SELECTING AND RANKING NUCLEAR REACTORS FOR MERCHANT SHIPPING

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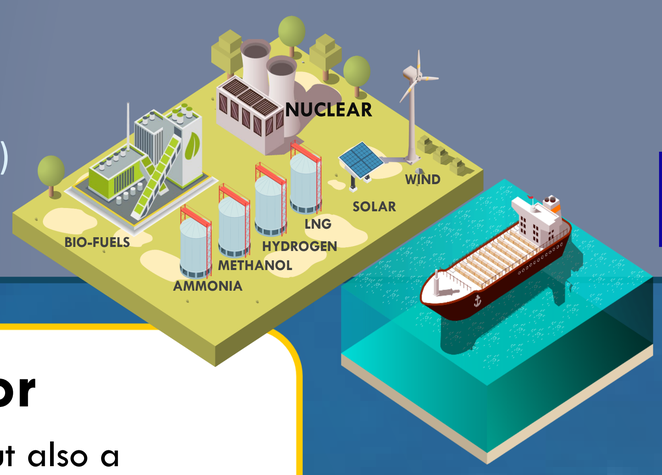
IAEA-CN-327-018



Nuclear propulsion for the maritime sector

Maritime transport of goods is a pivotal component of global trade, but also a significant contributor to greenhouse gas emissions.
HFO is consumed by the Deep Sea Fleet (DSF), comprising large ocean-crossing ships.
Transition to green ammonia would annually require 7,800 TWh, - more than twice the total EU electricity production in 2022.
Nuclear - SMR becomes a real option achieving decarbonization objectives by 2050.
But…more than 80 designs are competing.
How to choose the right one?

Methodology - Analytical Hierarchy Process

Using the Analytical Hierarchy Process (AHP) approach on a range of criteria for marine nuclear propulsion, reactor concepts are ranked according to their feasibility for nuclear propulsion.

EXCLUSION CRITERIA

FROM >80 SMR TO 7 SMR DESIGNS

SMR DESIGNS UNDER DEVELOPMENT

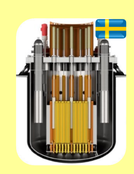
Advances in Small Modular Reactor Technology Developments
A Supplement to:
IAEA Advanced Reactors Information System (ARIS)
2022 Edition

The NEA Small Modular Reactor Dashboard

- WATER AS COOLANT
- ENRICHMENT & TOXIC BI-PRODUCTS
- ACTIVE SAFETY SYSTEMS
- LARGE POWER OUTPUT
- LOW TECHNOLOGY READINESS LEVEL
- EXPORT CONTROL VIOLATION
- < 5 y CONTINUOUS OPERATION
- HIGH PRESSURE LIMIT
- PEBBLE BED TECHNOLOGY
- VIOLENT COOLANT-WATER REACTION
- LIMITED PROLIFERATION RESISTANCE

