% of the total capacity of all power plants.

In addition to the construction of RES-based power plants, an energy-machine manufacturing cluster, which performs technology transfer and produces equipment for renewable energy sources, is developing in Russia. This cluster was created due to mandatory targets regarding the degree of localized production for RES equipment—if they are not met, the RES power plant does not receive full payment. Currently, Russia has established the production of mono- and multicrystalline silicon ingots and plates, photovoltaic modules, blades, nacelles, and wind power plant towers.

Currently, there is no policy to incentivize RES development in the Russian heating and cooling sectors, nor in the transport sector; there are also no reliable statistics in this area. However, according to industry participants, the demand for some new renewable energy technologies—in particular heat pumps and pellet boilers—have recently been growing, primarily among small- and medium-sized

[104] Greenpeace (2020). Russia's Green Deal. URL: https://greenpeace.ru/wp-content/uploads/2020/09/GC_A4_006.pdf.

enterprise (SMEs), and particularly during the pandemic, due to the economic efficiency of these technologies.[105]

Thus, over the past 7 years, a modern renewable energy industry has been created in Russia. Dozens of solar and wind power plants were built, and the production of equipment for renewable energy sources was established. However, in accordance with the currently available RES support mechanisms and energy development plans, by 2035, the share of RES will comprise up to 6% of the installed capacity in Russia and up to 3% of generation. These values are insignificantly small when compared with those of other leading world economies. In the first half of 2020, solar and wind power alone made up 21% of total power generated in the EU. In some EU countries, much more electricity was produced by solar and wind: for example, in Germany, this figure has reached 42%. In the United States, solar and wind generated 12% of electricity from January-June 2020. In China, India, and Japan, that figure is 10%. Russia is the only large economy in the world in which solar and wind energy is practically undeveloped: in the first half of 2020, only 0.2% of all electricity was produced from these sources in Russia.[106] In 2019, renewable energy sources—excluding hydroelectric power plants with a capacity of more than 25 MW—produced 0.28% of all electricity in Russia.[107]

The development of renewable energy technologies in Russia is limited by a conservative and extremely ponderous state energy policy as well as by the low cost of traditional energy resources, ensured, among other things, through state subsidies. In 2017, according to estimates by the International Renewable Energy Agency (IRENA), Russia ranked fourth in the world in subsidizing fossil fuels after Iran, Saudi Arabia, and China.[108] The amount of Russian energy subsidies—totaling almost USD30 billion per year—was distributed fairly evenly among the oil, gas, and electricity sectors. RES subsidies in Russia are so minute that there are no data about it.

---

[105] Greenpeace (2020). Russia's Green Deal. URL: https://greenpeace.ru/wp-content/uploads/2020/09/GC_A4_006.pdf

[106] Wind And Solar Now Generate One-Tenth Of Global Electricity // Ember, 2020. — URL: https://ember-climate.org/project/global-electricity-h12020/.

[107] Technological development of economic sectors // Rosstat, 2020. — URL: https://rosstat.gov.ru/folder/11189.

[108] Energy subsidies. Evolution in the Global Energy Transformation to 2050 // IRENA, 2020. — URL: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Apr/IRENA_Energy_subsidies_2020.pdf.

The world is rapidly moving towards low-carbon energy. This is largely due to the economic factor: renewable energy sources (RES) are already the cheapest. According to Lazard, the investment bank, the cost of 1 kWh of electricity from new wind farms in 2020 started at 2.6 cents (2 rubles), and 2.9 cents (2 rubles) from solar power plants. For new gas and coal power plants, the values of this indicator started at 4.4 cents (3.4 rubles) and 6.5 cents (5 rubles), respectively.[109] This is the reason solar and wind energy have recently become the most dynamically developing industries both in the renewable energy sector and the energy sector in general.

Given the speed and global nature of the transition to renewable energy sources and the fact that renewable energy sources are already the most cost effective, Russia needs to make renewable energy one of the priorities of its economic development, especially considering Russia's extremely limited experience in this area. This will create new companies and jobs while producing goods of high added value, develop international cooperation in new areas, form export potential, and maintain or even strengthen Russia's position among the world's largest economies.

Energy efficiency policies in the Russian Federation

Maxim Alekseevich Titov, Director of the Energy Policy Research Center of the European University at St. Petersburg

Russia planned to approach 2020 with significant progress in the field of reducing energy intensity. Reducing energy intensity makes our products more competitive in world markets and represents a more rational use of fossil energy sources. This important task was set before the Russian government by the Executive Order of the President of the Russian Federation No. 889 from June 4, 2008: to reduce the energy intensity of GDP by at least 40% from 2007 levels. The assessment of Russia's potential was based, in particular, on the conclusions and recommendations of the World Bank report "Energy efficiency in Russia: a hidden reserve".[110] In this report, the amount of inefficient energy use in Russia was compared with the annual consumption of primary energy in France.

---

[109] Levelized Cost of Energy and Levelized Cost of Storage — 2020 // Lazard, 2020. — URL: https://www.lazard.com/perspective/levelized-cost-of-energy-and-levelized-cost-of-storage-2020/.

[110] Energy efficiency in Russia: a hidden reserve // International finance corporation, The World bank. — Moscow, 2008 . — 162 p.

Nevertheless, the stated 40% goal was not achieved: by 2020, the energy intensity of Russia's GDP decreased by only 12% compared to 2007 levels.[111] Moreover, if that average rate of improvement continues, we will only be able to reach the goal of 40% by 2043. At the end of 2018, the energy intensity of the Russian Federation's GDP, according to the state report, exceeded the world level by 46%, the US level by 44% and the Canadian level by 17%.

The goal of improving energy efficiency in the foreseeable future must be prioritized. According to the same state report, between 2015 and 2018, just 4 sectors of the economy consumed the 83% of fuel and energy resources: electric power and heating power (28%), industrial manufacturing (22%), buildings and utilities (17%) and transportation (16%).

There is one sector on this list for which improving energy efficiency require joint efforts at the federal and regional levels: tightening government regulations in combination with special "green" financial instruments.

The "buildings and utilities" sector, which consumes 17% of energy and ranks third in the list of the largest energy consumers, requires special attention. More than half of the existing apartment buildings in Russia are energy-inefficient and consume twice the energy of their modern counterparts. From a technical point of view, if we apply the existing building codes and regulations for thermal protection of buildings, the potential for energy efficiency improvements in Russian buildings is 22% of the country's total potential. If we apply the best available technologies (BAT) of so-called passive houses, the potential is even higher.[112] Indeed, some houses that are currently being commissioned have high energy-efficiency classes (A and B), but mass development requires our attention first and foremost. The maintenance and repair of apartment buildings is the least reformed area since the beginning of economic reforms in Russia, and the housing and utilities sector is capable of absorbing massive funding without produc-

---

[111] The state report "On the state of energy saving and increasing energy efficiency in the Russian Federation", prepared in accordance with the Russian Governmental Resolution No. 1412 of December 18, 2014 "On the preparation and distribution of the annual state report regarding the state of energy saving and increasing energy efficiency in the Russian Federation" is the fifth edition of the annual official document. Prepared by the Ministry of Economic Development of the Russian Federation and published on December 26, 2019.

[112] Igor Bashmakov Improving the Energy Efficiency of Russia's Buildings // Problems of Economic Transition, 2016. — Vol. 58: 11-12, pp. 1096–1128.

ing any visible or measurable results. At the same time, implementing measures to increase energy efficiency in practice should require an increase in overall management efficiency in the housing and utilities sector. Ultimately, this will have a lot of additional positive effects for the economy, from improving quality of life to reducing energy costs, creating new jobs, and introducing new energy-efficient technologies like thermal insulating materials, intelligent lighting control systems, individual heating zones with weather regulation, and modern devices that account for energy consumption.

There are technical measures, which, in particular, include the installation of metering devices. According to the same state report, all apartment buildings should have been equipped with collective metering devices by July 1, 2012 to account for consumed resources. After 7 years, only 61% of buildings were equipped with such devices. The implementation level of modern technologies in the field of energy savings is insufficient: only 27% of the apartment buildings built in 2018 have increased energy efficiency classes (A++, A+, A, B, C); only 5% of operating apartment buildings are equipped with individual heating zones with weather regulation.

There are organization measures that can be taken: reorganizing municipal resource suppliers and operational organizations into commercial enterprises in order to develop competition. In general, improving energy efficiency in the housing and utilities sector is a national task that can only be solved systematically by creating a single federal program. This program should include a number of incentive tools, in particular:

- systematic increase in requirements for new buildings;
- an increase in the share of major repairs to buildings with the aim of increasing energy-efficiency class;
- co-financing of energy-efficiency projects in residential and public buildings.

Efforts of Russian businesses to reduce greenhouse gas emissions

Maxim Alekseevich Titov, Director of the Energy Policy Research Center of the European University at St. Petersburg

The issue of greenhouse gases has finally become a matter of good corporate governance—for Russian companies, as well. In 2019–2020, an important turning point took place in global financial markets: inves-

tors and board members of large companies realized climate risks could no longer be ignored and had to be taken into account in strategic decision making. In 2017, on behalf of the G20, the Task Force on Climate-related Financial Disclosures (TCFD) developed critical corporate guidelines for uniform voluntary disclosures. More than 1,500 private and public companies and organizations have already joined this initiative. Thus, the quality of initial information received has begun to improve rapidly. British regulators are preparing their country's largest companies and banks for the fact that within five years, these recommended disclosures will become mandatory.

In October 2019, one of the founders of the TCFD initiative, Mark Carney, in his role as Governor of the Bank of England, urged the corporate sector to move to full disclosure of climate risks. In January 2020, he was appointed Special Envoy for Climate and Finance to the UN, replacing Michael Bloomberg. Carney's task is to mobilize private investment for climate projects and the transition to a carbon-neutral economy. By the upcoming (26th) UN Climate Change Conference (COP26), to be held in Glasgow in late 2021, a framework for financial reporting and risk management is expected to be developed. The goal of this initiative is to ensure that climate change issues are taken into account when making significant investment and financial decisions.

Meeting investor requirements for climate change-related financial disclosure will ultimately lead to increased confidence from a broader pool of investors and lenders. Along with the investment community, lending institutions are beginning to look more broadly at the system for assessing the solvency of clients and the process of creating loan products, embedding ESG (Environment, Social, Governance) indicators in general and climate indicators in particular into project evaluation systems. In recent years, a banking trend has been the creation of so-called Sustainability Improvement Loans (SIL), which are tied to key performance indicators of sustainable development.[113] The product works as follows: a credit line between the bank and the borrower includes a provision according to which the loan's interest rate on the loan can fluctuate depending on the change in the sustainability development indicators of the borrower company.

Both the company's own key performance indicators (KPI) and ratings provided by independent agencies can be specified as bench-

[113] Ralite Sustainability Improvement Loans: a risk- based approach to changing capital requirements in favour of sustainability outcomes/ J. Thomä, B., Caldecott, S., //URL: https://www.smithschool.ox.ac.uk/research/sustainable-finance/publications/Thomae-et-al-2019-Sustainability-Improvement-Loans.pdf

marks. In most cases, the interest rate is tied to the ratings or indices of independent agencies or verifiers—for example, Sustainalytics—that conduct comprehensive assessments of the company's activities in the field of sustainable development.[114]

On the Russian market, this product is represented by credit agreements linked to sustainable development indicators. As an example, Polymetal, the mining company, signed a loan agreement with ING Bank with an interest rate tied to a Sustainalytics rating. In 2019, the company also signed a loan agreement with the Bank Société Générale based on five sustainable development targets, one of which was the implementation of a climate management system.[115] In November 2020, the company announced a $125 million "Green loan" from Société Générale to finance projects for the transition to a sustainable and low-carbon economy.[116]

In another instance, a bank linked the interest rate on a loan to Metalloinvest, the mining and metallurgical holding company, to the EcoVadis rating agency. There is also an example of ING, together with Natixis, acting as organizers and underwriters for a syndicated pre-export financing (PXF) deal with the Russian aluminum company Rusal for five years in the amount of $750 million, also tied to indicators of sustainable development.[117]

These examples illustrate that there are already companies in Russia implementing and supporting TCFD recommendations—and gaining certain competitive advantages from this. At the same time, the issue of reporting with standardized indicators concerns not just energy and natural resource extraction firms but all industries without exception. The transition to a low-carbon economy will require a massive redirection of capital flows and infrastructure investment in

---

[114] Methodological recommendations for climate change-related financial disclosures / Titov, M.A., Teplova, O.A., Ryazantseva, D. S. // IC ENERPO, St. Petersburg, 2020. — 20 p.

[115] Polymetal Investor Presentation November 2019 https://www.polymetalinternational.com/upload/iblock/0da/2019_11_Polymetal_Investor_Presentation.pdf

[116] First green loan under the new Green Finance Policy, Polymetal, press release, November 2, 2020. https://www.polymetalinternational.com/ru/investors-and-media/news/press-releases/02-11-2020/

[117] RUSAL raises $750 million for pre-export financing, FINAM, 23.09.2019. https://www.nam.ru/analysis/newsitem/rusal-privlek- predeksportnoenansirovanie-na-750-mln-20190923-170622/

the very near future, and no companies or industries will be immune to the changing tide of current events.

3.2. Adapting to the negative consequences of climate change as a stabilizing factor in a new climatic reality

Russian regional efforts to monitor and reduce greenhouse gas emissions

Olga Nikolaevna Senova, Co-chairman of the Russian Socio-Ecological Union, director of the Friends of the Baltic Association

National governments have traditionally been the main actors on climate policy, but subnational actors, like regions and municipalities, are beginning to play an increasing major role in combating climate change.

Such an opportunity for regions and municipalities is enshrined in Article 42 of the Russian Federation Climate Doctrine, which states that, "When developing regional and municipal programs for sustainable development, the following tasks related to climate change must be addressed:

- Legislation developed and applied by the constituent entities of the Russian Federation, should take into account the influence of climatic factors on development of territories, sectors of the economy, and society;
- Measures to adapt to climate change should be developed and implemented, taking into account climate change factors when formulating medium- and long-term plans for the socio-economic development of regions and municipalities, as well as for relevant economic sectors;
- Regional systems for effective response to hazardous weather and climatic events should be developed and implemented;
- Legislative action should be taken to regulate the inventory of greenhouse gas emissions (GHGs);
- Measures to mitigate anthropogenic climate impact should be implemented, including the introduction of technologies to reduce greenhouse gas emissions into the atmosphere, as well as technologies for the absorption of greenhouse gases."

On April 22, 2015, Russian Government Resolution No. 716-r was passed, which **mandates that greenhouse gas emissions be tracked regionally**, although experts from many regions say that the regulatory framework for this is still insufficient.

According to the Ministry of Natural Resources, 11 constituent entities of the Russian Federation voluntarily carried out an inventory of greenhouse gasses in 2017: the Republic of Bashkortostan, the Voronezh Region, the Yamalo-Nenets Autonomous District, the Leningrad Region, Moscow, the Altai Republic, the Sakhalin Region, the Khabarovsk Territory, the Kirov Region, the Novgorod region, and the Karachay-Cherkess Republic.[118]

The Ministry of Natural Resources (MNR) of the Russian Federation letter No. 05-13-53 / 11849 "On the collection of information on greenhouse gas emissions volume" dated May 24, 2019 ordered all organizations carrying out economic activities to submit reports to the Ministry of Natural Resources. This was associated with the implementation of clause 5 of Russian Government Resolution No. 504-r dated 02.04.2014 "On the approval of the action plan to ensure the reduction of the volume of greenhouse gas emissions to a level of no more than 75 percent of 1990 emissions levels by 2020." Unfortunately, no information about these reports is available on the MNR website.[119]

In recent years, a number of climate policy initiatives have been implemented in Moscow. In 2017, recommendations for the adaptation to and mitigation of climate impacts were published using the example of Moscow's approaches.[120] Moscow's implementation of measures aimed at energy sources, distribution networks, and consumers has led to significant effects for fuel economy and emissions reductions, with

---

[118] Inventory of greenhouse gases carried out by 11 constituent entities of the Russian Federation // Ministry of Natural Resources of Russia. — 2017. — URL: http://www.mnr.gov.ru/press/news/inventarizatsiyu_parnikovykh_gazov_proveli_11_subektov_rossiyskoy_federatsii/?Sphrase_id=64343.

[119] Reports on the volume of greenhouse gas emissions [no reports] // Rosprirodnadzor. — 2020. — URL: https://rpn.gov.ru/regions/23/intro/newsto/otchety-ob-obeme-vybrosov-parnikovyh-gazov.

[120] How to develop a city climate plan. Moscow's experience. Basic Recommendations for Adaptation and Impact Mitigation // Climate Forum of Russian Cities. — 2017. — URL: http://ecoline.ru/wp-content/uploads/how-to-develop-a-climate-plan-for-the-city.pdf.

increases in energy sector reliability and sustainability.[121] Moscow is a member of the C40 Cities Climate Leadership Group, and, since 2017, Moscow has annually hosted the Cities Climate Forum, a platform for the exchange of best practices on climate action. In 2011, Moscow joined the Carbon Disclosure Project to release data on greenhouse gas emissions. By 2018, the city has reduced emissions by more than 20% from 1990 levels, and by 2020, Moscow plans to ensure a reduction in greenhouse gas emissions to no more than 75% from 1990 levels.[122]

In the Sakhalin Oblast, a pilot project launch is planned to test the practical mechanisms of carbon regulation in order to then submit recommendations for federal implementation. A draft federal law "On conducting an experiment in the Sakhalin region to regulate greenhouse gas emissions and the registration of carbon units" was prepared, which provides for the necessary institutional infrastructure to be created for managing emissions quotas, implementing climate projects, managing a registry of participants and a system for registering carbon units; all procedures for verification of project activities and registering the release and circulation of carbon units are to be regulated by international standards.

On November 20, 2020, the strategic project "Climate" was approved at the Sakhalin Oblast Governor's meeting of the Strategic Council, which "aimed at achieving carbon neutrality in the region, stimulating development and introducing technologies to reduce greenhouse gas emissions by creating a system for regulating greenhouse gas emissions and removals, as well as registering the circulation of carbon units.[123] The system for regulating emissions and registering the circulation of carbon units, created within the framework of the project, will be based on inventory data of anthropogenic emissions and removals of greenhouse gasses over the past several years. The system for registering the circulation of carbon units will take into account

---

[121] Energy and climate strategies of Moscow. The search for a reasonable symbiosis/ Gasho, E.G. // Energy saving. — 2018. — No 2. — URL: https://www.abok.ru/for_spec/articles.php?nid=6871.

[122] Greenhouse gas emissions and energy consumption in cities // Analytical Center for the Government of the Russian Federation. — 2019. — URL: https://ac.gov.ru/archive/les/publication/a/24256.pdf.

[123] An important strategic project has been approved in the Sakhalin Region // Regional Project Office — Department of Project Management of the Government of the Sakhalin Region, information dated 11/26/2020. — URL: https://project-oce.sakhalin.gov.ru/blog/V-Sahalinskoy-oblasti-utverzhden-vazhnyy-strategicheskiy-proekt /.

international requirements for the design of climate projects, verification of their results, maintenance of registries, etc. The project will also develop a climate program for the Sakhalin region and a climate action plan for the period up to 2025."

There are examples of creating integrated climate action plans in other regions:

- A model climate strategy for sustainable development for the Murmansk region (2009);
- An action plan to reduce greenhouse gas emissions in the Republic of Tyva (until 2018);
- An action plan to ensure a reduction in greenhouse gas emissions in the Republic of Crimea by 2020;
- An action plan for researching regional climate change and its possible impact on the socio-economic development of the Khanty-Mansiysk Autonomous Okrug;
- An action plan for the Yamalo-Nenets Autonomous Okrug to ensure the reduction of greenhouse gas emissions by 2020;
- Scenarios of economic regulation of greenhouse gas emissions and possible adoption of additional measures to limit emissions, which are being developed in St. Petersburg;
- Conversion of cars and agricultural vehicles to natural gas in many regions;
- A system of voluntary "Green Standard" certification of real estate objects with high requirements for energy efficiency of buildings in the Republic of Bashkortostan;
- A control system for emissions of pollutants into the atmosphere of the Yamalo-Nenets region, including greenhouse gases; an inventory of pollutants emitted into the atmosphere was created and the volume of greenhouse gas emissions in municipalities was calculated.

In 2015, the Socio-Ecological Union" (RSEU), an all-Russian public organization, "conducted a survey of regions regarding the implementation of the Climate Doctrine of the Russian Federation.[124] Responses from 65 out of 85 regions showed that, in most regions, the main measures to reduce greenhouse gas emissions were carried out within

[124] On the results of the review of measures in the constituent entities of the Russian Federation for the implementation of the Climate Doctrine of the Russian Federation // SoES. — 2015. — URL: http://www.rusecounion.ru/ru/obzor_otvetov_regionov.

the framework of regional energy saving and energy efficiency programs in accordance with Federal Law No. 261-FZ "On Saving Energy and Increasing Energy Efficiency" dated 23.11.2009 and the State Program of the Russian Federation for "Saving Energy and Increasing Energy Efficiency for the Period until 2020".

In their responses to the RSEU survey, Arkhangelsk Oblast, Sverdlovsk Oblast, the Republic of Tatarstan, the Republic of Tyva, the Udmurt Republic, the Khanty-Mansi Autonomous Okrug (Yugra), and the Yamal-Nenets Autonomous Okrug all affirmed their intentions of carrying out GHG inventories. The Ministry of Natural Resources made methodological recommendations on how to conduct voluntary inventories of greenhouse gas emissions to large enterprises in the Saratov region and the Republic of Sakha (Yakutia).

During the active phase of the State Program on Saving Energy and Energy Efficiency (2010–2015), an energy audit was conducted in the vast majority of schools in the country and in other budgetary institutions. This was an important step: along with the audit materials that showed energy losses, the energy audit companies developed a plan to improve the energy efficiency of the institutions. However, this plan was not obligatory, and its implementation depended on two factors: the administration's understanding of the essential measures and access to financing, which was rather limited. In addition, according to experts, sometimes the specialists who conducted the energy audit did not have sufficient qualifications, and the results of the audit as well as recommendations for improving energy efficiency were incomplete.[125]

Nevertheless, in many regions there are successful examples of implementing measures that increase energy efficiency: switching to energy-efficient lighting in buildings and on public streets, improving the thermal insulation of buildings, and modernizing heating systems to energy efficient models, among others.

Despite the fact that, according to the responses of some regions, plans for 75% reductions in greenhouse gas emissions by 2020, "are not within the competence of the executive authorities of the constituent entities of the Russian Federation,"—and, formally, this is so—still, in a number of regions such measures are being implemented.

---

[125] Savings at Random: not all residential buildings in the North-West passed an energy audit/ Mikhailov, A. // Rossiyskaya Gazeta — Economy of the North-West. — 2017 . — No. 263 (7429). — URL: https://rg.ru/2017/11/21/reg-szfo/v-zapoliare- zhilye-doma-provalili-energoaudit.html.

State-sponsored renewable energy support program facilitate the regional introduction of renewable energy. As a result of Governmental Resolution No.1081-r of April 18, 2020, renewable energy sources with a total capacity of 5.2 GW were built or selected for implementation in Stavropol Territory, Rostov, Astrakhan, Volgograd, Saratov, Murmansk Samara, Omsk Regions, Republic of Kalmykia, the Republic of Bashkortostan, the Altai Territory, the Republic of Adygea, the Republic of Karelia, and the Trans-Baikal Territory. Renewable energy projects in the Orenburg region and Karachay-Cherkessia for a total 0.6 GW will still be provided for within the framework of the state-supported program.

