SMR-300: Holtec's 300 MW(electric) "Walk-Away Safe" Small Modular Reactor

SMR-300, illustrated in Figure 1, is a 300 MWe pressurized light water reactor that utilizes borated water in its reactor water (primary) side operating in a closed loop. The assemblage of the reactor, the steam generator, and the pressurizer, collectively referred to as the Reactor Cooling System (RCS) shown in Figure 2, is configured to produce a gravity-driven circulation of the reactor coolant. To maximize the recirculation rate, the reactor is located substantially *below-grade,* and the steam generator is of the once-through genre and is located above-grade. The nuclear commodities in the SMR-300 are located deep in the ground which ensures that the background radiation dose from the nuclear plant at the site boundary will be very small.

To improve the thermal performance of the reactor beyond that available from gravity-driven natural circulation, booster pumps located in each of the cold pipe runs in the RCS (blue lines are illustrated in Figure 2) are incorporated in the design which significantly increase the circulation rate of the reactor coolant, enabling the core to be operated with a greater heat generation rate. As the booster pumps are not needed to ensure continuous circulation of the RCS flow, they are classified as not-important-to-safety.

Figure 1: SMR-300 in Perspective View

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Some of the distinguishing features and compelling advantages of SMR-300 plant of user interest are:

1. *Bounding Standardized Design*: The design of the SMR plant utilizes bounding environmental loadings (such as .5 g reference seismic acceleartion) such that the plant's design will not have to be revised for each new site. Thus, all SMR-300 plants will be architecturally and functionally identical which would minimize the work effort needed for the Construction Permit Application for each specific site which is required under USNRC regulations.
2. *Compact Land area*: The Controlled area for a twin unit SMR-300 plant (total net electric output over 640 MW) requires 30 acres of land (about half the area of a large shopping mall) which makes it the most efficient user of land amongst its peers.
3. *Threat-resistant Containment Enclosure Structure (CES*): The CES is made of an innovative steel and concrete construction called METCON™ which has been used in Holtec's HI-STORM storage cask for over 30 years and is considered ideal for protecting the Containment from environmental hazards such as a crashing aircraft, high winds, tornado and hurricanes as well as human acts of terror.
4. *Walk Away Safe*: The evaporation of the stored water in the annular reservoir removes the decay heat from the reactor's core for as long as necessary which means limitless coping period after a postulated hypothetical loss-of-coolant accident. The plant does not need operator intervention in the wake of any accident (i.e., it is demonstrably Walk-Away-Safe).
5. *No need to be sited next to a body of water:* Unique among its peers, SMR-300 has been expressly designed to reject its waste heat (which is over 65% of total reactor-produced heat) directly to air or any conventional water source such as a lake, river or sea *at owner's option*. Thus, the SMR-300 can be deployed in the water-rich or arid region of any country without restriction. Furthermore, the annular space between the Containment and the Containment Enclosure Structure (CES) is filled with demineralized water which serves as a large *annular reservoir* of cooling water to receive and dissipate the waste heat generated during the plant's operation, thus eliminating the need for the plant to be sited close to a body of water altogether.
6. *On-site interim storage of used fuel*: Highly radioactive used nuclear fuel, a drawback of light water reactors, remains a drag on the development of new nuclear technologies as nations search for a solution. In the SMR-300, the used fuel is packaged in leak-tight canisters, called MPCs, and is loaded in below-the-ground storage cavities (called HI-STORM UMAX) from which it can be readily recovered and moved to a permanent repository or a processing facility. For one SMR plant operating for 120 years, less than 1/8th hectare of land is required. There is no need to transport the canisters until a national central storage facility is built or the technology to productively use the spent fuel becomes available. The fuel is stored and sealed in canisters that can be readily accessed, if required, for reprocessing or powering a future reactor.
7. *No Exclusion Zone*: Unlike large reactors in service today, the SMR-300 plant does not require an Exclusion Zone which means the Controlled Area Boundary is also the plant's site boundary.
8. *Functional Versatilty*: The SMR plant is configured to provide process steam for desalination and other industrial uses (such as paper mills, refineries, and steel mills) as well as hydrogen production with the remaining steam used to produce electric power. Thus, in addition to generating electricity, the SMR-300 can support local industry's process steam needs.

