



# gravitrlicity

Czech Energy Storage  
Frenštát Project Site Meeting  
28<sup>th</sup> April 2022

**CONFIDENTIAL**

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# Introduction / úvod



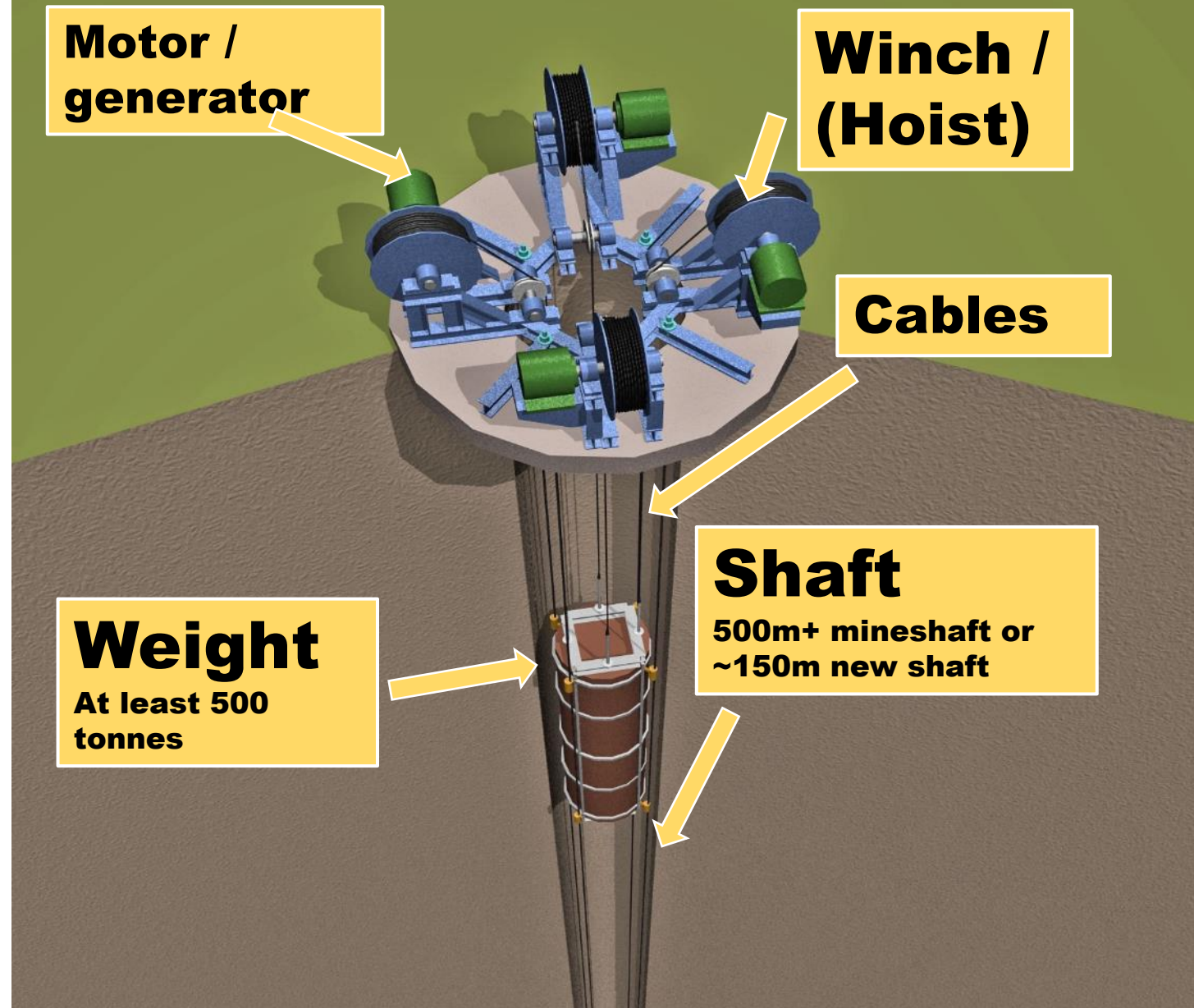
Topics	Areas covered
1. Gravitricity Background	<ul style="list-style-type: none"><li>• Technology &amp; Team</li><li>• Concept Demonstrator</li><li>• USPs</li><li>• Regions that we're working in</li><li>• Company achievements and next steps</li></ul>
2. Frenstat Project Vision	<ul style="list-style-type: none"><li>• Project vision</li><li>• How would a project be structured</li><li>• Additional project opportunities – Co-location / Heat / Research?</li></ul>
3. Technical Solution (Prototype)	<ul style="list-style-type: none"><li>• Performance criteria</li><li>• What does it look like?</li><li>• Space to be occupied at surface?</li><li>• Project Risks?</li></ul>
4 Market Insight	<ul style="list-style-type: none"><li>• Applicable Markets for Gravitricity</li><li>• CZ Market intel</li></ul>
5. Project Benefits	<ul style="list-style-type: none"><li>• Project Benefits</li><li>• Benefits to CERKA Village</li></ul>
6. Additional Details	<ul style="list-style-type: none"><li>• Timescales</li><li>• Funding</li></ul>

Témata	Pokryté oblasti
1. Gravitricity pozadí	<ul style="list-style-type: none"><li>• Technologie &amp; Tým</li><li>• Demonstrátor konceptu</li><li>• USP – jedinečnost společnosti</li><li>• Regiony kde pracujeme</li><li>• Úspěchy společnosti a další plány</li></ul>
2. Vize projektu Frenštát	<ul style="list-style-type: none"><li>• Vize projektu</li><li>• Jak by byl projekt strukturován</li><li>• Další příležitosti projektu – Společné umístění / Teplo / Výzkum?</li></ul>
3. Technické řešení (Prototyp)	<ul style="list-style-type: none"><li>• Výkonnostní kritéria</li><li>• Jak to vypadá?</li><li>• Potřebný prostor na povrchu?</li><li>• Rizika projektu?</li></ul>
4. Přehled trhu	<ul style="list-style-type: none"><li>• Trhy vhodné pro Gravitricity</li><li>• CZ Market Intelligence – informace o trhu</li></ul>
5. Přínosy projektu	<ul style="list-style-type: none"><li>• Přínosy projektu</li><li>• Přínosy pro projekt CÉRKA</li></ul>
6. Další detaily	<ul style="list-style-type: none"><li>• Časové osy</li><li>• Financování</li></ul>

# 1. Gravitricity Background

# The Technology

- Mechanical energy storage using gravity in vertical shafts
- Up to **20MW** Peak & up to **8 hours** duration
- Offers circular economy benefit for closing mine sites





# Gravitricity



- HQ: Edinburgh, Scotland
- Successful Concept Demonstration in 2021
- 7 Patents applied for (4 granted to date)





