Procedia
Environmental Science, Engineering and Management
http://www.procedia-esem.eu

Procedia Environmental Science, Engineering and Management **8** (2021) (2) 483-493

Environmental Innovations: Advances in Engineering, Technology and Management, EIAETM, 19th-23rd October, 2020

BUILDING THE INFRASTRUCTURE FOR TRANSFORMING RUSSIAN INDUSTRY TOWARDS BETTER RESOURCE EFFICIENCY AND ENVIRONMENTAL PERFORMANCE*

Skobelev Dmitry**

Research Institute "Environmental Industrial Policy Centre", Moscow, Russia

Abstract

This study is devoted to the principles and results of the development of the infrastructure for transforming Russian industry towards better resource efficiency and environmental performance. To support transition of the national economy (and first of all – industry) to more sustainable mode of operation, the concept of Best Available Techniques (BAT) is used. Russian environmental industrial policy includes two inter-related directions, namely: (1) implementation of Best Available Techniques and BAT-driven enhancement of resource efficiency and (2) return of secondary resources into the economic turnover. The infrastructure being built to implement the Environmental Industrial Policy is presented as a five-layer structure including (1) regulated community and authorities enforcing environmental and resource efficiency related legislation; (2) research bodies and training institutions developing new technological processes and technical solutions, working out economic rationale for transferring the national economy towards more sustainable development; (3) Russian BAT Bureau coordinating development of Reference Documents on Best Available Techniques (BREFs) and national standards and supporting collaboration of interested authorities; (4) the system of national BAT standards forming the methodological basis for working out BREFs, implementing BATs and achieving BAT-Associated Emission and Performance Levels; and (5) national laws, Government decrees and ordinances and BREFs setting requirements to the resource efficiency and environmental performance of Russian industries. The infrastructure is being continually developed using national and international experience and providing opportunities for gradually moving Russian economy towards better circularity and sustainability.

Keywords: Best Available Techniques, environmental performance, industrial transformation, resource efficiency, sustainable development

---

* Selection and peer-review under responsibility of the EIAETM
** Corresponding author: e-mail: training@eipc.center

1. Introduction

In 2018, new national development goals and priority objectives were identified in Russia. These aims and objectives are harmonized with the Sustainable Development Goals (SDG) adopted by all United Nations Member States in 2015. There is a clear correlation between the national goals and SDG 8: Sustainable economic growth, SDG 9: Industry, innovation and infrastructure, and SDG 12: Responsible production and consumption. To ensure economic growth, in Russia the goal is set as building up a strong and competitive export-oriented manufacturing (processing) sector of the national economy in this age of globalization and digitalization. To achieve it, it is necessary to transfer Russian industry towards better resource efficiency and environmental performance and to the use of secondary resources in production processes. The main objective of the industrial policy is to secure the competitiveness of Russian industry. This policy is closely linked to other key national policy sectors: research, development and innovation, employment, energy security and environmental conservation.

The concept of Best Available Techniques (BAT) is considered in Russia as a basis for both industrial modernization and even innovation and for better resource efficiency and environmental performance. This makes a difference of European and Russian approaches on one hand, and forms opportunities for the technological transformation of the national industry on the basis on BAT concept on another.

2. Research Problem and Methods

The technological transformation of the industry can be described as a series of changes in production methods and technological paradigms. In the 21st century, a lot of attention is paid to the sustainability issues and to the environmental characteristics of the technological transformation in particular. The research problem of the study lies in assessing needs and opportunities and formulating principles for development of the legislative and institutional infrastructure for the technological transformation of Russian industry towards better resource efficiency and environmental performance.

Methods used in this study are typical for economic studies and are based on the analysis and synthesis. Document and situation analysis approaches were used to study both the international experience and peculiarities of the national practices to the sustainable development goals and objectives. Research synthesis allowed to combine the results of primary research studies and to come up with the following conceptual hypothesis: in Russia, the infrastructure for the technological transformation of industry should be built around the BAT concept seen wider than just pollution prevention and control and including both the resource efficiency and waste recycling.

