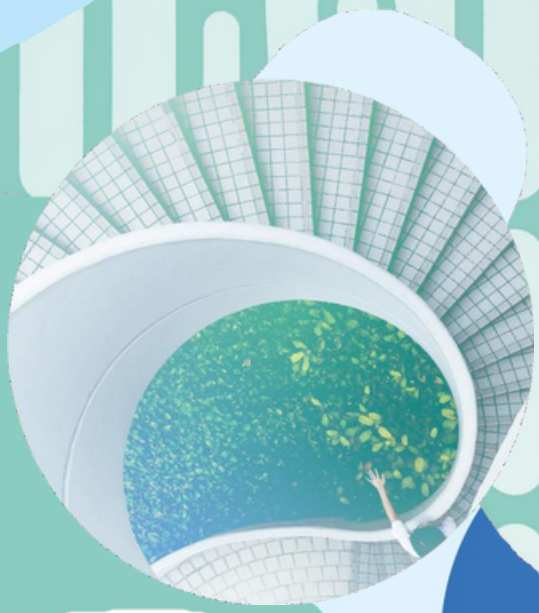

SERIES
"SOURCES OF NEW
INDUSTRIES"

ISSUE 4

Green Crossing in industry and cities

SAINT PETERSBURG

2022

SOURCES OF NEW INDUSTRIES. ISSUE 4. GREEN TRANSITION IN INDUSTRIES AND CITIES

Expert report

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This report was prepared jointly by the Center for Strategic Research "North-West" and the Innovations and Youth Initiatives Support Fund of St. Petersburg with the support of the Government of St. Petersburg.

The basis was the Foresight project "Frontiers in New Sciences". The aim of the project was to identify long-term trends and prospects for the development of new industrial and technological markets; to identify on this basis the most promising areas of research and development in the so-called "frontier" areas of R&D - advanced chemistry, synthetic biology, artificial intelligence and green technologies for industry and cities.

The methodological basis of the report is based on the analysis of the results of a foresight session with the participation of leading and young scientists, the processing of scientific data, a series of interviews with experts, surveys of executives from leading Russian companies, the evaluation of sustainable development strategies of cities and industrial concerns, the analysis of venture capital markets.

The report consists of five sections, which consider the current agenda of the green transition and the main components of its implementation: regulatory and investment policy, low-carbon development tools, carbon and fuel and energy balances of the city, the timing and cost of the green transition, scientific and technological frontiers and innovative infrastructure. The current situation and the significance of the green transition for St. Petersburg and Russia as a whole are analyzed.

The report is addressed to the government officials, specialists of the scientific and educational sector and the business community, as well as to a wide range of people interested in the issues of the green agenda.

The series "Sources of new industries"

Design: M. I. Petrova on demand of the Innovations and Youth Initiatives Support Fund of St. Petersburg

ISBN 978-5-9909736-7-1

Saint Petersburg 2022

The authors of the report express their special gratitude to the Ministry of of science and higher education of the Russian Federation for supporting of the "Frontsides in the New Sciences" foresight project

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Glossary

CCUS	Carbon capture, utilization and storage
COP	Conference of the Parties to the UNFCCC
EV	electric cars
ESG	environmental, social and corporate governance
ETS / STV	emissions trading system
GHG	greenhouse gases
PV	photovoltaics
APR	Asia-Pacific region
DVS	combustion engine
RES	renewable energy
IPCC	Intergovernmental Panel on Climate Change
IEA	International Energy Agency
UNFCCC	The UN Framework Convention on Climate Change
CBAM	Carbon Border Adjustment Mechanism
FEB	fuel and energy balance
FEC	fuel and energy complex
SDG	sustainable development goals

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Introduction

Despite the systemic changes in the macroeconomic and geopolitical context globally related to the events of February 2022, the need for a green transition in industry and cities remains an important part of the international and national agenda. Documents and programs aimed at decarbonizing the economy have been adopted in Russia. It is likely that these decisions will be optimized in the light of today's financial and economic situation.

An important milestone of the green transformation in Russia was the approval of the Strategy for socio-economic development of the Russian Federation with low greenhouse gas emissions until 2050. A law on limiting greenhouse gas emissions was adopted, as well as a national action plan for the first phase of adaptation to climate change, according to which 10 sectoral and 85 regional adaptation plans are to be prepared in 2022. A key component of the green transition is the transformation of the energy sector, which is responsible for 78% of greenhouse gas emissions in the Russian economy.

The international political environment has prompted a debate on the revision of the global energy transition agenda. The IEA has published a plan to reduce the EU's dependence on Russian natural gas[1]. This situation could both accelerate and slow down the green transition in Europe, which until recently was supplied by Russia for around 40 per cent of its gas needs. The plan proposes replacing Russian energy supplies with an accelerated deployment of renewable energy projects. On the other hand, natural gas from the Russian Federation is planned to be used as a transition fuel, and its shortage may increase consumption of fossil fuels, including coal. The geopolitical environment will also adjust the green agenda in Russia: restrictions on high-tech imports and the withdrawal of foreign companies developing green technologies could shift low-carbon development goals to a more distant future.

No matter how the geopolitical situation changes, the climate and decarbonization challenges will remain relevant in the long term. Global warming cannot be stopped in one particular country or region, it requires concerted action by all nations. Russia stands for depoliticized climate cooperation and intends to continue working with foreign partners[2]. A green agenda could be the fulcrum for communication between the countries. There is a demand for a new model for the climate agenda and international cooperation. The ESG trends of Asia-Pacific countries, Russia's most likely partners in trade relations, should also be taken into account.

Russian regions have already taken the first steps towards a green transition; we can talk about emerging leaders. To a large extent their actions are based on the initiative of local authorities and large local companies, and here first movers have a greater choice of instruments and timing of the energy transition. The establishment of international and national carbon regulation will draw all other regions into the green transformation.

The speed and quality of the green transition will largely determine the competitiveness of regions in the new post-carbon world. This raises key questions for St Petersburg. How should the green transition be implemented in the city? What will be an acceptable balance between the fuel and energy and carbon balances? How much will the green transition cost the city and what timeframe is it likely to take place? How do the costs relate to the benefits of transition? What kind of science and technology base will be needed to make a green revolution in industries? The report aims to show the forks and scenarios of the green transition that St Petersburg could follow.

1 A 10-Point Plan to Reduce the European Union's Reliance on Russian Natural Gas // IEA. URL: iea.org/reports/a-10-point-plan-to-reduce-the-european- unions-reliance-on-russian- natural-gas (accessed 03.03.2022).

2 Edelgeriev: sanctions may slow down transition to low-carbon development in RF, EU and USA // TASS. URL: tass.ru/politika/13950553 (access date: 05.03.2022).

The report is divided into five sections, outlining the main components of the green transition in the city and the current situation of St.Petersburg and Russia as a whole.

The first section outlines key transition parameters: international and Russian regulatory policies, and low-carbon development instruments.

The second chapter presents a benchmarking of climate and energy strategies of foreign cities; the challenges of the green agenda and an assessment of t h e carbon and fuel-energy balances, using St Petersburg as an example, are discussed.

The third section elaborates on the economics of the green transformation: the position of the business community, investment policies, and estimates of the timing and costs of transition.

The fourth analyses the science and technology fronts, innovation infrastructure and human resource training that will be required to realise the green transition in a modern metropolis.

The fifth chapter proposes a model for urban green transition that takes into account the components discussed in the report.

1 WHAT IS A GREEN CROSSING?

Green transition is a set of measures aimed at reducing greenhouse gas emissions and creating a sustainable resource-efficient economy in which emissions do not exceed the absorption capacity (carbon neutrality) and economic growth is not linked to the use of natural resources. The transition is realised through the use of energy-efficient solutions, clean technologies, low-carbon materials, green financial instruments, etc. A large part of the emission reduction comes from the energy sector, so it is often possible to speak of an energy transition to renewable energy sources.

ESG (Environmental, Social, Governance) criteria - environmental, social and corporate governance factors that are taken into account in the investment decision- making process - have recently become the main benchmark for the green transition for business. The report looks at environmental criteria (E), against which the environmental impact of companies is measured, including efforts to combat climate change.

The green agenda is being mainstreamed by the scientific evidence of climate change. The IPCC's sixth assessment report on climate change and its impacts was published in 2021-2022. The document provides evidence that human activities are the main driver of climate change and have been contributing to unprecedented warming for at least the past 2,000 years. Some of the changes that have started are irreversible for an enormous time period of hundreds to thousands of years (e.g., sea level rise). "The window of opportunity to avert the negative impacts of climate change is rapidly closing.[3]

3 AR6 Climate Change 2021: The Physical Science Basis //IPCC. URL: ipcc.ch/report/ar6/wg1/(accessed 07.02.2022).

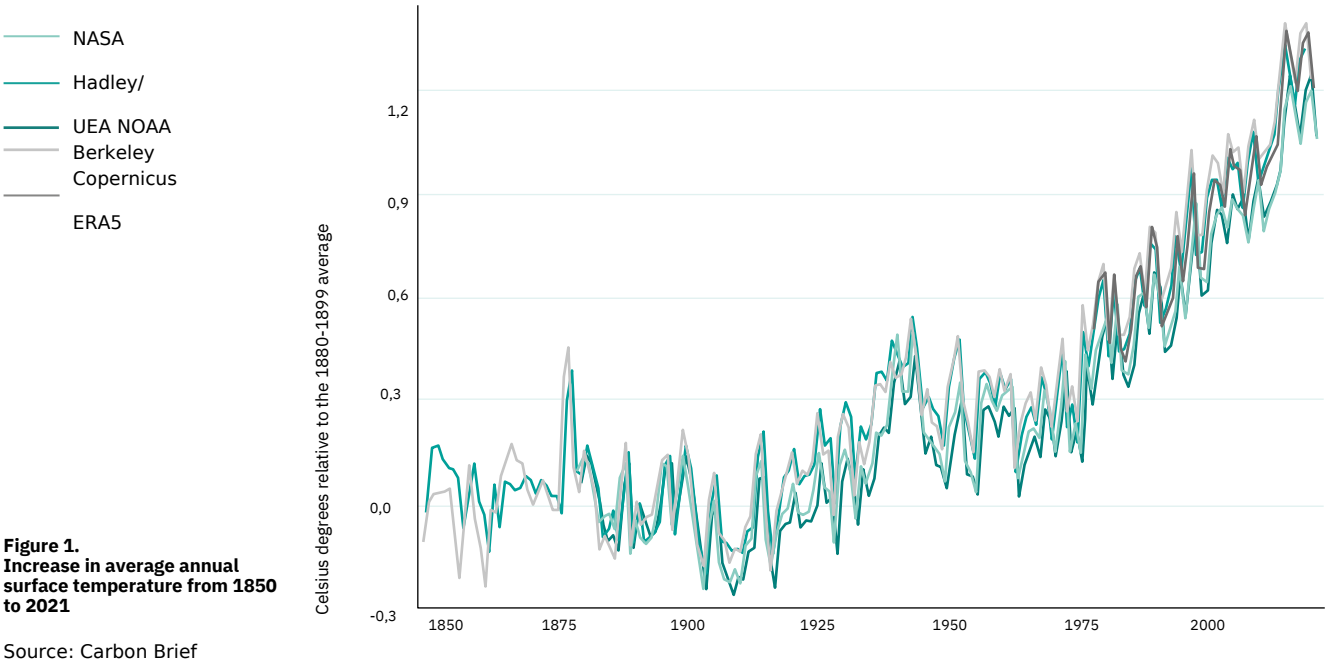


Figure 1.
Increase in average annual surface temperature from 1850 to 2021

Source: Carbon Brief

Green transition brings with it both economic risks and opportunities for transformation and the choice of a new vector of development. Experts make various forecasts about GDP losses in Russia, whose economy is heavily dependent on hydrocarbon exports. Oil and gas companies traditionally lead the list of the most profitable corporations in Russia[4], and the share of oil and gas revenues is estimated at 36% of the Russian federal budget in 2021[5].The introduction of cross-border carbon regulation in countries importing Russian energy could significantly reduce this revenue stream in the economy. Without convention, CBAM would affect the economy of St. Petersburg, a major social and economic centre where oil and gas companies are based.

For St Petersburg, the green transition means restructuring the transport sector, the energy sector and the renovation of the residential sector - the main sources of greenhouse gas emissions - as well as transforming other sectors of the economy. Complete decarbonisation of St Petersburg's economy by 2060 could cost around 10 trillion rubles. Implementing a green transition could seriously reduce losses from climate risks, in particular from flooding of coastal areas, and create a sustainable economic model with new promising industries. This would be significant even if climate policy in Russia and abroad were to soften due to the economic crisis.

4 RAEX Rating Review. URL: raex-rr.com/country/RAEX-600/rating_of_most_profitable_companies (accessed 05.03.2022).

5 Brief information on the execution of the federal budget // Russian Ministry of Finance. URL: minfin.gov.ru/ru/statistics/fedbud/execute/ (date of access: 05.03.2022).

1.1 WHICH OBLIGES CITIES TO AND INDUSTRY TO THE GREEN CROSSING?

In response to the climate agenda, international organisations have developed programmes and documents that call on countries to take action to reduce greenhouse gas emissions. The most economically developed nations are setting up cross-border carbon regulation projects. These measures will influence the economic development of cities and industries around the world.

Climate policy embodies two main approaches to climate change mitigation embedded in international instruments:

— adaptation to climate change (rebuilding infrastructures and systems to respond to extreme climate events);

— climate change mitigation (reduction of greenhouse gas emissions).

International politics

International climate change policy was legally enshrined at the international level in the early 1990s. In 1992, the UN Framework Convention on Climate Change (UNFCCC) was adopted in Rio de Janeiro at the UN Conference on Environment and Development. It is now the main international treaty on climate change.

A conference of the parties to the UNFCCC is held annually to review the application of the provisions of the Convention, decide on further development of the rules and negotiate new commitments. Important international documents (the Kyoto Protocol, the Paris Agreement) have been adopted at the conferences. The Paris Agreement is a significant international instrument that is relied upon on climate change issues. The Agreement aims to substantially reduce greenhouse gas emissions and limit the rise in global temperature this century to 2 °C, while finding the means to limit this rise even further (to 1.5 °C). By the end of 2021, 194 states and the EU had signed the Agreement, and in November of that year the 26th Conference of the Parties to the Convention was held, which led to the adoption of the Glasgow Climate Pact.

In 2015, the UN General Assembly developed a set of 17 interlinked Sustainable Development Goals (SDGs) and 169 related targets for the period up to 2030. The concept of sustainable development lies at the intersection of economy, environment and social policy. Addressing climate change is explicitly addressed in SDG 13: "Take urgent action to combat climate change and its impacts". Other SDGs are also linked to the green agenda: "Affordable and clean energy" (SDG 7), "Responsible consumption and production" (SDG 12) and "Sustainable cities and human settlements" (SDG 11). One of the central issues is to address the climate emergency within the framework of the 10-Year Action Plan to achieve the SDGs in 2020-2030.

In 2004-2005, under the auspices of the UN Global Compact, guidelines and recommendations were established on how to better integrate environmental, social and governance (ESG) measures in the financial sector[6] . These principles have now begun to be extended to other sectors of the economy.

6 Who Cares Wins // UN Global Compact. URL: d306pr3pise04h. cloudfront.net/docs/ issues_doc %2FFinancial_ markets%2Fwho_cares_w ho_ wins.pdf (accessed 25.04.2022).

The COVID-19 pandemic, sweeping the world, has brought the global challenge of climate change to the fore. The UN Secretary-General has proposed six climate improvement measures for governments to take as part of social and economic recovery from the COVID-19 pandemic. These include investing in a green transition, developing a green economy and creating green jobs.

Russian politics

To participate in shaping the global climate agenda, Russia has joined key international agreements. The Russian Federation ratified the UNFCCC in 1994, the Kyoto Protocol in 2004 and the Paris Agreement in 2019.

In order to implement the international agreements in our country, relevant laws and programmes have been approved: the Climate Doctrine of the Russian Federation (2009), the Comprehensive Plan for the Implementation of the Climate Doctrine of the Russian Federation to 2020 (2011).

In connection with the new climate agenda in 2019-2022, Russia has adopted a number of legal and regulatory instruments. Among the most important are:

—Presidential Decree No. 666 of 04.11.2020 "On Reducing Emissions of Greenhouse Gases";

—Federal Law of 02.07.2021 No. 296-FZ on limiting greenhouse gas emissions;

—Federal Law No. 34-FZ of 06.03.2022 on the Experiment to Limit Greenhouse Gas Emissions in Certain Constituent Entities of the Russian Federation;

—National Action Plan for the first phase of adaptation to climate change for the period up to 2022 (Decree of the Government of the Russian Federation of 25.12.2019 No. 3183-r);

—Strategy of socio-economic development of the Russian Federation with low greenhouse gas emissions up to 2050 (Decree of the Government of the Russian Federation of 29.10.2021 No. 3052-r);

—Criteria for sustainable (including green) development projects in the Russian Federation and requirements for the verification system for sustainable (including green) development projects in the Russian Federation (Decree of the Russian Government of 21.09.2021 No. 1587);

—The Energy Strategy of the Russian Federation for the period up to 2035 (Decree of the Government of the Russian Federation of 09.06.2020 No. 1523-r);

—The Concept of Hydrogen Energy Development in the Russian Federation (Decree of the Government of the Russian Federation No. 2162-r of 5.08.2021);

—The Concept for the Development of Production and Use of Electric Road Transport in the Russian Federation for the Period up to 2030 (Russian Government Regulation No. 2290-r of 23.08.2021).

The National Action Plan for the first phase of adaptation to climate change envisages the adoption of 10 sectoral and 85 regional climate change adaptation plans in 2022. The regional plan should be based on an assessment of the climatic risks of territories (atmosphere, hydrosphere, cryosphere and lithosphere) and primarily on the identification of climatic hazards to the anthropogenic or natural system of the region, its exposure and vulnerability to these factors (intensity, occurrence, duration), and be coordinated with a whole set of documents[7]. There is also a need to develop regional climate change mitigation plans: actions to combat greenhouse gas emissions.

For the period 2019-2024, Russia has a National Project "Ecology"[8]. Within the framework of the National Project, federal projects are being implemented aimed at reducing air emissions, eliminating landfills, and recycling and utilising waste. In April 2022, the Ministry of Natural Resources of Russia extended the term of the federal project "Clean Air" until the end of 2026[9].

7 Safety data sheet for the territory of the constituent entity of the Russian Federation in accordance with Order No. 484 of 25.10.2004 of the Ministry of Emergency Situations of the Russian Federation, e- The area passport is in accordance with the Methodological Recommendations No. 2-4-71- 40 of the Ministry of Emergency Situations of the Russian Federation dated 15.07.2016, the forest plan of the constituent entities of the Russian Federation in accordance with the Order of the Ministry of Natural Resources and Environment of Russia of 20.12.2017 No. 692, information on flooding and underflooding zones, climate safety passport for the territory of a constituent entity of the Russian Federation.

8 Passport of the National Project "Ecology" // Ministry of Nature of Russia. URL: mnr.gov.ru/activity/directions/natsionalnyy_prot_ekologiya/ (accessed 17.01.2022).

9 Ministry of Natural Resources has extended the deadline for the Clean Air project by two years // Kom- mersant. URL: kommersant.ru/doc/5315643 (access date: 27.04.2022).

The adopted documents allow for goals and actions that do not significantly change the usual strategies of the players. There is an opportunity to opt for a more radical strategy of action on climate policy in Russia and the Russian regions.

Carbon regulation mechanisms

There are carbon regulation mechanisms around the world. One is carbon markets; they can be mandatory or voluntary.

Mandatory carbon markets are created by legislation and may exist in the form of an emissions trading system (ETS) or a carbon tax. These forms are not mutually exclusive, and a hybrid format is possible. According to the World Bank, 65 carbon pricing initiatives have been implemented around the world by 2021. In 2021, these initiatives will be citivities covered 11.65 $GtCO_2$ eq, which is 21.5% of global greenhouse gas emissions.[10]

Emissions trading system

This implies setting a maximum allowable amount for certain sectors of the economy. Companies must have a permit for each unit of emissions. The largest emissions trading systems are in China and the European Union: in 2021, they cut 7.4% and 3.2% of global emissions respectively.

Carbon tax

It is a government-imposed tax rate per unit of emissions or per excess emissions over the allowable value. In contrast to ETS, the tax sets a fixed price for carbon emissions but does not guarantee that a predetermined level of emissions is achieved.