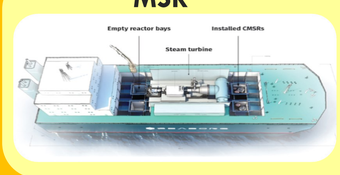
SUITABLE FOR MARINIZATION

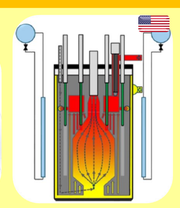
LFR

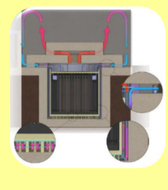


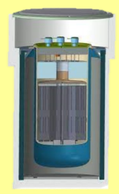
HTGR

MSR

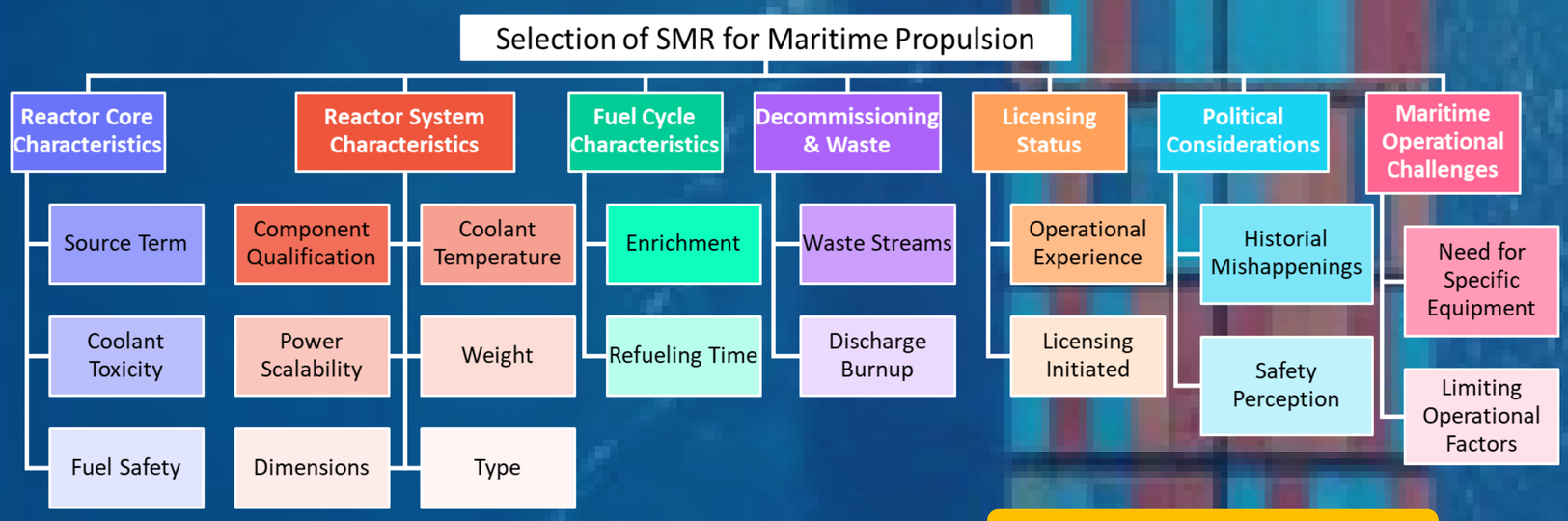




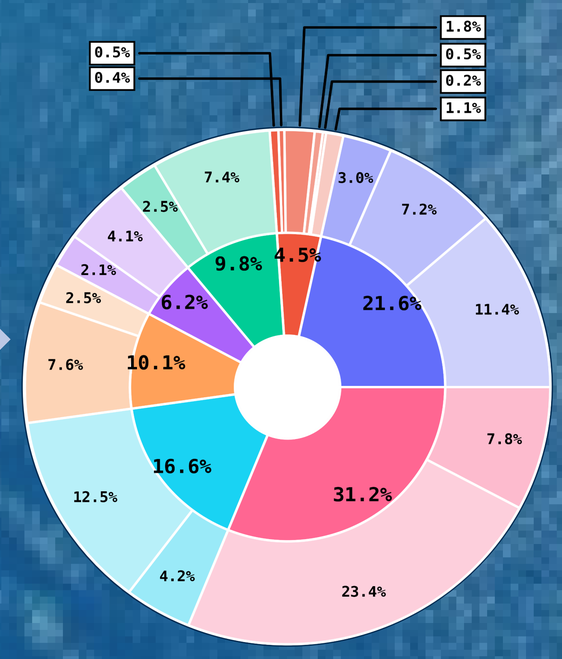




SELECTION CRITERIA & SUBCRITERIA



PAIRWISE COMPARISON



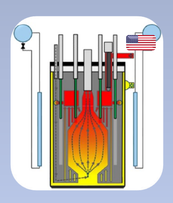
Criteria and subcriteria weights

REACTOR SCORES

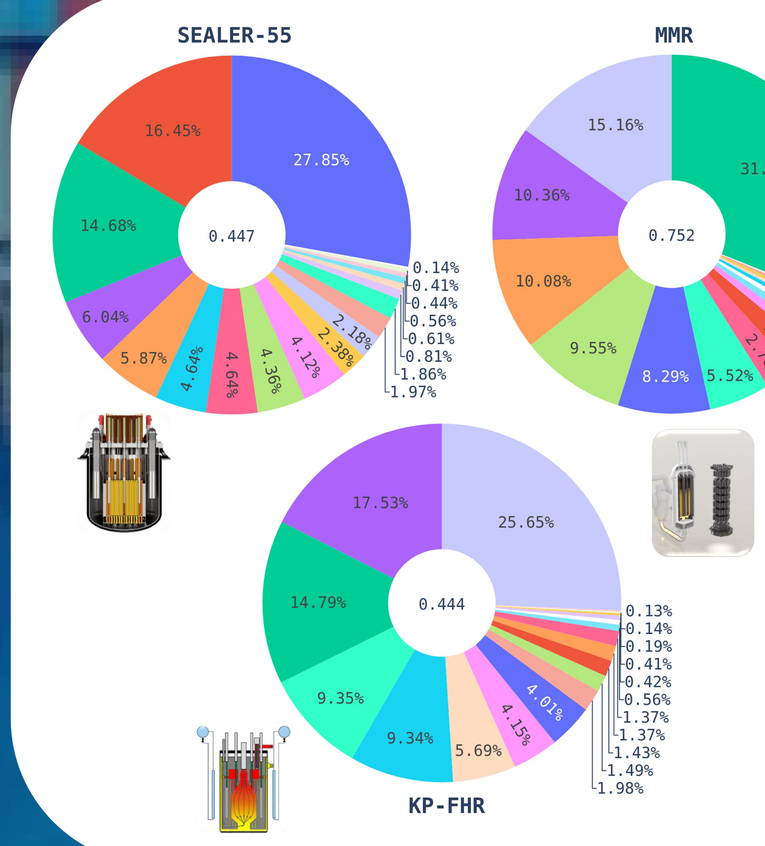
TOP 3 REACTORS FOR MARINIZATION

Ultra Safe Nuclear Corporation, MMR
- TRISO particles (Fuel Safety)
- No moving parts (Limiting Operational Factors)
- Inert gas as coolant (Coolant Toxicity)
- Experiences with GCR (Operational Experience)

Blykalla, SEALER-55
- No refueling (Refueling Time)
- Decommissioning as a whole unit (Safety Perception)



Kairos Power, KP-FHR
- TRISO particles (Fuel Safety)
- High (Discharge Burnup)
- Test Reactor Construction Permit (Licensing Initiated)



Reactor Scores

Conclusions

- 3 reactor concepts have been selected for further investigations:
  1. MMR → High Temperature Gas-Cooled Reactor (HTGR) by Ultra Safe Nuclear Corporation.
  2. SEALER-55 → Lead Fast-Cooled Reactor (LFR), by Blykalla.
  3. KP-FHR → Molten Salt Reactor (MSR), by Kairos Power.

Future work

- Engagement with national and international regulatory bodies and public stakeholders.
- Basic/Detailed design analysis and cost study (planning, budget, risks, CAPEX, OPEX, etc.) of the chosen reactors.
- Marinization version for licensing.
- Mapping onto various ship designs and operational modes