OFFSHORE FLOATING NUCLEAR PLANT

OFNP

AFFORDABLE - SAFE - FLEXIBLE NUCLEAR ENERGY

Offshore Floating Nuclear Power Plant (OFNP)

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Offshore floating nuclear power plant (OFNP)

A New Paradigm for Construction, Siting and Operations of Nuclear Plants

- Nuclear Power Plant siting concept, suitable for almost any reactor
- Shipyard fabrication to control capital costs
- Seismic and tsunami protection
- Passive cooling to Ocean
- No Emergency Planning Zone
- International siting

OFNP's top-tier safety objectives are inspired by the Fukushima lessons learned

- Eliminate earthquakes and tsunamis as accident precursors
- Eliminate the loss of ultimate heat sink, to reduce the core damage frequency (<< once in 100,000 years)
- Eliminate radioactivity releases, should a severe accident occur
- Eliminate the possibility of land contamination, should a release occur

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

Floating rig

+

Nuclear reactor

=

OFNP

≈ 800 naval reactors (>> total commercial power reactors)

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)

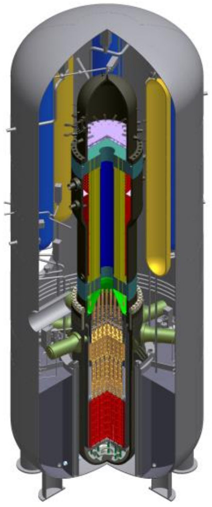
- Quick and cost-effective decommissioning in a centralized shipyard (U.S. sub and carrier model): return to "green field" conditions immediately

- Moored 10-20 km offshore, in relatively deep water (~100 m): no earthquake and tsunami concerns
- Nuclear island is underwater: ocean heat sink ensures indefinite passive decay heat removal

Design – Reactor

Class 1100-MW plant features Westinghouse's AP1000 reactor:

- NRC-certified
- Standard UO_2 fuelled core
- No new materials, fuels or components need to be qualified



Class 300-MW plant has an integral PWR (e.g. WSMR)

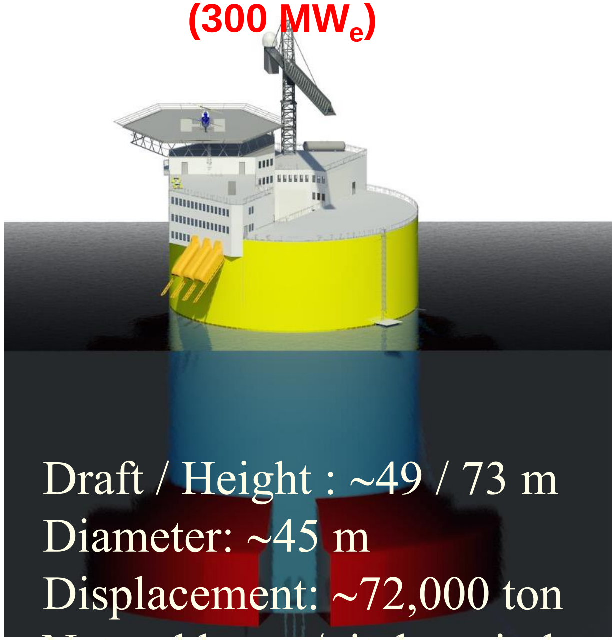
- All primary system components within a single pressure vessel
- Compact, high-pressure containment

Other reactor designs are possible

Design – Platform

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

OFNP-300 (300 MW_e)