An important instrument of carbon regulation is the price of carbon. So far, only about 1/5 of global emissions are covered by pricing initiatives, and the global average price of carbon is only $3 per tonne CO2. To reduce emissions more effectively, the International Monetary Fund (IMF) has proposed a price for carbon depending on the economic development of the country. The assumption is that developed countries will pay 75 euros per tonne of CO2. It is assumed that developed countries will pay €75 per tonne of CO2, while high- and low- income developing countries will pay $50 and $25 respectively.[11]

In addition to regulators' emission allowances and taxes, there is a voluntary market for carbon units. The main driver of the market is companies that set targets to reduce greenhouse gas emissions. The market is also influenced by regulatory initiatives that allow offsets for such projects. An example is the Carbon Offsetting and Reduction System for International Aviation (CORSIA), which allows offsetting of emission reduction initiatives in fuel production[12].

Carbon units are an instrument of the law to reduce greenhouse gas emissions. They are issued when companies reduce their emissions below their allocation, can be sold or transferred to companies whose emissions exceed the quotas, and are credited, to them in assessing their negative impact on the environment.[13]

The issuance of carbon units can be regulated by international standards, e.g. with art. 66.4 of the Paris Agreement. As a result of the twentieth UN climate change conference, rules for the international trading of Carbon Units were approved, allowing participating countries to purchase them from countries that have reduced emissions below their commitments. It is envisaged that emissions will be accounted for bilaterally to avoid duplication.[14]

10 Carbon Pricing Dashboard // The World Bank. URL:carbonpricingdashboard.worldbank.org/map_data (accessed 21.03.2022).

11 Five things to know about carbon pricing // IMF. URL: imf.org/en/Publications/fandd/issues/2021/09/fivethings-too-knowaboutcarbon-pricing-parry (accessed 11.05.2022).

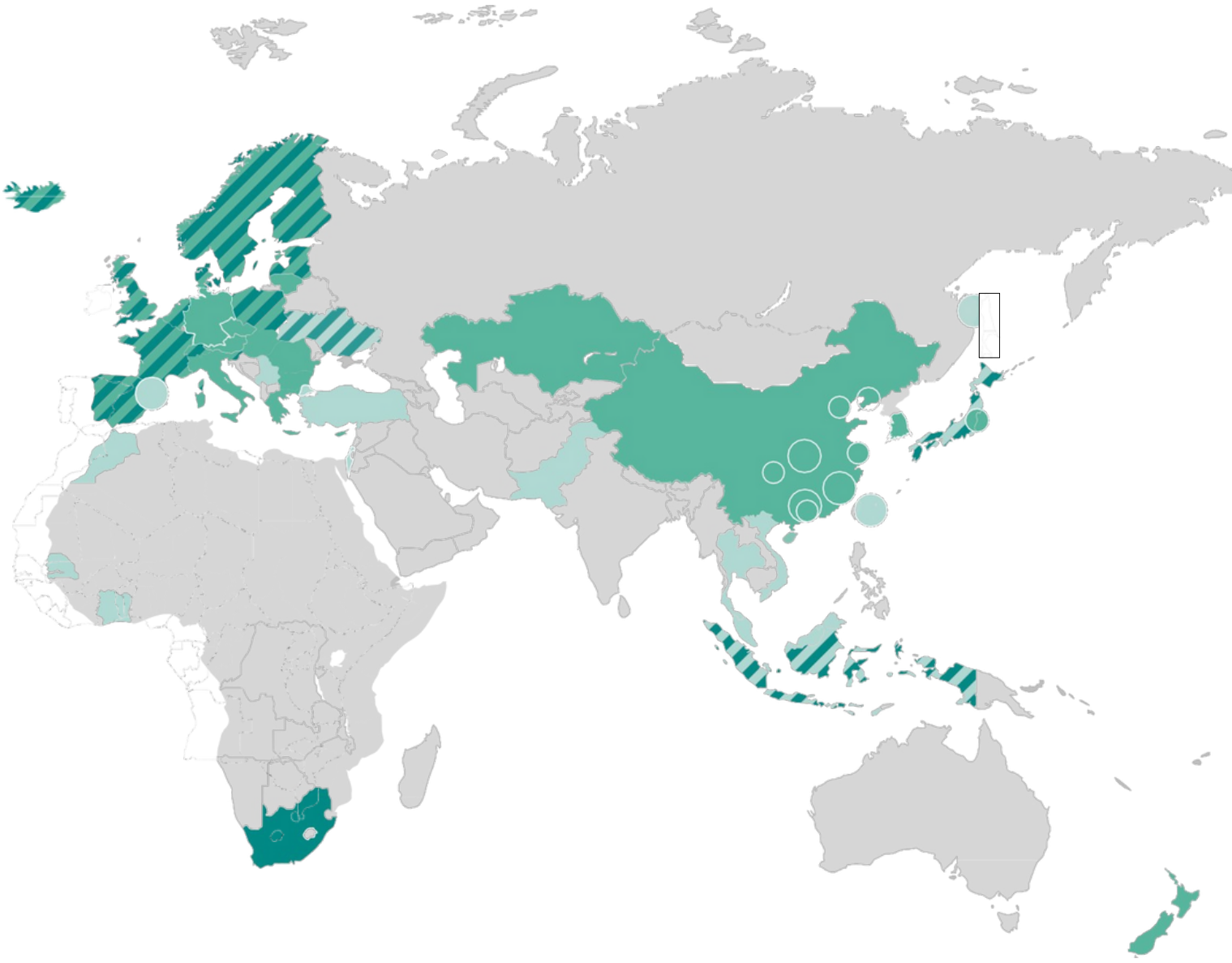
12 Carbon Offsets: Dynamics and Potential // EY. URL: ey.com/en/climate-change-sustainability-services/carbon- offsets-dynamics-and possibilities-2022 (accessed 21.03.2022).

13 Ministry of Economy: A market for carbon units in the Russian Federation is to be launched by mid-2022 // Komersant. URL: kommersant.ru/doc/5066465 (accessed on 21.03.2022).

14 Outcome of COP26: market-based andnon-market mechanisms in accordance with Article 6 of the Paris Agreement UNFCCC. URL: unfccc.int/ru/peregovorny-process- i-vstrechi/parizhskoe-soglashenie/klimaticheskiy-pakt-glazgo/ itogi-ks-26-rynochnye-i-nerynochnye-mekhanizmov- v-sootvetstvii- so-statey-6-Parizhskogo-soglasheniya#eq-1 (date of access: 17.01.2022).

Figure 2.
Map of carbon pricing initiatives, 2021

Source: The World Bank



1.2 TRANSITION SCENARIO ASSESSMENT: INTENSIVE AND INERTIAL

In 2021, the Government approved the Strategy for Socio-Economic Development of Russia with Low Greenhouse Gas Emissions until 2050. The document states the goal of achieving carbon neutrality with sustainable growth of the country's economy.

The Strategy assumes implementation of two scenarios: intensive (target) and inertial. The former envisages net emissions growth of 5.6 per cent by 2030 and a 60 per cent decrease from current levels by 2050, achieving carbon neutrality in Russia by 2060 through measures such as carbon pricing, development of green finance, support for distribution of certificates of energy origin and development of public non-financial reporting. Under the baseline scenario, net emissions would increase by 8 per cent by 2030 and 25 per cent by 2050.

The adoption of the Strategy sparked many discussions among domestic and foreign specialists. The role of absorptive capacity of managed ecosystems, which according to the target scenario is planned to increase by 124% by 2050, was particularly hotly debated. This is justified by the promotion of the principle of technological neutrality of low-carbon development in the Russian Federation - choosing the least costly options for the economy regardless of the chosen technology.

Vladimir Sklyar, Head of Electricity and Sustainability at VTB Capital	Source: Reporting interview with V.V. Sklyar, 24.01.2022

"There is a huge range of activities planned under the Strategy in different sectors. And they are reasonable in terms of the economic feasibility of decarbonisation. The problem is that no regulations have yet been adopted to regulate emission reductions in specific sectors. What incentives would encourage decarbonisation?
The problem is that regulations to reduce emissions in specific sectors have not yet been adopted. CO2 or preferential green finance?

There are no "sticks and carrots" yet. There is a goal, we will gradually reach it. Furthermore, the goal is to minimise the impact on
The goal is to minimise the impact on people so it doesn't turn into a mindless increase in prices for energy or products, as seen, for example, in the energy crises. seen, for example, in the EU energy crisis. That is why there will be some point programmes to stimulate for these investments.

Roman Lvov, Deputy Chairman of the North-West Bank, Sberbank:	Source: Reporting interview with R.V. Lvov, 10.12.2021

"Sber has been actively involved in the development of the Strategy for the Socio-Economic Development of the Russian Federation with Low Greenhouse Gas Emissions until 2050. This is a systematic document designed to unite the efforts of business, government and society to achieve the goal of

carbon neutrality. Investment in decarbonisation is a prerequisite for the implementation of the national strategy. New opportunities include the formation of carbon unit pricing and the development of a carbon trading market units".

The geopolitical situation and the introduction of anti-Russian sanctions may delay the realisation of the Strategy's goals. The Ministry of Energy has developed an anti-crisis plan in the context of sanctions for its subordinate industries: electricity, oil, gas and coal. According to the ministry, the Russian fuel and energy complex will not be able to implement the decarbonisation plan until 2050[15]. According to the Strategy's target scenario, modernisation of the power sector, oil and gas production and the introduction of CO_2 capture technologies are essential elements of decarbonisation. Together, they should reduce emissions by more than 800 million tonnes of CO_2-eq by 2050.

Energy efficiency could be one of the priorities in the new economic environment, especially for municipal residential sector, administrative and public buildings, and public transport. Increasing energy efficiency reduces CO2 and other pollutant emissions.
emissions and other pollutants while improving quality of life. quality of life. The term "energy efficiency" should be distinguished here from in the early 2010s, when the switch to energy-efficient lighting was being enforced. Energy efficiency now includes the consideration of social factors and requires adaptability and flexibility. The World Economic Forum defines an integrated energy approach as "system efficiency," with energy-efficient buildings and infrastructure, clean electrification, water and waste management as the main drivers. Central to this approach are planning and digital technologies that integrate building, energy, water and transport data.[16]

15 Plus the carbonisation of the entire country // Kommersant. URL: kommersant.ru/doc/5259768 (access date: 21.03.2022).

16 Net Zero Carbon Cities: An Integrated Approach // World Economic Forum. URL: weforum.org/docs/WEF_Net_Net_Zero_ Car-bon_Cities_An_Integrated_ Approach_2021.pdf (accessed 25.04.2022).

1.3 LOW-CARBON DEVELOPMENT TOOLS

The green transition ecosystem is in its infancy and needs incentive instruments, in particular financial ones. International and national practices of green transformation use non-financial reporting, climate risk stress testing, ESG ratings and green finance as basic tools. All these tools are now being standardised. Their consistent application will contribute to the successful green transition of companies.

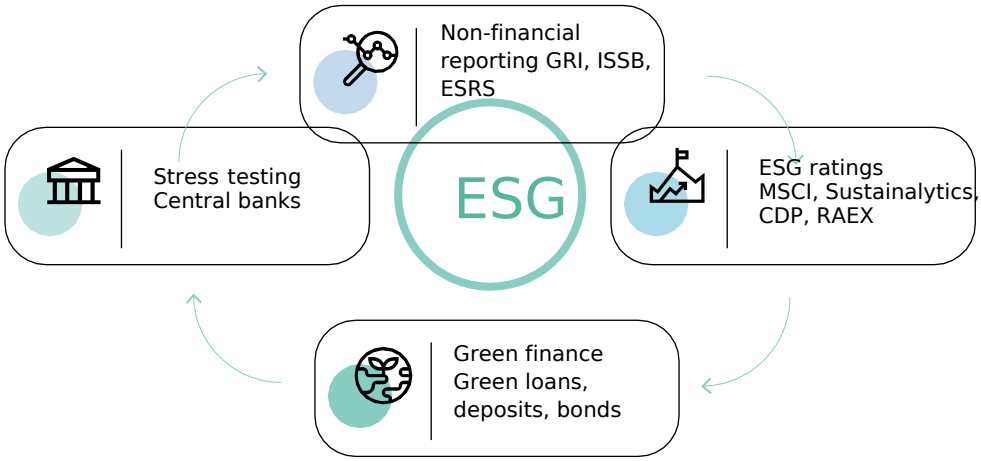


Figure 3.
Low-carbon development tools for business

Source: CSR North West

The benchmark for green transition tools is the ESG criteria: environmental, social and corporate governance. The report focuses on Dimension E: environmental principles that define how a company reduces environmental damage[17]. ESG standards are still under development, so there are differences in their assessment in relation to business.

17 ESG principles: what they are and why companies need them comply // RBC. URL: trends. rbc.ru/trends/green/614b-224f9a7947699655a435 (date (reference: 19.01.2022).

Vladimir Sklyar, Head of Electricity and Sustainability at VTB Capital

Source: Reporting interview with V.V. Sklyar, 24.01.2022

"There is a false perception in Russia right now - that ESG is separate, core business is separate. That is, you can continue pumping oil and planting trees at the same time. In fact, this is not the case. ESG is a new approach to long-term risk management. It is just that the timeframe in which these risks are realised, including climate risks, is very long. Global warming is a risk to coastal cities over a horizon of 70-80 years. Previously, such horizons were not considered.

But as the world's climate agenda has been mainstreamed and carbon taxes introduced, the long-term nature of this climate future has shrunk dramatically. We are now saying that Russian companies will have to pay an emissions tax in Europe as from 2026 and in China most likely from 2030. We do not exclude the possibility of introducing a carbon tax in the Russian Federation in 2024-2025. This is why we do not see on this as a separate new ESG business."

Stress testing to climate risks

Used as a tool to predict the financial sustainability of companies under the impact of climate change. Stress testing assesses what will happen to the business if the air temperature rises by a certain number of degrees, whether the company has facilities in a hypothetical flood zone, how it insures its risks against natural disasters, etc. The results are published as part of the annual accounts.

In Russia, climate stress testing is at an early stage of formation. The Central Bank has conducted one round of stress testing in 2021, but has not yet established a baseline forecast of 2, 3 or 5 degrees Celsius temperature rise. This forecast will be the basis for future stress testing in the Russian Federation[18].

18 Interview: Vladimir Sklyar, VTB Capital (Date:24.01.2022).

Non-financial reporting

This is corporate reporting that comprehensively reflects the results of activities and key performance indicators of the company in the field of ESG. In international practice, there are several main ESG reporting standards: GRI, ISSB, ESRS, TCFD. The Bank of Russia has developed recommendations for domestic PJSCs to disclose ESG factors [19]. The Central Bank also plans to create unified ESG reporting standards.

19 Information letter on recommendations for public disclosure by joint-stock companies of non-financial information related to t h e activities of such companies // Bank of Russia. URL: cbr.ru/Stat-icHtml/File/117620/2021071 2_ in-06-28_49.pdf (accessed 17.01.2022).

ESG ratings

They are designed to measure a company's resilience to long-term environmental, social and governance risks. Among international ratings, the best known are MSCI, Sustainalytics, CDP. There are internal Russian ratings produced by RAEX, AKRA, NCR and Expert RA agencies.

Vladimir Sklyar, Head of Electricity and Sustainability at VTB Capital	Source: Reporting interview with V.V. Sklyar, 24.01.2022

"The position of companies in ESG rankings affects access to international green finance markets. We have realised from experience that many Russian companies have significantly lower ratings than international companies with roughly similar carbon footprints. This is simply because there is not yet a proper disclosure system for non-financial climate reporting. This is a very important process, which in terms of financial costly in terms of financial investment, but also yields significant results in terms of improved ratings.

The energy company Inter RAO, without any major investment in green energy, was only able to improve its CDP rating from B- to A in 12 months through better disclosure of non-financial reporting. And there could be many such examples there could be many more.

In Russia, efforts are being made to develop a system of green finance support environmental and climate change projects. An important driver of development is the banking sector. VEB.RF, as a methodological centre for financial instruments of sustainable development, participated in the development of the taxonomy of green projects and green finance standard (criteria for sustainable development projects and requirements for the verification system)[20]. The taxonomy was a project of a working group under the Russian Ministry of Economic Development and was approved by Russian Government Resolution No. 1587 dated 21.09.2021. VEB.RF is compiling a list of verifiers of financial instruments for sustainable development, which includes seven entities as of April 2022.

20 ESG finance and the role of VEB.RF // VEB.RF. URL: veb.ru/ustoj- chivoe-razvitie/zeljonoe-finan-sirovanie/ (accessed 17.01.2022).

ESG principles are expected to be integrated into all major business lines of financial institutions. The toolkit for green finance is already very broad, ranging from green bonds to green mortgages.

Green bonds

Securities that are issued on a repayment basis and finance projects aimed at improving the environmental situation. Special attention is paid to green Eurobonds - green bonds in euros. VTB Group specialises in green Eurobonds in Russia: with its participation securities of RZD and Sovcombank have been placed.

Other advanced tools are also used in green projects. According to PwC, innovative financing is at the heart of climate technology growth. The SPAC tool[21]has raised $28 billion in climate technology in the second half of 2020 and the first half of 2021, accounting for around a third of all funding[22]. The SPAC mechanism is not yet operational in Russia; the Ministry of Economic Development of the Russian Federation planned to launch it in spring 2022.

21 Specialised company for targeted mergers and acquisitions.

22 State of Climate Tech 2021 // PwC. URL: pwc.com/gx/ en/services/sustainabilit y/ publications/state-of-climate- tech.html (accessed 10.01.2022).

2 WHAT DOES IT MEAN FOR THE CITY THE BACKLOG ON THE GREEN AGENDA?

Continuing to operate the city in the traditional paradigm, without paying attention to the challenges of the green agenda, will make it less attractive to businesses and investors who take ESG standards into account. Lagging behind the green transition entails numerous socio-economic risks: a reduction in the number of jobs, a decline in the city's position among similar centres in terms of public health, and risks of restrictions on international activities, including the tourism sector (higher costs of visits and lower attractiveness) and transport (restrictions on flights, transit and passenger traffic).

Today's green agenda requires cities to meet new environmental standards. Since the Paris Climate Agreement, many cities have developed their own climate strategies and programmes to reduce emissions and achieve carbon neutrality. The trend towards climate strategies can become a binding standard for all cities and influence their competitive advantage with investors and large corporations.

Cities and regions can be more ambitious than countries and set the trend for a green transition. For example, Finland has declared carbon neutrality by 2035 and the Finnish city of Lahti by 2025. Russia by 2060 and the Sakhalin Oblast (constituent entity of the Russian Federation) by 2025.

There are no approved climate strategies for cities in Russia. The draft climate strategies of St Petersburg (2015) and Moscow (2021) have been developed. In December 2021, the Sakhalin Oblast Climate Programme for the period up to 2025 was approved. The programme has a section on sustainable cities and includes goals for 2025: implementation of energy efficiency, resource efficiency, gasification and other programmes b y municipalities, and the start of construction of a new Ecopolis city. Given the events of February 2022, there is a risk that decarbonisation projects in Russian cities and regions will be delayed. This could result in a loss of competitiveness of the Russian cities' economies in the long term.

2.1 BENCHMARKING CLIMATE AND ENERGY STRATEGIES FOR CITIES

Cities' policy decisions to achieve carbon neutrality as part of the global energy transition address changes in the carbon and energy mix in three main areas - moving away from fossil fuels and increasing the share of renewables in energy generation, increasing energy efficiency and implementing CO2 capture and storage solutions, developing low-emission transport (including a ban on the sale of internal combustion engine vehicles) and developing electric transport and infrastructure.

There are two sides to the green transition in megacities. Big cities have diversified economies capable of low-carbon transition. On the other hand, they have developed extensive transport and utility systems that are difficult to transform. The position of St Petersburg as one of Europe's largest cities and Russia's second most populous city is important here.

Urban energy in advanced European and American countries is developing in line with three key trends: decarbonisation, digitalisation and decentralisation. The policy of decarbonising cities is becoming a prerequisite for dealing with their competitiveness, especially when interacting with international capital and urban-based exporters. Despite the move towards decarbonisation, the strategies of cities differ.

Identification of benchmark strategies of foreign cities allows to analyse mistakes and evaluate the advantages of the implemented solutions based on the experience of cities comparable in climatic, geographical, economic and social parameters. For the analysis of foreign climate and energy strategies, the cities with similar socio-geographical features to St Petersburg were selected.

The cities' strategies can be distinguished by their common features:

1. Most cities aim to achieve zero emissions or carbon neutrality by 2050. The intermediate deadline for the targets in most strategies is 2030.

2. Zero hydrocarbons will be achieved largely by increasing renewables in energy generation, reducing energy consumption and achieving energy efficiency, and greening transport (through the development of electric transport and the use of biofuels).

3. In addition to the main points, the strategies include plans to support and sponsor environmental projects, subsidies, citizen involvement in the energy transition, including loans for the installation of renewable energy sources for households and businesses (commercial buildings), material support from the city for the switch to electric vehicles.

