Nuclear Propulsion for Merchant Ships (NuProShip I/II)

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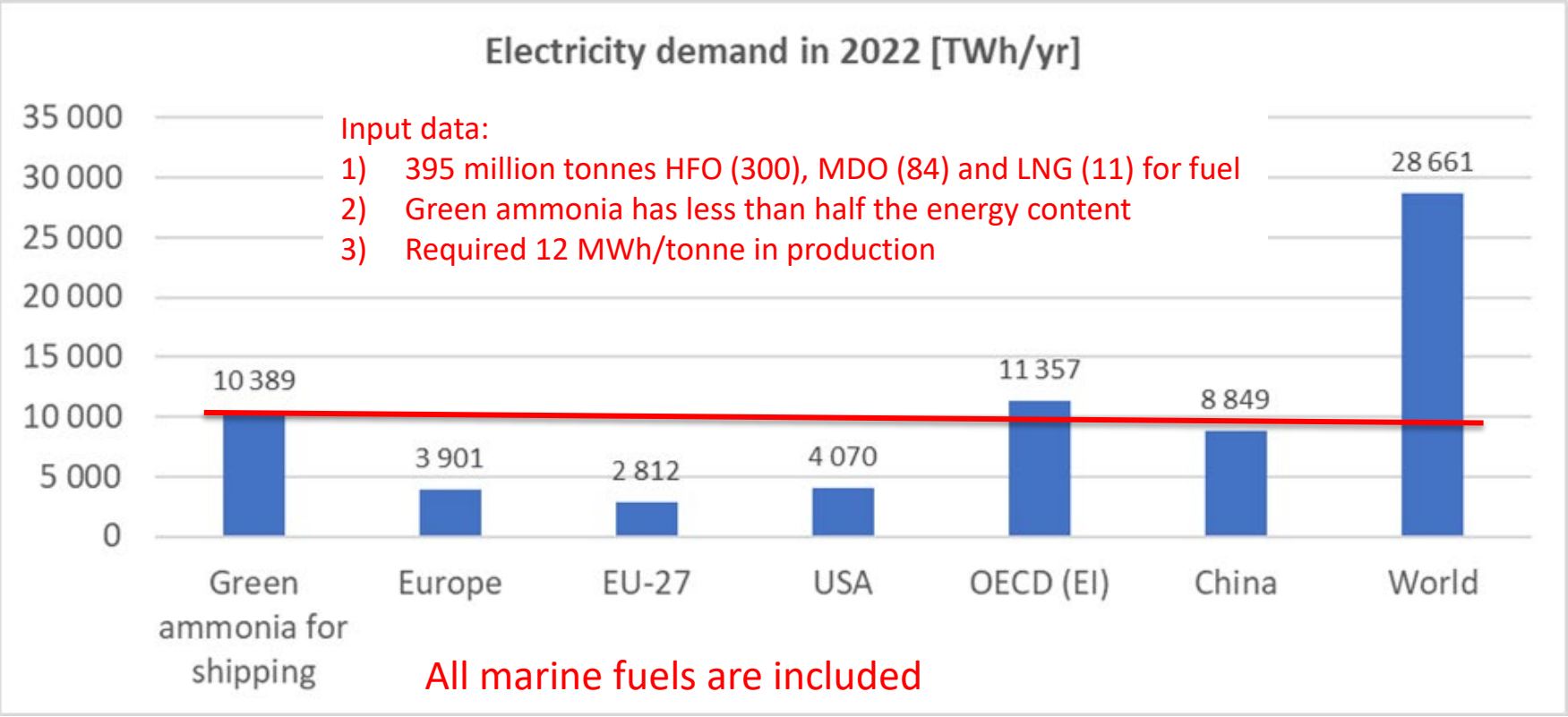
SEMINAR FOR ATOMBEREDSKAPSORGANISASJONEN

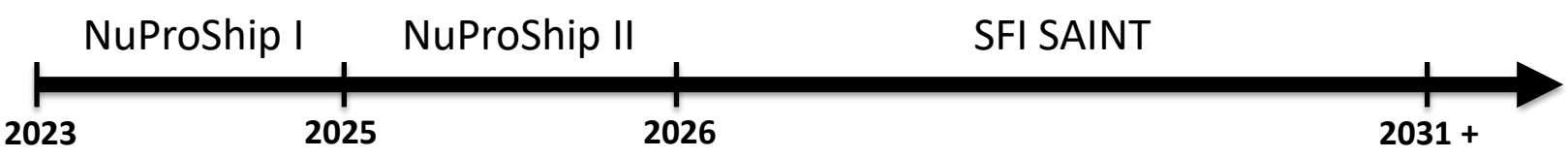
2025-10-14, TROMSØ

Fossil or nuclear is the choice!



