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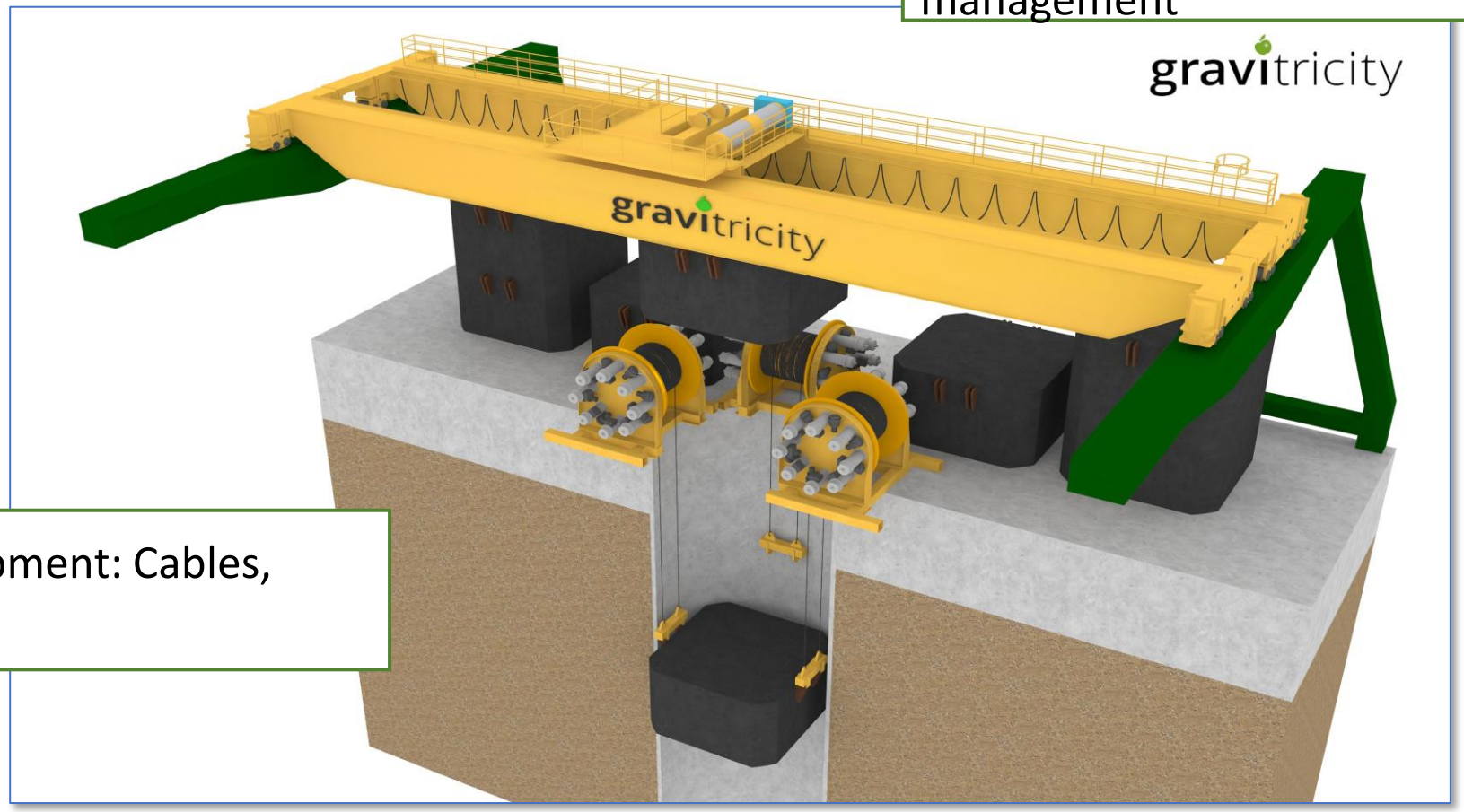
Versatile, fast response, long Life Energy Storage

Robin Lane
Commercial Director

World Bank Energy Storage Partnership
7th June 2022

Technology overview

Surface equipment - Heavy lift equipment / working as a generator in reverse / weight management



Underground equipment: Cables, weight and shaft

"Like hydro, but we don't need mountains or water"

"New engineering, new integration, but not new science"

Design of technology underpinned by scientific principle

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E=MGH… Energy = mass x gravity x height