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9. *No need to load-follow*: SMR-300 can be configured to load follow which is inherently wasteful of energy. Instead, Holtec's energy storage technology called the *Green Boiler* may be used to store the SMR plant's surplus power and use it when needed to produce electricity or steam.
10. *Black Start and Island mode capable*: SMR-300 is uniquely suited to provide the operational flexibility for it to be the primary or sole power source on a mini grid. The SMR-300's black start capability allows it to be used to start up from zero power. Operating in island mode provides the flexibility to allow a grid to go completely offline if required, while keeping the plant available to increase power output when demand returns.
11. *Distributed power generation leads to a resilient power supply*: SMR-300 is sized to provide distributed power generation and steam supply to the local region, thus eliminating the need for wheeling power over long-distance over high-tension wires that are vulnerable to weather and other forms of disruption. SMR-300s located across the country will produce all the power necessary to serve local needs, with any surplus easily shared to neighboring communities. Distributed generation has the inherent benefit of making power supply more resilient because the grid does not depend on long transmission lines supplied by a few large plants.
12. *High-capacity factor through very short refueling outages*: Extremely short outages are essential for a high-capacity factor. By locating the Fuel Pool adjacent to the Reactor Vessel and an innovative fuel management approach, the refueling of the plant is estimated to take no more than 7 calendar days.
13. *Small inventory of fissile material in the Plant*: SMR-300's fuel pool will typically contain only one batch of discharged fuel at any time. The discharged fuel resides in the pool for ~18 months after which it is transferred to the on-site subterranean storage system. We estimate that the quantity of fissile material in the SMR-300 pool at any time will be less than 10% of that in a typical operating light water reactor. There is no need for away-from-reactor fuel storage.
14. *Short construction cycle*: The Owner will have the option to build one plant or as many as needed at one site. The net energy generation at a site can be increased in multiples of 300 MWe. In fact, a site can start with one reactor installation and add more in future years to keep pace with the power demand. With a shovel-to-start time cycle of a mere 2-1/2 years, the additional generation timetable can be aligned with the evolving need of the community.
15. *Used Fuel Storage is a non-issue for SMR-300*: The used fuel produced by the SMR-300 reactor shall be stored on-site in a proven subterranean (below-ground) storage system called HI-STORM UMAX where it can be stored indefinitely without any risk of damage or degradation to the stored fuel.
16. *Maintenance and refurbishment friendly:* To support the 80-year Design Life, the SMR-300 is engineered to be maintenance-friendly. For example, a hatch opening in the Containment head is provided directly above the steam generator with an aligned opening in the Containment Enclosure Structure to facilitate steam generator change-out if it becomes necessary.
17. *No EPZ Required*: SMR-300 does not require an Emergency Preparedness Zone (EPA) which announces the plant's inherently safe credentials to surrounding communities.
18. *Commonly available nuclear fuel*: The nuclear fuel burned in the SMR-300 reactor is the most commonly used type in the world and is produced in several countries giving the plant owner the option of multiple sources of supply.

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19. *SMR-300's steam is CLEAN*: Unlike the steam from BWR reactors, whose steam is potentially contaminated, the steam from SMR-300 (which is a PWR) is uncontaminated and therefore can be used in electric power generation as well as process applications such as making hydrogen fuel.
20. *Combining Nuclear and Solar*: Holtec's latest solar energy capture system called HI-THERM HCSP can be employed around the perimeter of the nuclear plant (if land is available) to produce synergized nuclear/solar power. This marrying of solar and nuclear improves the cycle efficiency from the combined plant compared to SMR-300 alone.

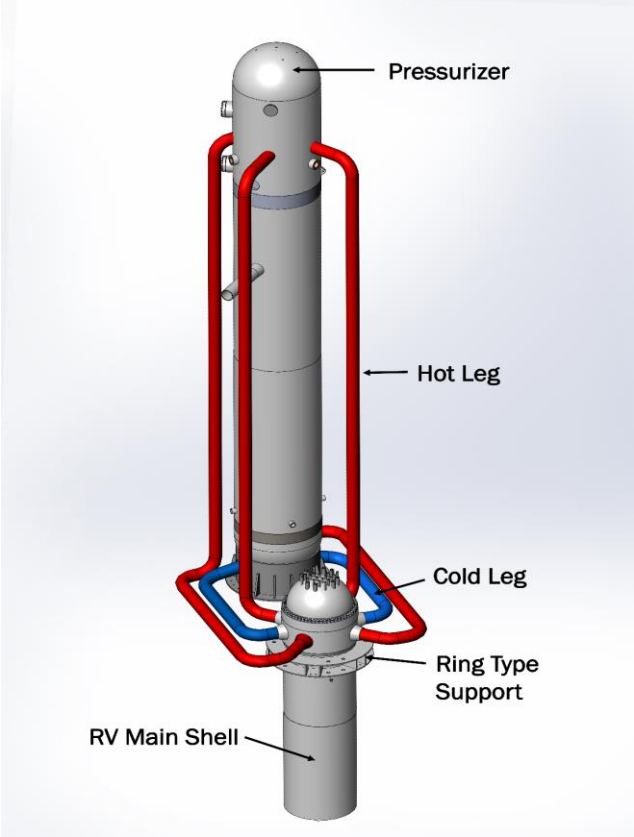

Figure 2: Reactor Cooling System (Subject to patent protection)

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