Source: Emblemsvåg, Jan. (2025) A Study on the Limitations of Green Alternative Fuels in Global Shipping in the Foreseeable Future. Journal of Marine Science and Engineering (JMSE). doi.org/10.3390/jmse13010079.

Overall timeline for research



- Concept- and feasibility study
- 2 years duration
- Result in design requirements for NuProShip II and a chosen reactor(s)

- Preliminary design study
- End Of Life
- Stakeholders
- Propulsion system
- Load mgt system
- Costs
- Detailed requirement for reactors and ship types to provide input to SFI SAINT

- Design- and engineering
- The entire fuel cycle
- Final details for ships and reactors
- Business models
- Education and training
- 5-8 years duration
- Develop a prototype
- Perform all relevant tests required for reaching a prototype level of technology maturity
- 2-3 demonstration projects

11 exclusion criteria

Too large power output	TRL	LWR	Using classic pebble bed technology	Limited proliferation resistance
15-200 MWth >5 MWe	Technology is not mature	Using Water as a coolant	No HTGR pebble bed technology	Avoid reactor designs where can

Then, another 26 selection criteria

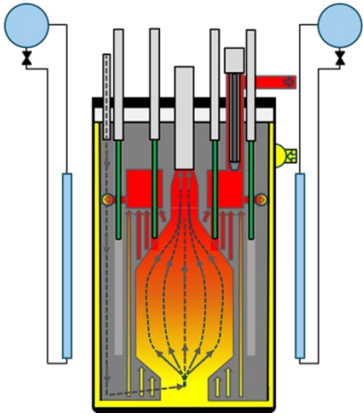
Active Safety	Violent interaction of coolant with water	Too high pressure in the reactor primary system	5 Year Continuous Operation	No designs with export control issues
Reliance of active safety systems	Sodium cooled reactors are discarded	Limit in case of explosion	Less than 5 years continuous operations to match docking	Technology from embargoed countries is not acceptable

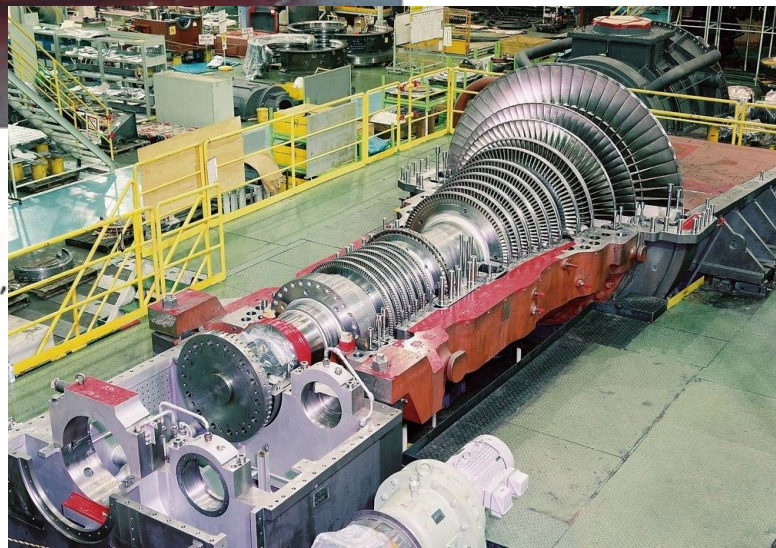
Fuel enrichment and highly toxic bi-products: Reactor concepts must require fuel enrichment below 20% of Uranium-235 and no significant Polonium 210 generation as in lead-bismuth reactors

