Holtec Technical Bulletin

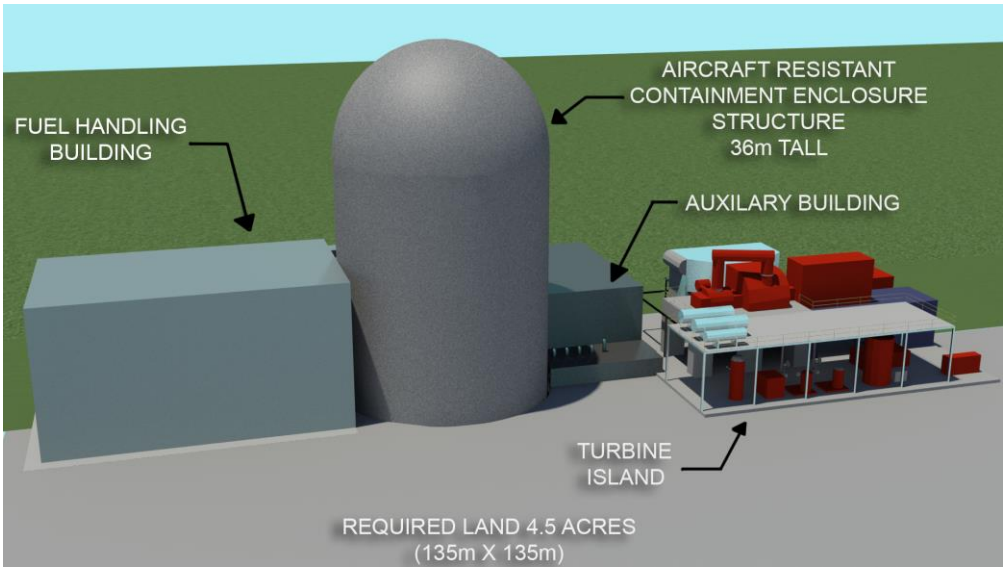
Essentials of SMR-160 Small Modular Reactor

Rev 9: May 14, 2015

SMR-160, developed by Holtec International (USA), is a *small modular reactor* designed to produce 160 megawatts of electricity using low enriched uranium fuel. SMR-160 is intended to serve as a distributed energy source that dispenses with the need for expensive high capacity transmission lines over long distances, making the electric grid more resistant to natural disasters or acts of sabotage.

Informed by over six decades of lessons learned from reactor operations, SMR-160 is designed to be an *unconditionally* safe reactor, which means it will not release radioactivity regardless of the severity of the natural or manmade disaster. Every conceivable catastrophic event - severe cyclones (hurricanes or typhoons), tsunamis, flood, fire and crashing aircraft - has been considered, with appropriate features incorporated in the design of SMR-160 to ensure that it will withstand these events without releasing radioactivity or pose any risk to public health and safety. In other words, SMR-160 is an industrial installation from which one will safely walk away in the wake of an unexpectedly severe natural disaster or act of sabotage, letting the plant's innate defenses look after the reactor's wellbeing.

Because SMR-160 is *walk away* safe, it can be sited next to population centers without any threat to the local environment or populace. It is as benign to its host locale as a cotton mill or a chocolate factory. Placing SMR-160 close to cities and towns will reduce transmission losses and enable the plant's workers to live in the local community. A SMR-160 installation takes up less than 4.5 acres of land; this is a fraction of the land area required by other types of power plants on a per megawatt basis (please see the illustration below).



A typical SMR-160 uses cooling water from a local natural source such as a lake, river or ocean to condense its exhaust steam. However, it can also be deployed in water-challenged regions by using air as the condensing medium. Note that a SMR-160 in an arid region will typically produce about 3% less power and require about one more acre of land.

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SMR-160 achieves its supreme safety by eliminating vulnerabilities that have been the source of accidents in nuclear plants, namely pumps and motors to run the plant's safety systems. Instead of motors and pumps, SMR-160 relies on Mother Nature's *gravity* to run all safety significant systems in the plant. Because *gravity can't fail*, a SMR-160 plant is assured to remain safe under every operating and accident scenario.

Replacing motors and pumps (that make a nuclear plant a menagerie of piping loops and networks) with gravity driven fluid flow systems not only hardens the plant against disasters like those that befell Fukushima, Chernobyl and TMI, but leads to huge reductions in the plant's overnight, operating and maintenance costs. Our best cost estimate indicates that a SMR-160 plant can be installed turnkey by Holtec for about $650 million dollars in 2015 dollars (which is less than half of the projected cost of the large nuclear plants on per megawatt basis being built in the U.S., France and Finland today) and constructed in half the time of current large nuclear power plants.

In short, the commercial case for SMR-160 is as compelling as its safety case.

To summarize, the core strengths and innovation of SMR-160 are its inherent safety, security, constructability and simplicity of operation. The SMR-160 design is driven by the principal criterion that all safety significant systems must be powered by natural circulation (which is also called *passive* in the technical literature). Passive in every aspect of its operation, the paramount technical mission of SMR-160 is safety and security. This passive design feature is effective in all operational modes, including off-normal and accident conditions, and applies to all safety-related systems of SMR-160. The technical innovations that underlie the heretofore unattainable level of safety in SMR-160 are documented in an array of patent filings (please see Holtec International's website, holtecinternational.com) which provide intellectual property protection to the Company.

Innovative features of SMR-160 include:

- Core located deep underground
- A Passive Containment Cooling System integrates decay heat removal from the spent fuel pool and reactor core under off-normal conditions, including station blackout
- The plant can be started without off-site power (i.e., it is "Black start" capable)
- A large inventory of water around and over the reactor core - with a gravity driven water replenishment system - makes the scenario of an uncovered reactor core non-credible.
- Easy access to critical components for in-service inspection and testing in compliance with the Code.
- No penetrations in the lower region of the Reactor Vessel; hence no pathway for inadvertent or accidental drainage of reactor water.
- Reactor coolant is demineralized water (no boron) which provides a natural ceiling against undesirable reactivity rise (known as having "a large negative reactivity coefficient" in the nuclear literature).
- Absence of boric acid in the plant helps increase the plant's service life (longevity) which is estimated to be well over 100 years.
- On-site *underground* storage of used fuel in welded multi-purpose canisters.