City	Strategy planning horizon	Share of RES development [24]	Share of RES use	Cost of electricity, USD/kWh	Proportion of greening of transport [25]	Reduced energy consumption	Support green projects (subsidies, grants)	Specific emissions per capita, t. CO2	National emission price emissions, USD/t. CO2 [26]
London	2050	15 %	12 %	0,24	25 %	+	+	10,4	25
Berlin	2030	50 %	17 %	0,32	+	+	+	10,4	29
Paris	2050	+	21 %	0,18	+	+	-	7,7	52
Amsterdam	2050	100 %	9 %	0,18	95 %	-	-	10,5	39
Tallinn	2030	+	32 %	0,24	100%	+	+	7	2
Oslo	2030	+	75 %	0,17	55 %	+	+	2,3	69
Helsinki	2035	20 %	43 %	0,2	30 %	+	-	7,4	62
Stockholm	2040	100 %	56 %	0,12	100%	+	-	8,1	137
Toronto	2030	50 %	17 %	0,13	30 %	-	-	9,7	32
Montréal	2030	~100 %	99 %	0,07	47 %	-	+	10,1	32
Shanghai	2060	8%	2%	0,09	~100 %	+	+	7,6	6

Table 1.
Benchmarking urban energy transition parameters 23

Source: CSR North-West based on public sources

In the table, a darker green colour indicates a higher energy transition

Some of the carbon-neutral solutions shown in the table refer to solutions that already existed at the time the city and national strategies were developed. Indicators for renewables in energy, energy efficiency in buildings, energy consumption levels, carbon-free fuel use in transport, etc. were present in foreign strategies long before the global trend towards energy transition. Many of them have been tested in practice and can serve as indicators that make sense in the context of the global green transition.

23 Despite the lack of quantitative indicators on some items, The strategies present these markers as targets for the green transition.

24 Intentions of cities to use renewables by 2030-2050. Sign The "+" indicates that there is an intention, but no exact figures are given or different figures are given.

25 Intentions of cities to replace internal combustion engine vehicles with more environmentally friendly ones (electric cars, bicycle sipeds, etc.).

26 The national price for CO2 emissions is quoted for 2021.

City	Key solutions based on energy transition strategies
London	15% RES (2030) - PV, hydro and wind energy, heat-to-energy; reduction of gas consumption; development of energy storage centers; increasing car-free and parking zones; expansion of infrastructure for EVs, 25% of the fleet is EV.
Berlin	Refusal from coal, gas, fuel oil in heat supply; development of PV and renewable energy sources (including popularization of the installation of environmentally friendly means of energy supply for individual tenants); reducing energy consumption by business; development of anetwork of city buses powered by renewable energy sources (2030).
Paris	Supply of 20% of roofs with PV (2050); achieving 100% renewable energy in the energy sector (2050); CCUS system; refusal of diesel fuel for heating buildings (2025).
Amsterdam	Refusal of gas in heat supply (2040), transition in energy supply to renewable energy sources (PV, installation of wind turbines, use of biomass for heating, H2 , development of geothermal energy, use of exhaust gas heat from data centers), modernization of heating networks, achievement of COÿ-free in city buildings and office premises (2030); CCUS development (spot); conversion of 95% of vehicles, including ferries and ships, to EV (2030), subsidies for the installation of chargers for electric transport.
Tallinn	Use of 90% biomass and non-recyclable waste for centralized energy supply; use of gas for peak loads; development of PV on roofs. Transfer of all public modes of transport to COÿ-free, reduction of parking in the city center, development of a charging network for EVs (2035).
Oslo	Refusal of fuel oil, development of energy supply using renewable energy sources (for example, the use of waste heat in industry); centralized CCUS system; new types of vehicles – hybrids and renewable energy sources. By 2030, all engines will be COÿ-free.
Helsinki	Refusal from coal (2030), from fuel oil in power generation (2035); development of renewable energy sources and a hybrid heating system (for example, the use of heat pumps), reduction of energy consumption by 40%, energy efficiency monitoring system; LED lighting and smart control, abandonment of personal transport (2050), development of a COÿ-free port (LNG/biodiesel), transfer of 30% of buses to EV (2025).
Stockholm	Transition from coal and fuel oil to renewable energy sources, from gas to biogas; reducing energy and water consumption of city buildings by 30% (2040). By 2040, the city should be 100% low-emission Zion transport.
Toronto	Energy supply to residential areas is 50% from RES, commercial buildings - 25% from thermal energy; zero GHG emissions from the construction of new buildings; city waste management system; 30% of the city's transport is EV (2030).
Montreal	Refusal of fuel oil and reduction of gas use in favor of renewable energy sources and biogas; reduction of energy consumption (law); development of energy-saving lighting; ban on the sale of internal combustion engines (2035); 47% of transport on EV (2030); 100% of buses are EV (2040).
Shanghai	Reducing the use of coal in industry; 8% RES (2025); ETS (200 enterprises), more than 100 factories with smart energy consumption; 50% of new vehicles are EV (2025); 200 thousand charges (2023); replacing the production of internal combustion engines with hybrids; 100% of buses are EV.
Saint Petersburg	Partial abandonment of coal, fuel oil and diesel, modernization of equipment, development of electric transport (including public) 27.

Table 2.
Key measures to implement the energy transition in city strategies

Source: Center for Social Research "North-West" according to open sources

27 Based on existing program documents and plans.

Cities whose energy systems are already developing in line with the new energy agenda are incorporating projects aimed at reducing emissions into their strategies. In addition to reducing costs for energy modernization systems, they contain new solutions for energy, a radical restructuring of the structure of the fuel and energy balance.

In comparison with the cities under consideration, St. Petersburg, on the one hand, has good indicators in terms of the quality of energy supply and fuel and energy resources: the energy system is stable, operates almost entirely on “clean” energy carriers (gas and nuclear energy), equipment is regularly modernized.

However, all sectors, changes in which can affect the city's carbon balance, are developing separately. There is no emphasis on reducing energy consumption in buildings and increasing energy efficiency. There is no large-scale program for the transition to electric transport. Measures to reduce the carbon footprint of industries are episodic, local and non- systemic in nature. Currently, a regional plan for adapting St. Petersburg to climate change is being developed, which will take into account all these aspects.

2.2 WHAT CHALLENGES DOES THE GREEN TRANSITION POSE FOR ST. PETERSBURG?

The climate agenda poses natural and socio-economic threats to the city. The report focuses on the second type of risks, which can cause significant economic losses. St Petersburg may lose some investors and jobs in industries where compliance with international requirements and ESG standards is important. Another risk is that the current environmental policy does not address climate change, shifting the focus of action towards the familiar measures implemented by existing state programmes.

As a result, it is possible to miss the moment to position St Petersburg among the promising investment centres in Russia and the world. The Russian regions will also compete by starting to establish carbon-free zones and participating in the carbon experiment . The first carbon-free zone in Russia will be formed on the basis of an industrial park in the Ulyanovsk region. There are already 10 carbon-free zones in operation in the country. There are also plans to set up a carbon polygon in the Leningrad region "Ladoga, with a carbon farm and a mobile landfill for the rapid study of greenhouse gas sources and sinks.

28 An experiment to limit greenhouse gas emissions in certain constituent entities of the Russian Federation, conducted in accordance with Federal Law No. 34-FZ dated 03/06/2022.

Natural risks

Climate change in St. Petersburg in the long term poses the risk of rising levels in the Baltic Sea and the Gulf of Finland, flooding and coastal erosion, and an increase in the number of extreme weather events. As aresult, there is arisk of flooding in elite areas located on the coastline of St. Petersburg. According to climatologists, in the next century

anniversary, changes in water levels threaten to destroy large cities in the country. St. Petersburg and Arkhangelsk are at risk 29.

Scenario estimates of the Baltic Sea level rise show that the greatest rise in water level will occur in the southern and eastern parts of the Baltic. Under afavorable scenario, the sea level rise in the St. Petersburg area by the end of the 21st century will be about 40 cm. Under unfavorable circumstances, the rise in level in the eastern part of the Gulf of Finland may reach one meter. The most vulnerable areas are Primorsky, Kirovsky, Petrodvortsovy, Petrogradsky and Vasileostrovsky districts 30.

29 St. Petersburg was predicted to be destroyed due to the flood // Lenta.ru. URL: tape. ru/news/2021/07/27/potop/ (date of access: 01/14/2022).

thirty Climate change in St. Petersburg // Ecological portal of St. Petersburg. URL: infoeco.ru/ index. php?id=1094 (access date: 01/14/2022).

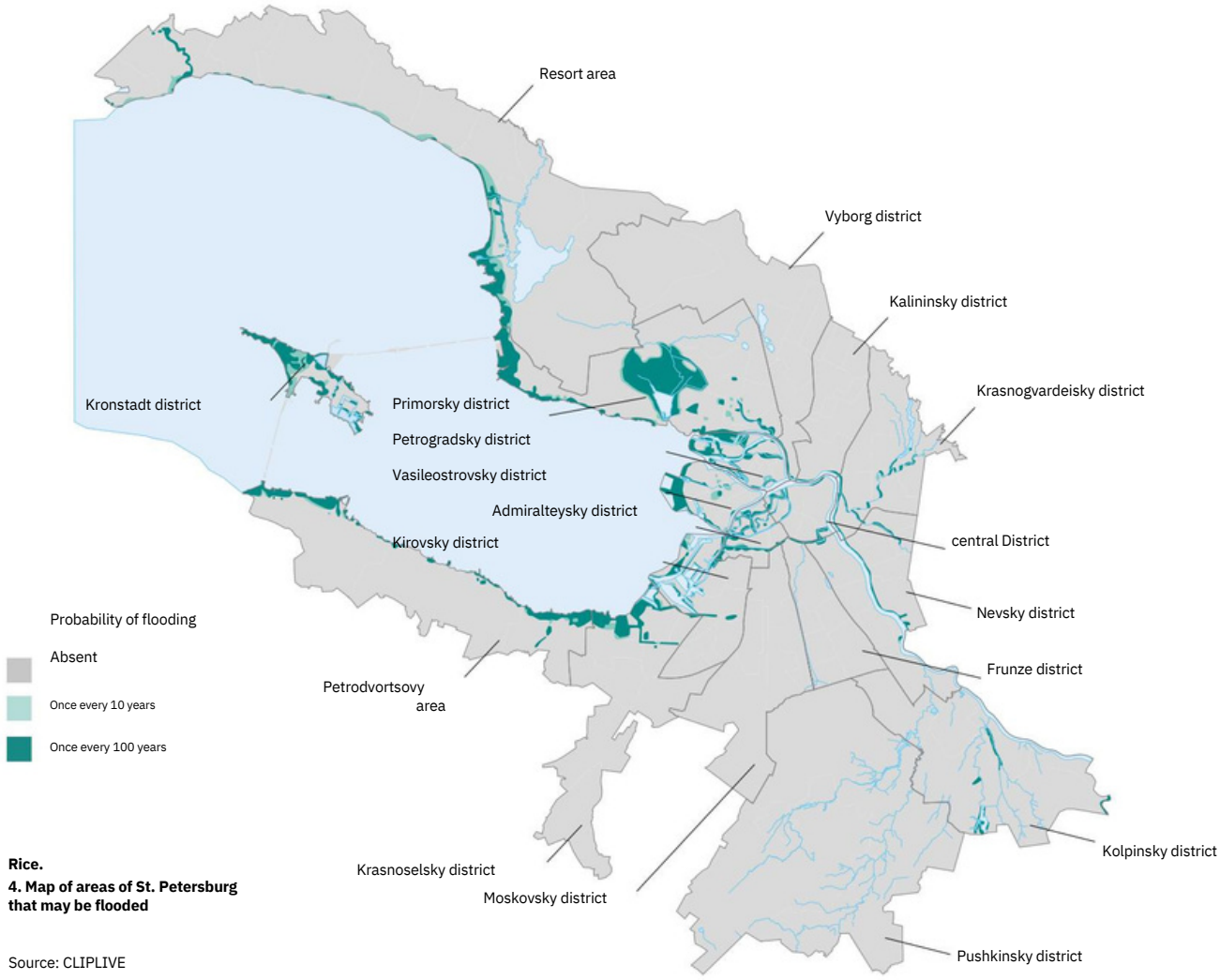
Socio - economic risks

Russian exporters will suffer the most from cross-border carbon regulation. TUR is anew post- carbon policy instrument that aims to achieve climate goals by regulating international trade. In 2021, the TUR project was presented to the EU; It is expected that similar mechanisms will be developed in the USA and China.

The draft European TUR regulation proposes the introduction of acarbon fee levied on certain goods imported into the EU. The goal is to prevent carbon leakage, i.e. moving production outside the EU to countries that do not have strong climate policies. Initially, TUR will apply to a limited set of goods (among others on the list

31 Mechanism of transboundary carbon regulation // EY. URL: ey.com/ ru_ru/ tax/ tax-alert/ 2021/07/ ey-mehanizm-transgranichnogo-uglerodnogo-regulirovaniya-20-july-2021- tax-rus (date of access: 01/19/2022).

32 Swam: now it's official. Possible effects for Russia // IPEM. URL: ipem.ru/ files/ 20210726_doklad_cenef. pdf (access date: 01/21/2022).



Rice.
4. Map of areas of St. Petersburg that may be flooded

Source: CLIPLIVE

cement, nitrogen fertilizers and their raw materials, cast iron, steel, aluminum and products made from them, as well as electricity). TUR is planned to be introduced in stages from 2023. From 2026, only importers with a permit issued by the competent TUR authority will be able to export goods covered by the cross-border carbon regulation 31 to the EU.

Direct losses for exporters from the introduction of the EU carbon tax, taking into account direct and indirect emissions, could amount to 2.3–9 billion dollars per year 32, 33. This will especially affect the Russian oil and gas sector, which could lose 1.4–2.5 per year billion dollars; metallurgical and mining industries ($0.4–0.6 billion); industries such as fertilizer production, pulp and paper and glass industry ($0.8–1.1 billion) 34. In the absence of measures to decarbonize the industry, the loss of energy exports for Russia could amount to $179 billion by 2035 and $192 billion by 2050 35.

With the introduction of an emissions tax of $75 per ton of CO2 , recommended by the IMF, the approximate losses for St. Petersburg for 2020 would be about 10% of exports 36. Most export goods (about 60%) have high carbon intensity (in their including electricity and mineral fuel). However, the current events will most likely introduce changes into the agenda of the energy transition of the new order. For the EU, the transition may boil down in the coming years to the abandonment of Russian energy resources. It is unlikely that this will happen in the foreseeable future, but the public setting of such goals has actually occurred. In such conditions, decarbonization of Russian exports is primarily important from the point of view of supplies to Asian countries (China, India, etc.). All of these countries also have decarbonization plans, and import requirements will be

regarding carbon footprint parameters.

33 How will Russian companies respond to growing pressure from ESG factors? // S&P Global. URL: spglobal.com/_assets/documents/ ratings/ ru/pdf/2021-02-08-how-russian-companies-are-responding-to-growing-pressure-from-esg-factors-ru.pdf (date of access: 01.21.2022).

34 Carbon challenge to Russian exporters // BCG. URL: bcg.com/ ru-ru/ press/ 29july2020-carbon-challenge-to-russian-exporters (date of access: 01/17/2022).

35 Sberbank: Russia's energy exports may fall by $179 billion // RIA Novosti. URL: ria.ru/20210903/eksport-1748470748.html (date of access: 01/17/2022).

36 According to calculations by the North-West Center based on data from the Committee for Economic Policy and Strategic Planning of St. Petersburg.

Among the risks of the energy transition, it is worth highlighting the rise in prices for electricity. Within the framework of the intensive scenario of the Strategy for the socio-economic development of the Russian Federation with low greenhouse gas emissions until 2050, the increase in the cost of electricity by 2030 will be 4%, by 2050 -26% 37. With complete decarbonization of the electric power industry, final prices for electricity by 2050 may grow by 28 %38.

The social challenges of the green transition include the creation of green jobs. The transition to alow-carbon and resource-efficient economy will affect the quality and quantity of jobs in some industries. Worldwide, the largest loss of jobs is predicted in the oil production and oil refining sectors -more than 1million. With the development of a sustainable economy, the creation of green jobs will largely cover the losses: by 2030, the creation of 24 million new jobs is projected, of which about 2, 5million will arise in production of energy generation using renewable energy sources (instead of 400 thousand in energy production using fossil fuels). In addition, the development of new areas of activity in acyclical economy will lead to the creation of approximately 6million jobs 39.

Oil and gas companies face significant risk
negative impact of introduced environmental standards, including due to loss of jobs. On the other hand, despite export and investment risks, carbon-intensive companies continue to operate, moreover, many of them are adopting adaptation plans as part of the green transition. In addition, oil and gas companies that form the basic sector of the economy of St. Petersburg are in high positions in the RAEX ESG rating: Gazprom -20th place, Gazprom Neft - 30th (2022) 40.

Many companies with high ratings for assessing their environmental footprint and their impact on society (IKEA, Procter &Gamble, Mars, Unilever) 41 have suspended operations in Russia due to the geopolitical crisis. In addition, the implementation of part of the decarbonization plans in Russia in the federal

ral level.

However, in order to eliminate long-term risks for the economy of St. Petersburg, the topic of decarbonization should remain among development priorities. It may need to be adapted to suit new

mi macroeconomic and geopolitical conditions.

37 By 2050, electricity in Russia may rise in price by 26% due to the energy transition // Kommersant. URL: kommersant.ru/ doc/5051467 (date of access: 02/07/2022).

38 ESG and decarbonization // VTB Capital. URL: vtbcapital.ru/ upload/iblock/9da/ESG_and_ Decarbonisation_211129_abr_ rus.pdf (date of access: 02/07/2022).

39 24 million jobs to open up in the green economy // ILO. URL: ilo.org/global/about-the-ilo/newsroom/news/ WCMS_628644/ lang--en/ index.htm (access date: 02/11/2022).

40 RAEX Rating Review. URL: raex-rr.com/esg/ ESG_rating (date accessed: 06/05/2022).

41 The best employers in Russia - 2021. Rating Forbes // Forbes. URL: forbes. ru/ biznes/ 447503-lucsie-rabotodateli-rossii-2021-rejting-forbes (date of access: 02/11/2022).

2.3 CARBON BALANCE AS A NEW OBJECT OF MANAGEMENT

To implement the green transition, it is important to record the current fuel, energy and carbon balance in the city. At the same time, the carbon balance should become anew object of management. It is necessary to continuously monitor the volume of the city's carbon balance. Otherwise, the introduction of a management system in the form of carbon regulation and ESG reporting will not be effective.

Currently, systematic monitoring of the carbon balance is carried out only for Russia as a whole. These data are provided for international reporting in accordance with the obligations of the Russian Federation under the UNFCCC. As for the constituent entities of the Russian Federation, only fragmentary data on pollutant emissions (from transport, stationary sources, etc.) can be found on federal statistical resources. A complete inventory of greenhouse gas emissions is carried out on avoluntary basis 42. In 2017, inventory was carried out only in 11 constituent entities of the Russian Federation: these are the Republic of Bashkortostan, Voronezh Region, Yamalo-Nenets Autonomous Okrug, Leningrad Region, Moscow, Altai Republic , Sakhalin region, Khabarovsk region, Kirov region, Novgorod region, Karachay-Cherkess Republic 43.

The situation may change dramatically in the direction of tightening regulation, and regions should prepare for this. In 2021, the federal law “On Limiting Greenhouse Gas Emissions” 44 was adopted, which provides for the introduction of a phased model for regulating emissions for companies. According to the law, from 2024, companies whose greenhouse gas emissions exceed 150 thousand tons of COÿ-equivalent will report on emissions. per year, and from 2025 - companies whose greenhouse gas emissions exceed 50 thousand tons of COÿ-eq. in year.

Climate policy will require new interregional work, since it is impossible to solve the problem of carbon balance by working within the borders of one constituent entity of the Russian Federation. The agglomeration approach is important here, when there is cooperation between the metropolis and satellite cities, the region. To implement such cooperation, a working group of St. Petersburg and the Leningrad region has been created.

42 Order of the Ministry of Natural Resources of Russia dated April 16, 2015 No. 15-r “On approval of methodological recommendations for conducting a voluntary inventory of greenhouse gas emissions in the constituent entities of the Russian Federation” // Code Consortium. URL: docs.cntd.ru/document/420278225 (date of access: 02.22.2022).

43 11 subjects of the Russian Federation carried out an inventory of greenhouse gases // Ministry of Natural Resources of Russia. URL: mnr.gov.ru/press/news/inventarizatsiyu_parnikovykh_gazov_proveli_11_subektov_rossiyskoy_federatsii/?special_version=Y (access date: 02/22/2022).

