



Ministry of Education and Science
of the Russian Federation



HIGHER SCHOOL OF ECONOMICS
NATIONAL RESEARCH UNIVERSITY



Institute for Statistical Studies
and Economics of Knowledge

Russian Long-Term S&T Foresight

2030









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“A Foresight exercise for Russia’s science and technology towards 2030 is due to be completed. It highlights specific ways to both revitalise traditional sectors and penetrate into new high-tech markets...”

V. Putin

Presidential Address to the Federal Assembly
of the Russian Federation
December 12, 2012

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Aim and organisation of S&T Foresight 2030

Russian S&T Foresight is aimed at identifying the most promising areas of science and technology development in Russia towards 2030 to ensure the realisation of the nation's competitive advantages

The Foresight exercise draws upon a wide range of information sources and expertise including:

- survey data collected from more than 2,000 experts in 15 countries
- review of over 200 international and national Foresight studies
- analyses of statistical, bibliometric and patent data

The process resulted with a set of global challenges, windows of opportunities and threats for Russia, with breakthrough future technology along with a list of priority S&T areas. Results were validated through a process of consultation, which involved:

- regular high-level expert panels
- series of workshops and seminars
- discussions at national and international scientific conferences
- presentations at the sites of federal and regional authorities, development institutions, business associations, companies, technology platforms, innovative regional clusters, domestic and foreign universities and research centres, and international organisations

A network of sectoral S&T Foresight centres was established. The network covers more than 200 research institutes, universities and companies from 40 regions of Russia

Scope and outcomes

S&T Foresight 2030 is designed across priority areas of S&T in the Russian Federation (approved by Presidential Decree of 07.07.2011, no. 899)



Information and communication technologies



Life sciences (medicine and biotechnology)



