Innovative models of sustainable development of the region in the context of technological transformation

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Abstract. The article is devoted to the formation of a model of sustainable development of the region in the conditions of technological transformation. The components of the new model, methodological principles, innovative model of technological development are revealed, taking into account environmental priorities; allowing to coordinate the cyclical nature of economic development and the features of the stage of technology development.

1 Introduction

Sustainable development of the region in the context of technological transformation in key sectors of the region's economy is gaining new opportunities and requires innovative models that include social, environmental priorities of sustainable development, minimizing human impact on the environment. The choice of a strategic alternative to Russia's development in the medium term is influenced, on the one hand, by a number of external and internal threats of technological lag, on the other hand, by new opportunities opening up to accelerate its innovation-oriented growth. The country found itself facing serious socio-economic, geopolitical, and technological challenges. The increase in anthropogenic pressures on the environment to the extent threatening the reproduction of natural resources, and the increase in risks associated with their inefficient use for the life and health of citizens remains the most significant challenge from the point of view of scientific and technological development of the Russian Federation. Technological transformation of economic sectors and the introduction of cross-cutting digital technologies, the list of which may change, are becoming fundamental stimulating innovation processes. According to the estimates of the HSE University, the introduction of new technologies will provide an additional 20.2% increase in labor productivity in the manufacturing industry until 2030 [3]

In the new model of sustainable economic development, the sectoral structure of the region's economy inevitably changes and new technological and social priorities are formed. The branches of the post-industrial economy (high-tech industry, information technology and communications, research and development, etc.), characterized by lower resource and energy intensity, are growing at a pace faster than the growth of gross

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domestic product as a whole, as a result, their share in the structure of gross domestic product should increase significantly by 6.8 percentage points in 2050 compared to 2020. The share of other sectors of the economy (electricity and water supply, construction and transport, public administration, etc.) remains fairly stable on the forecast horizon in the inertial scenario.

Of paramount importance are the goals and objectives of sustainable development, reflecting the new priorities of the technological transformation of the country's economy. At the federal level, the Strategy of Scientific and Technological Development of Russia (Decree of the President of the Russian Federation No. 642 of December 1, 2016) formulated priorities for scientific and technological development, the Government Commission for Advanced Technology and Innovations defined a list of technological platforms. In the system of regional management, approval and coordination of these processes are carried out by various councils for science and higher education, expert councils under the committees on economics, ecology and other areas of socio-economic development of the region. The formation of an innovative model of sustainable development is due, among other things, to climate change, new biological threats that pose significant risks, primarily for the population, national infrastructure and climate-dependent sectors of the economy and industries that, by their specifics, do not depend on the level of informatization and the introduction of digital technologies, but technologies create conditions for their development as socially significant industries.

The transition to eco-friendly technologies is associated with solving problems of economic growth and preservation of the natural environment. The elements of the new model of technological development of the region in the context of digital transformation are flexible mechanisms and tools for determining technological priorities and their implementation at all levels of innovation support infrastructure. The experience of industrial development and transformation of economic sectors of other countries deserves attention: models with a selective approach in determining priorities of scientific and technological development; dynamically organizational abilities and changes; a system of accumulation of knowledge, stimulating the introduction of new technologies and advanced development, borrowing innovations, and the creation of pioneering technologies, striving for internal cooperation and communication of the digital environment, branches of the digital economy with the real sector. The study of the best management practices of the regions of Russia, which occupy a leading position in the ratings of innovative development, allows us to identify factors of innovative performance and regional models in which technological priority made it possible to implement the principles of sustainable development. The formation of a global digital economic space, the creation of information and communication platforms and digital platforms have been considered in a number of works by foreign and domestic authors. The works of I. Ansoff (1979), R. Akoff (1972), P. Drucker (2007), H.E. Daly (1991), D. Meadows (2007), D. P. Marsh (1866), J. Randers (2007), N. Nigroponte (1996), N. D. Kondratiev (1982), M. Porter (2011), A. Chandler (1962), A. Sloan, G. Mintsberg (1994), K. Andrews (1971) are devoted to the study of the processes of technological transformation and sustainable development, strategic management. The current stage of developing the concept of sustainable development is characterized by an approach that takes into account the balance of social, environmental and economic goals and objectives of development. Technological transformation, putting forward new requirements for the level of innovation activity, leads to structural changes in industries and new technological priorities.