Natural heave/pitch period: ~21/23 sec

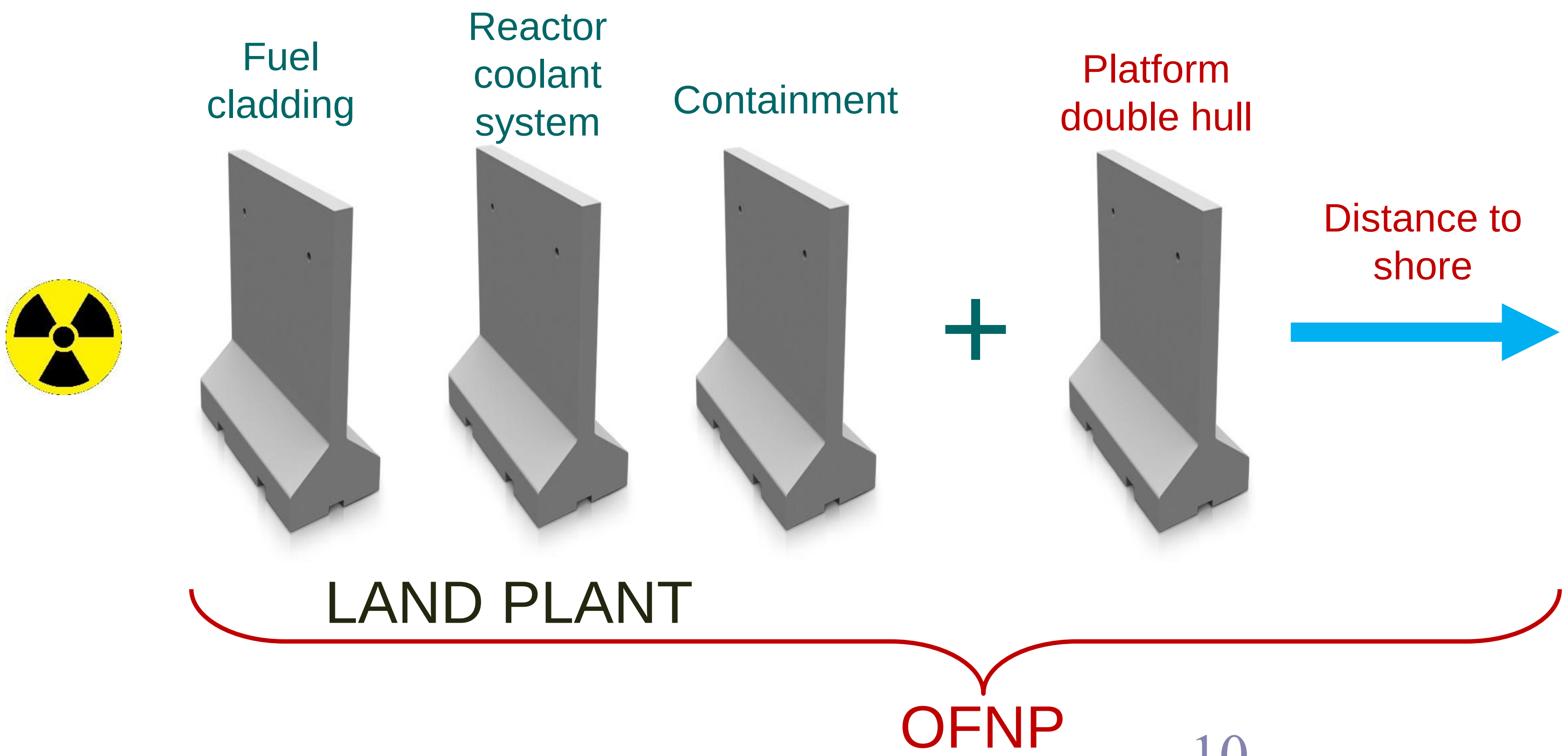
OFNP-1100 (1100 MW_e)

