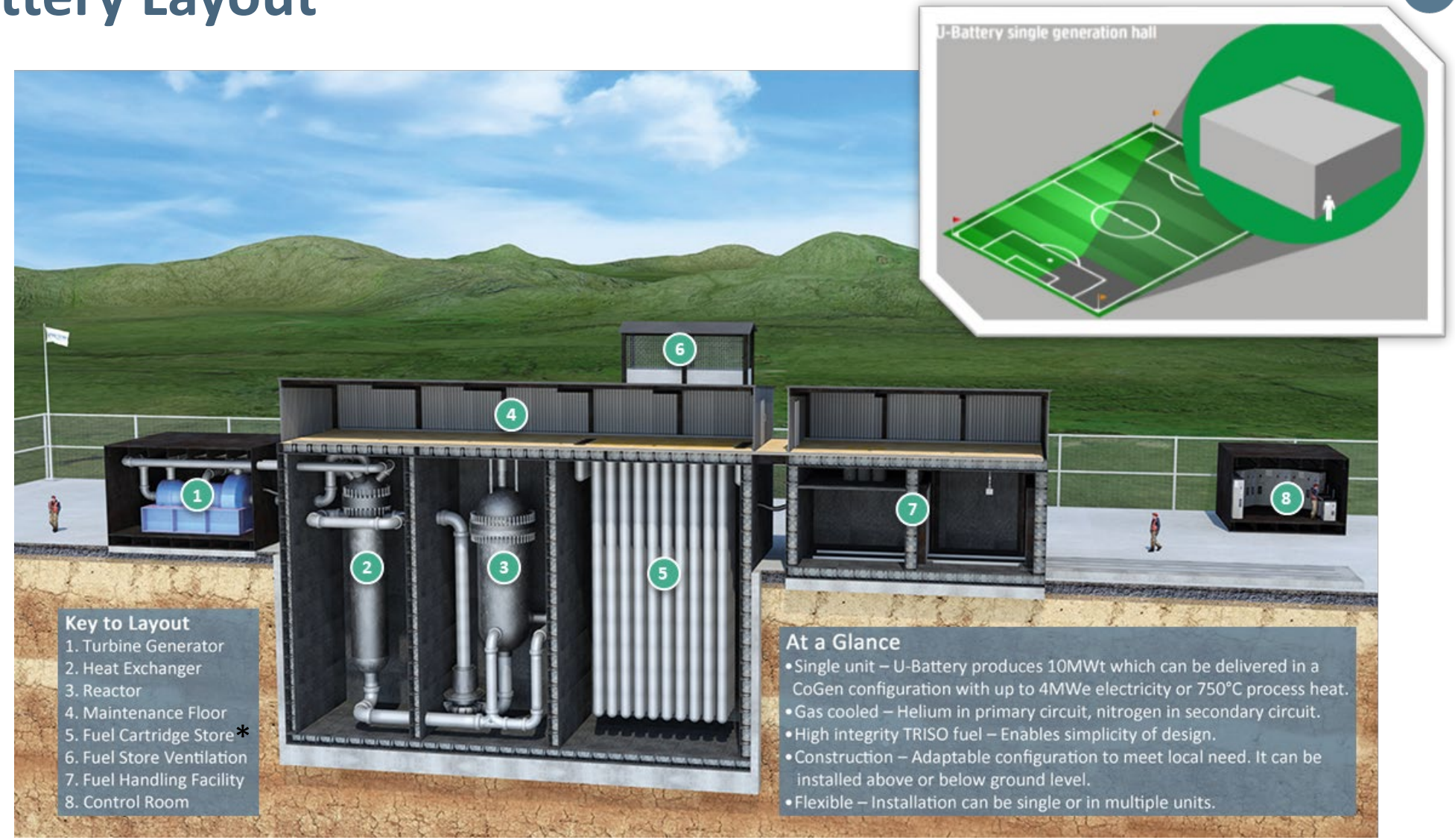
UK Academics Meeting, Cambridge

8th September 2021

U-Battery Layout



**Indicative fuel storage solution – dependent on intended lifetime of specific plant and potential for offsite alternatives*