There are also examples of private initiatives: for example, an energy-efficient house in Sochi that uses solar electricity and heating; an autonomous island in Tatarstan with no need for a gas generator due to solar panels, the "Warm Sea" recreation center in the Far East with heating and hot water provided by solar collectors, the Argos plant in the Leningrad region with heating and hot water supplied by heat pumps, etc.[126]

For regions to develop a full range of emission reduction measures—in the field of energy, transport, buildings—a regulatory framework is needed for setting and reporting reduction targets, providing methodological assistance in planning and implementing climate action, communicating successful examples, and offering economic incentives for implementing low-carbon solutions.

[126] According to the "Green Kilowatt" Association of Renewable Energy Specialists and AltEnergia, LLC

4. A New domestic climate policy

4.1. An ambitious climate policy and carbon regulation as an incentive for technological transformation

Review of the Russian Federation's domestic climate policy

Georgy Vladimirovich Safonov, Ph.D. Econ., Director of the Center for Environmental Economics and Natural Resources at the Higher School of Economics

The main document that regulates international cooperation regarding climate change is the UN Framework Convention on Climate Change (UNFCCC), proposed at the Earth Summit in Rio de Janeiro in 1992 and ratified in 1994. The Russian Federation became a party to that convention after its ratification (Federal Law No 34-FZ dated Nov. 4, 1994).

An important stage in the development of climate policy in Russia was the Kyoto Protocol, an extension of the UNFCCC, adopted in 1997 at the UNFCCC conference and implemented in 2005 after its ratification by Russia Federal Law No. 128-FZ of November 4, 2004. The first commitment period under the Kyoto Protocol was from 2008–2012, when the parties had to comply with the established quotas for greenhouse gas emissions, carry out an inventory of emissions, and report on climate action; additionally, during this period, several flexibility mechanisms were launched: carbon trading and joint projects. Russia has registered more than 150 Kyoto projects and has attracted significant investment from the global carbon market. However, after 2012, a second quantitative commitment period was not approved. Parties to the Kyoto Protocol continue to report on greenhouse gas emissions and removals as well as provide assistance with adaptation strategies to developing countries until the end of 2020.

On January 1, 2021, the Kyoto Protocol will be replaced by the Paris Agreement, which was adopted in December 2015 at the 21st Conference of the Parties to the UNFCCC. Russia joined the agreement in 2019 (Russian Governmental Resolution No.1228 of September 21, 2019).

The main goals of the Paris Agreement are: 1) to prevent an increase in the average annual global temperature by more than 1.5-2 degrees Celsius; 2) to improve the capabilities of adapting to the adverse effects of climate change; 3) to channel financial resources

into developing a low emissions economy with greater resilience to climate change (Article 2, paragraph 1 of the Paris Agreement).

The obligations of the Parties include setting goals to reduce greenhouse gas emissions for 2030 and beyond, creating a low-carbon development strategy for the long term until 2050, and regularly revising goals towards greater rigor (at least once every 5 years). Russia has formally submitted the "intended nationally determined contribution (INDC) to the Paris Agreement" to the UNFCCC secretariat, where the target for greenhouse gas emissions for 2030 was set at 70-75% of 1990 levels, with the maximum possible consideration given to the absorbing capacity of forests. Considering that emissions in 2018 reached about 50% of 1990 levels, the INDC targets seem to be easily achievable.

Russia's climate policy is based on a number of documents that define not only international obligations under the UNFCCC, but also domestic obligations and regulatory measures. These include the following documents:

- The climate doctrine of the Russian Federation (Executive Order No. 861-rp from December 17, 2009), which promulgates the goals, basic principles, methods and subjects of climate change policy.
- Executive order No. 752 "On Greenhouse Gas Emissions Reduction" from September 30, 2013: sets a target of reducing the volume of greenhouse gas emissions to no more than 75% of 1990 emissions levels by 2020.
- The Ministry of Natural Resources order No. 300 dated June 30, 2015 lays the foundations for an integrated system of accounting for greenhouse gas emissions and removals at the enterprise level and for constituent entities of the Russian Federation; however, a regular inventory of greenhouse gas emissions from economic entities has not yet carried out.
- Government Resolution No. 2344-r dated November 3, 2016—a set of measures approved for implementing the Paris Agreement—provides for the adjustment of existing strategic documents and the preparation of new decisions to determine the state policy regarding climate change, as well as developing a model of state regulation aimed at reducing greenhouse gas emissions in Russia.
- The National Plan for Adaptation to Climate Change until 2022 (Governmental Resolution No. 3183-r dated December 25, 2019), defines the first stage of adapting the economy and population to climate change, including institutional, organizational, and meth-

odological measures aimed at developing state approaches to climate change adaptation.

- The long-term development strategy for the Russian Federation until 2050 with an aim toward low levels of greenhouse gas emissions, which Russia's Ministry of Economic Development sent for approval to the federal executive authorities in accordance with Governmental Resolution No. 2344-r of Nov. 3, .2016. This strategy is aimed at ensuring the country's transition to a diversified economic development trajectory. According to the scenarios proposed by the ministry, greenhouse gas emissions may grow from 50% of 1990 levels in 2017 to 64–76% by 2030 and 52–90% by 2050.
- The draft federal law "On state regulation of greenhouse gas emissions in the Russian Federation" is in the stage of receiving input from the expert community and awaiting approval from federal executive authorities. It should define the foundations for state regulation of emissions, reporting requirements for greenhouse gas emissions from enterprises, and tools to stimulate emissions reduction measures.
- Executive order No. 666 "On reducing greenhouse gas emissions" from Nov. 4, 2020 sets a new national goal to "reduce" emissions by 30% of 1990 levels by 2030.

Climate policy is the subject of significant criticism from the expert community, business, and environmental organizations. In particular, the long-term goals to "reduce" greenhouse gas emissions for 2030 and 2050, which actually allow for large increases in GHG emissions from the current level, are puzzling. Despite the fact that the Paris Agreement calls for deep decarbonizing the economy and aims at climate neutrality by the middle of the 21st century, Executive Order No. 666 sets the new national target of "reducing" emissions by 30% of 1990 levels—but given the current emissions levels, this essentially means that emissions can be increased by 40%.

Plans for carbon regulation also lack carbon-pricing instruments. Also absent are mechanisms such as an emissions market, carbon projects with the issuance of "certified emission reductions" or carbon credits, and bilateral investment programs within the Paris Agreement framework such as the "Joint Crediting Mechanism" proposed by the Japanese government.

The targets for adaptation to climate change are assessed as too weak and too protracted. Thus, sectorial adaptation strategies are planned for development by the 3rd quarter of 2021, but funds for this

work have not yet been allocated. The constituent entities of the Russian Federation are only recommended to prepare regional adaptation strategies by the 4th quarter of 2022, but the source of funds for these are also undetermined. In such circumstances, it may be reasonable to fear that no effective economic, industrial, or regional plans that account for climatic factors will be forthcoming, even as the negative impacts of climate change on the economy, society, and ecosystems in the past years grow and continue to pose a real threat to sustainable development in Russia.

Historical overview of GHG emissions in Russia, forecasts for the future

Georgy Vladimirovich Safonov, Ph.D. Econ. Director of the Center for Environmental Economics and Natural Resources at the Higher School of Economics

Russia is a world leader in terms of greenhouse gas (GHG) emissions. In 1990, which has come to serve as the basis year for many countries of the United Nations Framework Convention on Climate Change (UNFCCC), Russia produced 3.1 billion metric tons of CO_2-equivalent, or 8% of global GHG emissions.[127]

The economic transformations of the 1990s led to significant reductions in GHG emissions in Russia. From 1990–2002, there was a 56% decline in emissions due to the socio-economic crisis, a GDP decline, a drop in industrial production, the economy's demilitarization, an increase in the service sector (from 20% to 50% of GDP), as well as a decrease in timber harvesting. As a result, the volume of carbon capture by forests increased from 78 to 565 million metric tons of CO_2 per year. Since 2002, however, GHG emissions have increased by an average of 1% per year. During this same period, emissions in the energy sector have grown annually, and the volume of carbon capture only continued to increase until 2010 (to a peak of 723 million metric tons of CO_2 per year), after which it began to decline, to 591 million metric tons of CO_2 in 2018.

By 2018, total emissions (accounting for carbon sequestration) amounted to 1.6 billion metric tons of CO_2-equivalent, or 52% of 1990 levels. Today, the energy sector is the primary source of GHG emissions in the country; in 2018, it produced 1.75 billion metric tons of CO_2, which includes the extraction, transportation, processing, and combus-

[127] UNFCCC, National Greenhouse Gas Inventories Database. https://di.unfccc.int/detailed_data_by_party

tion of fossil fuels. Industrial processes account for 0.24 billion metric tons of CO_2, 0.13 billion metric tons for agriculture, 0.1 billion metric tons of CO_2 for waste; forestry and land use absorbs 0.59 billion metric tons of CO_2.

National targets for GHG emissions volumes are determined by executive orders from the President of the Russian Federation. The target for 2020 was that emissions were not to exceed 70–75% of 1990 levels. Executive order No. 666 "On reducing greenhouse gas emissions" from November 4, 2020 set a new national goal for 2030: to "reduce" emissions to 30% of 1990 levels. Given the current level of emissions, this goal effectively allows for emissions to be increased by nearly to 40%.

In March 2020, Russia's Ministry of Economic Development presented a draft of a low-GHG national development strategy. According to official forecasts, emissions may increase from the current level by 28–52% by 2030, and by anywhere from 4–80% by 2050. No scenarios for a decrease from 2017 levels are expected.[128]

Such formal goals are quite understandable because they are largely based on previously-adopted official development strategies, including "Energy Strategy 2035", the general plan—regarding the coal, gas, and oil industries—for the placement of electric power facilities until 2035. All of these strategies provide for increases in production, transportation, storage, combustion of fossil energy resources—hence, an increase in GHG emissions.

Alternative scenarios for decarbonizing the economy were developed by a number of research centers using complex economic and mathematical models, and the Center for Energy Efficiency (CENEF) carried out a comparative analysis of such scenarios.[129] A set of long-term scenarios was identified in which GHG emissions in the country could decrease until 2050, though many researchers predicted an increase in GHG emissions, since a significant factor hindering efforts to decarbonize the Russian economy is the high share of fossil fuels in the energy balance.

---

[128] Ministry of Economic Development of Russia. Strategy for a long-term, low-GHG development of the Russian Federation until 2050. Project. https:// economy.gov.ru/material/ le / babacbb75d32d90e28 d3298582d13a75 / proekt_ strategii.pdf

[129] Costs and benefits of low carbon economy and social transformation in Russia. Prospects for before and after 2050 / Edited Bashmakov, I. A. — M .: CENEF, 2014.http: //www.cenef.ru/le / CB-LCE-2014-rus.pdf

Model calculations by the RANEPA research group and the Higher School of Economics for the Deep Decarbonization Pathways Project (DDPP) showed that reducing CO_2 emissions by 90–95% of 2010 levels in the energy production and consumption sector is possible by 2050.[130]

Measures to maximize the electrification of the Russian economy, improve energy efficiency, and reduce unitary CO_2 emissions per 1 kWh of electricity generated can play a major role in the process of deep decarbonization. Also critical are measures to reduce methane emissions in the oil, gas, and coal industries, as well as in the production of new materials (capital stocks currently account for 60% of the global carbon footprint) by strengthening the potential of forests to store carbon, developing industries for the production of carbon-free types of energy ("green" hydrogen, biofuels, etc.) and green technologies (solar, wind energy, etc.).

The electric power industry has the greatest estimated potential for reducing GHG emissions due to a wide range of technologies that allow switching from fossil fuels to alternative fuels (nuclear power plants, hydroelectric power plants, renewable energy sources) and using carbon dioxide capture and storage (CCS) technologies when they become commercially available. The phased replacement of aging generators with more modern, carbon-free technologies can significantly reduce the cost of switching to "green" energy. On average, for the world's 16 leading countries, the cost of deep decarbonization is estimated to be 0.8–1.2% of GDP per year.[131] This is significantly lower than the estimated damage from climate change (5–20% of global GDP).[132]

---

[130] SDSN-IDDRI (2014) Deep Decarbonization Pathways Project, 2014 Report. Paris, France.

[131] SDSN-IDDRI (2015) Deep Decarbonization Pathways Project, 2015 Report. Paris, France. https://www.iddri.org/sites/default/les/import/publications/ddpp_2015synthetisreport.pdf

[132] Stern Report, 2006. https://doi.org/10.1111/j.1728-4457.2006.00153.x [151] DOI: 10.13140/RG.2.2.25178.77766

Methane Capture Technology as a Necessary Tool in the Battle with Global Warming [133]

Alexander Gusev, General Director of the TATA Scientific and Technical Center, LLC and the Hydrogen Economics Institute, LLC,

A climate change model developed by researchers at the Norwegian Business School in Oslo showed that if anthropogenic greenhouse gas emissions peak in the 2030s and fall to zero by 2100, global temperatures will still rise 3 degrees by 2500, leading to a sea level rise 2.5 meters above 1850 levels. Moreover, such a progression of events is currently considered to be the most favorable of possible scenario.

Even in the event of an immediate one-time cessation of all anthropogenic greenhouse gas emissions, global temperatures would continue to rise for about a hundred more years due to the momentum of the global climate system and the self-sustained melting of Arctic ice and permafrost.

The following are the primary causes: 1) a decrease in the Earth's albedo due to a reduction in the ice area; 2) an increase in the atmospheric water vapor content associated with an temperature increases; 3) an increase in the content of greenhouse gases in the atmosphere due to the emission of CO_2 and methane from permafrost degradation.

Positive feedback loops, which aggravate all these processes, make it extremely difficult to stop them; according to scientists, they were initiated back in the 1950s, when the industrial stage of human development began, and by the 1960s and 1970s, they had already passed the point of no return.

The need for climate management activities

It is already obvious that preventing the worst consequences of global warming and rising sea levels now requires a complete cessation of all emissions, and for more favorable options, an annual capture of at least 33 gigametric tons of carbon dioxide from the atmosphere is required, which in the future must be somehow stored, used, or disposed of [1-5].

The aforementioned Norwegian model is not ideal, as its authors themselves admit that their formulation is much simpler, for example, than IPCC climate models. However, importantly, it takes into account the feedback mechanisms between the key factors influencing climate

[133] DOI: 10.13140/RG.2.2.25178.77766

change. Fundamentally important is that the calculations extend for a significantly longer period than the traditional 2100.

Methane is considered the third most important greenhouse gas in the natural and anthropogenic hierarchy, after water vapor and carbon dioxide: its contribution to global greenhouse gas emissions is estimated to be 15–20%. Its presence in the Earth's atmosphere lasts 9-12 years (for comparison: carbon dioxide passively lasts for hundreds of years in the atmosphere, removable only through absorption by the ocean and terrestrial ecosystems). In this regard, methane is classified as a short-lived climatic pollutant, but it is often overlooked that the potential impact of methane on global warming is 28–36 times higher than that of carbon dioxide (when the effect is averaged over 100 years).

Compared to the early 2000s, annual methane emissions have now increased by 9 percent, and the growth of anthropogenic emissions has exceeded the ability of natural processes to absorb methane, which has led to the excess accumulation of this gas in the atmosphere [6–12].

There is a clear need for methane to be captured and used in the field of alternative energy to solve the problem of climate change.

Potential technologies for capturing major greenhouse gases

There are a number of potential technologies for the utilization of water vapor, carbon dioxide, and atmospheric methane:

- Convection power production towers for collecting atmospheric water vapor as well as vortex convection towers for the utilizing surface carbon dioxide (CO_2 is not oxidized in the atmosphere). The Burj Khalifa is an example: it was designed with a condensate collection system piped to a collection tank in the basement of a building. The collected water—up to 40 million liters of water annually—is used for irrigating green spaces on the grounds of the complex
- Lighter-than-air methane-powered vehicles can be used for collecting relatively more concentrated methane where it is emitted then filling individual methane-transport aerostatic-gas vessels for transportation by airship haulers.
- Flooring methane-emitting territories (methane craters and methane bubbles in lakes, seas and oceans) with a film shell that rolls up into a parachute-like structure, which, during takeoff, is tightened to form of an aerostatic methane balloon.

A number of engineering solutions involve pressurizing the shells of transport balloons through vortex-tube separation structures placed on airship-like mobile filling platforms. The gas can be transported in bundles of such methane balloons over long distances for use in infrastructure purposes.

As such, compressed methane from these vessels can be fed into the inlet pipes of natural gas pipelines, as well as into stationary storage gas tanks for local household, industrial, and transportation uses.

Helium airship-haulers can be equipped with a powerful navigation and altitude- control system based on gyroscopic devices (analogous to the Spektr system for the "Mir" space station) and methane-fueled propulsion engines.

All these, of course, are extremely small measures, which, even if they were to number in the thousands, would not be capable of significantly affecting the concentrations of atmospheric methane, CO_2, or water vapor.

In addition to capturing methane from the atmosphere, other options are possible:

Underwater drones are planned for oceanic methane production from methane hydrates, (this could also potentially be used to prevent methane emissions during the decomposition of methane hydrates on the shallow Arctic shelf);

Subterranean drones can also be used for the underground outflows of methane hydrates (which had already been implemented in the USSR, particularly in Taimyr), also usable in mineral extraction infrastructures;

Methane can be processed into carbon and hydrogen, with carbon further used in nanomaterials science, and hydrogen for domestic purposes, chemical industry production, and transport.

Conclusions

The fight against global climate change can no longer be effectively conducted by simply reducing the damage caused to nature. Proactive actions are needed to compensate for previously done damage and to halt positive feedback chains [13–17].

Of course, capturing methane is still very far from common practice. A gigantic scale of implementation is required to even slightly affect global atmospheric methane concentrations. Though seemingly fantastic—and we can most likely talk only of the XXII or XXIII centu-

ries—it is important to note that atmospheric methane-capture technologies already exist.

Sources

1. Climate Change // U.N Electronic Resource. — URL: https://www.un.org/ru/sections/ issues-depth/climate- change/index.html (retrieved: 11.30.2020).
2. The Global Methane Budget 2000–2017 / Saunois, M. et al. // Earth Syst. Sci. Data. — 2020. — No 12. — Pp. 1561–1623. DOI: https://doi.org/10.5194/essd-12-1561-2020.
3. 2 Degrees from Hell. Why Delay Global Warning? [Electronic Resource] // EKA—Russia' s Green Movement. — URL: https://zen.yandex.ru/media/ecamir/2-gradusa-do-ada-zachem-sderjivat-globalnoe-poteplenie-5f568aba9080502492ed567a (retrieved: 11.30.2020).
4. 100-year Memorandum to the Heads of the G8 from November 13 / A.L. Gusev et al. // Alternative Energy and — International Scientific Journal of Alternative Energy and Ecology. — 2007. — No 3. — Pp. 11–12.
5. Russia' s Economic, Energetic, Ecologic, and Geologic Security in the 21st Century. Does Russia Need Hydrogen Energy? The Economy, Ecology, and Society of Russian in the 21st Century / Gusev, A.L., Dyaduchenko, Y.P., Chertov, V.M.// Works from the 4th International Scientific-Practical Conference Volume 1, St. Petersburg: Nestor, 2002.
6. Using ship-borne observations of methane isotopic ratio in the Arctic Ocean to understand methane sources in the Arctic / Berchet, A., Pison, I., Crill, P.M., Thornton, B., Bousquet, P., Thonat, T., Hocking, T., Thanwerdas, J., Paris, J.D. Saunois, M. // Atmos. Chem. Phys. — 2020. — 20. — Pp. 3987–3998. DOI: https://doi.org/10.5194/acp-20-3987-2020.
7. Greenhouse gas emissions from lakes and impoundments: Upscaling in the face of global change / DelSontro, T., Beaulieu, J.J., Downing, J.A. // Limnol. Oceanogr. Lett. — 2018. — No 3. — Pp. 64–75. DOI: https://doi.org/10.1002/lol2.10073.
8. Preindustrial $^{14}CH_4$ indicates greater anthropogenic fossil CH_4 emissions / B. Hmiel et al. // Nature. — 2020. — No 578. — Pp. 409–412. DOI: https://doi.org/10.1038/s41586-020- 1991-8.
9. Global ocean methane emissions dominated by shallow coastal waters / T. Weber T., N. A. Wiseman, Kock, A. // Nat. Commun. — No 10. — Pp. 1–10 DOI: https://doi.org/10.1038/s41467- 019-12541-7.
10. Development of a global synthetic map of Wetland Area and Dynamics for Methane Modeling (WAD2M) / Zhang, Z. et al., in preparation, 2020.
11. Inter-model comparison of global hydroxyl radical (OH) distributions and their impact on atmospheric methane over the 2000–2016 period / Y. Zhao et al. // Atmos. Chem. Phys. — 2019. — No 19. — Pp. 13701–13723. DOI: https://doi.org/10.5194/acp-19-13701-2019.
12. Influences of hydroxyl radicals (OH) on top-down estimates of the global and regional methane budgets / Y. Zhao et al. // Atmos. Chem. Phys. Discuss, in review, 2020. — DOI: https://doi.org/10.5194/ acp-2019-1208.

13. Economic aspects of nuclear and hydrogen energy in the world and Russia / Zhiznin, S.Z., Timokhov, V.M., Gusev, A.L. // International Journal of Hydrogen Energy. — 2020. — No 45(56), pp. 31353–31366.
14. Economics of secondary renewable energy sources with hydrogen generation / Zhiznin, S.Z., Vassilev, S., Gusev, A.L.// International Journal of Hydrogen Energy, 2019. — 44(23). — Pp. 11385–11393. DOI: https://doi.org/10.1016/j.ijhydene.2019.03.072.
15. Hydrogen production by low-temperature plasma decomposition of liquids/ Bulychev, N.A., Kazaryan, M.A., Averyushkin, A.S., Chernov, A.A., Gusev, A.L. // International Journal of Hydrogen Energy. — 2017. — No 42(33). — Pp. 20934–20938. DOI: https://doi.org/10.1016/j.ijhydene.2016.09.226.
16. Cleaning system for corrosive gases and hydrogen / Gusev, A.L. // Chemical and Petroleum Engineering. — 2009. — 45(9–10). — P. 640. DOI: 10.1007/s10556-010-9251-7.
17. Thermodynamic peculiarities of low-temperature regeneration of cryosorption devices in heat-insulation cavities of hydrogenous cryogenic tanks/ Gusev, A.L. // International Journal of Non-Linear Mechanics. — 2001. — No 26(8), pp. 863–871. DOI https://doi.org/10.1016/ S0360-3199(01)00024-6.

4.2. Financial and economic instruments for implementing a new climate policy

Green finance for the Russian Federation

Maxim Alekseevich Titov, Director of the Energy Policy Research Center of the European University at St. Petersburg

For Russia, one easily apparent solution in the field of green finance is the widespread introduction of green loans by commercial banks. The simplest type of green lending is financing energy-efficiency projects. “Center-Invest Bank” (based in Rostov-on-Don) has been building its green loan portfolio since 2005 by offering loans to customers for upgrading to energy-saving technologies and implementing measures to modernize outdated equipment. In November 2020, the bank’s total investment exceeded 18.5 billion rubles spread over 24.7 thousand projects. The environmental impact of these loans will be a reduction of more than 200 thousand metric tons of CO_2 emissions.[134]

[134] Press release of the bank dated November 27, 2020 https://www.centrinvest.ru/ru/about/news/36416/

Expert estimations of Russia's green financing potential suggest that if each of Russia's regions had at least one such commercial bank offering green loans, total green investment in the country would be close to USD313 billion.[135] A significant share of this potential relates to improving the energy efficiency of buildings, industry, energy and transportation—these four sectors are the largest consumers of fuel and energy resources in Russia, accounting for 83% of consumption.[136]

Bank loans for energy-efficiency projects, which are usually referred to as "climate" financing or green financing, are not new inventions. Since the early 2000s, international financial institutions (EBRD, IFC, EIB, NEFCO and others) have been actively introducing specialized loan products in commercial banks in emerging markets to finance energy-efficiency projects, projects that improve the effective use of scarce (they can also be classified as best available technologies, or BAT), renewable energy projects, and others. The program of the International Finance Corporation (IFC, a part of the World Bank group) implemented in Russia from 2006–2012 allowed commercial banks to finance projects worth US$300 million.