Natural heave/pitch period: ~22/36 sec

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

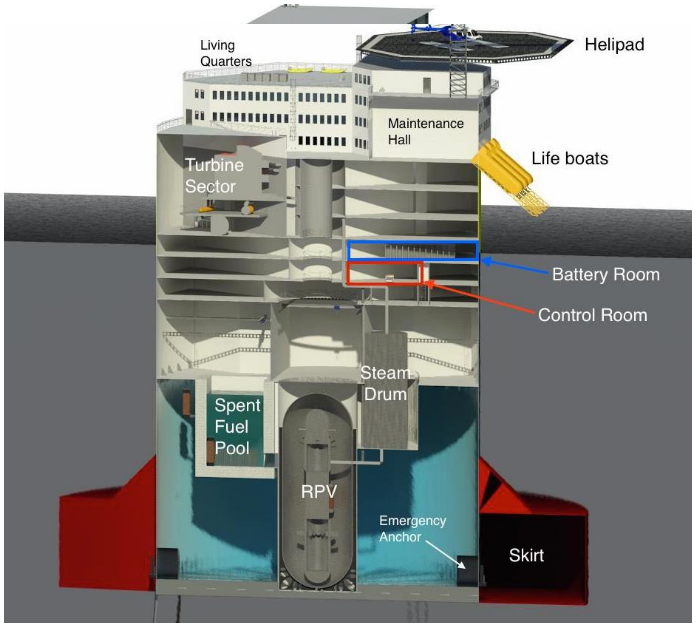
Defense in Depth

- OFNP has two additional barriers
- OFNP EPZ is at sea



Design – Platform

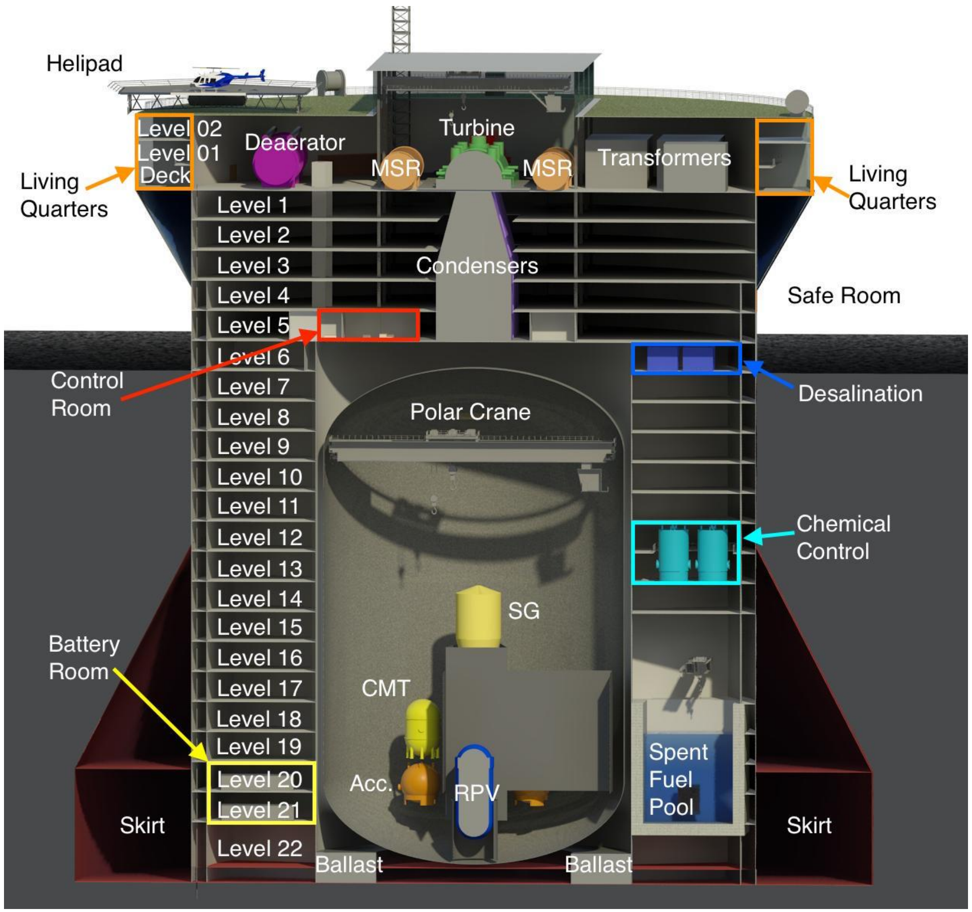
- All safety-critical components are in water-tight underdeck compartments
- High deck enhances security
- Minor maintenance at sea; major infrequent (~10 years) maintenance in centralized shipyard
- Operate in monthly or semi-monthly staff shifts with onboard living quarters (oil/gas offshore platform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



