



Transitioning from Fossils to Nuclear Safely and Affordably

A presentation at the
Institute of Marine Engineering Science
Annual Conference on July 1, 2021

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Founding President
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Decarbonization



James Hansen Father of Climate Change; “**Nuclear Power MUST** Make a Comeback for Climate’s Sake”

Listen to his passionate appeal at TED Talk “Why I must speak out about climate change.” and on Youtube on Nuclear Power



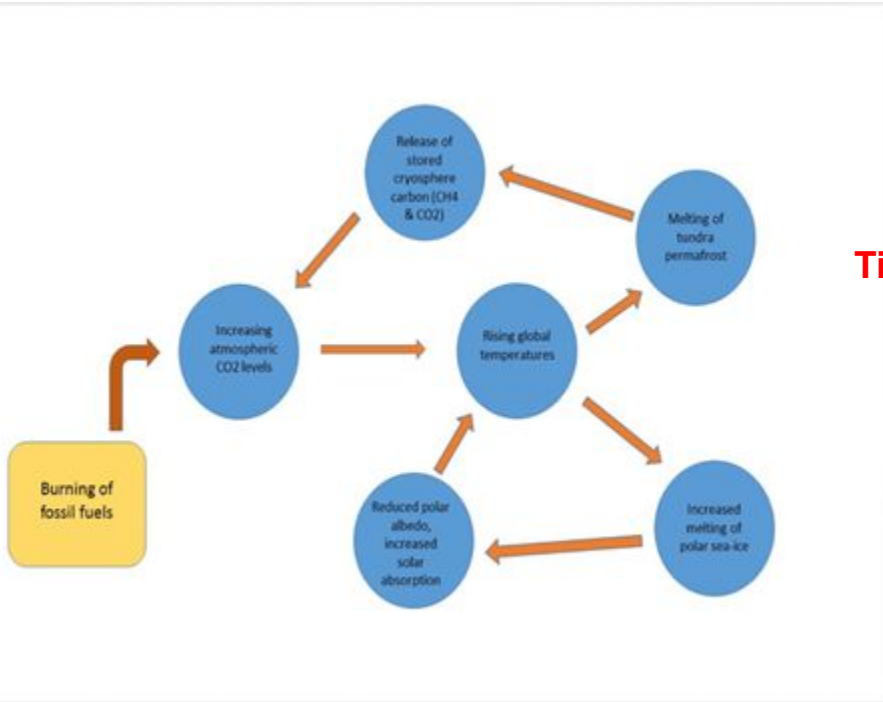
Sir David Attenborough: “If we don’t take climate action **the collapse of our civilizations and the extinction of much of our natural world is on the horizon.**”



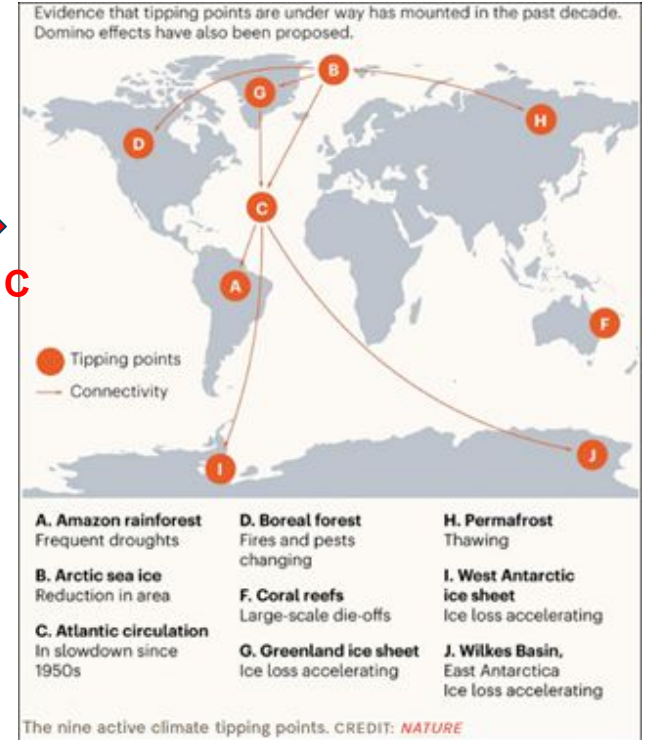
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Positive Feedback Loops Amplify Climate Change