2 design principles

Heavy weights

- Tonnes? ✗
- Tens of tonnes? ✗
- Need weights in hundreds of tonnes to generate interesting amount of electricity ✓

Big drops

- Cranes? ✗
- Buildings? ✗
- Going underground allows us to use the geology of the earth to hold up the weight* ✓

* Existing shaft depths may be 800m or 1km. New, purpose built shafts, at c.250m, will be less deep but will be larger diameter of 8m or more

Timeline of achievements & next steps

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2018-2021

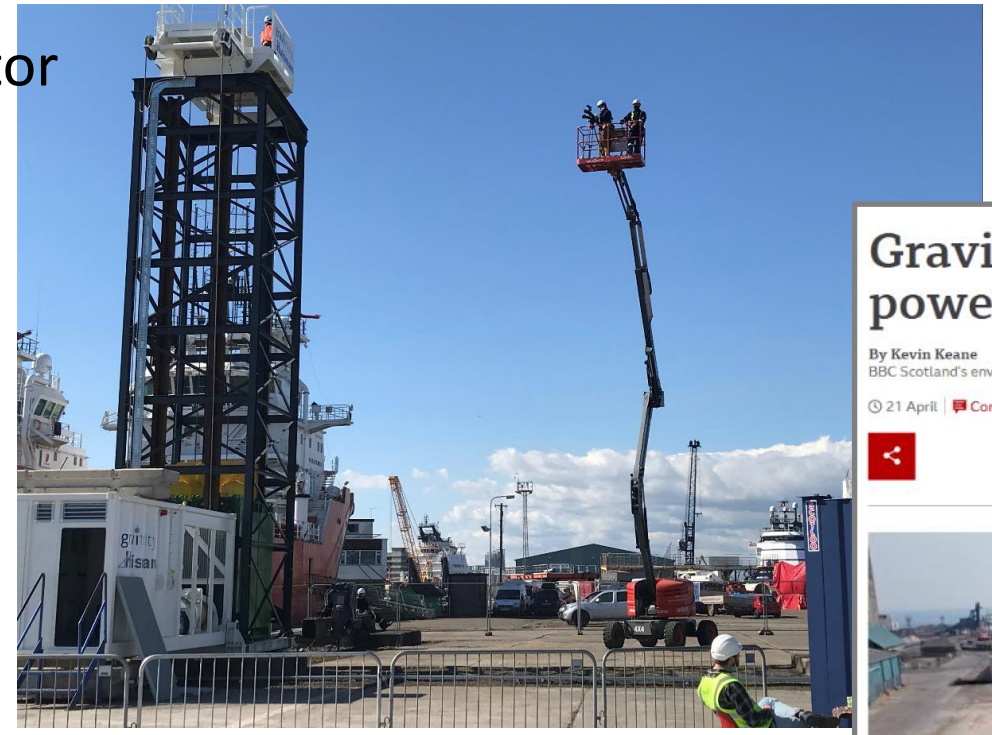
> £3.5m	Total R&D funding
> £4m	raised in equity funding
7	Patents filed (4 granted, 3 pending)
2	Independent studies by Imperial College London verifying levellised cost of storage over 25 yrs below Li-ion, CAES, Flow batteries
1	Grid connected, 250kW Concept Demonstrator validates technology capabilities (<s response, multi weight system)