2 Materials and Methods

The purpose of the article is to reveal the methodological basis for the formation of an innovative model of sustainable development of the region in the conditions of technological transformation. The article reveals the content of the main stages of technological development, the features of the technology life cycle; examines foreign and domestic models of economic development taking into account technological priorities, reveals the essence of sustainable development of the region. The differences in the structure of sources of funding for research activities and mechanisms for the implementation of innovative processes are identified, a retrospective analysis and examples of changes in models of innovative economic development that ensure economic growth are given. The task of coordinating the stages of the technology life cycle and the period of economic development is presented in the article as the basis for strategic planning of innovative development of production systems. From the point of view of the proposed methodological approach and taking into account the peculiarities of Russian conditions, the exceptional features of the Russian model are determined. The model of sustainable development in terms of creating conditions for the development of innovation and stimulating economic growth is revealed only in the context of environmental priorities. It is necessary to qualitatively change the infrastructure, technological audit and determination of the innovative potential of the territory, calculation of indicators of innovative performance for this territory. The methodological basis of this work includes fundamental research by Russian and foreign scientists in the field of scientific and technological development, strategic management, innovation management, and regional economics. In the process of preparing the article, the following methods of scientific research were used: methods of systematic and formal-logical, scientific analysis and synthesis, comparative analysis, economic and statistical methods.

3 Equations and mathematics

The decline in productivity growth in traditional industries was intensified by the crisis of transition from the fifth to the sixth technological order. Globalization has ceased to stimulate the development of the world economy by accelerating the introduction of digital technologies in the economy and social sphere. According to a number of researchers, the post-industrial innovation model is not characterized by high rates of general economic dynamics of 2-3% of GDP in the long term. Such rates are natural for developed economies, but cannot satisfy the catching-up model of the economy (R.S. Grinberg, 2007). It is necessary to take into account the patterns of technological development of the economy at the last stage of the post-industrial phase, determined by special conditions, reduction of cycles technology development. Since 1995, Gartner has proposed the term Hype Cycle for planning, reflecting the technology maturity curve. It is necessary to take this indicator into account for marketing analysis of the prospects of innovative projects and programs. For example, Gartner presents in its annual analytical reports about 30 new technologies that can have a significant impact on business, society and people over the next 5-10 years.The technology life cycle begins from the Innovation Trigger stage to the Plateau of Productivity stage as a phase of market implementation of an innovative product, after the technology has proven its viability and economic efficiency, public recognition.

Modeling of the innovative development of the region, therefore, should be implemented taking into account the phase of technology development and the features of the economic formation, which has its own cyclical development.

Differentiation of regions according to the level of economic development and the introduction of digital technologies for the development of priority industries, taking into

account the level of practical implementation of the technology, the level of its maturity, opens up opportunities for using the necessary factors of innovative growth. Russia has its own methodological recommendations in order to determine the degree of maturity of the technology. Significantly higher investments in R&D, high wages attract scientists, researchers in advanced scientific and applied areas, talented young people. Opportunities to realize the research potential, of course, form the necessary infrastructure and play a crucial role in the innovative development of the country. The motivational component of national and regional innovation systems in relation to all participants in the innovation process affects the initiation of innovative projects and the effectiveness of technological transfer in the economy of the region. The role of new knowledge in the model of innovative economic development can be demonstrated by historical examples that are associated with the speed of the country's recovery. In August 1945, the explosions of two nuclear bombs over the cities of Hiroshima and Nagasaki ended the war between Japan and America. By now, Japan was far behind other countries in terms of the scale of application of the latest technology in industry, it was thanks to the import of knowledge and the accumulation of new technologies that it managed to catch up with other industrialized countries in the shortest possible time. The country has achieved success and switched to a new model of economic development due to innovative factors, has achieved success in the field of professional development of workers, the development of creative abilities of managers, their technological horizons. In the next five years after the atomic bomb explosions, the country achieved steady economic growth, labor productivity growth primarily in traditional manufacturing industries. From 1954 to 1963, Japan annually increased labor productivity by 9.9%, thus taking the first place among industrialized countries. It was followed by Italy (5.6%), West Germany (5.0%), France (4.7%), the USA (2.9%) and England (2.3%) (Tsuru Shigeto, 1981). Another example of China's rapid economic growth is also characterized by the accumulation of knowledge and technology. In 1952, China's GDP was only 67.9 billion yuan. In 2021, this figure exceeded 114 trillion yuan, or 17.7 trillion dollars at the average annual exchange rate. For almost 40 years since 1978, GDP has grown by an average of more than 9%, which is higher than in Japan, South Korea and Singapore. After a long economic growth characterized by accelerated economic development, China's economy inevitably faced a situation characteristic of other developing countries and regions, namely, a slowdown in economic growth, the subsequent decline in economic growth and global trends of falling labor productivity in traditional sectors of the economy of many countries illustrate some inertia of the economic model. The constant outflow of carriers of implicit knowledge reduces the innovative, intellectual potential of the region's development. These factors restrain innovative development, create chain reactions and reduce the pace of economic development in the next time period. There are also demographic and financial manifestations of these situations. The problem of technological lag is relevant both within the framework of the strategy of diversified growth and technological development within the existing directions and specialization of the region. Territorial development is also aimed at changing and improving the spatial structure of productive forces, subject to the effective use of natural resource, material, technical and human potentials, the formation and qualitative transformation of territorial and economic systems. The existing models of innovative development of foreign countries include the investment of innovative companies as the main mechanism of technology commercialization. For example, in the Japanese and American models of innovation policy, according to the results of statistical studies, more than 80% of the R&D costs are borne by the business sector of the economy. In the EU countries, more than 60% of R&D funding is also from non-government sources. In Russia, this figure is 30%. This indicates both a different level of entrepreneurial activity in the innovation sphere, as well as motivation, opportunities for organizing innovative business, and different models and