# Gravitricity Team



Peter Fraenkel



Martin Wright



Charlie Blair



Juliet Davenport



Robin Lane



Simon Wright



# 250kW Demonstrator

Built under collaboration  
with lifting equipment  
partner Huisman



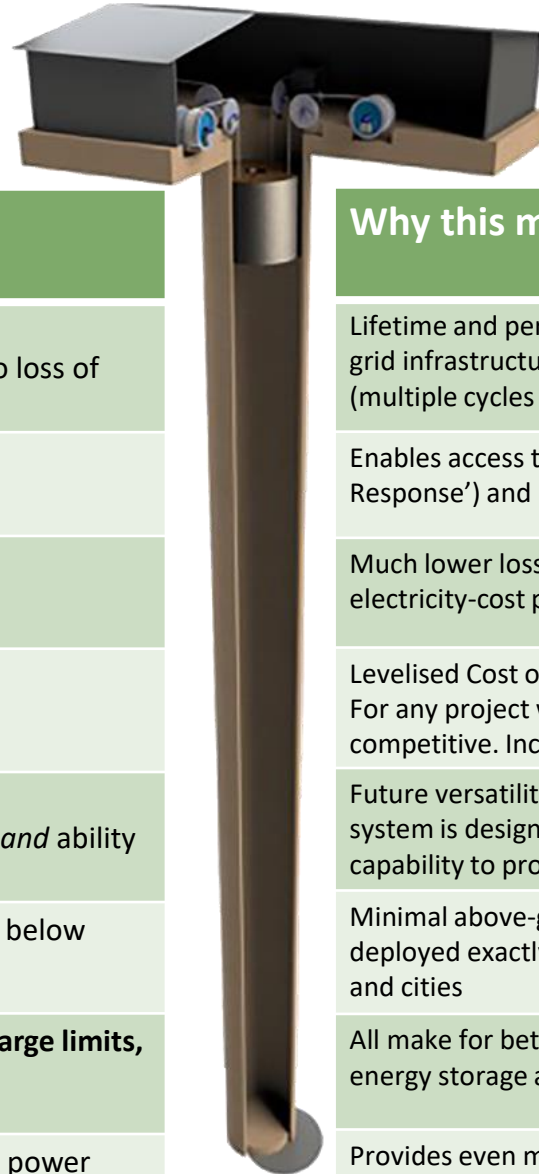
## Elements Tested:

1. MECHANICAL SYSTEM COMPETENCE
2. SAFETY SYSTEMS AND LIMITS
3. ENERGY STORAGE FUNCTIONALITY + RATED SYSTEM POWER
4. VARIABLE OUTPUT POWER
5. SPEED OF RESPONSE
6. POWER FACTOR





# Gravitricity vs alternatives



## Technical Characteristics (USPs)

**Extremely Long life – storage as infrastructure asset**  
(25+ years, 75,000+ cycles until cable replacement with no loss of performance)

**Rapid response:**  
Full rated power <1s

**High efficiency:**  
80-90%. As good or better than all alternatives

**Low levelised (lifetime) cost of storage**  
Potentially less than half the cost of Lithium Ion batteries

**Versatile infrastructure.**  
Flexible power to energy ratio (15 min to 4+ hour output) *and* ability to store gases or heat in same infrastructure.

**Small footprint:** <30mx30m for 8MW facility. Can be sunk below ground. No locational constraint at new-shaft sites

**No parasitic loads, no standing losses, no depth-of-discharge limits, no explosive chemistry risk and no rare materials**

**Unique capability to store fuel gasses and heat alongside power storage**

## Why this matters

Lifetime and performance characteristics are like other components of electricity grid infrastructure. Cyclability enables ‘stacking’ of multiple revenue streams (multiple cycles per day).

Enables access to highest value revenue streams (i.e. ‘Enhanced Frequency Response’) and rapid-reaction backup power

Much lower losses than PHS or CAES. Enables multiple daily cycles with minimal electricity-cost penalty

Levelised Cost of Storage (LCOS) is the key metric for comparing storage options. For any project with a duration of more than 10 years Gravitricity’s LCOS is very competitive. Including for new-shaft projects.

Future versatility is essential as energy storage markets are evolving. Gravitricity system is designed so that modular units can be added at later dates, and has capability to provide multiple services.

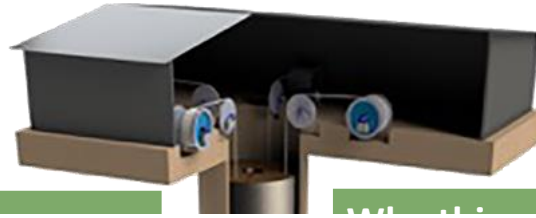
Minimal above-ground disruption. Very important at new-shaft sites, which can be deployed exactly where storage is required, including constrained industrial sites and cities

All make for better long-term commercial project ROIs than chemical energy storage alternatives

Provides even more versatility to project developers and operators as energy systems evolve.



# Gravitricity vs alternatives



## Technical Characteristics

**Extremely Long life – storage**  
(25+ years, 75,000+ cycle performance)

**Rapid response:**  
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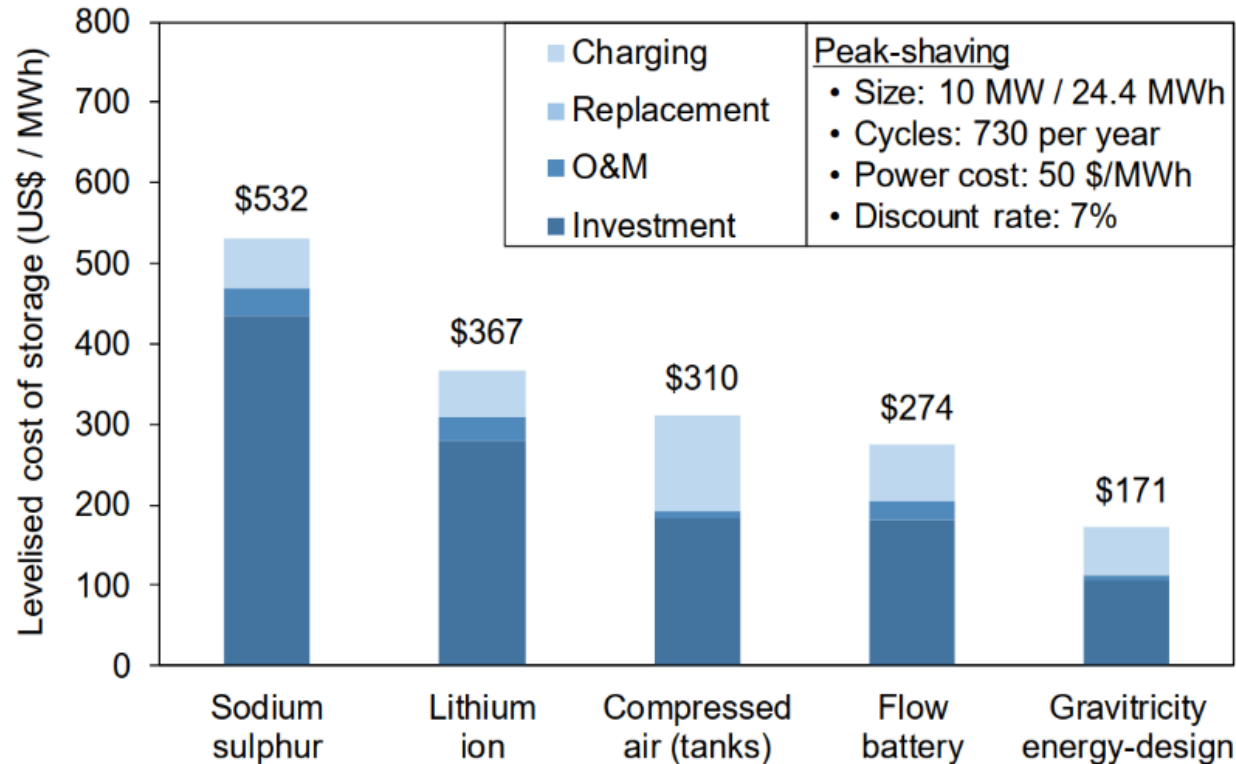
**Low levelised (lifetime) cost**  
Potentially less than half