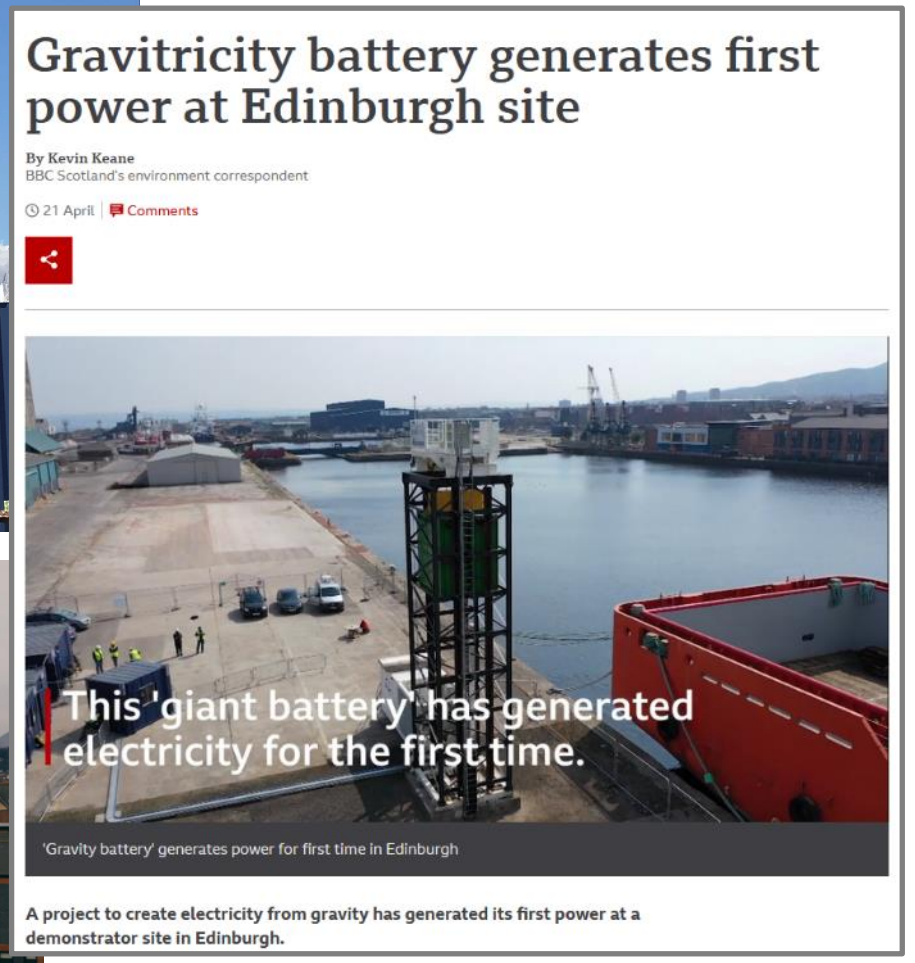
2021-'24

Full scale, 'first of a kind' commercial deployment

- Evaluation of potential sites underway in Czechia & Poland
- 4MW / 1MWh, single weight system designed to optimise revenues from balancing services
- Series A, Tranche 2, scheduled for 2022, seeking £6-£10m

