TECHNOLOGY FOR BUSINESS

GENXFIN – Exploring the options of advanced nuclear energy for near-term future

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Background

GENXFIN explores the potential of advanced nuclear systems for Finnish society. The potential depends on:

- Timeline to deployment
- Safety
- Economics
- Licenciability in Finland
- Unique features of some Gen IV technologies

Modular[1] high temperature gas-cooled reactor (HTGR) technology has made significant progress on these issues. **IAEA timeline** of SMR deployment ranks Chinese HTR-PM HTGR as ready for immediate deployment. For comparison, several LWR SMR's such as NuScale and SMART are estimated to progress more than a decade behind.

HTR-PM

HTR-PM is a twin-reactor modular pebble bed HTGR demonstration plant. It is under construction at Huaneng Shidao Bay site, People's Republic of China and will connect to grid within a year. HTR-PM features:

- 250 MWth/100 MWe per reactor **(40 % efficiency)**
- **567 ºC** secondary circuit steam
- **Passive safety:** fully passive capacity for decay heat removal. Prototype HTR-10 reactor was used to demonstrate the reactor behaviour by initiating **several ATWS events**. The reactor shut itself down safely with no damage in all cases. Similar tests with HTR-PM are expected this year to prove the design **meltdown-proof.**
- Thermal reactor design avoids the issues of fast reactors.
- **Modular** on the scale of the power plant. Multiple reactor units driving a single turbine leads to cost savings.

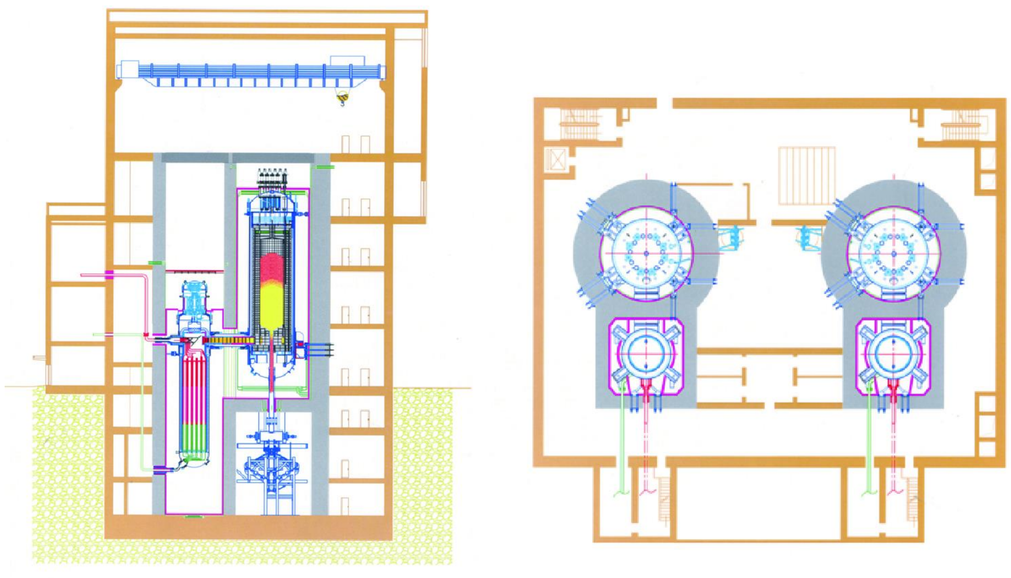

Figure 1. The layout of the HTR-PM demonstation plant in Huaneng Shidao Bay site. A proposal for a 2x600 MWe unit consisting of six such twin-reactor modules passed initial feasibility review in 2015 for a site in Ruijin City, People's Republic of China.
Sources: Engineering (journal) http://dx.doi.org/10.1016/J.ENG.2016.01.020, *The State Council, People's Republic of China*

Figure 2. The pressure vessel of one of the HTGRs being installed at Huaneng Shidao Bay site in People's Republic of China in March 2016. China has signed memoranda of understanding with Saudi Arabia and United Arab Emirates for co-construction of HTGR nuclear power plants. Source: The State Council, People's Republic of China

Long-term potential

The high temperature of the secondary circuit steam supports combined heat-and-power (CHP) production. This is relevant in the Finnish climate and especially for the Helsinki metropolitan area which is heavily dependent on district heat. Using nuclear power for the district heating of the metropolitan area could reduce Finnish CO_2 emissions by up to **4.0 - 4.5 million tons** annually (Source: Fortum Oyj).

In addition, pebble bed HTGR technology supports the development of advanced fuel cycles, as the German HTGR THTR-300 utilized thorium fuel.

Modular heat and power of the future

- **Modular gas-cooled high temperature pebble bed reactor technology is ready for immediate deployment with the first demonstration plant (HTR-PM) connecting to the grid within a year in People's Republic of China.**
- **HTR-PM has a secondary circuit steam output of 567 ºC. This has potential for CHP production.**
- **The first-of-a-kind HTR-PM's actualized costs per MWe exceed corresponding traditional LWR costs by 10-20% before cost reductions from modularity or establishment of HTGR industry.**

1: Modularity can be understood in two ways:
** Complete modularity where the reactors are usually not refuelled and the primary and/or secondary circuit is integral to the unit. Units are transported and installed as is.*
*** Modularity on the scale of the power plant, allowing scaling of the site for flexibility of investment and for saving costs by constructing multiple identical units. Here, the latter is implied.*

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