**Versatile infrastructure.**  
Flexible power to energy to store gases or heat in

**Small footprint:** <30mx3 ground. No locational co

**No parasitic loads, no storage no explosive chemistry r**

**Unique capability to store fuel gasses and heat alongside power storage**



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

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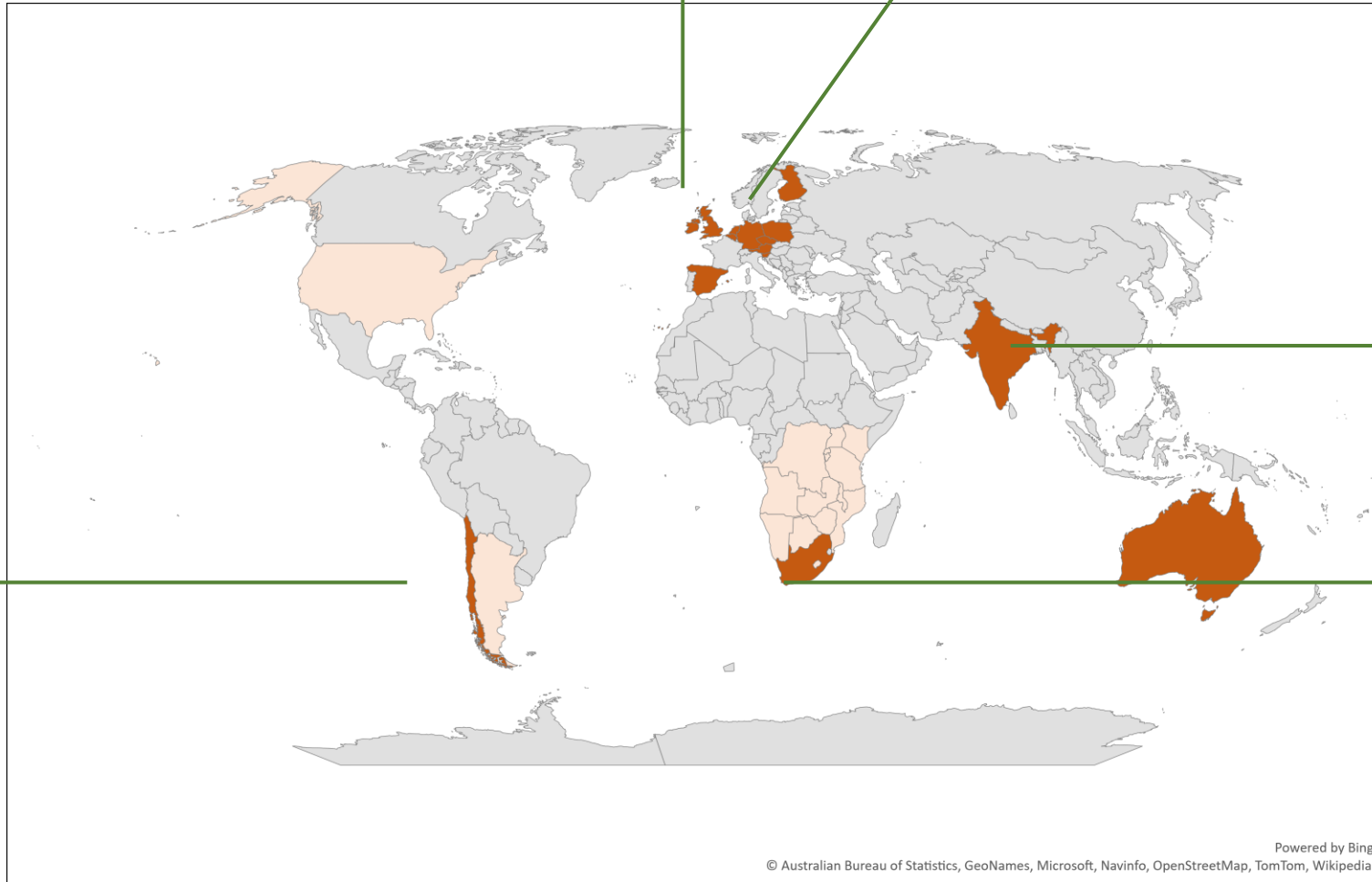
Provides even more versatility to project developers and operators as energy systems evolve.

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

FEED Study commenced in 2022



Talks on site leasing and deployment



• Feasibility study commenced in December '21

• Feasibility study commenced in December '21



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



Secondary target markets  
Primary target markets

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# Timeline of achievements & next steps

Gravitricity focus



Grants & commercial

IP protection

Funding

Pre- money Valuation

	2017 -2018	2019	2020	2021	2021-'24	2024-
	<ul style="list-style-type: none"> <li>£175k Energy Catalyst</li> <li>Collaboration agreement with winch partner Huisman (who have Czech Manufacturing facility)</li> </ul> <ul style="list-style-type: none"> <li>£650k Infrastructure Systems Innovation Grant</li> </ul>	<ul style="list-style-type: none"> <li>LCOS analysis proves commercial case</li> </ul> <ul style="list-style-type: none"> <li>£300k Energy Catalyst Grant</li> </ul>	<ul style="list-style-type: none"> <li>Energy Catalyst feasibility study focussing on South Africa, including market analysis and developing dialogue with mine owners</li> <li>Project Development work underway in UK, Central Europe and South Africa</li> </ul>	<p><b>250 kW Concept Demonstrator Completed:</b></p> <ul style="list-style-type: none"> <li>&lt; 1 s response time</li> <li>Multi weight system delivering continuous output</li> </ul> <ul style="list-style-type: none"> <li>Dialogues w/ 3 global mining companies;</li> </ul>	<p><b>Full scale, 'first of a kind' commercial deployment</b></p> <ul style="list-style-type: none"> <li>Work underway in Czechia – the country is currently closing mines offer ideal location for world first project.</li> <li>4MW / 2MWh, single weight system designed to optimise revenues from balancing services</li> </ul>	<ul style="list-style-type: none"> <li>i. Mineshaft projects:                             <ul style="list-style-type: none"> <li>Closing</li> <li>Disused mines</li> <li>Operating mines</li> </ul> </li> <li>ii. New shaft projects</li> </ul> <p>Revenues from merchant markets, balancing services and on site energy users</p>
	Patent filed - cable handling, counterweight configurations (Granted)	Patent filed for multi weight system for lower cost / energy unit (Granted)	Patent filed for suspended platform system (Pending)	Patent filed for ES system with fuel gas		
	£75k - Founder Equity	• £754k Seed	• £775k 'Seed Plus'	• £2.1m Series A 'Tranche 1'	• £10-20m Series A 'Tranche 2'	Growth Finance / Exit
		£1.2m	£4.265m	£10.66m		