The practice of implementing energy-efficiency projects has shown that they require special financing due to the particular characteristics of these projects, but commercial banks can and should work with these massive, exemplary projects. Energy-efficiency improvements can significantly affect the financial performance of such projects and the payback period, resulting in additional incomes. If company leaders at commercial banks are educated about the feasibility of such projects, new market segments of lending will become available to them: new industries, regional niches, and project types.

---

[135] Climate Investment Opportunities in Emerging Markets Report by the World Bank Group International Finance Corporation 2016 https://www.ifc.org/wps/wcm/connect/59260145-ec2e-40de-97e6-3aa78b82b3c9/3503-IFC-Climate_Investment_Opportunity-Report-Dec-FINAL.pdf?MOD=A JPERES&CVID=lBLd6Xq

[136] The state report "On the state of energy conservation and energy efficiency improvement in the Russian Federation" was prepared in accordance with the Russian Governmental Resolution No.1412 "On the preparation and dissemination of the annual state report on the state of energy conservation and energy efficiency improvement in the Russian Federation" dated December 18, 2014 and is the fifth issue of this official annual document. Prepared by the Ministry of Economic Development of the Russian Federation and published on December 26, 2019.

Specialized loans to finance energy-efficiency projects can bring certain benefits to a bank:[137]

1. Sustainable business development, increasing (maintaining) market share in services offered:
- offering a new banking product aimed at modernizing and improving the energy efficiency of client businesses;
- increasing sales due to repeated and cross-sales of new banking products to existing clients;
- adding fees for new products and a growth in non-interest income;

attracting new high-quality borrowers

2. Improving the quality of the loan portfolio and reducing the borrowers' credit risk:[138]
- improving the bank's portfolio through diversification—redistributing the loan portfolio with an increase in investment loans and reducing the share of working capital financing;
- improving client solvency and increasing their credit rating due to the additional cash flows from implementing energy-efficient solutions.

3. Creating a positive reputation as a banking brand committed to supporting environmental stewardship and socially responsible business:
- developing a positive image in society;
- raising the bank's status in the eyes international financial institutions—expanding opportunities for attracting long-term financing;
- the presence of a green portfolio in the general portfolio of a bank is attractive for further use in more complex financial instruments.

Of course, to solve problems related to energy efficiency and implement the best available technologies (BAT) for realizing environmental projects, other types of green financial instruments are also necessary: guarantees, sureties, leasing, revolving funds, and securities. Moving toward more complex products is only possible once the bank has gained experiences with creating and selling green products such as energy-efficiency credits. Having gained experience from creating

---

[137] Bank financing of energy efficient projects / M. A. Titov, E. V. Shonya. — M.: International Finance Corporation, 2012 . — 66 p.

[138] Additional stable volumes of positive cash flows generated from implementing energy conservation programs can significantly affect the the borrower's risk profile in the bank's scoring models.

a portfolio of financed green projects, the commercial bank can expand its line of green products in accordance with the development strategy.

It is difficult for a commercial bank to independently solve the problem of launching green loans. There are objective difficulties in attracting long-term financing: there is limited experience and no standardized methodology for structuring green products. A development institution, such as the VEB investment company, should play a role in introducing green financial instruments to Russia. In a way analogous to the practice of international financial development institutions, VEB can offer Russian commercial banks comprehensive integrated solutions consisting of dedicated green lines of credit and methodological assistance in developing standardized green loans according to uniform criteria. By introducing and launching massive green credit products, aggregating data on project types and their achieved benefits for the economy (energy resource savings, reduced greenhouse gas emissions, etc.), VEB could solve environmental problems and climatic problems at a national scale while also developing new financial markets.

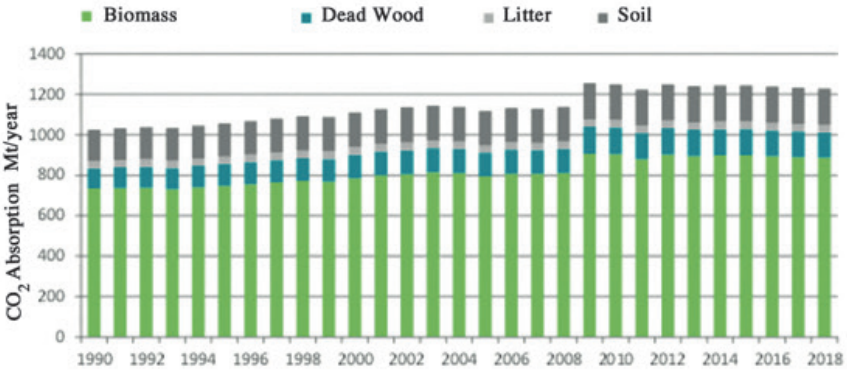
4.3. New approaches in forest management

The role of forests and other ecosystems in CO_2 absorption

Anna Anatolyevna Romanovskaya, Ph.D. Bio. Director of the Institute of Global Climate and Ecology, Corresponding Member of the Russian Academy of Sciences (RAS)

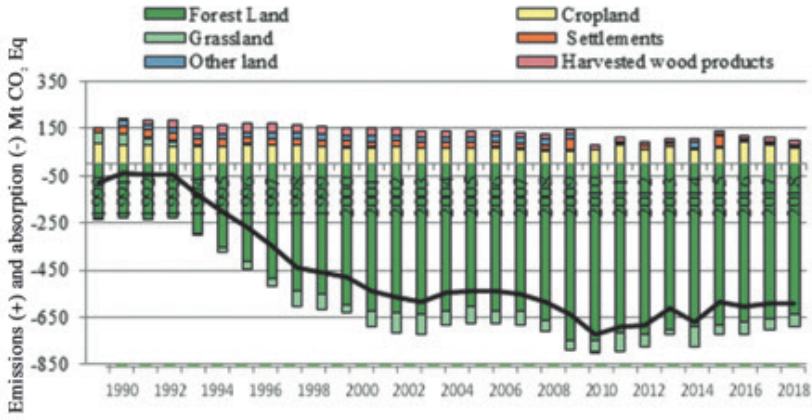
The main source of information regarding the role of forests and other ecosystems in the terrestrial-atmospheric exchange of greenhouse gases within Russian territory is the National Cadaster of Anthropogenic Greenhouse Gases Emissions and Sinks (hereinafter referred to as the Cadaster) [1], which is maintained by the Russian Federation in accordance with obligations under the UN Framework Convention on Climate Change [2]. The cadaster data are limited by the fact that only anthropogenic flows of greenhouse gases are subject to accounting in terms of both emissions and sinks. Difficulties of attributing the latter within natural ecosystems are resolved through the concept of "managed lands", which are lands under anthropogenic pressure—all emissions and sinks are accounted for in these areas. Managed lands in the Russian Federation include forests where conservation measures are being carried out, as well as forest use and logging; arable agricul-

Figure 1. Dynamics of CO2 absorption by carbon sinks in managed forests of the forest fund, million tons of CO2



tural land, pasture and grassland; drained and irrigated wetlands, peat extraction; inhabited lands, industrial facilities and areas containing linear infrastructure, as well as land transferred between these categories. In accordance with international agreements, natural ecosystems that do not contain anthropogenic activities (a significant part of the tundra, steppe, bog ecosystems, forest preserves) are not accounted for in national reporting under the UNFCCC [2].

Figure 2. Balance of greenhouse gases in the sector "Land use, land use change and forestry" for the period 1990–2018, Mt CO_2-eq.

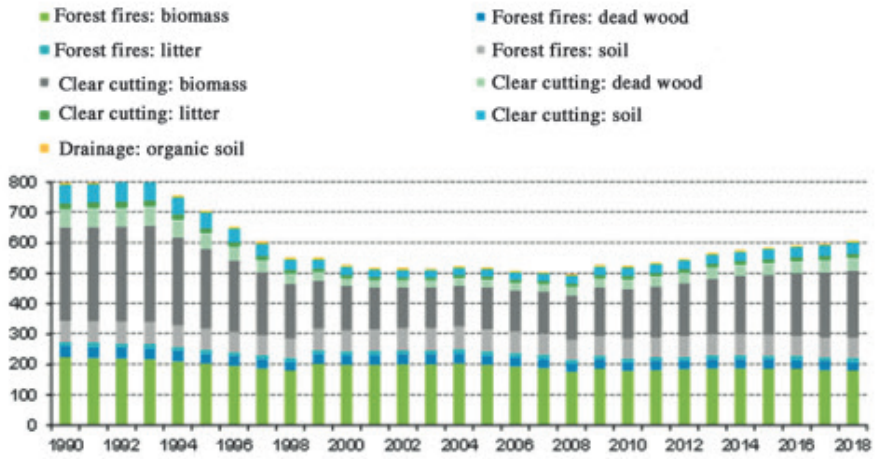


It is worth noting that any domestic decision within the RF to create a system of monitoring greenhouse gas flows from all types of natural ecosystems will have only intellectual or scientific value, as these estimates cannot be included in reporting under the UNFCCC and the Paris Agreement.

The logic of taking into account only anthropogenic flows of greenhouse gases is obvious: these are flows that humanity can control and manage, which means they can reduce emissions and increase absorption. Natural flows are worth tracking and monitoring, but controlling them is unlikely.

According to the 2020 Cadaster (see Figure 1), the forest carbon budget determined 60% of the dynamics of carbon capture and greenhouse gas emissions by managed ecosystems in 1990 and 80% in 2018. At the same time, the reduction in emissions and the increase in absorption of forests for that period were associated with a 2.5-fold decline logging activity in the mid-1990s. Thus, the net absorption of CO_2 in managed forests shifted from 248.5 million metric tons of CO_2 in 1990 to 674.1 in 2018. An increase in absorption by overgrown agricultural land is also noticeable, which is included in the Grasslands category of the Cadaster (Figure 1). In general, this sector went from offsetting 2.4% of industrial emissions from other economic sectors in 1990 to 26.6% in 2018.

Figure 3. Dynamics of CO_2 sink losses from managed forests of the forest fund by as a result of economic activities, million tons of CO_2



Analysis of gross CO_2 fluxes on forest lands—presented in Figures 2 and 3 below—indicates that fires lead to annual losses of 25% — 30% in terms of absorption, which is comparable to the magnitude of carbon capture loss during logging. It should be noted that no other developed country has such a large impact on the balance of greenhouse gases in forests due to fire violations. For example, in Finland, fires lead to losses of less than 1% of the annual absorption [3].

In accordance with the UNFCCC requirements, official state statistics regularly collected by the Russian Federal Agency for Forestry (Rosleskhoz), The Federal Service for State Registration (Rosreestr), and the Federal State Statistic Service (Rosstat) are used as the preliminary data for Cadaster calculations. In this way, the methodology of this approach differs from the methods of scientific research, and they cannot be considered as real alternatives for the development of reporting within the framework of international agreements due to the use of these heterogeneous methods and multi-temporal data. In this regard, the Cadaster data on forests often does not coincide with data from scientific sources, which estimate a range from 100 to 2500 million metric tons of CO_2 per year for Russian forests [4, 5, 6, 7, 8, 9, 10]. The problem of data comparability is considered in detail in the following articles: [11, 12, 13].

The Cadaster methodology regarding forest lands is simple and represents a summary estimate of the moving average for the growth of 6 age groups of various tree species in each of the country's regions tracked by State Forest Register; the carbon capture losses resulting from forest fires, epiphytotic outbreaks, felling, and other causes is subtracted from this total. An alternative methodology is proposed for the Cadaster: the method of the All-Russian Research Institute of Silviculture and Mechanization of Forestry (ARRISMF) [5], which is based on the use of average increments of forest stands (that is, the total stand increment divided by age) and does not take into account the age dynamics of tree growth and carbon accumulation, which, in the case of significant areas of mature and overripe forest stands in Russia, leads to a violation of the law of conservation of mass and matter and a significant artificial overestimation of CO_2 absorption [11].

At the same time, it is objectively obvious that improving the Cadaster estimates is necessary: this requires refining the state statistics that serve as preliminary data on the conditions of forest areas and other ecosystems, and not in changing the equations used. Broad discussions and initiatives on the "development of a national methodology" and on changing the "wrong formula" for forests should be direct-

ed towards a constructive channel for building up scientific research, integrating remote sensing data into state statistical reporting on forests, as well as maintaining a system for reconciling calculated Cadaster monitoring data with observational data. A preliminary analysis carried out jointly by specialists from Yuri A. Izrael Institute of Global Climate and Ecology (IGCE), the Center of Forest Ecology and Productivity of the Russian Academy of Sciences, the Space Research Institute of the Russian Academy of Sciences, and ARRISMF, showed that refining the initial data on carbon stocks by using data from the State Forest Inventory might increase the Cadaster estimates of forest absorption capabilities by 40%; however, proper accounting of areas of forest death from annual fires and other causes can reduce those estimates by a factor of 3 times.

An analysis of greenhouse gas emissions from various sources on managed lands in Russia leads to a set of priority measures that can be identified as capable of significantly reducing emissions and increasing the absorption of greenhouse gases (see table). According to the authors, the efforts of the Russian government should be concentrated on these measures, which should be prioritized over creating a system for accounting for natural flows of greenhouse gases in the country.

Table 1. Potential measures to reduce emissions and increase absorption of greenhouse gases on managed lands [11]

Measures	**Total potential, million metric tons CO_2-eq/ year**
Forestry	
Forest fire prevention	220–420
Low-impact logging techniques	15–59
Minimizing carbon capture losses during logging	61–76
Replacement monocultural reforestation with heterogeneous planting	50–70
Reduction of round timber exports and transition to processed timber exports	17–26
Increased recycling of paper and increased production of long-lasting wood products	51–79
Offsetting deforestation with new plantings	0.2–0.4

Agriculture	
Reducing soil carbon losses in arable land	101–159
Protecting grasslands from fire	0.5–1.5
Promoting carbon storage in grassland soils	13–19
Reduction of nitrogen losses by using mineral and organic fertilizers	4–8
Land Use	
Watering of previously drained peatlands	0.1–0.3
Land reclamation	13–19
All measures	~545–940

Measures to reduce emissions and increase absorption are especially important in light of new forecasts of net losses in CO_2 absorption by Russian forests (Figure 4) and increasing methane emissions from the permafrost zone [14], including those within the territory of managed ecosystems.

According to the available forecasts [15, 16, 17], the gradual aging of Russian forests is leading to a decrease in their carbon-sequestration role in all scenarios of changes in forest use—ranging from the unchanging scenario to a rapid increase in the volume of logging. According to our calculations, the average values of the net CO_2 absorption by managed forests for 2021–2030 will amount to 546.3 million metric tons of CO_2 per year under Scenario 1 (no growth in logging), 489.5 million metric tons of CO_2 per year under Scenario 2 (brief moderate growth in logging), and 457.9 million metric tons of CO_2 per year under Scenario 3 (long-term moderate growth in logging).

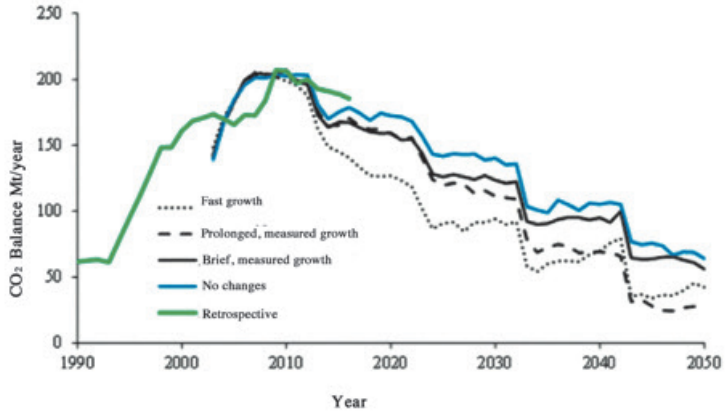
Data on the balance of greenhouse gases of all ecosystems in the Russian Federation—managed and unmanaged—show that all natural ecosystems in Russia in total are net sinks in the amount of 1,040 million metric tons of CO_2-eq. [18]. This is generally consistent with the data (Sitch et al., 2015; Pan et al., 2011). Taking into account total annual anthropogenic emissions in the Russian Federation for 2220—one million tons of CO_2-eq. [1]—it turns out that when considering solely carbon dioxide, Russia can be considered an ecological donor; however, accounting for other greenhouse gases from natural ecosystems—primarily methane—shows that, at present, the country has a total negative balance of greenhouse gases (natural ecosystems are

able to compensate for only about half of the anthropogenic release) [18] and will become a net source in the coming years [14]. Further research in this direction is advisable.

Unfortunately, the impulse of large businesses to hide their carbon footprint behind the absorption of CO_2 by natural ecosystems misdirects the attentions and actions of decision-makers towards looking for opportunities to calculate existing absorption and attempting to take the absorption of unmanaged ecosystems into account within the framework of the Paris Agreement. Thus, instead of an active policy towards strengthening the protection and conservation of forests through low-impact logging and timber processing, and preserving soil fertility on arable land, no actions are taken, pressing problems are left unaddressed, and the adoption of necessary measures is postponed.

Recently, a naive opinion has also been circulating: that absorption by natural ecosystems will help Russian companies avoid a cross-border carbon tax, which the EU intends to introduce in 2023. Obviously, this initiative is aimed at offsetting the carbon footprint from the exportation process for products entering into the EU. At the same time, the only opportunity to use the natural advantages of our country may through offsetting the carbon footprint by implementing projects to reduce emissions and increase the carbon capture capabilities of forests or other lands. The time for contemplating the problems of

Figure 4. Forecast of the carbon balance of managed forests in Russia using the CBM-CFS3 model in accordance with scenarios of forest use growth and retrospective assessment based on the data of the 2019 national greenhouse gas cadaster report [15, 16, 17]



a gradual transformation towards low greenhouse gas emissions has long since passed; it is now time to make balanced decisions on executing such a transition and leveraging the goals of the Paris Agreement to realizing our national interests: closing the technological gap, providing for growth in energy efficiency, modernizing production, diversifying the economy, ensuring food security, reducing emissions of pollutants, as well as preserving forest and other ecosystems from fires and anthropogenic pressures.

Literature

1. National report on the cadaster of anthropogenic greenhouse gas emissions and sinks not regulated by the Montreal Protocol [Electronic resource] // Roshydromet. — 2020. — URL: http://www.igce.ru/performance/publishing/reports / (Date of treatment 10/27/2020).
2. United Nations Framework Convention on Climate Change (UNFCCC) Article 4.1 [Electronic resource] // UN. — 1992. — URL: https://www.un.org/ru/documents/decl_conv/conventions/climate_framework_conv.shtml (Date of treatment 10/27/2020).
3. Greenhouse gas emissions in Finland 1990 to 2018. National Inventory Report under the UNFCCC and the Kyoto Protocol // Statistic Finland. 2020. — URL: https://unfccc.int/documents/219060 (Date of treatment 10/27/2020).
4. Absorption capacity of Russian forests and emissions of carbon dioxide by energy facilities / Fedorov, B.G., Moiseev, B.N., Sinyak, Yu.V. // Problems of forecasting. — 2011. — No 3. — P. 127–142.
5. Methods for assessing the carbon balance in forest ecosystems and the possibility of their use for calculating annual carbon storage / Malysheva, N.V., Moiseev, B.N., Filipchuk, V.N., Zolina, T.A. // Forestry Bulletin. — 2017. — No. 1, vol. 21. — P. 4–13.
6. Recent trends and drivers of regional sources and sinks of carbon dioxide // Sitch, S. et al. // Biogeosciences. — 2015. V. 12. — P. 653–679. DOI: 10.5194/bg-12-653-2015.
7. Large and Persistent Carbon Sinks in the World's Forests / Pan, Y. et al. // Science. — 2011. — V. 333. — Pp. 988-993. DOI: 10.1126 / science.1201609
8. Modern carbon sink reductions in the forests of Russia / Zamolodchikov, D.G., Grabovskiy, V.I., Shulyak, P.P. Chestnykh, V.V. // Reports of the Academy of Sciences. — 2017. — T. 476. — No. 6. — P. 719–721.
9. Carbon pools and flows in the terrestrial ecosystems of Russia / Kudeyarov, V.N. et al. — M .: Nauka, 2007. — 315 p.
10. The Carbon budget of Russian forests / Shvidenko, A.Z., Shchepashchenko, D.G. // Siberian forest journal. — 2014. — No 1. — P. 69–92.
11. Greenhouse gas fluxes and mitigation potential for managed lands in the Russian Federation / Romanovskaya, A.A., Korotkov, V.N., Polumieva,

P.D., Trunov, A.A., Vertyankina, V.Y., Karaban, R.T. // Mitigation and Adaptation Strategies for Global Change. -2019. — Vol. 25 (4). — Pp. 661–687. DOI: 10.1007/s11027-019-09885-2.
12. Science-based approach for credible accounting of mitigation in managed forests / Grassi, G.,Pilli, R., House, J., Federici, S., Kurz, W.A. // Carbon Balance and Management. — 2018 . — 13: 8. DOI: https://doi.org/10.1186/s13021-018-0096-2.
13. New estimates of CO_2 forest emissions and removals: 1990–2015 / Federici, S., Tubiello, F.N., Salvatore, M., Jacobs, H., Schmidhuber, J. // Forest Ecology and Management. — 2015. — Vol. 352. — Pp. 89–98. DOI: https://doi.org/10.1016/j.foreco.2015.04.022.
14. Contribution of Natural and Anthropogenic Emissions of CO_2 and CH_4 to the Atmosphere from the Territory of Russia to Global Climate Changes in the Twenty-first Century / Denisov, S.N., Eliseev, A.V., Mokhov, I.I. // Dokl. Earth Sc. — 2019. — 488. — Pp. 1066–1071. DOI: https://doi.org/10.1134/S1028334X19090010.
15. Carbon budget of managed forests in the Russian Federation in 1990–2050: retrospective assessment and forecast / Zamolodchikov, D.G., Grabovsky, V.I., Korovin, G.N., Guitarsky, M.L., Blinov, V.G., Dmitriev, V.V., Kurtz, V.A. // Meteorology and Hydrology. — 2013. — No 10. — P. 73–92.
16. Forecast estimates of forest runoff for the period up to 2050 and the contribution of the forest sector to the obligations of the Russian Federation under a new climate agreement / Zamolodchikov, D.G., Grabovskiy, V.I. // Bulletin “Use and protection of natural resources in Russia“. — 2014. — No 3. — P. 23–27; No 4. — P. 31–34.
17. The fourth biennial report of the Russian Federation, presented in accordance with decision 1 / CP.16 of the Conference of the Parties to the United Nations Framework Convention on Climate Change [Electronic resource] // Roshydromet. — 2019. URL: http://downloads.igce.ru/publications/Two_years_Doklad_RF/124785_Russian%20Federation-BR4-2-4BR_RUS_rev.pdf (Date of treatment 10/27/2020).
18. Scientific research in the field of assessing the ability of various types of ecosystems to absorb carbon dioxide and the preparation of scientifically grounded proposals for calculating the amount of carbon dioxide absorption by ecosystems of Russian Federation regions: research work / Korotkov, V.N. et al. / / In accordance with the State Contract dated July 21, 2017 No. DK-14-23/55, code 17-14-NIR/01.