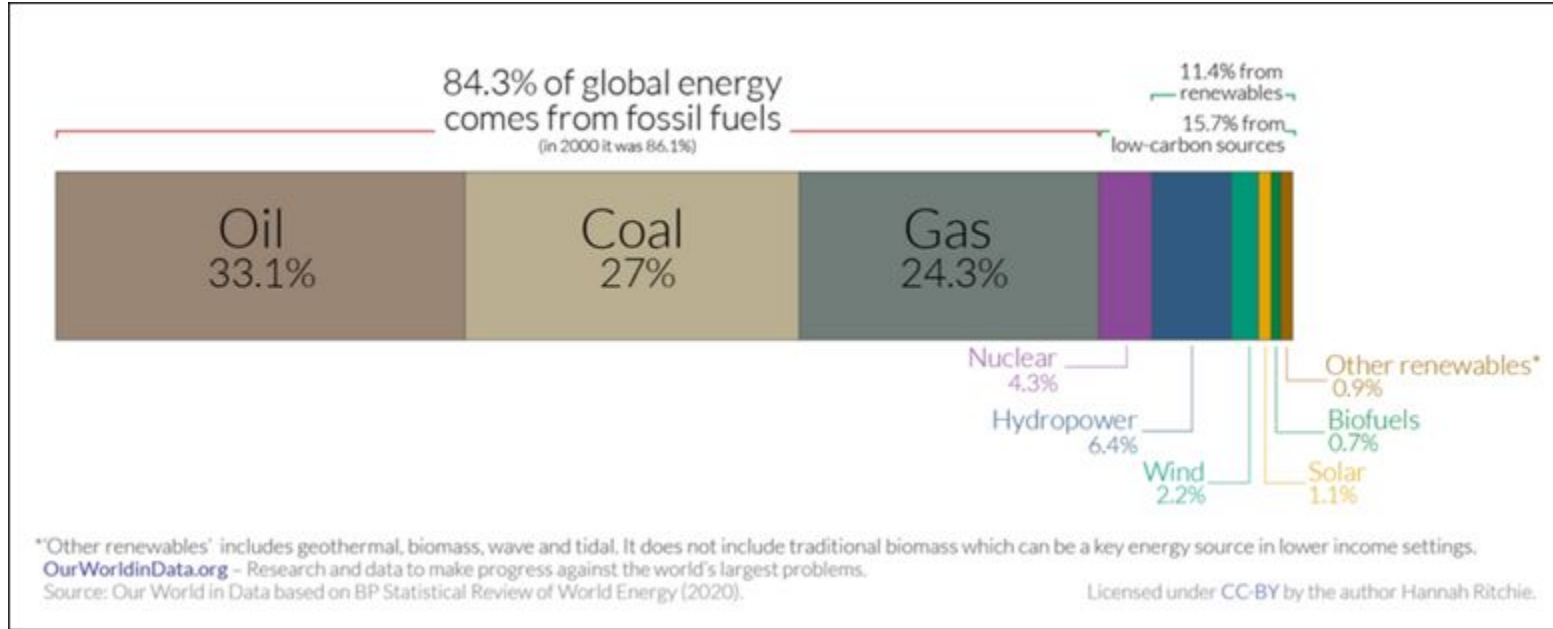
Tipping Point 2 C



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Unsustainable dependence on fossil fuels!



