

Renewables and storage, markets and intermittency



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Four Questions

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1.

What contribution can renewables and storage make to powering the UK electricity grid?

2.

What storage technologies make sense for this role?

3.

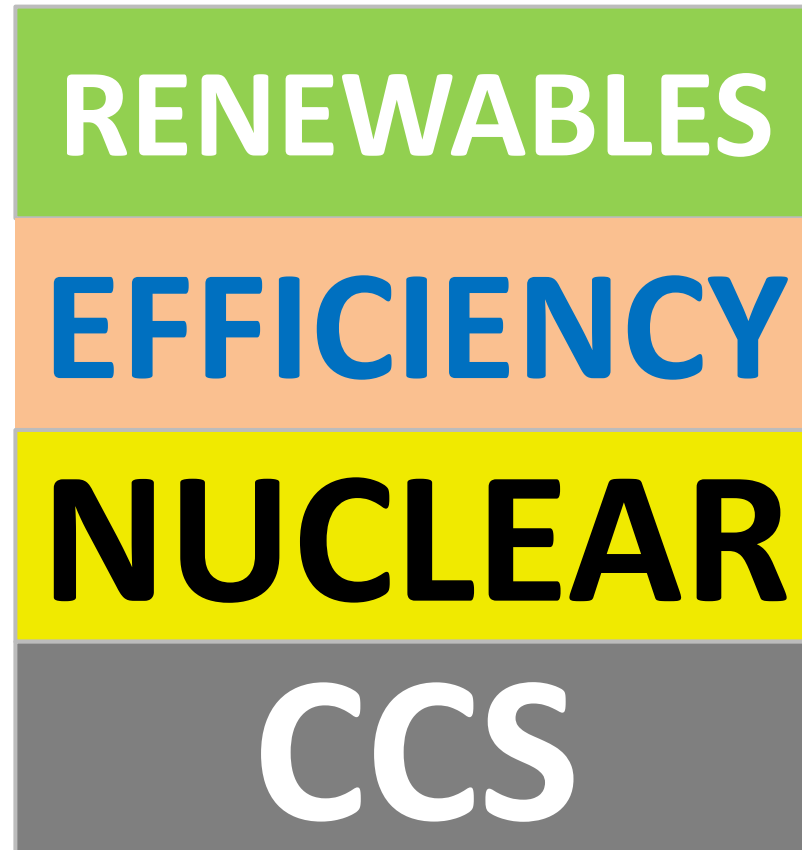
Under what market conditions might they be implemented?

4.

**What keeps the lights
on?**



Pathways to a lower carbon generation mix



Generation Issues

RENEWABLES

Intermittency! Cost!

EFFICIENCY

Penetration! Cost!

NUCLEAR

Safety! Capacity! Cost!

CCS

Capacity! Workable? Cost!

Notes from Another Island

Caribbean Island: Peak demand = X

Average demand = $X/2$

- PV rating = X
- Power storage rating = $X/4$
- Autonomy = 3 h (6 h @ $X/4$)
- Stable
- 30% fuel saving

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JUST
ONE
PROJECT

Sources of value in the UK

Absorbing the peak output:

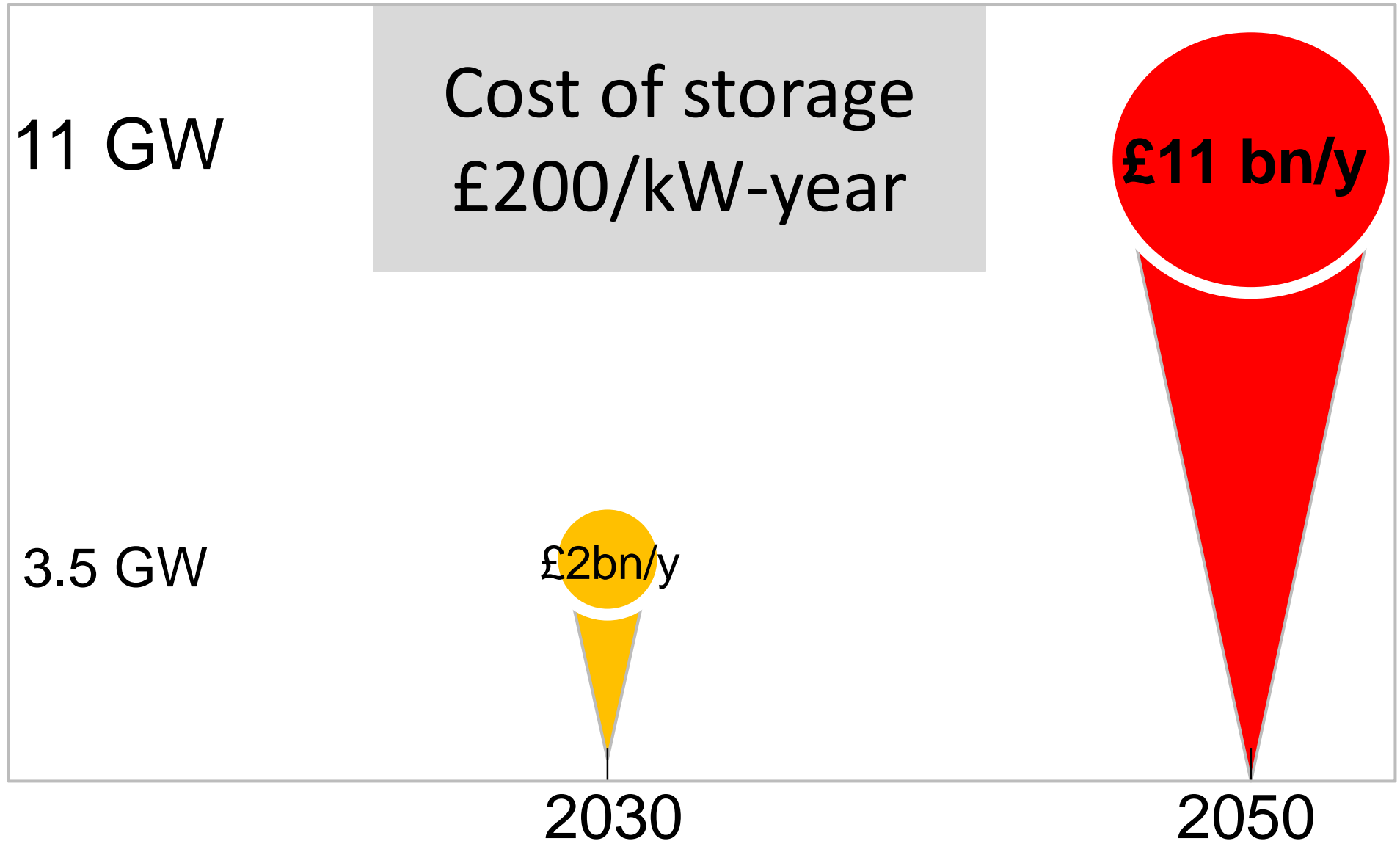
- Less curtailment of renewables

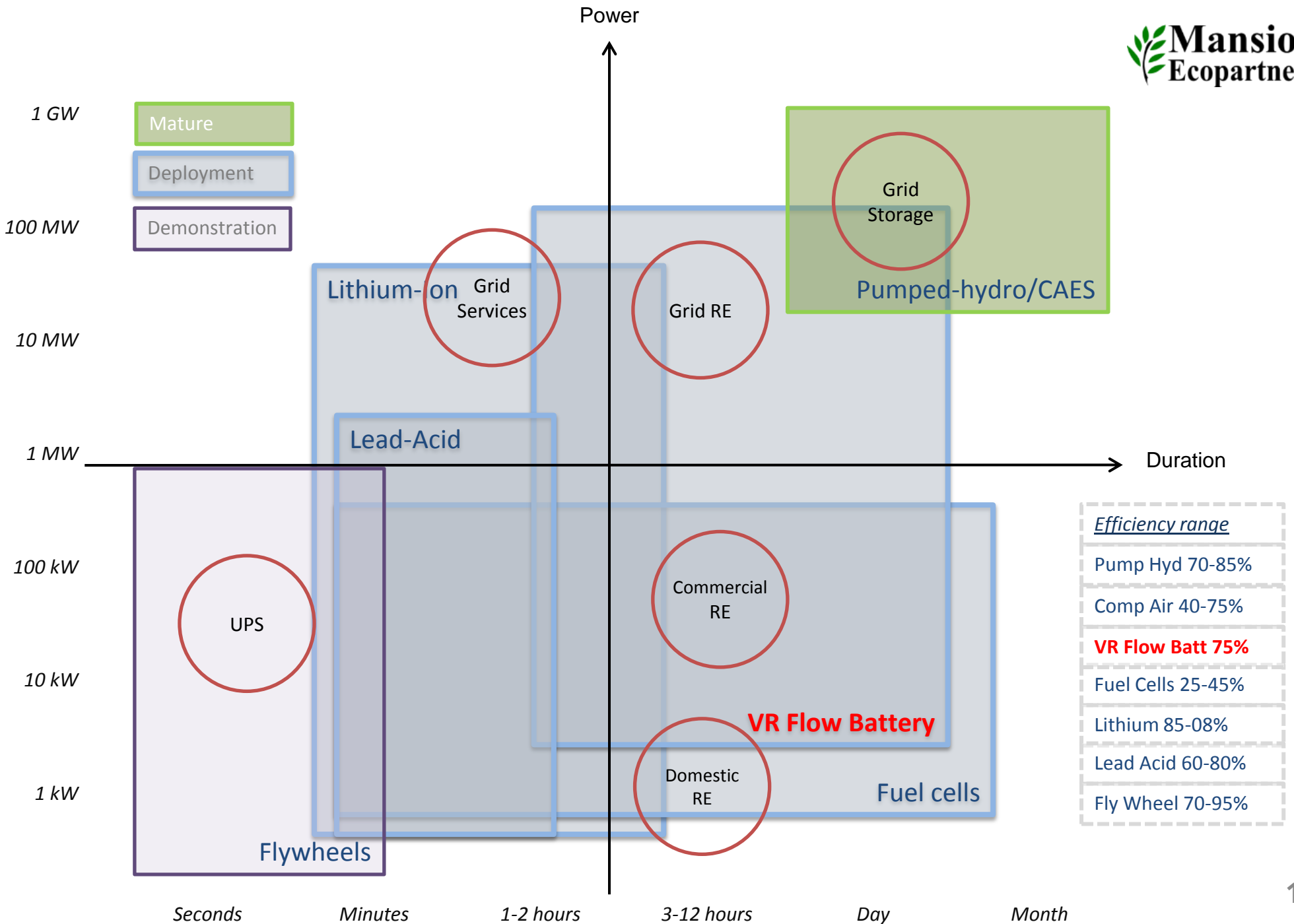
Meeting the peak demand:

- Savings in high cost CCS CAPEX
- Savings in distribution

Greatest value – distributed storage.