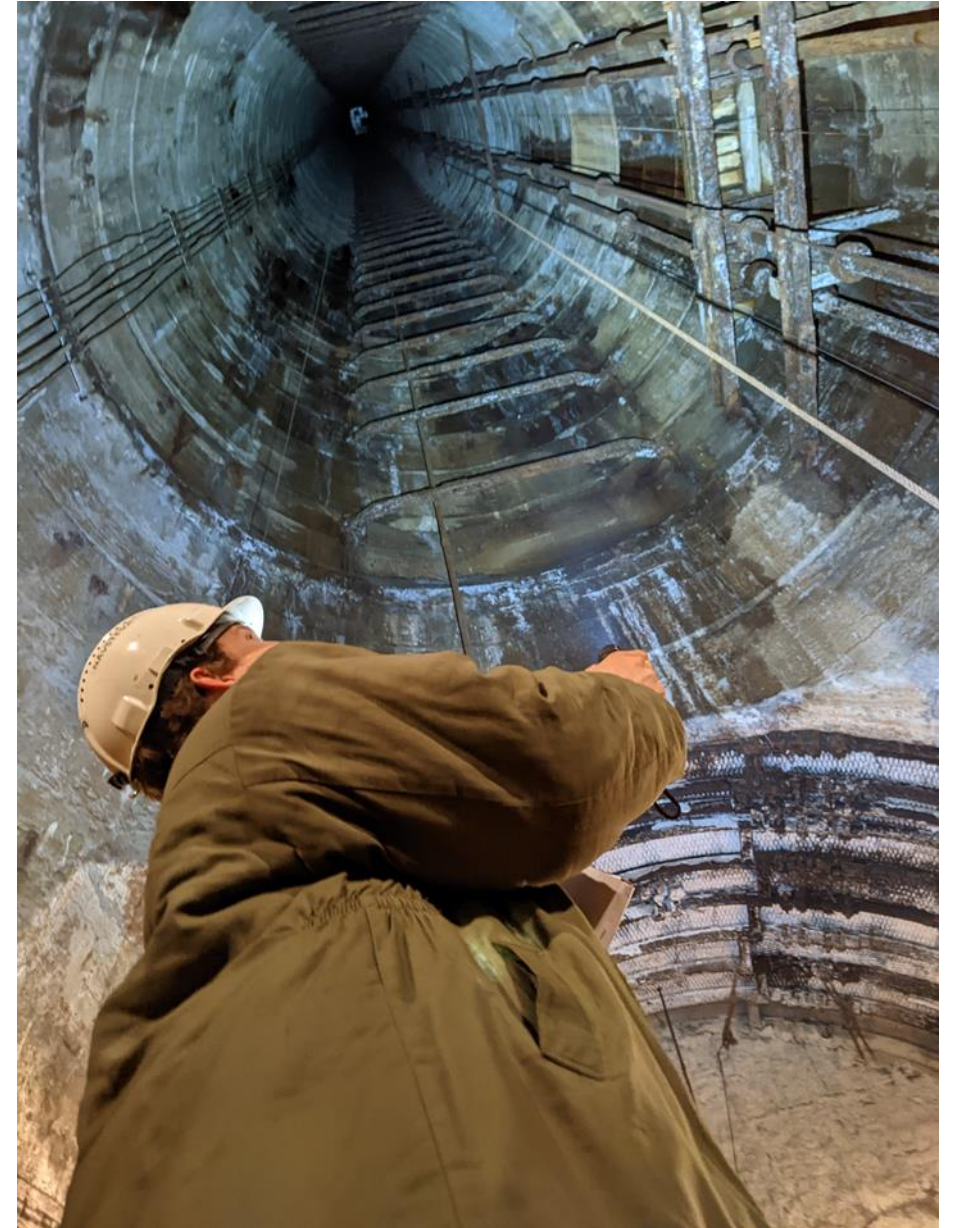
## 2. Frenstat Project Vision



# Frenstat Mine Overview

- 2x shafts in superb condition.
  - Proposed site for first full-scale Gravitricity project
  - Contact via site owner DIAMO
  - Possible second project using Shaft#2
- Site visit January 2022. Assessment:
  - Negligible methane or water Ingress
  - Bare shafts with wide cross sectional area
  - Depth and Dimensions attractive

04/05/2022



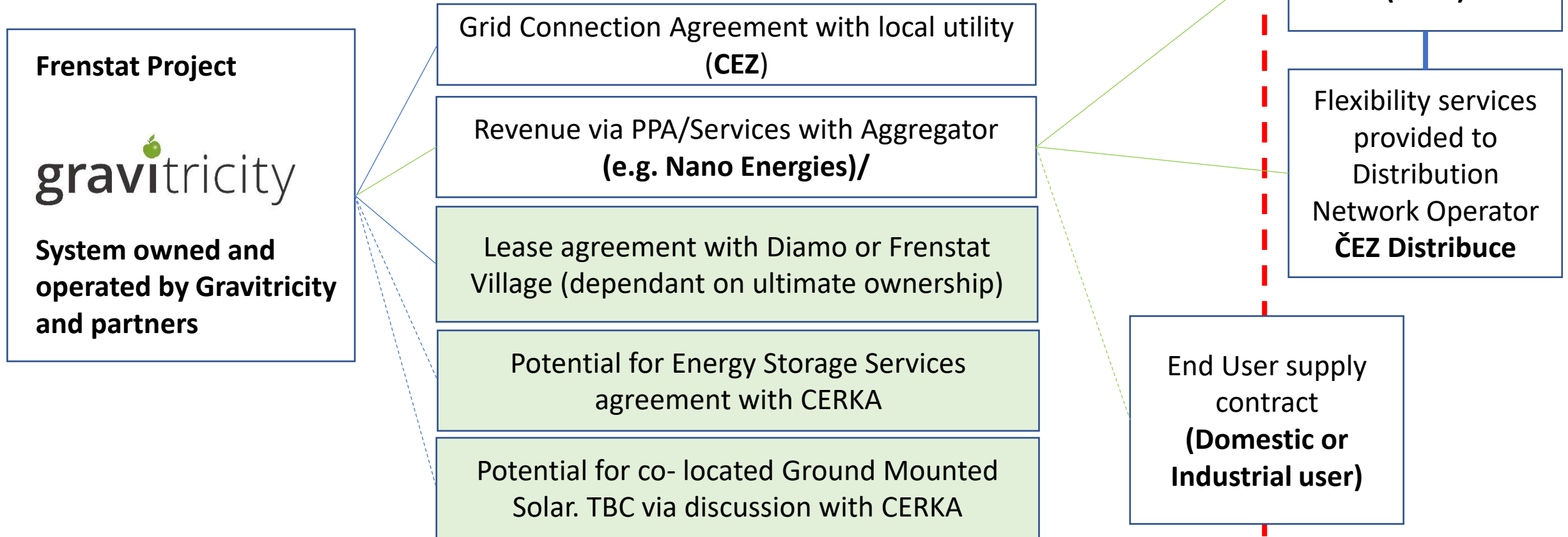
# Frenstat Mine Overview

- Mine area could conceivably be classed as “Underground Object” (tbc)
  - This may alter status in positive step away from Coal
  - Mine maintenance would need to be reviewed
- Three main areas for consenting including via:
  - District Mining Authority for the Moravian-Silesian and Olomouc Regions
  - Locally competent Building Authority
  - Energy Regulation Office
- Final consenting route to be confirmed following decision on whether site will transition to “Underground Object”.
- Commercial Model being developed – energy services provision through Nano-Energies or similar