MSR and steam turbine

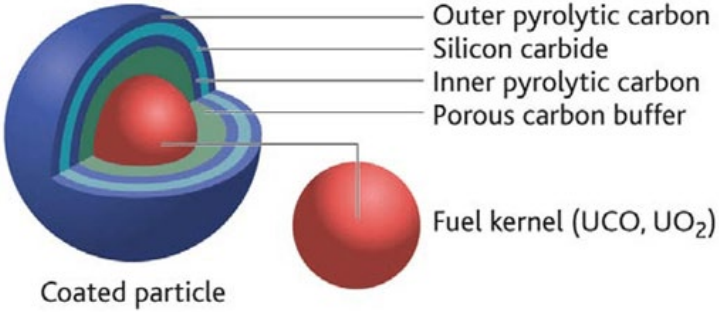
« Cadiz Knutsen »

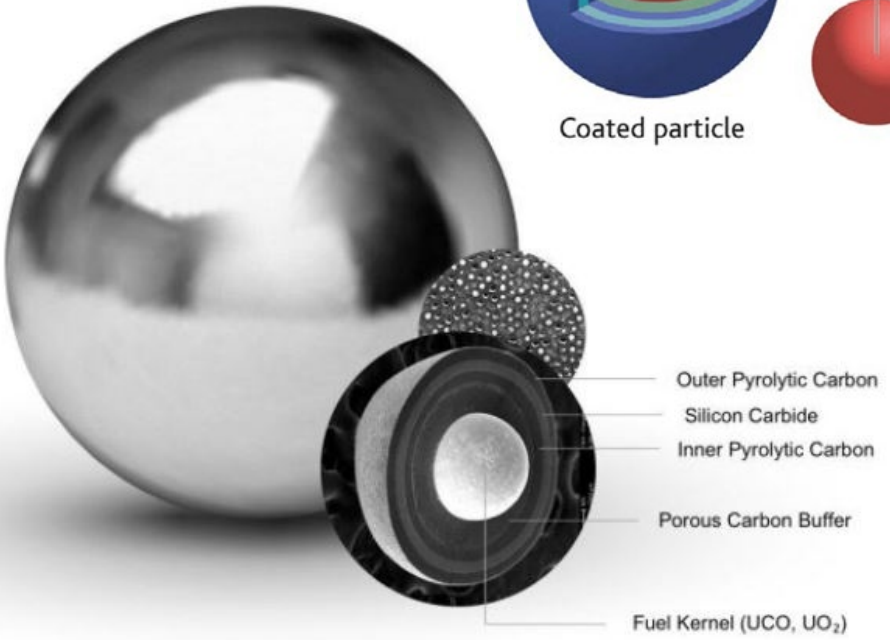
Main Dimensions		Cargo arrangement
Vessel type	LNG Carrier	Four (4) cargo tanks,
Length overall	284.40 m	138,000 m^3