New materials and nanotechnology



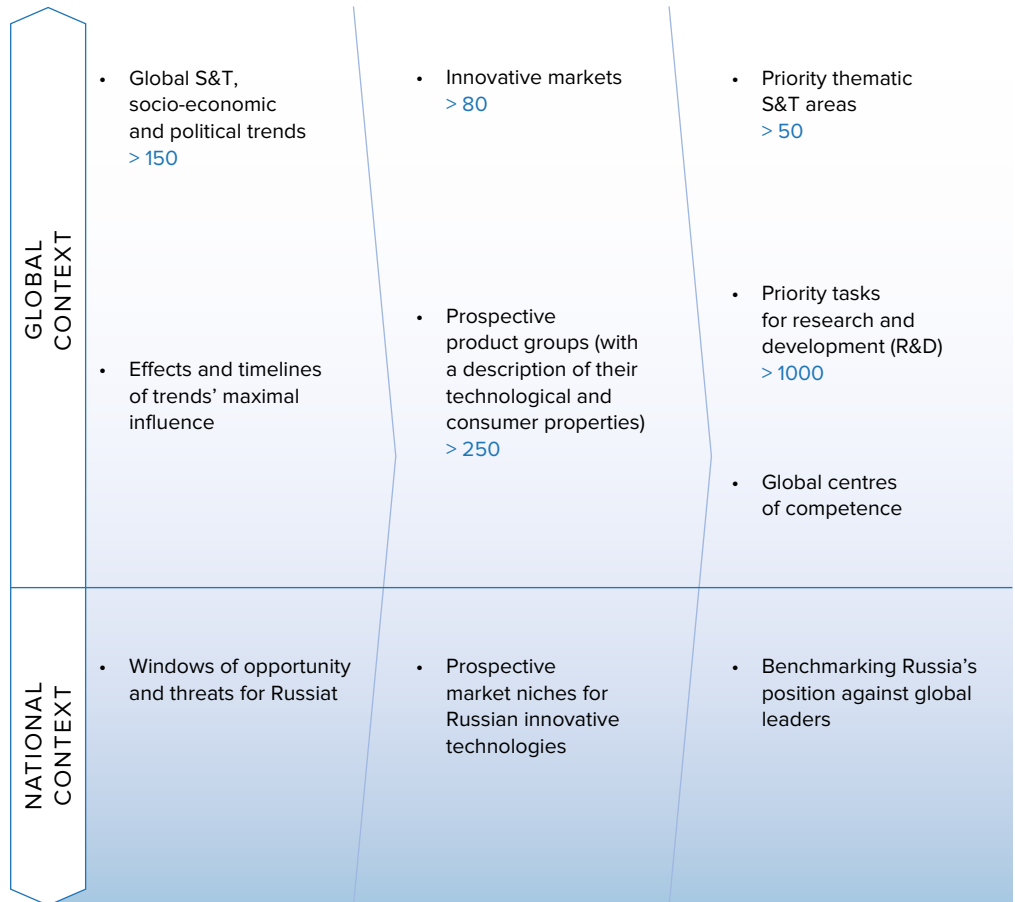
Rational use of natural resources



Transport and space systems



Energy efficiency





Information and communication technologies*

Global challenges

- ✓ Control of information over the Internet
- ✓ Growing imbalance between security and personal freedom
- ✓ Expansion of cybercrime and the scale of its effects
- ✓ Radical transformation of ICT markets in parallel to rapidly developing hardware components technologies (the end of Moore's Law, development of new materials, photonics, etc.)

Windows of opportunity

- ✓ Production and maintenance of supercomputers
- ✓ Big Data analytics
- ✓ Creation of new “human-computer” interfaces
- ✓ Convergence of information platforms
- ✓ Ensuring of ubiquitous access to high-speed network infrastructure
- ✓ Formation of a unified management environment
- ✓ New principles of computing
- ✓ Development of effective forms of visual presentation of information, content and knowledge
- ✓ Evolution of the Internet (“Semantic Web”, “Internet of Things”)
- ✓ Simulation of human intelligence, cognitive models of conscience and behaviour
- ✓ Development of biosimilar and anthropomorphic robotic devices

Threats to Russia

- Accelerated development of a global information space
- Aggravation of the “digital divide”
- Failure to provide the citizens with ICT-based health care and other social services on a large scale
- Possibility of using ICTs to undermine national security, breach of law and order
- The need to ensure secure document circulation
- Unreadiness to the widespread use of virtual reality technology

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* Here and below, certain most significant challenges, windows of opportunity, threats, radical products and technologies, as well as priority thematic S&T areas are highlighted. For details, please refer to: Russian S&T Foresight 2030. Moscow: Higher School of Economics, 2013

Wide-spread use of radical products and technologies

Priority thematic S&T areas

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- Telecommunication technologies
- Data processing and analysis technologies
- Hardware components, electronic devices and robotics
- Predictive modeling and simulation
- Algorithms and software
- Information security
- Computer architecture and systems

New principles and technologies for hardware components creation

Metacomputing

Algorithms and software for verification of large programs

ICT services for forecasting, modeling and simulation

“Internet of Things”

Self-replicating and self-repairing digital devices

Algorithms and software for knowledge engineering

Products and services for quality of life enhancement

Technologies and materials for 3D-printing

Anthropomorphic robots with the capability of interacting with humans

New-generation machine-to-machine interaction technologies (M2M)

Augmented reality

“Smart” infrastructures

Cloud solutions

4G technology and communication services

“Smart” businesses

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Life sciences

Global challenges

- ✓ Spread of diseases related to poor hygiene
- ✓ Increase in death rate due to cardiovascular diseases
- ✓ Growth of cancer and related death rate
- ✓ Spread of genetically modified organisms
- ✓ Spread of allergic diseases
- ✓ Growth of diseases related to metabolic disorders
- ✓ Increased incidence of chronic obstructive pulmonary diseases
- ✓ Spread of diseases specific to urban population
- ✓ Increase of disease incidence related to the aging of the population
- ✓ Growth of musculoskeletal system pathologies due to lifestyle changes