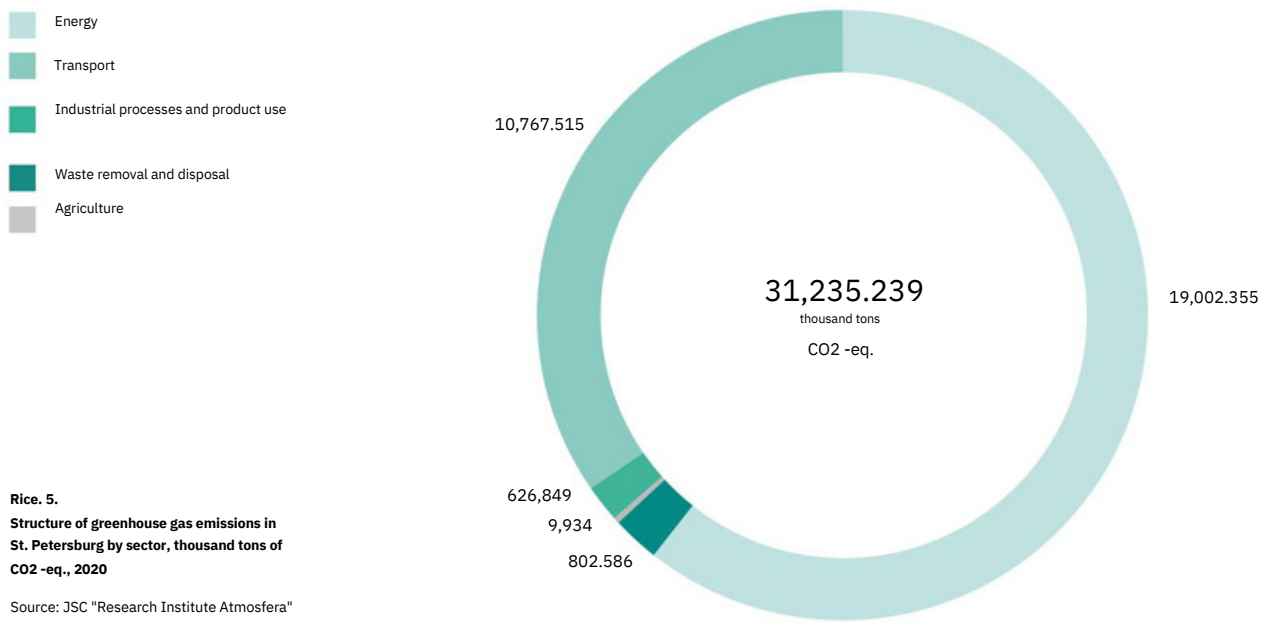
44 Federal Law of July 2, 2021 No. 296-FZ “On Limiting Greenhouse Gas Emissions” // Consultant-Plus. URL: consultant.ru/document/ cons_doc_LAW_388992/ (date of access: 02/22/2022).

2.4 ASSESSMENT OF THE CARBON BALANCE OF ST. PETERSBURG

St. Petersburg is among the top 5regions for maximum emissions of pollutants into the atmosphere. The main contributors to urban air pollution are carbon dioxide, ammonia, suspended solids 45, nitrogen dioxide, ozone and formaldehyde 46. The largest amount of greenhouse gas emissions comes from energy sector.

45 Suspended substances are dust (aerosol) not differentiated in composition, contained in the air of populated areas.

46 Report on the environmental situation in St. Petersburg in 2020 // Ed. D. S. Belyaeva, I. A. Serebritsky. Izhevsk: PRINT LLC, 2021. - 253 p.

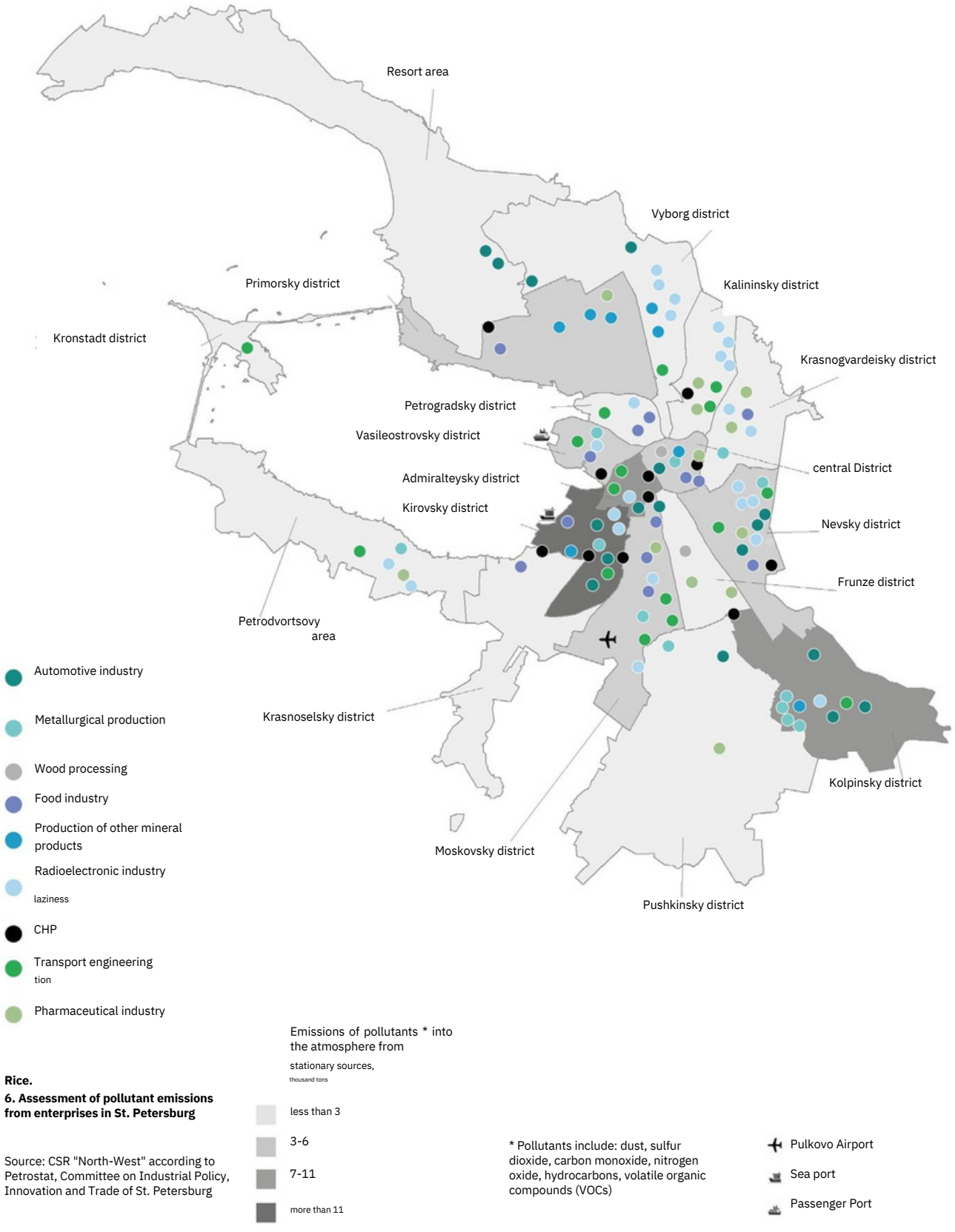


Rice. 5.
Structure of greenhouse gas emissions in St. Petersburg by sector, thousand tons of CO2 -eq., 2020

Source: JSC "Research Institute Atmosfera"

The total volume of emissions in St. Petersburg in 2020 is 31235.239 thousand tons of CO2 -eq. This significantly exceeds the budget of all ecosystems of the city, which on average for 2009–2018 amounted to -103.5 thousand tons of CO2 -eq.

In St. Petersburg, high levels of emissions are observed in areas where a large number of large heavy industry enterprises are concentrated, in particular in the Kirov and Kolpinsky districts (Fig. 6).



Rice.
6. Assessment of pollutant emissions from enterprises in St. Petersburg

Source: CSR "North-West" according to Petrostat, Committee on Industrial Policy, Innovation and Trade of St. Petersburg

The main volume of carbon dioxide emissions in Russia is produced by enterprises of the fuel and energy complex. Among the manufacturing industries, the first places are occupied by ferrous and non-ferrous metallurgy enterprises 47. In 2021, the share of the manufacturing industry in the total number of large and medium-sized enterprises in St. Petersburg was 82%.

47 How the industries responsible for greenhouse gas emissions are changing // Vedomosti. URL: vedomosti.ru/partner/articles/ 2021/06/02/872559-otrasli-parnikovih-gazov (date of access: 11/11/2021).

2.5 ASSESSMENT OF THE FUEL AND ENERGY BALANCE OF ST. PETERSBURG

The energy system of St. Petersburg is quite stable and relies on Russia's own energy resource base. The most popular type of fuel for energy supply and industry is natural gas (99.5 %) 48. Fuel oil and diesel fuel (0.5%) are used as backup.

In St. Petersburg, centralized heat supply predominates from large district and industrial boiler houses and sources with combined heat and power (CHP). There are 135 heat supply organizations, 1,183 boiler houses, 15 thermal power plants 49 in the city.

Over the past 20 years, the main changes in the energy system of St. Petersburg have occurred in the area of equipment modernization. As the programs were implemented, several important indicators were achieved in favor of the city's energy efficiency: the degree of deterioration of infrastructure is gradually decreasing (the overall level of depreciation of fixed assets of municipal infrastructure for 2021 was 50%), the GRP energy intensity indicator decreased to 3.66 t.e. ./

million rubles, specific fuel consumption remained the same. for supply of thermal energy (166.25 kg t.e./Gcal) 50.
As the carbon balance increases, the region's ability to export energy resources and other products dependent on clean energy production will be limited. The geopolitical crisis and the desire of EU countries to decarbonize can cause adecrease in energy exports and carry economic risks. The excess energy generated can be used in new energy-intensive industries (for example, in the production of hydrogen) or for the development of an urban charging structure for electric vehicles.

In St. Petersburg, further preservation of the structure of the existing fuel and energy system, which is based on carbon energy resources, carries anumber of opportunities and risks at the same time. In St. Petersburg, where the main fuel in the fuel and energy system is gas (more than 90%), the cost of electricity is lower than in foreign megacities, the fuel and energy resources of which include renewable energy sources. But in the long term, the carbon footprint generated by the city's energy sector can reduce the opportunities for localizing enterprises focused on export.

48 Expert opinion on the Scheme and program for the long-term development of the electric power industry in St. Petersburg for 2020–2024. // Administration of St. Petersburg. URL: gov.spb.ru/static/ writable/ ckeditor/ uploads/ 2006/20/03/11/%D0%AD%D0%BA%D1%81%D0%BF%D0%B5%D1%80%D1%82%D0%BD%D0%BE%D0%B5_%D0%B7%D0%B0%D0%BA%D0%BB%D1%8E%D1%87%D0%B5%D0%BD%D0%B8%D0%B5_%D0%A1%D0%B8%D0%9F%D0%A0_%D0%A1%D0%9F%D0%B1_2020-2024.pdf (access date: 02/22/2022).

49 State program of St. Petersburg "Comprehensive development of communal infrastructure systems, energy and energy saving" // Administration of St. Petersburg. URL: gov.spb.ru/ static/ writable/ ckeditor/ uploads/ 2021/03/18/46/%D0%93%D0%9F_486_%D0%BE%D1%82_03/17/2021__124.pdf (access date: 02/22/2022).

50 ESG report of St. Petersburg for 2020 // Government of St. Petersburg. URL: docviewer.yandex.ru/view/588747741/?page=398&*=QkxrlxhpWgVjsZtSSuVqjqVZadV7InVybCI6InlhLWRpc2stcHVibGljOi8vR0kwbnpQajBkU0NhNzI5Q2RUVWdzV0VDamJlZ1BtaU1tdDBlUm52UVM4RkVwS2ZrcmVvelN3UlZxMU14UjliL0c3cFdwVlFZc3VieXJjYWpIaW1QRnc9PSIsInRpdGxlIjoiRVNHX1NQQl8yMDIwLnBkZiIsIm5vaWZyYW1lIjpmYWxzZSwidWlkIjoiNTg4NzQ3NzQxIiwidHMiOjE2MzgyNzI4Mzg4NDAsInl1IjoiOTU4Mzg1MDA4MTYzMDM5MTQ2OCJ9 (accessed 02/22/2022).

3 HOW THE GREEN TRANSITION IS TRANSFORMING THE ECONOMY CITIES?

In what time frame and at what cost the green transition will be implemented in the city are the key issues on the agenda. It is also important to determine for what purpose the transition is being made: to comply with federal regulations or for the individual position of the city, justified by economic benefits and the well-being of residents? The choice of strategy and priority projects for the low-carbon economy will depend on these parameters.

The development of existing and new sectors of the economy and ensuring their competitiveness in the Russian and foreign markets will require compliance with the requirements of carbon regulation. These standards are in the process of being formed both in Russia and in other countries. But it is already obvious that the carbon regulation model will be revised taking into account new economic conditions.

The economy of St. Petersburg is dominated by industrial production, which is based on heavy and power engineering. Industry accounts for aquarter of the gross regional product (GRP) and about a third of tax revenues into the budget system 51. The basis of the complex is manufacturing enterprises. In 2021, their share amounted to 83.9% of the total industrial production in the city. Among processing enterprises, the maximum volume of shipped products falls on the production of coke and petroleum products - 858 billion rubles. The largest share in the structure of St. Petersburg's exports was made up of mineral products - 68.7 %52.

Thus, asignificant share of St. Petersburg's exports and GRP is at risk of transboundary carbon regulation. But in the current geopolitical situation, the carbon regulation model and the relationships between countries within this framework are likely to be revised. For example, in August 2022, the Chinese Foreign Ministry announced the severance of relations with the United States in some areas, including regarding climate change 53. Earlier (in November 2021), China and the United States signed a declaration on cooperation in the fight against climate change at the UN Climate Change Conference COP26 54.

51 Profile of the region (St. Petersburg) // Bank of Russia. URL: cbr.ru/spb/ekonom_profil_sp-g/#dropdown_content_item_2 (access date: 03/16/2022).

52 Committee for Economic Policy and Strategic Planning of St. Petersburg // Administration of St. Petersburg. URL: gov.spb.ru/gov/otrasl/c_econom/statistic/ (date of access: 03/16/2022).

53 China has suspended cooperation with the United States in some areas // TASS. URL: tass.ru/mezhdunarodnaya-panorama/15404115?utm_source=google.com&utm_medium=organic&utm_campaign=google.com&utm_referrer=google.com (access date: 08/05/2022).

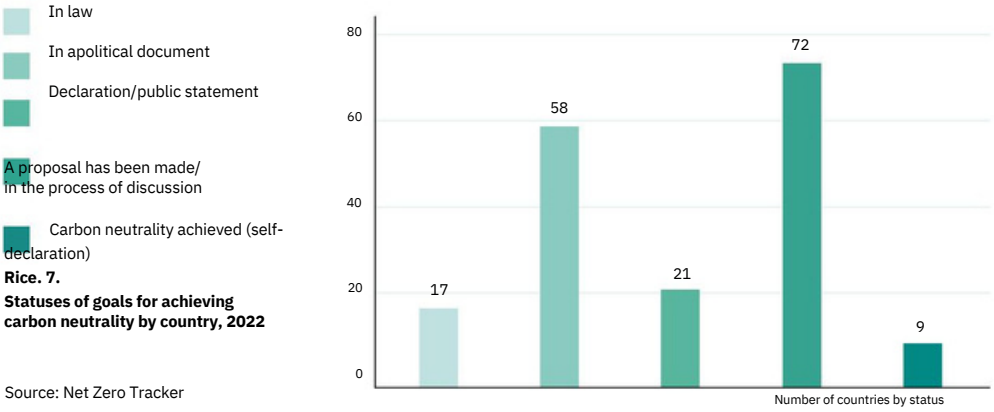
54 The United States and China signed an agreement on climate cooperation at COP26 // Vedomosti. URL: vedomosti.ru/ecology/news/2021/11/11/895394-ssha-i-knr-podpisali-soglashenie-o-sotrudnichestve-v-sfere-klimata (date of access: 08/05/2022).

3.1

HOW LONG WILL THE GREEN TRANSITION LAST?

Leading countries have already launched large-scale programs for decarbonization of the economy and international cooperation on the green agenda: European Green Deal in the EU, Green New Deal in the USA, Green Industrial Revolution in the UK, etc. Other countries, including Russia, have less time left to take aposition on the global green transition. At the time of Russia's declaration of intention to achieve carbon neutrality by 2060, such goals were declared in approximately 80% of the world's countries55.

2050––2060 2060 -keym daantye s c onuanmtreieds b, ycit mieasny countries, cities key dates named by ladies and companies as a deadline for achieving carbon neutrality. According to Net Zero Tracker 56, 16 countries and the EU have introduced carbon neutrality goals into their laws, 58 states have indicated them in political documents, and another 21 have declared the same intentions (including the Russian Federation). The goals of most countries (72) are under discussion. And nine states have already declared themselves carbon neutral - these are countries in Africa (Benin, Comoros, Gabon), Asia (Bhutan, Cambodia) and South America (Guyana, Suriname).



Rice. 7.
Statuses of goals for achieving carbon neutrality by country, 2022

Source: Net Zero Tracker

The key dates for the green transition in Russia are outlined in the Strategy for the socio-economic development of the Russian Federation with low greenhouse gas emissions until 2050 57. Under the target scenario, emissions are expected to reduce by 2050 by 60% from the 2019 level and by 80% from the 1990 level. Further implementation of this scenario assumes that Russia will achieve carbon neutrality by 2060. However, at the moment the legislation does not clearly establish the achievement of carbon neutrality.

Among the cities and regions of Russia, several subjects have set deadlines for achieving carbon neutrality: Sakhalin region (until 2025), Kazan (until 2050), Moscow (until 2060). The deadline for the Sakhalin region is related to the law on conducting a carbon experiment, which will take place from September 1, 2022 to December 31, 2028 (inclusive) 58. Other constituent entities of the Russian Federation can join the experiment. The deadline for achieving carbon neutrality in Kazan was announced at the Tatarstan Petroleum and Gas Chemical Forum in 2021 59. And Moscow's goal is planned to be enshrined in the city's Climate Plan 60.

Compliance with deadlines for climate obligations will also be monitored by international regulators. Already, the Glasgow Climate Pact calls for countries to "review and strengthen" their 2030 climate plans by the end of 2022 to align them with the goals of the Paris Agreement.

55 About 80% of the world's countries have set deadlines for achieving carbon neutrality // TASS. URL: tass.ru/obschestvo/12812589 (date of access: 03/16/2022).

56 Net Zero Tracker. URL: zerotracker.net/ (access date: 03/16/2022).

57 The government approved the Strategy for Social economic development Russia with alow level of greenhouse gas emissions until 2050 // Ministry of Economic Development of Russia. URL: economy.gov.ru/material/news/pravitelstvo_utverdilo_strategiyu_socialno_economicskogo_razvitiya_rossii_s_nizkim_urovnem_vybrosov_parnikovyh_gazov_do_2050_goda.html (access date: 03/16/2022).

58 Federal Law dated March 6, 2022 No. 34-FZ "On pro-conducting an experiment on emission control greenhouse gases in aseparate ny subjects of the Russian Federation" // Official Internet portal of legal information. URL: sozd.duma.gov.ru/bill/37939-8 (date of access: 04/15/2022).

59 By 2050 we must achieve "carbon neutrality" // Realnoe Vremya. URL: realnoevremya.ru/articles/222812-o-chem-budut-govorit-uchastniki-nyneshnego-tnf-i-pochemu-eto-aktualno (date of access: 02/17/2022).

60 Official website of the Mayor of Moscow. URL: mos.ru/news/item/98771073/ (date of access: 06/05/2022).

3.2 HOW MUCH WILL THE GREEN TRANSITION COST?

As arule, the cost of a green transition is assessed according to several cost items: losses from climate risks due to inaction, costs directly for the green transition and benefits from its implementation.

Extreme natural events caused by climate change are leading to increased economic losses. In the EU, on average they already exceed 12 billion euros per year. Conservative lower bound estimates suggest that atemperature rise of 3°C above pre-industrial levels would result in annual losses of at least €170 billion (1.36% of EU GDP). The slow rise in sea levels is also alarming: coastal areas produce about 40% of the EU's GDP and are home to about 40% of its population61.

A conservative estimate is that strong action to combat climate change globally could result in direct economic benefits of $26 trillion by 2030 compared to business-as-usual 62.

According to areport by the Coalition for Urban Transitions 63, the investment needed to reduce urban emissions would be $1.83 trillion (about 2% of global GDP) per year, but would generate annual savings of $2.8 trillion in 2030 and 6.98 trillion in 2050. This gives anet profit of 23.9 trillion dollars. With higher energy prices and faster technology learning, the net present value of these investments rises to $38.19 trillion. These amounts do not include broader benefits such as long-term growth

productivity or improving public health.

Thus, the costs of the green transition should be perceived not as irrecoverable losses, but as the cost of restructuring to a low-carbon way of life, the effects of which in the future should significantly exceed

expenses.