250kW Concept demonstrator





Gravitricity battery generates first power at Edinburgh site

By Kevin Keane
BBC Scotland's environment correspondent

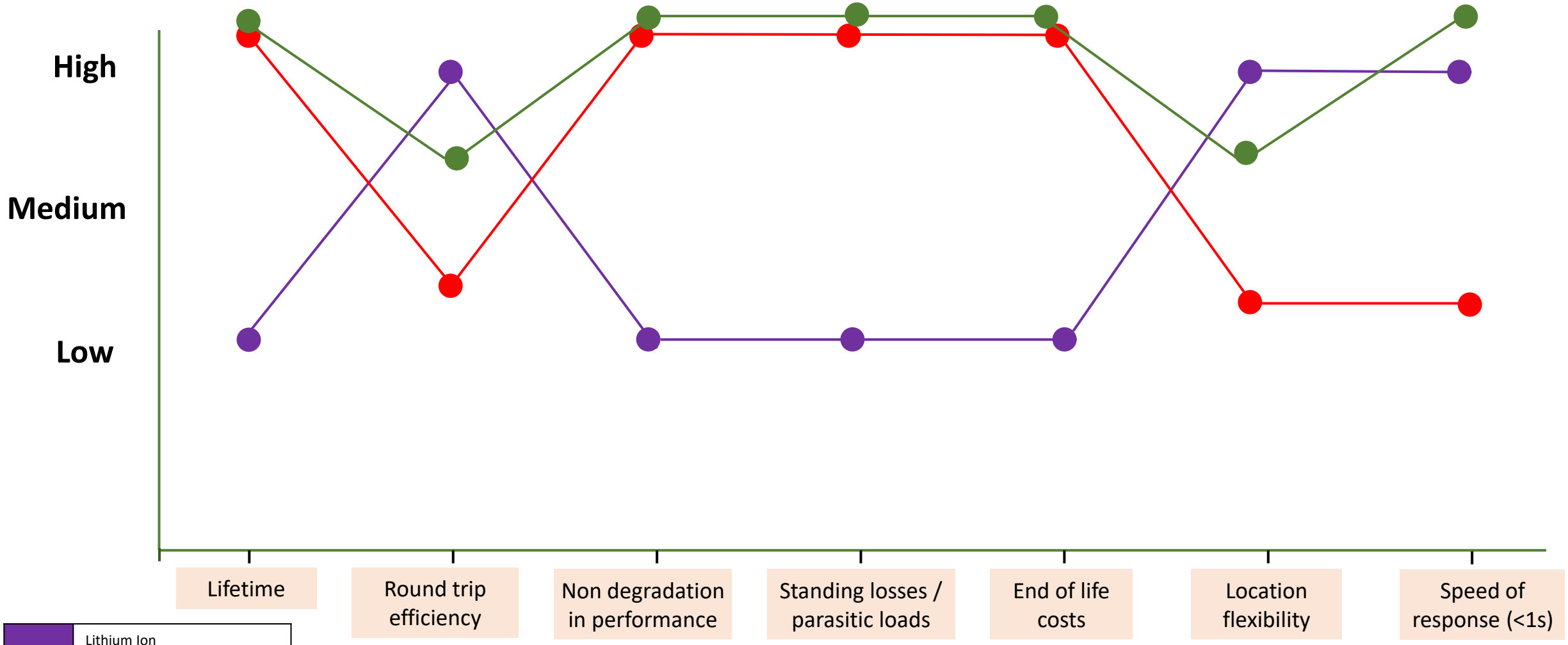
21 April | Comments

This 'giant battery' has generated electricity for the first time.

'Gravity battery' generates power for first time in Edinburgh

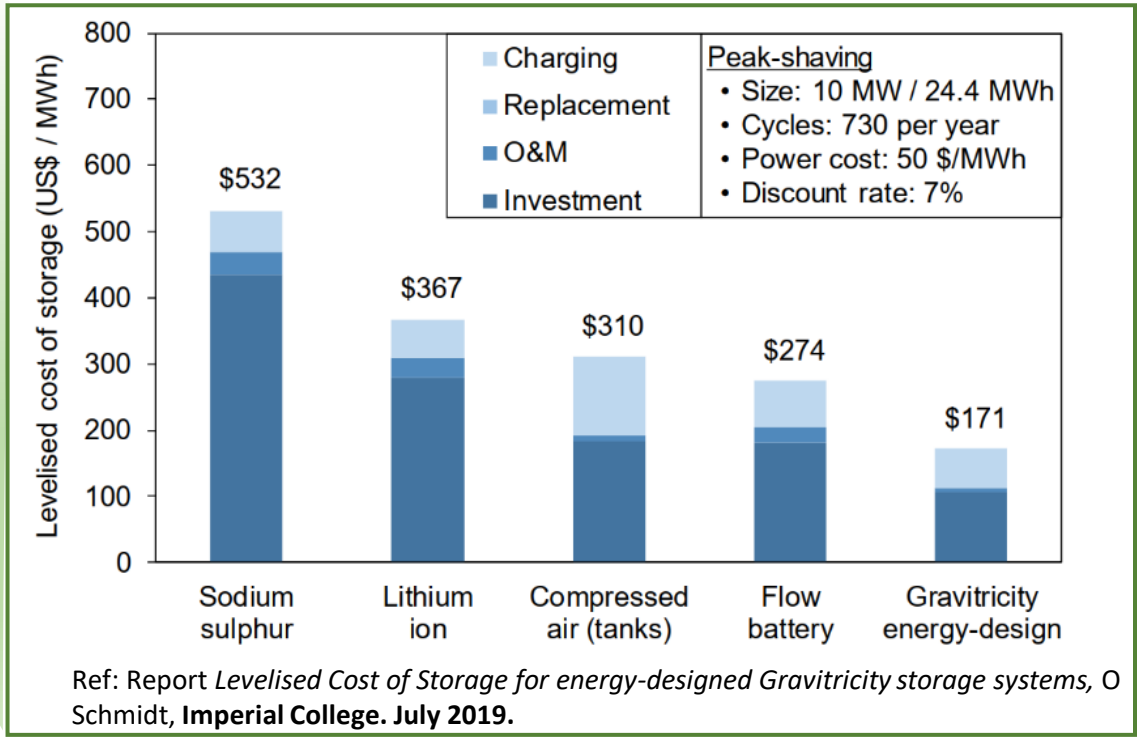
A project to create electricity from gravity has generated its first power at a demonstrator site in Edinburgh.