Windows of opportunity

- ✓ New players in the global pharmaceutical market
- ✓ Development of the principles of targeted therapy
- ✓ Growth of demand for materials with new properties
- ✓ Increase in global food demand
- ✓ Development of targeted regulation of cell differentiation
- ✓ Increased need for personalised medicine
- ✓ Implementation of “smart” agriculture technologies
- ✓ Increase in demand for remote diagnostics methods
- ✓ Widespread use of “smart” drugs
- ✓ Diversifying the application areas of bioelectronic interfaces

Threats to Russia

- High death rate due to cardiovascular diseases, cancer, injuries and poisonings
- Ineffective measures for the prevention of infectious diseases
- Inefficient rehabilitation system
- High costs for drug treatment of socially significant diseases
- Low productivity in the agricultural sector
- Critical lagging behind in research, industrial and technological base of biotechnology
- Lack of business interest in the development of biotechnology industries
- The transformation of the national economy to become a source of raw materials for the leaders at global biotechnology markets

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Wide-spread use of radical products and technologies

Priority thematic S&T areas

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“Brain-computer” interface for transmitting signals to specific neural patterns

Materials stimulating regeneration, activation and differentiation of body cells

Biotechnological processes of animal- and plant-origin recombinant proteins production

Components and systems of targeted drug delivery

Cell-culture products for medications stimulating regeneration processes

Drugs based on living cells

New generation biofuels

Bioelectronic interfaces

Genetic passports

Metabolic engineering products

Biomaterials and organic synthesis products to substitute traditional chemical industry products

Systems of data analysis related to low and high molecular biomarkers

Highly sensitive biosensors

Surgical robots

Surgical optical equipment

Software for the analysis of static macromolecular markers

Devices for monitoring the current state of the body

New species of plants

Bio-substitutable materials

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- Molecular diagnostics
- Molecular profiling and identification of molecular and cellular pathogenesis mechanisms
- Biomedical cell technologies
- Biocomposite materials for medical application
- Bio-electrodynamics and radiation medicine
- Genomic passportisation of humans
- Discovery of candidate drugs
- Development of the scientific and methodological basis of biotechnology R&D
- Industrial biotechnology
- Agrobiotechnology
- Environmental biotechnology
- Food biotechnology
- Forest biotechnology
- Aqua biotechnology



New materials and nanotechnology

Global challenges

- ✓ Increasing environmental standards for manufacturing
- ✓ Global shortage of energy sources and raw materials for the production of new materials
- ✓ Possible negative impacts of nano products on human health and safety
- ✓ Spread of new contaminants (including nanoparticles) in the environment
- ✓ Threat of uncontrolled proliferation of nano-enabled products

Windows of opportunity

- ✓ Creation of new types of nanoscale catalysts for deep processing of raw materials
- ✓ Development of high-strength materials
- ✓ Development of new optical materials for lighting engineering
- ✓ Creation of new types of lightweight materials (primarily composites)
- ✓ Development of technologies of computer-aided material and process modeling
- ✓ Creation of prospective biomimetic materials and materials for medical applications
- ✓ Development of new materials for energy sector and electrical engineering
- ✓ Spread of production technologies based on molecular self-assembly
- ✓ Development of intelligent and adaptive structural materials

Threats to Russia

- Lack of modern scientific and industrial equipment for designing and producing new materials and nano products
- Barriers for imports of technologies and materials
- Shortage of high-quality raw materials for the manufacturing of nano products
- Lack of highly qualified personnel
- Intense competition with foreign manufacturers
- Need for substantial investment in the organisation of mass production to achieve the economy of scale

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Wide-spread use of radical products and technologies

Priority thematic S&T areas

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Memristor-based electronic elements

Electronic elements based on graphene, fullerenes, carbon nanotubes, quantum dots