Value potential

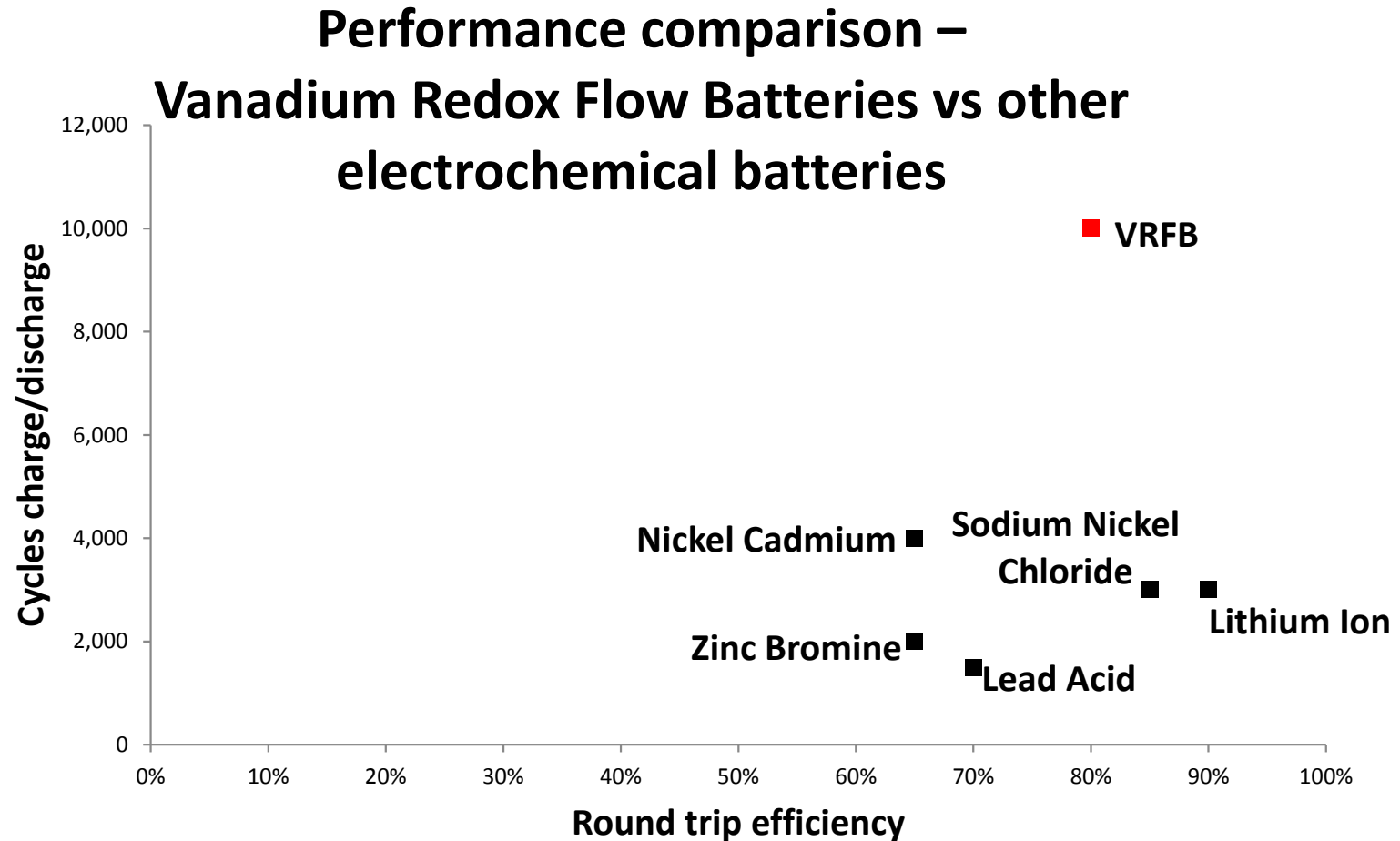




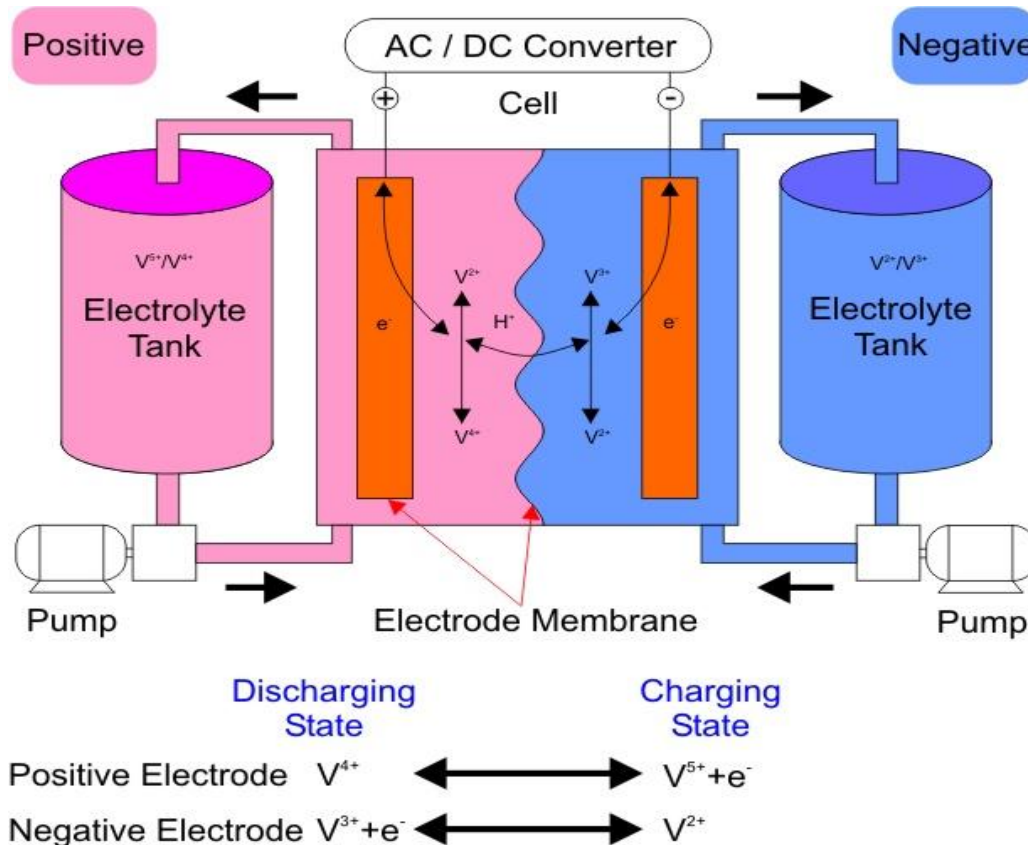
Which storage technologies?

Electrochemical batteries	Resources! Cost!
Thermal	Efficiency! Cost!
Compressed air	Efficiency! Cost!
Pumped hydro	Planning! Cost!

What storage technologies?



Vanadium Redox Flow Batteries



Key features for reliability

- **Power and energy independent** - scalable up to 10MW , 6+ hours duration
- **Very low maintenance** – Symmetrical Vanadium chemistry tolerates cross membrane mixing
- **Safe operation** – non flammable reactants
operating at ambient temperatures, environmentally sound, fully recyclable
- **Very long life** >10,000 cycles.
Electrolyte has 20 year life, reusable, with high residual value

Vanadium Resources

Mined: – 76,000 tonnes/year

Petcoke potential: 100,000 – 200,000 t/y

Identified resources – 63,000,000 tonnes

World demand for storage by 2050: 300 W-h/person,
equivalent to 14,000,000 tonnes vanadium.

UK market for storage by 2050: 400 W-h/person
equivalent to 160,000 tonnes vanadium.