# Frenstat Mine Energy Storage Project – Example Project Structure



**Other Mine Projects in Region?**

**Heat?** (Geothermal, Inter-seasonal)

**Integration with Research Facilities?**

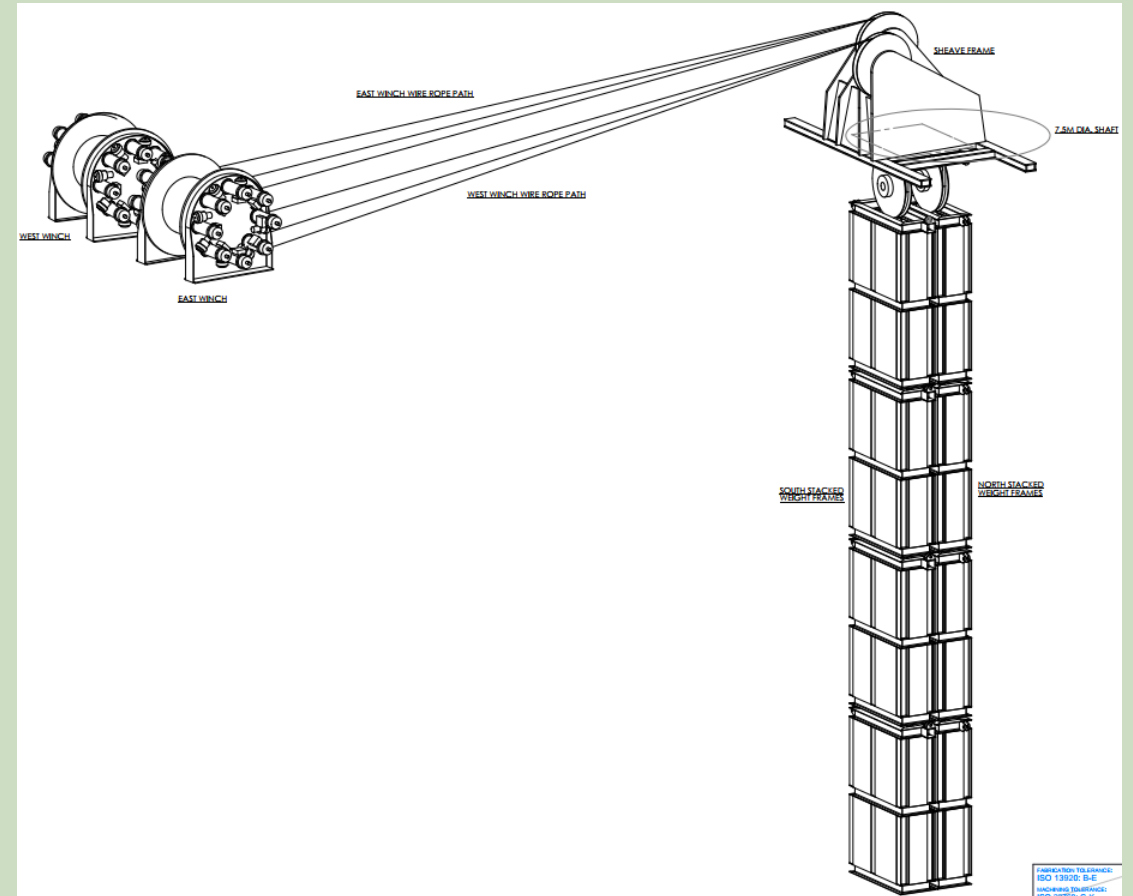
**Note:** Organisations to the right of red line will not deal directly with Gravitricity.

## 3. Technical Solution

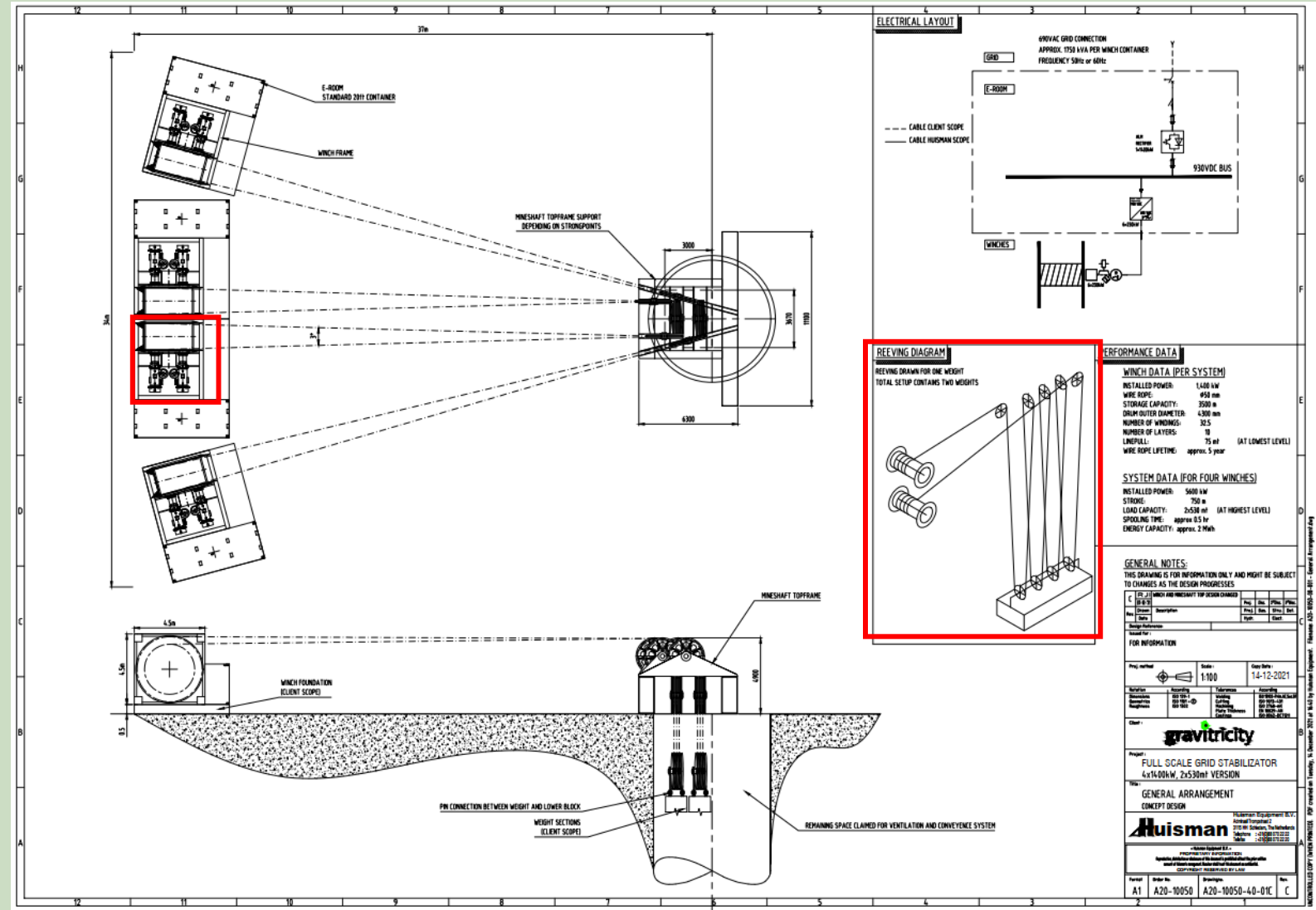
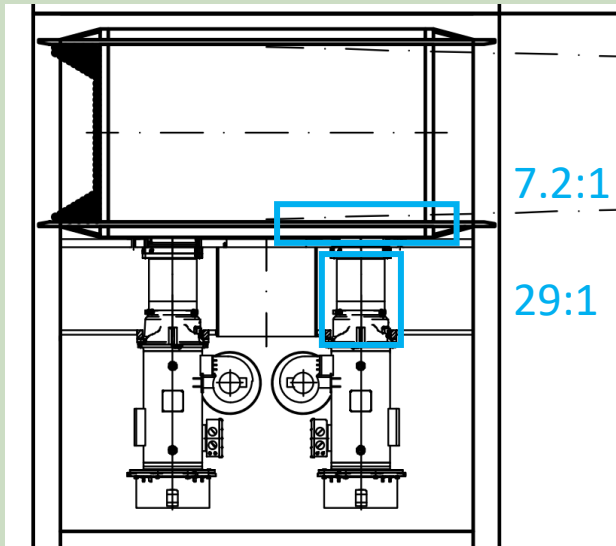
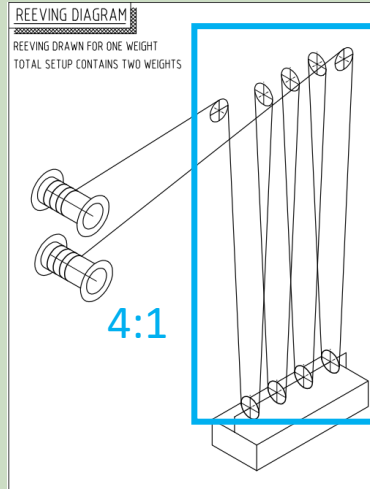