Fuel cells and catalysts for the development of innovative energy carriers

Nanostructured composite materials with special properties (e.g. electrical conductivity and magnetic and optical characteristics)

Heat-resistant nanostructured composite, ceramic and metallic materials

Materials for chemical current sources

Drug delivery systems

Nano- and micro-robotic systems

New types of light and high-strength materials

Nanostructured anti-friction and adhesive materials

Emitters based on nano-heterostructures

Nanostructured biocompatible materials

Sensors for the analysis of different media contents

Physical quantity sensors based on nanomaterials

Nanostructured materials and reagents for water treatment processes

Molecular self-assembly and self-organisation of nanomechanical systems

- Structural and functional materials
- Hybrid materials, converging technologies, biomimetic materials and medical supplies
- Diagnostics of materials
- Computer simulation of materials and processes

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Rational use of natural resources

Global challenges

- ✓ Increasing death-rates and disease incidence caused by air pollution
- ✓ Spread of new environmental pollutants (including nanoparticles)
- ✓ Climate change, intensification of dangerous hydrometeorological processes
- ✓ Increase in the proportion of urban population
- ✓ Growth of oil production from oil sands and oil shale
- ✓ Introduction of measures for carbon reduction in manufacturing and trade
- ✓ Intensification of adverse geomorphological and river-bed erosion processes and changes in the cryosphere
- ✓ Growing number of inhabitants under “water stress”
- ✓ Loss of biodiversity
- ✓ Intensification of migration caused by environmental and climatic factors

Windows of opportunity

- ✓ Development of technologies for environmentally safe recycling and disposal of toxic substances
- ✓ Creating super-computing technologies and information infrastructure
- ✓ Creating effective technologies of remote monitoring and evaluation of ecosystems
- ✓ Development of methods of forecasting hydrometeorological processes
- ✓ Development of methods of forecasting natural and technogenic emergency situations
- ✓ Conducting complex exploration of the Arctic
- ✓ Wide-range use of materials with new properties and technologies, “green” construction
- ✓ Development of environment-friendly transport
- ✓ Development of new technologies of production and deep processing of hydrocarbons

Threats to Russia

- Adverse environmental conditions (air, water and soil pollution, degradation of biotic ecosystem components)
- Growth of production and consumption waste and of accumulated environmental damage
- Increase in the negative impact of climate change
- Lack of effective monitoring of natural and technogenic disasters
- Lack of markets for environmental services
- Low level of raw materials extraction in the development of hydrocarbon deposits
- Inadequate quantity and low efficiency of geologic explorations

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Wide-spread use of radical products and technologies

Priority thematic S&T areas

- Environmental protection and safety technologies
- Monitoring of environment, assessment and forecasting of natural and technogenic emergencies
- Rational use of natural resources
- Exploration of subsoil assets, mineral prospecting and integrated development of mineral and hydrocarbon resources
- Exploration and utilisation of oceanic resources, the Arctic and Antarctic

Systems to increase oil recovery factor, including the directional change in the properties of the reservoir layers

Mesoscale models for predicting severe hydro-meteorological phenomena

Diagnostic systems of natural and hazardous technogenic systems

Development and extraction of raw materials from unconventional sources

Land-use optimisation techniques

Long-term long-range weather forecasts

Inventories based on geographic information systems

Web services (geoportals)

Remote sensing satellite systems

Methods of forecasting natural and technogenic disasters and their effects on the basis of observations

Systems of pre-concentration of new generation useful components

New generation water treatment systems

Eco-friendly and resource-saving recycling and utilisation of municipal waste with the production of secondary raw materials

Eco-friendly and resource-saving waste recycling during the production of goods, materials and valuable components

Eco-friendly and energy-efficient systems for complex and deep processing of mineral raw materials