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

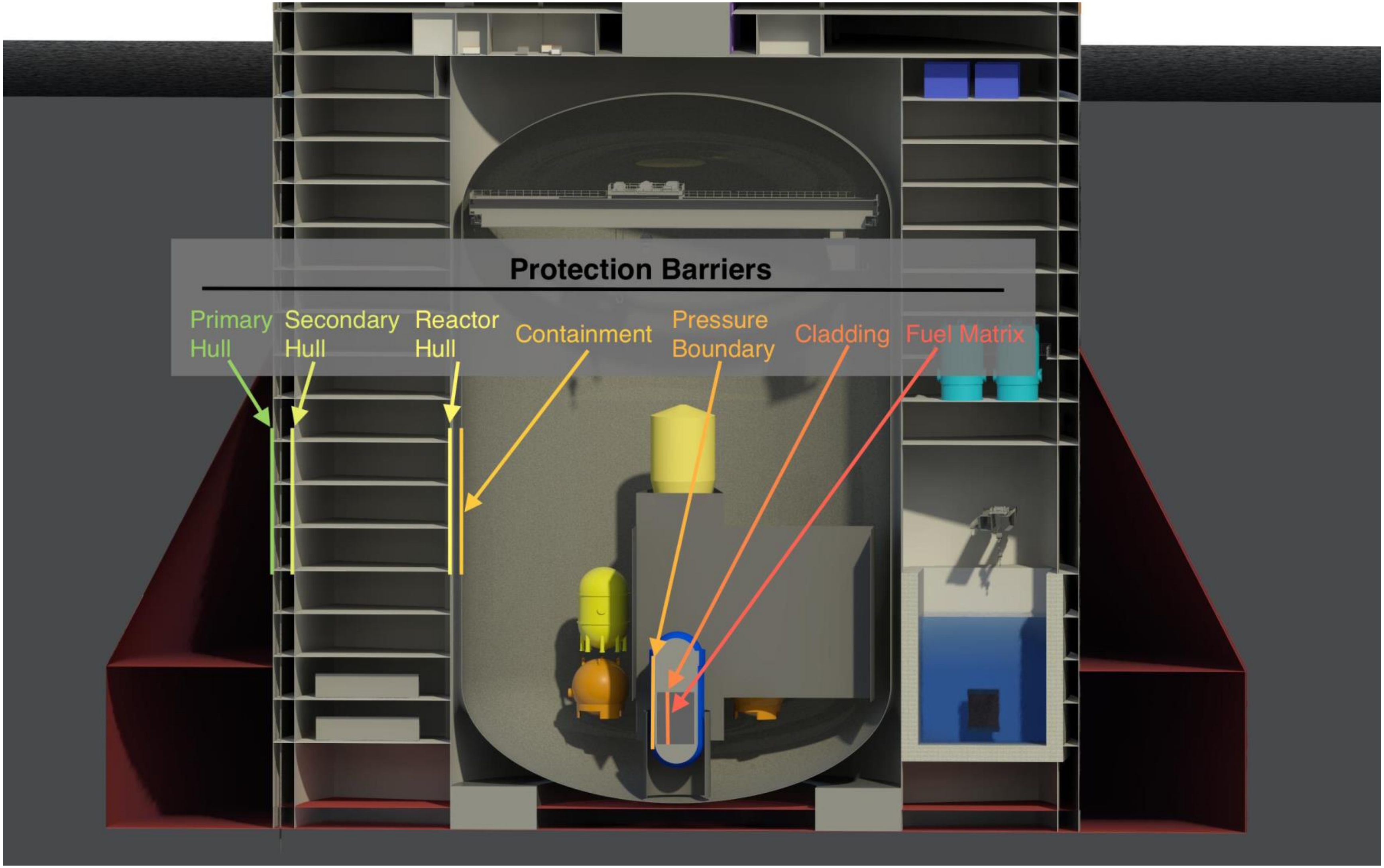
Design – Platform

- Double hull + all levels at the waterline and below are water-tight with azimuthal bulkheads
- >90% reduction in structural concrete vs. terrestrial plants
- Operate in monthly or semi-monthly shifts with onboard living quarters (oil/gas offshore platform model)



- Spent fuel stored in pool designed for up to plant lifetime, with passive decay heat removal system