Gravitricity vs. alternative ES technologies



Gravitricity vs. alternative ES technologies

Category	Feature / benefit	
Economics	• High efficiency, every year (no degradation) • Long life • No standing losses or parasitic loads	✓
Performance	• Rapid response (<1s) for lucrative fast response markets • Versatile energy / power ratio (15 mins – 8 hrs)	✓
Implementation	• Low embedded carbon footprint (no ore mining) • No explosive chemistry • Small footprint	✓



Ref: Report *Levelised Cost of Storage for energy-designed Gravitricity storage systems,* O Schmidt, **Imperial College. July 2019.**

Long-life, reliable, energy storage for Critical National grid support infrastructure

LCOS = (Capex (initial) + Capex (replacement) + O&M + Charging cost) / units generated; n.b. no end of life costs are included

Behind the year on year growth, we see three key trends changing the shape of the energy storage market in years to come

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Key trends in global large scale energy storage market

Longer duration

- Increased renewable penetration will drive need for longer duration energy storage – average duration of 1.8 hours in 2013 has already grown to 3.3 hours
- Ancillary services … daily peak shaving … solar & storage for 24/7 power

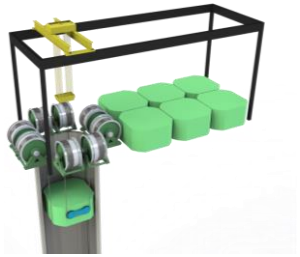
Longevity of service

- Growing vision of storage as an infrastructure asset, with associated requirements for asset lifetime
- Short term opportunism vs. long term strategic

Higher cycling

- Storage increasingly used to balance fast changing, localised variations in supply & demand
- Fast changing = need high cycling

Our Single weight system has been focus to date; other variants entering product roadmap



Variant	Description	TR Level	Existing / new mine	Work to date	Work underway
1. Single Weight	Gravity based electricity storage deploying single weight	5/6	Both	• Imperial College (2018) validates cost competitiveness • Concept demonstrator	Actively assessing sites for 'first of a kind' full scale commercial deployment
2. Multi weight	Gravity based electricity storage deploying multiple weights	4/5	New	• Imperial College (2019) validates cost competitiveness	Funded FEED development now under way
3. Single weight w/ hydrogen	Mine shaft deploys single weight system and stores hydrogen	3	New	Preliminary analysis undertaken	Working with Arup to develop FEED (BEIS Funded project)

Other possible variants include interseasonal heat storage, and adaptations for open cast mines, boreholes and raised bore mining