Cost of green transition for Russia

Leading experts and Russian banks also provide estimates of the cost of the green transition for the country. In particular, such assessments were given in anticipation of the adoption of the Strategy for the socio-economic development of Russia with low greenhouse gas emissions until 2050.

According to First Deputy Prime Minister of Russia Andrei Belousov, the energy transition for Russia (according to the intensive scenario of the Strategy) will cost approximately 90 trillion rubles over 28 years. Every year this is 3.2 trillion rubles (less than 3% of GDP) 64. The same amount was announced by the Russian Ministry of Economic Development at the 26th UN Climate Change Conference: investments in reducing carbon emissions in Russia by 60% could amount to 88.8 trillion rubles according to the target (intensive) scenario. The implementation of the target scenario will require investments in reducing greenhouse gas emissions in the amount of about 1% of GDP in 2022–2030 and up to 1.5–2% of GDP in 2031–2050 65.

Speaking at the Eastern Economic Forum in 2021, Vice-President of VEB.RF Andrei Baida said that for the complete decarbonization of the Russian economy at the current technological level, apeak of up to 15 trillion rubles (14–15% of the country's current GDP) will be required annually until 2060 year 66. According to the head of Sberbank German Gref, the energy transition in Russia will last at least 40 years, and its cost could range from 657 billion to 1 trillion dollars 67.

61 Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change // EUR-lex. URL: eur-lex.europa.eu/ legal-content/ EN/TXT/?uri=COM:2021:82:FIN (date of access: 02/17/2022).

62 The 2018 Report Of The Global Commission On The Economy And Climate // New Climate Economy. URL: newclimateeconomy. report/2018/key-findings/ (date of access: 02/17/2022).

63 Climate Emergency, Urban Opportunity // Coalition for Urban Transitions. URL: urbantransitions.global/ wp-content/uploads/2019/09/ Climate-Emergency-Urban-Opportunity-report.pdf (accessed 02/17/2022).

64 Belousov estimated the cost of the energy transition for Russia // RBC. URL: rbc.ru/economics / 18/10/2021/616cd8de9a7947 c1621ebf91 (accessed 02/09/2022).

65 The government approved the Strategy for the socio-economic development of Russia with a low level of greenhouse gas emissions until 2050 // Ministry of Economic Development of Russia. URL: economy.gov.ru/ material/ news/ pravitelstvo_ utverdilo_strategiyu_socialno_ economicskogo_razvitiya_ rossii_s_nizkim_urovnem_ vybrosov_parnikovyh_gazov_ do_2050_goda.html (date of access: 02/09/2022).

66 VEB.RF estimated the complete decarbonization of the Russian economy at 15 trillion rubles annually. // TASS. URL: tass. ru/ekonomika/12290687 (date of access: 02/09/2022).

67 Gref assessed the benefits for Russia from the energy transition // RIA Novosti. URL: ria.ru/20211108/ energoperekhod-1757994286. html (access date: 02/09/2022).

According to VTB Capital 68 calculations, a25% reduction in emissions will cost 43 trillion rubles (or 1.3% of GDP annually), and a50% reduction will cost 86.6 trillion (2.7% of GDP annually). Achieving carbon neutrality by 2060 will require investments amounting to 479.8 trillion rubles (15% of GDP annually). However, the cost of decarbonization varies across industries. The least costly options for Russia: reducing methane emissions (in the oil and gas and coal industries), reducing the carbon footprint of the electric power industry (by increasing the share of renewable energy sources) and projects in the field of forestry. These industries together account for 59% of total emissions in Russia, and their decarbonization will require 102.7 trillion rubles. The most expensive sectors for decarbonization are transport, cement industry, iron ore production

and steel.

The international community also follows the logic of gradual decarbonization of the least expensive industries. At the 26th UN Climate Change Conference, agreements were signed in the field of forestry projects (on stopping deforestation by 2030), reducing methane emissions (by 30% by 2030), and electricity (on the transition from using coal power plants to clean energy) . According to the Ecosystem Marketplace, there has been asignificant increase in the volume of carbon units issued for forestry and agriculture projects: in the first eight months of 2021, this area accounted for 45% of issued and 47% of purchased carbon units. In second place are projects to improve energy efficiency and renewable energy sources 69.

The World Bank has developed four scenarios for Russia's financial losses from the green transition. The level of well-being of Russians may fall by 3–9% by 2050. However, according to the World Bank representative in Russia Reno Seligmann, maintaining the status quo regarding the global energy transition is a riskier choice. Seligmann noted: “Regardless of what Russia thinks (in which direction it should go), our analysis shows that the negative impact on Russia’s GDP and income will be doubly greater if there is inaction than if Russia actively adapts to changes.” 70 .

Cost of green transition for St. Petersburg

Based on the cost of decarbonization of Russia, two estimates of the approximate cost of decarbonization of the economy of St. Petersburg until 2060 have been derived.
The first estimate bases the cost of decarbonization on VTB Capital calculations. The calculation method is relevant for the regions of Russia, since the main factor is the cost of capital, which is generally evenly distributed throughout the country. The basis was taken on the cost of 100% decarbonization of Russian economic sectors. From these amounts, the cost of 100% decarbonization of St. Petersburg’s sectors was calculated based on the city’s share of emissions from Russia’s total emissions. The total cost of decarbonization of all sectors of St. Petersburg amounted to about 10 trillion rubles (5% of GRP annually), excluding the cost of decarbonization of forestry.

The second estimate calculates the cost based on the volume of emissions in St. Petersburg and the price per ton of CO2 by sector. The cost of decarbonization of sectors is calculated over 39 years - until Russia achieves carbon neutrality in 2060. The total cost of decarbonization of all sectors of St. Petersburg amounted to 5trillion rubles, excluding the cost of decarbonization of forestry. This estimate is based on decarbonization costs only and does not include standard operating expenses and annual return on investment costs. Due to high interest rates in Russia, the cost of return investments can reach up to 70% of the cost of decarbonization projects.

68 ESG and decarbonization // VTB Capital. URL: vtbcapital.ru/upload/iblock/9da/ESG_and_Decarbonisation_211129_abr_rus.pdf (date of access: 02/07/2022).

69 Carbon units: dynamics and potential // EY. URL: ey.com/ru_ru/climate-change-sustainability-services/carbon-offsets-dynamics-and-prospects-2022 (accessed: 02/09/2022).

70 The World Bank has developed 4 scenarios for Russia's losses from the “green” transition // RBC. URL: rbc.ru/economics/01/12/2021/61a6502d9a79471618b9b6c3 (date of access: 02/09/2022).

Sector		CO2 emissions, 2020, thousand tons of CO2 -eq.	Share of CO2 emissions in St. Petersburg 71, %	Average price per ton of CO2, dollars/t	The cost of the 100th decarbonization until 2060, billion rubles.	
					Score 1	Score 2
	Energy	19,028.355	2.64	thirty	1,223.629	1,580.685
	Transport	10,767.515	5.82	108	8,462.685	3,220.047
	Industrial nal sector	802.586	0.34	52 72	243.075 73	115,563
	Agriculture	9,934	0.01	48	n/a	1.32
	Removal and disposal waste disposal	626,849	0.63	14	6,882	24.3
Total					**9,936.27**	**4,941,916**

Table
3. Emissions and cost of decarbonization in St. Petersburg

Source: Center for Social Development "North-West" according to Rosstat, Research Institute "Atmo-sphere", VTB "Capital"

71 Share of COÿ emissions in St. Petersburg from the total COÿ emissions in Russia.

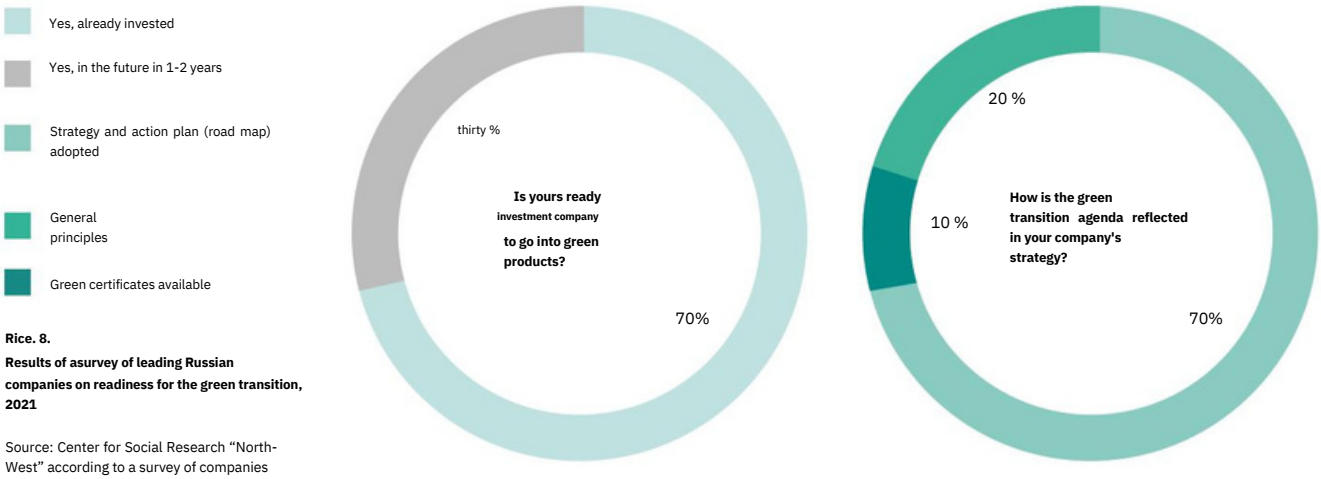
72 Average price per ton of CO2 in the oil and gas, metallurgical, chemical and cement sectors.

73 Calculated based on the cost of decarbonization of the oil and gas sector.

There may be inaccuracies in the estimates due to differences in the breakdown of emissions by sector for St. Petersburg and Russia. Cost estimates will be adjusted depending on changes in market prices per ton of CO2 in different sectors. In addition, the price may be higher due to new economic conditions caused by the geopolitical crisis.

3.3 BUSINESS RESPONSE TO THE GREEN AGENDA

In developed countries, the leading players in the green transition are technology companies producing innovative products in the field of decarbonization. These organizations are ready to invest huge amounts of money in the development of green technologies and the formation of new industries, such as electric vehicles, hydrogen energy and renewable energy sources. In Russia, a similar niche is occupied by oil and gas and financial companies. It is obvious that these sectors are not enough to implement agreen transition throughout the country's economy.
Recently, large Russian corporations, including the oil and gas (Rosneft, Lukoil) and coal (SUEK) industries, have adopted strategies to reduce their carbon footprint. Asurvey of leading Russian companies showed a high readiness for the green transition: 7out of 10 consolidated the green agenda in corporate strategies and programs, the rest developed general principles and acquired green certificates necessary for exporting products. Also, 7 out of 10 are already financing green projects, the rest plan to start financing in the next year or two.



Rice. 8.
Results of asurvey of leading Russian companies on readiness for the green transition, 2021

Source: Center for Social Research "North-West" according to a survey of companies

Among the markets for green products, foreign markets (EU, Asia-Pacific) occupy a significant share. This emphasizes the need to take into account the prospect of introducing transboundary carbon regulation that imposes taxes on export products, the production of which is accompanied by the emission of greenhouse gases.

Product direction	Sales markets
Social treasury (integration with the government platform)	All recipients of social payments / benefits from the state stva
Ecomortgage	Mortgage market, developers
Financial eco-initiatives	Citizens of the Russian Federation (clients and non-clients of the bank)
Electric transport	EU, China, USA
Gas engine technology	Russia, CIS, Latin America
Green hydrogen	EU
Wood fuel pellets	EU
Spliced beams from sawings of full-size LVL timber	—
Hydrogen	EU, Japan, China
Green ammonia	Marine fuel cell/transportation hydrogen
Lithium compounds	EU, Southeast Asia, China

Table 4.
Results of asurvey of leading Russian companies on the topic of green products and sales markets, 2021

Source: Center for Social Research "North-West" according to a survey of companies

The geopolitical situation has made adjustments to the plans of the main players in the green transition. With continued exports of oil and gas products, industry companies continued their decarbonization policy. In March 2022, Gazprom and Zarubezhneft published information on the development of sustainable development strategies, Tatneft confirmed the goal of achieving carbon neutrality by 2050. The financial sector also intends to continue implementing ESG principles, but sanctions and the difficult economic situation have reduced the priority of these tasks. The Bank of Russia, VEB.RF and other members of the Expert Council on Sustainable Development and Green Finance announced their intentions to form a national regulatory system for sustainable development 74. The sanctions also affected companies producing renewable energy sources. The Association for the Development of Renewable Energy in an appeal to the Government of the Russian Federation noted the high risk of disruption of the equipment supply chain and a multiple increase in the cost of credit resources 75. The implementation of projects in Russia may be negatively affected by the departure of foreign manufacturers of equipment for renewable energy sources (Fortum, Vestas, Enel, Siemens).

74 The State Duma discussed the prospects for the ESG agenda in the new conditions // State Duma. URL: duma.gov.ru/news/53779/ (date of access: 03/28/2022).

75 The Association for the Development of Renewable Energy, taking into account the risks, appeals to the Government // ARVE. URL: rreda.ru/news/ tpost/ 9o1hagje91-assotsiatsiya-razvitiya-vozobnovlyaemoi (date of access: 03/28/2022).

HOW WILL THE INVESTMENT POLICY CHANGE?

The largest investment organizations and hedge funds require companies to comply with ESG standards, request emissions reports and conduct stress testing for exposure to green transformation risks. And this is only part of the overall picture. Investors will be the first to change the economic vector
miki, and following them, strategies in industry, infrastructure construction and other sectors will change.

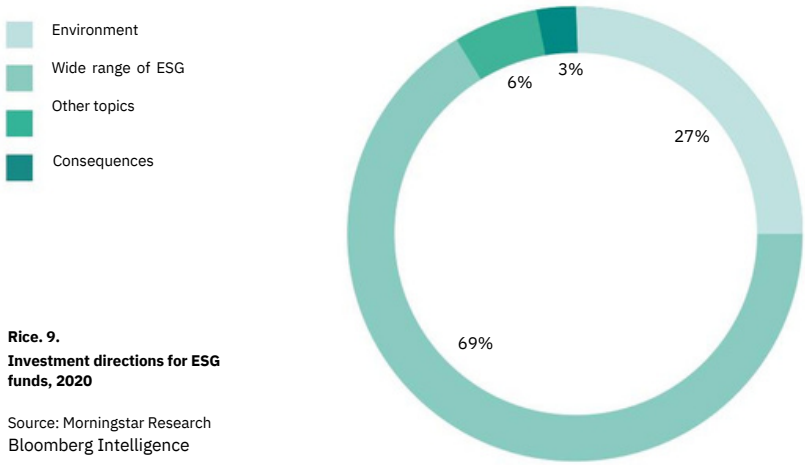
Company	Policy
BlackRock	The investment company announced green investment principles: it will exit investments in companies without an ESG agenda
Swedbank Robur	By 2025, all of the bank's investment funds plan to invest only in companies that already produce emissions below the market average and continue to reduce emissions by at least 7% per year
SNPE	The fund invests in companies from the S&P500 index that meet ESG criteria. In 2020, assets grew by 53.3%

Table 5.
Examples of the influence of ESG factors on the investment decision-making process

Source: Center for Social Development "North-West" according to open sources

ESG factors are becoming an integral part of the investment decision-making process. Compliance with ESG principles makes a company attractive for investment, including on a long-term basis. Businesses that monitor energy efficiency have greater productivity and profits, allowing investment funds to make more investments. The performance of ESG funds is influenced by factors such as low reputational, political and regulatory risks, which in turn leads to more stable cash flow and increased profitability. In 2019, US ESG funds outperformed conventional funds, with many even matching or beating the S&P 500 index.

In line with decarbonization goals, public funding can support increased investment in ESG funds, which will increase investment in the promising energy sectors of renewable energy sources and electric vehicles. 27% of ESG funds launched in 2020 have climate goals.

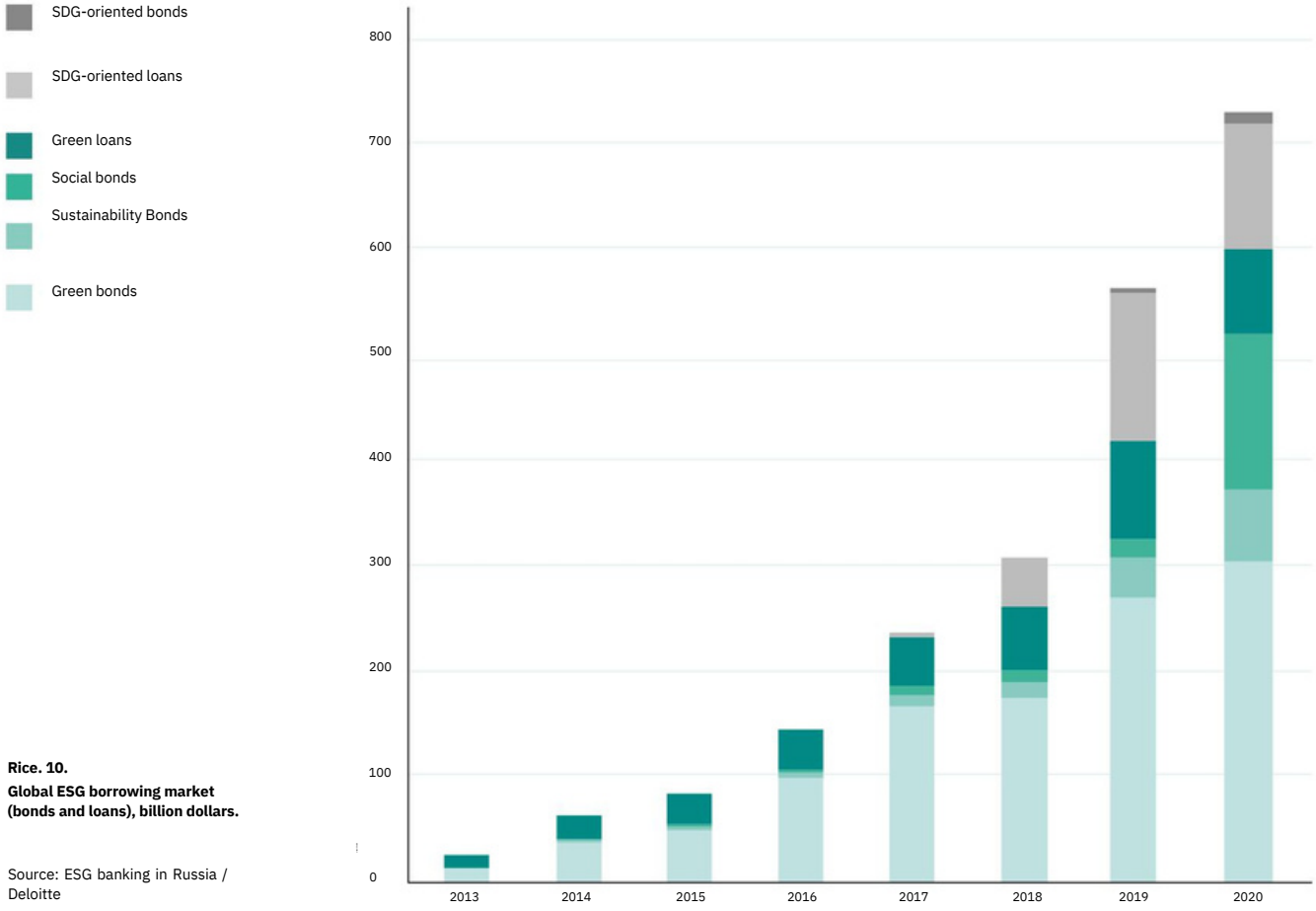


Rice. 9.
Investment directions for ESG funds, 2020

Source: Morningstar Research
Bloomberg Intelligence

In banking, the volume of investments in ESG funds doubled (to $50 billion) in 2020 compared to 2019 and will continue to grow annually. By 2025, international ESG assets will reach $140.5 trillion 76.

76 ESG Banking in Russia // Deloitte. URL: asros.ru/upload/iblock/f6c/q0b1qh8xpem8vb3bsrh9oneb1241pnr1/ ESG_banking-in-Russia.pdf (date of access: 12/17/2021).



Rice. 10.
Global ESG borrowing market (bonds and loans), billion dollars.

Source: ESG banking in Russia / Deloitte

Company	Projects
Goldman Sachs Group Inc. (USA)	The share of investments in green buildings and innovative green technologies was $2 billion (2020)
ING Group (Netherlands)	Support 62 green bonds; investments amounting to billions of euros in projects on renewable energy sources, green buildings, sustainable transport and infrastructure (2019)
Bank of China (Hong Kong) (China)	— Increase in the number of green loans by 60% in 2020 compared to 2019, cooperation with companies within the framework of the online platform “Electronic green loan assessment" — Introduction of green finance incentives — Leadership in issuing green bonds — Support for 13 projects to protect endangered species
Sberbank (Russia)	— Investments of 40 billion rubles in green metallurgy (2020) — Launch of ablockchain platform to control the supply of certified raw materials (volume of transactions with green certificates 320,000 MWh)
VTB Group (Russia)	— Issue of green perpetual bonds of Russian Railways in the amount of 100 billion rubles (2020) — Financing of green industries - innovative Russian energy projects aimed at reducing the carbon footprint (construction of a wind power plant in the Rostov region, modernization of hydroelectric power stations in Tatarstan, etc.)

