

# R&D

Considering the systemic role that the Inter RAO Group plays in the energy industry, projects involving scientific research and innovations are of the highest priority. The measures of the Innovative Development Program allow for strengthening the Group's position as one of the key players in the process of global technological development. As part of this strategic focus, the Group's companies are actively expanding the infrastructure of their innovative activities, which is consistent with current global trends in science and technology. Innovative projects help to develop and strengthen the Group's inter-sectoral and international scientific and technical relations.

The goals of the R&D Program are to provide the Inter RAO Group with competitive advantages and achieve scientific and technological leadership in the industry through the development and introduction of advanced technologies and innovative solutions that are consistent with the global level and the state policy of the Russian Federation in the energy sector.

The following tasks had to be solved to achieve the goals of the R&D Program in 2018:

- enhancing the technical level, reliability, safety, and efficient operation of generating assets to the level of the best world analogues
- improving the environmental safety of electric power production as well as the production and transmission of thermal power
- cutting production costs
- energy savings
- improving the quality of goods and services for end users of energy resources
- developing and promoting proposals for the development of the industry's regulatory framework

The effectiveness of the implementation of the R&D Program measures in 2018 is assessed based on the following key indicators:

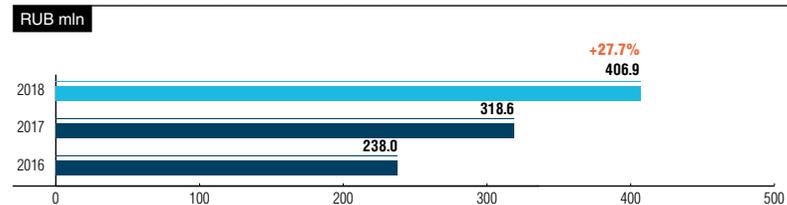
- the proportion of R&D costs versus the revenue of generating assets
- the number of intellectual property items

Over the course of the reporting year, the companies of the Group and the Energy Without Borders Foundation prepared R&D projects, supported the process of their inclusion in the R&D Program, and subsequently implemented and introduced the results that were obtained.

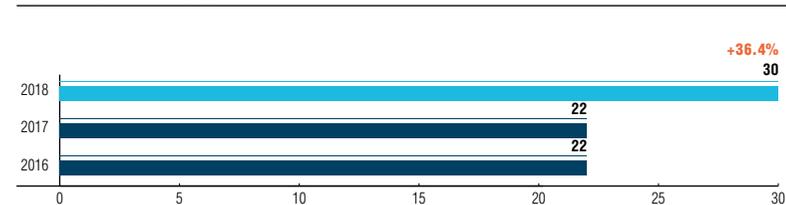
Main objectives for the development of R&D in the context of strategic priorities

- Inter RAO attaining the position of a technological and innovative leader in the industry
- promoting the innovative development of the energy industry in the Russian Federation
- developing and introducing breakthrough technologies and innovative projects with industry-wide importance
- creating a scientific, engineering, and production framework for the innovative development of Inter RAO and the Russian electric power industry

## EXPENDITURES ON THE PJSC INTER RAO INNOVATIVE DEVELOPMENT PROGRAM



## NUMBER OF PATENTS OBTAINED



## Innovative activity management system

The Innovation, Investment, and Cost Management Unit handles the centralized management of the Group's innovative activities. The unit monitors the achievement of goals based on targets developed on the basis of the Group's strategic benchmarks and the results of a comparative analysis with leading foreign and Russian energy companies.

### Energy Without Borders Foundation

In an effort to improve the management of R&D projects, the Inter RAO Group in 2011 created the Energy Without Borders Foundation to provide corporate support for research, scientific, technical, and innovative activities. The Foundation collects funds for major projects, creates an independent center of excellence to implement the R&D policy, performs the functions of a center for interaction with external partners and the government, and also helps to replicate and commercialize R&D results.

The Energy Without Borders Foundation provides an example of a systematic approach to organizing all innovative processes at a large corporation. The Foundation operates on the One-Stop Shop principle: it is the entry point for innovations at the Inter RAO Group and simultaneously the intersection point of expertise and demand. Its main objective is to form counter-flows of inquiries from the corporation and proposals from developers and organize the innovation

process without interruption. To this end, the foundation has developed a clear and consistent methodology that is embedded in the existing system of the corporation's internal policies and procedures. The Foundation accepts applications for work within the R&D program and proposals on the introduction of innovative solutions. Proposals and applications are accepted on the website <http://energy-fund.ru/> both from representatives of the Inter RAO Group as well as from any third-party individual or legal entity.