management systems of the innovation sphere, the peculiarities of regional policy in different countries. The majority of small and medium-sized businesses, which can be attributed to innovative entrepreneurial structures in Russia, are organized within the framework of the research and educational sphere in the form of a spin-off enterprise. However, the Russian model of innovation policy in the region has its own characteristics. The transfer of the "smart specialization" strategy to Russian realities requires taking into account these features and limitations of the key mechanism for determining priorities and regional specialization. The state order system has firmly taken its place in the Russian model, but the high risk of investment in innovation should be taken into account. They often invest at the stage of scientific research, at which the applied prospects are not obvious. There is no guarantee that the new one will be more effective and reliable than the one already used or foreign.

At the initial stage, high-tech products have a high price. The problem of compensation for inflated prices in the Russian procurement legislation has not yet been solved for this procedure. It is noteworthy that in American history there is a practice of using this model of financing innovation in the economy. Professor of Harvard University E. Hansen, studying the cycles of economic development and the post-war economy of the United States, noted the opposite conclusions about the sources of financing of production systems. During the fifteen years of observations, out of the five factors noted that have an impact on the economy, state and local government spending actually played a crucial role. These expenditures were the only factor that gave the economy an equally strong forward push both in the period 1948-1956 and in the period 1956-1963. The increase in state and local government spending was six times higher than the increase in private investment (E. Hansen, 1966). Foreign and domestic researchers in the field of economic theory and innovative development Glazyeva S.Yu. (2010), Ivanov V. V. (2016), Lucas R.E. (1988), Mensch (1979), Nelson R.R. (1993), Romer P.M. [10], Shigeto Tsuru (1981), Tis D. (1997), Schumpeter J. (1982), Chemezov S.V. (2017), Hamel G., Prahalad K.K. (2002), , Hansen E. (1966), and other researchers have revealed the role of innovative factors in achieving faster rates of economic growth and the formation of regional capabilities of advanced development. Real GDP at purchasing power parity, millions of dollars. In macroeconomic studies, it is observed that the gap in labor productivity between Russia and leading foreign countries is mainly due to a lower level of aggregate factor productivity, which is traditionally interpreted as the level of overall efficiency of using factors including the technological level of production development. Figure 1 shows the dynamics of the macroeconomic indicator for a number of countries, adjusted for the impact of inflation to obtain an indicator of real GDP as gross domestic product, refers to the total market value of all finished goods and services produced by the country.

Real GDP at purchasing power parity is calculated by measuring output using the price level for the previous year, and then linking statistical data to reflect actual changes in output and exclude any monetary (inflationary) changes.

