THE SMALL (or Large) MODULAR CANDU

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Abstract

The origins of this work go back many years to a comment by John Foster, then President of AECL CANDU, the organization now owned by CANDU Energy, Inc. Foster noted that the CANDU reactor, with its many small fuel channels, was like a wood campfire. To make a bigger fire, just throw on some more logs (channels). If you want a smaller fire, just use fewer logs.

Consider the standard fuel channel used in modern CANDU reactors. With its length reduced from 6 to 5 metres, this channel can produce an average of 5 megawatts (thermal) for one year when fuelled with natural uranium. Replacement of fuel is carried out with the reactor at full power using a computer-driven, remotely operated fueling machine. Included in this assembly is the fuel, the coolant flow path, the high-pressure boundary needed to contain the high pressure coolant, the insulating gas gap and support tube needed to separate the hot channel from the cool moderator, and the closure fittings required to give access for refueling. Given this assembly, the remainder of the plant consists of more or less conventional heat transfer equipment. Heat transport sub-systems move fission heat to the turbine working fluid, control sub-systems regulate the power production process, and safety sub-systems monitor the whole system to ensure that operating parameters remain within tolerance ranges.

The design process is greatly simplified – just choose the desired output power, select the standard fuel channel and you have the number of channels needed. Using the standard spacing between channels gives the reactor vessel (calandria) size. Then carry on to design the systems and structures around this basic unit, given the major site parameters. Computer-aided drafting and design packages are easily adapted to detail any given final design with output ranging from about 25 up to around 1400 megawatts electric.

The Table shows a preliminary list of the main perceived requirements for a CANDU-SMR installed in Canada's Northern Islands. Underlying this list is a basic requirement to store and/or retain a minimal amount of both new and used fuel on-site, especially any fuel that is not located in-reactor at any given time.

One unique aspect of this SMR is the use of fuel strings; that is, regular CANDU fuel bundles with the centre fuel pin removed, to allow for a tie rod to pass full length through ten identical fuel bundles. This fuel string will be handled as a unit by the automatic fuelling machine, in the style first used on the Gentilly-I reactor design. This arrangement makes it possible to carry out automatic replacement of fuel at

regular intervals with only annual intervention of skilled operators. New fuel supply will be brought to the site once a year, and the discharged use fuel will be shipped out in flasks.

Fully skilled and licensed operators will be posted at a central facility in the far North. These operators will have monitoring and limited control capability over each of several sites. They will be assisted by local site operators authorized, under direction, to carry out a specified range of operation in the absence of the fully licensed operators – but with their oversight.

In order to enable full range load following and frequency control, two heat-storage facilities are proposed. The first is a conventional atmospheric hot water tank. This tank can be used as a district heating source as well as a turbine feedwater heat source. The second proposed storage unit is intended as a high-temperature heat dump for excess electricity. The storage medium in this case will be molten salt. This high temperature heat storage would be appropriate for auxiliary electricity sources such as wind and solar installations.

An alternative project arrangement envisages a larger CANDU unit located at a central base site, with small satellite units at low-demand locations. These units would be fuelled typically by synthetic petroleum produced at the base site. In this option, a more or less conventional CANDU unit would be installed. This alternative is still under study.