Targeting four markets with distinct use cases, customers and areas of value

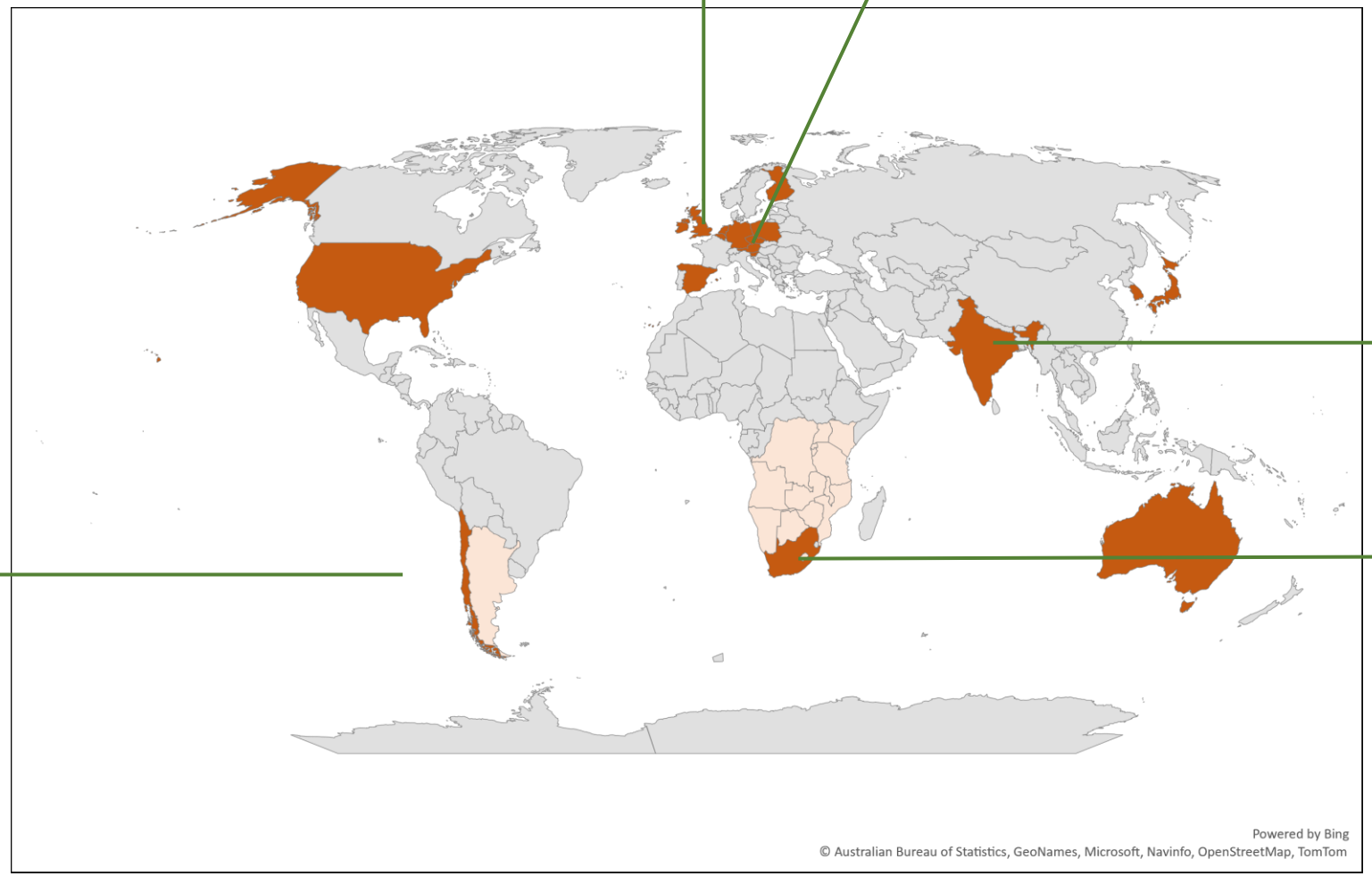
	Description	End Customer	Value to End customer
 **1. Grid services**	Power or energy for grid balancing & frequency regulation	• DNOs / TSOs	• Ensuring quality & security of supply • Longevity of operation
 **2. Co-location**	Coupling storage and large scale renewable generation at same site	Solar farm owners & operators, asset optimisers	• Time shift solar supply to high price peak periods • Reduced connection costs • Revenue stacking (voltage control)
 **3. Commercial & industrial**	Supporting industrials to decarbonise operations	• Mining • Oil & Gas • Data centres	• Reducing grid demand (Triad or similar) • Resilience / reliability of supply • Ancillary service income
 **4. Energy Access**	Designed into mini grids delivering energy access to rural and off grid communities	• Utilities • Mini grid developers	• Mini grid integration • Improves energy access to off grid communities, esp. during non daylight

* Connection costs based on capacity not throughput, which means developers have to choose between having to curtail at times or paying costs for a capacity they rarely use. Particularly acute with solar, with c. 12% load factor (av. output / peak output)

Selected use cases & local demand drivers support selection of key geographies c

LD FEED Study underway

Site evaluations underway. Probable site for first full scale deployment



- Feasibility study underway

- Feasibility study underway

- IUK funded EC7 feasibility study now complete
- Discussions ongoing with mine owners, & other stakeholders

Secondary target markets

Primary target markets

Is Energy Storage a format war?

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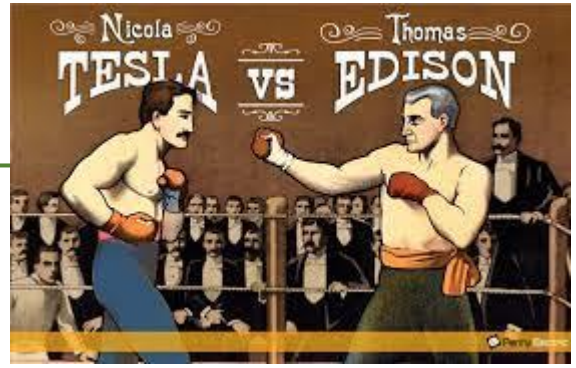
Format wars – one problem, two solutions

1890's



1980's

1990's

Is Energy Storage a format war?

1. At Gravitricity, we don't think so!
2. Identifying characteristic of energy storage is the variance in requirements:
   - Duration
   - Energy & Power
   - Location
   - Conditions
   - High / low cycling
   - Importance of efficiency
   - Durability and longevity
   - Capex vs opex … and more

Different requirements = different technology solutions

Thank you

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