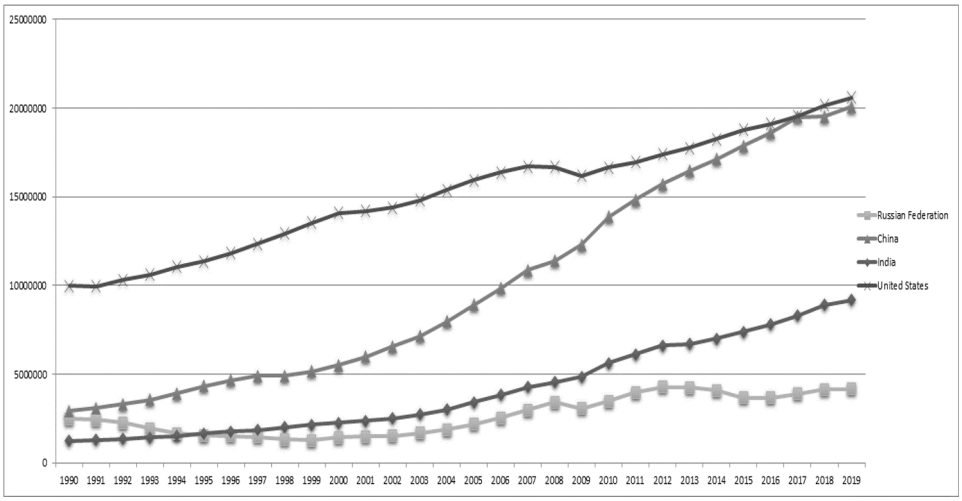

Fig. 1. Output-side real GDP at chained PPPs (in mil. 2017US$)

The alternation of economic cycles is usually associated with the change of technological patterns in social production. The famous Russian scientist N. Kondratiev (1982) revealed the law according to which there is a change of long-term cycles and technological patterns. S.Yu. Glazyev (2007), continuing the theory of long-term technical and economic development, also called the theory of technological patterns of economic development, which in the last period are passing into the stage of rapid growth. Figure 1 shows the economic dynamics over a long-term interval. High rates are natural for developed countries, but they cannot satisfy countries in the catching-up phase of economic development. As already noted, the post-industrial innovative model of economic development provides for rather low topics of economic dynamics. On the other hand, it is possible to talk about a change in the phases of economic development with a change in the technological order (S.Yu. Glazyev, 2010).

Environmental factors put restrictions on the possibilities of economic growth, which led to the emergence of the concept of a "green economy". Long-term development and prosperity is impossible without taking into account the balance and satisfaction of all stakeholders in the implementation of innovative processes in the economy. Initiation, conceptualization, optimization and the emergence of new innovative products, as well as the stages of development of innovative organizations, business projects, starting from the startup stage, require proper prioritization (Leonard M., Pisani-Ferry J., 2021). Knowledge-intensive and high-tech spheres absorb a huge share of resources, but at the same time they are associated with high risk. The cyclical nature of economic development determines some misconceptions about the effectiveness of innovations as factors of economic growth, actualizes the search for new methodological approaches to the formation of a model of innovative development of the territories of the region, taking into account natural limitations and big challenges. The European Green Deal Strategy, presented by the European Commission in 2019, is designed to achieve a level of sustainable economic development. This European strategy provides incentives for innovation activity in the region and includes tools, measures and subsidies aimed at reducing environmental pollution while expanding technological horizons and increasing investment in R&D. Since the end of the 20th century, there has been not only a reduction in labor productivity in traditional sectors of the economy. Global warming manifests itself in a significant change in temperature, an increase in the concentration of greenhouse gases in the atmosphere due to an increase in their anthropogenic emissions. Achieving the 17 Sustainable Development

Goals and preserving the living natural environment is a common priority for all countries. In Russia, the warming processes are proceeding at a faster pace. In 1992, the UN Convention on Climate Change was adopted, in the development of which the Kyoto Protocol (since 1997) and the Paris Agreement (since 2015) are being implemented.

Sustainable development is a special model of development in which the needs of current generations are met without compromising the ability of future generations to meet their own needs.

Figure 2 shows an innovative model of sustainable development of the region based on the technology life cycle. Of fundamental importance is the relationship between the cycles of economic development and the stages of maturity, the life cycle of technology. Considering the current trends in accelerating technological development and reducing technological cycles, it is necessary to take into account the selected stages of technology launch (initiation, identification of needs and the possibility of using new technological solutions). This stage is very important for obtaining the necessary results and influencing the economy of the region after a certain period of time. It is important to coordinate with economic cycles and form supportive conditions. Technology launch (innovative search and innovative trigger). This is followed by the promotion of technology in the pre-market phase of ideas as the basis for the architecture of future markets. G. Hamel and K.K. Prahalad presented their concept of key competencies based on ideological leadership in the market, gave the necessary conceptual basis for the development of the company based on the use of new technologies. Building the future needs of the market, developing a strategic architecture for the implementation of innovative projects is impossible without taking into account the pre-market phase of competition for research and development, solving issues of intellectual property rights protection, implementing patent and licensing policy and forming strategic alliances. The combination of material resources and knowledge of participants in the innovation process provides a synergistic effect.