U-Battery Applications

Sector	Key application	Market Size 2035	Market drivers	Market Size 2050	U-Battery Target
Remote communities	Diesel/oil replacement	125-150 units	Regional electrification; wider adoption rates	+100 units	
High value mining	Asset life; economics; diesel replacement demanded	25 units	Wider adoption rates; learning curve economics	many units	
Industrial CHP	Replacing gas/carbon red.	175-350 units	Net zero targets; application of carbon tax	+30 units	
Hydrogen economy	Poly-generation for transport and energy storage	75-100 units	Net zero targets; 18% of final energy demand by 2050	Order of magnitude higher than 2035 est.**	
Data centres	Payback over short life	50 units	Gig-economy growth	+40 units	
Low value mining	Asset life; economics	30 units	Wider adoption rates; Learning curve economics	+20 units	
Desalination	Remote location	25 units	Population growth; climate change	+110 units	
Flexible baseload	LCOE competitive gen.	100-190 units	Wider adoption rates; Learning curve economics	+110 units	
Nuclear power back-up	Safety/life extensions	230 units	NPP growth; new nuclear countries	+30 units	
Strategic military	NATO requirements	60 units	Wider adoption (50% rate); higher defence spending	+60 units	✗
Total estimated potential		**~900-1,200 units**		**+ ~500 units + 1,000 H_2 overlay**	

* Delivered by increased adoption and/or market growth beyond 2040. Default growth is EIA 1% p.a.

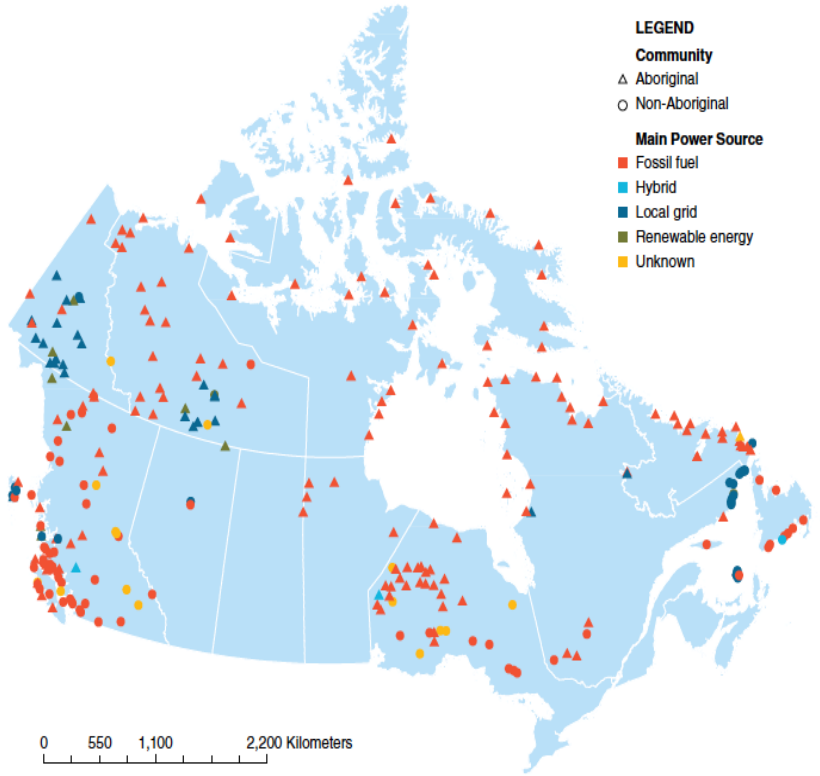
** Up to 1,300 units based on increase adoption of hydrogen to decarbonise the transport sector; for which MIT foresees a global demand of 1,315GWe for nuclear capacity

Source: Internal Urenco review of market studies by Nuvia, Collinson Grant, NRCan, Aurora, University of Manchester

Application: Remote communities and mines

The opportunity:

- U-Battery's modularity and unique capabilities, make it significantly adaptable to meet broader local needs in remote communities and off-grid location, such as mining operations. Typically energy costs are 2-4 times as high as UK.
- In Canada, remote regions facing higher food and energy costs could see these significantly reduced and low-carbon sustainable energy generated for these diesel-dependent communities
- Improve the competitiveness of Canadian mining operations in remote areas like Ontario's Ring of Fire and other parks of Northern Canada, by accelerating their transition away from diesel.
- U-Battery could provide a cheaper, green electricity solution for remote communities and mines reliant on diesel, which is transported via air freight.
- Natural Resources Canada has identified 600 diesel generators for remote communities and mine sites that could be replaced by U-Batteries
- While Canada is a first focus, there is a global market for remote energy supply



Indicative cost c. £100-200/MWe[1]
(vs flown in diesel c.£400/MWe)[2]

Source: Natural Resources Canada SMR Roadmap 2018

[1] Costings being refined through Phases 2 and 3 [2]BEIS report November 2016

Application: Decarbonisation of industrial heat

The opportunity:

- Providing clean process heat and electricity to the hard to decarbonise Foundation Industries, which currently contributing 10% of all UK CO2 emissions
- The sector is worth around £52 billion to the UK economy alone, provides 500,000 skilled jobs in 31,400 firms, mainly in North of England and Midlands
- We have identified a sizeable initial market
- Particular focus of UK Government, but with global potential
- Potential to scale up reactor size within inherent safety envelope to gain economies of scale for specific use cases

	Sector	Use
	Glass	Heating raw materials and annealing
	Paper	Drying paper
	Steel	Less likely – due to scale of demand

	Sector	Use
	Ceramics	Process heat need 220-650^{O}C for drying and spray drying
	Minerals	Cement production
	Chemical	Heating fluids at 450^{O}C

Indicative cost c.£100-120/MWh[1] – at 10MWth perhaps half at 50MWt and reducing further at larger scale

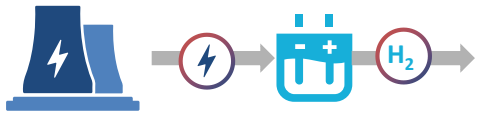
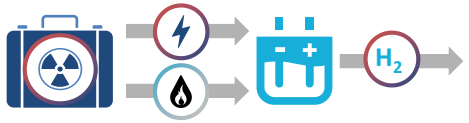
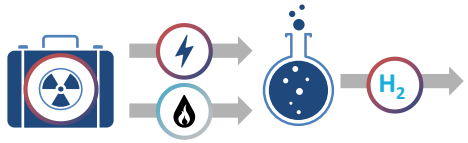
Source: Cranfield University, 2021; UK Research and Innovation, 2021

[1] Costings being refined through Phase 2 and 3

Application: Clean hydrogen production

Use of SMRs in high temperature hydrogen production could be more competitive than conventional nuclear powered low temperature solutions

U-Battery study underway with a leading UK solid oxide electrolyser developer

	Low-T electrolysis in dedicated NPP	High-T electrolysis in dedicated SMR	Thermochemical cycling in dedicated SMR
	Electrolysis (50-150 ºC) with electricity directly from conventional nuclear power plant (NPP)[1]	*High-T (600-850 ºC) electrolysis with heat & electricity directly from high-T SMR (HTSMR)[2]*	*TCC (600-850 ºC) with heat & electricity directly from HTSMR[3]*
H_2 production process chain	 NPP PEM/AEC	 HTSMR SOEC	 HTSMR TCC
Overall efficiency	20-30%	35-45%	25-45%
H_2 production cost €/kg	5.5 - 6.5	4 - 6	6 - 10
	• H_2 production sourcing fixed amount of NPP output through PPA • Nuclear costs based on current values, assumed to remain constant over time • AEM electrolyzer technology on-site on NPP	• H_2 production sourcing fixed amount of heat/ electricity output through PPA • Nuclear costs mainly based on projections from JAEA's HTTR reactor • SOEC electrolyzer technology close to SMR and off taker	• H_2 production sourcing fixed amount of heat/ electricity output through PPA • Nuclear costs mainly based on projections from JAEA's HTTR reactor • TCC costs based on projection for Copper-chlorine pilot plant
	Benchmark for low-carbon H_2 from nuclear as most mature technology	Good potential in mid term to increase competitiveness of nuclear low-carbon H_2	Despite high efficiency potential still out of the money due to technology immaturity

1. Source: World Nuclear Association 2. Source: JAEA 3. Source: General Atomics, University of Ontario

High maturity, tested in field · Mid maturity, significant uncertainties · Low maturity, R&D phase

UK Government Support

Department for Business, Energy & Industrial Strategy

UK Government has selected HTGR as AMR technology (July 2021)

- Following Royal Society report HTGRs are now being considered as focus for AMR demonstrator **£170m budget**.
- Recent "Call for Evidence" by 9 September reinforces the likelihood of HTGR selection.
- Budget is to cover supply chain and regulatory framework as well as direct reactor development costs
- HTGRs prioritized since they *"could help unlock the decarbonisation of several energy vectors such as efficient hydrogen production and industrial processes like steel, cement and paper production".*
- NIRAB has recommended further funding for AMR development in future spending periods

U-Battery is natural focus for Government initiative – it has the potential to be a "national endeavour"

- ✓ U-Battery is the only HTGR design of three projects currently funded under the AMR programme
- ✓ UK Government is aligned with U-Battery on key applications – hydrogen and industrial process heat
- ✓ BEIS are inviting U-Battery to propose a route forward with their funding

U-Battery is well placed.

Source: "Government progresses demonstration of next generation nuclear reactor" 29 July 2021