UNDERWATER POWER PLANTS

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3/13/2013

INTRODUCTION

A naval construction French company DCNS is developing a nuclear reactor that will operate offshore and sit somewhere along the ocean floor. DCNS announced its innovative Flexblue concept following preliminary studies lasting over two years. Flexblue is a small nuclear power plant producing 50 to 250 MWe designed to be installed on the seafloor off the coast of maritime nations.

It would be enclosed inside a cylinder the length of a football field. The "Flexblue" reactor would have a power of 250 MWe, enough to power a million homes.

The reactor's design coupled with the concept of mooring it 300 feet below the sea surface is thought to ease some of the safety issues of land-based nuclear power plants.

The reactor is thought to be resistant to natural disasters such as earthquakes, tsunamis, and floods. It would have the benefit of the ocean as a built-in coolant and heat sink.

Figure 1. Underwater Flexblue nuclear reactor concept. Source: DCNS.

Although these relatively portable reactors cannot compete with large-scale nuclear power plants that supply about 1,200 MWe of power, they do not need a large amount of capital cost. Compared to nuclear power complexes that can require a hefty investment of 5-9 billion dollars, the estimated cost for a small modular reactor that delivers 25 MWe of power is around 50 million dollars.

SMALL MODULAR REACTORS, SMRs

The potential for small and medium size reactors, SMRs is under study in the USA, Japan, Russia and other countries.

France's naval construction firm DCNS has agreed with Areva, Electricité de France, EDF and the Commissariat à L'Energie Atomique, CEA research organization on a joint study of DCNS' concept for the submerged nuclear power plant unit. It could provide energy for coastal locations worldwide.

The concept is called FlexBlue and involves a cylindrical vessel about 100 meters long and 15 meters in diameter that would encase a complete nuclear power plant with an electrical capacity of between 50 MWe and 250 MWe.

The cylinder with the power plant inside would be lowered to the seabed at a depth of 60 meters or 196 feet to 100 meters, at a site between 5 and 15 kilometers from the coast. Undersea cables would bring the electricity to customers at the shore, much like offshore wind turbines. It is estimated that 3/4 of the world's population lives within 80 km of the sea.

Russian industry has developed the design for a floating nuclear power plant which uses two 70 MWe reactors derived from those used in Russian submarines and icebreakers with a prototype launched in 2010.

A submerged power plant, unlike a floating one, would not be vulnerable to earthquakes, tsunamis, or floods, and would be far less vulnerable to voluntary attack.
It would also have an "unlimited" source of coolant from the surrounding sea and the plant's environmental footprint would be minimal.

The cylindrical vessel concept obviates the need for civil engineering which has proved challenging at Areva's and EDF's ongoing nuclear power plant construction projects in Finland and France and means the plant can be built in a factory in a modular way with standardized components.

If a safety issue developed with the reactor, it could be brought to the surface and taken to a DCNS' shipyard for repair.

It could be refueled in the same way, and at end of life would be repatriated to the shipyards for decommissioning, which would resemble the decommissioning of nuclear submarines.

Areva has already begun developing a Small Modular Reactor, or SMR, of about 100 MW, based on the experience of its Technicatome unit in building reactor plants for submarines and France's nuclear-power aircraft carrier, the Charles De Gaulle. Such a reactor could be embarked in a FlexBlue power plant.

The market for SMRs is estimated at about 200 units worldwide over the next 20 years. Flexblue could grab a significant share of that market.

DCNS' shareholders are the French state at 74 percent, defense firm Thales at 25 percent, and employees at 1percent.

AREVA, a world leader in nuclear energy, has launched a program to study small reactors rated at 100 MWe with a view to rounding out its range of third-generation reactors comprising the EPR, ATMEA and Kerena types. This study draws on AREVA's expertise in small shipboard reactors to assess the product's feasibility and market potential.

TECHNICAL SPECIFICATIONS

The concept is based on proven technologies that draw on DCNS's 40 years' experience in nuclear propulsion and submarine power plants built under AREVA TA as a prime contractor.

It combines the inherent benefits of SMRs, including phased investment and ready tailoring to demand. It features standard subsystems integrated at shipyards and shipped to the installation site by sea.

Both EDF and Areva have expressed interest in Flexblue's modularity and standardization.

France is setting up detailed studies to position the country as a leading player in SMRs. DCNS will work with AREVA, EDF and the CEA on the next phase of Flexblue development. This will include detailed reviews of:

1. Technical and production options
2. Market potential
3. Flexblue's competitive standing compared with other sources of energy
4. Nuclear proliferation issues
5. Safety and security aspects of seafloor power plants with a view to demonstrating that Flexblue offers a level of safety comparable with that of third-generation land-based nuclear power plants.

The technical specifications of the concept are:

Hull shape: cylindrical
Length: 100 m
Diameter : 12 – 15 m
Power: 50 – 250 MWe
Design concept: small nuclear reactor, steam turbine-alternator set, electricity to be carried to coast by submarine power cables)
Weight: 12,000 tonnes
Siting: seafloor moorings at a depth of 60 - 100 m, a few km off the coast.

SAFETY CONSIDERATIONS

Many earthquakes have epicenters off shore. As long as the containment cylinder is not attached to the sea floor, it would not be cracked and/or torn apart like a land based structure.

As to vulnerability with respect to Tsunamis, it depends on how the Tsunami is generated. The 2005 Tsunami in Southeast Asia was caused by a fault line that was 600 miles long, which shifted upwards approximately 23 feet. This generated a wave, which went all the way from the bottom of the ocean to the surface.

The phenomenon known as Turbidity Current which results from an underwater land slide can cause damage to underwater technology.

Freak currents associated with storm surges can also cause damage.

Concerning a failure of the containment vessel, it would be better that it would happen under the water surface rather than on land.