3. Results and Discussion

3.1. Technological Paradigms and Sustainable Development Goals

The term “technological paradigm” is used in economic studies to explain the radical changes in technology as the material basis for producing goods and services (Dosi, 1982). In the economic transformation theory, needs for the transition from the dominance of the 4th technological paradigm technologies and to the accelerated development of the 6th paradigm are discussed by many scientists. Publications of the leading Russian scholars are widely cited by both national and international researchers (Barnett, 1998), (Cvetanovic et al., 2012).

Sergey Glazyev pointed out that world economy has already developed a rapidly growing core (30-40% per year) of the new technological paradigm: nano- and bioengineering, information, communication, cognitive and digital technologies will spur technological revolution and transform almost all sectors of the world economy (Glazyev and Fetisov, 2013). Not arguing about numbering, we can cite Professor Klaus Schwab, who wrote, that modern technological revolution is characterized by a fusion of technologies that is blurring the lines between the physical, digital and biological worlds (Schwab, 2016). It has already started disrupting nearly every sector in every country, creating new opportunities and challenges for people, places and businesses to which we must respond.

Information, communication and digital technologies are significantly changing the industries of the 4th and 5th technological paradigms: contemporary metallurgical and chemical processes are inconceivable without digital design and online monitoring and control, development of new processes, as well as risk minimization (in the context of the industrial and environmental safety), that are carried out with the help of information and communication technologies. Nowadays, resource-intensive industries continue manufacturing products and goods typical for 4th and 5th technological paradigms. At the same time, technologies of the 6th paradigm can be considered as a sort of the staple without which it is difficult to imagine the post-industrial society. This society will require a wide variety of new chemical compounds and structural materials, pure metals and non-metals, and, of course, services of numerous enterprises providing for wastewater treatment, waste management and processing, etc.

Authors of some articles, describing the 6th paradigm, focus their attention not on listing industrial sectors, but underlining their main features. The 6th – sustainability – paradigm is characterized by high resource efficiency, use of renewable energy sources, eco-design (which takes into account the importance of ecosystem services (Yigitcanlar, 2011). International experience suggests that neither the member states of the European Union (EU), nor the United States of America (USA) or United Kingdom (UK) intend to abandon metallurgy, chemical and petrochemical production, or the manufacture of construction materials, although new regulation priorities are emerging embracing modern automated technological processes, efficient use of natural resources throughout the entire life cycle, replacement of natural resources by the technogenic (secondary) resources, minimization of negative environmental impacts, etc. The European Green Deal is a response to these challenges. It is a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy with toxic free environment and zero net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use (Skobelev, 2019), (Domenech and Bahn-Walkowiak, 2019). UK Clean Growth Strategy sets out a comprehensive set of policies and proposals that aim to deliver increased economic growth and decreased emissions (first of all – greenhouse gases emissions) (Department for Business, Energy & Industrial Strategy, 2018). In order to determine the international priorities for cooperation in the economic, social and environmental areas, the Sustainable Development Goals (SDGs) were formulated in a document “Transforming our world: the 2030 Agenda for Sustainable Development” back in 2015 (Bobylev and Solovyeva, 2017),(United Nations, 2015).

SDGs in the areas of economic growth (SDG 8), innovation and industrialization (SDG 9) and responsible consumption and production (SDG 12) define a system for setting specific tasks for resource and technological transformation of the world economy. This is why in 2018 RF Government identified national goals and priorities for the development of the Russian Federation (RF) and formed several national projects (NP) in order to achieve these goals (RF Government, 2018). It is worth mentioning that there is a clear correlation between the RF national goals and sustainable development goals: ensuring economic growth, creating a highly productive export-oriented sector on the basis of modern technologies and accelerating technological development – all these goals reflect the internationally accepted SDGs simultaneously taking into account Russian specifics. The NP system is designed to achieve their synergy, that is, the combined result of the interconnected implementation of these projects should exceed the sum of the planned results of each of them (Evstigneeva and Evstigneev, 2007), (Hjort et al., 2019). In the context of the technological transformation of the Russian economy the interaction between NPs "Science", "Digital Economy", "Environment", "Safe and High-Quality Roads" is especially valuable.