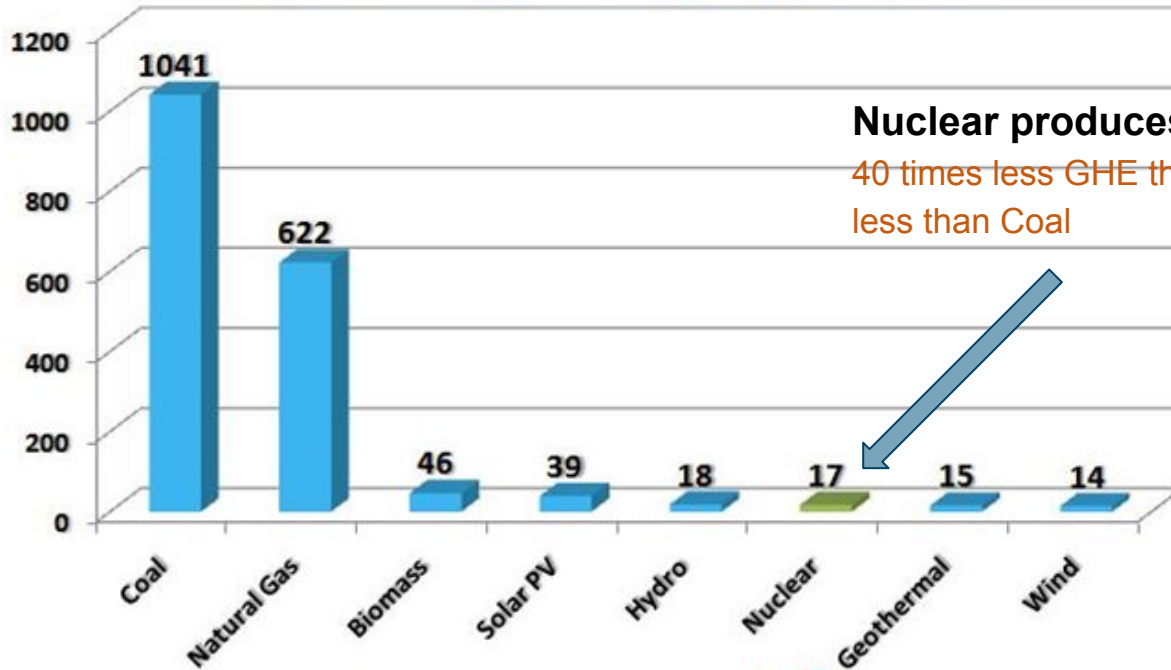
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Comparison of Life-Cycle CO2 Emissions

Tons of CO2 Equivalent per Gigawatt-Hour



Source - "Life-Cycle Assessment of Electricity Generation Systems and Applications for Climate Change Policy Analysis," Paul J. Meier, University of Wisconsin-Madison, August 2002.

 Clean Energy Insight
RENEWABLE ENERGY FORUM



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Nuclear plant is Cleaner --3 times higher capacity factor than wind or solar and lasts 4 times longer



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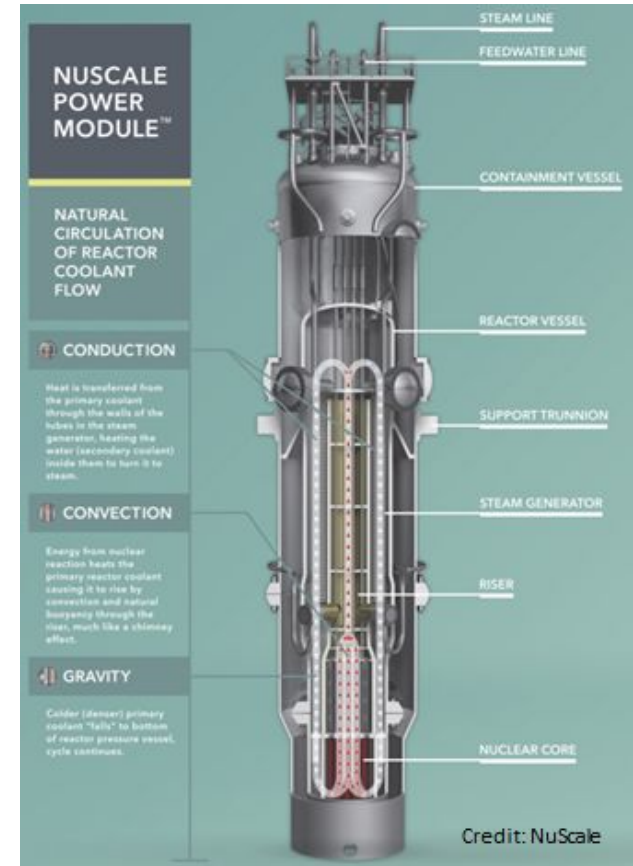
Smaller is Safer

Why is SMR Safer than Tradition Nuclear Plant?

Smaller > Safer (Risk is inversely proportional to size)

Factory Manufactured (higher quality control)

Higher Production volume > more opportunities to improve subsequent model.



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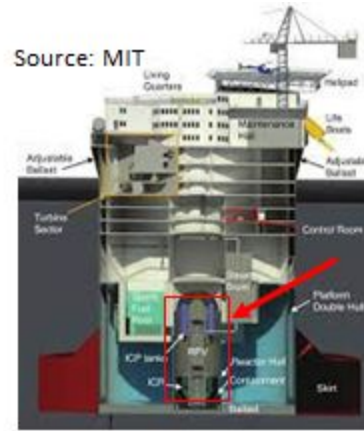
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Easy to transport with barge and erect with floating crane



Source: FAIRTEX

An illustration of barge transportation.
Floating crane needed to install reactor.