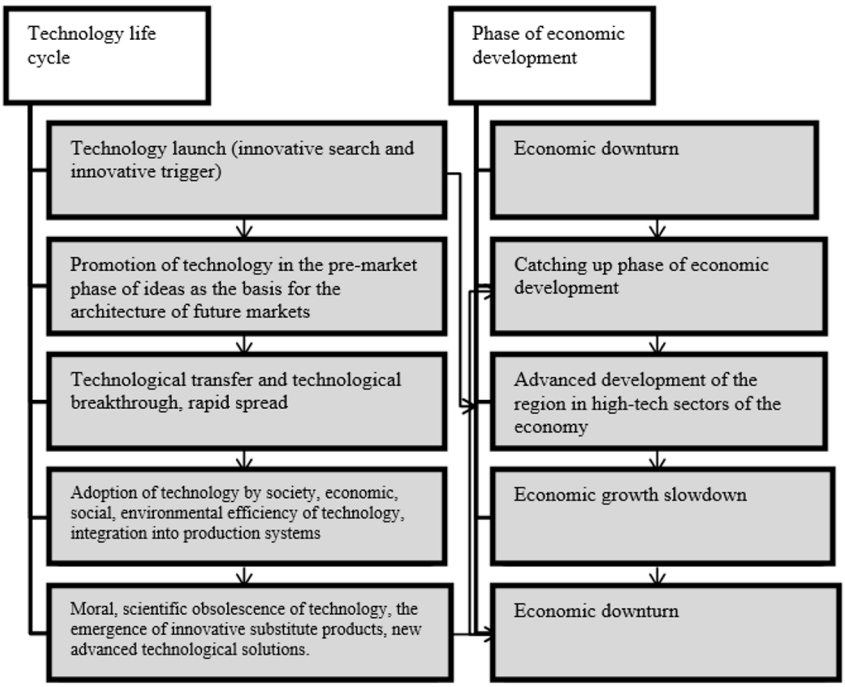

Fig. 2. Innovative model of sustainable development of the region based on the technology life cycle

Technological transfer and technological breakthrough, rapid spread of technologies as a stage of the technology life cycle should be provided by the existing regional infrastructure. An innovative product differs from a product of "market novelty", it is implemented when it is put on the market. Production and organizational innovations are such, that is, new approaches are introduced when they become in demand. An innovative firm is one that has implemented any innovation during the time period established during the survey. Innovative entrepreneurship is a segment of the economy that satisfies changing social needs and forms fundamentally new objects of demand. The promotion of technology in the pre-market phase of competition ensures the efficiency of technological transfer, investment attractiveness, competitiveness and the leading position of the company in the market of innovative products.

The adoption of technology by society, the economic and social efficiency of technology, integration into production systems, also singled out as a stage of the technology life cycle, determines the importance of developing a strategy for promoting and popularizing both the product itself and its production technology, including organizational and managerial innovations.

The moral, scientific obsolescence of technology, the emergence of innovative substitute products and new advanced technological solutions represent the final stage of technology development. But, it is necessary to take into account the possibility of changes and updates, then, from our point of view, a new cycle begins.

At all stages of the technology life cycle and phases of the innovation process, state participation is required at the regional and sub-regional, local, and sectoral levels. It is necessary for the state to participate both as a principal of an innovative project and as a guarantor of achieving social goals and objectives, observing the boundaries of negative impact on society and the environment in the course of satisfying economic interests, and at the stage of scientific research – compliance with moral and ethical principles. The development of infrastructure, institutions and tools to support participants in the innovation process, the creation of a collaborative environment for the exchange of knowledge, the use of motivational mechanisms and the formation of competencies, the promotion of innovation activity at the level of mentality are mandatory components of the model of innovative development of the region in terms of technological transformation. The state's directions for supporting research activities and creating favorable stimulating conditions for innovative entrepreneurship in order to develop environmentally friendly technologies include both fiscal and non-fiscal, differentiation of preferences by stages of technology development and innovative business model, organizational conditions, creation of motivational mechanisms and expert communities to determine priorities. The state is the main participant in technological transfer, the introduction of innovations into production, the commercialization of new technologies from the research stage to the introduction into production.

The formation of an innovative model of sustainable development in the context of technological transformation is impossible without understanding the relationship between the goals and objectives of scientific, technological, social, economic and environmental policy.

The basic formulation revealing the essence of sustainable development first appeared in 1987 in the report "Our Common Future". Sustainable development is development in which the needs of current generations are met without compromising the ability of future generations to meet their own needs.

The Sustainable Development Goals are common and these priorities should become an element of innovative development models for all countries. This is a universal call for action to eradicate poverty, protect our planet, improve the quality of life and improve prospects for all people around the world. The 17 Goals were adopted by all UN Member

States in 2015 as part of the 2030 Agenda for Sustainable Development. Climate warming in Russia, for example, is happening faster than global trends and strategic initiatives have been taken to develop the country with decarbonization priorities. The causes of climate warming identified by modern scientists are associated with many natural and artificial anthropogenic processes. Greenhouse gas emissions play an important role in this. In order to integrate and implement the Sustainable Development Goals, the UN Framework Convention on Climate Change was adopted in 1992, in the development of which the Kyoto Protocol (since 1997) and the Paris Agreement (since 2015) are being implemented. Figure 3 shows the dynamics of greenhouse gas emissions in the world.