Modular distributed power storage

60 kWe/3 hour battery unit

Augment to 90 kWe
for 15 minutes

Link in 1 MWe sets

Site maintenance

Remote monitoring

20 year expected life



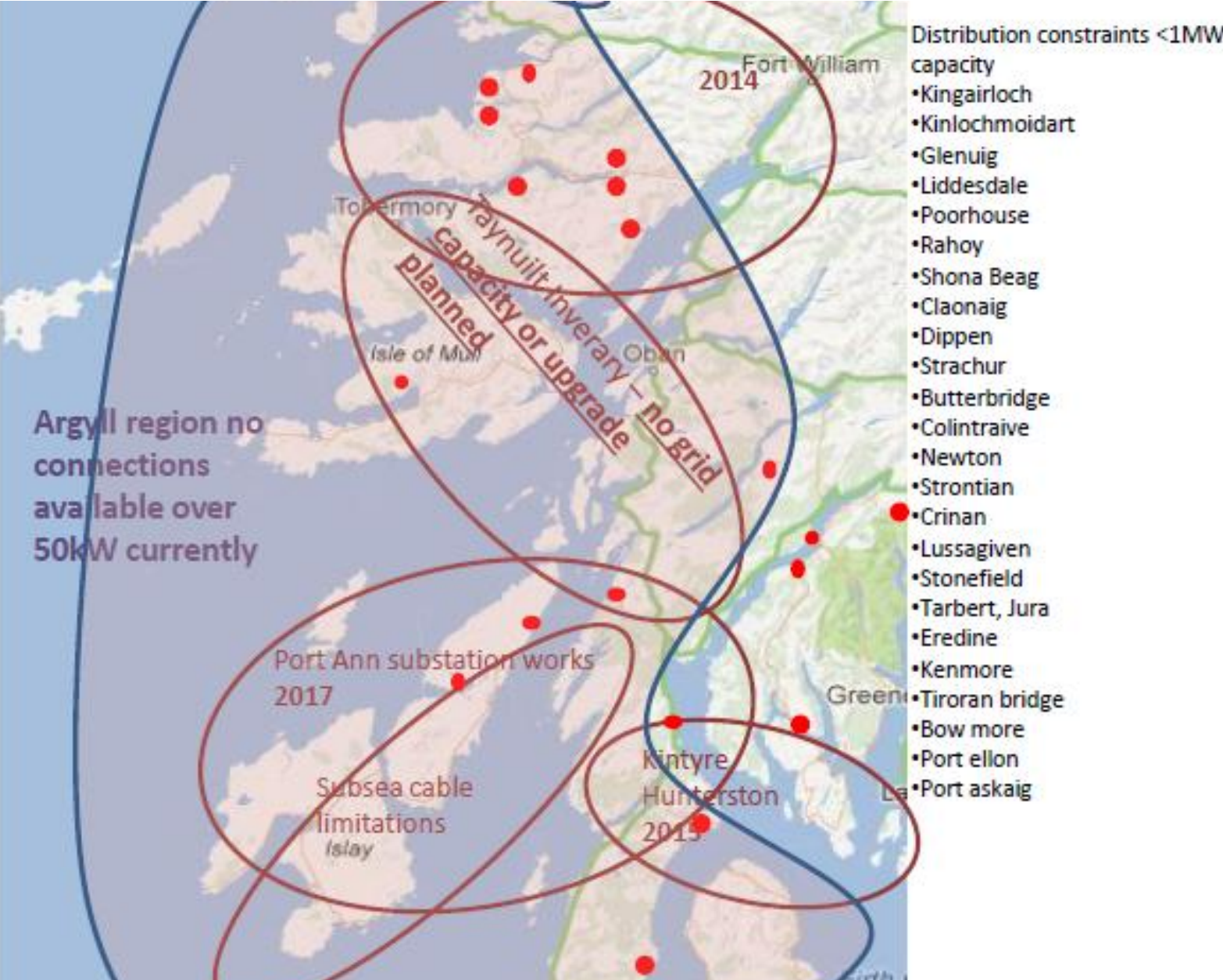
Can Vanadium Flow Batteries provide grid-scale storage for distributed power storage?

- £200/kW-year will be achieved before 2030:
 - Design optimisation
 - Volume production
 - Recycled materials
- Excluding financing costs, £200/kW-year already achieved.

Market Conditions for Storage

1. Commitment to carbon reductions
2. High cost of CCS
3. Low cost of wind and solar
4. Low cost of storage
5. Rapid supply of storage
6. Market mechanisms reflect full value of storage

Start where the grid is weak



Balancing generation

- Gas based generation – conventional
- Coal based generation with CCS
- Efficiency
- Demand-side management
- More interconnection
- Nuclear

Renewables, storage and the rest

- Addition of storage will tend to crowd out gas-fired CCS, due to lower cost of storage
- More than half of the UK generation capacity could be renewables by 2050
- Storage capacity $>4\%$ of grid capacity by 2050
- Storage matches wind variability to generation agility to preserve grid stability.

Advantages of renewables+storage pathway

- Rapid implementation
- Competitive
- Least regrets
- Home grown (more balance to the economy)
- Compatible with alternatives if these are also successful

One Big Happy Battery