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Transport and space systems

Global challenges

- ✓ Increasing the safety standards for vehicle and transport systems
- ✓ Increased requirements for hardware elements of on-board electronics, radio equipment, space instrument engineering
- ✓ Strengthening environmental requirements for the spacecraft launch and landing systems
- ✓ Growth in demand for means of protection for space apparatuses and stations from space-related objects and factors

Windows of opportunity

- ✓ Development of hydro- and aerodynamic flow control theory
- ✓ Creation of effective transport system design with internal combustion engines
- ✓ Transition to new construction materials
- ✓ Formation of delivery systems and systems of refueling vehicles with compressed natural gas
- ✓ Large-scale use of light alloys and polymers in manufacturing of vehicles
- ✓ Implementation of intelligent transport systems
- ✓ Transition to hybrid vehicles
- ✓ Creating a rocket engine with increased thrust
- ✓ Increase of demand for intelligent on-board systems
- ✓ Development of aircraft engine concepts, based on new principles of forming thrust

Threats to Russia

- Inadequate transport infrastructure (including ones in urban areas)
- Need for system solutions for the development of transport infrastructure
- Demand for new technologies and materials for the construction and maintenance of transport infrastructure
- Lag in the development of high-speed and intelligent transport systems
- Lack of a balanced system of international and transit traffic
- Increase in the negative impact of transport on the environment

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Wide-spread use of radical products and technologies

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“Space elevator”

New generation space stations

Methods and models of contingency control in intelligent transportation systems

Transportation of heavy loads into orbit with the help of heavy spacecraft and orbital module boosters

Energy-efficient and safe vehicles and next generation transport systems

New generation telecommunication services based on the space systems

Tools and systems to reduce the negative impact of air transport on the environment

New materials for vehicles and transport infrastructure

Computer-aided systems for monitoring of vehicles and transport infrastructure

New generation boosters

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Priority thematic S&T areas

- Models of transport-economic balance and smart transportation systems with the use of supercomputing resources at the exaflop level
- New materials and technologies for construction and operation of transport infrastructure in the Arctic and sub-Arctic areas
- Technologies to reduce the harmful impact of transport on the environment
- Technologies to ensure safe travel in difficult conditions
- Small spacecraft clusters
- Aircrafts and spacecrafts for launching suborbital small satellites
- Systems for wireless energy transmission to transport and space equipments
- Systems of autonomous landing of aircrafts and landing space vehicles, and autonomous navigation of land and water vehicles
- Extra-long flexible elements for static and dynamic space tether systems
- Materials for the extreme conditions of space flights, high-speed travel in terrestrial and aquatic environments

Energy efficiency

Global challenges

- ✓ Stricter safety requirements in the nuclear power engineering
- ✓ Increased competition in the global energy markets
- ✓ Depletion of cheap stocks of traditional hydrocarbons
- ✓ Development of renewable energy technologies
- ✓ Increasing costs of extraction of fuel energy resources
- ✓ Development of unconventional hydrocarbon resources
- ✓ Increasing efficiency in the use of renewable energy
- ✓ Development of new types of fuel cells

Windows of opportunity

- ✓ Development of new technologies to ensure the safety of nuclear power plants
- ✓ Increase of technical and economic parameters of heat and power plants
- ✓ Using efficient technologies of uranium enrichment
- ✓ Growth of global energy consumption
- ✓ Development of novel methods for the exploration of new hydrocarbon reserves
- ✓ Development of forecasting and management methods in the energy sector
- ✓ Creation of prospective technologies of nuclear fuel circuit
- ✓ Development of “hard-to-extract” hydrocarbon resources
- ✓ Development of energy storage technologies
- ✓ Creation of new technologies in hydrogen power engineering