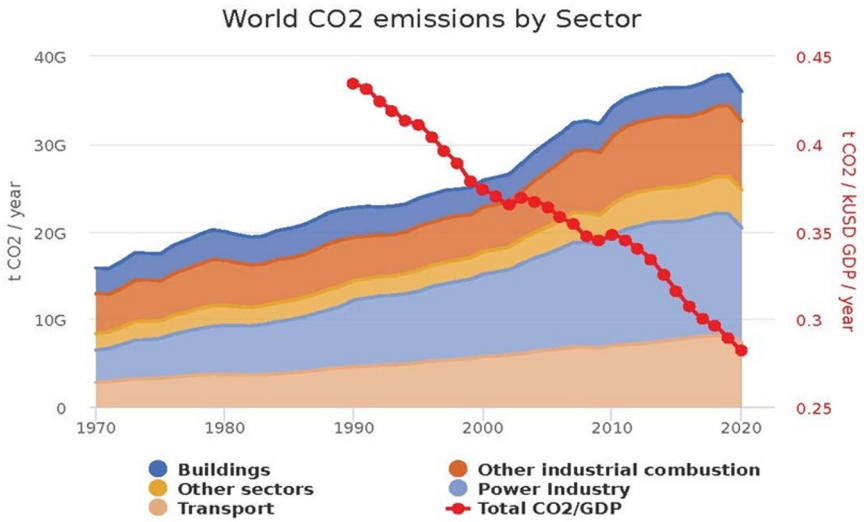

Fig. 3. Greenhouse gas emissions

Significant climate change is expected to have a significant impact on natural resources, the global economy and human health. This will lead to an increase in temperature, an increase in the level of the world's oceans and a change in weather conditions, the frequency of extreme weather events such as floods and droughts.

Global carbon dioxide emissions from combustion and fossil fuel combustion processes decreased by 5.1% in 2020 (they increased by 0.9% in 2019), amounting to 36.0 Gt, which is slightly lower than the 36.2 Gt emissions recorded in 2013.

In 2020, China, the United States, European countries, India, Russia and Japan together polluted with these emissions in the structure: 49.5% of the population, 61.8% of the world gross domestic product, 65.2% of the total world consumption of fossil fuels and 66.7% of the total world fossil CO2. China showed an increase in emissions in 2020 (+1.5%), while all others have reduced their emissions.

This environmental problem determines the need to use new technologies. Technological transformation for sustainable development in this system is associated with the use of digital technologies in order to calculate greenhouse gas emissions and carbon emissions. Consolidation of information using digital platforms will support the formation of infrastructure for achieving sustainable development goals, namely the formation of innovative models of technological transformation for sustainable development. The effects of technological changes are deeper, including the education of responsible consumption of resources and production, and the fight against climate change, thanks to extensive

information collection, increasing the reliability of information, the level of competence. The possibilities of traditional energy in achieving sustainable development goals, for example, are also associated with the introduction of new green technologies (for example, in oil and gas exploration) into traditional energy will ensure greater environmental safety, reduce the carbon footprint and greenhouse gas emissions.

The Russian Government has approved the Strategy of Socio-economic Development of the Russian Federation with a low level of Greenhouse Gas Emissions until 2050. By adopting a long-term decarbonization strategy, Russia has taken its rightful place in the process of achieving global climate protection goals.

Technological priorities of the region's development in innovative models of technological transformation for sustainable development include the introduction of digital solutions in various fields of activity, such as environmental protection, energy, including the development of energy-saving and waste-free technologies based on cross-cutting technologies: big data, artificial intelligence; remote sensing of the Earth; unmanned aerial vehicles; Internet of Things technologies; analytical data processing and other technologies.

The following priorities of the strategic direction in the field of digital transformation of the ecology and nature management industry have been identified:

Artificial intelligence technology will be used as part of the development of the ecology and nature management industry to analyze monitoring information (state observation network of the Federal Service for Hydrometeorology and Environmental Monitoring, remote sensing of the Earth, unmanned aerial vehicle), integrated hydrometeorological and environmental forecasting of dangerous meteorological phenomena, fire hazards in forests, automation of decision-making in real time (including the creation of methods and models), detection and identification of objects of the animal and plant world in a complex environment.