Forest policy aimed at preserving the climate-regulating role of forests and their ability to mitigate climate change

Alexey Yaroshenko, Ph.D. Bio. Head of the Greenpeace Forestry Program

Forests play a large and diverse role in climate regulation and mitigation, which can significantly change over time, particularly under the influence of human economic activity. During photosynthesis, forests bind carbon from the atmosphere and accumulate it in different segments of the ecosystem: in living trees and perennial parts of other plants, in dead wood, in forest litter, in the organic matter of the soil. The forest is also a powerful evaporator of moisture, returning it to the atmospheric cycle and facilitating moisture transfer to inland regions over long distances; numerous microparticles and volatiles released by the forest into the atmosphere: pollen, essential oils of coniferous trees, etc. make an additional contribution to the regulation of precipitation. Forests affect the reflectivity of the earth's surface and atmosphere: although the reflectivity of forests is usually lower than that of non-forest ecosystems, the moisture evaporated by forests and the microparticles they release contribute to the formation of clouds, which have a higher reflectivity. Finally, in the coldest regions of the planet, forests serve as a vast blanket that stabilizes the permafrost, protecting it from rapid heating and melting.

It is impossible to fully assess what Russian forests contribute to regulating the global climate and mitigating its changes because of the insufficient quantity and extremely low quality of detailed information available on forests. Traditionally, the main source of such information was forest management: a system for assessing forest resources and planning forestry activities, but the actual current forest management contains data on just about 1/7 of the Russian forest area, and the average age of recent forest management activities is about 25 years while the average age of the last qualitative forest management is well over thirty. The State Forest Register simply presents a collection of this outdated information—a sort of compost heap of forest information. An attempt to create an alternative system for collecting statistical information—the state forest inventory—failed: its first 14-year cycle (2007–2020) has not yet brought any significant results, and is unlikely to bring any. Even if something is done following the results of this cycle, there will be unresolvable doubts about the reliability of the data obtained and the correctness of the methods.

But this does not interfere with determining which actions can increase and which can reduce the absorption and climate-regulating capacity of forests in general; it is sometimes even possible to approximate the magnitude of these increases and decreases.

It may seem obvious that if trees absorb carbon dioxide, bind carbon, and release oxygen, then the more trees there are, the faster this process takes place, and therefore planting trees will always lead to an increase in absorption capacity. But this is not at all the case. Forest planting includes reforestation—planting in place of a felled, burnt, or otherwise destroyed forest—and afforestation, which is planting where there was no forest in the probable past. In most cases, afforestation leads to an increase in the absorptive capacity of forests since a new forest appears that did not previously exist and would not have appeared by itself in a compressed time frame; this growth begins to accumulate carbon faster than the former non-forest ecosystem. But, in most cases, reforestation either does not affect the absorptive capacity of forests, or affects it negatively. The explanation for this is simple: without specialized reforestation, most clearings or burnt areas very quickly overgrow with so-called "pioneer" tree species such as birch and aspen, which grow fastest and are ideally suited to life in the open. Reforestation is not carried out just so that some trees appear in the place of felled ones or in a dead forest but in order to create trees that are useful for humanity, not necessarily those fast-growing pioneers that appear by themselves. In order for these "useful" trees (usually spruce, pine, or oak) to grow successfully, they have to be protected from fast-growing competitors in the first couple of decades precisely because spruce, pine, or oak grow more slowly. Therefore, the young forest itself grows either more slowly (if the maintenance—removal of unwanted fast-growing trees—is successful), or at its own pace (if the maintenance is unsuccessful or lacking). Of course, in some particular cases, peculiarities do arise: in some places reforestation can increase the absorptive capacity of forests, while afforestation, on the contrary, may have no influence or even decrease it. The conclusion is simple: planting a forest is not always good in terms of climate—sometimes it is ineffective, and sometimes it's bad. Therefore, it is necessary not only to plant, but to plant competently, in each case assessing the consequences.

Fires present a more obvious example. Fires always return some amount—sometimes very large amounts—of carbon that was previously bound into the atmosphere. Additionally, fires generate large quantities of smoke and soot, microparticles of carbon, which, spread over

long distances in the atmosphere and, when settling on snow and ice, accelerate their melting. To a certain extent, fires from lightning, volcanoes, and meteorites have existed in forests for hundreds of millions of years; but for a very long time, humans have been the primary sources of forest fires. There are no exact data on the proportion of fires caused by humans, but long-term statistics show that the proportion of thunderstorm-induced fires is approximately one tenth of the total; the contribution of volcanoes and meteorites is negligible. The maxim that what is caused by humanity can effectively be fought by humanity is clearly evidenced by the experience of Central and Northern European countries, which just a few centuries ago burned no less than we do now. The most important tasks are: ending dangerous practices of fire in land use and forest use (agricultural burns, pseudo-controlled burning, hazardous burning of felling residues); prohibition of legislative motives for burning forests (for example, allowing young forest growth on agricultural land, could quite recently result in large fines or land confiscation); effective fire-prevention education for the population; restoring forest protection systems of early detection and extinguishing, at least in accessible forests.

More effective measures of protecting forests from fires and promoting afforestation on unused agricultural land are two main actions that can significantly increase the absorbing capacity of Russian forests and their ability to mitigate climate change in the medium term (the next two to three decades). There are other actions, but they are much more difficult, expensive, or only promise significant results in the much more distant future.

4.4. Climate change adaptation approaches

Analysis of the effectiveness of climate change adaptation measures undertaken in Russia so far: world practice, possible tactics, and scenarios

Georgy Vladimirovich Safonov, Ph.D. Econ. Director of the Center for Environmental Economics and Natural Resources at the Higher School of Economics

Climate change in Russia affects all regions, major industries, and sectors of the economy; consequences vary considerably based on the geographic location of the regions. In the 21st century, winter tempera-

tures are expected to increase across 60% of the country's territory, the water content of large rivers will increase; an increase in the number and scale of dangerous hydro-meteorological phenomena (floods, droughts, forest fires, etc.) is expected as well, and their number has already grown by a factor of 3 over the past 25 years.[139]

Despite the fact that the climate-related agricultural productivity has, on average, increased over the past 30 years, it is possible to predict a decrease in the productivity of agricultural crops—especially cereals—in the coming decades from increasing droughts, water shortages, the spread of pestilent insects and epiphytotic diseases; physical impacts in the form of floods, steppe fires, and similar phenomena threaten to intensify as well. Russian agriculture has already faced the first manifestations of climate change: in 2010 and 2012, droughts led to a sharp decline in grain production and increases in grain prices. The total damage from the drop in yield alone during these years amounted to more than 300 billion rubles. The consequences fell mainly on the poor as most of the damage was compensated by rising bread prices. In the absence of adequate measures to adapt agriculture to climate change, the expected annual economic damage from climate-dependent crop yields in Russia is estimated at USD3.5 billion by 2020 and over USD3.9 billion by 2050.[140]

Risks to public health, which already are a cause for concern, will increase: heat waves (like that of summer 2010 in the European part of Russia, when more than 38 thousand people died), the spread of infectious and parasitic diseases (malaria, encephalitis, borreliosis and others), the degradation of sanitary infrastructure in cities, and the deterioration of the epidemiological.[141]

The dangerous consequences of climate change will not manifest themselves uniformly on Russia territory, so adaptation measures will require regional approaches, as indicated in the Climate Doctrine of the Russian Federation, adopted in 2009. In December 2019, the Russian government adopted the National Plan for Adaptation to Climate Change until 2022, which provides for a number of measures, including

---

[139] Report on climate risks on Russian Federation territory // Roshydromet, 2017.

[140] Economic analysis of the agriculture impact of climate change in Russia: national and regional aspects/ Safonov, G. V., Safonova Yu. A. // Oxford: Oxfam, 2013. https://grow.oxfam.ru/attach_les/le_public_1028.pdf

[141] Heat waves, air quality and mortality of the population of the European part of Russia in the summer of 2010: results of a preliminary assessment / Revich, B.A. // Human Ecology, 2011.07.

the development of methodological materials, the creation of a model climatic passport for the region, and the clarification of powers accorded to various government bodies at the federal and regional levels. By the 3rd quarter of 2021, the development of sectorial adaptation strategies is planned for completion, and by the 4th quarter of 2022 regional strategies should be in place. However, the plan does not provide funding for these activities to be carried out, and there are concerns that comprehensive plans for considering and adapting to climatic factors in strategic planning at the level of industries and regions will not be ready within the specified time frame, especially since full-fledged work toward this goal has not yet begun.

In world practice, however, there are examples of successfully implementing adaptation measures. In 2015, the European Commission and the European Environmental Agency launched the Climate-ADAPT Climate Change Adaptation Platform, a partnership that shares adaptation resources across all of Europe.[142] EU member states are required to regularly report on relevant national strategies and action plans, assess impacts, analyze vulnerabilities and adaptation plans; create research programs, services and monitoring systems, online resources on climate issues, as well as educational and training resources. Through this platform, member countries receive financial, methodological and analytical support, including funding to implement practical measures.

For example, Croatia is actively carrying out projects in Eastern Europe. The country has developed a Strategy for Adaptation to Climate Change until 2040 and an Action Plan that includes long-term measures up to 2070. The government attracted a wide range of stakeholders and experts and selected 81 priority measures from 155 proposals regarding the management of water and marine resources, fisheries, agriculture, forestry, biodiversity, energy, tourism, health, landscape planning, coastal area management, and risk management. A system of indicators was adopted to monitor the implementation and effectiveness of measures to reduce vulnerability and strengthen the resilience of societal and natural systems. Most of these adaptation measures receive financial support from the EU.

Hungary has adopted an economic development plan that includes programs for climate protection, agricultural support, water resource management, quality drinking water, biodiversity, and green infrastructure development. Financing for these climate projects is coming

[142] The European Climate Adaptation Platform Climate-ADAPT. https://climate-adapt.eea.europa.eu/

from the European Regional Development Fund, the Norwegian Financial Mechanism, the Balkan Regional Trust Fund, and other sources. Hungary's impressive success in attracting resources for climate adaptation stems from the country's ability to offer donors a wide range of projects and programs.

The Czech Republic has developed an effective funding mechanism for adaptation as well. The EU GHG emission reduction regulations oblige member states to use at least 50% of revenues generated from the auction sale of carbon credits under the EU emissions trading scheme for stipulated purposes, primarily to reduce greenhouse gas emissions and to take steps related to climate adaptation.

In 2020, the Czech Republic is eligible to receive more than 1 billion euros from the sale of carbon credits and even more in the period from 2021 to 2030. Most of this revenue will be invested in energy efficiency and renewable energy sources, but other national priorities including improvements in agriculture, forestry, air quality, and waste management. In the post-2020 period, the EU is permitting the sale of carbon credits generated from CO_2 capture projects in forestry and agriculture on the open market, which will provide additional funds for adaptation measures.

International experience in climate change adaptation management

Ivan Alexandrovich Serebritsky, Ph.D. Geol. Full Member of the Russian Mineralogical Society, Full Member of the European Academy of Natural Sciences, Honorary Worker of Nature Conservation, State Counselor of St. Petersburg, 1st Class, Deputy Chairman of the Committee for Nature Management, Environmental Protection, and Environmental Safety of St. Petersburg

International experience shows that preparation for climate change occurs at all levels—transnational, national, regional, urban and municipal. This planning takes into account not only the need to reduce emissions, but also expected increases in temperatures and water levels. This overview contains examples of existing approaches, and emphasis is placed on presenting the full range of existing documents and measures taken at different levels.

Global Standards

The key documents for coordinating work on climate change issues are:

- The Framework Convention on Climate Change, UN FCCC [1] — an agreement signed by more than 180 countries around the world, including the entire set of post-Soviet republics and all of the world's industrialized nations (Russia ratified this agreement in 1994)[2]. The main goal of the Convention is to prevent "dangerous anthropogenic impact on the climate system" [3].
- The Kyoto Protocol [5], which obliges parties to the Protocol—developed nations—to reduce greenhouse gas emissions. 192 states are parties to the Kyoto Protocol. Within the UN FCCC, the "Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP)" is responsible for ensuring the implementation of the protocol [6].
- The Paris Agreement [7] builds on the mandate of the UN Convention and, for the first time in history, unites all peoples of the world in taking decisive steps to combat and mitigate climate change and to help developing countries in this endeavor. The main goal of the Paris Agreement for this century is to keep the rise in global temperature within 2°C and even to try bringing it down to 1.5°C. The Paris Agreement was signed by the heads of 175 states, including the Russian Federation.

The European Union

In April 2013, the European Commission adopted the EU Strategy for Adaptation to Climate Change [8]. It established the framework and mechanisms for raising the EU's preparedness for current and future climate impacts. The Strategy responds to the question of "How will climate change affect Europe?" with the following answer: "Temperatures in Europe over the past decade have averaged 1.3°C above pre-industrial levels, compared to the global average increase of 0.8°C ... extreme weather events have increased in frequency, southern and central Europe is experiencing more recurrent heat waves, forest fires and droughts. Increased precipitation and flooding have amplified the risk of coastal flooding and erosion in the north and northeast of Europe. An increase in the frequency of such events can increase the scale of disasters, leading to significant economic losses, health problems, and increased mortality." The Strategy notes that the benefits of implementing an adaptation strategy outweigh the costs.

Every euro spent on flood protections can save 6 euros in damages. Between 1980 and 2011, floods in Europe killed more than 2,500 people, disrupted the lives of more than 5.5 million people, and caused more

than 90 billion euros of direct economic losses. The minimum cost of ignoring climate change adaptation is estimated at 100 billion euros in 2020 and 250 billion euros in 2050 for the entire EU.

It is important to note that the Strategy takes Europe's geographic heterogeneity into account, thus the EU was divided into zones according to the expected climate change processes and anticipated consequences in these territories. During the preparation of the Strategy, a key focal point was providing informational support to the project. The European Climate Adaptation Platform (Climate-ADAPT)[8] provides any developer with the necessary information resources to implement and support adaptation policies and decision-making. Climate-ADAPT includes a suite of adaptation planning tools, a database of projects and case studies, and information on adaptation actions at all administrative levels from local to pan-European. The platform is regularly revised with up-to-date information. Modern estimates have shown that, due to climate change, Europe's annual damage to critical infrastructure alone can increase tenfold by the end of the century, if current conditions persist (i.e., without the implementation of adaptation measures–author's note) from the current 3.4 billion euros to 34 billion euros [9]. The industry, transportation, and energy sectors will bear the highest losses. And there is growing evidence that Europe is also vulnerable to the impacts of climate change beyond its borders—through trade, international financial flows, migration [10] and security. Climate risk operates across borders due to complex global relationships between people, ecosystems, and economies. Approaching adaptation as a global public good to cope with cross-border risks can provide opportunities for strengthening international cooperation toward sustainable development. The 5-year experience of implementing the Strategy has shown that the key provisions need to be strengthened: spreading awareness to technical and executive authorities at all levels on the need to develop, adopt and implement adaptation strategies and plans remains critically important. At the same time, there is an obvious imbalance between the efforts made at national (state) and municipal (local) levels.

This deserves particular attention when implementing the National Action Plan for the first stage of adaptation to climate change for the period up to 2022 in the Russian Federation [11]. The core difficulties in developing strategies for adaptation at the municipal (local) level are often caused by the lack of necessary information, lack of dedicated specialists, insufficient funding to attract outside experts, and, in some cases, the lack of authority accorded to municipalities (as, for example,

in St. Petersburg) for the development and implementation of environmental management, environmental protection, and environmental safety programs. Our Western colleagues faced a similar problem, noted in the above report. Especially noted was a lack of understanding of the need for adaptation actions at the leadership level of some municipalities; this was associated with insufficient efforts to properly inform the leaders responsible for implementing the EU climate change mitigation policy at the local level.

At the National level

In cooperation with Member States, the European Commission has developed an Adaptation preparedness scoreboard as part of Action 1 of the EU Climate Change Adaptation Strategy (COM (2013) 216). This assessment, which evaluates the readiness of EU countries as of June 1, 2018 and analyzes the actions taken by each since 2013, can be found on the Commission website. More up-to-date and detailed information can be found on the government websites of the EU member states.

The assessment was carried out according to standardized questionnaires, which include questions related to the National Adaptation Strategies and Plans of the participating States:

- institutional structure;
- quality of national vulnerability assessments;
- creation of knowledge bases (national observation systems in relevant sectors: meteorological conditions, floods, droughts, sea level, coastal erosion, biodiversity, human / animal / plant health, etc. and climate modeling); dissemination and use of this knowledge;
- action plans:
  — quality (including the basis for assessing adaptation options),
  — mechanisms of actual implementation;
- financing mechanisms;
- inclusion in industry policy, particularly:
  — disaster risk reduction,
  — spatial planning,
  — environmental impact assessments (EIA),
  — insurance;
- cross-border cooperation;
- mechanisms for monitoring management levels and performance in different sectors

The experience of the USA in developing plans and programs for adaptation to climate change is also interesting. In accordance with the Global Change Research Act of 1990 [12], a group of experts from the United States Global Change Research Program (USGCRP) submits a report to Congress and the President at least every four years, in which it:

1. Summarizes, evaluates and interprets the Program's conclusions.
2. Analyzes the impact of global changes on the environment, agriculture, energy production and use, land and water resources, transport, human health and well-being, social issues, and biodiversity.
3. Analyzes existing anthropogenic and natural trends in global changes and predicts the anticipated developments for the next 25–100 years.

Some countries around the world conduct climate change self-assessments for their territories or in partnership with other states (such as Canada, which conducts model calculations based on data obtained from the US National Climate Assessment, NCA report). Assessment models can be different: in Saudi Arabia they are conducted according to UN recommendations; in India, they are completed in accordance with an independently developed structure of the assessment document and on the basis of research by its own scientists; in Singapore, it is done with the involvement of foreign experts. Each of the assessments contains a list of adaptation measures taken.

At the municipal (local) level

It has become critical to bring cities together to share experiences and best practices in adaptation and mitigation of climate change at the international level. Thus, in October 2005, at the initiative of Ken Livingston, the Mayor of London, 18 of the world's megacities united to develop and implement joint actions to reduce pollutant emissions and reduce the climate impact from cities. By 2006, the number of participating cities increased to 40, and, since then, the initiative has been called C40 [13]. Today this platform unites 96 cities from 50 countries (including Moscow).

The working groups created by C40 (C40 networks) help participating cities replicate, improve, and accelerate measures of accounting for and adaptation to climate-related risks. Through C40, cities find

opportunities to carry out joint projects in areas of mutual interest and benefit.

The development of strategies and plans for urban adaptation to climate change involves private investors in addition to state and international structures. To help cities build resilience to the natural, social and economic challenges of the 21st century, the Rockefeller Foundation launched the 100 Sustainable Cities Initiative in 2013. The Foundation supports its 100 selected cities in addressing sustainability issues by: providing expert support in developing resilience strategies; finding ready-made solutions and partners from the private, public, and non-governmental sectors who can help in the development and implementation of resilience strategies; maintaining an information platform for the global network of member cities to share experiences and assistance.

Conclusions

Today, at the international level, there is a sufficient volume of regulatory documents to provide a roadmap for creating strategies to adapt to climate changes and mitigate their negative consequences.

World practice in developing adaptation strategies for large territories involves addressing the needs of individual zones according to geographic and climatic conditions rather than according to administrative division: this makes it possible to increase the efficiency of the implementation of adaptation strategies.

The quality of the adopted strategies and the resulting action plans—as well as the implemented management decisions—is directly dependent on the quality of the initial data, the frequency of its revision, and the professional, scientific analysis of this data.

The development of municipal (local) adaptation plans is most effective in the presence of clearly defined rules for the development of such documents at the national (state) level, as well as the availability of information and expert support from the state and the scientific community.

The most successful and widespread dissemination of adopted and implemented adaptation strategies at the local level is observed in those places where state structures have created and supported accessible, high-quality tools for their development.

Despite the fact that adaptation issues have been on the international agenda for about 20 years, they have not generally been disseminated at the local level and, as a result, their adoption is sporad-

ic because it is dependent on legislation, financial capabilities, and the availability of local expertise.

International public, nongovernmental, and private-sector initiatives to share lessons learned in climate change adaptation can be extremely useful to municipalities and cities developing their own strategies and plans, as well as for fostering international cooperation.

Sources

1. United Nations Framework Convention on Climate Change // United Nations. New York, 1992. URL: https://unfccc.int/resource/docs/convkp/convru.pdf.
2. UN Framework Convention on Climate Change // Wikipedia. URL: https://ru.wikipedia.org/wiki/Un_Framework_convention_on_climate_Change (date accessed: 10.10.2020).
3. Climate change // United Nations. URL: https://www.un.org/en/sections/issues-depth/climate-change/ (date accessed: 10/10/2020).
4. Kyoto Protocol to the United Nations Framework Convention on Climate Change // UN Conventions and Agreements. 1997. URL: https://www.un.org/ru/documents/decl_conv/conventions/kyoto.shtml.
5. Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP) // United Nations Climate Change. URL: https://unfccc.int/process/bodies/supreme-bodies/conference-of-the-parties-serving-as-the-meeting-of-the-parties-to-the-kyoto-protocol-cmp.
6. Framework Convention on Climate Change // United Nations Organization. Paris, 2015. URL: https://unfccc.int/resource/docs/2015/cop21/rus/l09r.pdf.
7. EU Adaptation Strategy // European Commision. URL: https: //ec.europa.eu/clima/policies/adaptation/what_en.
8. 'Escalating impacts of climate extremes on critical infrastructures in Europe', Forzieri et al. (2018), Global Environmental Change 48 97–107. Study from the European Commission's Joint Research Center.
9. Climate change, impacts and vulnerability in Europe 2016, EEA Report No 1/2017, European Environment Agency, 2017.
10. Russian Federation Governmental Resolution No. 3183-r dated 25.12.2019.
11. Global Change Research Act of 1990. Pub. L. No. 101–606, 104 Stat. 3096-3104, November 16, 1990. http://www.gpo.gov/fdsys/pkg/STATUTE-104/pdf/STATUTE-104-Pg3096.pdf.
12. C40 Cities. URL: https://www.c40.org/.

Climate Change Adaptation Recommendations: Urban Infrastructure

Irina Aleksandrovna Shmeleva, Ph.D. Psych. Associate Professor of the Institute of Design and Urban Studies, Head of the Laboratory for Sustainable Urban Development at ITMO University, Director of the ANO Institute for Sustainable Development Strategy

The role of cities as central to sustainable development was outlined in Agenda for the 21st century, with a detailed analysis of the research presented in the footnoted articles.[143],[144],[145] However, UN Sustainable Development Goal (SDG) 11 regarding Sustainable Cities and Communities was only announced in 2015 with the aim of "making cities and towns democratic, safe, flexible, and sustainable."[146]

After the international community ratified the Kyoto Protocol and subsequently the Paris Climate Agreement, climate change has come to be regarded as a major issue regarding urban development and functioning at the international level.[147]

In the near future, the problem of climate change will become a central problem of urban development.[148] By 2030, climate disasters will put millions of people and their financial assets at risk; cities will be responsible for 75% of global CO_2 emissions, and will experience serious consequences from these impacts. For example, modeling 140 cities around the world has shown a correlation between CO_2 emis-

---

[143] Agenda for the 21st Century. Adopted at the UN Conference on Environment and Development. https://www.un.org/ru/documents/decl_conv/conventions/agenda21.shtml (Date accessed: 10/28/2020).