3.2. Interrelatedness of resource efficiency, economic and environmental performance

The European Commission describes resource efficiency as "improving economic performance while reducing pressure on natural resources through efficient use of them" (Roadmap to a Resource Efficient Europe COM(2011) 571). The UN defines it as "reducing the environmental impact from the consumption and production of products over their full life cycles by ensuring that natural resources are produced, processed, and consumed in a more sustainable way". In addition, it is emphasized that "by producing more wellbeing with less material consumption, resource efficiency enhances the means to meet human needs while respecting the ecological carrying capacity of the earth" (Ekins and Hughes, 2016).

On the other hand, an unsustainable use of resources is the root cause of various environmental hazards, such as environmental pollution, climate change, desertification, deforestation, and the weakening of ecosystem services. Moving to resource efficiency and circular economy requires systemic change, affecting all stakeholders in the value chain, and substantial innovations in technology, businesses and society as a whole.

Fig. 1 illustrates this logic in the mass flow form. It shows a life cycle of a product, in which raw inputs are converted into this product that provide wealth and wellbeing to the society. This diagram contains six important elements that are common to both resource efficiency and the circular economy (van Ewijk, 2018).

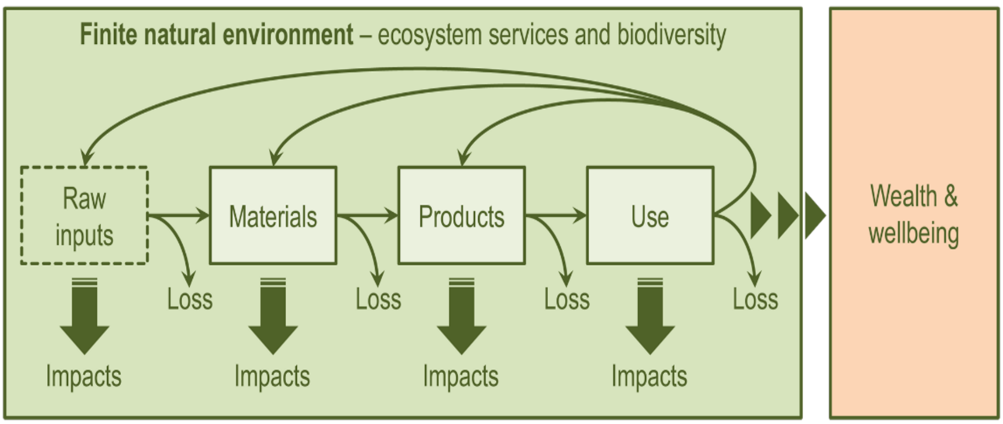

Fig.1. Resource efficiency and the circular economy (Van Ewijk, 2018)

Raw inputs into the economy. Here we speak of raw materials and may also consider water and land. Special attention should be paid to scares non-renewable resources.

Wealth or wellbeing are the results of the exploitation of natural resources, often measured through economic output metrics. Economies with rich mineral resources often pay less attention to the resource efficiency aspects and circular economy opportunities.

Environmental impacts include emissions of toxic compounds to air and water as well as such phenomena as forest or land degradation and climate change. Impact minimization is the ultimate goal of environmental regulation.

Finite natural environment describes ecosystems and their limited capacity to deliver ecosystem services under increasing pressures.

Inefficiencies (losses) occur between raw inputs and economic outputs across the value chain and lead to waste. Minimization of losses (through technological, technical and managerial solutions) allows to reduce waste.

Loops between inputs and outputs reflect circulation of materials back into the value chain or, for some organic materials, back to their origin instead of being lost as waste. This is the key principle of the circular economy.

While Fig. 1 focuses on the mass flow, Fig. 2 considers flows of both mass and energy and shows the progress in oil refinery technology from 1880s to 2010s. Of course, the scale of hydrocarbon exploration had increased dramatically, but Fig. 1 shows schematically shares of products manufactured, heat recycled and losses not avoided. The lower the losses, the more products provide wealth to the society. At the same time, rational use of energy, energy efficiency and energy recovery (recuperation) help to reduce negative environmental impacts – decrease toxic emissions and emissions of greenhouse gases.

