Small Modular Reactors

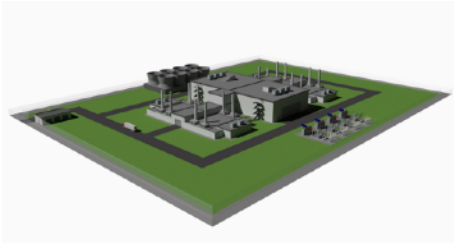
A global revolution

Janne Wallenius
Nuclear Engineering
KTH
janwal@kth.se

A matter of urgency

2022

2030



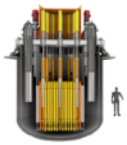
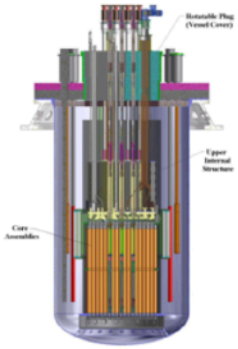
- Global use of electricity expected to double until 2050.
- Quality problems during nuclear new-build of large light water reactors cause increased costs: 10 MEuro/unit, out of which 50% is interest.
- Small Modular Reactors is the missing piece in the puzzle for creating a net-zero carbon future.

The SMR solution: a revolution.

- Considerably lower investment risk
- Shorter time from order to production
- Teething problems addressed once several units have been built
- Passive safety easier to implement
- Source term from a severe accident is smaller

A variety of technologies

SUNRISE
Sustainable Nuclear Energy Research in Sweden

2020	2021	2026	2027	20XX
Water	Helium	Lead	Sodium	Salt
				
NuScale	Xe-100	SEALER	ARC	Terrestrial
RITM	HTR-PM	BREST	Natrium	Moltex
ACP	U-Battery	SVBR	e-Vinci	Elysium
CAREM	USNC	ALFRED	Oklo	TerraPower
SMART		Mini-LFR		Kairo
BWRX		URANUS		Flibe
RR SMR		CLFR		Thorcon
NuWard		BLESS		Seaborg
				Copenhagen Atomics
				Naarea

Modern SMRs operate today

- Arktika & Sibir ice-breakers
- 2 x 175 MWt RITM-200 iPWRs
- Maiden trips in 2020 & 2021
- Reactor designer: OKBM Afrikantov
- Fuel enrichment: < 20%
- Fuel active height: 1.65 m
- Fuel residence time: 5 years
- 14 more RITM reactors to be installed prior to 2028, two land based (Yakutia), eight on barges, four on ice-breakers.

Helium cooled-reactors online in China

- HTR-PM 210 MWe (2 x 250 MWth)
- Connected to grid in December 2021.
- Pressure vessel dimensions: 5.7 x 25 m
- Coolant temperature: 250 - 750°C
- Fuel: TRISO coated particle, pebble bed.
- Fuel enrichment: 8.5%
- Fuel residence time: 35 months

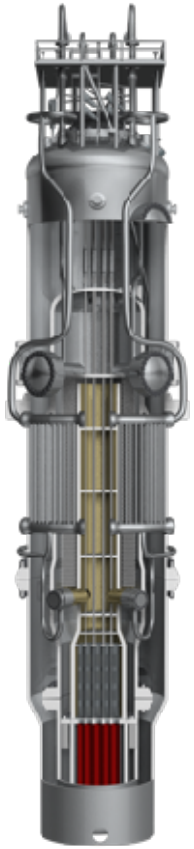
Under construction

- CAREM: 32 MWe iPWR, Argentina

- ACP100: 125 MWe iPWR, China

- BREST-300: 300 MWe LFR, Russia

NuScale's VOYGR



- 77 MWe iPWR
- No primary coolant pumps
- Design certified by NRC in 2020
- Multi-unit plant planned for UAMPS in Idaho, intended operation in 2029. Co-sponsored by US government grant of 1355 MUSD.
- 6 unit plant considered by Romanian national energy company SNN.
- Selected by Polish mining company KGHM for intended deployment in Poland.

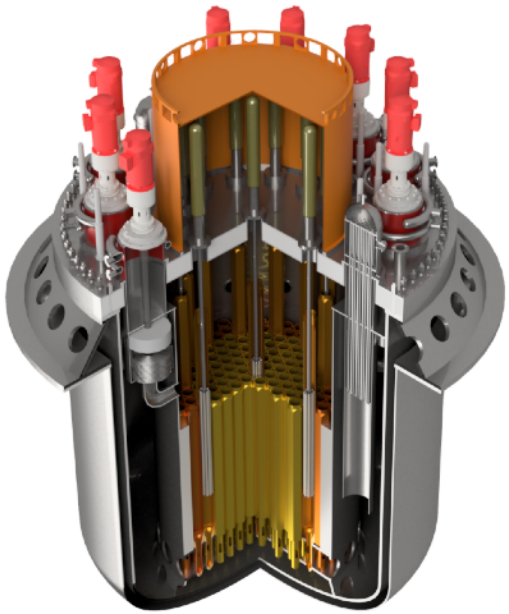
GE-Hitachi's BWRX-300

- 300 MWe BWR
- No primary coolant pumps
- Site assembled
- Selected by Ontario Power Generation for Darlington New Nuclear Project. Intended operation in 2028.
- Selected by Fermi Energia for intended deployment in Estonia.
- Selected by Synthos Green Energy for intended deployment in Poland.
- Selected by Kärnfull NEXT for intended deployment in Sweden.

Global interest in SMRs

- In the US, Canada, Argentina, South Africa, Ghana, Kenya, China, Republic of Korea, Indonesia, Saudi Arabia, UK, France, Sweden, Finland, The Netherlands, Poland, Estonia, Romania, Bulgaria, Czech Republic and Russia, public and private actors are expressing intent to deploy SMRs for production of power and other utilities.
- Many projects intend to connect first units to grid before end of the 20's.
- Privately owned utilities are likely to prefer SMRs over large power plants, due to lower investment risks.
- Estimated global market for SMRs prior to 2050: 5000 TWh ≈ 2 000 - 10 000 units @ 50-300 MWe.

Lead-cooled SMRs in Sweden



- Electricity demand expected to double in mid 2030's
- > 100 TWh new base-load production required.
- KTH spin-off LeadCold develops SEALER-55, a 55 MWe lead-cooled SMR with UN fuel, designed for Swedish market.
- Uniper and LeadCold has formed joint venture "Swedish Modular Reactors" to demonstrate SEALER-technology.
- 3 MW electrically heated prototype, co-funded by Energy Agency, to be in operation in Simpevarp by 2024.
- 80 MWth demonstration unit intended to operate on OKG site in 2030. Conceptual design by SUNRISE-project.
- Reactor factory planned to be built in Oskarshamn.
- Commercial roll-out foreseen in mid 30's.