Source: MIT

Small Modular Reactor in an
Offshore Spar. 300 – 500 mW



Gigawatt Reactor longer site work
and subject to inclement weather

Manufacturers

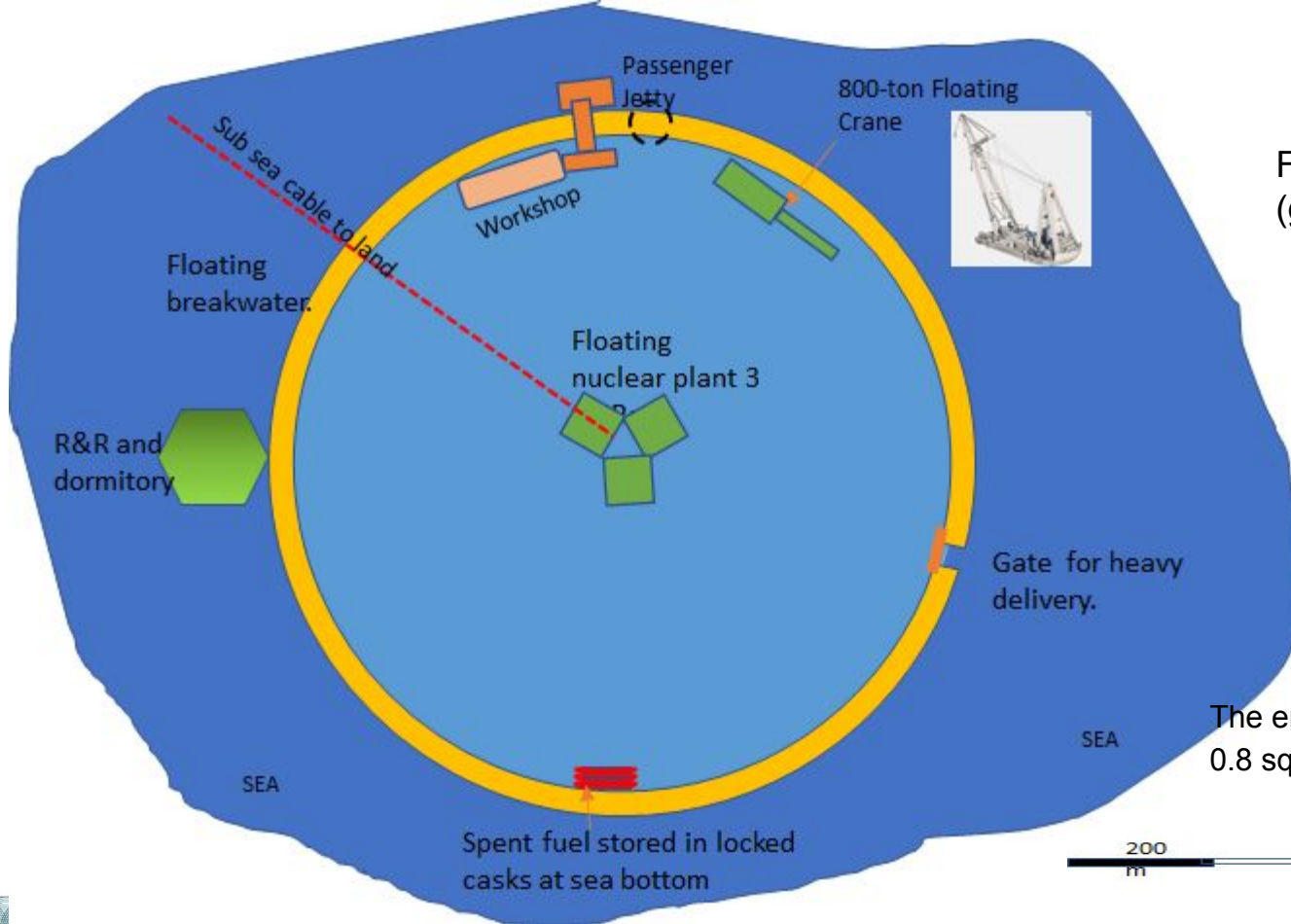
- Rolls Royce/NuScale/ GE Hitachi Nuclear Energy/ China National Nuclear Corporation /Rosatom /Others across the world



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FLOATING SMRs (general layout)



The enclosure is 1km in dia., approx.
0.8 sq. km. Water depth approx. 25 m.