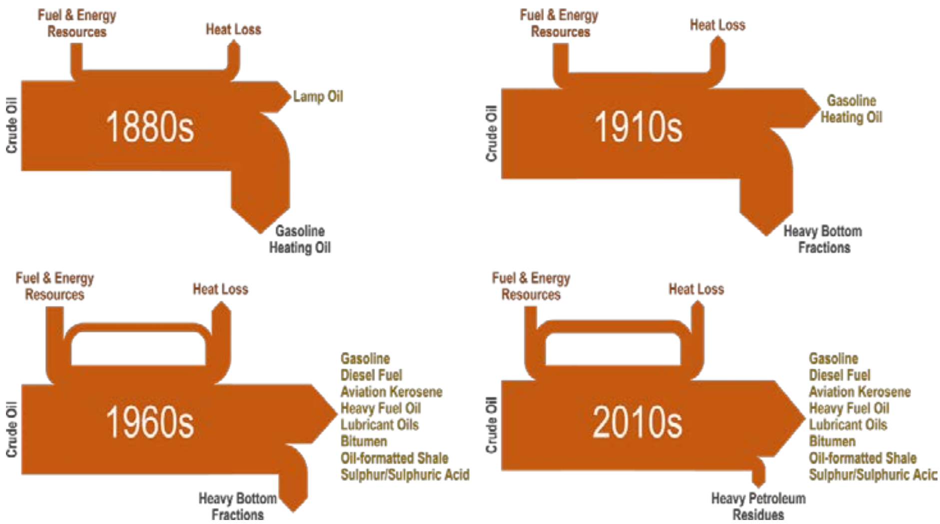

Fig.2. Resource efficiency in oil refinery processes

Both the EU and RF policies aim to ensure coherence between industrial, environmental, and energy policy to create an optimal business environment for sustainable economic growth, job creation and innovation. To support this, the Commission has established an ambitious agenda to transform EU economy into a circular one, where the value of products and materials is maintained for as long as possible, bringing major economic benefits. In Russia, it is the environmental industrial policy which is being gradually developed to harmonize the industrial and the environmental policy, to promote higher resource efficiency and better environmental performance of industrial enterprises (Skobelev, 2019).

3.3. Environmental Industrial Policy: Best Available Techniques and Resource Efficiency

In Russia, the NP "Environment" consists of 11 federal projects (FP), "Implementation of the Best Available Techniques" being one of them. It is designed in such a way that the results of its implementation correspond to several SDGs; they are also significant for achieving a number of Russian national goals and contribute to synergy between national and federal projects (for example, FPs "Clean Water", "Clean Air", "Clean Country"). This project ("Implementation of the BAT") aims to ensure the transition of Russian industry to a new regulation based on the BAT concept which are understood as a set of technological, technical and managerial solutions aimed at the consistent technological transformation of the industry with a purpose to increase production resource efficiency, return waste in the economic turnover and reduce the negative environmental impact.

In the EU, BATs are described as means the most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing the basis for emission limit values and other permit conditions designed to prevent and, where that is not practicable, to reduce emissions and the impact on the environment as a whole (European Commission, 2010).

At the same time, lessons learned by various countries prove that the BAT concept has potential for a much wider application, going beyond pollution prevention and control; the idea of "BAT flower", petals of which reflect BAT application for solving various problems, was put forward in 2019 (Hjort et al., 2019). First of all, the BAT concept is gradually strengthening its position in the development of industrial policy. Stringent BAT requirements do not jeopardize industrial development and economic growth, but help harmonizing progress towards SDG 8: Sustainable Economic Growth. This is why, in Russia, the concept is promoted by the Ministry for Industry and Trade (Minpromtorg). BAT-based legislation is developed by Minpromtorg and by the Ministry for Natural Resources and Environment and enforced by the Federal Supervisory Natural Resources Management Service (Rosprirodnadzor).

Russia has been developing and adopting legislative and regulatory legal acts that shape the conditions for the technological transformation of the industries towards better resource and environmental efficiency since 2014. The first document that laid the foundation for infrastructure transformation has been adopted on March 19, 2014 and consisted of set of measures for refusing to use obsolete and inefficient technologies (Volosatova et al., 2020); the logic behind this transformation infrastructure can be described as a system with interrelated and gradually developing components (Fig. 3). It is far too early to assess results of the transition to the new regulation or the effectiveness of the related policy. In the EU, attempts to run such assessments were made only in 2015-2019 while the fundamental legislative act – Integrated Pollution Prevention and Control Directive (IPPC) – was passed back in 1996 (OECD, 2018),(OECD, 2019).

