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Opportunities for the Deployment of Small and Micro-Reactors for Mines and Remote Communities in Australia

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Australian Mining Electrical Supply

- 41% diesel
- 33% gas
- 22% grid

(ARENA 2017)

Gas and diesel prices exposed to international markets – fuel cost is a high percentage of total electrical supply cost

Diesel transport costs to remote sites

Drive to change site supplies to low emissions but retain reliability of supply

Drive to convert vehicles and machinery to electrical – increased electrical load

Mine life consideration – is electrical system easily relocatable?

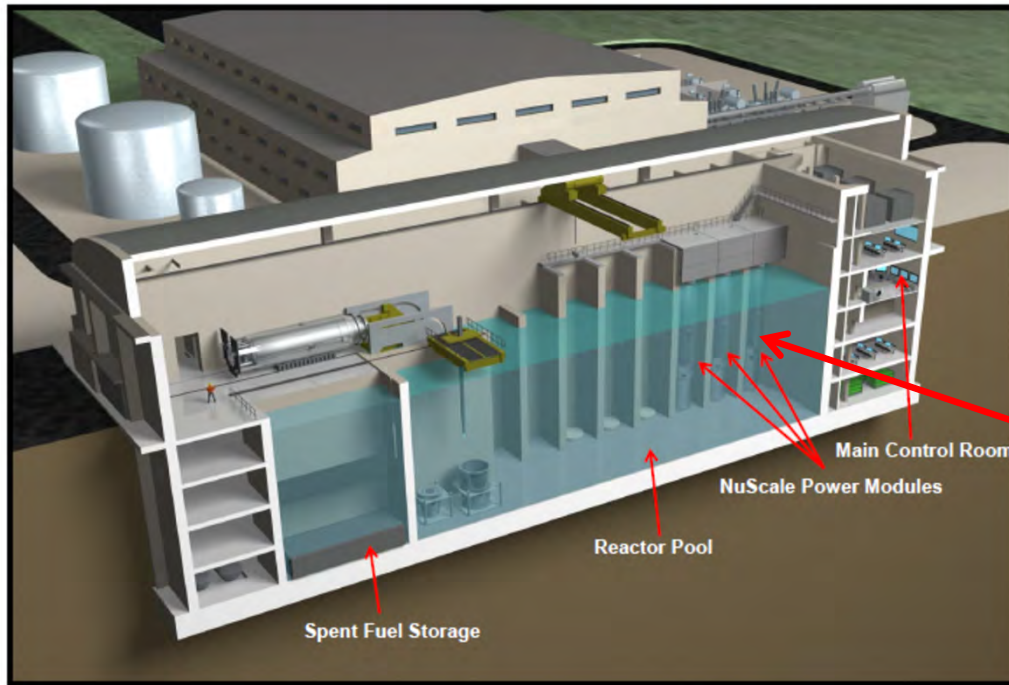
Small Modular Reactors (SMRs)

- Less than 300 MWe output
- Provide reliable, low emissions power in remote locations or for small grid systems
- High level of passive or inherent safety
- Reactor vessel can be installed below ground
- Compact, factory built, transportable module – reduced on-site construction time
- Lower initial capital cost and modules can be added as demand increases
- One module shutdown for refuelling, remaining modules producing power
- Load following capabilities
- Multipurpose – electricity, process heat, desalination
- Compact site – 5-20 hectares

Nuclear is the only low emissions electricity generation technology that is independent of the weather

NuScale Power (USA) 77 MWe power modules

Reactor Building



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Up to twelve x 77 MWe modules in 6m x 6m x 30m bays. Modules underground in a large common pool of water (assured heat sink).
Pressurised Water Reactor (PWR) Module 25m high x 4.6m diameter.
First SMR to achieve US NRC design approval.