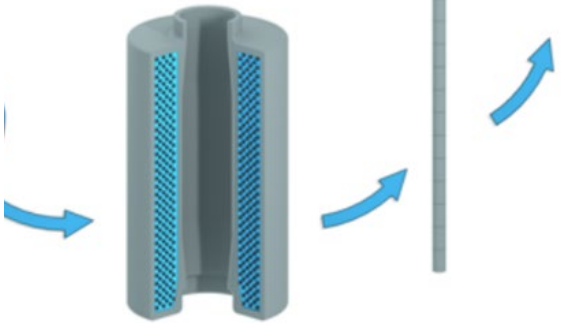




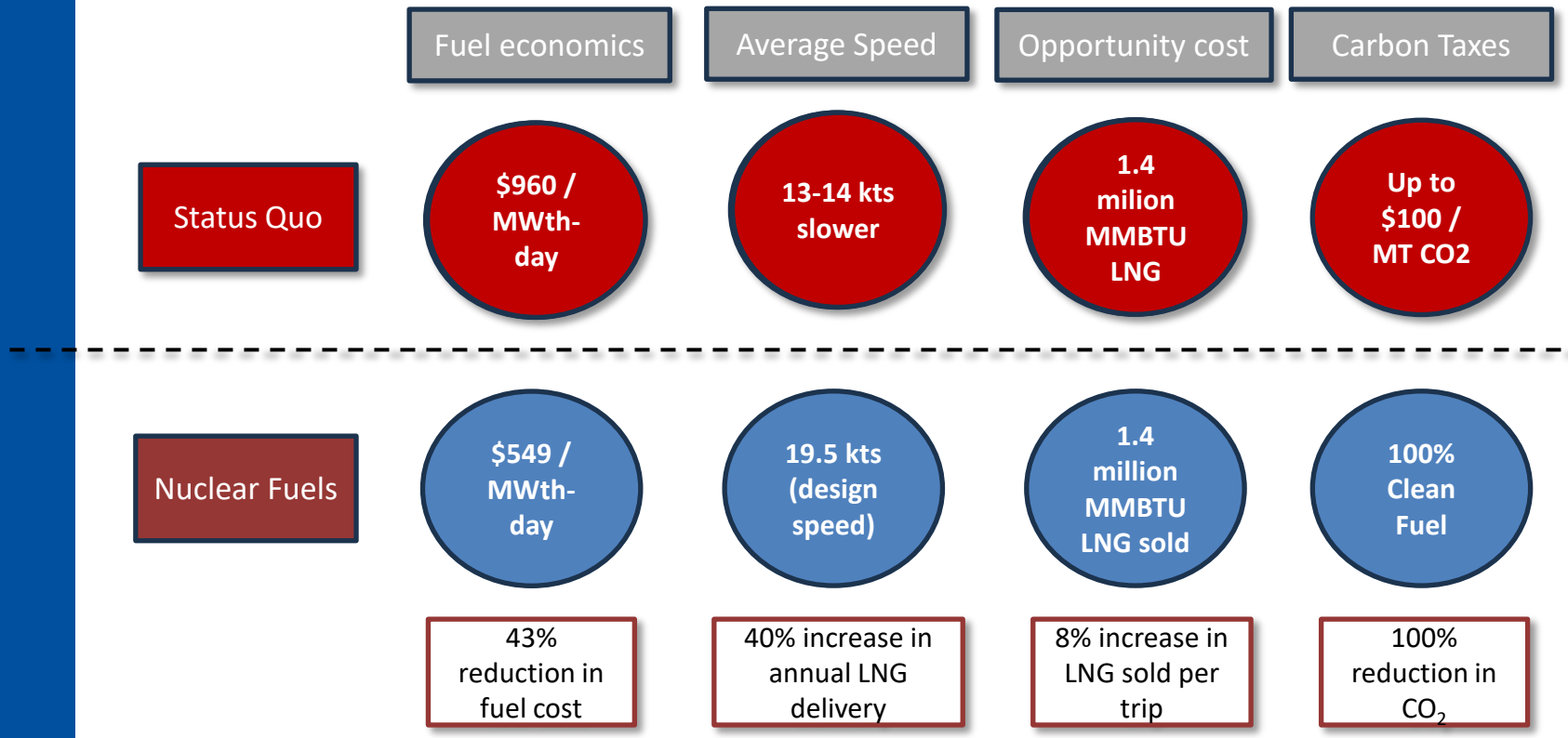
TRISO fuel – a game changer?





