

# HTGR-BASED NUCLEAR HYDROGEN TECHNOLOGIES

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Currently, one of ROSATOM's key goals is to develop technologies in the field of nuclear hydrogen economy, which is part of one of the strategic areas of development of the Russian nuclear industry.

The main development objective in the field of hydrogen technologies is to implement an investment project for the construction of a nuclear power-and-process station with a high-temperature gas-cooled reactor and a chemical process part for the production of hydrogen-containing products through hydrocarbon conversion. The product lineup of the nuclear power-and-process station consists of hydrogen, ammonia, and urea. The final product will be determined by the potential consumer.

To date, the detailed design of the reactor plant has been developed and the site of the station has been selected; the development of investment feasibility study documentation for the project is planned for 2024. According to the project road map, the nuclear power-and-process station is scheduled to be put into pilot-commercial operation in 2035.

In order to effectively develop engineering and design solutions, companies cooperate in research and development work on fuel, graphite, high-temperature materials, manufacturing processes for elements and assemblies of the reactor plant main equipment, on verification of design codes, the regulatory framework is being developed and updated, the concept of spent nuclear fuel and radioactive waste management is being developed.

For heat-resistant XH55MBII (ЧС57) nickel alloy, the manufacturing process for the required shape and the welding process are being developed, long-term strength characteristics (up to  $5.0 \cdot 10^5$  h) are being achieved, welded joints are being certified (up to  $t = 950^\circ\text{C}$ ), and the alloy is being included in the list of base materials (due in 2028).

For graphite, the manufacturing process for large-scale graphite workpieces is being improved, the necessary equipment is being designed and manufactured, manufacturing processes and equipment are being improved and updated, prototype batches of graphite workpieces are being manufactured, pre-irradiation, irradiation, and post-irradiation examinations and studies of mechanical, thermal, and nuclear properties of graphite in the temperature range from 20 to  $1600^\circ\text{C}$  are being carried out, graphite certification is being carried out (due in 2027).

For thermal insulation, mechanical, thermal, nuclear properties, dust and gas emissions are being studied (due in 2027).

At the current stage of development, preliminary cost estimates for the construction of a two-unit station have been calculated. The capital costs for a two-unit nuclear power-and-process station, taking into account that the chemical process part would include an ammonia skid, are estimated at RUB 550–600 bln in 2023 prices, VAT excluded; assuming urea production, the capital costs increase and will amount to about RUB 700–750 bln in 2023 prices, VAT excluded. The production cost under standard taxation varies: ammonia is about 19 rubles/kg; urea, about 14 rubles/kg in 2023 prices exclusive of VAT. At wholesale prices for electricity and natural gas and taking into account the property tax preferences (tax reduction to 0% for 10 years) and income tax preferences (tax reduction to 0% for 10 years), the cost of production is roughly reduced by 12%: ammonia, 16.9 rubles/kg; urea, 12.3 rubles/kg.

Taking into account the 7% discount rate, the present value of ammonia and urea is estimated at 27.5 and 20 rubles/kg, respectively.

The economic efficiency of the project and the key project indicators, including the product sales rate, will be calculated by the general designer of the station not earlier than 2026.

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