Offshore Floating Nuclear Power Plant (OFNP)

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Take-away message

The **offshore floating nuclear power plant (OFNP)** concept will make nuclear energy:

- **More affordable**
- **Safer**
- **Easier to scale and deploy**

Key challenges

- **Reduce capital cost** ⇒ simpler reactor designs; max modularity; centralized construction; min at-site construction and decommissioning

- **Improve public confidence in safety (post-Fukushima) and security (post 9/11)** ⇒ no loss of heat sink (to minimize likelihood of severe accidents); no loss of land, should severe accidents occur; robustness with respect to terrorist attacks

Key challenges (2)

- **Find suitable sites** ⇒ Nuclear plants should be *near* the coast, but not necessarily *on* the coast

>40% of the World's population lives within 60 miles of the ocean and sea coasts + coastal land is expensive real estate

http://all-that-is-interesting.com/map-population-density

The offshore floating nuclear power plant combines two mature and successful technologies

Floating rig

+

Nuclear reactor

=

OFNP

… and resolves the key challenges

The Offshore Floating Nuclear Power Plant Concept

- Built in a shipyard and transported to the site: reduced construction cost and time (target is <36 months); enhanced quality

The Offshore Floating Nuclear Power Plant Concept (2)

- Quick and cost-effective decommissioning in a centralized shipyard (U.S. sub and carrier model): return to “green field” conditions immediately

- Moored 5-12 miles offshore, in relatively deep water (~100 m): no earthquake and tsunami concerns
- Nuclear island underwater: ocean heat sink ensures indefinite passive decay heat removal

The Offshore Floating Nuclear Power Plant Concept (3)

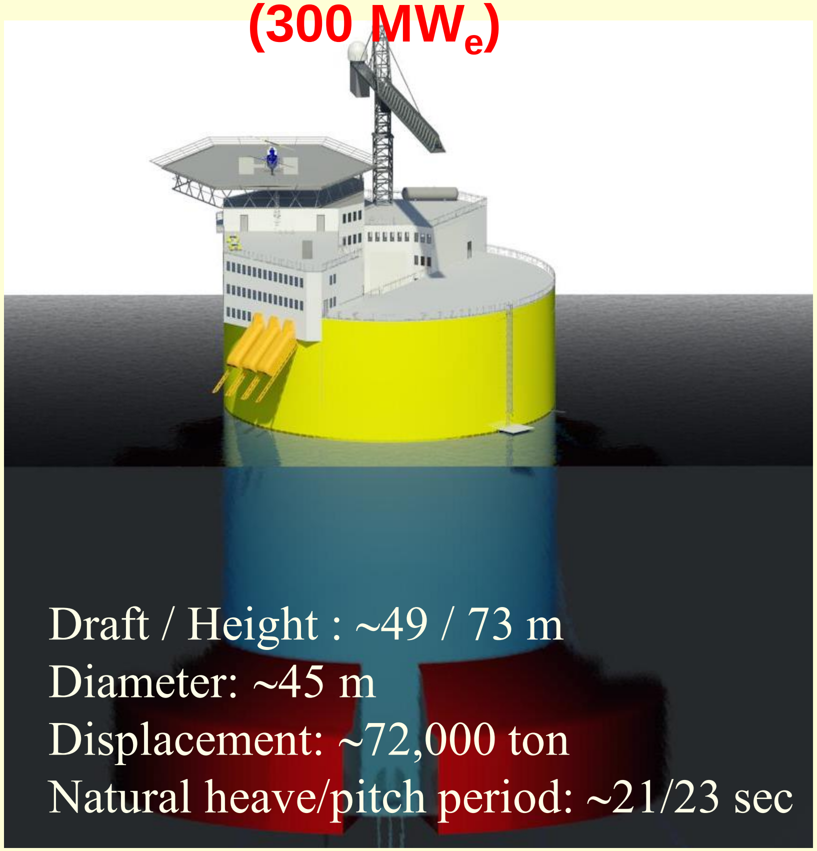
- Connected to the grid via AC transmission line: only structure on land is the electric switchyard (land usage is reduced to essentially zero)