In all countries, BAT-related regulations aim at improving resource and environmental efficiency of resource-intensive (4^{th} and 5^{th} technological paradigm) industries. In the EU, industrial sectors are listed in the Annex I (Categories of Activities) to the Industrial Emissions Directive (European Commission, 2010). Initially the list was issued as the Annex I to the IPPC Directive, and regulated installations are often addressed as IPPC installations. In the EU, for over 20 years, major emissions were reduced and resource efficiency of key IPPC installations improved significantly, but other that IPPC policy measures and instruments (for example, industrial safety, carbon and energy efficiency related acts) played their roles, too (OECD, 2018), (OECD, 2019).

In Russia, IPPC installations are called Category I industries (or installations), and the technological transformation and new state BAT-based regulation are focused on Category I installations both being resource-intensive and causing significant negative impacts on the environment (Decree 1029, 2015). The criteria for categorizing installations are based on setting lists (sectors, sub-sectors) and thresholds; the threshold values generally refer to production capacities or outputs. Thus, Russian Category I installations represent such sectors as production and processing of metals, chemical, petrochemical facilities, mineral industries, energy industries, waste management as well as food industry and agricultural enterprises (intensive rearing of poultry or pigs). Coal and ore mining, exploration of hydrocarbons and municipal wastewater treatment are also included in Category 1 to reflect specific features of the national economy.

3.4. Infrastructure for Transforming Russian Industry towards Better Environmental and Resource Efficiency

The infrastructure for transforming Russian industry towards better environmental and resource efficiency can be imagined as a multi-layer structure (Fig. 3) embracing:

- legislative acts, norms;
- Reference Documents on Best Available Techniques, national standards;
- institutions developing BAT-related legislation and enforcing laws and regulations;
- institutions working out BREFs, standards, methodological and training materials;
- institutions running resource efficiency and BAT-related research and training programs;
- project design, engineering and consulting companies working in the field of BAT, energy and resource efficiency;
- regulated community.

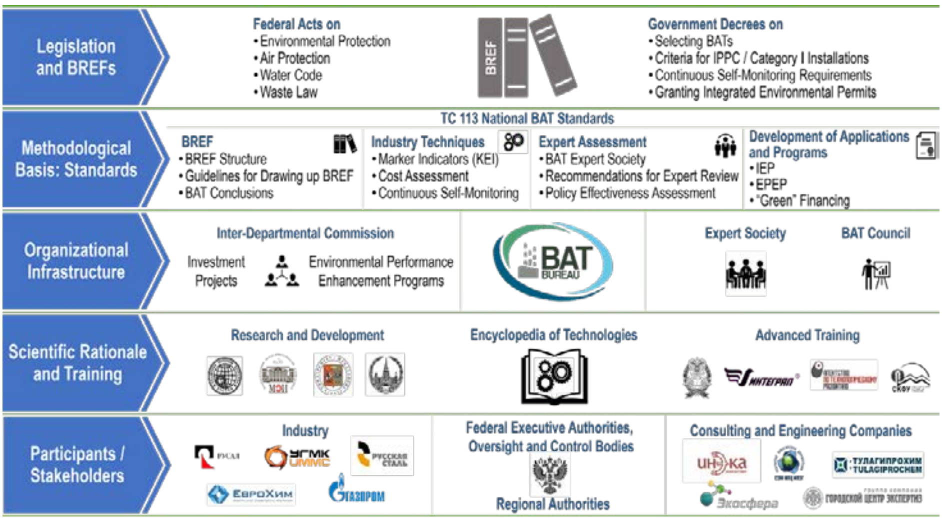

Fig.3. Infrastructure for transforming Russian industry towards better resource efficiency and environmental performance

It is necessary to emphasize that both federal laws and government decrees and orders in Russia are being consistently developed and refined taking the first results of law enforcement thus contribution towards establishing clear requirements for BAT-based regulation system. The system of legislative acts, decrees and orders of the Government (schematically presented on the top fifth "floor" of Figure 3) sets targets for the technological transformation towards better resource efficiency and environmental performance.