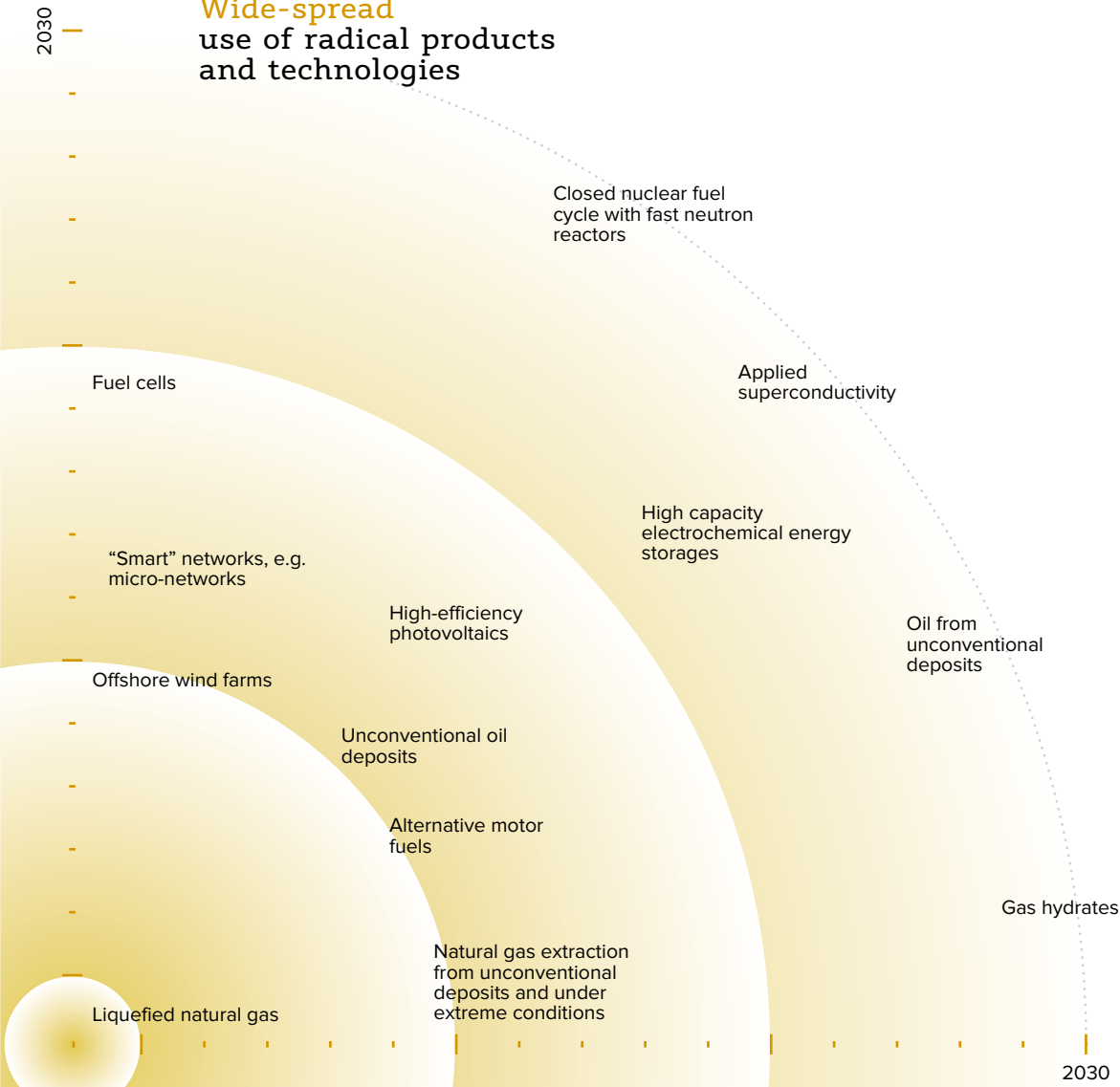
Threats to Russia

- Low extraction level and processing depth of hydrocarbons
- Insufficient reliability of energy supply
- Irrational structure of electricity transmission and generation capacities
- Lack of technologies of efficient electricity transfer across extra long distances
- Low levels of end-use energy efficiency
- Technological backwardness and high level of equipment wear and tear
- Underdeveloped energy infrastructure in significantly large-scale areas of the country
- Inadequate and low efficiency of geological exploration