Table 6.
Cases on ESG investing using the example of large Russian and foreign banks

Source: Center for Social Research “North-West” according to open sources

As the RAEX rating agency notes, investors are already well versed in the economic realities of the constituent entities of the Russian Federation, and the focus of the rating of the attractiveness of the economies of Russian regions is shifting to ESG factors. In accordance with the Decree of the Government of the Russian Federation No. 1587 dated September 21, 2021, VEB.RF has formed apermanent list of verifiers of financial instruments for sustainable development, asignificant part of which are rating agencies (ACRA, NRA, NKR, Expert RA) 77. This is likely to be supported by There is a growing trend of integrating ESG criteria into national ratings.

In 2021, St. Petersburg took second place in the ESG rating of Russian regions for all three factors, but only 54th in environmental risks. The Leningrad region is in first place in the ranking and 13th in terms of environmental risks. In other respects, the region is inferior to St. Petersburg (social risks, quality of management) 78. Thus, neglect of environmental factors
tori may reduce the investment attractiveness of the region, and in the future this trend will intensify.

77 VEB.RF approved the first verifiers of financial instruments for sustainable development // VEB.RF. URL: xn--90ab5f.xn--p1ai/press-tsentr/51960/ (date of access: 02/09/2022).

78 ESG ranking of regions // RAEX. URL: raex-rr.com/esg/ESG_rating_regions#table (accessed 02/09/2022).

4 WHAT TECHNOLOGICAL CHANGES ARE THE BASE OF THE GREEN TRANSITION?

The green transition is not just a matter of investment, exports and industrial policy. One of the aspects that determines the success of the transition is the position in scientific research and technologies that ensure green transformation of the economy.

St. Petersburg is one of the largest scientific centers in Europe and the Russian Federation. Here, projects of the country's first electric vehicles were implemented, technologies for using low-carbon raw materials were developed, and institutes of climatology and ecology were developed. There are about three hundred organizations associated with Roshydromet alone in St. Petersburg and the Leningrad region. However, the vector and general strategy of the city's scientific sector in this area have not yet been determined.

divided.
In the developed world, significant attention is being paid to the development of climate technologies as a way to accelerate the achievement of carbon neutrality. In 2021, at the 26th UN Climate Change Conference, the global program Breakthrough Agenda for the development of clean technologies until 2030 79 was agreed upon. The agreement was signed by more than 40 states, Russia was not among them. Countries have committed to annually monitoring progress in the development of affordable clean technologies among the highest-emitting industries. Five key areas have been selected for the first stage: energy, road transport, steel production, renewable and low-carbon hydrogen, and agro-industrial complex.

Climate technology is highlighted as an emerging asset class, showing strong investment growth. In the second half of 2020 and the first half of 2021, the total investment in climate technology amounted to $87.5 billion. At the same time, in the first half of 2021, arecord level of investment was achieved -$60 billion, which is an increase of 210% year on year.

Russia is also taking steps to develop the scientific, technological and logical base for the implementation of the green transition. Lately there has been
Several significant programs and documents were approved.

In 2022, the Government adopted the Federal Scientific and Technical Program in the field of environmental development of the Russian Federation and climate change for 2021–2030 81. The volume of budgetary allocations for its implementation from the federal budget is 5926.652 million rubles. The objectives of the Program include the development of high-tech technological solutions, the study of climate and adaptation mechanisms to climate change, ensuring sustainable and balanced socio-economic development of Russia with low greenhouse gas emissions.

In the same year, the Russian Ministry of Education and Science launched an initiative to create carbon test sites on the basis of scientific and educational organizations 82. Industry documents were approved: Concept for the development of hydrogen energy in the Russian Federation, Concept for the development of production and use of electric road transport in the Russian Federation for the period until 2030.

Important actions have been taken to develop the scientific and technological base of the green transition in Russia. However, for now these are point solutions that do not have asystematic approach, and such conditions are not enough to implement green
transition at the country and city levels.

79 Breakthrough agenda — launching an annual global checkpoint process in 2022 // COP26. URL: ukcop26. org/ breakthrough-agenda-launching-an-annual-global-checkpoint-process-in-2022/ (accessed 02/17/2022).

80 State of Climate Tech 2021 // PwC. URL: pwc.com/gx/ en/services/sustainability/ publications/state-of-climate-tech.html (accessed 02/17/2022).

81 Decree of the Government of the Russian Federation of February 8, 2022 No. 133 "On approval of the federal scientific and technical program in the field of environmental development of the Russian Federation and climate change for 2021–2030." // Russian Government. URL: static.government.ru/ media/ files/ Ekv7TcPAJBv4n3oU n6ofUdAR5cu5W1PM.pdf (access date: 02/17/2022).

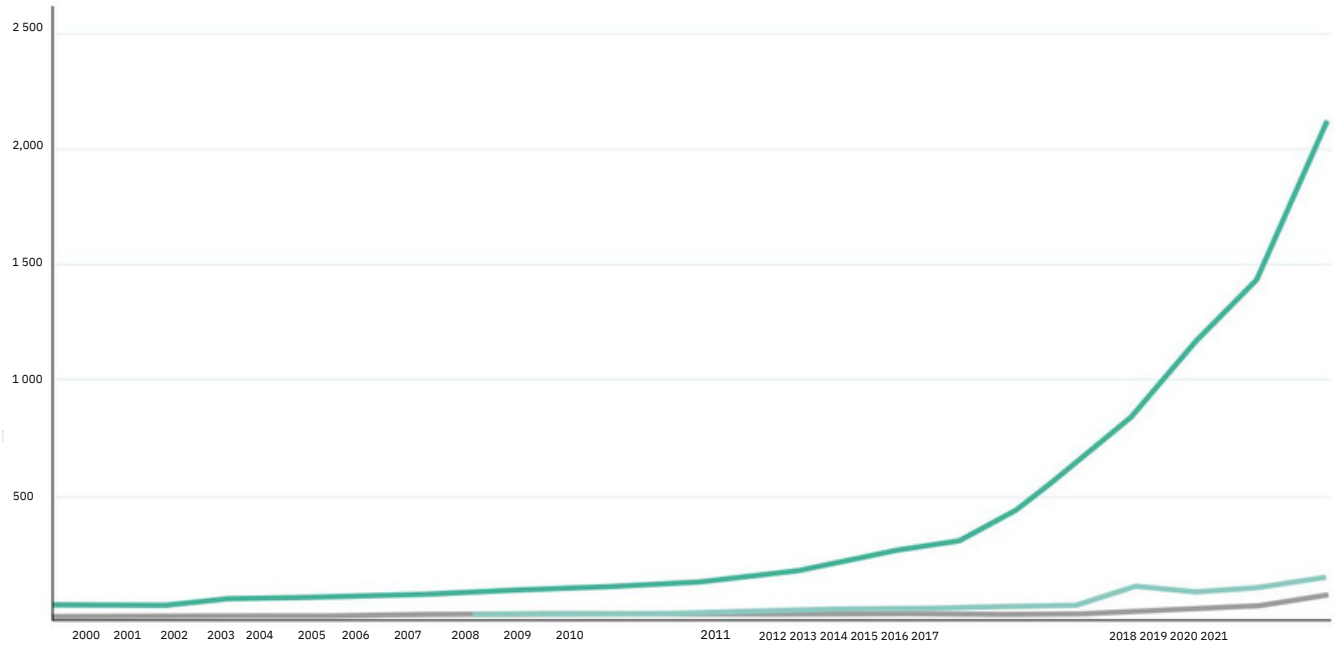
82 Carbon polygons // Ministry of Education and Science of Russia. URL: minobrnauki.gov.ru/ action/poligony/ (date of access: 02/17/2022).

4.1 WHAT TOPICS FORM THE SCIENTIFIC FRONT OF THE GREEN TRANSITION?

Climate risks and decarbonization policies, which society has not previously had to deal with, pose the task of developing frontier scientific topics and innovative technologies that help reduce the negative impact on the environment. The definition of climate (green) technologies is deliberately broad, as they cover a large number of techniques and are used in many sectors of the economy.

Climate technologies Climate technologies agrere tehnohsoeu tseec h gnaosl oegmieiss tihoants a orre eelixmpilnicaitliyn gai tmhe d e f afet c retsd u ocf i gnlgo b al warming. Based on their application, they can be divided into three groups: 1) direct reduction or elimination of emissions; 2) direct reduction or elimination of emissions; 2) assistance in adaptation assistance in adaptation to the condsefqinuietionnce osf othf e c lgimreaeten ctrhaannsgiteio;n 3i)s i meqpuroavlliyn g b ruonade. rRsetalantdeidn g to opfi cthse in ncalutudre t ohfe celimneartgey 8 t3ra. n Tshiteio n and low-carbon transition. As scientometric analysis shows, an increase in the number of publications is noted in all areas. The maximum increase in the number of publications is observed on the topic of energy transition - more than 10 thousand for all time, and the first date back to 1932. The depth of the topic is justified by the fact that the current transition to renewable energy sources is considered the fourth energy transition in human history. The terms “green transition” and “low-carbon transition” are more recent, with the earliest publications on the latter topic appearing in 2007.

83 State of Climate Tech 2021 // PwC. URL: pwc.com/gx/en/ services/ sustainability/ publications/state-of-climate-tech.html (accessed 02/17/2022).



Rice. eleven.

Dynamics of publications indexed by Scopus around the world for 2000–2021

Source: SSR North-West according to Scopus

Based on the results of the foresight session “Frontiers in the New Sciences”, a series of expert interviews and scientometric analysis of publications in the Scopus database, amatrix of scientific and technological frontiers of the green transition was compiled (Fig. 12). About 100 topics with a volume of more than 1000 publications for the years 2000–2021 were selected. For acomplete list of scientific frontiers, see the Appendix.

According to the frontier matrix, mature science includes research into various energy sources - from fossil to renewable: carbon, hydrogen, biomass, coal, solar and nuclear energy, electricity, natural gas, etc. The topics of climate change and sustainable -chievous development. Breakthrough science is dominated by the topics of regulation and governance in the field of green transition. There are three thematic blocks here: green finance, climate and energy regulation, industrial decarbonization. Thus, there is atransition of research from the object of management (energy sources, greenhouse gases) to the development of amanagement model. An illustrative example of publications on the topic of carbon: “carbon” is the most published topic (4.5 million articles, CAGR 9.5%), and “carbon price” is one of the breakthrough topics (6.7 thousand articles, CAGR 35.5%).

The main clusters of scientific and technological frontiers in the field of green transition are listed below.

Green finance Topics highlighted include carbon price, carbon tax, green securities. From green finance the vector of low-cocarbon development.

Management model The issues of developing climate and energy strategies, adaptation and mitigation of climate change, energy security, ESG, risk assessment in the field of energy transition.

Energy management Application of smart and flexible technologies in energy management: smart electrical networks, energy flexibility systems, power transmission networks gii.

Decarbonization of industry Industrial symbiosis, decarboni-ation, green production, green construction, green IT technologies.

Energy sources In general, research into energy sources (based on fossil fuels, as well as renewable energy sources and alternative sources) is amature science. But green hydrogen is considered one of the most breakthrough topics (2.4 thousand articles, CAGR 40%). In the energy sector there are

There are several types of hydrogen in depending on the environmental friendliness of its production. Green hydrogen is the most environmentally friendly, it is obtained by electrolysis of water using renewable energy sources. Other types of hydrogen were not included in the frontier matrix in terms of the number of publications, but have prospects for development. Gray hydrogen (23 articles, CAGR 10%) is produced through steam reforming of methane, during which carbon dioxide is released. Blue hydrogen (163 entries, CAGR 26%) is also produced by steam reforming methane, but subject to carbon capture and storage 84.

The strategy for the socio-economic development of the Russian Federation with low greenhouse gas emissions until 2050 involves atransition to the best available technologies. This partly explains that the technologies specified in the Strategy, for the most part, belong to mature science (RES, nuclear energy, recycling, etc.). An important area is carbon capture, utilization and storage (CCUS) technologies. According to the expectations of the Russian Ministry of Economic Development, under the intensive scenario, the implementation of CCUS technologies will require investments in the amount of 35 trillion rubles for the period 2031–2050. In addition, CCUS is aclosing technology, its cost tends to decrease. Currently, using CCUS costs an average of $100 per ton of CO2 . As technology develops, the price will fall and cut off more and more decarbonization activities, the cost of which will be beyond this price limit.

84 Classification of hydrogen by color // Neftegaz.ru. URL: neftegaz.ru/tech-library/energoresursy-fuel/672526-klassifikatsiya-vodoroda-po-tsvetu/ (date of access: 05/13/2022).

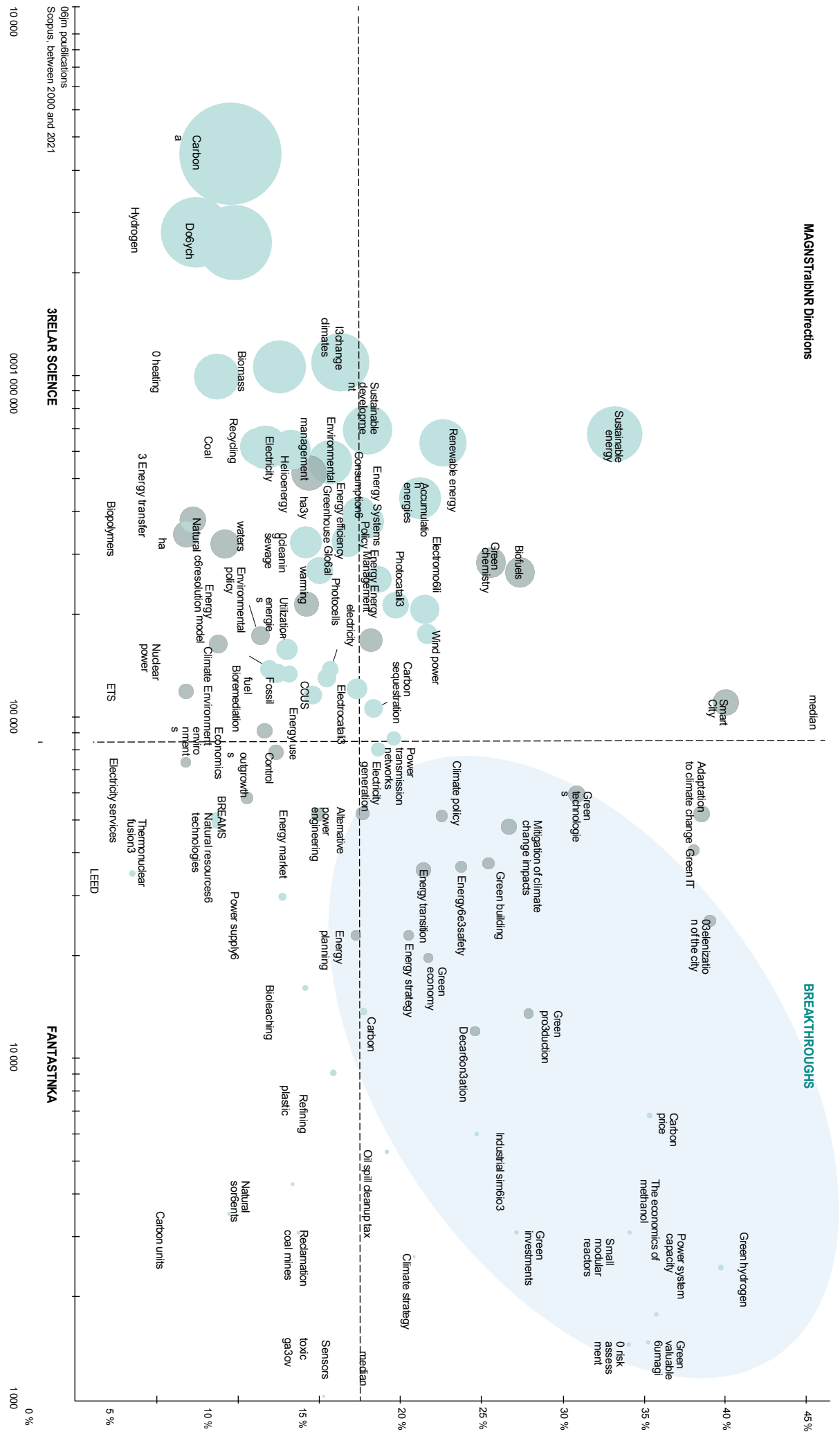
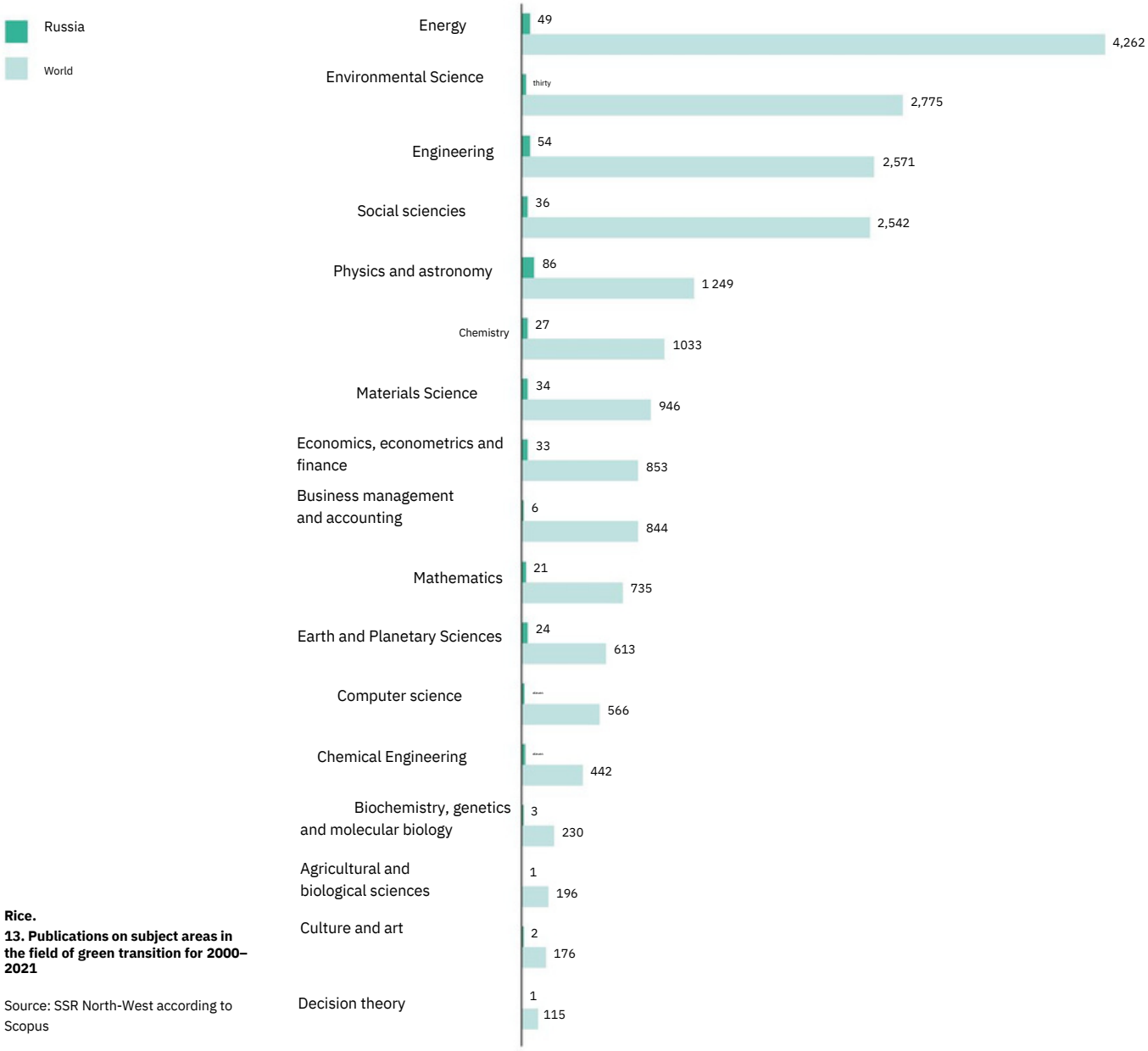


Figure 12.
Matrix of scientific a n d technological fronts, 2000-2021
*** The matrix reflects frontiers with a volume of more than 1,000 publications for 2000-2021. Punson size - volume of Scopus publications for 2021**

Source: CSR North-West according to Scopus data

According to Scopus data on publications on the topic of the green transition, 85, among the subject areas, energy, environmental sciences, engineering and social sciences are far ahead. A large number of publications in the social sciences section can be explained by the fact that the energy transition changes the usual socio-economic structure and requires the transformation of social systems and behavioral habits. The number of publications in the field of economics and management is quite large, which may indicate the importance the importance of taking into account the impact of the energy transition on economic activity and the management system. Russia has the most publications in the field of physics and astronomy, followed by engineering and energy.