# Technical Solution

- Gravitricity preparing to deploy first full scale prototype project in mine shaft
- Storage Capacity:
  - Power = 4MW
  - Energy = 2MWh
- 2 x 550 t masses
- Shaft depth ~ 800 m
- Winch diameter 4.2 m
- Cable Diameter 50 mm



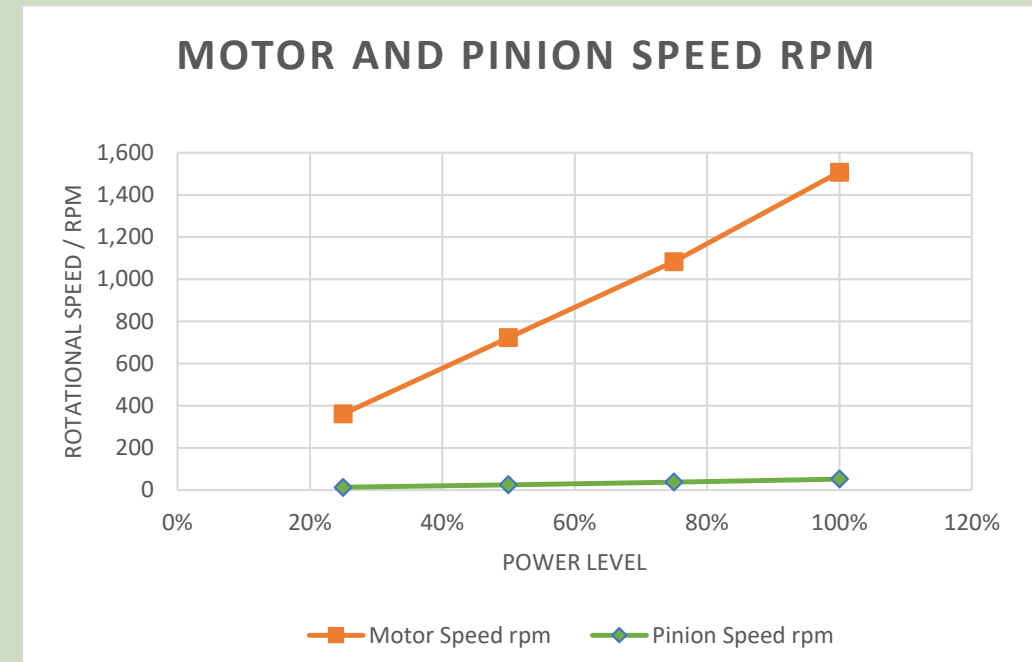
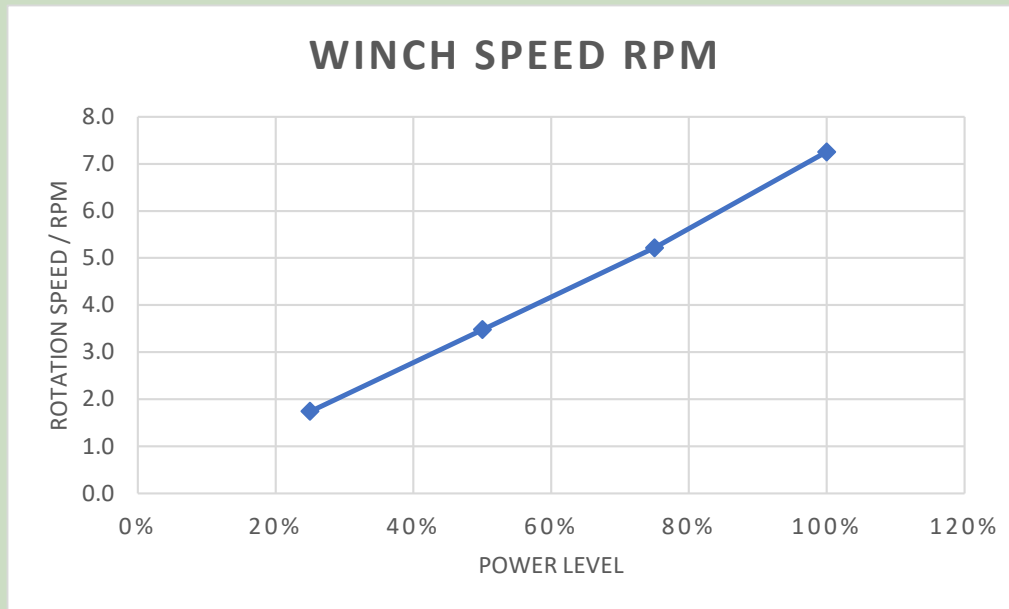
# Technical Solution





# Technical Solution

- Storage Capacity:
  - Power = 4MW
  - Energy = 2MWh



# Heavy Lifting with Huisman



2 x 400 t heavy lift system  
(to 3000 m depth)

4 x 1600 t system  
1 x 4000 t system

All manufactured at Huisman  
Sviadnov plant, near Ostrava



1 x 3000 t




# Gravitricity and Huisman



← → 🌐 huismanequipment.com/en/media\_centre/press\_releases

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10 March 2021  
**Edinburgh's gravity energy storage demonstrator takes shape**

A ground-breaking project to store renewable energy using gravity is taking shape in Edinburgh. The demonstration project – at Forth Port's Prince Albert Dock – is being developed by Gravitricity and Huisman, who aim to use underground shafts and massive weights to store large amounts of energy.

