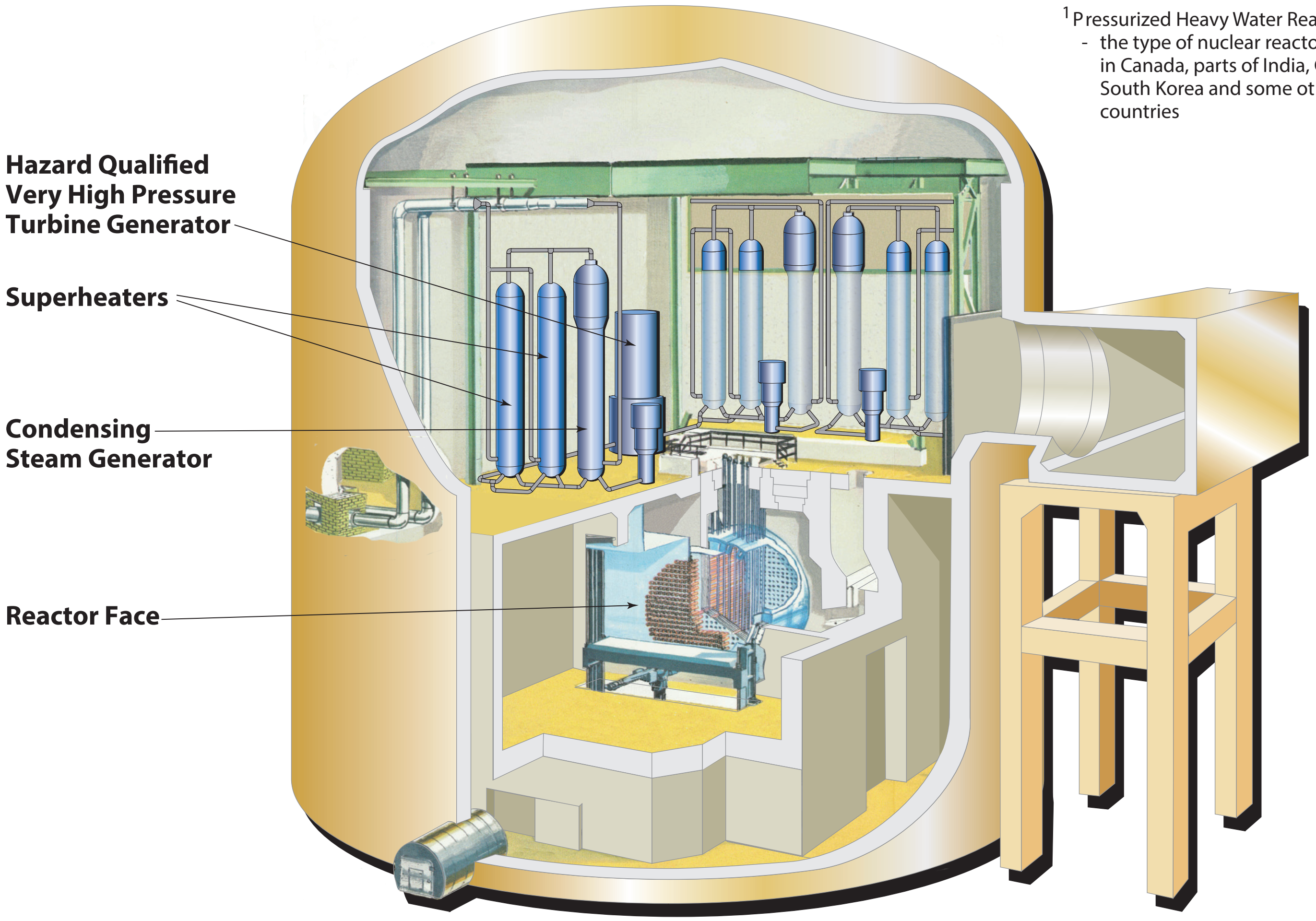
Supercritical Nuclear Power Plant Refit

Suretech Development Limited is developing technology that would allow a supercritical water cycle to be introduced into Ontario's existing reactors. This technology is specifically aimed at improving the competitive position of electricity generation in Ontario, although it can also be combined with an existing Pressurized Heavy Water Reactor (PHWR) design to create a new build product.