In 2014, when the Governmental Decree on March 19, 2014 No 398-r (Decree 398-r, 2014) and the Federal Law of July 21, 2014 No 219-FZ "On Amendments to the Federal Law "On Environmental Protection" and certain legislative acts of the Russian Federation" were issued, it became clear that a unified infrastructure for technological transformation of the Russian industry should be developed as soon as possible (Federal Law No. 219FZ, 2014). It was proposed to work out approaches for determining Best Available Techniques and lay the scientific and methodological basis for resource and technological transformation in a form of Information and Technical Reference Guidance Documents on BAT (Russian BREFs) and supporting national standards. To date, 51 Russian BREFs and more than 65 national standards have been developed within the framework of the Technical Committee on Standardization No 113 "Best Available Techniques". Moreover, in 2019, the first Russian BREFs were reviewed and updated, and this process made it possible to attract wider stakeholders – representatives of the regulated community, research and project design institutes, educational establishments (see the first and the second "floors" of the infrastructure) to discuss draft BREF and BAT-associated Emission Levels (BAT-AELs). Thus, the scientific task of the development of BAT-related requirements within the national standardization system has been solved.

National standards setting requirements to step-by-step development of BREFs, the identification of BATs and BAT-AELs, etc. are used while drawing up and reviewing Reference Documents. Standards on estimating BAT implementation costs, on developing environmental self-monitoring programs, etc. are currently applied at the installation and sector levels. The overall system of BREFs and BAT standards attracts international attention: methodological approaches were analyzed in detail by experts of the Organization for Economic Cooperation and Development within the framework of "Best Available Techniques to Prevent and Control Industrial Pollution" project (OECD, 2018), (OECD, 2019). The system continues to be developed; new standards on expert assessment and comparative analysis of technologies will be released in 2020-2021.

The Russian Bureau of Best Available Techniques (BAT Bureau) plays the key role in the development of the overall transformation infrastructure providing information and analytical support for BAT implementation and interacting with federal executive bodies during drawing up and updating of Russian BREFs in accordance with the Governmental Decree issued December 28, 2016 No. 1508 "On some issues on activities of the Bureau of the Best Available Techniques" (Decree 1508, 2016). This is why the BAT Bureau forms the core of the third "floor", provides organizational, methodological and expert support for the activities of the Inter-Departmental Council on the transition to BAT principles in the Russian Federation, and forms BAT expert society of the Russian Federation (Guseva et al., 2018). BAT expert society deserves a special attention. In fact, it began to function long before the concept of "expert assessment of technologies" was even mentioned in Russian BAT-related regulation, still, it is expected that expert assessment of BAT compliance will be included in the Russian BAT-related legislation this year with the adoption of next amendments to the Federal Law No 7 "On Environmental Protection".

BAT experts are professionals with research and practical knowledge in the field of Best Available Techniques, business and professional reputation, as well as the necessary qualifications. In the near future, requirements for experts should be approved by the order of Minpromtorg. The expert society has been consistently formed (and continues to develop) since the 2010s, when a number of BAT projects were carried out in Russia and the first national standards on BAT were worked out (for example, for the production of cement, glass, ceramics) (Skobelev et al., n.d.). In 2015-2017, experts played a leading role in the drawing up 51 Russian BREFs and took part in training practitioners in Siberia, the Urals, in the North-West, Central and Southern Federal Super-regions. Experts represent research organizations, educational institutions, consulting companies; collaboration of the expert and academic communities (third and fourth "floors" of infrastructure) helps to increase the level of research in the field of the Best Available Techniques, contributes to the formation of a training system in this field. In 2019, 17 Russian Category I installations were granted Integrated Environmental Permits. The pilot facilities included oil, gas, coal, iron and copper ore extraction industries and aluminum, cement, and paper producers. In order to achieve the established requirements seven Category I objects had to develop environmental performance enhancement programs (EPEPs) and undergo review by the Inter-Departmental Commission (IC) (Decree 999, 2015). The Russian BAT Bureau has developed methodological recommendations and procedures for evaluating EPEP projects in order to render support for IC activities. Thus, the third “floor” of the infrastructure was formed and confirmed its viability.