[Read more →](#)

← → 🌐 huismanequipment.com/en/products/renewables/gravitricity#specs

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## / gravitricity

While every day more renewable energy is added to today's power grids, the instability of the grids increases day by day as well. This instability is mitigated by frequency response applications. Gravitricity is based on a simple principle: raising and lowering a heavy weight in a deep mineshaft to store and release energy.

Huisman has been performing full electric lifting and lowering of large loads since 1984 and uses various solutions to stabilise the power system of offshore vessels (basically stabilising the power grid). Gravitricity and Huisman share the ambition to further develop this principle for land grids into a step changing solution. [Read more: www.gravitricity.com](http://www.gravitricity.com)

**250kW demonstrator**  
The 250kW energy storage demonstrator has been installed in Edingburgh in 2020. The system will demonstrate the Gravitricity working principle and will also confirm commercially important output characteristics and grid compatibility.

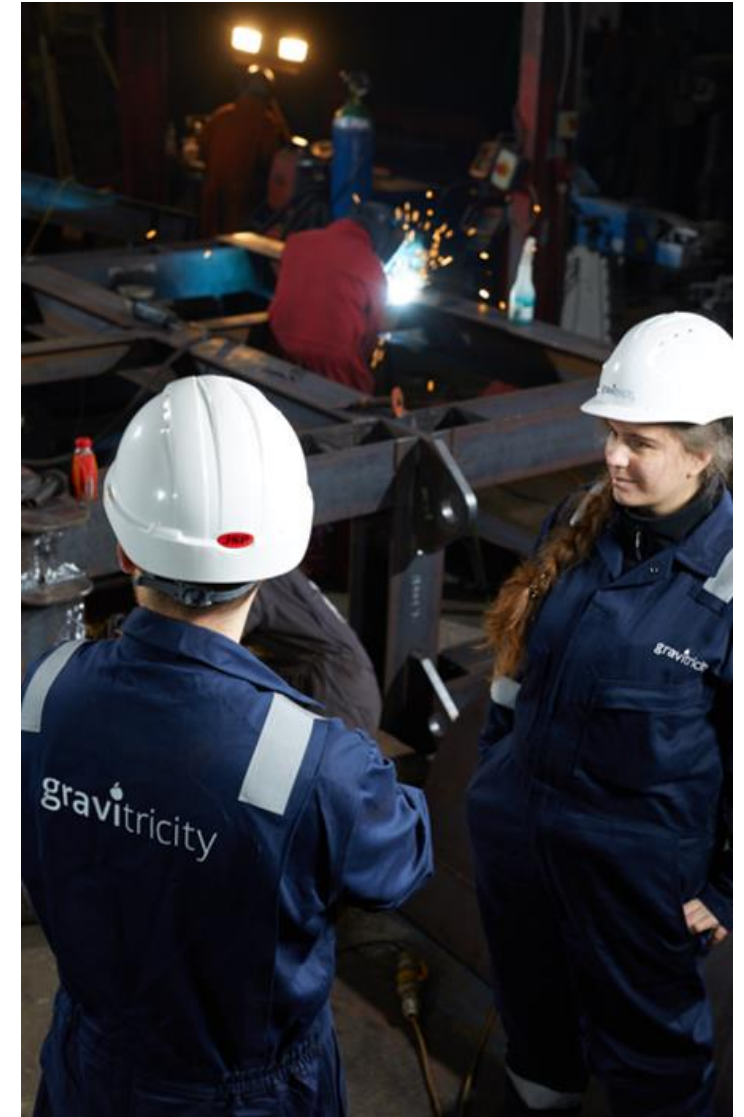
After successful testing, a full scale prototype will be installed in a European mineshaft by 2022.





# Innovation Risks

Risk	Impact	Risk Level	Mitigation	Residual Risk	Remarks /Next Steps?
First Full-scale System Build	Potential unforeseen major issue during construction	M	Gravitricity has already proven capability with demonstrator system; Key Gravitricity team have successfully delivered major 'first of a kind' technologies before. Huisman 50 Years plus of successful delivery of large scale lifting systems in challenging environments.	L	
Much heavier weights compared to conventional mining	Impractical rope and winch sizes?	M	Huisman have built cranes lifting over 10,000 tonnes (significantly greater mass than proposed here). Technical team have considered necessary equipment sizes which are of acceptable size.	L	Detail will be available in Frenstat Feasibility Report (currently being drafted)
New infrastructure fo planning process to consider	Potential for elongated / uncertain timescales	M	Planning route well understood and has potential to become further simplified if mine moves to "Underground Object" Status. Design phases clearly mapped out already and lead times well understood following demonstrator project.	L	Commence consultation with relevant consenting departments
Mine Backfilling	Mine backfilling not planned but if necessary in future, there could be significant disruption to CERKA Village	H	Shaft closure plan must be agreed before Gravitricity project can commence - Closure options may include capping, thus avoiding large volumes of material on site. (Capping also endorsed my Ministry of Circular Economy due lower material usage)	M	Draft shaft closure plan
Gas Protection Zone	System may require some infrastructure to be sited outwith Gas exclusion zone	H	Overall Space required in this scenario may increase from desired shaft head equipment only. Building size can be advised already and external finish can be aligned with CERKA architecture	M	Issue Surface Level GA showing building layout for further review alongside CERKA Plans
New type of Grid Infrastructure	Chance of CEPS compliance issues	M	Demonstrator was designed to comply with UK Grid codes. CZ Codes believed to hold many similarities. De-risking achieved through consultation with CEPS where necessary following completion of Grid CODE review.	L	Review of CEPS Grid CODE to confirm System suitability
Disruption to mine maintainance	Safety Risk	M	Mine maintenance schedule and associated infrastructure requirements will be agreed with competent body (i.e. Diamo). Potential for any above ground infrastructure to be redesigned to be more in keeping with CERKA architecture	L	Agree Future Maintenance Plan with all Parties







## 4. Market Insight



# Gravitrlicity target markets, use cases, customers and areas of value



Description	Customer	Value to identified customer
 <p><b>1. Merchant trading &amp; grid balancing</b></p> <p>Power or energy for grid balancing &amp; frequency regulation</p>	<ul style="list-style-type: none"> <li>• Distribution &amp; transmission system operators</li> <li>• Aggregators &amp; asset managers</li> </ul>	<ul style="list-style-type: none"> <li>• Ancillary services incl frequency regulation, black start and others</li> <li>• Addressing d / s mismatch</li> </ul>
 <p><b>2. Co-location</b></p> <p>Coupling storage and large scale renewable generation at same site</p>	<p>Solar farm owners &amp; operators, asset optimisers</p>	<ul style="list-style-type: none"> <li>• Time shift solar supply to high price peak periods</li> <li>• Enables more solar generation capacity to be incorporated into facility</li> <li>• Fast response voltage control</li> </ul>
 <p><b>3. Industrial decarbonisation</b></p> <p>Supporting industrials to decarbonise operations</p>	<ul style="list-style-type: none"> <li>• Mining</li> <li>• Oil &amp; Gas</li> <li>• Data centres</li> </ul>	<ul style="list-style-type: none"> <li>• Shifting grid demand (Triad or similar)</li> <li>• Storing excess generation</li> <li>• Resilience / reliability of supply (UPS)</li> <li>• Ancillary service income (esp. voltage smoothing)</li> </ul>
 <p><b>4. Energy Access</b></p> <p>Designed into mini grids delivering energy access to rural and off grid communities</p>	<ul style="list-style-type: none"> <li>• Utilities</li> <li>• Development Finance Institutions</li> <li>• Mini grid developers</li> <li>• Int'l agencies incl. UN</li> </ul>	<ul style="list-style-type: none"> <li>• Utilities – isolated assets in remote locations cheaper than extending grid</li> <li>• Improves energy access to off grid communities, esp. during non daylight</li> <li>• Resilience / reliability of supply</li> </ul>