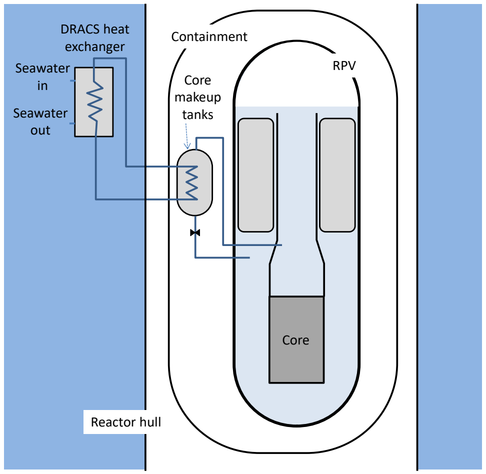
Defense in Depth



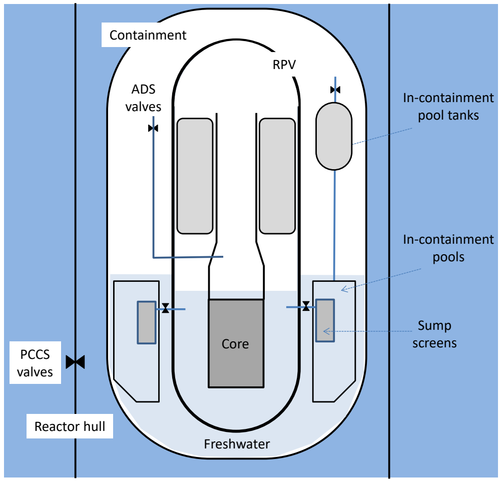
Designed for Superior Safety

- Ocean-based safety systems **remove decay heat from core and containment passively and indefinitely**
- **Loss of ultimate heat sink is eliminated by design**
- **No need to vent even under severe accident conditions**

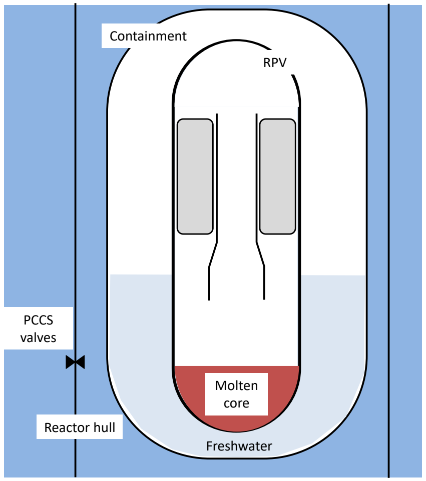
Transients (e.g. loss of offsite power, loss of flow)