[144] Sustainable Cities. Problems of Integrated Interdisciplinary research/ Shmelev S.E., Shmeleva I.A. // International Journal of Sustainable Development. 2009. Vol.12, Issue 1. P. 4–24.

[145] Methodological problems of interdisciplinary sustainable development research in large cities/ Shmeleva I. A., Shmelev, S. E. // Interdisciplinary and applied journal "Biosphere", 2010, vol. 2, No. 1, pp. 112–125.

[146] Sustainable development Goals https://www.un.org/development/desa/disabilities / envision2030.html. (Date accessed: 10/28/2020)

[147] Cities and Climate change/ Bulkeley, H., Betsil, M. // Urban sustainability and global environmental governance. Routledge, 2005.

[148] Six research priorities for cities and climate change / Bai, X., Dawson, R.J., Ürge-Vorsatz, D., Delgado, G.C., Salisu Barau, A., Dhakal, S., Dodman, D., Leonardsen, L., Masson-Delmotte, V., Roberts, D., Schultz, S. // Nature, 2018.

sions, energy balances, and sustainable urban mobility (public transport, making cities more pedestrian friendly).[149]

According to technical standards established by GOST R 54139-2010, climate change adaptations are understood to be "strategies, policies, and measures taken to reduce the potential adverse effects on human health associated with climate change."[150] Meanwhile, many researchers consider the best option to be a combination of adaptation and mitigation measures.

The following are considered to be drivers of climate change impacts:

- population growth;
- energy and transportation policies;
- urbanization in general;
- changes in land use and development practices.

There are no mentions of cities as integral units to climate change adaptation in the "National Action Plan until 2022", but elements of urban infrastructure exposed to climatic influences are mentioned: transport, fuel and energy complex, construction, housing, utilities, and public health.[151]

Climate change problems are already reflected in a number of current building regulations (SP 131.13330.2012), while others require prompt adjustments.[152],[153],[154]

---

[149] Global cities: a multi-criteria assessment of sustainable development/ Shmeleva, I. A., Shmelev, S. E. // Interdisciplinary scientific and applied journal "Biosphere", 2019. — V. 1, pp. 1–18.

[150] GOST R 54139-2010 National standards of Environmental management in the Russian Federation. Guidelines for the application of organizational security measures and risks. Climate change.

[151] National action plan for the first year of climate change adaptation for the period up to 2022. Approved by the Russian Government Resolution No. 3183-r dated December 35, 2019 https://docs.google.com/document/d/1kelqxYACcwTdDJPOlHueDV6cwHqPe5UV93qvo 73UrSo/edit?Ts=5faaaf3d

[152] On the development and implementation of priority measures to adapt St. Petersburg to climate change / Pavlovsky, A.A. // Hydrometeorology and ecology. No 58, 2020, pp. 11–126

[153] SP 131.13330.2012 "Construction climatology. Updated edition of SNiP 23-01-99

[154] SP 32.13330.2012 "Sewerage. External networks and facilities. Updated edition of SNiP 2.04.03-85

In Russian cities, depending on their geographic location, size, and population, the problems of climate change have the following manifestations:

- for cities in coastal zones: flooding of coastal areas;[155]
- for cities in the Arctic zone: melting of permafrost and destruction of infrastructure;
- for megalopolises: citywide transformation into a "heat islands", and the emergence of localized "heat islands" inside high-rise areas; heat waves or cold waves;[156]
- for megalopolises and industrial cities: increases in the level of anthropogenic pollutants—industrial and transportation-related—as well as biogenic emissions (plant pollen, mold spores) influenced by changing weather and climate conditions; the appearance of clouds with a high concentration of pollutants over cities;
- for large cities: population health impacts from the previously-listed climate change factors;[157]
- for all cities: increases or decreases in precipitation depending on geographic location;
- changes in biodiversity, the appearance of invasive species;
- a decrease in the absorptive capacity of green spaces, and a decrease in the positive impact of green infrastructure on adaptation to climate change due to a reduction in green space areas from deforestation caused by construction, death from epiphytotic diseases and pollutants.

Moscow is the only Russian city to join the C40 International Organization of Mayors to Combat Climate Change, in 2006 and to proceed with implementing a number of projects aimed at reducing greenhouse gas emissions and climate change adaptation.[158] In 2016–2017, in Moscow, the results of climate change adaptation measures from 2011 to 2017 in the urban economy were aggregated: the efficiency of

---

[155] On the development and implementation of priority measures to adapt St. Petersburg to climate change / Pavlovsky A.A. // Hydrometeorology and ecology. No 58, 2020, pp. 11–126

[156] Humanity in a metropolis. Experience from interdisciplinary research/Ed. Revich, B.A., Kuznetsova, O.V.// M., 2018

[157] Climate change and health. Assessment, indicators, forecasts/ Revich, B.A., Maleev, V.V., Smirnova, M.D. // Moscow: 2019

[158] c40.org/cities

the energy sector increased due to gas savings from heating and new real estate was added without increases in heat consumption.[159]

St. Petersburg is extremely vulnerable to the impacts of climate change, especially the coastal areas in the Gulf of Finland.[160],[161] In 2013, the city began developing a climate adaptation strategy, but it has not yet been approved.[162] A complex of protective structures for St. Petersburg was commissioned in 2011, and a conceptual plan was developed to protect the coastal zone of the eastern part of the Gulf of Finland and water bodies within the city boundaries.[163]

The city participates in a number of international projects on the Baltic Sea: in the "Helcom project" since 1992, and in the "Russia-South-East Finland project" (2014–2020).[164]

A detailed description of St. Petersburg's experience with adapting to climate change and mitigating anthropogenic impacts on the climate system is presented in the analysis by the Committee on Nature Management, Environmental Protection, and Ecological Safety.[165]

Recommendations based on publications, expert opinions and suggestions:[166],[167],[168]:

---

[159] Approaches to forming a climate change adaptation strategy based on the example of Moscow/ Gasho, E.G.. Stepanova, M.V., Guseva, T.V. // Bulletin of the D.N. Mendeleev Russian University of Chemical Technology: Humanities and socio-economic research. — 2017, Volume 2, No VIII, pp. 136–146.

[160] The "Climate Strategy of St. Petersburg for the period up to 2030" project /Serebritskiy, I. A. //http://www.infoeco.ru/assets/les/presentation/02_prezent_klimat.pdf

[161] On the development and implementation of priority measures to adapt St. Petersburg to climate change/ Pavlovsky, A. A. // Hydrometeorology and ecology. -2020. — No. 58, pp. 11–126.

[162] https://www.gov.spb.ru/gov/otrasl/ecology/news/94902/

[163] Directorate of the complex of protective structures https://dambaspb.ru/#intro

[164] http://helcom.ru/

[165] http://www.infoeco.ru/index.php?id=8780#4

[166] On the development and implementation of priority measures to adapt St. Petersburg to climate change/ Pavlovsky, A. A. // Hydrometeorology and ecology. -2020. — No. 58, pp. 11–126.

[167] Organizer of the "Trees of Petersburg" movement.

[168] http://www.infoeco.ru/index.php?id=8780#40

- create a registry of greenhouse gas emissions in cities: a unified system for monitoring and updating data, collecting reliable statistical information through a series of long-term observations, collect updates and provide open data;
- include fuel and renewable energy sources used in the energy balance for all cities;
- limit the growth of megalopolis populations (Moscow, St. Petersburg) by implementing the Russian Federation's regional development strategies;
- reduce heat islands by reducing high-rise construction and concentrations of high-rise buildings on the boundaries of cities;
- introduce climate change adaptation measures to current planning and zoning documents;
- create special conditions of use to borders of coastal zones in coastal cities to protect residential areas from flooding;
- develop measures to climate change adaptation measures for water-supply and sanitation systems;
- develop a federal law protection, conservation, and management of green spaces in cities and a similar law for the maintenance and management of inland water bodies in cities;
- pass legislation to establish the influence of the city's "green frame" as a critical ecosystem to climate change adaptation management;
- return green space management services to ranks of the city administration;
- ensure the widespread introduction of green standards to construction by modernizing the existing regulatory framework: require green roofs on buildings and structures, adapt international standards of green certification to buildings and structures;[169],[170]
- organize professional development training of municipal, city, and regional managers regarding the problems of climate change adaptation and mitigation;
- introduce the UN sustainable development goals and climate change problems as a mandatory part of higher and secondary education curricula; educate city residents on the issues of climate change adaptation;

[169] GOST R 58875-2020 "Green" standards. Greened and maintained roofs of buildings and structures. Technical and environmental requirements.

[170] GOST R 54694-2012 Conformity assessment. Environmental requirements for real estate objects

- promote interaction and cooperation between stakeholders and citizens;
- use the experience of European projects on the dynamic impact of cities on the climate and climate change adaptation.

5. Public demand for environmental modernization as part of the technological transformation of the Russian economy

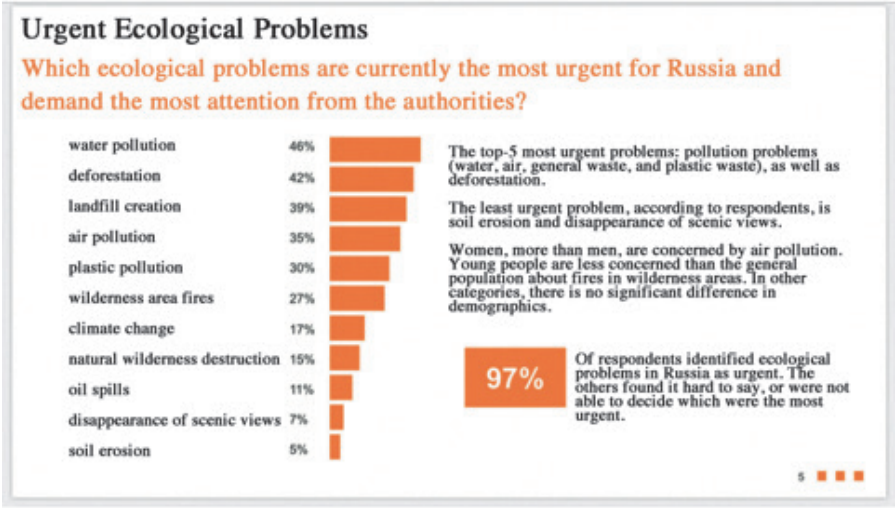
5.1. Public demand for environmental modernization

What do Russians think about climate change?

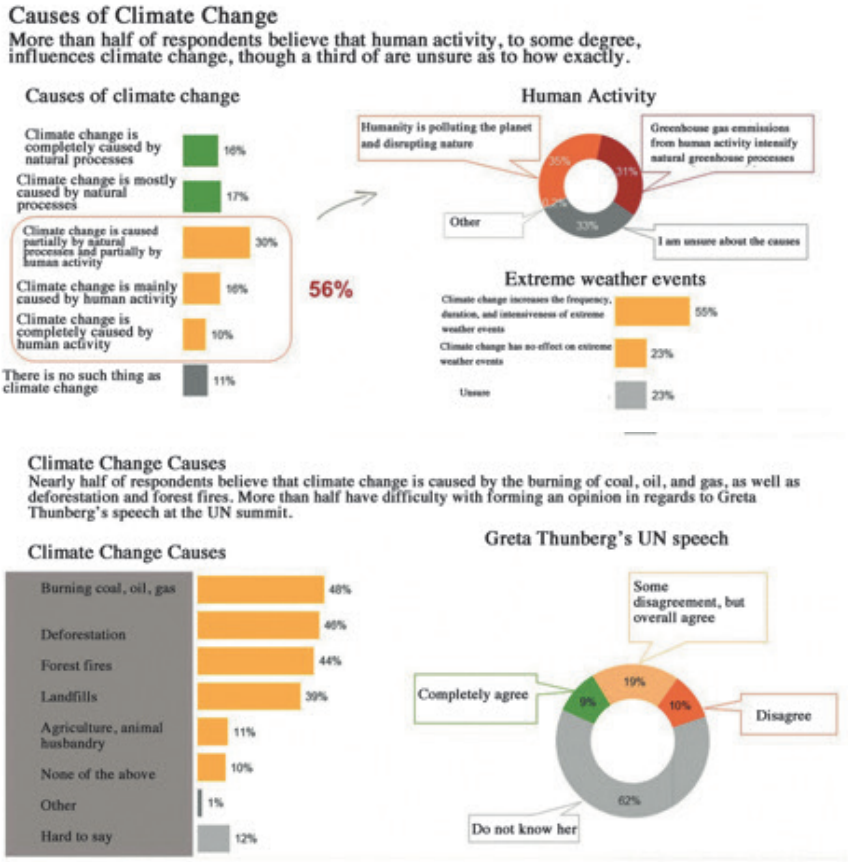
Angelina Vladimirovna Davydova, Senior Lecturer at St. Petersburg State University and the European University at St. Petersburg, editor of the "Ecology and Law" journal

Data from recent sociological studies show that the problem of climate change is becoming more urgent for Russia's residents. Until recently, climate change was of little concern to Russian society, especially when compared to waste recycling, air quality, or green spaces in cities. Now, however, the situation has begun to change.

Due to the growth of environmental protest campaigns, the influence of eco-trends, and the increased importance of conscious con-



Source: ROMIR, 2020

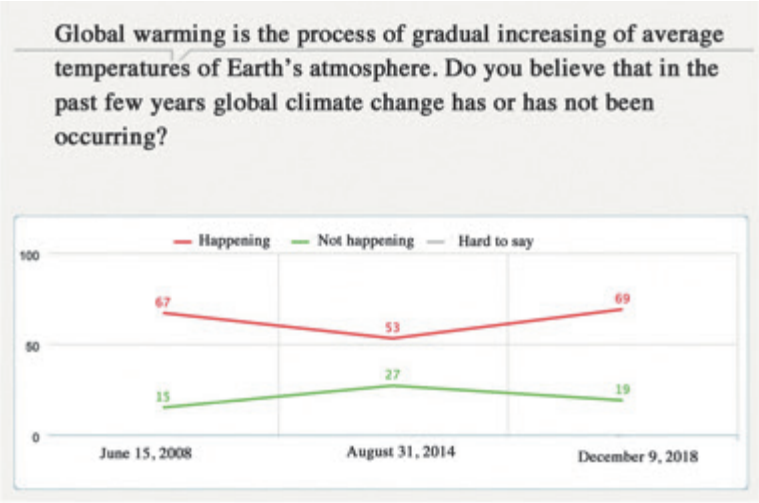


Source: ROMIR, 2019

sumption, opinion polls show that the topic of the climatic crisis has become much more of a concern for Russia's residents.[171]

The 2019 ROMIR research survey—in which 1,500 residents from different regions of Russia participated—showed that 76% of respondents "notice changes in the climate", 56% believe that these changes are at least partly caused by human activity, and 55% believe that

[171] Yuri Levada Analytical Center, "Environmental Issues" Survey, January 2020. URL: https://www.levada.ru/2020/01/23/problemy-okruzhayushhej-sredy/



Source: FOM, 2018

the frequency, duration and intensity of extreme weather events increase due to climatic changes.[172]

The more recent 2020 ROMIR survey (also polling about 1,500 residents from Russia's different regions) gives a comparable picture: 66% of the respondents believe that climate change is a "real threat now," 90% agree that change climate is a "real problem," and 86% believe that "Russia will suffer losses from climate change." Additionally, 80% of those surveyed say they are, "already experiencing the negative impact of climate change," and 69% associate it with anthropogenic activities.[173]

Results from detailed surveys reveal certain patterns (FOM, the Public Opinion Foundation of Russia, December 2018).[174]

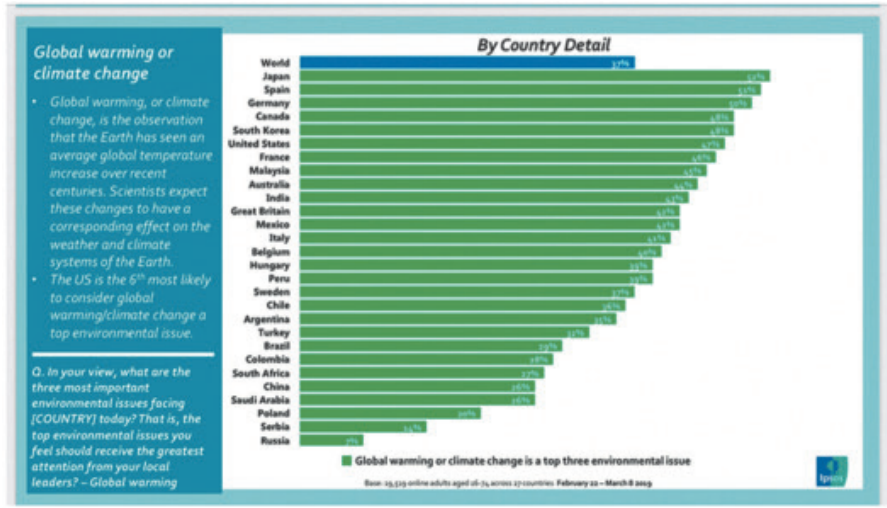
In international rankings, Russian attitudes toward the climate crisis are maturing to become more generally in line with global trends, but the climate problem is still not always included in Russia's top "green" priorities.

---

[172] "Popular attitudes to climate change" ROMIR—2020

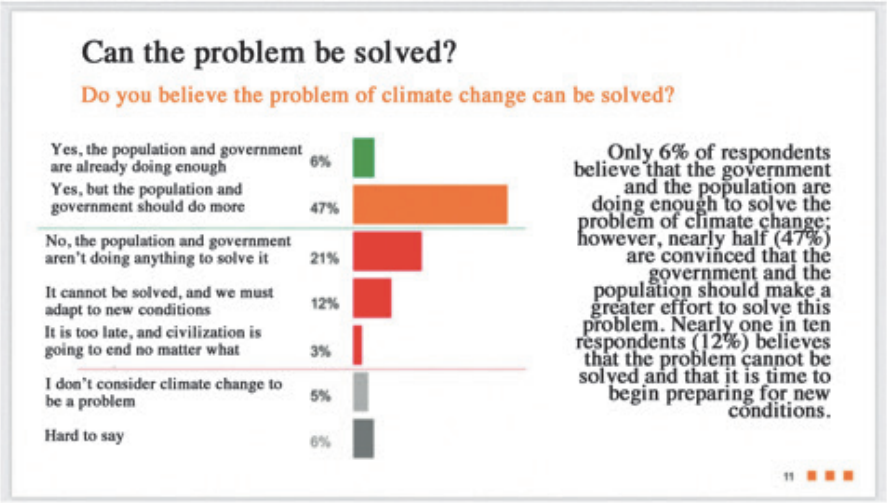
[173] Ibid.

[174] Global warming. Ideas about the causes and consequences of global warming, Public Opinion Foundation, 2018. URL: https://fom.ru/Obraz-zhizni/14149



Source: IPSOS 2018, 2019

Moreover, attitudes toward problems do not always coincide with willingness to act. Thus, the results of a study by the Russian Public Opinion Research Center (VTsIOM) and the National Energy Security Fund indicate that only 12% of Russians believe that each individual should reduce the consumption of various resources to combat global warming, and 43% of respondents believe that



Source: ROMIR, 2020

the fight against climate change should be carried out primarily by the state, through the creation of a legislative framework that controls the use of natural resources.[175] The 2020 ROMIR study shows that almost half of survey respondents are convinced that both the state and the people should take greater steps toward solve the climate crisis.

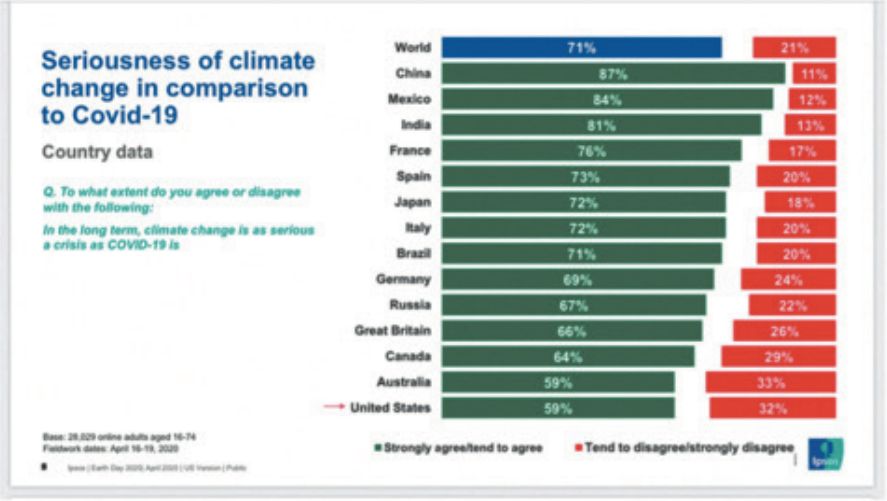
Only 15% of the respondents—22% in Moscow and 21% in other cities with populations over one million—were ready to give up travel by private car, but 43% were prepared to reduce water usage, and 59% to economize on electricity (VTsIOM, 2020). The 2019 ROMIR study gives a largely similar picture: 44% of respondents expressed interest in energy sources, and 57%, of respondents considered the transition to renewable energy sources to be correct, which is important for Russia, but 82% are not ready to add more than 5% to their bills when switching to renewable energy sources.

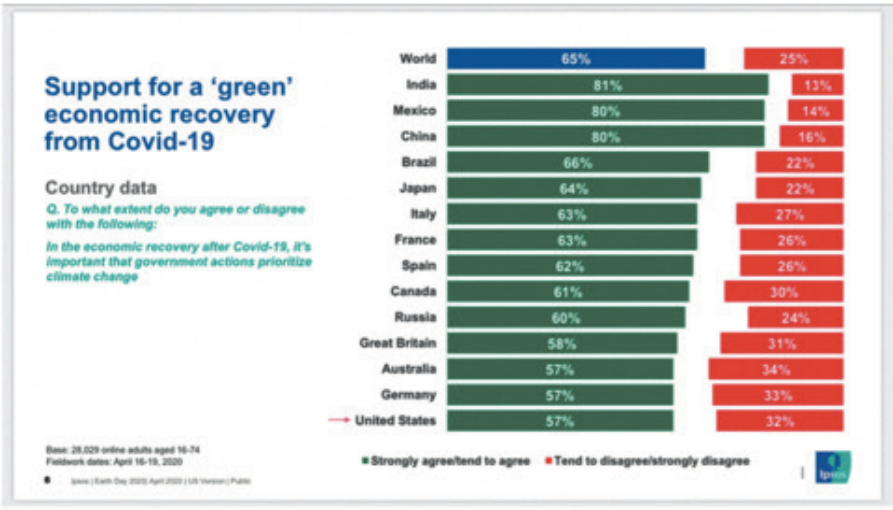
The 2020 ROMIR study provides new data related to environmentally responsible consumption: 48% of respondents believe that the quantity of purchased goods affects climate change (42% do not). Two-thirds of the respondents believe that they consume an excessive amount of disposable goods, and most respondents

[175] VTsIOM: 12% of the Russian population agrees with Greta Thunberg—August 18, 2020// https://tass.ru/obschestvo/9223313

Source: ROMIR, 2020

were ready to individually separate waste (56%), reduce the use of disposable things in everyday life (49%), and save water (42%) to solve the climate problem.





Source: IPSOS, 2020

What are you prepared to do to fight climate change?