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Wide-spread use of radical products and technologies

Priority thematic S&T areas



- Safe nuclear power engineering
- Efficient exploration and mining of fossil fuels
- Efficient utilisation of renewable energy sources
- Efficient and environmentally clean heat and power engineering
- Prospective bioenergy
- Efficient storage of electric and thermal energy
- Efficient transportation of fuel and energy
- Modeling prospective power generation technologies and systems
- New materials and catalysts for power engineering of the future
- Efficient energy consumption
- Development of advanced electronic component base for power engineering
- Smart power generation systems of the future
- Hydrogen power
- Deep processing of organic fuels

Global benchmarking

Analysis of priority S&T areas

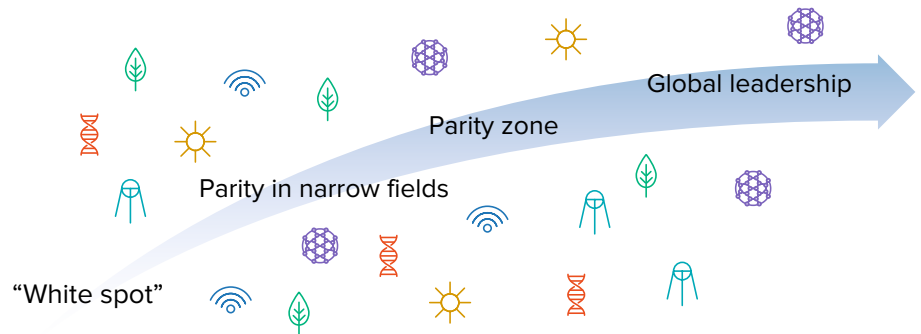
Priority areas of S&T

- ↳ Thematic S&T areas
 - ↳ Priority R&D tasks
 - ↳ Publications in peer-reviewed journals (Scopus, Web of Science)
 - ↳ Research fronts