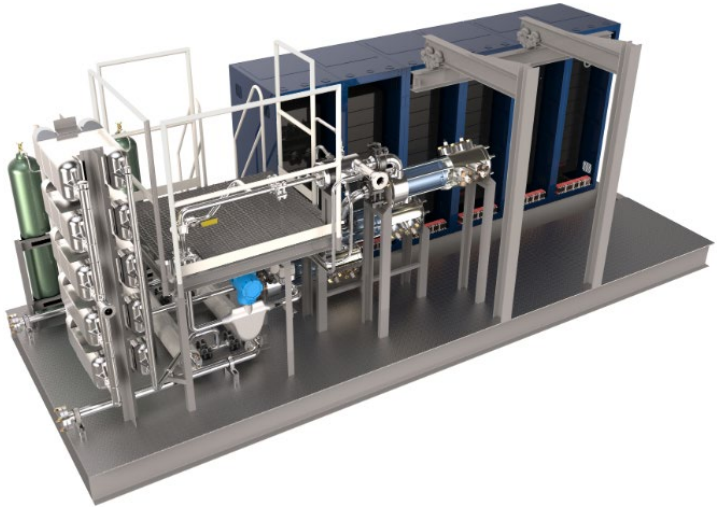


Highly attractive economically…



Helium gas-cooled and SC CO_2 turbine

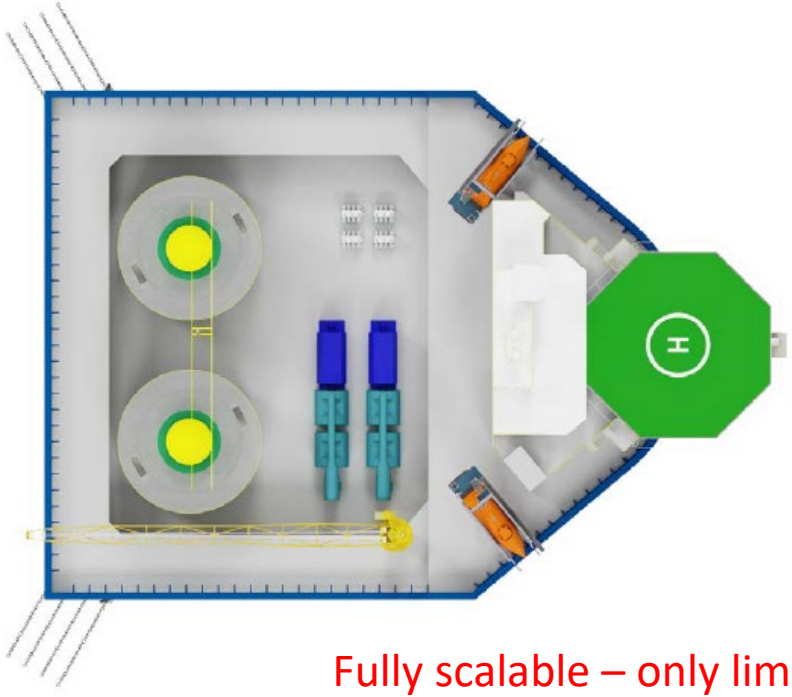
Emerald Gem – 5 MW in 20 feet container

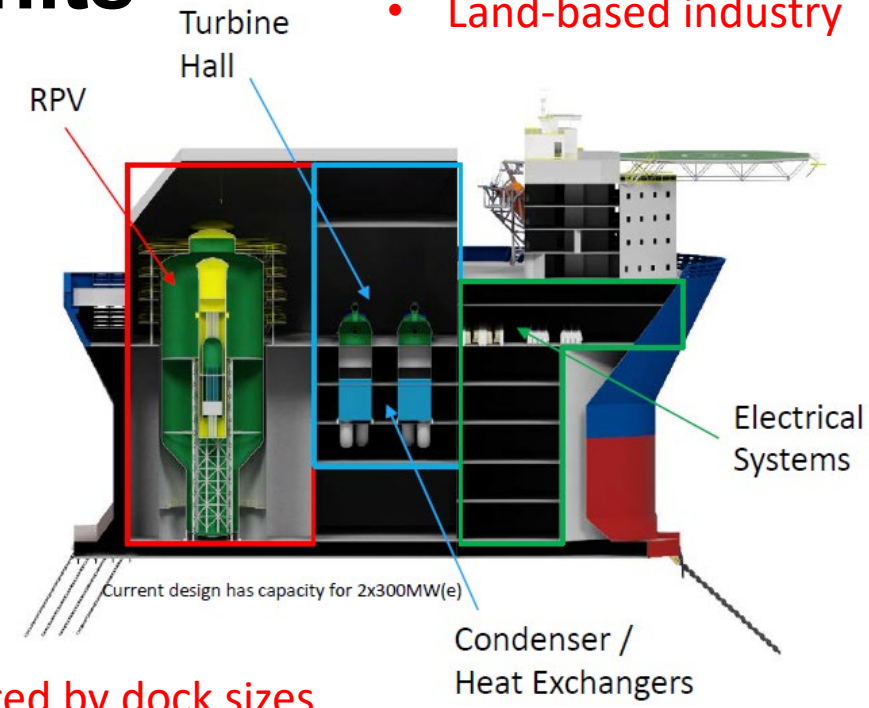


- 5 MW (6705 HP) electric power available anytime
- 5 – 15 years depending on load
- Modern advanced nuclear technologies (helium gas-cooled, TRISO-fueled, Advanced neutron moderators, Brayton power conversion, Modular, skid mounted)
- Supercritical CO_2 turbine offers about 50% conversion efficiency and small footprint

Lead-cooled reactors (base load) at stationary units

- Offshore
- Ship refueling
- Land-based power
- Land-based industry





Fully scalable – only limited by dock sizes

Source: Cefront Technology

Findings, thus far?