Source: NuScale Power

NuScale first deployment for Utah Associated Municipal Power Systems (UAMPS) on Idaho National Laboratory (INL) site



Image:
NuScale

VOYGR plants can be supplied with:

- 4 modules (308 MWe)**
- 6 modules (462 MWe)**
- 12 modules (924 MWe)**

- Sept 2020 Final Safety Evaluation Report issued by NRC
- Feb 2022 site fieldwork completed
- 2024 Combined Construction and Operating licence application
- 2029 First module operating



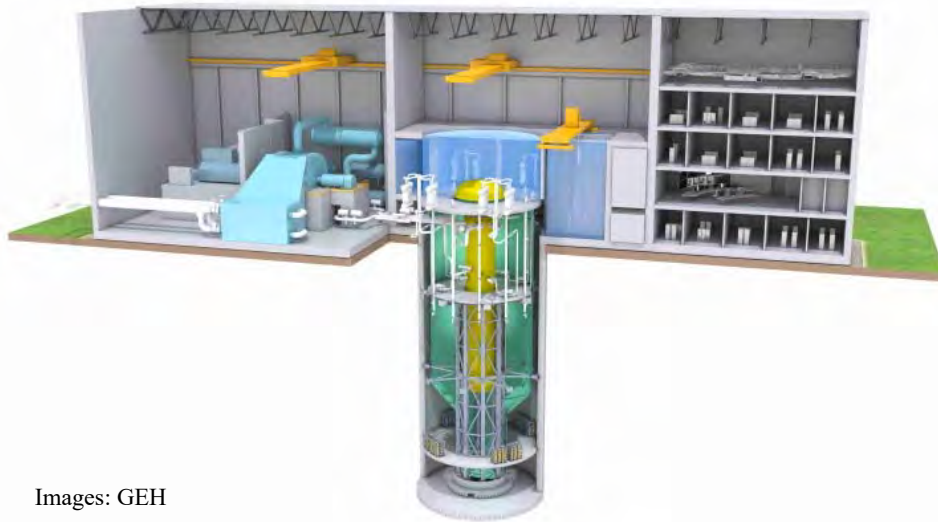
GE Hitachi BWRX-300

300 MWe

Dec 2021 selected
by Ontario Power
Generation for
Darlington site.

2022 Construction
licence application
Operating 2028.

Natural circulation
with passive safety
features.



Images: GEH

Floating Nuclear Power Plant - Akademik Lomonosov at Pevek



Two 35 MWe pressurised water reactors (PWR) on a 140m long, 21,000 tonnes displacement non-self propelled barge

December 2019 – deployed at Pevek, most northern city in Russia. Supplying electricity and heat to remote arctic community and local gold, silver and copper mines.

Next floating nuclear power plants based on 2 x RITM-200 reactors (103 MWe) used in latest icebreakers.

Four barges under construction for the Cape Naglounyn project to supply mining developments in the Baimskaya ore zone (copper and gold), Russian arctic. First scheduled operating 2027

Requires 300 MWe electrical supply – four x 103 MWe plants to be installed

Images_X- Energy

X-Energy (USA)

- 80 MWe High Temperature Gas Reactor (HTGR), configure in 4-pack 320 MWe
- Outlet temperature 750°C, helium cooled
- Produces process steam at 565°C
- TRISO pebble HALEU fuel
- Undergoing pre-licensing review by NRC and CNSC
- Oct 2020 US DOE Advanced Reactor Demonstration Program (ARDP) award USD 80 million