### Strategic partners

The Group has expanded the range of its search for new technologies and innovative solutions by maintaining and building working relationships with independent experts, leading Russian and foreign organizations, and their associations. The Group's strategic partners include:

- the Skolkovo Foundation
- the International Energy Agency
- the Institute of Innovation Management at the National Research University Higher School of Economics
- the RUSNANO Fund for Infrastructure and Educational Programs
- the Urals Branch of the Russian Academy of Sciences
- JSC All-Russian Thermal Engineering Institute

## Projects implemented in 2018

### In electric and thermal power generation:

#### Steam and gas equipment

Commissioning of progressive equipment based on modern combined-cycle technologies (Zatonskaya CHPP-2, the PGU-220 unit with capacity of 440 MW);

#### Data management system

Development of a system for the collection, transfer, and calculation of technological information of the executive office of JSC Inter RAO – Electric Power Plants and its branches.

#### Reagent VTIAMIN KR-33

Development of the VTIAMIN KR-33 new generation amine-containing reagent (right holders: Energy Without Borders Foundation and JSC All-Russian Thermal Engineering Institute), which is the domestic equivalent of foreign reagents (Helamin, Cetamine, and PuroTech). The reagent is used to support the amine water chemistry conditions at power facilities. The introduction of the Russian-made reagent reduces the cost of reagents by up to 40% per year.

The reagent is currently used at the following facilities of the Inter RAO Group and beyond:

- Ufimskaya CHPP-2 (LLC BGC)
- Zatonskaya CHPP (LLC BGC)
- Adlerskaya TPP (OJSC OGC-2)
- LLC Agrosnabsakhar (a sugar factory in the Lipetsk Region city of Yelets)

Work is underway to expand the supply market and the items introduced for the production of a new reagent.

### Simulators for TPPs

New generation simulators are being developed to train the operating personnel of power plants based on innovative Russian-made information technologies. The use of simulators enhances the reliability and safety of equipment operation at thermal power plants by providing staff with the skills to make and implement decisions involving equipment management in real-time. Work is being carried out as part of projects to create mathematical models that simulate the operation of TPP equipment, and software products have been developed to implement these mathematical models. Each project aims to create intellectual property – computer programs – that can be protected legally.

### Power equipment test site

A project is being developed to build a test site for power equipment with a test bench, including laboratory facilities as well as hardware and software systems with licensed software that meets modern IT solutions. The test site solves thermal power engineering challenges in the following areas: Fuel, Ecology, Water Treatment, Improving Reliability, and Maneuverability.

### Gas turbine engine for power plants

A project for the creation of GTD-110M and GTE-110M production technologies was launched on December 25, 2013. It is being implemented by a consortium of PJSC Inter RAO, the RUSNANO Fund for Infrastructure and Educational Programs, PJSC Saturn NPA, and the Innovative Energy Technologies Center nonprofit partnership at the facilities LLC Gas Turbine Technologies Engineering Center.

The entire range of R&D has been completed for the fine-tuning and modernization of the GTD-110M in accordance with the project schedule. The restoration and modernization of the GTD-110M pilot engine has been completed. The GTD-110M pilot turbine underwent three test stages on a test bench. Measures were developed and tested at the batch-produced compartment of the Ivanovskiye CCGT to reduce the noise level, vibration, and heat emitted by the GTE-110M unit to standardized values. A set of 20 parts and components of a low-emission combustion chamber (MEKS) was manufactured for installation and testing within the GTD-110M engine. All the parts and components of GTD-110M No. 6 have been manufactured, and the general assembly of the engine is underway.

The plan is to complete the assembly of the engine and deliver GTD-110M No. 6 to the Ivanovskiye CCGT test bench in March 2019. The engine is to be tested for a total duration of 700 hours in April 2019. Following the completion of the prolonged testing, the engine GTD-110M No. 6 will be under controlled pilot operation at the Ivanovskiye CCGT. The Company has registered three patents and eight production secrets (know-how) based on the research and development activities carried out as part of the project.

## Power supply activities:

### Unified billing

Launch of a unified billing system for legal entities at supply companies of the Inter RAO Group.

### FORSAZH settlement system

FORSAZH standardization of settlements with individual consumers of the Inter RAO Group's power supply companies.

### BYT automated power supply control system

Development of new generation IT products for settlements with individual subscribers on the basis of the BYT automated power supply control system.