- Water intake from colder lower layer + discharge at ambient temperature: thermal pollution can be eliminated
- Mobile power plant: more flexibility for customer ('plug and play')

Design – Platform :

- Spar-type floating platform
- Simple, stable and cost-effective design

OFNP-300 (300 MW_e)

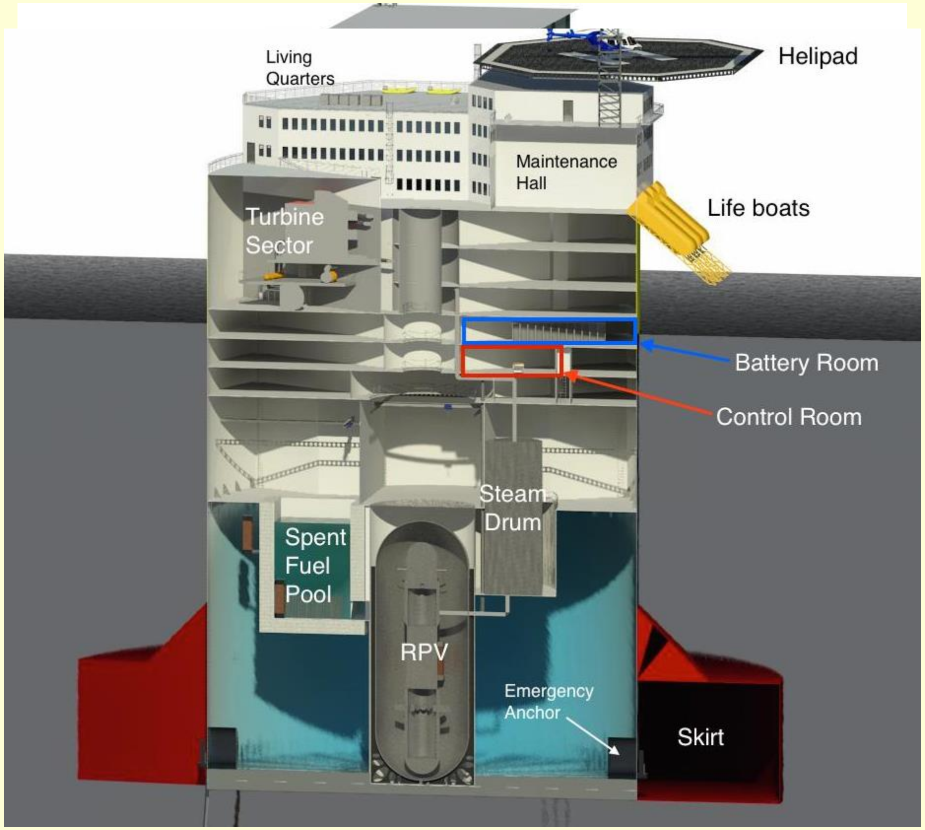


OFNP-1100 (1100 MW_e)

Natural period must be < tsunami wave period (plant rides tsunami) and > peak storm wave period (minimized oscillations in storms)

Design – Platform (2)