In 2019, the Russian BAT Bureau and experts have launched the “Encyclopedia of Technologies” project by preparing and disseminating a series of collective monographs. The authors of the first volume traced the patterns of genesis, formation and “sunset” of such industries as mining, metallurgy, construction materials; analyzed the main cycles during development of certain technology; identified key indicators of resource efficiency. The monograph is addressed to industrial decision makers and basic departments of leading companies in higher educational institutions; it should help prepare for scientific, technical, economic, social and regulatory changes, create an image of the sustainable technological paradigm. The "Encyclopedia of Technologies" should be the first step towards the developing approaches to the assessment of the production resource efficiency (Khachaturov et al., 2017; Skobelev, 2019).

4. Conclusions

Thus, the research problem described at the beginning of the article is solved. Principles for the development of the infrastructure for technological transformation of Russian industry towards better resource efficiency and environmental performance are formulated. The infrastructure is being formed, continually improved and strengthened based on the concept of Best Available Techniques.

The concept lays out the necessary basis both for pollution prevention and control and for more rational use of resources and recycling.

Government Decrees were drafted in collaboration with the leading researches in the field of environmental chemistry and monitoring and self-monitoring. BAT Bureau coordinates drawing up and revision of 51 Reference Documents on Best Available Techniques. Russian BREFs were issued for all industry sectors covered by the BAT legislation. For the first time, Russian BREFs were developed as the documents of the national standardization system and supported by a series of national standards providing the methodological background for the BAT implementation.

BAT Bureau also coordinates the formation of BAT Expert Society. Leading researchers, technologists and engineers participate in drawing up and reviewing of BREFs and national BAT standards. They also run research projects, support pilot installations in their attempts to identify opportunities for improving resource efficiency and environmental performance and to turn to more sustainable production moods.

Training programs – both at the higher education level and at the level of advanced training for professionals (industry engineers and managers, federal and regional authorities, consulting companies) – are developed and implemented by BAT Bureau jointly with the leading national and foreign universities.

As it can be seen, the infrastructure has a multidimensional nature (research, legislative, institutional, etc.) and is characterized by the active involvement of various stakeholders representing both regulators and regulated community, research and educational establishments, engineering and consulting companies, and the society concerned about wealth wellbeing and supporting Sustainable Development Goals.

References

Barnett V., (1998), Kondratiev and the Dynamics of Economic Development: Long Cycles and Industrial Growth in Historical Context, (in English), Studies in Russian and East European

History and Society, Palgrave Macmillan UK, London, On line at: http://link.springer.com/10.1007/978-1-349-26327-1.

Bobylev S.N., Solovyeva S.V., (2017), Sustainable development goals for the future of Russia, *Studies on Russian Economic Development*, **28**, 259-265. DOI: 10.1134/S1075700717030054.

Cvetanovic S., Despotovic D., Mladenovic I., (2012), The concept of technological paradigm and the cyclical movements of the economy, Facta Universitatis, *Economics and Organization*, **9**, 149-159.

Decree 398-r, (2014), On the approval of a set of measures aimed at abandoning the use of outdated and ineffective technologies., RF Government, (in Russian).

Decree 999, (2015), On the interdepartmental commission for the consideration of programs to improve environmental efficiency, RF Government, (in Russian).

Decree 1029, (2015), On approval of criteria for classifying objects that have a negative impact on the environment to objects of categories I, II, III and IV, RF Government, (in Russian).

Decree 1508, (2016), On some issues related to the Bureau of Best Available Technologies, RF Government, (in Russian).

Department for Business, Energy and Industrial Strategy, (2018), Clean Growth Strategy: Leading the way to a low carbon future, On line at: https://www.gov.uk/government/publications/clean-growth-strategy.

Domenech T., Bahn-Walkowiak B., (2019), Transition Towards a Resource Efficient Circular Economy in Europe: Policy Lessons From the EU and the Member States, *Ecological Economics*, **155**, 7-19. DOI: 10.1016/j.ecolecon.2017.11.001.

Dosi G., (1982), Technological paradigms and technological trajectories: A suggested interpretation of the determinants and directions of technical change, *Research Policy*, **11**, 147-162. DOI: 10.1016/0048-7333(82)90016-6.