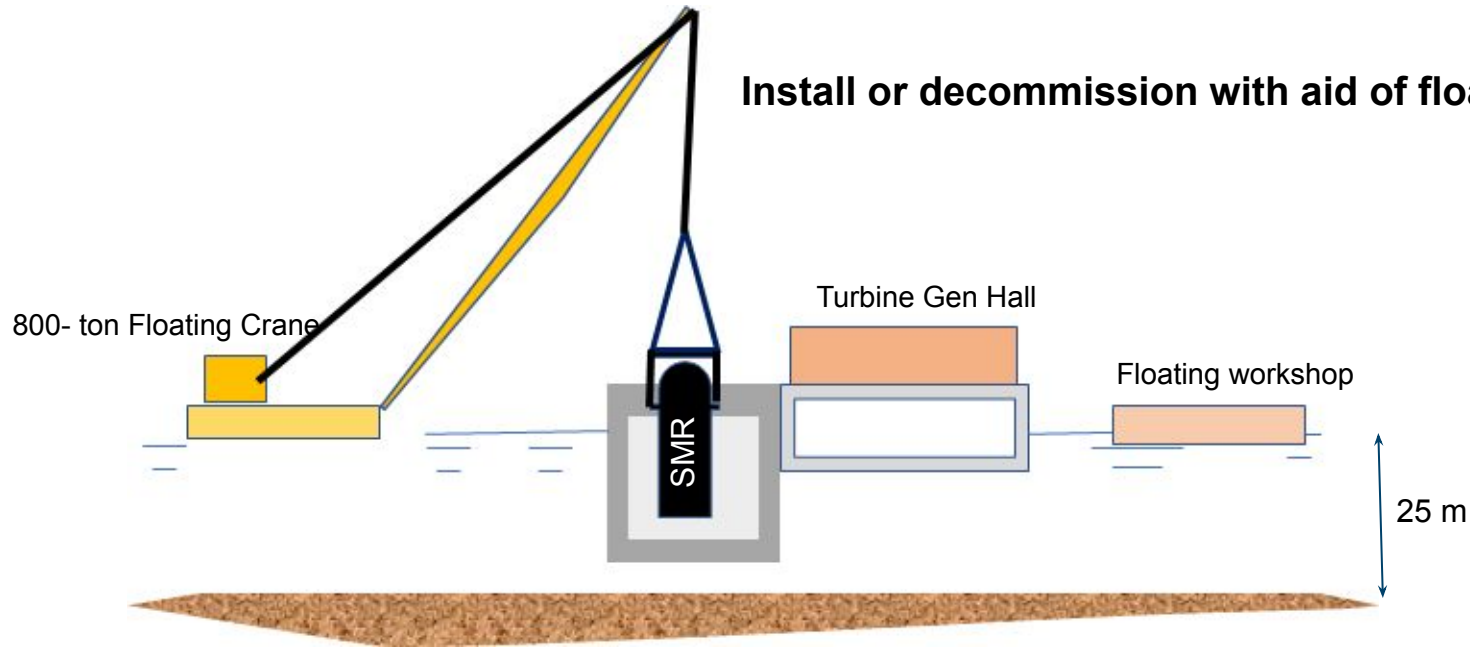
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Install or decommission with aid of floating crane



A 800-ton capacity floating crane and a floating workshop 150 m x 30 m make light work of a complex operation for mounting or removal of the SMR for maintenance, refuelling, or following a SCRAM.



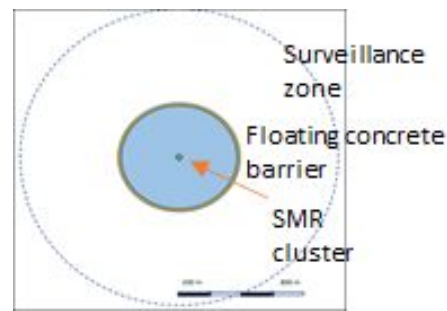


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Terrorism, Tsunamis, Spent fuel security, Rising sea, Redundancy,

- Security against terrorism and state actors (wider area of active surveillance 24x7)
- Spent fuel security (lagoon serves as supersize cooling pool. Concrete box)
- Coolant loss not possible so meltdown impossible (surrounded by infinite heat sink)
- Resilient against Wind, Waves, Earthquakes, Tsunamis and Rising seas
- Multiple independent reactors, higher redundancy, supply reliance