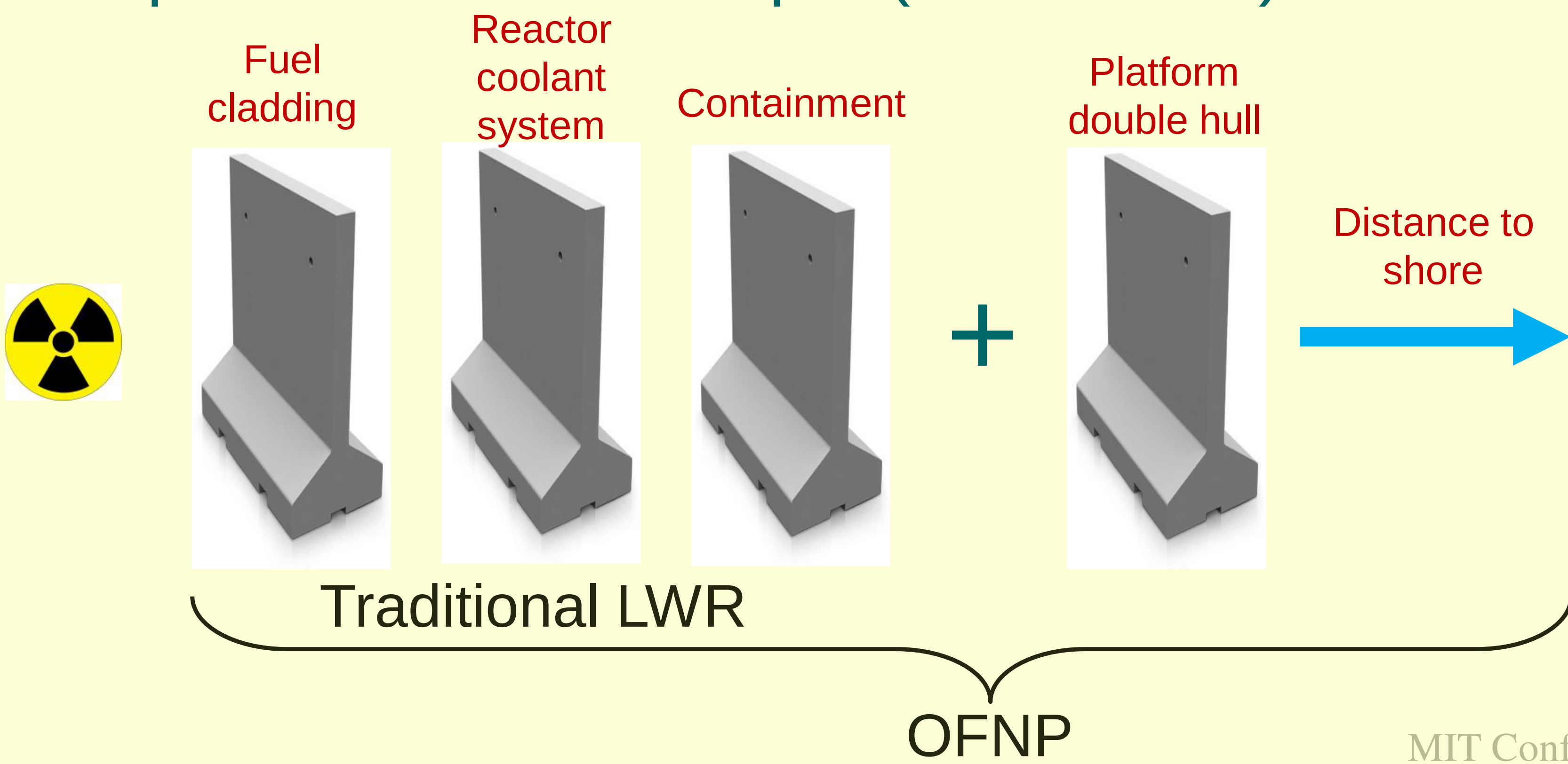
- All safety-critical components are in water-tight underdeck compartments
- High deck enhances security
- Minor maintenance at sea; major infrequent (~10 years) maintenance in centralized shipyard
- Operate in monthly or semi-monthly shifts with onboard living quarters (oil/gas offshore platform model)



- Flexible refueling (12-48 months); spent fuel stored in pool designed for up to plant lifetime, with passive decay heat removal system
- Includes desalination units + condensate storage tank for water makeup

Designed for Superior Safety

- Elimination of earthquakes and tsunamis as accident precursors
- Passive safety systems with infinite coping time
- Superior defense in depth (EPZ at sea)