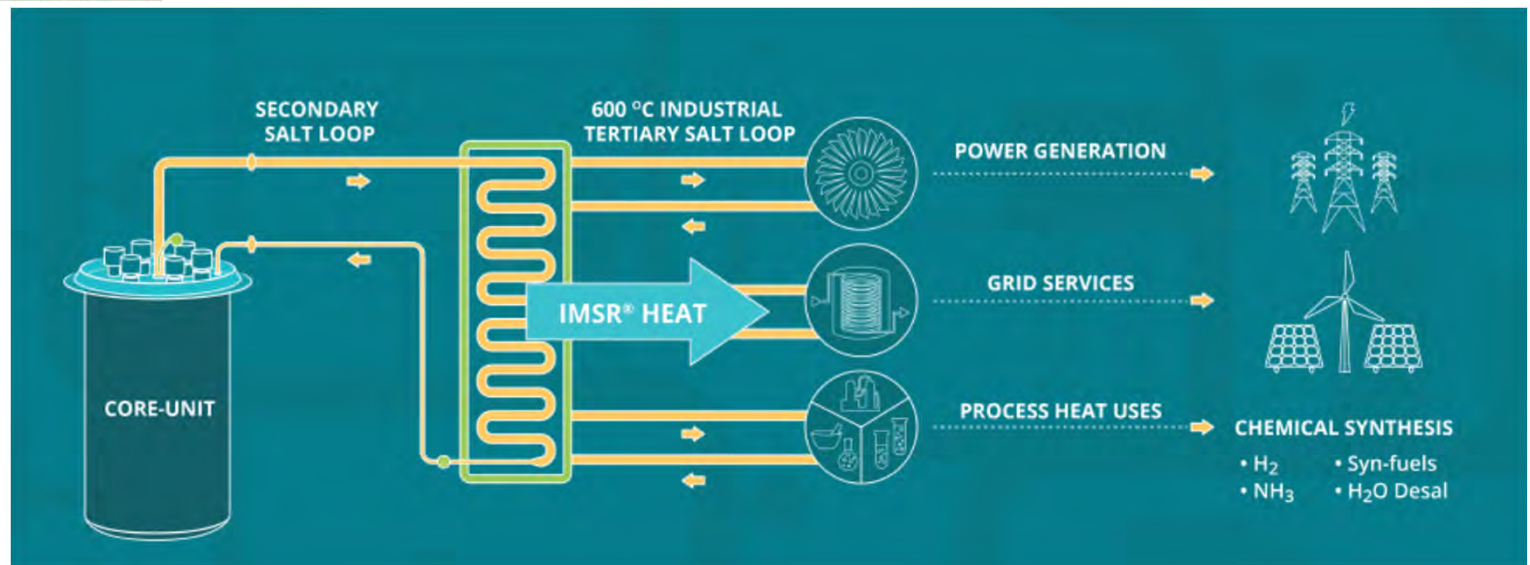


Aug 2022- agreement with DOW chemicals for supply of power and process heat to US Seadrift plant, South Texas

Terrestrial Energy (Canada) Integral Molten Salt Reactor (IMSR)



Images: Terrestrial



400 MW_{Th}, 190 MW_e, load following capable plus 585°C process heat
Seven hectare site, first deployment 2020's , looking at sites at Canadian National Laboratories and INL.
Canadian Nuclear Safety Commission (CSNC) phase 1 and 2 design reviews completed.

Micro Modular Reactors (MMR) for Off-Grid Applications

- Demand for low emissions energy supply for off-grid applications
- Microreactors defined as < 10 MWe power capacity
- Load following capabilities
- Over 1,000 islanded electricity systems and microgrids across Australia serving a population of 450,000 (Australian Energy Council 2015)

In Canada, Governments of Ontario, New Brunswick, Saskatchewan and Alberta February 2023 Strategic Plan for deployment of MMR designed primarily to replace the use of diesel in remote communities and mines.



Ultra Safe Nuclear Corporation (USNC)

High Temperature Gas-cooled Reactor (HTGR) , 5-10 MW electrical output, or 15 MWt process heat

Helium cooled, heat transferred to molten salt heat exchanger (decouples reactor from power conversion).
Fuel is a further development - TRISO enveloped in Fully Ceramic Micro-encapsulated (FCM)

*Demonstration plant at Canadian National Laboratories
Chalk River site, target operation 2026*

BWX Technologies (USA) Microreactor

- High Temperature Gas Reactor (HTGR), generating 1-5 MWe
- Transportable in 20-foot long ISO-compliant CONEX shipping containers
- Assemble on site and operational in 72 hours

June 2022 – US Department of Defence contract to BWXT to complete and deliver the prototype full-scale transportable microreactor by 2024 for testing at the Idaho National Laboratory (INL) site



Summary

- Mines require reliable electricity supply at least cost
- Transitioning to low emissions technologies
- Transitioning to more electrification of mining equipment
- Several SMR designs ready for deployment
- MMRs suitable for off-grid applications