Foundation "Energy Beyond Borders" and its R&D Progam

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Inter RAO is a diversified power generating company that owns or runs power generation assets and electricity networks located on the territory of the Russian Federation and abroad.

The core of Inter RAO Group activities is electricity and thermal power generation The INTER RAO owns or runs 26 thermal power plants, 2 hydro stations and one wind farm with the total capacity of 28 GW and total power output of 117 bln. kW h (in 2011). Besides power generation, Inter RAO Group is an active electricity trader in the Scandinavian, Baltic and Caucuses markets.
Inter RAO supplies electricity to Finland, Belarus, Latvia, Lithuania, Ukraine, Georgia, Azerbaijan, South Ossetia, Kazakhstan, China and Mongolia. Recently INTER RAO has started to operate in the engineering sector and considerably enlarged its electricity retail sectors.

In 2011 the number of people employed by Inter RAO Group exceeded 47,000 people.

The recently adopted Program for Innovative Development of the INTER RAO Group envisages a number of initiatives to be implemented in the Group. The implementation of this Program is entrusted to "Energy Beyond Borders" Foundation that has recently been established to support science and technology development activities in the Group.

The Foundation is a non-commercial organization that has it as its aim

- to support research, science, technology and innovation;
- to provide funding for science, technology and innovative product development activities;
- to maintain working relation with the best academic schools in the Russian Federation (RF) and in the world;
- to support market introduction of innovative products and small innovative/spin-off companies;
- to provide support and financial contributions to major projects initiated by the leading Russian companies aimed at development of perspective

technologies in the energy sector and promotion of advanced technologies in the electricity industry.

While implementing its R&DD program and pilot projects, the Foundation has established and intends to expand a close partnership with a number of power industry companies, research organizations and universities and cooperates with the governmental bodies.

As an example of the Foundation's activities in establishing partnerships can serve a project co-funded with Skolkovo Foundation for the creation of innovation system infrastructure in Skolkovo Technopark including:

- establishment of a R&DD center at Skolkovo cluster;
- establishment of the Center for Innovations and Technology Development designed to accelerate market introduction of the R&D project results;
- participation in Skolkovo Science and Technology Institute programs and expert panels.

The Foundation's program is instrumental in supporting the activities of the national technologies platforms. The Foundatio's R&DD Program is meant to provide for system-based activities in the priority research areas identified in collaboration with the national technology platforms:

- R&DD in the area of environmentally clean thermal power generation of high efficiency,
- R&DD in the area of small-scale distributed power generation,"
- R&DD in the area of intelligent power systems (smart grid),
- Bioenergy technology R&DD.

To this end, the program has been structured around the four portfolios:

- A portfolio of activities aimed at development of advanced energy technologies, including emerging one;
- A portfolio of activities aimed at raising the efficiency of the existing power plant equipment, its reliability, safety and environmental performance characteristics;
- A portfolio of activities aimed at organizational and marketing innovations,

- A portfolio of activities aimed at building up innovation-supporting infrastructure (capacity building activities).

The development of advanced ultra-super critical coal fired power plants (with steam pressure over 35 MPa and temperature – over $700^{O}C$), including development of the relevant materials is one of the program's priorities as well as one of the key areas to be elaborated by the Technology Platform "Environmentally clean and efficient electricity and heating power generation".

The Foundation is focused on the development of new materials: a call for proposals on development, certification and approbation of steels to be applied for construction of a steam boiler, steam turbine and resuperheated steam ducts operating under advanced ultra-super critical parameters (35 MPa, 700/720 °C).
To support the R&D activities in ultra-supercritical construction materials of a commercial grade is was decided to establish an R&D laboratory working on thia problem. The laboratory sponsored by the Foundation will be operating under the umbrella of Skolkovo Science and Technology University.

The necessity to establish a laboratory can be accounted for by the following reasons:

- The first pilot steam boiler "60-OP" operating under supercritical parameters of steam (30 MPa, $600^{o}C$) was constructed on the power plant site of the All Russian Thermal Institute in 1949, later it was upgraded to operate under 650^{oC}.
- Brilliant research works performed in the period of 1956-1968 resulted in construction and start up of operation of the power unit "SKR-100" under 30 MPa steam pressure and steam temperature of $650^{o}C$. Austenite grade steels were used as construction materials for the boiler PK-37 and turbine R-100-300. Unfortunately, lately the investigations in the field of steel behavior under supercritical parameters were frozen and therefore the achievements of late 60^{th} were not further developed and applied widely.
- Later during $1980\text{-}1990^{th}$ the construction steels P-91 and P-92 were created and therefore made it possible to start construction of supercritical units, and since that time a considerable number of supercritical units have been installed worldwide. A material of similar properties, steel DI-82, other heat resistant chrome based steels have been developed in Russia.

The task of the development of ultra-supercritical coal units cannot be fulfilled without the creation of material and technology production basis.

First of all the creation of material science basis for advanced ultra-supercritical units need to be started with the following objectives:

- Theoretical and experimental studies of existing and developing steels and alloys to evaluate the possibility of their use for coal fired advanced ultra-supercritical units;
- To determine the mostly potential group of the above materials from the technical and economy points of view;
- Classification of the above groups of materials on the basis of their performances;
- Determination of the trends for further investigations;
- Development of the scientific basis for the creation and application of the newly developed construction materials (including nanotechnology methods);
- Elaboration of the development philosophy of the ultra-critical material science basis and the roadmap of its development process.

We see the results of investigations in obtaining the reliable knowledge on the possible use of tested existing and newly developed steels and alloys for the construction of coal fired ultra-supercritical units to define the margins of technically and economically effective use of different groups of materials, to be used in the construction of power plants with steam conditions of up to 750^{o}C. On the basis of the above results a roadmap for the development of commercially attractive new construction materials of advanced ultra-supercritical units could be elaborated.

One of the possibilities is to install testing facilities at the site of an experimental power plant of All Russian Thermal Institute. This alternative is the economy attractive one as a number of existing power facilities could be utilized under the project: testing gas firing boiler (600^{O}C, 30 MPa) as well as its boiler feed water pumps. The superheated steam leaving the boiler will be sent to a firing heater as to be constructed downstream the boiler where its temperature will be increased up to 800^{O}C and the pressure will be kept at a level of 30 MPa. Downstream the heater the following two testing facilities are planned to be installed: armored chambers for testing of materials and turbine elements.

Tests of materials will be performed by the specialists of All Russian Thermal Institute in collaboration with Tsniitmash Institute. Turbine element tests will be

performed by the specialists of All Russian Thermal Institute in collaboration with Moscow Power Engineering Institute (Technical University).

The Foundation and its partners among the Russian research organizations are open for collaboration both on a bilateral and multilateral basis to advance the development of advanced USC technologies.