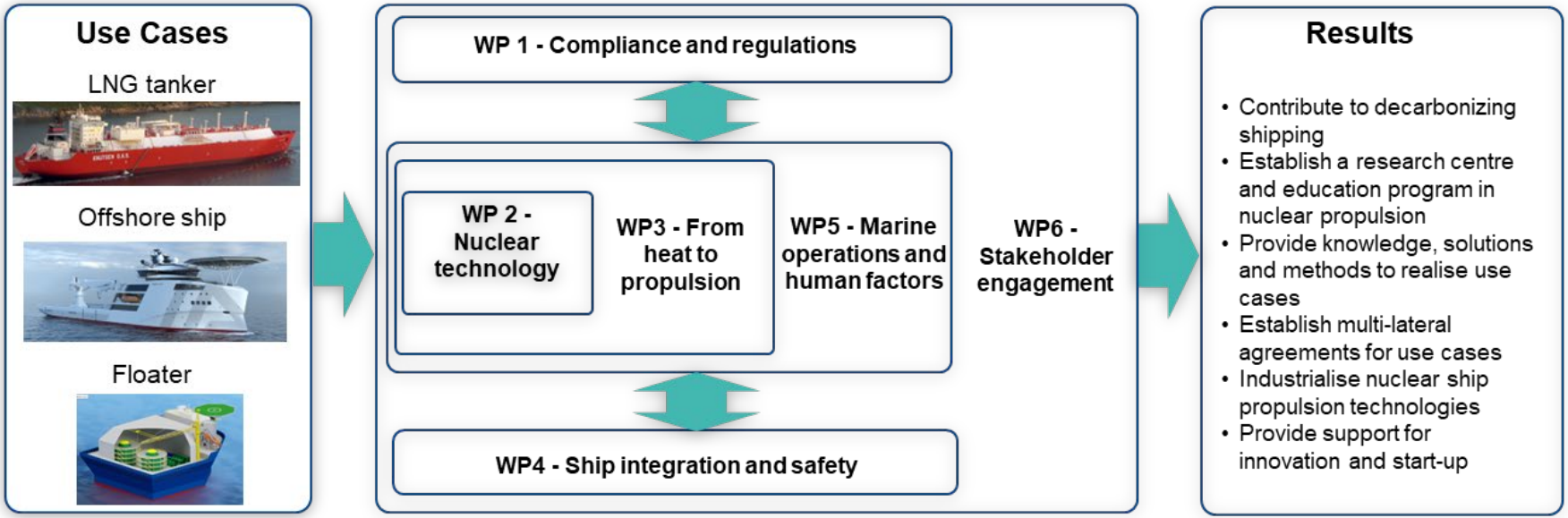
Possibilities:

- Cheaper fuel (MWh delivered)
- Lower total costs
- Lower fire risk
- Faster/larger ships
- 'No' distance limitations
- After some time;
  - Cheaper insurance
  - Much less downtime

Limitations (in the beginning):

- Limited to competent ship owners (operational license) and flag states (regulatory knowledge, trust and indemnification)
- Limited operational area (nuclear corridor)
- Stakeholder sentiments

SFI SAINT application submitted



1) 29 organizations
2) Total budget of 270.2 MNOK over 8 years
3) 96 MNOK from Research Council of Norway
4) 3 use cases – separately funded -> demonstration projects in the 2030s