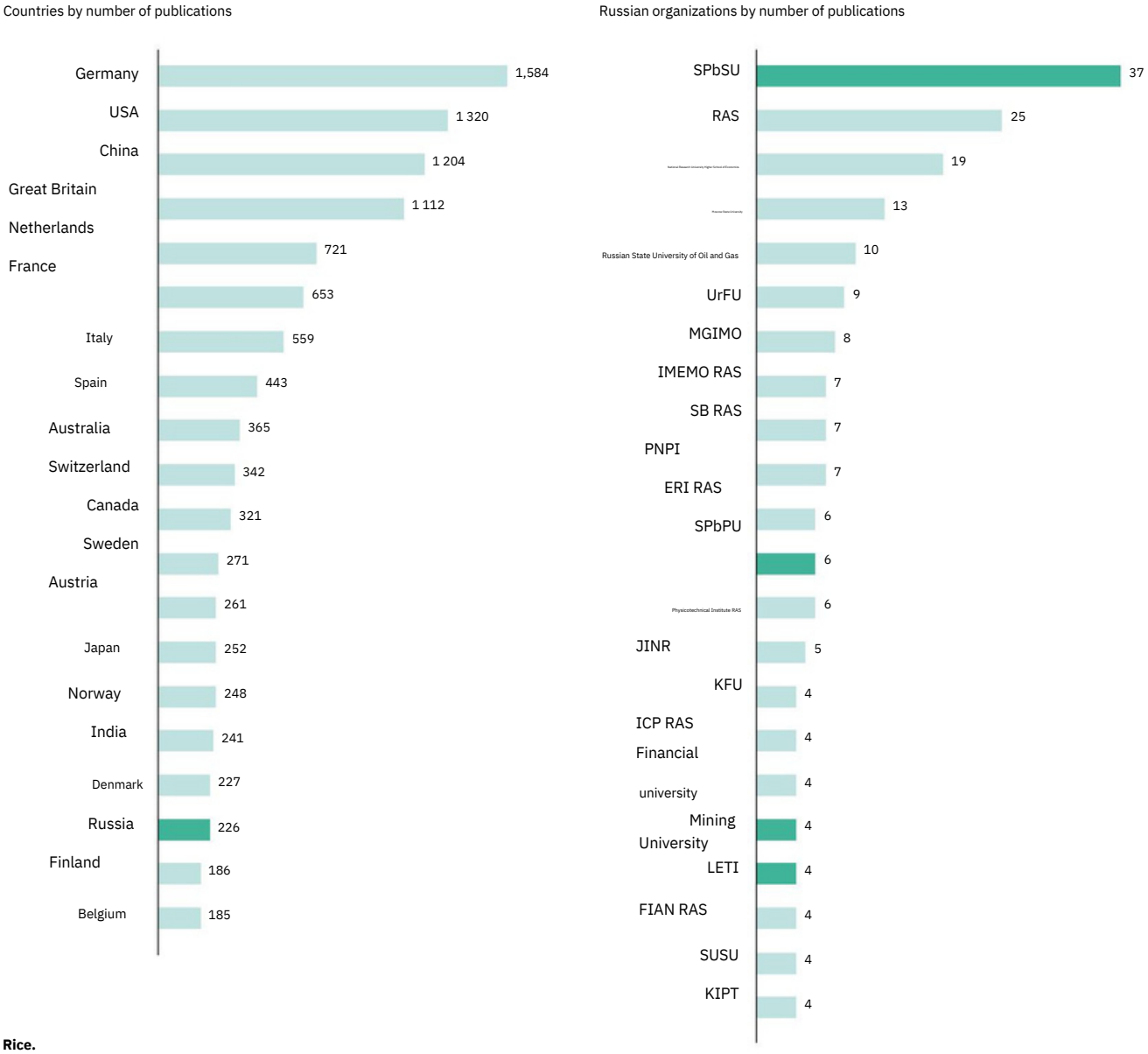
85 The themes "Energy Transition" and "Low Carbon Transition" were also taken into account.



Rice.
13. Publications on subject areas in the field of green transition for 2000–2021

Source: SSR North-West according to Scopus

Russia is among the top 20 countries in terms of the number of publications in the field of green transition over the past 20 years. The top three are Germany, the USA and China. Moscow is the leader among Russian cities. St. Petersburg is in second place, represented by St. Petersburg State University, Peter the Great St. Petersburg Polytechnic University, Mining University and LETI. At the same time, St. Petersburg State University leads among all Russian organizations in the number of publications.



Rice.
14. Statistics of publications in the field of green transition for 2000–2021

Source: SSR North-West according to Scopus

4.2 INNOVATIVE INFRASTRUCTURE FOR GREEN R&D

To ensure a green transition, it is necessary to create an innovation infrastructure that allows the development and testing of carbon-free technologies. Similar projects are already being developed in Russia. They include the creation of carbon test sites and farms, laboratories and scientific and educational centers (RECs) specializing in climate technologies.

Carbon polygons

Carbon polygons are one of the key infrastructures for launching green transition, since there is still no understanding of how to measure many of its aspects. In February 2021, the Russian Ministry of Education and Science launched a pilot project to create carbon testing sites in the regions of the country for the development and testing of carbon balance control technologies.

polygons - territories with aunique ecteorsryitsotreiems, wcriteha ate udnique ecosystem, created -Carbon polygons Carbon suitable for the implementation of measures to control climate-active gases with the participation of universities and scientific organizations 86.
Carbon test sites were created in ten regions: Kaluga, Kaliningrad, Novosibirsk, Sakhalin, Sverdlovsk, Tyumen, Moscow regions, Krasnodar Territory, the Chechen Republic and the Republic of Tatarstan. It is planned to expand the geography of carbon polygons to another 12 regions 87.

The Russian Ministry of Industry and Trade proposed creating test sites and clusters for testing hydrogen energy technologies in the fuel and energy complex, industrial production and transport in the Russian Federation. Already existing mechanisms can be used for them support of industrial clusters.

Scientific and educational centers

In 2021, a world-class climate research center “Yenisei Siberia” was created on the basis of the Siberian Federal University. It includes 28 organizations: universities, scientific institutes and industrial companies.

Sergey Verkhovets, director of the world-class Scientific and Educational Center “Yenisei Siberia”:

Source: interview during the preparation of the report with S. V. Verkhovets, 02.25.2022

“Within the REC, the climate agenda has several aspects. First of all, this is taking into account the carbon footprint and finding ways to reduce it. Development as management and new technological solutions based on advanced scientific achievements. The second block is expert and informational support for the preparation of plans for adaptation to climate change. With the distance from Moscow, there is probably such an urgency of need development of separate comprehensive plans for adaptation to climate change is not yet felt. But we are just now working on setting the task with the Krasnoyarsk Territory. In the future, we will have joint work with the Republic of Khakassia and the Republic of Tyva, which are also the initiators of the Yenisei Siberia REC.”

86 Carbon polygons // Ministry of Education and Science of Russia. URL: minobrnauki.gov.ru/action/poligony/ (date of access: 02/17/2022).

87 Falkov V.N. Report “On the new state program for scientific and technological development of the Russian Federation and the development of scientific and technological potential of the regions of the Russian Federation,” 12/16/2021.

Some other research and educational centers are also taking part in the development of the green agenda. For example, on the basis of the REC of the South of Russia, an ESG expert assessment center was created to examine projects being implemented in the region for compliance with sustainable development goals. On the basis of the Eurasian REC, there is a center “ESG models for the growth of new eco-territories” for the development of eco-territories and achieving carbon neutrality of the region using the technology of sequestration of greenhouse gases by biological and physico-chemical

Chinese methods.

Regional hubs and clusters

An important infrastructure for accelerating green projects is regional clusters and hubs. In the Northern capital, we can highlight the “Energotechnohub St. Petersburg” and the “St. Petersburg cluster of clean technologies for urban

environment."

Nikolay Pitirimov, Deputy Chairman of the Board of Directors of the international consortium “St. Petersburg Cluster of Clean Technologies for the Urban Environment”:

Source: interview during the preparation of the report with N.V. Pitirimov, 11/19/2021

“The mission of the cluster is to make St. Petersburg an eco-logical and safe city to live in, to combine clean technologies in all sectors of the city’s economy and its value chains. To achieve this goal, the efforts of government authorities, business, educational institutions and civil society have been coordinated to develop an ecosystem of industrial symbiosis in St. Petersburg and Leningrad region and the creation of an ecosystem of industrial symbiosis in Russia. The consortium today unites 56 organizations in Russia and abroad. The revenue of enterprises and organizations of the cluster in St. Petersburg exceeded 21 billion rubles in 2020. Average headcount per

enterprises and organizations of the cluster amount to 44,500 people.”

Name	Year of creation	Participants	Description
St. Petersburg cluster of clean technologies for the urban environment	2014	The cluster includes educational institutions, government agencies, and the private sector	The project is being implemented with the support of the Cluster Development Center of JSC Technopark of St. Petersburg. The activities of the cluster meet the main goal of the development of St. Petersburg -a stable improvement in the quality of life of the population with a focus on ensuring the European quality of life based on the formation of St. Petersburg as a multifunctional city integrated into the Russian and world economy, strengthening its role as the main Russian contact center. tra of the Baltic Sea region and North-West Russia 88.
"Energotechnohub Petersburg"	2019	The Government of St. Petersburg, PJSC Gazprom Neft and ANO Agency for technological development"	Attracting engineering departments of industrial and energy corporations to St. Petersburg, supporting local technology startups. Residents of Energotechnohub are working to overcome the most important technological challenges in the energy industry, including developments in the field of renewable energy sources, creation of high-tech geological exploration tools, underwater systems and robotic technologies 89.

Name	Year creation	Participants	Description
Hydrogen hub based on PES in Penzhinskaya Bay	2021	Ministry of the Russian Federation for the Development of the Far East and Arctic, Kamchatka Development Corporation region, Government of the Kamchatka Territory, N2 Clean LLC energy"	Project for the construction of ahub for the production of green hydrogen based on tidal power plants (TPP). It is planned to create a low-carbon metallurgical cluster, which will allow the formation of a complete supply chain for metallurgical production: extraction of raw materials, transportation, energy-intensive processing and production of products for export 90.
Industrial cluster for the production of renewable energy equipment	2019	Cooperation of industrial enterprises and scientific centers of the Russian Federation with large international industrial companies	In Russia, solar power plants are already operating, built under the program to support renewable energy sources, which generate electricity in excess of 1,200 MW. This volume turned out to be sufficient to attract significant investments in the creation of industrial production of generating equipment for solar power plants. The largest projects are Hevel Group of Companies, Helios-Resource LLC and Solar Silicon Technologies LLC. The production potential of established factories in the Russian photovoltaic equipment sector currently exceeds 700 MW per year 91.

Table 7.
Examples of clusters and hubs for green R&D in Russia

Source: Center for Social Research "North-West" according to open sources

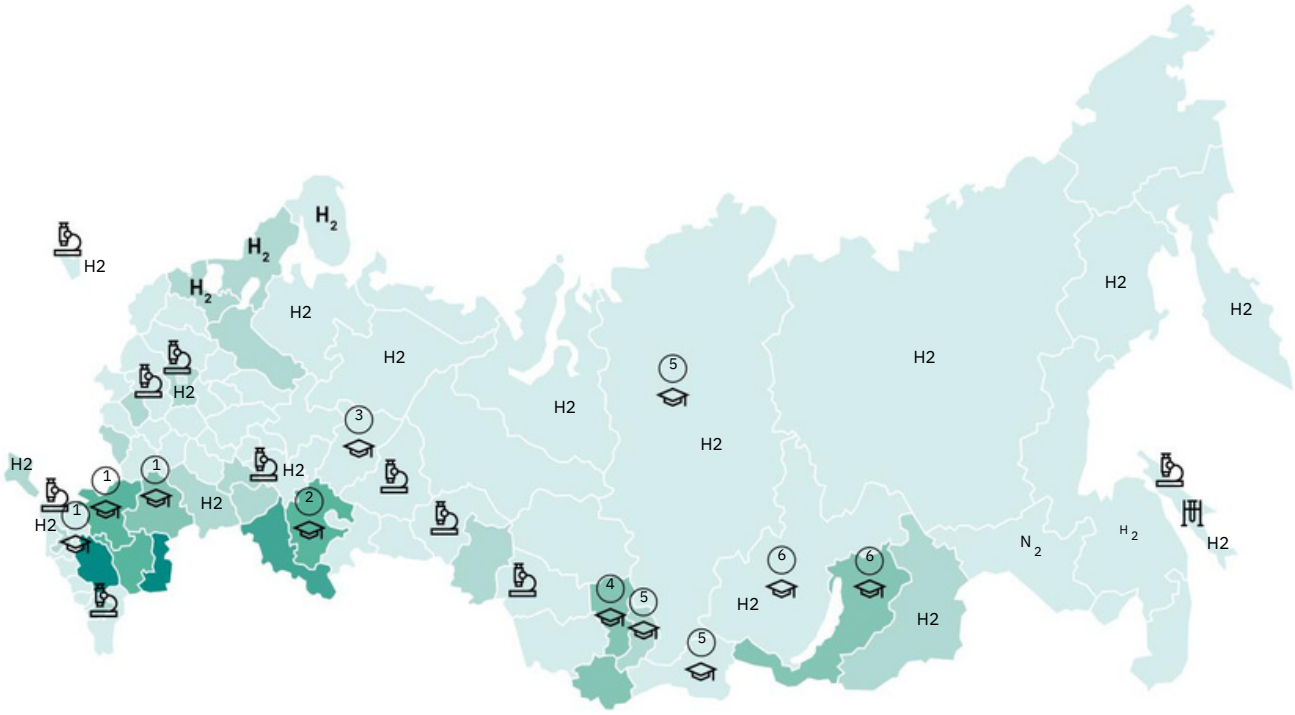
88St. Petersburg cluster of clean technologies for the urban environment. URL: spbcleantechcluster.nethouse.ru/ (date of access: 03/14/2022).

89Smart energy: Gazprom Neft launched the Energotechnohub St. Petersburg project // 78.ru. URL: 78.ru/articles/2020-12-29/umnaya_energetika_gazprom_neft_zapustila_proekt_energotehnohab_peterburg (date of access: 03/14/2022).

90Hydrogen hub based on TPP in Penzhinskaya Bay // KPMG. URL: minvr.gov.ru/upload/iblock/ 13c/ perspektivy-sozdaniya-vodorodnogo-khaba-na-baze-pes-v-penzhinskoy-gube.pdf (date of access: 03/14/2022).

91The Russian renewable energy market: current status and development prospects // ARVE. URL: bigpowernews.ru/ photos/ 0/0_QpMU3sFiiWS8DWQGAjebKaVDm6WVTGiO.pdf (access date: 03/14/2022).

Based on infrastructure projects aimed at decarbonization, a map of the regions of the Russian Federation has been compiled (Fig. 15). The South turned out to be the leader -due to the number of qualified generating facilities based on renewable energy sources. The greatest diversification of projects (three types, including renewable energy sources) is observed in the Sakhalin and Moscow regions.



Rice. 15.

Map of Russian regions by the number of decarbonization projects

Source: Center for Social Development "North-West" according to NP "Market Council", Ministry of Education and Science of Russia, Ministry of Industry and Trade of Russia

Number of RES *

from	before
0	0
1	5
6	10
	15
	20
1	25
6	
2	
1	thirty
2	
6	

* Qualified generating facilities based on renewable energy sources are taken into account (Decree of the Government of the Russian Federation dated June 3, 2008 No. 426, as amended as of December 25, 2021)

Climate projects

- Projects for the production of low/carbon-free hydrogen and ammonia (Atlas of the Russian Ministry of Industry and Trade)
- Carbon test site (Order of the Ministry of Education and Science of Russia dated 02/05/2021 No. 74)
- World-class scientific and educational center (REC) ** (Resolution of the Government of the Russian Federation of April 30, 2019 No. 537)
- Carbon experiment (Federal Law dated March 6, 2022 No. 34-FZ)

** RECs implementing climate projects are taken into account

1. REC of the South of Russia
2. Eurasian REC
3. REC "Rational Subsoil Use"
4. REC "Kuzbass"
5. REC "Yenisei Siberia"
6. REC "Baikal"

4.3 WHAT COMPETENCIES ARE NEEDED FOR A GREEN TRANSITION?

The transition to a post-carbon economic system will reduce asignificant number of jobs, but at the same time require the creation of new ones -for green industries. The International Labor Organization (ILO) has introduced anew concept - “green professions”. ILO research shows that implementation of the Paris Agreement on climate change could lead to anet gain of 18 million jobs by 203092.

92 Green jobs // ILO. URL: ilo. org/ global/ topics/ green-jobs/ langen/index.htm (date of access: 03/14/2022).

Green professions contribute to the conservation or restoration of the environment, whether in traditional industries (manufacturing and construction) or new and rapidly developing green sectors (renewable energy and energy efficiency). Based on the results of the foresight session “Frontiers in the New Sciences,” alist of knowledge, skills and tools necessary to form the image of a future key investigator (PI) in the field of green transition was compiled.

Knowledge	Skills	Tools
basic education in chemistry (some sections), biology	working with the product life cycle	Software for computer modeling nia
green economy	possession of several special news	work with environmental databases: uninterrupted open data exchange system
understanding of the essence and progress of synthesis (synthetics, organics and inorganics)	sustainable total experience	crowdfunding platform for green projects
designing urban environments with decarbonization in mind	ability to plan interdisciplinary research	a new focus on assessing the feasibility of actions and their impact on the environment, assessing knowledge and research
establishing and using strong interdisciplinary connections	skills of energy service regulation in the city	BIM
		citizen science

Table 8.
Image of the future PI in the field of green transition

Source: foresight session “Front Tiers in New Sciences”, November 9–10, 2021

An analysis of foreign vacancies in the field of green transition showed that the most in demand are researchers in the field of environmental technologies and specialists in managing the transformation of sustainable development.
Many educational programs in the field of green transition are presented in foreign countries. They are mainly aimed at studying green technologies and are interdisciplinary. Basic disciplines are chemical engineering, energy, sustainable development, ecology, biomedical engineering, electrical engineering, mechanical engineering, etc. In addition to technical disciplines, programs are aimed at studying financial engineering, industrial engineering, project and risk management, green information technology, understanding the product life cycle from origin to processing or disposal.

Based on the analysis, an image of anew PI was formed that meets modern tasks and challenges in the green transition. The expert must have knowledge, skills and competencies in the specialized field of research, basic knowledge in related fields of science, as well as additional skills and competencies in the field of project management, HR, GR, PR for the effective organization of work on research projects.

The PI must be knowledgeable in economics in order to carry out calculations to justify the introduction of green technologies 93. With the widespread penetration of digital technologies and solutions in the field of artificial intelligence, it is mandatory to have basic knowledge of modern information technologies and programming sufficient to organize effective communication with project participants - representatives of the IT department, development of technical specifications. Special knowledge of inorganic chemistry is important for those involved in the production of green products.

Experts note that in Russia there has not yet been ademand for green personnel.
Unlike foreign countries, Russian city administrations do not have positions of sustainable development specialists or sustainable development departments. Many positions on the domestic labor market are represented by international companies. Their supply will be affected by the departure of IKEA, Unilever, Nestle, etc. from Russia. 94. This means that it is necessary to form anational system for training and employing green personnel.

93 Foresight session “Frontiers in new sciences”, November 9–10, 2021.

94 Online networking “How to survive a green business”, 03/18/2022.

5 A MODEL OF GREEN CROSSING IN THE CITY. RECOMMENDATIONS.

The components considered in the report allow us to draw conclusions about their role and interaction in the green transition. In the model of the green transition in the city, the main actors are the city administration, the business community, universities and research institutes. Three levels of influence affect the decisions of actors in the field of climate policy: the regulatory framework of Russia in the field of green agenda, largely formed in 2021; transboundary carbon regulation, which in the medium term will be introduced in developed countries of the world; fundamental international documents and programs in the field of climate, such as the UNFCCC, the Paris Agreement, the 2030 Agenda for Sustainable Development.