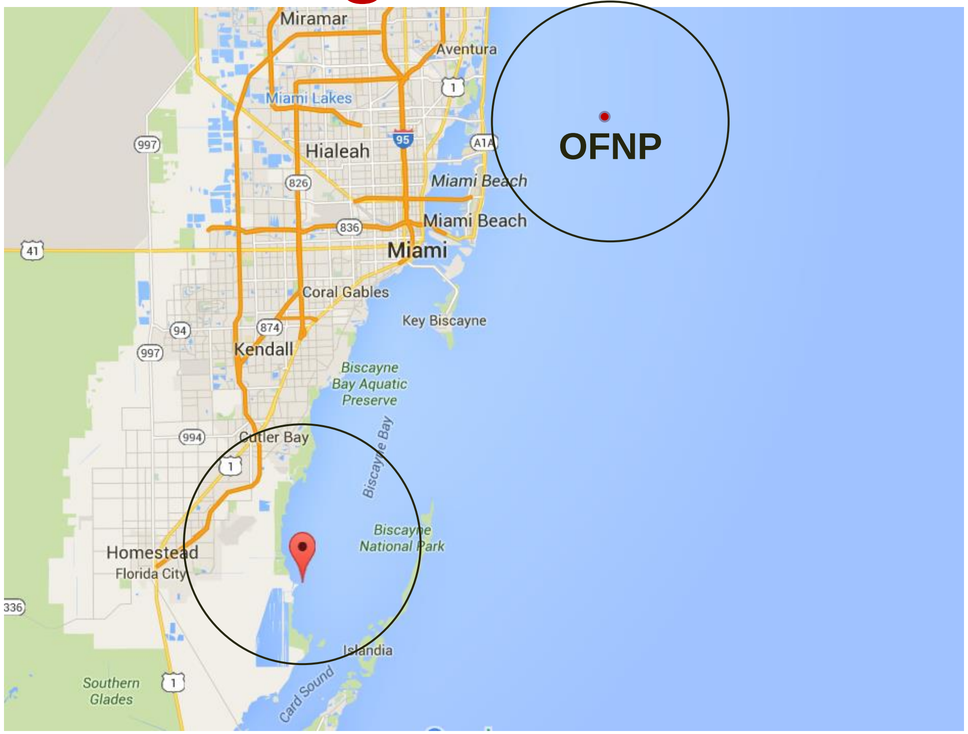
Design-Basis Accidents (e.g. loss of coolant)



Severe Accidents (e.g. core meltdown)



No Resident Population in Emergency Planning Zone



Plant	Population within 16-km radius	Evacuation plan	Distance from major load center
Indian Point	~270,000	Yes	40 km from NYC
OFNP NYC	0	No	<25 km from NYC
Turkey Point	~160,000	Yes	30 km from Miami
OFNP Miami	0	No	<25 km from Miami

Economic Potential

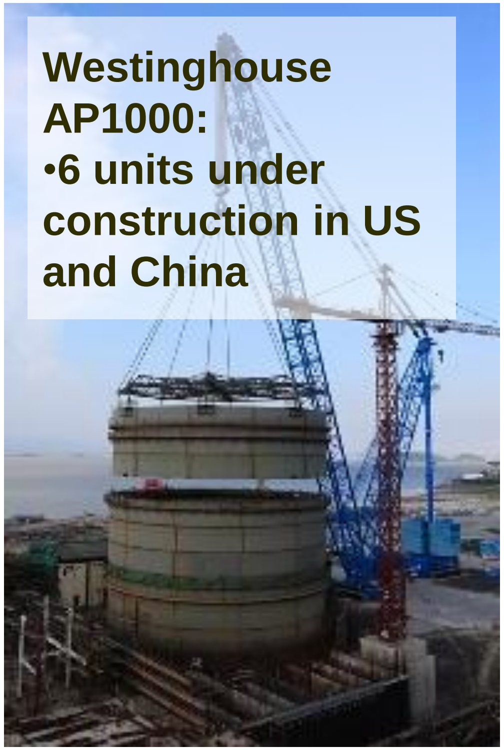
- Traditional plants: build large reactor at the site; some modularity used to accelerate schedule, not reduce fabrication costs (AP1000 example)
- Small Modular Reactors (SMRs): build many small reactors in a factory; requires expensive dedicated factories to build the modules
- New OFNP cost paradigm 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, temporary facilities and associated labor