Ekins P., Hughes N., (2016), Resource Efficiency: Potential and Economic Implications. Summary for Policy-Makers, United Nations, On line at: http://www.un-ilibrary.org/environment-and-climate-change/resource-efficiency_32af0674-en.

European Commission, (2010), Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control), Policy Document, (in English), European Environment Agency, On lin at: https://www.eea.europa.eu/policy-documents/directive-2010-75-eu-of.

Evstigneeva L.P., Evstigneev R.N., (2007), Economic synergetics, (in Russian), Institute of Economics, RAS, Moscow.

van Ewijk S., (2018), Resource efficiency and the circular economy: Concepts, economic benefits, barriers, and policies, EV0276, UCL Institute for Sustainable Resources, London, UK, On line at: http://randd.defra.gov.uk/Document.aspx?Document=14264_Resourceefficiencyandcirculareconomy.pdf.

Federal Law No. 219FZ, (2014), On amendments to the Federal Law ‘On Environmental Protection’ and certain legislative acts of the Russian Federation ", (in Russian).

Glazyev S.Y., Fetisov G.G., (2013), On the strategy of sustainable development of Russia’s economy, *Economic and Social Changes: Facts, Trends, Forecast*, **1**, 18-28.

Guseva T., Potapova E., Tikhonova I., Molchanova Y., Begak M., (2018), *Training Russian practitioners in best available techniques and integrated environmental permits*, (in English), Proc. of the 18th Int. Multidisciplinary Scientific GeoConference SGEM 2018, 18, 313-320. DOI: 10.5593/sgem2018/5.4.

Hjort M., Skobelev D., Almgren R., Guseva T., Koh T., (2019), *Best Available Techniques and Sustainable Development Goals*, Proc. of the 19th Int. Multidisciplinary Scientific GeoConference SGEM-2019, 19, 185-192. DOI: 10.5593/sgem2019V/4.2/S06.025.

Khachaturov A., Lukutina M., Belkovsky A., (2017), The Need for New Approaches to Strategic Planning in the Transition to the Sixth and Seventh Technological Paradigms, (in Russian), *Management in Russia and Abroad*, 3-22.

OECD, (2018), Best Available Techniques (BAT) for Preventing and Controlling Industrial Pollution, Activity 2: Approaches to Establishing Best Available Techniques Around the World, Environment, Health and Safety, Environment Directorate, OECD, On line at: https://www.oecd.org/chemicalsafety/risk-management/approaches-to-establishing-best-available-techniques-around-the-world.pdf.

OECD, (2019), Best Available Techniques (BAT) for Preventing and Controlling Industrial Pollution, Activity 3: Measuring the Effectiveness of BAT Policies, Environment, Health and Safety, Environment Directorate, OECD, On line at: https://www.oecd.org/chemicalsafety/risk-management/measuring-the-effectiveness-of-best-available-techniques-policies.pdf.

RF Government, (2018), National Projects: Key Objectives and Expected Outcomes, (in Russian).

Roadmap to a Resource Efficient Europe COM(2011) 571, Policy Document, European Environment Agency, https://www.eea.europa.eu/policy-documents/com-2011-571-roadmap-to.

Schwab K., (2016), The fourth industrial revolution, Crown Business, New York.

Skobelev D. (Ed.), (2019), Encyclopedia of technologies. Evolution and comparative analysis of industrial resource efficiency, (in Russian), Renome, Moscow, Saint-Petersburg.

Skobelev D., Guseva T., Chechevatova O., Begak M., Tsevelev V., n.d., *Chartered experts in best availble techniques in Russia: key principles and first practices*, Proc. of the 18th Int. Multidisciplinary Scientific GeoConference SGEM 2018, 18, 183-190. DOI: 10.5593/sgem2018/5.1/S20.024.

United Nations, (2015), Transforming Our World: The 2030 Agenda for Sustainable Development, (in English), United Nations, New York, NY, USA, On line at: https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf.

Volosatova A., Morokishko V., Tsai M., Begak M., (2020), Analysis of the legal regulation of granting integrated environmental permits, (in Russian), *Competency*, 18-25.

Yigitcanlar T., (2011), Position paper: redefining knowledge-based urban development, (in English), *International Journal of Knowledge-Based Development*, **2**, 340-356.