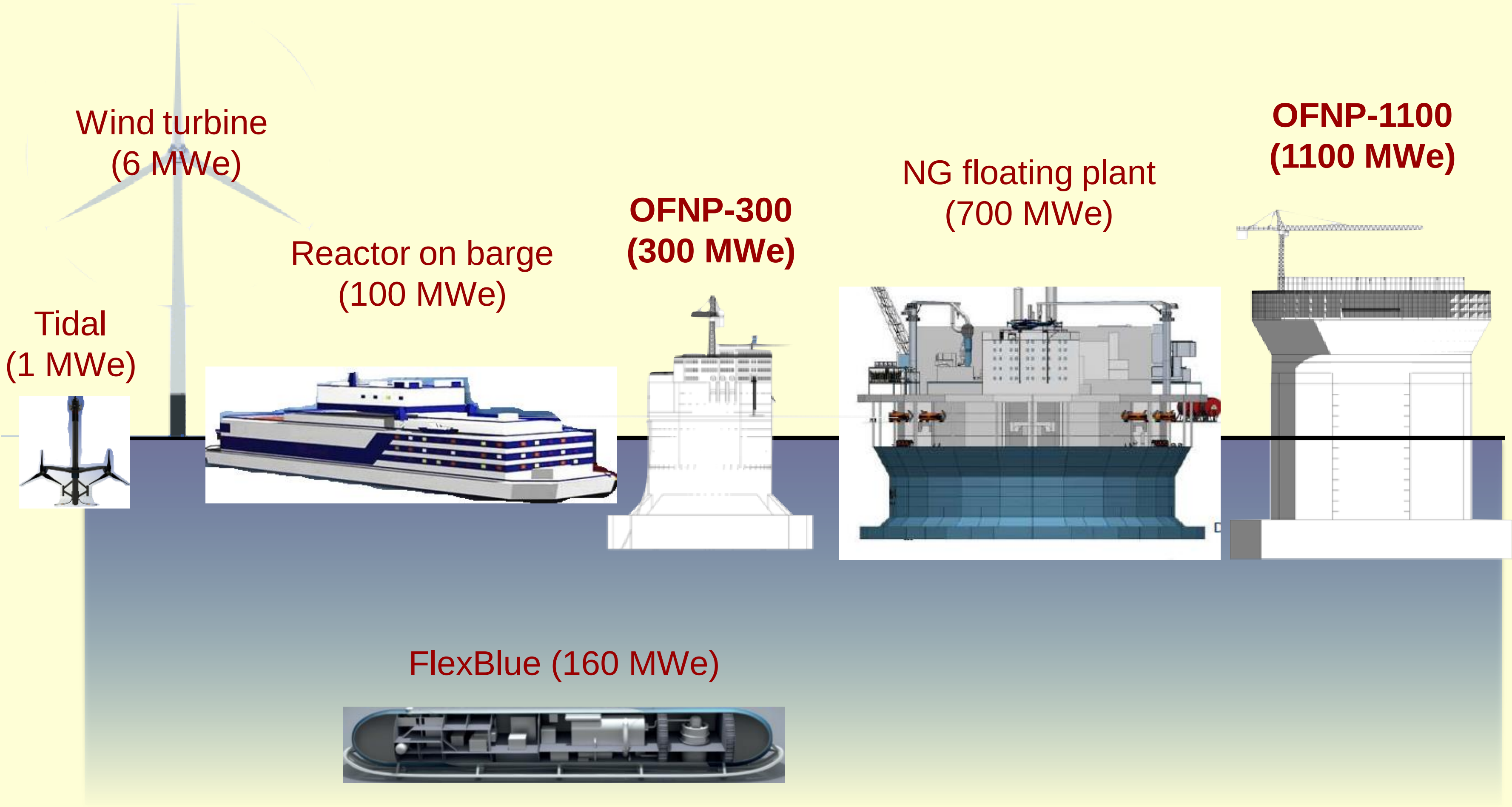
Economic Potential

$$\downarrow\downarrow \quad LCOE_{Nuclear} \propto \frac{C_{plant}\ \downarrow}{\dot{W}\ \uparrow}$$

Potential game changer

- Traditional plants: build large reactor at the site; some modularity used to accelerate schedule, not reduce fabrication costs (AP1000)
- Small Modular Reactors (SMRs): build many small reactors in a factory; requires expensive dedicated factories to build the modules
- New OFNP cost paradigm combines:
  - Economy of scale: high power rating possible (OFNP-1100)
  - Economy of modules: built in series in *existing* shipyards
  - Lower construction cost: elimination of excavation work, structural concrete, temp facilities and associated labor