ECONOMICS

- Low LOCE (Levelised cost of electricity)
- Fuel cost predicatbility
- Final construction cost predictable
- Closer gap between demand and supply
- Size suitable for installation by floating crane
- Lower financing cost (shorter lead time)
- Lower decommission cost (may be relocated and repurposed)

OECD electricity generating cost projections for year 2015 on – 5% discount rate, c/kWh

Source: OECD electricity generating cost projections

country	nuclear	coal	Gas CCGT
Belgium	6.6	7.7	10.4
Czech R	-	-	-
France	6.5	-	9.5
Germany	-	7.1	10.4
Hungary	7.0	-	9.9
Japan	7.4	10.1	13.6
Korea	3.4	7.9	12.0
Netherlands	-	8.3	9.9
Slovakia	6.7	-	-
Switzerland	-	-	-
USA	6.5	8.8	6.3
China*	3.5	8.0	9.1



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ECONOMICS

“In 2013 the Nuclear Energy Institute (NEI) announced the results of its financial modelling of comparative costs in the USA, based on figures from the US EIA’s 2013 Annual Energy Outlook.

The NEI assumed 5% cost of debt, 15% return on equity and a 70/30 debt/equity capital structure. The figures are tabulated below. The report went on to show that with nuclear plant licence renewal beyond 60 years, power costs would be **\$53-60/MWh.” World Nuclear Org.**

	EPC cost	capacity	Electricity cost
Gas combined cycle, gas @ \$3.70/GJ	\$1000/kW	90%	\$44.00/MWh
Gas combined cycle, gas @ \$5.28/GJ	\$1000/kW	90%	\$54.70/MWh
Gas combined cycle, gas @ \$6.70/GJ	\$1000/kW	90%	\$61.70/MWh
Gas combined cycle, gas @ \$6.70/GJ, 50-50 debt-equity	\$1000/kW	90%	c \$70/MWh
Supercritical pulverised coal, 1300 MWe	\$3000/kW	85%	\$75.70/MWh
Integrated gasification combined cycle coal, 1200 MWe	\$3800/kW	85%	\$94.30/MWh
Nuclear, 1400 MWe (EIA’s EPC figure)	\$5500/kW	90%	\$121.90/MWh
Nuclear, 1400 MWe (NEI suggested EPC figure)	\$4500-5000/kW	90%	\$85-90/MWh
Wind farm, 100 MWe	\$1000/kW	30%	112.90/MWh

5% cost of debt, 15% return on equity and a 70-30 debt equity capital structure.



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Benefits of Small Modular Reactors (SMRs)

Office of Nuclear Energy

Read more at this link:

✓ <https://www.energy.gov/ne/benefits-small-modular-reactors-smrs>

- ✓ MODULARITY
- ✓ LOWER CAPITAL INVESTMENT
 - ✓ SITING FLEXIBILITY
 - ✓ GREATER EFFICIENCY
- ✓ SAFEGUARDS & SECURITY / NONPROLIFERATION
- ✓ U.S. INDUSTRY, MANUFACTURING, AND JOB GROWTH



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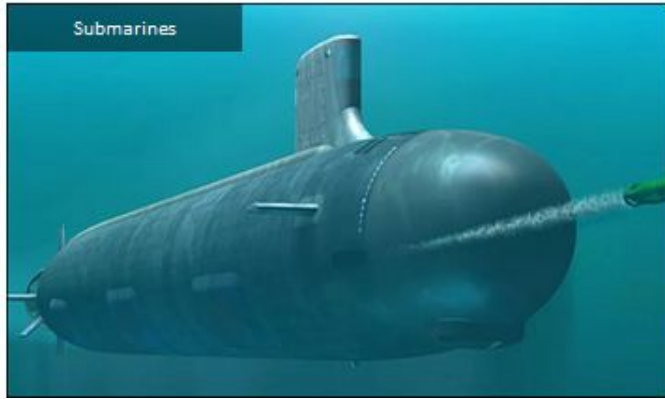


Aircraft carriers



Icebreakers

SAFE, MOBILE, AND SUSTAINABLE



Submarines



Power plants



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TAKEAWAYS

- Without Nuclear Power, it would be impossible to keep the planet safe.
- SMRs are much safer than gigawatt nuclear power plants
- SMR can better reduce the gap between supply and demand.
- SMRs at sea are resilient and sustainable
- The low LCOE and fuel cost stability is attractive



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**Society of
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THANK YOU

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