NTNU

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Francesco Venneri

Per Peterson

Janne Wallenius

Larry LeGree

https://nettskjema.no/a/487203

NTNU

Charles Duelfer

27 years in government (OMB, State, CIA and

Tom Walters

LERØY HAVFISH

Wallenius Wilhelmsen

Knutsen OAS

Pranay Vaddi

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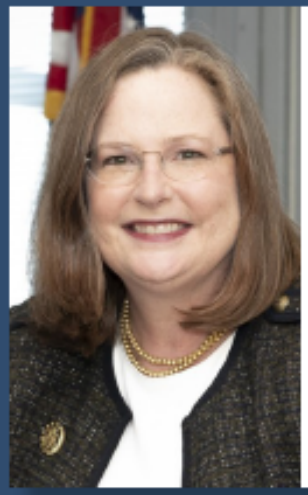
Robert Spalding



Laura Holgate

Former U.S. Ambassador to the International Atomic Energy Agency (IAEA), with a 30-year national security career in and out of government, including managing nuclear risks and promoting nuclear energy.

Ian Salter

Nuclear Law expert.

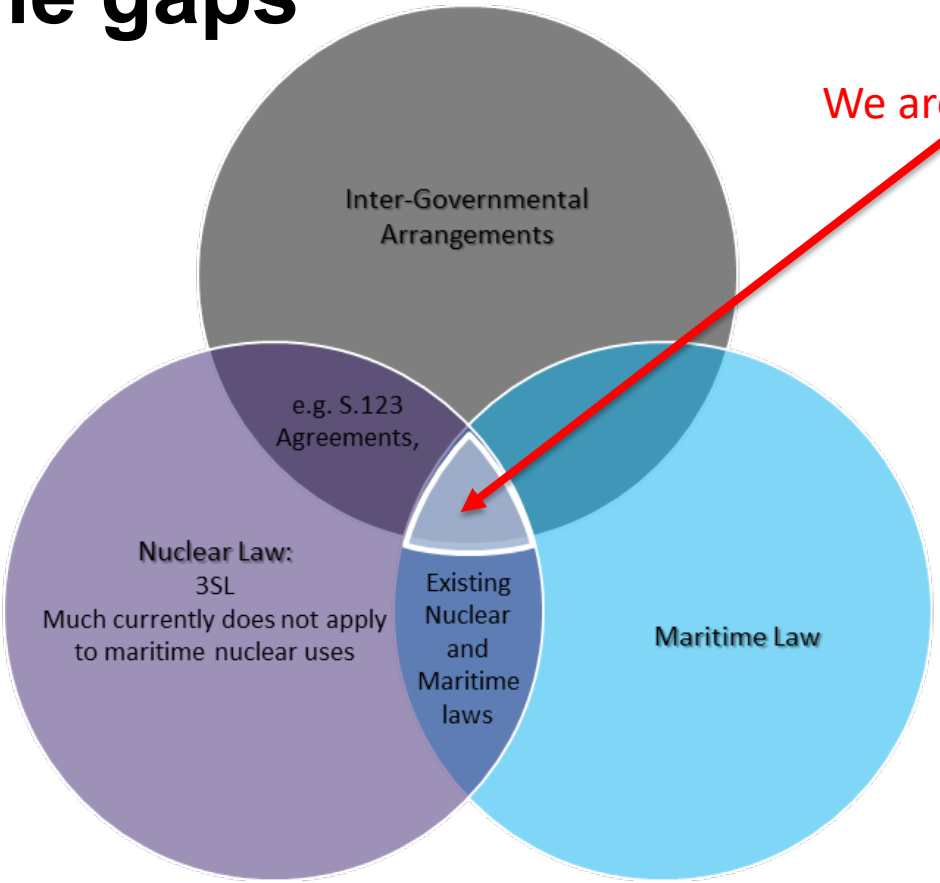
Chair of the Nuclear Industry Association's Legal and Financial Affairs Working Group.

IAEA is supportive

Rafael Mariano Grossi meeting Jan Emblemsvag
Rafael Mariano Grossi, IAEA Director-General, met with Jan Emblemsvag, Head of NuProShip, Norway, during his official visit to the Agency headquarters in Vienna, Austria. 27 May 2025.