Economic Potential (2)



Better economy of scale than any other offshore power plant

Plant Construction and Deployment

Robust global supply chain exists for floating platforms and Light Water Reactors

Sevan 1000 FPSO

- **112 m tall**
- **90 m diameter**
- **30.5 m draft**
- **210,000 tonnes**
- **Crew 120**

Westinghouse AP1000:

- **8 units under construction in US and China**

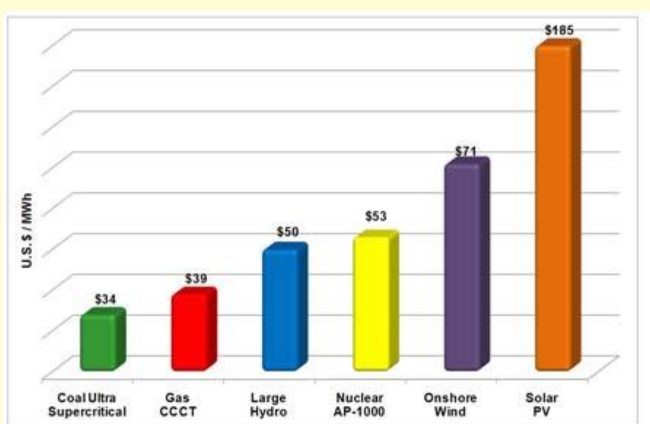
Plant Construction and Deployment (2)

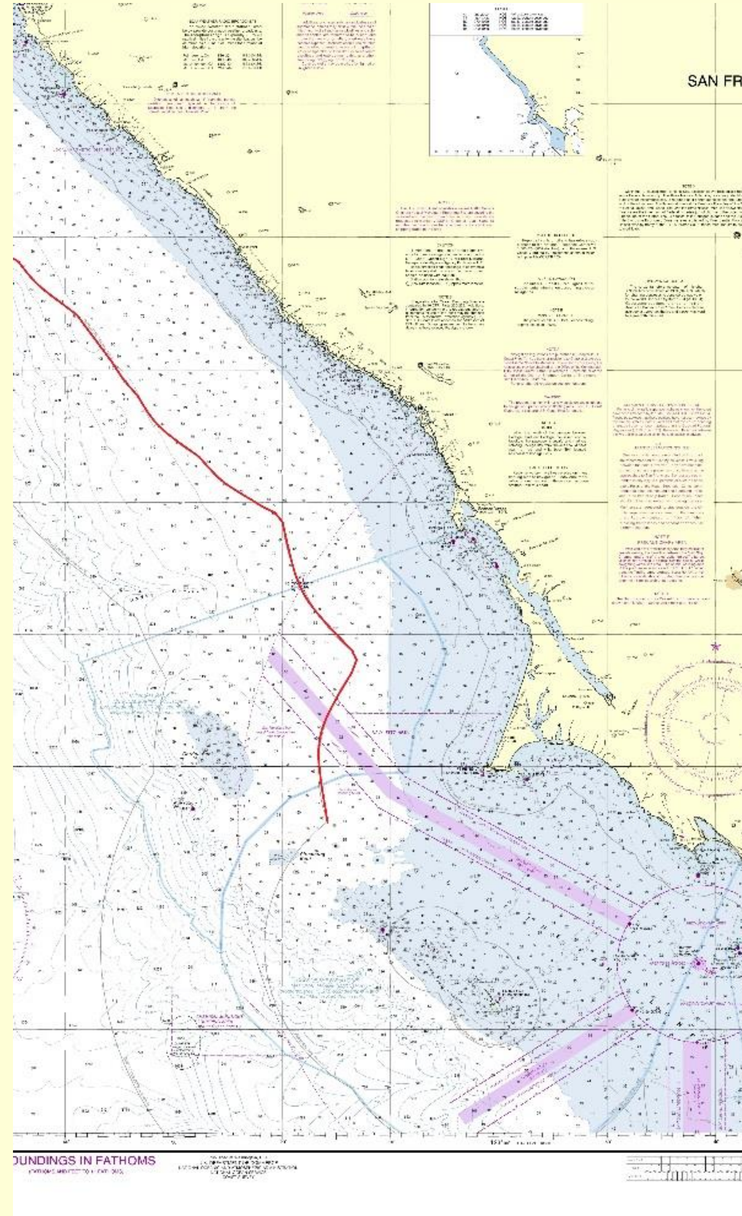
Built vertically on skid, moved to transport ship, and lowered into water