Within this context, and even in the context of a pandemic and nationwide restrictive measures, Russians (67% of survey respondents)—like the residents of most other countries—continue to recognize the importance of the climate crisis, even during the

COVID pandemic, and 60% also support "green" economic recovery measures, according to the IPSOS Earth Day 2020 Report. According to the 2020 ROMIR study, 43% of respondents believe that "the Russian authorities should increase spending to combat climate change and prioritize this issue as part of anti-crisis measures."

5.2. Conditions in which ecological actors are found in civil society

Pressure on activists and NGOs protesting against climate change and environmentally unfriendly energy

Vitaly Servetnik, Co-chairman of the Russian Socio-Ecological Union / "Friends of the Earth — Russia"

Since the 2000s, legislation regarding environmental protection and public participation has been weakened while legislation on NGOs and civil society has grown more restrictive: this has led to the proliferation of unresolved environmental problems throughout the country. Global environmental and climate-related crises have grown increasingly obvious, which has also led to an increase in social tension and the number of public conflicts.

Since 2012, the law on foreign agents has led to the liquidation of 22 out of 32 environmental NGOs, which were declared to be foreign agents.[176] Significant suppressions of public environmental organizations caused tensions from environmental problems to boil over into street protests and direct clashes between local residents, builders, and private security guards.

Instead of dialogue with the local population, environmental NGOs, and independent experts, the response to such conflicts and protests has often been an attempt to suppress the protest and subdue environmental activists.[177]

Pressure on activists who oppose climate change and dirty energy, as well as insincere solutions to the climate crisis and the preservation of forests are all vivid examples of the deadlock in relations between society and the state regarding environmental problems and the resulting conflicts.

The climate

Fridays For Future, the youth and student movement that emerged in 2019 as a reaction to insufficient government action to the climate crisis, was met with numerous bans on pickets and rallies, fines, detain-

[176] List of NGOs identified as foreign agents from 2014 to 2020 http://rusecounion.ru/ru/ecoagents

[177] Nature's defenders under threat // Russian Socio-Ecological Union — 2020. — URL: http://rusecounion.ru/ru/defenders-envday2020.

ments and arrests of activists, as well as pressure from FSB officers on teenagers in Murmansk and Nizhny Novgorod.[178]

Dirty energy

Dirty energy projects, especially coal, are provoking more and more protests from the local population both in mining sites (Kemerovo Oblast) and shipping locations (Primorsk, Leningrad Oblast), but these protests are followed by pressure on activists.

In the fall of 2019, in Kiselyovsk, Kemerovo Region, activists were detained before a rally.[179] In 2020, journalists were persecuted for publishing a story about underground fires ignited by spent coal slag

[178] International Climate Movement Fridays for Future, 2020. — URL: http://fridaysforfuture.ru/. Disagreement in Russia regarding actions within the framework of an international climate strike // OVD-Info. — 2019.- URL: https://ovdinfo.org/news/2019/11/28/v-rossii-ne-soglasovyvayut-akcii-v-ramkah-mezhdunarodnoy-klimaticheskoy-zabastovki. A Moscow court fined an eco-activist for a picket demanding attention to the climate crisis // Apology of protest in Telegram [19.08.2020]. — 2020.- URL: https://t.me/apologia/2476. A second detention on Pushkin Square @FFFRussia activist Sonya Epifantseva // Postcard on Twitter [17.07.2020]. — URL: https://twitter.com/openrussia_team/status/1284131631473860608. At a one-person picket in Moscow // OVD-Info — 2020. — URL: https://ovdinfo.org/express-news/2020/07/24/v-moskve-na-odinochnom-pik. An activist of the climate movement Extinction Rebellion was detained in Moscow // OVD-Info. — 2020. — URL: https://ovdinfo.org/express- news/2020/01/13/v-moskve-zaderzhali-aktivista-klimaticheskogo-Dvizheniya- extinction. The court has arrested a Russian follower of Greta Thunberg/ N. Zotova // BBC. — 2020. — URL: https://www.bbc.com/russian/features-50823012. A member of the #FridaysForFuture movement said that people from the FSB came to her work // OVD-Info. — 2020. — URL: https://ovdinfo.org/express-news/2019/09/27/uchastnica-dvizheniya-fridaysforfuture-rasskazala-chto-k-ney-na-rabotu. The FSB visited an eco-activist's home // OVD-Info-2020.-URL: https://ovdinfo.org/express-news/2020/06/24/domoy-k-ekoaktivistke-prishli-iz-fsb-eyugrozhali-ugolovnym-delom.

[179] [Video] Rally in Kiselyovsk: detentions, provocations, resolution // Abazhur: View from Kuzbass — 2019. — URL: http://abajur-journal.rf/video_miting_v_kiseljovske_zaderzhanija_provokacii_rezoljucija/2019-10-27

and dust, which lasted for several months.[180],[181]The authorities later acknowledged the fire.[182]

Residents of the Novokuznetsk district of the Kemerovo region, who had been protesting against coalmines for many years, were detained and searched, and authorities attempted to fabricate a case under an extremism law against them.[183],[184]

In August 2020, also in the Kemerovo region, riot police dispersed residents of the Cheremza village who were protesting against the construction of a coal loading station near the village.[185] This resulted in 19 legal cases [212], and a journalist was accused of organizing a rally.[186],[187]

In the nearby town of Myski, that same August, five activists received fines of 25,000 rubles each for blocking the road to the Kiizasskiy open pit while attempting to draw attention to violations in the construction and operation of the utility road in the water protection zone

---

[180] In the Kemerovo Region, a case was brought against a journalist for publishing about underground fires // Siberia. Realities. — 2020. — URL: https://www.sibreal.org/a/30611554.html

[181] An activist from Kiselevsk is accused of spreading fake news/ Ivanov A. // Activacia. — 2020.- URL: http://activatica.org/blogs/view/id/10440/title/kiselevskogo-kanadca-vitaliya-shestakova-obv.

[182] Kuzbass authorities admitted that coal was burning near residential buildings in the city of Kiselevsk // Stopcoal.ru. — 2020. — URL: http://stopcoal.ru/2020/05/28/v-kiselevske-gorit-ugol /.

[183] The police detained three people protesting against the open-pit mines in Kuzbass //Taiga.Info. — 2019.- URL: https://tayga.info/148494.

[184] Kuzbass eco-activists remain witnesses after interrogation about the arson of the coal miners' tractor // Taiga.Info. — 2019.- URL: https://tayga.info/148606

[185] In Kuzbass, residents demanded that a station coal loading not be built near the village. The riot police dispersed them and detained three elderly people // Takie Dela — 2020. — URL: https://takiedela.ru/news/2020/08/14/zaderzhali-zhiteley-cheremzy/.

[186] In Kuzbass, 19 legal cases were initiated against people protesting the coal loading station // OVD-Info. — 2020. — URL: https://ovdinfo.org/express-news/2020/08/29/v-kuzbasse-na-protestuyushchih-protiv-uglepogruzochnoy-stancii-vozbudili-19.

[187] Free with fines // Stopcoal.ru. — 2020. — URL: http://stopcoal.ru/free-with-fines.

of the water intake well.[188],[189]Earlier, the governor of the Kemerovo region, Sergei Tsivilev, instructed that the coal loading station be removed, but those instructions were not carried out.[190]

In Primorsk, Leningrad Region, local residents are protesting the construction of a coal port, where deforestation is carried out without official permission, more than 200 hectares of vegetation have already been destroyed.[191] In March 2020, a hooliganism case was opened against activist Anatoly Yakimenko for comments he made on the Internet.[192]

Pressure on activists protesting against this unpromising industry looks doubly absurd at a time when ever more major countries are quitting coal, and increasing numbers of financial institutions are refusing to invest in it.[193],[194]

Forests and fires

Deforestation and forest fires also trigger reactions from activists, especially deforestation in the Central Ecological Zone of the Baikal Natural Territory. In Ulan-Ude, Nikolai Tikhonov, a deputy of the Pribaikalsk municipal formation, was fined 20 thousand rubles for organizing an

---

[188] Activists on trial for fighting coal companies in the Kuzbass town of Myski. Online updates (completed) // Stopcoal.ru-2020.-URL: https://stopcoal.ru/2020/08/27/1931/.

[189] Police will check the legality of the utility road in the Kiyzassky mine in Kuzbass // TASS. — 2020. — URL: https://tass.ru/sibir-news/9105521

[190] Marina Matienko Panov spoke about violations at a large open-cut mine in Kuzbass / Marina Matienko // Vashgorod.ru Novokuznetsk. — 2020. — URL: https://vashgorod.ru/novokuznetsk/news/1135911

[191] Shiьies moves into Primorsk. The Traber and Co. port rouses a spirit of protest in the Leningrad region // 47 News. — 2019. — URL: https://47news.ru/articles/160972/.

[192] The head of the administration complained about an eco-activist for comments posted on Vkontakte, the case went to court // OVD-Info — 2020. — URL: https://ovdinfo.org/express-news/2020/03/06/glava-administracii-pozhalovalsya-na-ekoaktivista-za-kommentariy-vkontakte

[193] European countries are giving up coal in favor of other energy sources/ Trifonova, P. //Vedomosti. — 2020. — URL: https: // www. vedomosti.ru/business/articles/2019/09/29/812345-evropeiskie-otkazivayutsya- uglya.

[194] World Bank's IFC adopts new climate rules to deter lenders from backing coal/ Green, M. // Reuters — 2020. — URL: https://www.reuters.com/article/idUSKCN26F06Y.

uncoordinated public event by inviting participants to protest against deforestation.[195] In Irkutsk, the environmental activist Egor Lesnoy was assigned 80 hours of compulsory work for repeatedly violating the rules for participation in a public event.[196]

Defenders of forests also faced pressure in Vladivostok, Barvikha, and Korolev of the Moscow Region.[197],[198],[199]

Forest fires are a systemic problem. In the Kuban, fires are caused by deliberate incineration, including agricultural burns. In recent years, the development of volunteer firefighter activity has growing. But, instead of supporting voluntary firefighters and improving fire-extinguishing systems, the Russian Ministry of Justice added the "Civil Initiative against Environmental Crime" non-profit into the register of foreign NGOs, and the organization was fined 300 thousand rubles at the end of 2019.[200] In addition, the brutal 2016 attack on the Ecological Watch camp of fire-fighting activists from the North Caucasus and

---

[195] In Ulan-Ude, a deputy was fined for using a loud speaker to invite action against deforestation // OVD-Info — 2020. — URL: https://ovdinfo.org/express-news/2020/08/08/v -Ulan-ude-oshtrafovali-deputata-priglashavshego-cherez-gromkogovoritel-na

[196] The Irkutsk court considers the cases of the participants of the August 1 rally // OVD-Info. — 2020. — URL: https://ovdinfo.org/express-news/2020/08/25/sud-v-irkutske-rassmotrel-dela-uchastnikov-mitinga-1-avgusta

[197] In Primorye, an eco-activist was fined for reading poetry near the court // OVD-Info. — 2020. — URL: https://ovdinfo.org/express-news/2020/07/24/v-primore-ekoaktivistku-oshtrafovali-za-chtenie-stihov-okolo-suda

[198] In Barvikha, people were trapped in the forest by cops // Readovka in Telegram [21.07.2020] — 2020. — URL: https://t.me/readovkanews/13482

[199] A journalist was detained in Korolev: allegedly for standing too close to another person // OVD-Info — 2020. — URL: https://ovdinfo.org/express-news/2020/04/05/v-koroleve-zaderzhali-zhurnalista-yakoby-stoyal-na-slishkom-blizkom.

[200] "Civil Initiative Against Environmental Crime" was fined under the law on foreign agents // OVD-Info — 2020. — URL: https://ovdinfo.org/express-news/2019/12/17/grazhdanskuyu-iniciativu-protiv- ekologicheskoy-prestupnosti-oshtrafovali-po

Greenpeace Russia in 2016 has not yet been investigated, and criminal proceedings have been terminated.[201],[202]

False solutions

Projects related to false solutions to the climate crisis also provoke protests from local residents. This applies to projects in the field of nuclear energy and projects aimed at obtaining energy from waste incineration.

Nuclear power

Rosatom's persecution of opponents has a rich history.[203] Activists who oppose uranium mining in the Kurgan region face threats, legal claims, and criminal lawsuits from the "Dalur" company.[204],[205],[206] In Krasnoyarsk, the activist Fyodor Maryasov, who opposes the radioactive waste burial site near the Yenisei, was accused of inciting hatred towards the social group of "nuclear scientists", a criminal case for

[201] Night attack Greenpeace and eco-watch firefighting expedition camp in Primorsko-Akhtarsk // Ecological watch in the North Caucasus-2020. — URL: http://www.ewnc.org/node/23022.

[202] Time has run out for Greenpeace/ Perova, A. // Kommersant — 2020. — URL: https://www.kommersant.ru/doc/3854095.

[203] Stories of anti-nuclear resistance: problems, protests, persecution // Russian Socio-Ecological Union — 2020. — URL: http: // rusecounion.ru/ru/antinuclearresistancereport.

[204] The Kurgan court acquitted Navalny's campaign coordinator in the bribery case // Mediazona — 2020. — URL: https://zona.media/news/2019/09/30/kurgan /.

[205] In Kurgan, the FSB opened a criminal case against an eco-activist // OVD-Info — 2020. — URL: https://ovdinfo.org/express-news/2020/04/15/v-kurgane-fsb-vozbudila-ugolovnoe- delo-protiv-ekoaktivistki

[206] Residents of the Kurgan region oppose the development of the "Dobrovolnoye" uranium deposit, fearing an environmental catastrophe // Russian Socio-Ecological Union. — 2020. URL: http://rusecounion.ru/ru/kurgan_antiuran.

extremism was initiated, and he was let go with a warning after being tried for high treason.[207],[208]

Individuals opposed to the import of German uranium waste (DUHF) into Russia were detained in Novouralsk and in St. Petersburg.[209],[210]Environmental organizations that opposed the import of "uranium tailings" were declared to be "foreign agents" by the Ministry of Justice. Ekozashchita (Ecodefense!), an environmental NGO, was included in the list of "foreign agents" for campaigning against the construction of a nuclear power plant in the Kaliningrad region. In 2019, five criminal cases were opened against Alexandra Koroleva, the director of Ekozashchita, after which she was forced to leave the country.[211],[212]

Energy from waste

Conflicts around projects for the construction of waste incineration plants have arisen in several regions of Russia. In December 2019, there was a mass detention of participants in a peaceful tent camp against illegal construction of a road to an incineration plant in the village of Osinovo in the Republic of Tatarstan.[213] Ecoactivists received

---

[207] Krasnoyarsk activist was accused of inciting hatred towards"nuclear scientists" // Meduza. — 2016. — URL: https://meduza.io/news/2016/08/25/krasnoyarskogo-aktivista-obvinili-v-razzhiganii-nenavisti-k-atomschikam.

[208] Activists in Krasnoyarsk are fighting against a radioactive waste burial ground // Russian Socio-Ecological Union — 2020. — URL: http://rusecounion.ru/ru/noradwaste.

[209] Uranium tailings created opposition in Novouralsk. There have never been any arrests and trials for protest here/ Yamshchikova, V. // 66.ru — 2020. — URL: https://66.ru/news/society/226814/.

[210] Petersburg does not want radioactive gifts/ Fomin, K. // Greenpeace.ru, blog [17.12.2019]. — 2019. — URL: https://greenpeace.ru/blogs/2019/12/17/peterburg-ne-hochet-radioaktivnyh-podarkov/.

[211] Five criminal cases brought against ecologist // Eco-protection, blog [19.06.2019] — 2019. — URL: https://ecodefense.ru/2019/06/19/ve/

[212] Alexandra Koroleva receives asylum in Germany // Eco-protection, blog [30.12.2019]. — 2019. — URL: https://ecodefense.ru/2019/12/30/alexandra-koroleva-political-refuge/

[213] Participants of an eco-camp protesting the construction of an incineration plant were detained near Kazan // OVD-Info. — 2019.- URL: https://ovdinfo.org/express-news/2019/12/16/pod-kazanyu-zaderzhali-uchastnikov-eko-lagerya-protiv-stroitelstva.

a total of 167.5 thousand rubles in fines.[214] For organizing a series of one-person pickets against the incineration plant in Kazan, Irina Nikiforova was assigned 30 hours of compulsory work.[215]

Protests and pressure on activists who opposed an incineration plant also occurred in the Noginsk District, Voskresensk, and Solnechnogorsk of the Moscow Region.[216],[217],[218]

Conclusion

Unresolved environmental problems lead to the emergence of social and environmental conflicts; unresolved tensions with local populations and environmental organizations lead to an escalation of conflicts, pressure on environmental activists, and to the further politicization of protests.[219]

The most striking example of the politicization of a local environmental conflict can be observed around the landfill near the Shiyes railway station in the Arkhangelsk region, which led to a change of governors in the Arkhangelsk region and the neighboring Komi Republic.[220]

---

[214] Judicial conveyor/ Bakin, I. // Znak. — 2019. — URL: https://www.znak.com/2019-12-17/zaderzhannym_pod_kazanyu_ekoaktivistam_vypisali_shtrafov_na_167_5_tys_odin_chelovek_arestovan.

[215] Kazan activist was assigned compulsory work for a series of pickets against the incineration plant // Mediazona. — 2020. — URL: https://zona.media/news/2020/03/18/nikiforova-30.

[216] Environmental activists in the Moscow region, were detained because of an attempt to meet with the head of the police department // OVD-Info. — 2019. — URL: https://ovdinfo.org/express-news/2020/05/19/v-podmoskove-ekoaktivistov-zaderzhivali-iz-zapopytki-vstretitsya-s.

[217] To the post and to the protest/ Vasilyeva, A. // Kommersant. — 2020. — URL: https://www.kommersant.ru/doc/4408272.

[218] In Solnechnogorsk, picketers against the incineration plant were detained after the protest // OVD-Info-2019. — URL: https://ovdinfo.org/express-news/2020/06/30/v-solnechnogorske-piketchikov-protiv-musoroszhigatelnogo-zavoda-zaderzhali.

[219] The Shiyes candidate. Environmental protest has become political/ Britskaya, T. // Novaya Gazeta. — 2020. — URL: https://novayagazeta.ru/articles/2020/08/08/86582-kandidat-shiesa.

[220] Victims of Shiyes. How one landfill killed two governors — Komi and the Arkhangelsk region // Meduza. — 2020. — URL: https://meduza.io/feature/2020/04/03/zhertvy-shiesa.

In March 2019, the UN Human Rights Council adopted a resolution recognizing the contributions of environmental rights defenders to human rights, environmental protection, and sustainable development.[221] The Russian Federation has an obligation to respect, observe, protect and fulfill human rights, including environmental rights.

The Russian Social and Environmental Union (RSEU) has been monitoring pressure on environmental activists since 2012 and has formulated a set of measures necessary for exiting the current situation. As a priority measure, it is necessary to end pressure on environmental defenders, to investigate all cases of attacks and persecutions of activists. Indispensable for the protection of environmental activists is the proper investigation of environmental violations, which are associated with harassment against activists. To prevent conflict situations, the following are necessary: free access to environmental information, broad public participation in solving issues of environmental significance, and the real consideration of the views of ecologists and other citizens.[222]

5.3. The role of science and education in shaping a new climate policy

Recommendations for the support of further scientific research in the field of climate change within the Russian Federation

Alexander Vladimirovich Chernokulsky, Ph.D. Phys. Senior Researcher at the Laboratory of Climate Theory of the A. M. Obukhov Institute of Atmospheric Physics at the Russian Academy of Sciences, science secretary of the Scientific Council of the Russian Academy of Sciences on the problems of the Earth's climate

In 2009, Russia adopted the Climate Doctrine (hereinafter — the Doctrine), which formulated the main principles of climate policy, including those related to the development of climate science in Russia. Noted in it are the need for developing and implementing a state program to provide high-tech equipment to national climate research centers,

[221] Human Rights Council, fortieth session. UN General Assembly. — 2019. — URL: https://undocs.org/ru/A/HRC/40/L.22/Rev.1.

[222] Old hot spots, ne persecutions: Shiyes, Kushtau, Stop-GOK, Moscow Khorda, "green" territories in Vologda, Nizhny Novgorod and Moscow // Russian Socio-Ecological Union. — 2020. — URL: http://rusecounion.ru/ru/ehrd-sept2020.

the need for deeper integration of Russian climate science with international research programs, and the need to ensure that climate research in Russia complies with the world standards.

Adhering to these principles would make it possible for the results of Russian studies to be more reliable and useful in interstate political dialogue regarding climate problems. However, most of the declared principles were not put into practice and remained on paper.

The technology gap in Russian climate research and Russia's non-participation in large-scale climate research or international experiments all push Russian scientists to the periphery of climate science. For example, among the top 2006 most cited scientists in the field of meteorology and atmospheric sciences, only 8 are Russian (for comparison, 125 scientists from this list work in China, 120 in Germany, and 1021 in the USA); Among the top 528 most cited scientists in the field of forestry, only one is from Russia.[223] In the CMIP6 international project for comparing models of earth's systems, there is only one model from Russia, and its involvement is limited due to insufficient computer processing power. In the AERONET project for monitoring atmospheric aerosols, only 11 stations (out of the more than 600 installed globally) are operating on Russia territory. Of the more than 750 stations in the FLUXNET observation network for flows of greenhouse gases from terrestrial ecosystems, only 15 operate in Russia. Russia does not participate in the Argo global international oceanographic project, which studies ocean density using drifting profiling buoys. Observation data from Russian research satellite systems are not widely used due to their lagging technology and difficulties with accessing data. Paleo-climatological studies are limited due to the lack of modern mass-spectrometry equipment. Unfortunately, this list can be continued at much greater length.

Nonetheless, Russia once possessed a very strong scientific school in the field of theoretical climate research—one need only recall the names of M. F. Spassky, G. I. Wild, A. I. Voeikov, A. M. Obukhov, A. S. Monin, M. I. Budyko, and G. I. Marchuk. However, without new personnel, without modern equipment, and without the ability to carry out complex numerical calculations and participate in large-scale observational experiments, schools of climatology science in Russia are falling into decay. The voice of Russian climatologists is growing faint-

[223] According to data on 160 thousand of the most cited scientists in the world for 2019, according to the Scopus database 2019: https://journals.plos.org/plosbiology/article?Id=10.1371%2Fjournal.pbio.3000918.

er. This means that Russia's arguments on climate problems in international political dialogue will be increasingly weak.

In order to advance climate research in Russia, it is expedient to implement the idea of developing a state program to provide high-tech equipment to national climate research centers (for example, within the framework of the planned Federal Scientific and Technical Program "Climate and Ecology") as laid down in the Doctrine.

Both existing organizations and newly created centers within specialized academic institutions, institutions of higher education, and Roshydromet can act as national centers for climate research. High-tech equipment for such centers should include, among other things, modern supercomputers (for carrying out numerical calculations with climatic models), mass spectrometers (for studying air composition, paleo-climatological studies), etc., in order to ensure Russia's full participation in the Global Climate Observing System (and capabilities of observing various layers—the atmosphere, hydrosphere, biosphere, cryosphere and lithosphere). The observational data must be open to researchers, both Russian and foreign. Adequate funding should address the issue of "data trading".

It must be noted that such high-tech equipment and participation in long-term observation campaigns is not possible within the framework of grant funding for science.

The issue of scientific and engineering personnel should be resolved as soon as possible. While several funding options have recently appeared to support young researchers in science, there are no such mechanisms for engineering personnel. Such an imbalance can lead to the fact that there will be no one to operate the acquired high-tech equipment for climate research.

