Title: **Energy Multiplier Module (EM^2) – Advanced Small Modular Reactor for Electricity Generation**

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Energy Multiplier Module (EM^2) – Advanced Small Modular Reactor for Electricity Generation

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In order to provide cost effective nuclear energy in other than large reactor, large grid applications, fission technology needs to make further advances. "Convert & burn" fast reactors offer long life cores, improved fuel utilization, reduced waste and other benefits while achieving cost effective energy production in a smaller reactor. General Atomics' Energy Multiplier Module (EM^2), a helium-cooled compact fast reactor that augments its fissile fuel load with either depleted uranium (DU) or used nuclear fuel (UNF). The convert and burn in-situ provides 250 MWe with a 30 year core life. High temperature provides a simple, high efficiency direct cycle gas turbine which along with modular construction, fewer systems, road shipment and minimum on site construction support cost effectiveness. Additional advantages in fuel cycle, non-proliferation and siting flexibility and its ability to meet all safety requirements make for an attractive power source, especially in remote and small grid regions.

The basic construct of a 250 MWe module is presented in Figure 1, showing a below-grade core flanked on one side by a power conversion unit (PCU) and on the other side by a direct reactor auxiliary cooling system (DRACS). The primary coolant system is enclosed by the containment, which is divided into three connected chambers with structural ligaments around the reactor chamber that also serve as shielding.

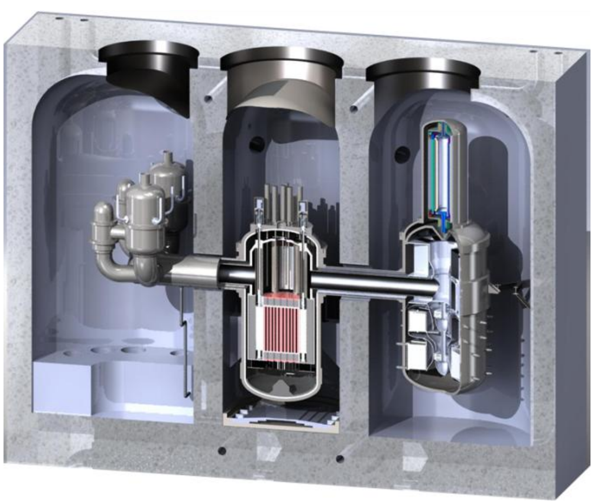

FIGURE 1: 250 MWe EM^2 power module in a below-grade sealed containment.

A cutaway view of the reactor system is shown in Figure 2. The reactor vessel is an internally insulated 4.7 m diameter, 10.6 m high structure constructed from standard SA533-Grade B plate steel. In contrast to conventional LWR vessels, this unit is of a size that can be manufactured by many vendors. All vessels are small enough to be shipped by truck to the construction site. Table 1 summarizes materials used for EM^2 core design and selection bases.

Figure 3 shows a cutaway of the PCU vessel, which incorporates several features that distinguish it from previous Brayton cycle designs. The turbo-compressor-generator is a variable speed machine operating above synchronous frequency (6800 rpm at full load). Speed control is used to track load changes rather than the more traditional approaches of turbine bypass or primary coolant pressure changes. This has several advantages. The diameters of the turbine, compressor and generator are reduced by the inverse of the design rotational speed, so that the overall size and weight is greatly reduced relative to a synchronous machine.

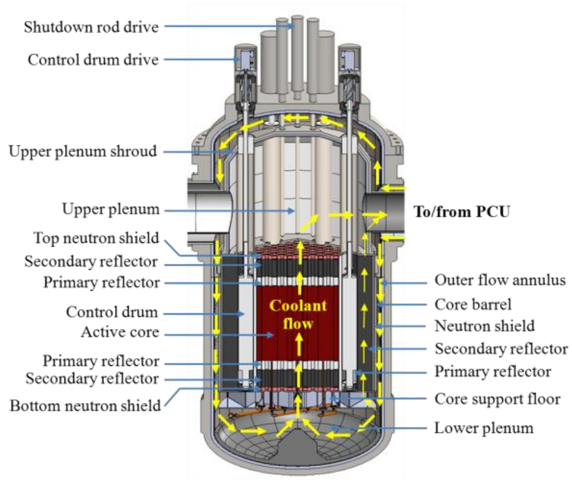

FIGURE 2: EM[2] reactor system provides convert and burn in situ.

TABLE 1: Materials used for EM^2 core design.