Market Potential

Top-tier siting requirements:

- Favorable topography, i.e., relatively deep water (~100 m) within territorial waters (<20 nautical miles)
- Unavailability or high cost of other modes of energy generation

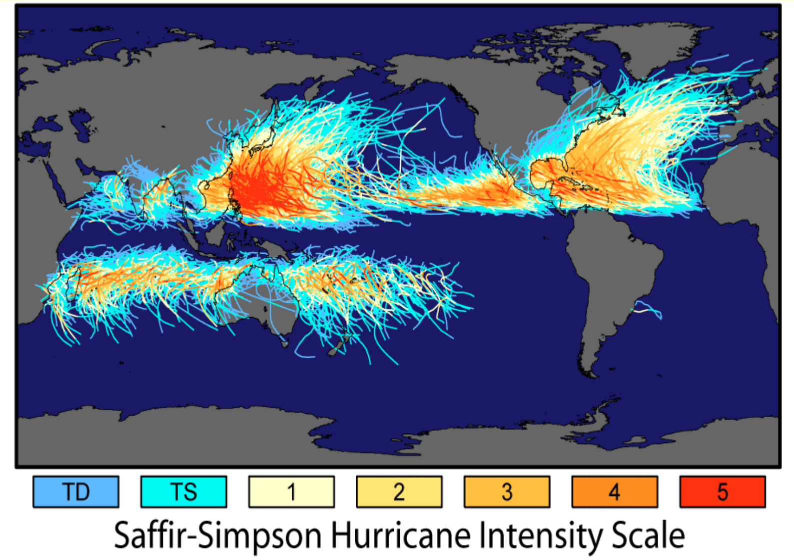


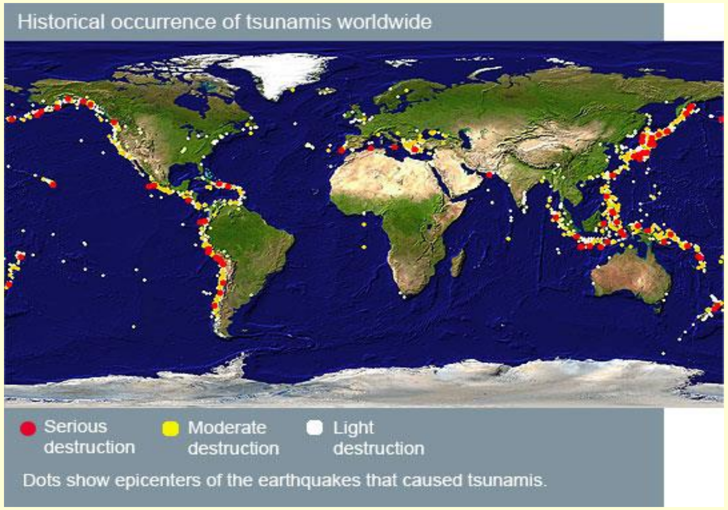


Market Potential (2)

Desirable siting features:

- Low frequency and intensity of storms
- Low disturbance to shipping traffic and marine life
- Proximity to load centres
- Unavailability or high cost of coastal land
- Low visual impact to scenic setting





Market Potential (3)

EAST AND SOUTH-EAST ASIA (high seismicity and tsunami risk, high coastal population density, and limited domestic energy resources)

Japan, Indonesia (oil/gas better exported), South Korea, Vietnam, Malaysia, Philippines, China, India ...