The supercritical refit technology can double the electrical output from Ontario's existing nuclear plants, extend the useful life of existing plants, significantly increase safety and reduce the fuel consumption, nuclear waste and thermal emissions per megawatt of electricity produced. The deployment of this technology involves a modular replacement of the primary heat transport system that is not much different than activities currently undertaken during 'mid-life' refurbishment.

Suretech's development focus to date has been on plant system modelling and layout, enabling technology identification, initial development including

- **Up to 100% Increase in Electrical Output from Existing PHWR[1] Plant**
- **Higher Efficiency Leading to:**
  - Less Fuel Consumption
  - Less Spent Fuel to Manage
  - Less Thermal Waste
- **Major Increase in Safety**
  - Two Fully Passive Decay Heat Sink Paths
- **Easy to Implement - Similar to Refurbishment**



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[1] Pressurized Heavy Water Reactor - the type of nuclear reactor used in Canada, parts of India, China, South Korea and some other countries

patent applications for the enabling technology. Our next development steps are to test six underlying technologies to establish that there are no fundamental technological barriers to implementation.

The supercritical refit technology development is structured to occur in phases with each phase reducing uncertainties. The first phase is intended to demonstrate six enabling technologies at modest levels of capital investment.

The initial phase of development involves proving out material performance, physical phenomena and mechanical mechanisms independent of each other and at reduced scale. Physical testing will be central to proving out most of the technologies.

Once the basic technologies are proven, engineering scale single component testing would be required. This testing would generate engineering data to be used in the actual design of a refit.

The final stage of testing is the qualification testing that will prove-out the final design of components and generate validation data to be used in CNSC licence applications.

Basic Principles of Super Critical Refit

Supercritical water is water at conditions above the critical pressure[2], where there is no phase change between the gas and liquid phase. The use of supercritical water allows operation at higher temperatures and pressures than conventional steam plants giving significantly higher plant thermal efficiencies. Coal supercritical plants are now commonplace, particularly in Europe and the far east, and achieve thermal efficiencies in the range of 44% to 48%, or 50% more efficient than current PHWRs.

The obstacle to deploying supercritical water to nuclear reactors has been the application of high temperature materials (that tend to be neutron absorbing) to reactor core components and the general risk of deploying new technology to a high capital cost plant. There is however a path to deploying this technology to existing PHWR plants that gets around many of these risks. A very high pressure primary topping turbine cycle exists[3], whereby supercritical water can be introduced to an existing PHWR without any significant changes to the secondary side. When this cycle is combined with other aspects of PHWR, a development path exists for getting up to 100% more power out of an existing plant, with manageable development risks. The additional power is provided through two very high pressure hazard qualified air cooled turbine generators within containment. A vertical configuration with overhead crane is used for both space and maintenance material handling considerations. The steam generators operate in fully condensing mode to achieve both much higher and more even heat transfer. The steam generator volume required to transfer a given amount of heat is much reduced, freeing up space within containment.

A superheater may be provided to superheat the secondary side steam with the degree of superheat selected to minimize or avoid changes to the secondary side. Additional power can be obtained from the secondary side by superheating the steam which remains at the same pressure.

Safety is improved by having two fully passive decay heat sink paths.

The normal operation decay heat sink path is via a decay heat / start-up flow leg that rejects heat through heat pipes in the containment wall to air convection heat duct radiators outside containment. The relatively high temperature of hot pressurized coolant provides an adequate driving force for air convection heat transfer.

The abnormal operation decay heat sink is through the pressure tube to the moderator and then by flash driven natural circulation of the moderator to a heat exchanger cooled by either a passive emergency water supply or a heat pipe radiator system as described above. The high temperature clad fuel and specially configured pressure tube insulator will allow decay heat to be rejected from a post LOCA dry fuel channel without failing the fuel clad or releasing fission products.

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[2] The critical pressure of heavy water is 21.67MPa

[3] Bushby, S.J, Dimmick, G.R. et al., "Conceptual design for advanced high temperature CANDU Reactors", SCR-2000, Nov. 6-8, 2000, Tokyo