- Grossi stated that our approach and project was the most advanced he had seen so far – we think he found it both concrete and comprehensive involving all parts of the supply chain
- Next day we had meetings with his direct reports
- Collaboration initiated

The Demonstration Projects can help fill in the gaps



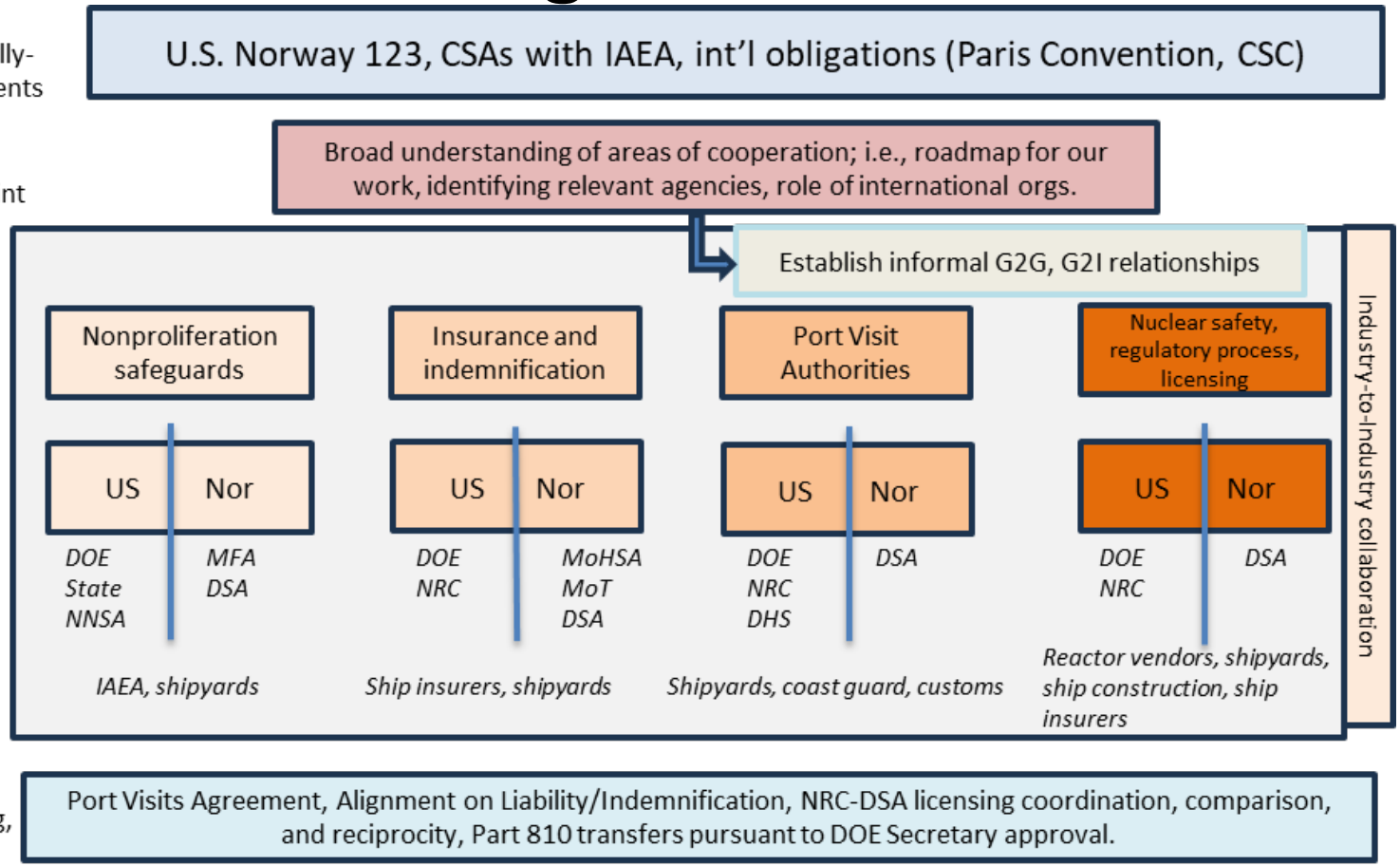
We are here

Exists between Norway and U.S. for military nuclear-powered ships; the gap is for commercial nuclear- powered ships

Initial meetings held with:

- DSA
- IAEA
- US NRC
- US DOE
- MNAG at INL

Nested bilateral agreements



Thank you for your attention ☺

Question
and
Answer