State, societal, and business demand for the results of climate science, along with decent wages, should become an incentive for attracting new personnel. Applying research results to assessing the risks and benefits associated with the effects of climate change—as well as finding opportunities for adapting to these effects—is a prerequisite for climate policy, which is separately noted in the Doctrine. However, at the moment, the short-term planning horizon does not allow for the results of climatological research to be fully utilized. A societal paradigmatic shift is required: we must transition from reacting to current events toward proactively adapting to the changes expected in the coming decades. In the case of expanding the planning horizon, the demand for climate research will be extremely high.

Such steps will allow Russian climate research to correspond to global standards (and even surpass them in some areas). Fundamental problems of climate physics should be addressed within the framework of these studies by: performing quantitative assessments of the role of natural and anthropogenic factors of climate change at different temporal and spatial scales; identifying specific mechanisms that cause rapid climatic changes; developing scenario forecasts for climate change in the coming decades with an assessment of uncertainty factors; studying climate predictability at various scales; evaluating the impact of climate change on air quality, etc. Applied problems of climate physics should be addressed within the framework of these studies as well by: creating effective "climate services" that provide information on possible climactic changes and their consequences in specific regions; recommending adaptation strategies to mitigate the consequences of climate change on society, on various economic sectors, and on specific companies; creating technologies for regulating the climate regionally; effectively managing climatic and natural resources; participating in the development of plans for low-carbon economic development, etc.). It is also wise to promote the education of the population by popularizing research on climate and ecology, which is actually an effective way to increase society's potential for adapting to climate change.

Climate change education

Olga Nikolaevna Senova, Co-chairman of the Russian Socio-Ecological Union, director of the Friends of the Baltic Association

Education about climate change is critically important, and while it has already received serious development in world practice, it is still underrepresented in the Russian educational system. Often, knowledge about climate change causes, consequences, prevention methods and adaption strategies to is presented in a fragmentary fashion or not presented at all: for the younger generation this contributes neither to a holistic understanding of the problem nor a sense of how to respond to it.

Environmental education actively began developing in our country in the early 1990s, and the topic of climate change could be appropriately added to that segment of the curriculum. Russian Governmental Resolution No. 1208 "On measures to improve the environmental education of the population" from November 3, 1994 determined how environmental knowledge would be publicized through the school system and through public communications; additional budgetary funds

were also set aside for the purposes of this environmental education. Between 1994 and 2004, educational programs in ecology were developed and introduced for primary schools and grades 9-10. But, in 2004, the decree expired, and the ecology course is hardly used in schools while the topic of reducing anthropogenic contributions to climate change is absent from school programs. In middle school geography courses, the concept of climate is taught, but the topic of anthropogenic climate change is not covered; the same is true for the elementary school-level course "The World Around Us".

The topic of anthropogenic contribution to climate change and the reduction of greenhouse gas emissions is touched upon in a fragmentary fashion within specialty training programs and in specialized higher and secondary education curricula: in the programs of some majors directly related to energy savings and energy efficiency, the development of renewable energy, environmental solutions in construction, etc.

The issues of reducing anthropogenic contributions to climate change are normally not even integrated into the educational curricula of such specialties as geography, construction, housing, urban planning, and forestry (where the link to climate change should be obvious). Moreover, the topic of climate change is not discussed at all in the educational curricula of humanities or technical specialties that are not directly about issues of origin, accounting, and reduction of greenhouse gas emissions.

The closest thing to education on the topic of climate change for adult specialists is the training provided in the program "Energy savings and energy efficiency" in accordance with the requirements of Article 24 FZ No. 261-FZ dated November 23, 2009. A number of organizations offer advanced training to persons responsible for energy conservation and energy efficiency in state and municipal housing and utilities organizations in accordance with the requirements of the Russian Ministry of Energy. Such training covers practical goals and methods of realizing potential energy savings and increasing the energy efficiency of budgetary institutions and organizations, taking into account the specific natures of their activities.

Additionally, a number of Russian universities are creating UNESCO departments as part of an initiative by the UNESCO Institute for Information Technologies, which has been operating in Moscow since 1997. There are about 70 such departments in Russia, including in Moscow, St. Petersburg, Kemerovo, Yekaterinburg, Kazan, etc. These departments are introducing educational programs on sustainable develop-

ment goals, which include the subject “Sustainable Development Goals No. 13: Combating climate change”.

UNESCO’s Climate Change Education for Sustainable Development (CCESD) program, launched in 2010, aims to increase climate literacy—especially young people—by explaining the existing impact of global warming. UNESCO is working with national governments to develop innovative teaching and learning approaches for integrating climate change education (CCE) into national curricula.

In state-sponsored supplementary education: at faculty development trainings, in children’s art programs, at field stations for young naturalists, and in centers of creative development, the theme of ecological and nature conservancy is developing successfully thanks to the enthusiastic efforts of teachers.

The directors of each supplementary program teach according to their own syllabus, which makes these programs ideal for environmental education, including topics of energy and resource conservation and other aspects of climate action. Teachers began introducing these topics primarily from participating in international projects initiated by public organizations.

It is now becoming more and more obvious that all sectors of society must understand the nature of climate challenges, particularly how to adapt to climate change, how to reduce damages and losses, and how to slow down climate change.

To this end, it is very important to integrate the topic of reducing the anthropogenic contributions to climate change into educational programs at all levels of the state education system, from primary schooling to the professional education of those who will seek and implement solutions in the technological, managerial, public, and industrial spheres.

Equally important is the broad informal education about climate change and responsible lifestyles to all population groups, which will reduce the human impact on the environment and climate. This requires the support and widespread distribution of proactive educational programs.

6. International climate policy: Russia's role and capabilities in the international arena for implementing a technological transformation policy

Russia's role and prospects of in developing international climate cooperation

Elena Aleksandrovna Bliznetskaya, Lecturer at the Department of Integrated International Ecological Problems and Wildlife Management, MGIMO, Ministry of Foreign Affairs of Russia

The Russian Federation ratified the UN Framework Convention on Climate Change in 1994; since then, climate issues have become an integral part of Russian foreign policy. In September 2019, Russia joined the Paris Agreement by passing a governmental resolution.[224] In this resolution and in the letter of accord sent to the UN depositary of international treaties, Russia declared three conditions for participation in the agreement: that there be no obligation to provide international climate assistance to developing countries, that the maximum possible consideration be given to the absorptive capacity of forests in the implementation of the agreement's mechanisms, and that the agreement could not be allowed to become a barrier to economic development.

Participation in international climate cooperation by any state presupposes two interconnected "contours" or delineations: external and internal. The external contour is formed through interaction with the international community on climate issues within the framework of bilateral and multilateral diplomacy. Russia regularly participates in the Conferences of the Parties to the UNFCCC, the Intergovernmental Group of Experts on Climate Change, discussions on the climate agenda in the G7 and G20, BRICS, the Conferences of the Parties to the Vienna Convention on the Depletion of the Ozone Layer and the Montreal Protocol, the Arctic Council, as well as a number of other specialized UN agencies dealing with climate issues: the World Meteorological Organization, ICAO, the International Maritime Organization, FAO; in this way, projects within the framework of international assistance to developing countries are carried out.

[224] Russian Governmental Resolution No. 1228 of September 21, 2019

Since 2007, the Russian Federation has gradually moved away from being categorized as a net recipient of international aid and into the donor category. In April 2014, consideration of new projects under the Global Environment Fund, in which Russia is a recipient of assistance, was suspended.[225]

Under the Paris Agreement, Russia has no legal obligation to provide financial assistance to developing countries in their fight against climate change; however, at the end of 2019, Russia announced a contribution of USD10 million for the period of 2020–2022 to the UNFCCC Green Climate Fund.[226] In 2017, within the framework of the Russia-UNDP Trust Fund, a thematic direction called the "Climate Window" was created, which finances and implements projects to mitigate the effects of climate change and support adaptation measures in developing countries, mainly in Central Asia. In the period from 2017 to 2020, projects totaling nearly USD9 million were implemented.[227] In addition to this, Russia provides assistance—amounting to USD7.5 million—to small island developing countries within the framework of the larger UNDP project called "Building resilience to natural disasters".[228] Under the aegis of the UN Economic and Social Commission for Asia and the Pacific (ESCAP), Russia participates in the implementation of the project to "Support countries in the Asia-Pacific region in fulfilling their obligations under the Paris Agreement", and develops guidelines to support the preparation of reports and calculations of greenhouse gas emissions for Central Asian countries (Table).

Russia's international climate-related assistance to developing countries

Project	**Recipient Country**
UNDP	
Strengthening forest fire management capacities to mitigate climate change	Armenia

[225] The World Bank acts as the trustee for the Global Environment Facility and administers the GEF Trust Fund.

[226] Russian Governmental Resolution No. 3034-r "On the implementation of the Russian Federation's payment of a voluntary target contribution to the budget of the Green Climate Fund from budgetary allocations of the federal budget of in 2020-2022." Dated 12/14/2019

[227] Based on data from https://expertsfordevelopment.ru/partners/

[228] Based on data from the UNDP Open Portal https://open.undp.org/ projects / 00112837

Building up Armenia's resilience to climate change by upgrading the hydro-meteorological service	Armenia
Drought adaptation: improving water resource planning and management in Santiago de Cuba to increase resilience and adapt to climate change	Cuba
Strengthening climate resilience in the Batken region of Kyrgyzstan by introducing climate-based irrigation and mudflow protection measures	Kyrgyzstan
Promoting resilience to climate change	Tajikistan
Building resilience to climate change in the agriculture and the water sectors	Tajikistan
Building resilience and adapting farmers in the Fergana Valley to the risks of climate change	Uzbekistan
Facilitating the implementation of the Nationally Determined Contribution under the Paris Agreement	Zimbabwe
Expanding Access to Climate Finance in the European Region and CIS	Azerbaijan, Armenia, Kazakhstan, Kyrgyzstan, Moldova, Serbia, Tajikistan, Turkmenistan, Uzbekistan
Climate Change Education and Awareness — "Climate Box"	Armenia, Kazakhstan, Kyrgyzstan, Moldova, Tajikistan, Turkmenistan, Uzbekistan
Building resilience to natural disasters for Pacific small-island developing States	Cook Islands, Fiji
ESCAP	
Supporting countries in the Asia-Pacific region to fulfill their commitments under the Paris Agreement	Central Asian states

As part of international scientific cooperation, Russian scientists regularly participate in the preparation of Intergovernmental Panel on Climate Change assessment reports.

The inner contour or delineation is associated with fulfilling agreed-upon international commitments through certain domestic policy measures aimed at accumulating scientific knowledge about climate change, reducing greenhouse gas emissions, and adapting to the observed and predicted consequences of climate change. In Russia, for 26 years, a great deal of effort has been made to fully establish climate policy as a sector of the state's activity: an organizational foundation has been created in the form of the Presidential Interdepartmental Working Group on Climate Change, the Presidential Advisory Institute on Climate Issues is operational; the Climate Doctrine and Regulatory Framework for Energy Saving and Development of Renewable Energy has been adopted; channels of scientific and political interaction have been created, which provide timely reporting under the UNFCCC and develop strategies for socio-economic development that take into account the factor of climate change.

It is important to note that Russia became an active participant in international climate cooperation and implemented all these measures in conditions when global climate policy had just begun to take shape, and Russia as a state had virtually no obligation to reduce domestic emissions or to provide international climate change assistance to developing countries. Lack of preparation regarding necessary domestic regulatory and organizational frameworks prevented Russia from taking advantage of opportunities for international trading in quotas in the first period of Kyoto Protocol obligations, and the transfer of unspent quotas in the second period, as expected, was severely limited due to their serious surplus in the European market. This situation served as a lesson that the potential for participation in international climate cooperation, as well as the potential for reducing emissions internally, remains only a potential without careful planning and timely deployment of regulatory measures. The soft conditions under which climate cooperation agreements were entered meant that, over time, Russia would develop the necessary domestic policy that would allow it to become an independent player in the fields of climate diplomacy on a par with other developed and major developing countries.

In modern realities, the state has to implement both external and internal contours of climate policy in dozens of different directions. Without clearly defined goals and objectives in the field of solving the problem of climate change, or a clear distribution of responsibil-

ity for their implementation, Russia's climate policy is doomed to be reactive and dependent on external factors, the strength and nature of which are beyond its control. The lack of a comprehensive, pragmatically implemented political plan aimed at solving the problem of climate change will result in direct economic damages from the physical impacts of the changing climate, which, according to available estimates, can reach 1–2% of GDP, and in some cases up to 4–5% of regional GDP.[229] Although estimates of indirect damages—financial losses to Russian exporters in the range of 6-50 billion euros associated with Russia's key trading partners adopting climate regulation measures—seem to be premature, they are indicative.[230]Ignoring the ongoing processes of Earth's physical systems and international economic trends will nullify any government efforts to improve the welfare of Russian citizens and the stability of its economy.

From 2009–2020 The climate doctrine served as the primary normative political and legal act for Russia's climate policy of Russia. Since its adoption, international conditions have changed dramatically, and the document that will replace the doctrine should take these changes into account when forming a solid foundation for state policy until 2030 and 2050. The key task of future climate strategy should be increasing synergy between the external and internal contours of Russia's climate policy, as well as between the short-term and long-term objectives of climate policy.

The UN Framework Convention on Climate Change stipulates that the participating countries form their own policies toward protecting the climate system from anthropogenic changes, taking into account specific national conditions. The Paris Agreement continues this line of reasoning but with a significant addition: the policies (declared commitments) should demonstrate progress made toward achieving a balance between anthropogenic emissions and removals of greenhouse gases by the second half of the 21st century (Article 4 of the Paris Agreement). The countries of the European Union, which serve as the main sales market for Russian raw materials, are building a regu-

---

[229] Assessment of the macroeconomic consequences of climate change on Russian Federation territory for the period until 2030 and beyond (summary of the report)/ Katsov, V.M., Porfiriev, B.N., // Proceedings of the Main Geophysical Observatory named after A. A.I. Voeikova. — 2011. — No. 563 . — S. 52.

[230] KPMG assessed the damage to Russia from the introduction of a carbon tax in the EU // https://www.rbc.ru/business/07/07/2020/5f0339a39a79470b2fdb51be

latory framework with an eye to 2050, where 2030 is no longer the final goal but a passing checkpoint period.

In connection with the above, several recommendations were formulated to help in gradually transitioning away from the current strategy of **situational response tactics to emerging climate risks while postponing specific, results-driven measures and toward a consistent, proactive climate policy** corresponding to Russia's status within the framework of the international climate movement and the real state of affairs in its economy.

1. Develop the necessary domestic regulatory and legal framework for climate regulation, which would allow activities to reduce greenhouse gas emissions and adapt to climate change to be implemented on a permanent and systematic basis, taking into account the obligations of the Paris Agreement and other international standards aimed at reducing anthropogenic load on the Earth's climate system.
2. In the next Paris Agreement NDC update cycle (2023–2025), establish commitments to reduce greenhouse gas emissions that are on par with those of leading countries—Russia's trading partners.
3. In developing Russia's second-round NDC and low-carbon strategy, focus on creating national conditions contribute to the fulfillment of obligations under the Paris Agreement, which will be based on the approaches and accounting methodologies recognized by the framework of the United Nations Framework Convention on Climate Change; use the most accessible emission reduction options. Such proven opportunities are available, for example, in the forest management sector.
4. Priorities for international climate cooperation must be developed. This would generally contribute to the implementation of the obligations under the Paris Agreement, taking into account national conditions and existing capacities, but also provide opportunities for a productive expertise exchange with countries facing similar climate challenges. One form of such cooperation could be an open scientific and political dialogue on reducing greenhouse emissions from forest fires with countries such as the USA, Canada, France, and Germany.
5. Develop a federal law "On the basis of state regulation of climate change mitigation", which establishes the goal of transitioning to a low-carbon development model and distributes responsibility for implementing climate-change mitigation measures between

government authorities and designates one of the ministries as the lead agency responsible for formulating climate policy and achieving the goals of government regulation.
6. Develop a federal law "On adaptation to climate change", which establishes the goal of increasing the adaptive potential of housing, utilities, transportation, and water systems, and sets the task of accounting for climate change factors when formulating the development of state sectorial strategies and programs, providing funding for programs that increase the adaptive potential of Russia's budgetary systems.
7. Develop incentive measures for institutions of higher, secondary specialized, and supplemental education to train personnel in the following specialties: "climatologist" "climatologist-economist", "climatologist-engineer".
8. Stimulate research in predicting economic consequences from climactic change and increasing the adaptive potential to climactic changes through the system of state support for basic and applied science.
9. Launch a system of state reporting on greenhouse gas emissions by Russian industries.

The hydrogen Economy and solutions to climate challenges

Vladimir Aleksandrovich Sidorovich, Ph.D. Econ., General Director of the Information and Analytical Center "New Energy"

Hydrogen is the lightest element in the periodic table: a colorless, odorless, and tasteless gas that has long been familiar to mankind and used in numerous industries.

In the scientific literature of the last century, hydrogen was initially described as a promising transportation fuel, as well as a substance for the temporary storage of "excess" energy generated by solar and wind power plants (from the electrolysis of water using solar and wind energy, "Power-to-Gas"). Some energy-importing countries have long been developing plans for building a hydrogen economy based on hydrogen technologies that replace fossil fuels in some processes and reduce dependence on imports.

In the past few years, interest in hydrogen has grown significantly. Many states have set the goal of achieving climate neutrality by the middle of this century, and hydrogen is increasingly seen as the missing link for decarbonizing economies and solving climate

problems (the use of hydrogen energy is associated with insignificant greenhouse gas emissions). In many countries, strategies for building a national hydrogen economy have been approved and budgets allocated toward solving relevant problems, which further fueled interest in the subject of hydrogen. Additionally, the issues of integrating the growing volumes of solar and wind energy into energy systems have also moved into the realm of practical questions.

In other words, the world has moved from decarbonization in theory to full-scale action. The initial stage—the formation of the RES industry—is already behind us. Other means of reducing greenhouse emissions are now receiving increasing attention, and hydrogen technologies stand out among them.

The basic principles of decarbonizing the structure of energy production and consumption in the economy can be schematically described as follows:

1. A growing proportion of power is generated by low-carbon technologies.
2. "Electrification of energy consumption": electricity's share as energy consumed by end-users is growing.
3. A significant portion of consumed energy that cannot be directly electrified can be decarbonized with hydrogen. Namely, the use of H_2 in industry (metallurgy, cement production, etc.), transportation (aviation, heavy road and sea transport), and heat supply.

In the case of such widespread adoption, hydrogen becomes equal in value to current energy from raw materials (oil, gas, coal). The practical use of hydrogen for solving climatic problems is currently at the initial stages. The first (albeit quite numerous) pilot projects are currently being initiated and implemented, and, in all cases, investors expect government co-financing due to the novelty of the topic and the lack of established value chains.

At this early stage, it is impossible to predict the potential global scale of the hydrogen economy, although such predictions are innumerable, and stakeholders talk about values in the trillions. For example, according to the vision of the Hydrogen Council, the market size in 2050 could reach USD 2.5 trillion, including sales of hydrogen and equipment, which is comparable to the current volume of the oil market.[231]

[231] Hydrogen scaling up. A sustainable pathway for the global energy transition // Hydrogen Council. — 2017. — URL: https://hydrogencouncil.com/en/study-hydrogen-scaling-up/.

This value can be considered as a theoretical upper bar, but data for more accurate quantitative estimates are currently insufficient. However, there is no doubt that hydrogen consumption will grow exponentially and the market will be massive.

According to BloombergNEF, the global demand for hydrogen in 2050 may reach 187–696 million metric tons, depending on the development of the world economy. The previously indicated upper limit corresponds to almost a quarter of the end-use energy consumption on Earth.[232] For comparison, today the world consumes about 70 million tons of hydrogen.

Much debate is focused on the origin of hydrogen in the hydrogen economy (hydrogen is not obtainable in its pure form; it must be produced). Today hydrogen is produced mainly using fossil fuels—natural gas (primarily), oil and coal. Greenhouse gases are emitted in the process of its separation. For solving climatic problems, such hydrogen, known as "gray hydrogen", is not suitable; the process must be decarbonized using carbon capture and storage technologies (CCS). Hydrogen produced from fossil fuels with CO_2 capture in the process is often referred to as "blue hydrogen". Hydrogen produced by electrolysis using renewable energy is called "green hydrogen". Already, there are lively discussions about the role of one or another type of low-carbon hydrogen in the medium- and long-term. The differences in opinion are due, among other things, to different in interests of economic entities (for example, raw materials companies are interested in promoting blue hydrogen, and electric companies, green). As a general rule in politics, green hydrogen is declared a priority while noting, "blue hydrogen can also play an important role in the first stage of the hydrogen transition, when the demand for green hydrogen exceeds supply."[233]

An intriguing aspect of the development of the hydrogen economy is the dynamics of green hydrogen's cost, which, today, is much more expensive than gray.[234] By 2050, BloombergNEF estimates that, in most regions of the world, hydrogen will be produced from solar and

---

[232] Hydrogen Economy Outlook//BloombergNEF.— 2020. — URL: https://about.bnef.com/blog/hydrogen-economy-offers-promising-path-to- decarbonization/

[233] Mainstreaming green hydrogen in Europe // Material Economics. — 2020. — URL: https://materialeconomics.com/latest-updates/mainstreaming-green-hydrogen-in-europe.

[234] Even current estimates of the cost of green hydrogen vary widely. For example, BloombergNEF (2020) cites the range of USD 2.6–4.6 per kg, which is a very optimistic estimate. According to Material Economics (2020), the cost of green hydrogen in Europe today is 5.1 euros per kilogram.

wind energy for $0.7 to $1.6 per kilogram. This roughly corresponds to current prices for the energy equivalent natural gas ($ 6–12 per million BTU).[235] However, there are also more pessimistic assessments. For example, in its report on "Estimates of the cost of hydrogen production by electrolysis: United States and Europe", the International Council on Clean Transportation (ICCT) predicts that the lowest possible price for green hydrogen in the EU and the United States in 2050 will be between USD2.23–2.44 /kilogram.[236]

If a few years ago Japan was the most active builder in the hydrogen economy, today Europe, aiming at "climate neutrality" by 2050, has taken over the leadership in terms of the scale of hydrogen tasks it has set.

The EU—and a number of its members (France, Germany)—has adopted several hydrogen strategies. Large-scale "hydrogen transition", both in Europe and Asian, may require importing hydrogen.[237]

Russia aims to become a global player in the growing hydrogen economy through the production and sale of hydrogen. According to the country's approved energy strategy, by 2024, hydrogen exports should amount to 200 thousand tons, and 2 million tons by 2035. "At the same time, Russia intends to bet not only on the export of hydrogen, but also on supplying the technologies necessary to produce this promising carbon-neutral fuel."[238]

Governmental Resolution No. 2634-r from October 12, 2020 outlines and approves an action plan ("roadmap") for the development of hydrogen energy in the Russian Federation until 2024; it is "aimed at increasing production and expanding the scope of application of hydro-

---

[235] Hydrogen Economy Outlook // BloombergNEF. — 2020. — URL: https://about.bnef.com/blog/hydrogen-economy-offers-promising-path-to-decarbonization /.

[236] Assessment of Hydrogen Production Costs from Electrolysis: United States and Europe // ICCT. — 2020. — URL: https://about.bnef.com/blog/hydrogen-economy-offers-promising-path-to-decarbonization /.

[237] The EU has published details of its hydrogen strategy/ Sidorovich, V.A. // RenEn. — 2020. — URL: https://renen.ru/opublikovana-vodorodnaya-strategiya-es-detali /.