The Internet of Things technology will be used as part of the development of the state observation network of the Federal Service for Hydrometeorology and Environmental Monitoring to improve the efficiency of data collection and transmission from stationary and mobile observation stations.

Earth remote sensing and unmanned aerial vehicle technologies will be used as part of the development of the ecology and nature management industry for survey, planning of effective use and reproduction, protection of natural resources, environmental protection and control over climate change.

Big data and analytical data processing technologies will be used as part of the development of the ecology and nature management industry for the accumulation, storage, analysis and processing of data in the federal state information systems and digital platforms being created.

The digital twin technology will be used as part of the development of the ecology and nature management industry to update and create a database of a new generation of natural objects (ecosystems), including subsurface, water bodies, forests, wildlife habitat.

As part of the implementation of the strategic direction, it is planned to introduce radio-electronic products (including data storage systems and server equipment, automated workstations, software and hardware complexes, communication equipment, video surveillance systems) of Russian origin

Priority digital solutions for the purpose of technological transformation of the energy sector based on the use of cross-cutting digital technology: modeling of weather scenarios, advanced cloud technology, image processing of cloud movement surveillance cameras on a time scale close to real time, increasing the efficiency of wind and solar energy up to 92%; visual inspection of objects, equipment, operational search for failures, survey of contacts and monitoring of heating networks, analysis of the number and location of trees threatening to fall on power lines, etc. Also, the use of artificial intelligence is the modeling

of human intelligence processes by machines, especially computer systems. Artificial intelligence is the hypothetical ability of a computer machine to understand or study any intellectual task that a person can handle.

Industrial Internet of Things as a cross-cutting technology in order to build a multi-level system for transmitting the collected data and their visualization, interpretation of the information received and other components.

A new national project will appear in Russia — Data Economy, which is associated with new principles of operation and management, infrastructure that ensures the functioning of the digital ecosystem at the level of each territory for socio-economic development. For example, this includes a new level of medical care, the development of telemedicine, improving the efficiency and effectiveness of government agencies, a new level of logistics, online education projects. Data management in the economy for the purpose of innovative development includes not only the technical component of the digital system, but also the inclusion of the conceptual framework of the knowledge management system. It implies two components: organizational and technological. The evolution of approaches to data management should take into account not only a technocratic approach, including the use of information technology and the use of appropriate infrastructure. It is impossible to predict a fundamentally new innovative model of sustainable development without taking into account the role of a person, a new field of responsibility in the process of making managerial decisions. P. Drucker, even at the first stages of the formation of a new economic formation and paradigm, noted that a new kind of labor activity in the field of knowledge is emerging. At the same time, he is different from the worker of the industrial era. In the West, the intuitive, religious type of cognition was often considered less valuable than the rational, scientific type of cognition, while in the East the opposite point of view was widespread. When comparing the Eastern and Western approaches, one can see the differences between explicit and tacit knowledge. Therefore, the most important direction in the formation of new models of technological development is the accumulation of implicit formalized knowledge. The innovative model of sustainable development translates this concept to the level of humanization and concern for future generations, understanding the role of a person and his knowledge, inseparable knowledge from their carrier. This is becoming relevant in the light of the development of digital management solutions, the use of artificial intelligence. The principles of sustainable development should contribute to the preservation of a unique experience, human nature in a technogenic developing system. It is necessary to create both a technological infrastructure, the formation of a single data ecosystem, and internal motivational mechanisms for human implementation. Technological development is based on the processes of generation, diffusion, preservation, systematization and elimination of knowledge in various socio-economic systems. A rational approach to most of the research aimed at accumulating a database. Programs for mastering new technologies and using them in practice in socially significant industries go through certain stages, each of which correlates with one of the three strategic objectives:

1. Building a database and digital architecture, infrastructure, including the necessary control points, controllers and indicators, allowing the implementation and use of high-tech solutions for sustainable development in various industries and sectors of the economy, to implement the process of data preservation, knowledge base. This includes scientific research on all aspects of the industry, technological outlook; interaction with external sources of new knowledge. The most important aspect is the technological transformation and the formation of a digital model of territorial management, data management in priority sectors of the region's economy.

2. Occupying a strategic position, including identifying and implementing marketing potential in high-tech industries with conditions of social interests and environmental

constraints. Ensuring the effectiveness of any new technical field identified through scientific inquiry, research-and-development activities often involves significant resources; marketing positioning processes for the realization of potential commercial opportunities for technologies, technical developments taking into account the principles of sustainable development differ from traditional ones, innovative models of technological transformation of industries include fundamentally new strategies for market positioning, building a competitive strategy with a pre-market phases, taking into account the interests of society and the priorities of sustainable development.