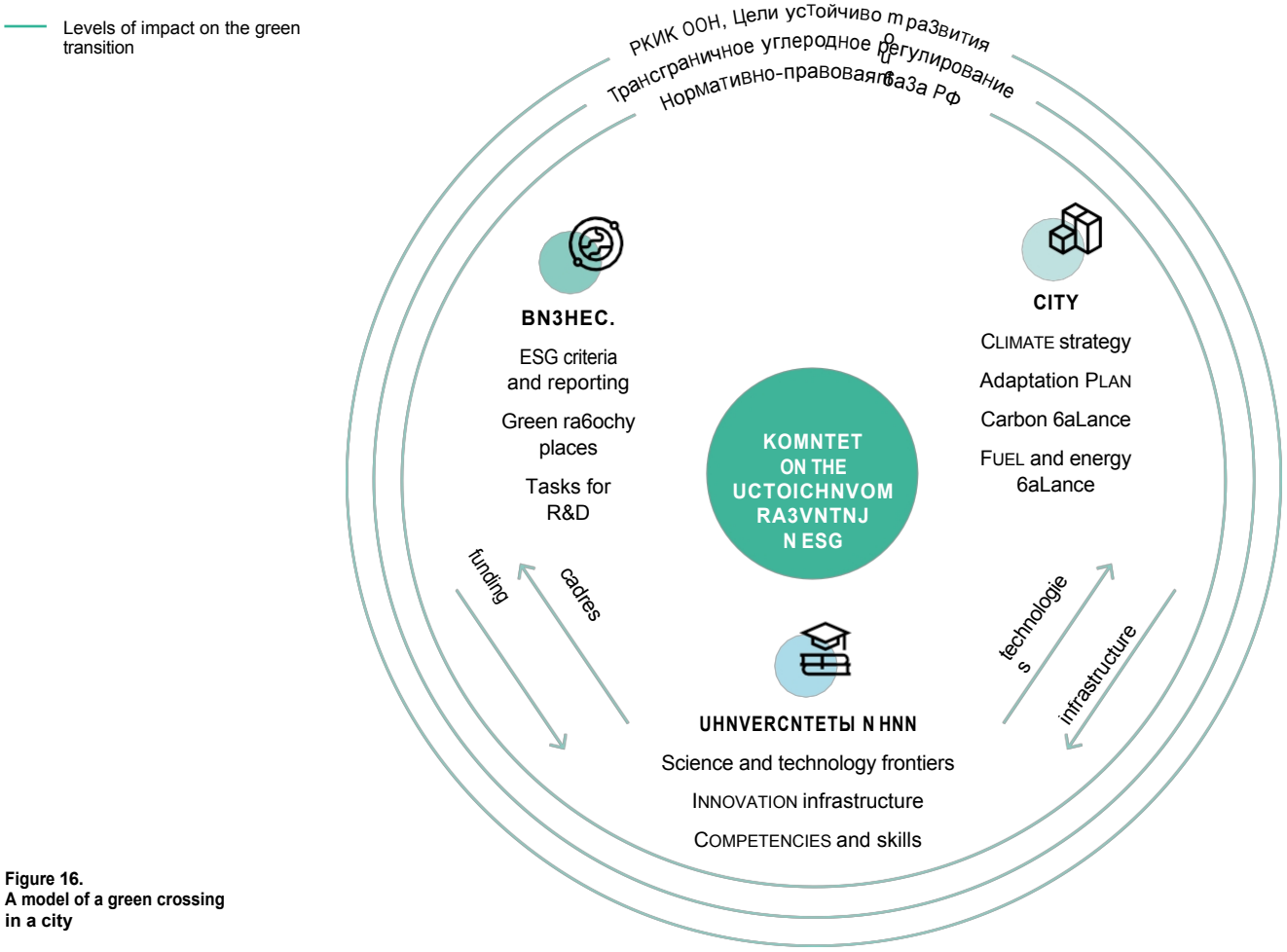


Figure 16.
A model of a green crossing in a city

Source: CSR "North-West"

The peculiarity of the green transition model in Russia is that the leading role belongs to business, mainly the financial and raw materials sectors. This is justified by the prospect of introducing cross-border carbon regulation and investors' demands for companies to comply with ESG criteria confirmed by ratings. But as aresult of the imposition of sanctions restrictions, for most companies the risks of introducing TUR have lost paramount importance. In this regard, the implementation of the green transition may slow down. Therefore, the role of transition driver should be taken by the scientific and educational sector, which has the power to develop advanced technologies and train personnel for business and the city. Universities and research institutes should receive real tasks from business for R&D and educational programs. It is necessary to provide financial and infrastructural support for scientific and educational activities. To converge the actions of all actors, it is recommended to create a governing body under the city administration - the Committee for Sustainable Development and ESG.

Green transition is an interdisciplinary field requiring environmental knowledge, engineering and socio-economic competencies. More recently, the green agenda has emerged within engineering disciplines. Renewable energy sources and methods of their production are being widely researched. Climate change research has become firmly established in science; scientists can calculate the increase in the average annual temperature of the Earth over the past thousand years and predict it for hundreds of years in the future. However, the energy transition is also amatter of changing behavioral habits and social patterns, and it is important to develop a socio-economic approach in conjunction with engineering sciences. Analysis of scientific and technological frontiers shows ashift in the focus of research towards management and economic disciplines. This is confirmed by trends in the global community: achieving international consensus on reducing emissions is one of the key tasks. In recent years, countries have adopted many programs and strategies to achieve carbon neutrality, and the introduction of transboundary carbon regulation is being discussed. In Russia, the formation of a regulatory framework in the field of the green agenda has begun. It is also necessary to develop amanagement approach at the city level: carbon and fuel and energy balances should become new objects of management, the parameters and directions of the green transition should be reflected in the climate strategy and plan adaptation to climate change.

Despite the shift towards management, new frontiers are emerging in engineering sciences: carbon balance measurement (development of carbon polygons), green hydrogen production, flexible technologies for storing and distributing electricity from renewable energy sources, smart city technologies and energy-efficient solutions, etc. etc. In today's economic conditions, it is promising to lay down green standards in reengineering and development of new production processes.

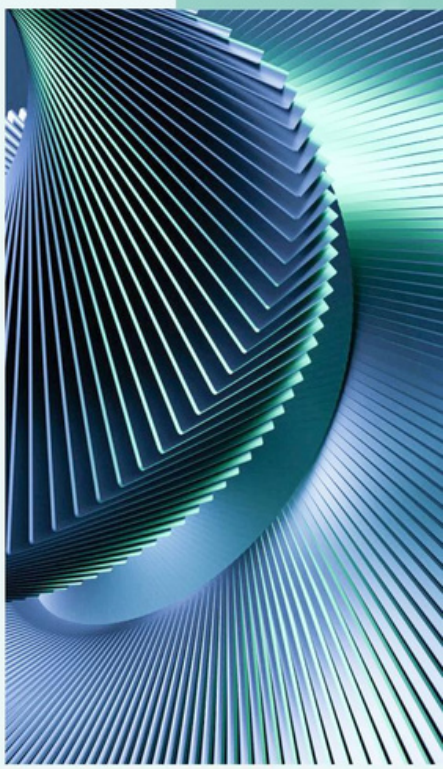
An interdisciplinary approach to the green transition is in the process of formation, so it is important to develop projects and platforms for communication between representatives of different scientific fields and industries. Examples of such initiatives in Russia can be world-class scientific and educational centers, clusters and hubs for climate and energy projects.

Conclusion

The geopolitical situation in the first half of 2022 has deprioritized decarbonization goals, but they remain important in long-term climate change projections. Russia's increased attention to the decarbonization agenda was largely facilitated by the likelihood of the introduction of TUR into the EU. With the cessation of major trade relations with European states, this task ceased to be considered paramount. At the same time, the development of cooperation with Asia-Pacific countries (which pay attention to ESG policies) seems promising. Relations with Western countries will most likely resume sooner or later, but it will be much more difficult to overcome the gap on the ESG agenda

more difficult.

For Russian cities, the priority of ESG agenda tasks is changing. During times of high turbulence, social development (S) and corporate governance (G) come to the fore: it is important to support people and companies during times of economic instability. Environmental factors are becoming more significant in relation to the quality of the urban environment, and decarbonization tasks are receding into the background. At the same time, the role of environmental marketing (in particular greenwashing) among decarbonization projects is expected to decrease,



because for some time the green agenda will cease to play a significant role
role in companies attracting capital and customers.
Despite the difficulties generated by the new economic conditions, ademand for defining a strategy and model for the green transition will begin to emerge. This is due to the requirements of new foreign partners, including from Asia-Pacific countries. Corresponding assessments began to appear in strategic and program documents of the constituent entities of the Russian Federation (Kaluga, Sakhalin, Leningrad regions, St. Petersburg).

St. Petersburg is amajor socio-economic center and the second largest city in Russia. However, even before the start of the economic crisis in 2022, it practically did not stand out on the green agenda among the regions of the Russian Federation, and even more so among the cities of the world: St. Petersburg does not have a comprehensive decarbonization program in the field of energy, transport, construction and industry, and the date for achieving carbon neutrality has not been approved , there are no qualified generating facilities based on renewable energy sources. These issues must be resolved with the development of aregional climate change adaptation plan, scheduled for 2022.

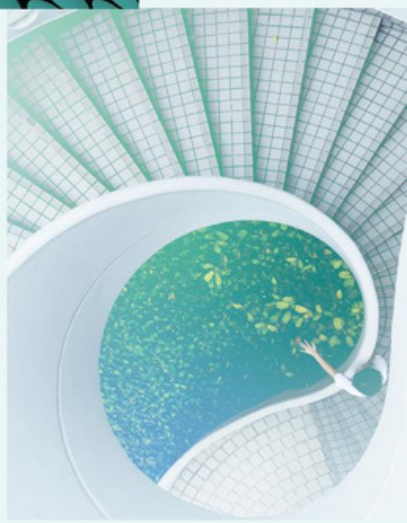
A number of documents have been adopted at the government level to form a post-carbon economy, so the implementation of agreen transition in cities is a matter of time. At the moment, the creation of aregulatory, legal and financial system for the energy transition across the country is underway. St. Petersburg still has the opportunity to prove itself and take a favorable position among the regions of Russia.

Despite all this, there are several forks on the city's path to the green transition. Firstly, it can follow the inertial path of Russia's overall development, based on the adopted regulatory acts and put forward requirements in the field of decarbonization. Secondly, St. Petersburg can take the initiative in green projects that are being implemented nationwide: carbon polygons, hydrogen projects, renewable energy sources. And thirdly, the city can find its unique profile and thereby stand out among other regions to retain and attract investors and large companies. The strength of the Northern capital should be the development of research centers and the training of green personnel. For example, St. Petersburg does not have large areas for creating carbon polygons, but it is capable of becoming a center for the development of green technologies. Training highly qualified specialists for the country is also a potentially strong

ron of the city, useful for attracting new human capital.
St. Petersburg should develop a list of measures to reduce emissions achievable over the horizon of 2030 and 2050. Taking into account the experience of other cities, it is necessary to establish preferences for the development of transport in

gas or electricity, up to the abolition of transport tax and parking fees for electric vehicles. The production of vehicles powered by gas or electricity should be given priority -their purchase should be subsidized. An economic effect, combined with areduction in large volumes of emissions, can be achieved by introducing preferences for maritime passenger and cargo transport with low emissions in the ports of St. Petersburg and the Leningrad region.

An important aspect is increasing the energy efficiency of new buildings. Regional requirements for major repairs and renovations should be strengthened in terms of energy saving. The same applies to landscaping urban areas. City-controlled banks should develop targeted green



ny loans to entrepreneurs implementing projects that are significant for the city. St. Petersburg should follow Moscow's example by issuing green bonds to modernize passenger transport and heat supply infrastructure.

The difficulty of the energy transition for St. Petersburg is that its energy system relies on its own base of traditional resources without the presence of renewable energy generation in the city's fuel and energy balance. The carbon budget must become a new subject of management, and for this it is important to continuously monitor emissions. Among the regions of Russia on voluntary

On the basis, only afew do this, and the proposed measure may become a distinctive feature of St. Petersburg. The decarbonization policy of large companies in the energy sector (primarily Gazprom) will be of great importance.

localized in the city since the recent past.
Because carbon emissions and infrastructure are often over-
There are administrative boundaries, the policy for regulating the green transition must be coordinated at least within the boundaries of the agglomeration of St. Petersburg and the Leningrad region. It is also promising to establish cooperation
cooperation on this issue with other regions and cities.
While the green transition ecosystem has not yet formed, asignificant role is given to supporting the city government, stimulating the business community to reduce emissions and develop green projects. In general, the consolidation of all parties is important: the government, the business community, the scientific and educational sector, NGOs and city residents.

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102. Interview: V.V. Sklyar, VTB Capital (date: 01/24/2022).

103. Interview: V. I. Mlynchik, VOLTS Battery (date: 11/16/2021).

104. Interview: N.V. Pitirimov, St. St. Petersburg cluster of clean technologies for the urban environment (date: November 19, 2021).

105. Interview: R.V. Baskakov, SETCleanTech (date: 01/27/2022).

106. Interview: R.V. Lvov, Sberbank (date: 12/10/2021).

107. Interview: S. V. Verkhovets, REC "Yenisei Siberia" (date: 02.25.2022).

108. Interview: S.K. Boyarkin, Russian Railways (date: 12/15/2021).

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Application

No.	Scientific and technological frontier	Quantity publications for 2000–2021	Average annual growth in the number of publications, CAGR, 2000–2021	Quantity publications for 2021
1	Carbon / Carbon	4 471 922	9.51%	452 767
2	Hydrogen / Hydrogen	2 630 025	7.38%	231 475
3	Extraction / Production	2 448 867	9.74%	264 250
4	Climate change / Climate change	1,089,798	16.33%	149 717
5	Biomass / Biomass	1 060 585	12.56%	131 836
6	Heating / Heating	987 375	8.68%	94 106
7	Sustainable development / Sustainable development	697 486	17.99%	111 839
8	Sustainable energy / Sustainable energy	668 897	33.27%	133 647
9	Renewable energy energy	633 060	22.68%	99 680
10	Recycling / Recycling	618 009	11.69%	79 819
[illegible]	Coal	616 728	11.26%	70 679
12	Electricity / Electricity	607 803	13.19%	69,436
13	Environmental management / Ecological management	556 014	15.69%	85 160
14	Solar energy / Solar energy	517 389	14.42%	57 411
15	Energy storage / Energy storage	439 150	21.21%	79,584
16	Energy efficiency	393 312	17.52%	50 472
17	Energy transfer / Energy transfer	378 382	7.21%	30 190
18	Energy systems	374 948	17.92%	55 013
19	Energy consumption	370 052	17.57%	51 401
20	Biopolymers / Biopolymers	341 756	6.78%	26,774
21	Greenhouse gases / Greenhouse gases	330 049	16.77%	46 189
22	Wastewater treatment	323 439	14.23%	45 180
23	Natural gas / Natural gas	316 915	9.13%	35,876
24	Green chemistry / Green chemistry	281 908	25.63%	40 342
25	Global warming / Global warming	267 336	15.01%	34,913
26	Biofuel / Biofuel	265 402	27.37%	35 718

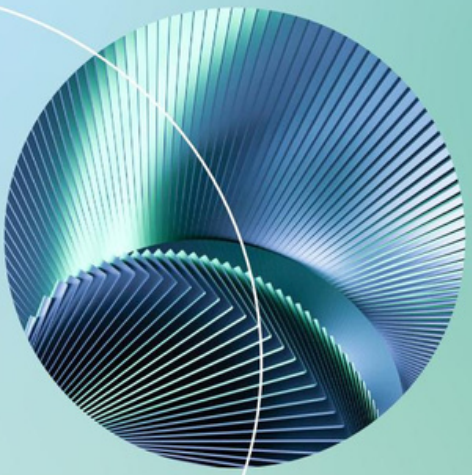
No.	Scientific and technological frontier	Number of publications for 2000–2021	Average annual growth in the number of publications, CAGR, 2000–2021	Number of publications for 2021
27	Energy policy / Energy policy	252 024	18.69%	33 271
28	Energy utilization / Energy utilization	215 385	14.26%	24 110
29	Photocatalysis / Photocatalysis	212 611	19.70%	31 154
thirty	Electric vehicles / Electric vehicles	205 704	21.54%	34 436
31	Wind power / Wind energy	175 290	21.72%	21,076
32	Energy conservation / Energy saving	172 652	11.42%	16 403
33	Energy management / Electricity management	168 357	18.20%	23,664
34	Nuclear power / Nuclear energy	163 069	8.75%	13 493
35	Environmental policy / Environmental policy	157 975	13.08%	19,500
36	Climate model / Climate model	138 225	11.94%	14,817
37	Photovoltaic cells / Photocells	137 522	15.67%	13,599
38	Bioremediation / Bioremediation	134 166	12.44%	16,321
39	Fossil fuels / Fossil fuels	133 400	13.10%	16,535
40	CCUS	129 446	15.50%	17,867
41	Electrocatalysis / Electrocatalysis	120 470	17.39%	19,508
42	ETS	119 252	6.76%	9,747
43	Energy use / Energy use	115 272	14.58%	14,466
44	Smart city / Smart city	110 003	40.15%	29,949
45	Carbon sequestration / Carbon sequestration	105 530	18.34%	13,263
46	Environmental economics / Environmental Economics	91 189	11.64%	10,739
47	Electric power transmission networks / Power transmission networks	86 433	19.62%	11 009
48	Electricity generation / Production electricity	80 190	18.66%	11 305
49	Emission control	78,993	12.39%	9,024
50	Electric utilities / Electric power services	73 759	6.77%	4,532

No.	Scientific and technological frontier	Number of publications for 2000–2021	Average annual growth in the number of publications, CAGR, 2000–2021	Number of publications for 2021
51	Green technology / Green technologies	59 372	30.93%	12,909
52	BREAMS	57 397	10.54%	5 551
53	Carbon footprint / Carbon footprint	53 011	63.07%	10,842
54	Alternative energy / Alternative energy	52 129	17.70%	7 112
55	Energy market / Energy market	51,832	14.93%	6 370
56	Climate change adaptation / Adaptation to climate change	51,812	38.61%	9 496
57	Climate policy / Climate policy	51 174	22.60%	7 361
58	Nature-based solutions / Nature-like technologies	50 436	8.69%	6 365
59	Thermonuclear fusion / Thermonuclear fusion	49 015	8.61%	4,036
60	Climate change mitigation / Mitigation of the effects of climate change	47 547	26.75%	9 149
61	Smart power grids / Smart power grids	41,050	45.89%	3,814
62	Green IT / Green IT	40 825	38.19%	5 350
63	Circular economy / Economy of the closed cycle	39 361	62.15%	15,789
64	Green building / Green building	37 166	25.46%	5,851
65	Energy security / Energy security	36 407	23.79%	5,571
66	Energy transition / Energy transition	35 411	21.47%	9 210
67	LEED	34,770	3.46%	2 267
68	Electricity supply / Electricity supply	29 640	12.67%	3 211
69	Urban greening / City greening	25 243	39.14%	6 176
70	Energy planning / Energy planning	22,898	17.30%	3 196
71	Energy strategy / Energy strategy	22,886	20.54%	4 800
72	Green economy / Green economy	19,673	21.72%	3,724
73	Bioleaching / Bioleaching	16,085	14.15%	1,965
74	ESG	13,712	17.03%	2,746
75	Carbon tax / Carbon tax	13,667	17.73%	2 372

No.	Scientific and technological frontier	Number of publications for 2000–2021	Average annual growth in the number of publications, CAGR, 2000–2021	Number of publications for 2021
76	Green manufacturing / Green production	13,498	27.94%	3,536
77	Decarbonization / Decarbonization	11,964	24.59%	3,746
78	Plastic recycling / Plastic recycling	9 004	15.88%	1,857
79	Carbon price / Carbon price	6,783	35.46%	1 173
80	Industrial symbiosis / Industrial symbiosis	5,996	24.74%	1 141
81	Oil spill cleanup	5 327	19.14%	830
82	Natural sorbents / Natural sorbents	4,258	13.36%	418
83	Nationally determined contributions / Climate obligations of countries	3,971	146.05%	1,092
84	Carbon units / Carbon units	3,509	9.42%	371
85	Green investing / Green investments	3 100	27.27%	949
86	Methanol economy / Economics of methanol	3,091	34.21%	399
87	Mine reclamation / Coal reclamation mines	3,088	13.73%	358
88	Small modular reactor / Small modular reactors	2,909	32.91%	504
89	Climate strategy / Climate strategy	2 617	20.87%	375
90	Green hydrogen / Green hydrogen	2 449	39.82%	1 140
91	Power system flexibility themes	1,774	35.83%	457
92	Green securities / Green securities	1 465	35.35%	576
93	Risk assessment / Risk assessment	1 449	34.11%	528
94	Toxic gas sensors / Toxic gas sensors	1,014	15.28%	198

Table 9.
List of scientific and technological frontiers of the green transition with avolume of more than 1000 publications for 2000–2021

Source: SSR North-West according to Scopus



ISBN 978-5-9909736-4-0

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