[238] Ambrose J. Russia rules out cutting fossil fuel production in the next few decades // The Guardian. — 2020. — URL: https://www.theguardian.com/world/2020/nov/01/russia-rules-out-cutting-fossil-fuel-production-in-next-few-decades.

gen as an environmentally friendly energy carrier, as well as establishing the country as a world leader in its production and export."[239]

Russia can export hydrogen to both Europe and Asia. This can be either in the form of "electrolysis" hydrogen produced using nuclear electricity on the Kola Peninsula or from renewable energy sources in the Far East, or "blue hydrogen" produced from natural gas-powered steam reforming with CO_2 capture or pyrolysis.

As previously indicated above, this policy declares the priority of green hydrogen, but notes that, "blue hydrogen can also play an important role in the first stages of the hydrogen transition, when the demand for green hydrogen can exceed supply."

It should be noted that although plans for the export of green hydrogen are being worked out by a number of states—apart from Russia, these include Australia, Chile, the countries of the Middle East, North Africa, and others— at the current stage, it is difficult to estimate the potential volume of world trade in this gas. Additionally, there are doubts about the competitiveness of export hydrogen, since transport costs can offset its economic advantages.[240]

---

[239] Action plan ("road map") for the development of hydrogen energy in the Russian Federation until 2024 // Ministry of Energy of the Russian Federation — 2020. — URL: https://minenergo.gov.ru/node/19194.

[240] Assessment of economic prospects, including the import of green hydrogen / Sidorovich,V.A. // RenEn. — 2020. — URL: https://renen.ru/otsenka-ekonomicheskih-perspektiv-v-tom-chisle-importa-zelenogo-vodoroda /.

Appendix 1

A global warming forecast made 50 years ago is still accurate

Andrey Gennadievich Lapenas, Professor, Head of the Department of Geography and Planning, Director of the Educational Program on Biodiversity Conservation and Environmental Policy, University at Albany, State University of New York

In 1972, Mikhail Ivanovich Budyko used a simple methodology to make climate forecasts; these forecast remain surprisingly accurate today and can be used as the "business as usual" scenario for outcomes that could be expected under the, "normal course of events."

This year marks the 100th anniversary of Mikhail Ivanovich Budyko's birth (1920-2001). Fifty years ago, when the science of predicting climate change was in its infancy, this Soviet scientist made a number of climate predictions that have since proven to be surprisingly accurate.

In the West, these predictions were not as well known as some of his other works. As Budyko himself recalled in an interview in 1990, this was because most of his colleagues at that time rejected the idea of inevitable, long-term global warming, calling it completely impossible.[241]It took the scientific establishment nearly 20 years to accept Budyko's paradigm.

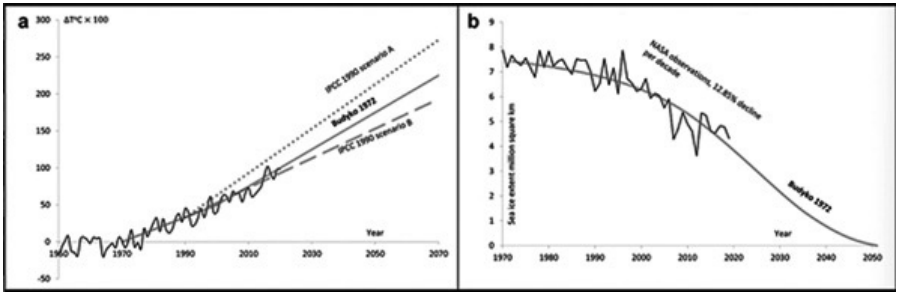
This article presents the underlying methods of Budyko's predictions, demonstrates why his forecast was an important step in the development of modern climate science, and explains why it should be the basis for a new "business as usual" global warming scenario, which illustrates the changes that could happen on Earth if we do not take additional steps above current actions to mitigate or reverse climate change.

A prophetic view of the modern climate

In 1972, even before global average temperatures began to rise sharply—which has since then been observed for half a century—Budyko published a lesser-known climate forecast for the next 100 years. He predicted that Earth's average global temperature would rise by about

[241] Oral Histories: Mikhail Budyko, Interviewed by: Spencer Weart, 25.03.1990 // American Institute of Physics. — URL: https://www.aip.org/history-programs/niels-bohr-library/oral-histories/31675.

Figure 1. Mikhail Budyko's 1972 predictions (solid gray lines): (a) surface temperature and (b) changes in Arctic sea ice. In figure (a), the thin black solid line shows the 5-year average observations of changes in global mean temperature made by NASA's Goddard Space Research Institute for "Surface Temperature Analysis" (version 4). The dotted line (periods) represents the "business as usual" scenario presented by the Intergovernmental Panel on Climate Change (IPCC); the dashed line (hyphens) represents the IPCC's low-emissions scenario. In Figure (b), the thin black solid line shows satellite observations of changes in the area of the Arctic perennial ice. The forecast of the sea ice area was calculated on the basis of Budyko's initial forecasts of the average latitude of the sea ice boundary [Budyko, 1972], assuming a round shape of the multiyear ice field and correlating this area with 1970 indicators.



2.25°C by the year 2070, and that by 2050 the Arctic would no longer be covered with ice year-round [Budyko, 1972]. (Budyko briefly mentioned the Arctic ice portion of his forecast in a 1972 paper for Eos, which has since been cited over 100 times).[242] Despite his confidence in his work, he warned that the estimates were based on assumptions about a greatly simplified climate system and should be treated as such [Budyko, 1972]; so, he might be surprised at how accurately reality has coincided with the forecasts.

Budyko predicted a 1°C increase in average global temperature and the disappearance of about 50% of perennial ice in the Arctic in 2019 as compared to 1970. Observations have confirmed these trends, demonstrating that the average global temperature has increased by 0.98°C over this period and that the area of perennial Arctic sea

[242] The future climate/M. I. Budyko // [Electronic resource] American Geophysical Union. — 1972 . — URL: https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/EO053i010p00868

ice in September 2019 was about 46% smaller than in 1970 (Figure 1).[243],[244]

The accuracy of these predictions is especially impressive in light of the prevailing degree of uncertainty in modern complex global circulation models [Zelinka et al., 2020].[245] Although these newer models allow for greater complexity, until around 2009, most models of Arctic sea ice dynamics have consistently underestimated the actual rate of ice loss in the Arctic over the past several decades.

Predictions for the new millennium. 100-year forecast

In 1972, Budyko went beyond these previously mentioned studies and published his forecast of global warming until 2070 [Budyko, 1972]. Budyko estimated the rate of global warming using simple calculations that presumed a linear relationship between the annual growth rate of global energy production and the temperature of the Earth's surface. For example, Budyko assumed that the annual increase in global primary energy consumption would increase by about 1.5 times after 2000—from 4% in the early 1970s to 6% after 2000—which should have led to the estimated a global warming rate of 0.25°C per decade instead of the 0.5 °C increase over the 30 years from 1970 to 2000 (~0.17°C per decade) that was stated in the SMIC report [Budyko, 1972]. Budyko did not give a detailed explanation of his calculations regarding the 1.5 times increase in energy consumption, but he wrote that the rate of energy consumption would inevitably increase, possibly reaching 10% per year during the 21st century [Budyko, 1972].

From 1970 to 1999, average global temperature did increase by 0.17°C per decade, and after 2000, this figure increased to 0.25°C per decade [GISTEMP Team, 2020] (Graph 1a). However, over the past several decades, annual primary energy consumption has only grown by about 2.9% per year [BP, 2019]. Obviously, Budyko overestimated the relative growth rate of primary energy consumption but correctly predicted the proportion of the absolute rate at which energy con-

---

[243] GISS Surface Temperature Analysis (GISTEMP v4) / NASA — 2020. — URL: https://data.giss.nasa.gov/gistemp/

[244] Sea Ice Concentrations from Nimbus-7 SMMR and DMSP SSM / I-SSMIS Passive Microwave Data, Version 1 // National Snow and Ice Data Center — 2020. — URL: https://nsidc.org/data/NSIDC-0051/versions/1.

[245] Why us the Climate More Sensitive in the Latest Earth System Models? / David Shultz // Eos 101 — 2020. — URL: https://eos.org/research-spotlights/why-is-climate-more-sensitive-in-the-latest-earth-system-models.

sumption increased before and after 2000, as well as the corresponding increase in temperature. From 1970 to 1999, the absolute growth in energy consumption was 15 petawatt-hours (PWh) per decade; from 2000 to 2019, it was 25 PWh per decade [BP, 2019], which corresponds to an increase of about 1.6–1.7 times. During these time periods, the ratio of the temperature trend to the increase in primary energy consumption was almost identical: 0.011°C / PWh for 1970–1999 and 0.010°C / PWh for 2000–2019. In other words, Budyko's assumption about the linear nature of the influence of energy consumption on temperature turned out to be very close to reality.

About 20 years after Budyko published his 1972 forecast, two similar scenarios, called Scenario A (the high-emissions scenario) and Scenario B (the medium-emissions scenario), were published in the first report of the Intergovernmental Panel on Climate Change (IPCC).[246] These scenarios, which are now called Representative Concentration Pathway (RCP) scenarios RCP 8.5 and RCP 6.0, respectively, are reflected in recent IPCC reports.[247] Scenario A, called "business as usual," assumes a coal-intensive energy supply, continued deforestation, uncontrolled emissions of methane and nitrous oxide from agriculture, and only partial implementation of the Montreal Protocol, which regulates emissions of ozone layer-destroying chemicals. This scenario predicts an increase in global average temperature from 0.2°C to 0.5°C per decade (averaging 0.3°C per decade). Scenario B presumes a shift towards the increased use of natural gas, significant improvements in energy efficiency, tightened controls on carbon monoxide, reversal of deforestation trends, and full implementation of the Montreal Protocol. As a result, Scenario B predicts an increase in mean global surface temperatures that is 0.2°C per decade lower than that of Scenario A. With such a spread in warming rates predicted by the IPCC in 1990, Budyko's forecast for 1972 falls right in the middle of this range (Graph 1a).

The arctic ice model

Budyko made his forecast for perennial Arctic sea ice (ice that does not melt annually) based on a semi-empirical model of the energy balance in sea ice freeze-thaw processes (graph 1b) [Budyko, 1966].

---

[246] Climate Change The IPPC Scientific Assessment [Electronic resource] // IPCC. — 1990. — URL: https: //www.ipcc.ch/report/ar1/wg1/.

[247] History of the IPPC [Electronic resource].— URL: https://www.ipcc.ch/about/history/.

Budyko realized that temperatures would rise faster in the Arctic than at lower latitudes, and that this so-called polar amplification would accelerate the melting of Arctic ice. He calculated that given an Arctic temperature anomaly of 4°C compared to 1970, a 4-meter-thick layer of ice in the central part of the Arctic would disappear within approximately 4 years [Budyko, 1966]. With a polar amplification of a factor of 2—that is, with warming in the Arctic twice the average global warming—an anomaly of 4°C in the Arctic would be reached by 2050–2060, when average global temperature would be 2°C higher than in 1970 (Graph 1a). Current climate models based on the RCP 8.5 and RTC 6.0 scenarios predict that the first ice-free summer is likely to occur somewhere between 2042 and 2054 [Peng et al., 2020].

The most realistic vision of "business as usual"

Currently, anthropogenic carbon emissions remain high. To avoid 1.5° warming by 2060 (compared to pre-industrial levels), global emissions need to be reduced by 7% per year starting today [Höhne et al., 2020]. By comparison, the COVID-19 pandemic and related lockdowns are expected to temporarily reduce annual carbon emissions by 4-7% in 2020 [Le Quéré et al., 2020]. Previous crises, such as the global financial crisis of 2008-2009 and the oil crisis of the early 1970s, also temporarily reduced carbon emissions, but these indicators have always recovered before the next crisis and often exceeded pre-crisis values. The same is likely to happen after the current pandemic, as low oil prices and economic recovery measures spur consumption growth.

Regardless of such short-term downturns and surges in emissions, even if we stopped burning all fossil fuels today, the Earth would continue to warm up by a few tenths of a degree per century for a century or longer due to accumulated thermal energy in the ocean and due to the reduced cooling effect of aerosols, which would rapidly cease entering the atmosphere after stopping the combustion of fossil fuels.[248] However, real temperature increases are likely to be more intense than this residual warming from past emissions. For example, early IPCC scenarios did not take into account such sources of GHGs as methane release from the heating of bottom sediments in the Arctic Ocean and

[248] Continued global warming after CO_2 emissions stoppage / Frölicher, T.L., Winton, M., Sarmiento, J.L. // Nature Climate Change — 2014. — URL: https://cmi.princeton.edu/wp-content/uploads/2020/02/froelicher_ncc13.pdf

diffusion through the water column, or methane release as a result of abrupt melting of permafrost.[249],[250]

The IPCC "business as usual" scenario is based on the absence of any political or economic actions to control emissions. However, over the past 30 years, the world has become more interconnected, has recognized the dire consequences of global warming, and has taken several practical steps to reduce carbon emissions. Therefore, it has recently been suggested that the current version of RCP 8.5 should be considered the worst-case scenario [Hausfather and Peters, 2020]. Yet natural methane emissions from the Arctic, or the potentially rapid increase in carbon emissions from cheap oil and other fossil fuels after COVID-19 could lead to an even worse worst-case scenario.

Reflecting on the previous 20 years, we can see that average global temperature continues to rise by 0.25°C per decade, in line with Budyko's forecast. Looking ahead, many different predictions can be made; for example, temperature trends can be assumed to worsen if the world follows the worst-case RCP scenario, or they may improve slightly if promised policy decisions and future technologies decarbonize the economy by transitioning it to alternative energy sources. At the moment, we do not see any cheap and painless methods for such a transition. Perhaps in the future we will have to resort to using Budyko's "blanket" of stratospheric aerosols to cool the planet. However, such geo-engineering projects always carry the risk of nature reacting to these external influences in different ways than we expect. Radical climate control projects need to be considered further, but their implementation should be delayed until simpler methods of mitigation no longer bring about the necessary results. It seems most likely that in the coming decade or even two, existing trends in the growth of atmospheric carbon dioxide concentration and temperature will continue, exactly as Budyko predicted in 1972.

---

[249] Arctic permafrost thaw would amplify climate change / Witman, S. // Eos, 98, — 2017. — URL: https://eos.org/research-spotlights/arctic- permafrost-thaw-would-amplify-climate -Change

[250] Carbon release through abrupt permafrost thaw / Turetsky, R.M., Abbott, B.W., Jones, M.C., Anthony, K.W., Olefeldt, D., Schuur, E.A.G., Grosse, G., Kuhry, P., Hugelius, G., Koven, C., Lawrence, D.M., Gibson, C., Britta, A., Sannel, K., McGuire, A.D. // Nature Geoscience — 2020. — URL: https://www.nature.com/articles/s41561-019-0526-0

Sources

1. BP statistical review of world energy, 68th ed. [Electronic resource] // BP. — 2019.- URL: www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2019-full-report. pdf. (Date of access: 30.11.2020).
2. On the possibility of changing climate by action on the polar ice / Budyko, M.I. // Contemporary Problems of Climatology [in Russian]. — St. Petersburg: Gidrometeoizdat. — 1966. — Pp. 347–357.
3. The effect of solar radiation variations on the climate of the Earth / Budyko, M.I.// Tellus. — 1969 . — 21. — Pp. 611–619. DOI: https: /doi.org/10.3402/tellusa.v21i5.10109.
4. Man's Impact on Climate [in Russian]/ Budyko, M.I.// — St. Petersburg:Gidrometeoizdat, 1972.
5. GISS Surface Temperature Analysis (GISTEMP), version 4, accessed 3 Mar.2020 [Electronic resource] // NASA Goddard Inst. for Space Stud., NewYork. — URL: data.giss.nasa.gov/gistemp/ (Date of access: 03.03.2020).
6. Emissions — the 'business as usual' story is misleading / Hausfather, Z., Peters, G. P.// Nature. — No 577. — Pp. 618–620. DOI: https: //doi.org/10.1038/d41586-020-00177-3.
7. Emissions: World has four times the work or one-third of the time / N. Höhne et al. // Nature. — 2020. — No 579. — Pp. 25–28. DOI: https://doi.org/10.1038/d41586-020-00571-x.
8. Temporary reduction in daily global CO_2 emissions during the COVID-19 forced confinement / Le Quéré, C. et al. // Nat. Clim. Change. — 2020. — No 10. — Pp. 647–653. DOI: https://doi.org/10.1038/s41558-020-0797-x.
9. (1972), The role of the oceans and biosphere in the carbon dioxide cycle / Matcha, L. // The Changing Chemistry of the Oceans: Proceedings of the Twentieth Nobel Symposium Held 16–20th August, 1971 at Aspenasgarden, Lerum and Chalmers University of Technology, Goteborg, Sweden, edited by Dyrssen, D. and Jagner, D. Wiley Intersci. Div., Stockholm, 1972. — Pp. 121–145.
10. Estimates of future change of climate due to the increase of carbon dioxide concentration in the air / Manabe, S.// Man's Impact on the Climate: Report of the Study of Man's Impact on Climate (SMIC), edited by Matthews, W. H., Kellogg, W.H. and Robinson, G.D.- MIT Press, Cambridge, Mass., 1971. — Pp. 249–264.
11. Inadvertent Climate Modification: Report of the Study of Man's Impact on Climate (SMIC) / Matthews, W.H., Kellogg, W.H., and Robinson, G.D. (Eds.). — MIT Press, Cambridge, Mass., 1971. — 332 p.
12. Sea ice export through the Fram Strait derived from a combined model and satellite data set / Min, C. et al. // Cryosphere. — 2019. — No 13. — Pp. 3.209–3.224. DOI: https://doi.org/10.5194/tc-13-3209-2019.
13. An emergent constraint on transient climate response from simulated historical warming in CMIP6 models / Nijsse, F.J.M.M, Cox, P.M., and

Williamson, M.S. // Earth Syst. Dyn. — 2020. — No 11. — Pp. 737–750. DOI: https://doi.org/10.5194/esd-11-737-2020.
14. What do global climate models tell us about future Arctic sea ice coverage changes? / Peng, G. et al. // Climate. — 2020. — No 8 (1), 15. DOI: https://doi.org/10.3390/cli8010015.
15. Causes of higher climate sensitivity in CMIP6 models / Zelinka, M.D. et al. // Geophys. Res. Lett. — 2020. — No 47, e2019GL085782. DOI: https://doi.org/10.1029/2019GL085782.

Appendix 2

A forgotten treaty is still in effect

In 1975, M.I. Budyko was working at the State Hydrological Institute, where he started the Climate Change Research Department. While working at the Russian State University for the Humanities, he created Working Group VIII (WG-8) within the framework of the Intergovernmental Agreement between the USSR and the USA on environmental protection and climate change. WG-8 anticipated UNESCO's activities on this topic, held numerous international meetings on the problem of climate change, and also sponsored a number of joint publications by Soviet and American climatologists such as, "Coming Climate Changes" (1991). Budyko was the permanent chairman of WG-8 during all the years of its existence. After the collapse of the USSR, the activities of WG-8 were essentially terminated, but the agreement was never terminated.

We propose resuming the work of WG-8 on environmental protection and climate change under this agreement.

Agreement on Cooperation in the Field of Environmental Protection between the United States of America and the Union of Soviet Socialist Republics

The United States of America and the Union of Soviet Socialist Republics; Attaching great importance to the problems of environmental protection; Proceeding on the assumption that the proper utilization of contemporary scientific, technical and managerial achievements can, with appropriate control of their undesirable consequences, make possible the improvement of the interrelationship between man and nature;

Considering that the development of mutual cooperation in the field of environmental protection, taking into account the experience of countries with different social and economic systems, will be beneficial to the United States of America and the Union of Soviet Socialist Republics, as well as to other countries;

Considering that economic and social development for the benefit of future generations requires the protection and enhancement of the human environment today;

Desiring to facilitate the establishment of closer and long-term cooperation between interested organizations of the two countries in this field;

In accordance with the Agreement between the United States of America and the Union of Soviet Socialist Republics on Exchanges and Cooperation in Scientific, Technical, Educational, Cultural, and Other Fields in 1972-1973, signed April 11, 1972, and developing further the principles of mutually beneficial cooperation between the two countries, have agreed as follows:

ARTICLE 1

The Parties will develop cooperation in the field of environmental protection on the basis of equality, reciprocity, and mutual benefit.

ARTICLE 2

This cooperation will be aimed at solving the most important aspects of the problems of the environment and will be devoted to working out measures to prevent pollution, to study pollution and its effect on the environment, and to develop the basis for controlling the impact of human activities on nature.

It will be implemented, in particular, in the following areas:

- air pollution;
- water pollution;
- environmental pollution associated with agricultural production;
- enhancement of the urban environment;
- preservation of nature and the organization of preserves;
- marine pollution;
- biological and genetic consequences of environmental pollution;
- influence of environmental changes on climate;
- earthquake prediction;
- arctic and subarctic ecological systems;
- legal and administrative measures for protecting environmental quality.

In the course of this cooperation the Parties will devote special attention to joint efforts improving existing technologies and developing new technologies which do not pollute the environment, to the introduction of these new technologies into everyday use, and to the study of their economic aspects.

The Parties declare that, upon mutual agreement, they will share the results of such cooperation with other countries.

ARTICLE 3

The Parties will conduct cooperative activities in the field of environmental protection by the following means:

- exchange of scientists, experts and research scholars;
- organization of bilateral conferences, symposia and meetings of experts;
- exchange of scientific and technical information and documentation, and the results of research on environment;
- joint development and implementation of programs and projects in the field of basic and applied sciences;
- other forms of cooperation which may be agreed upon in the course of the implementation of this Agreement.

ARTICLE 4

Proceeding from the aims of this Agreement the Parties will encourage and facilitate, as appropriate, the establishment and development of direct contacts and cooperation between institutions and organizations, governmental, public and private, of the two countries, and the conclusion, where appropriate, of separate agreements and contracts.

ARTICLE 5

For the implementation of this Agreement, a US-USSR Joint Committee on Cooperation in the Field of Environmental Protection shall be established. As a rule this Joint Committee shall meet once a year in Washington and Moscow, alternately. The Joint Committee shall approve concrete measures and programs of cooperation, designate the participating organizations responsible for the realization of these programs and make recommendations, as appropriate, to the two Governments.

Each Party shall designate a coordinator. These coordinators, between sessions of the Joint Committee, shall maintain contact between the United States and Soviet parts, supervise the implementation of the pertinent cooperative programs, specify the individual sections of these programs, and coordinate the activities of organizations participating in environmental cooperation in accordance with this Agreement.

ARTICLE 6

Nothing in this Agreement shall be construed to prejudice other agreements concluded between the two Parties.

ARTICLE 7

This Agreement shall enter into force upon signature and shall remain in force for five years after which it will be extend for successive five year periods unless one Party notifies the other of the termination thereof not less than six months prior to its expiration.

The termination of this Agreement shall not affect the validity of agreements and contracts between interested institutions and organizations of the two countries concluded on the basis of this Agreement.

DONE on May 23, 1972 at Moscow in duplicate, in the English and Russian languages, both texts being equally authentic.

For the Union of Soviet Socialist Republics:

N. V. Podgorny, Chairman of the Presidium of the Supreme Soviet of the USSR

For the United States of America

Richard Nixon, President of the United States of America

"Bulletin of the Supreme Soviet of the USSR", 1972, N. 23.

The Green Turn

Climate change as a political and economic challenge: a unique opportunity for the Russian Federation to technologically transform and respect the environmental rights of its citizens

Report of the Standing Committee on Environmental Rights to the Presidential Council for Civil Society and Human Rights of the Russian Federation

Published 01/11/2021
Translated from the Russian by Sasha Grafit