Identification of fast-growing areas

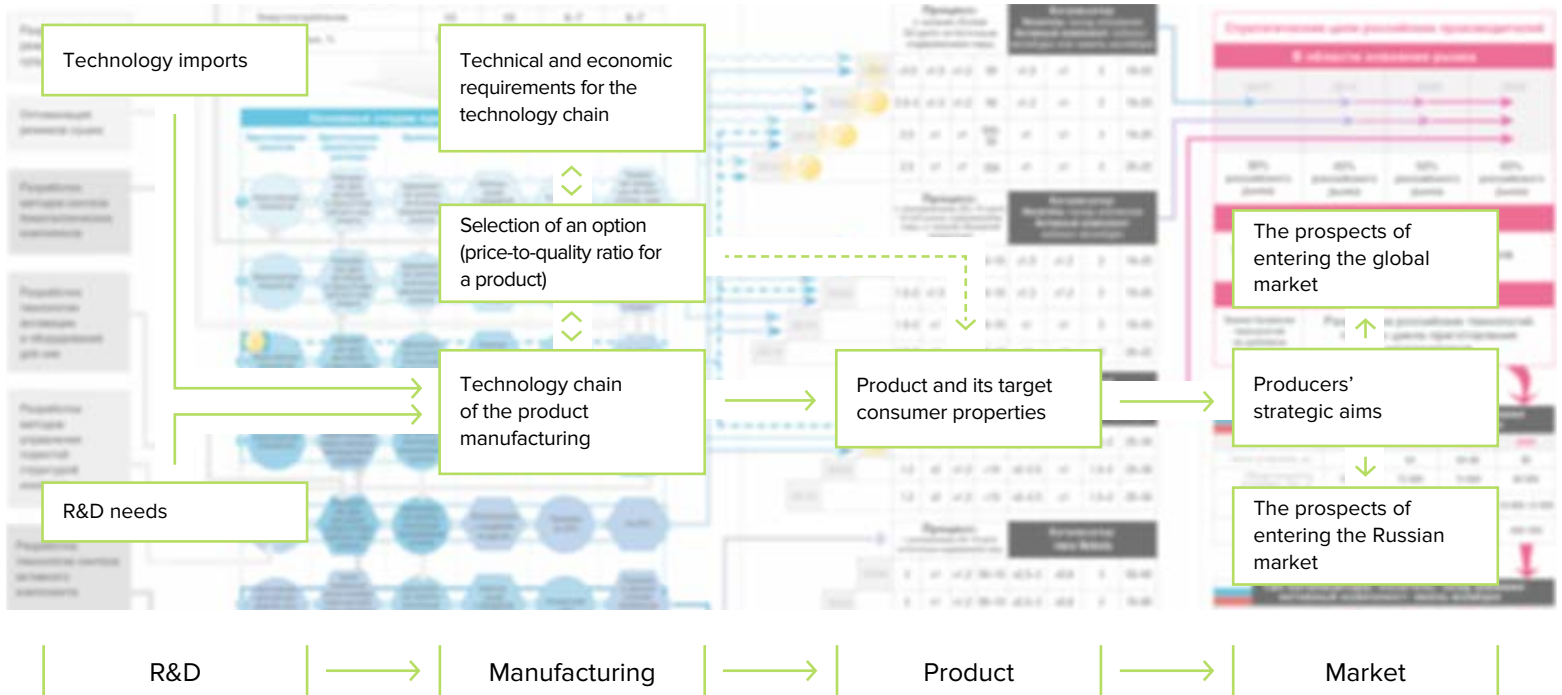


Assessment of the R&D level in Russia vis-à-vis leading countries in the world



Implementation of results

Technology roadmaps: selection and specification of alternative development trajectories



The Foresight results were implemented in

- Long-term Forecast of Socio-economic Development of Russia until 2030 (ratified by the Government of the Russian Federation 25.03.2013)
- State Programme “Development of Science and Technology” for 2013-2020 (ratified by the decree of the Government of the Russian Federation on 20.12.2012 # 2433-p)
- Sectoral Foresight studies and roadmaps (for space navigation; aircraft S&T; shipbuilding; petrochemistry; biotechnology and gene engineering; production of composite materials; etc.)
- Strategies and programmes of regional innovative clusters, technological platforms and companies

Foresight studies at HSE

- Theory, methods and practices of S&T Foresight
- Long-term Foresight and identification of priorities for S&T, innovation and socio-economic development at the national, regional, sectoral and corporate levels
- Formulation of strategies, programmes and roadmaps for the innovation development of companies, industry sectors and regions
- Monitoring of global trends in the development of the economy, society, science and technology

HSE International Advisory Board on Foresight

- Chairman – Prof. Luke Georghiou (University of Manchester, UK)
- Representatives of the OECD, UNIDO, the Institute for Prospective Technological Studies (EU), the Fraunhofer Institute for Systems and Innovation Research (Germany), University of Ottawa (Canada), Georgia Institute of Technology (USA) et al.

Major publications

- Russian S&T Foresight 2030. Moscow: HSE, 2013
- Long-term Priorities of Applied Research in Russia. Moscow: HSE, 2013
- Composite Materials: Manufacturing Carbon Fibers and Products on their Basis. A Roadmap. Moscow: HSE, 2013
- Sokolov A., Chulok A. Russian Long-term S&T Foresight 2030: Key Features and First Results // Foresight-Russia, 2012. V. 6. N. 1
- Meissner D., Gokhberg L., Sokolov A. (eds.) Science, Technology and Innovation Policy for the Future: Potentials and Limits of Foresight Studies. Heidelberg, New York, Dordrecht, London: Springer, 2013



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