MIDDLE EAST (massive water desalination plants, oil/gas better exported):

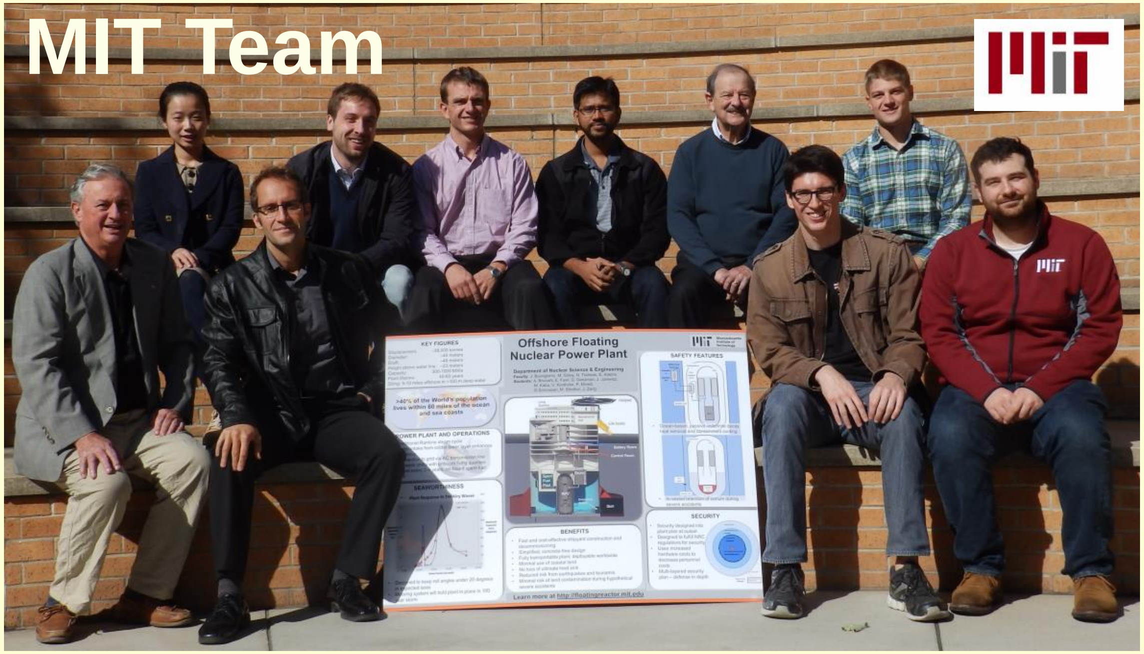
Saudi Arabia, Qatar, Kuwait, UAE, Bahrain, ...

AFRICA AND SOUTH AMERICA (small grids, high prices of electricity, water desalination, no incentives to develop large domestic nuclear infrastructure)

Algeria, Egypt, Nigeria, Tanzania, South Africa, Chile, Argentina, ...

OTHERS (Europe, large mining operations, small island countries, military bases)

U.K., Turkey, France, Spain, Australia, Alaska, Micronesia, large offshore oil/gas operations anywhere, DOD bases, ...



Collaborators

Newport News Shipbuilding
A Division of Huntington Ingalls Industries

SEVAN marine

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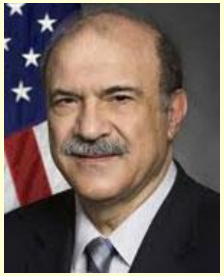

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Project Structure

Phase	Project Integrator	MIT	Platform Designer	Reactor Vendor	Shipyard Constructor	Financer
I Preconceptual Design (year 1)		x				
II Conceptual Design (years 2-3)	o	x	*	*	*	*
III Detailed Design (years 3-4)	o	*	x	*	*	*
IV Licensing (years 4-6)	o	*	x	x	*	*
V Construction and Deployment (years 7-9)	o	*	*	*	x	x
Notes:	o overall leadership, x technical lead organization(s), * participant					

Next steps:

- Create consortium
- Find investors and prospective customer(s)