Component	Material
Fuel	Uranium carbide
Clad	Silicon carbide
Coolant	Helium
Control absorber	Boron carbide
Reflector	Beryllium carbide
Reactor vessel	Steel

The primary system temperatures are maintained at near constant levels over the full turn-down ratio, and the thermodynamic efficiencies are high at the lower power levels. The variable, non-synchronous operation is made possible by commercial power inverters that convert variable input to line frequency at 99% efficiency.

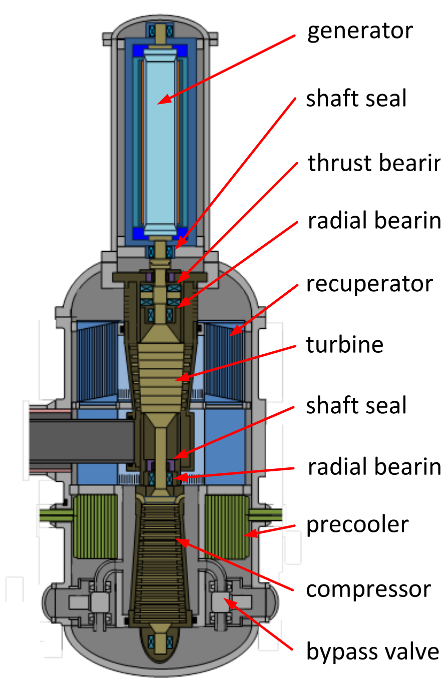

FIGURE 3: PCU/generator provide high efficiency electricity

Figure 4 illustrates a closed fuel cycle based upon 60% extraction of every fission product at each cycle. The end-of-life discharge from the 1st core is used as the starter for the next 1.2 cores and while LEU is required for the first core, no fissile addition is needed for follow-on cores.

The physical size of all the EM^2 subsystems is compatible with factory fabrication and truck shipping to the site. The use of small, modular equipment allows nuclear plant providers to take advantage of more cost-effective manufacturing and assembly practices. This makes EM^2 ideal for remote locations for the following reasons:

1) Minimize on site construction efforts required.
2) Acceptable transport weight/size for remote regions
3) Long fuel life minimizes fuel/spent fuel shipments
4) Available dry cooling allows for site location flexibility and reduced water requirements
5) Allows for added modules as demand grows
6) Less waste heat per MWe due to high efficiency

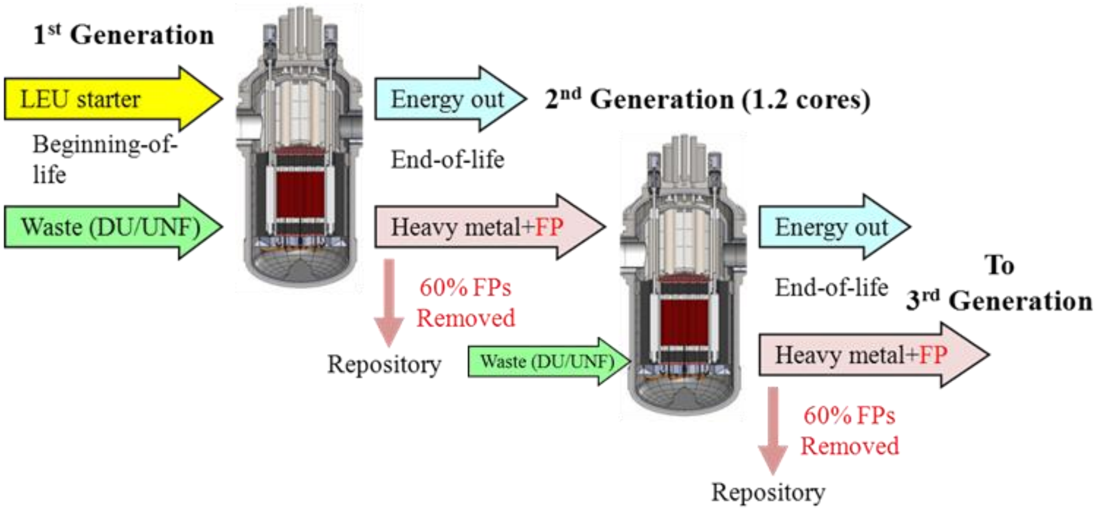

FIGURE 4: EM^2 closes the fuel cycle without conventional reprocessing.

In contrast to small modular LWR concepts, the higher energy conversion efficiency in EM^2 improves plant economics. EM^2 appears to offer distinct advantages in (on a per unit power delivered basis) the amount of materials required for construction, the amount of real estate needed for the plant, the life cycle cost of fuel, the on-site labor, the cost of financing, the cost of waste handling, and the cost of heat rejection. These considerations provide a basis for optimism that the economics of EM^2 will be very attractive, perhaps competitive with natural gas fired energy sources, today's lowest cost technology.