Nuclear, business as usual | **New model?**

	ON LAND	OFFSHORE
Licensing	Site specific (ground and seismic requirements)	Standardized (site-independent design)
Construction	At site + lots of concrete (cost and delays)	In centralized shipyard + structural concrete is virtually eliminated
Ownership and Operations	Domestic utility owns and operates with domestically trained workforce	International utility could own and operate a worldwide fleet of plants, with crews that receive standardized training and operate in semi-monthly shifts (onboard living quarters)
Safety	Passive safety (new plants); evacuation possibly needed in case of severe accident	No loss of heat sink; no earthquake and tsunamis; superior defense in depth; no evacuation needed
Plant lifetime	60 years; all at one site	60 years; can track most profitable markets with minimal local infrastructure (plug-and-play)
Decommissioning	At site (decade-long project)	Immediate return to "green field"; Decommissioning in shipyard

Plant Construction and Deployment

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



Plant Construction and Deployment

Could be built vertically,
- on a skid, or
- on a barge (and completed afloat) or
- in a dry dock

Plant Construction and Deployment

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

Plant Construction and Deployment

Moved to transport ship (dry tow, 15-20 km/hr) or launched to sea (wet tow, 10 km/hr)

Key challenges

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

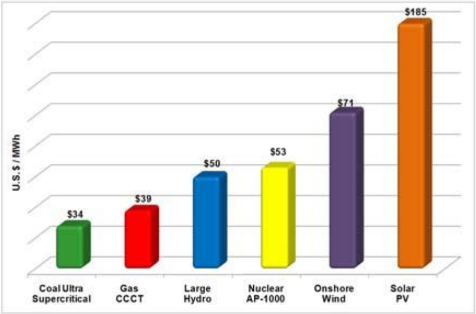
>40% of the World's population lives within 60 miles of the ocean and sea coasts + coastal land is expensive real estate

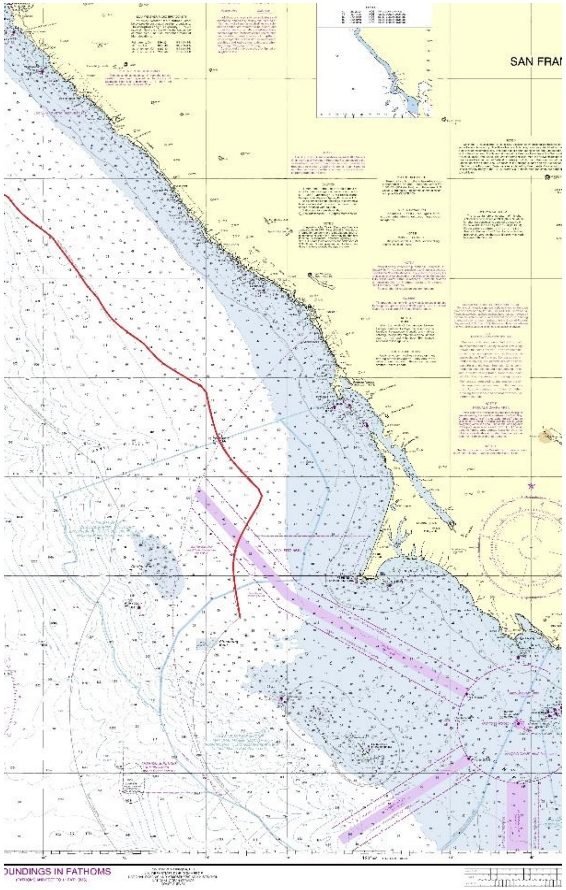
http://all-that-is-interesting.com/map-population-density

Market Potential

Top-tier siting requirements:

- Favorable topography, i.e., relatively deep water (~100 m) within territorial waters (<30 km)
- Unavailability or high cost of other modes of energy generation





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, ...

Future Needs

- Essentially no R&D, but design development
- Investors, Customers
- Stable regulatory environment

END

Back-up slides follow