3. Technological transfer and commercialization of technologies. This most important stage is a clearly defined task of most innovative projects and programs, the organization of innovative infrastructure in the region, including the production sector, together with research and educational institutions, can create the necessary conditions, but it requires differentiation of technological transfer for sustainable development and separation of projects pursuing exclusively commercial benefits. The solution of this problem in innovative models of technological transformation for sustainable development, which are new models of sustainable development in modern conditions, is based on taking into account the social effectiveness of the innovation project, as well as the level of social responsibility of business, the level of resource intensity, environmental friendliness of production systems.

As building a knowledge base through taking a strategic position moves to investing in business, the expenses and cost of the project increase, but the level of uncertainty decreases.

Well-known researchers in the field of strategy I. Ansoff and others defined environmental turbulence as a cumulative measurement of variability, instability and predictability, internal analysis of discontinuities to assess one's internal position in relation to the external environment. In this part, the data management system and the model of technological development of the region in the conditions of digitalization should ensure the collection of weak signals and their interpretation, completely depend on a well-developed training system. Thus, the presented components and characteristics of the model of technological development of the region in the conditions of digitalization are aimed at developing the ability to self-renew, adapt to changes, generate and commercialize products of scientific and technological progress.

The traditional management model should be adapted taking into account the phase of development of society, the economy in accordance with key technologies and principles of sustainable development, including the priority of environmentally friendly energy-saving technologies, safety and security of knowledge and information sources, social orientation and humanization of the decision-making process, communication openness and relationships between participants in innovation processes in the territories of the relevant specialization, its changes. Innovations for the sustainable development model define a new level of the public administration system, define new requirements for the professional level of managerial personnel, the competence profile of civil servants.

Improving the comfort of living in the territory due to the investment and innovative development of the region's economy is the goal of socio-economic development of each territory. The current environmental situation determines the relevant goals of territorial development and innovative priorities aimed at solving environmental problems, sustainable development of the territory. The path of modern technologies from the idea to the market is different. It is especially difficult to implement models of economic development based on radically new principles and technological platforms in order to solve environmental problems and with success, because, in addition to the deep transformation of all links in the value chain, habits are seriously changing and the most important values are affected. The EU countries are approaching the implementation of the

recently adopted sustainable growth strategy — the European Green Deal. The European Green Deal is a plan to decarbonize the EU economy by 2050. The new strategy sets an ambitious goal for the European Union to achieve climate neutrality by 2050, that is, to stop emitting greenhouse gases into the atmosphere, transferring the entire European economy to the principles and technologies of resource efficiency. In this case, the digital platform acts not only as a tool for the development of eco-friendly production and reducing human impact on the environment, but, most importantly, it is a unifying platform for all stakeholders in the innovative development of the territory.

Technological transformation, digitalization can accelerate the process of transition from an environmentally hazardous business model, in which goods are practically not processed, to the so-called waste-free economy, energy-saving technologies. In addition to reducing environmental risks, the formation of a new model of technological development of the region should create a large number of new jobs in the green sectors of the economy, create new sectors of the economy, increase the level of technology of existing industries. The level of environmental friendliness and the implementation of the principles of a green economy is largely determined by the state of the region's production, transport, and energy infrastructure. For example, Siberia has large reserves of hydrocarbon raw materials, coal, uranium, ferrous, non-ferrous and precious metals, wood, water and hydropower resources, which determines the structure of GRP (a high share of the extractive industry, petrochemical, gas industry, metallurgy, woodworking, electric power and other industries). They require changes in the methodological approach to territorial development, taking into account environmental priorities, the emergence of new technologies and substitutes for raw materials; the implementation of a strategy of "smart specialization" based on a selective approach with a choice of environmental and social goals for the development of the region in the digital environment.

The traditional paradigm of implementing the strategy of technological development of determining the priorities of scientific and technological development does not so much demonstrate the relationship with technological development as a core component, as it includes technology as a factor determining the choice of strategy. In many sectors of the economy in Russia, in the conditions of the crisis stage, new models for the development of priority industries and changes in technological priorities are needed. The strategic goal of territorial development and improving the distribution of productive forces is to diversify the economic structure and employment of regions and cities, overcome infrastructural and institutional constraints in the socio-economic development of territories, increase production efficiency in accordance with the requirements of the green economy. Therefore, it is important to form the principles of an innovative model of technological development, taking into account environmental priorities that cannot be realized without a digital environment, solutions for the use of digital tools; principles of technological forecasting and the formation of goals for the advanced development of the region.

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