# Cz Market



Single-weight Gravitricity system can provide multiple Ancillary Services in Czechia. FCR is Frequency Containment Reserve

(Study completed in late 2021 for Gravitricity by Nano Energies)

Category	Service/product	FAT*	Auction	Volumes	Remuneration	Capable for Gravitricity
Ancillary services	FCR	30s	Quarterly	90 MW	reservation	✓
Ancillary services	aFRR	5m	Daily	1 100 MW	reservation + activation	✓
Ancillary services	mFRR	12,5m	Daily	500 MW	reservation + activation	✓
Short-term markets	Day-ahead + intra-day	No limit	N/A	No limit	Market prices	✓
Imbalance market	Imbalance market	No limit	N/A	No limit	Market prices	✓

## FCR volume required is expected to grow

- FCR volume is determined by a formula ignoring intermittency from new wind turbines a PV-panels, it is expected that:
  - Wind and solar irradiation are sufficiently correlated at the European level that they might bring high power gradients.
  - Growing installed power of intermittent RES is expected to bring short-term power variations higher than 3000 MW in Europe.
- TSOs expected to redefine the contracted volume of FCR required for Europe, but there is currently **no official road-map on FCR market revision!**

### CZ perspective

- Intermittent RES deployment leads to increased max power gradients (ČEPS minute data):
  - Current situation: CZ Wind produces cca 0,6 TWh/year, Solar PV 2,3 TWh/year, max observed gradients cca **236 MW/min**
  - NECP (conservative) scenario: CZ Wind would produce 1,8 TWh/year, Solar PV 4,2 TWh/year, max gradients to be cca **434 MW/min**
  - Ember (progressive) scenario: CZ Wind would produce 9,8 TWh/year, Solar PV 10,5 TWh/year, max gradients to be cca **1126 MW/min**
- CZ would need **FCR = 166 MW\*** (NECP scenario) resp **428 MW\*** (Ember scenario)

### EU-level perspective

- At the European level, the deployment of intermittent RES would lead to the following gradients (extrapolated from ČEPS minute data):
  - Wind producing 25% EU electricity: up to 27 GW/min (European portfolio effect could reduce it to  $1/3 = 9$  GW/min)
  - Solar PV producing 25% EU electricity: up to 84 GW/min (European portfolio effect could reduce it to  $1/3 = 28$  GW/min)
- Were EU FCR volume redesigned to react to those gradients, then **840 MW FCR** would be **needed in CZ** for its 3% share



# 5. Project Benefits

# Project benefits

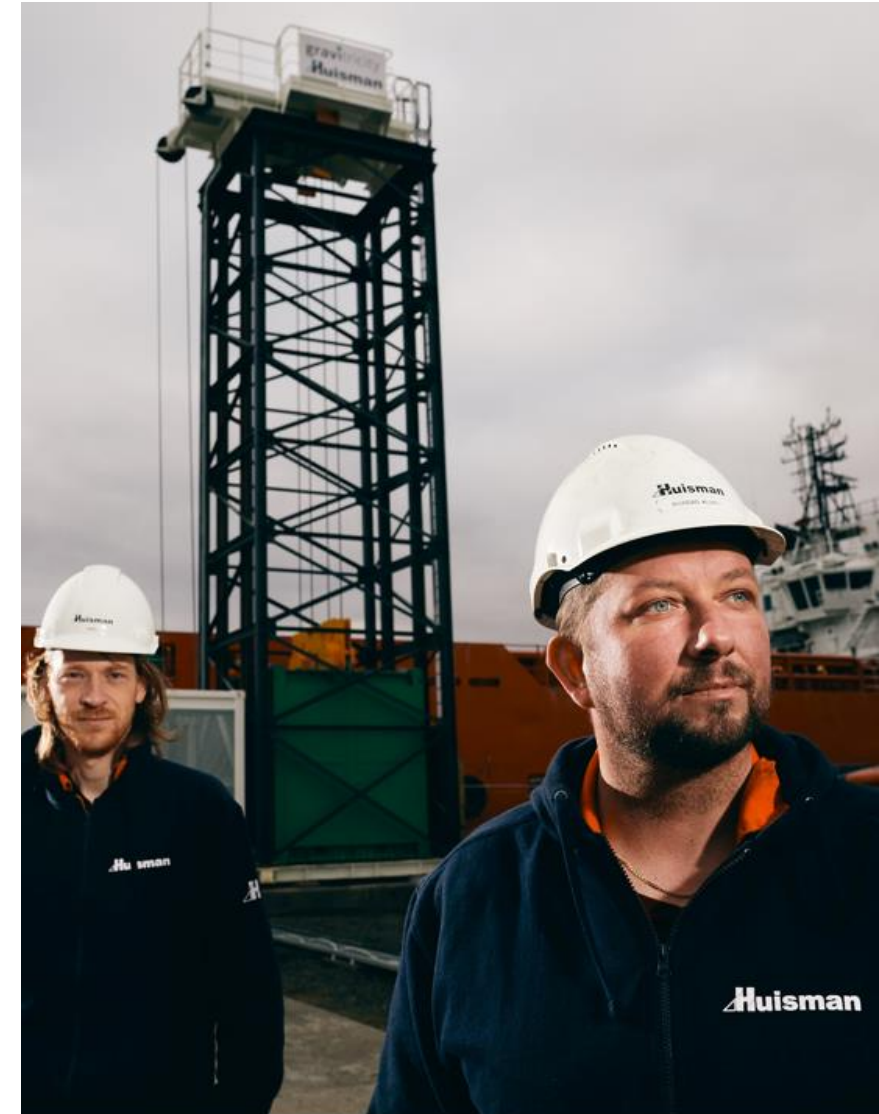
- Demonstrate **Leadership in the global energy transition** to deploy internationally leading clean energy storage technology which fulfils fundamentally important decarbonisation goals.
- Significant **financial investment** in the area – local jobs in construction, hospitality etc
- High-value Winch **manufacturing** in Ostravae (Huisman Konstrukce, s.r.o)
- Potential for roll out at **multiple sites in Czechia** and across Europe
- **Skilled roles** likely in long term in Frenstat if first-of-a-kind project goes ahead there. Future potential to export such skills.
- Major Press visibility (Global first of kind)...



# Project benefits

## Potential permanent Benefits to CERKA Village

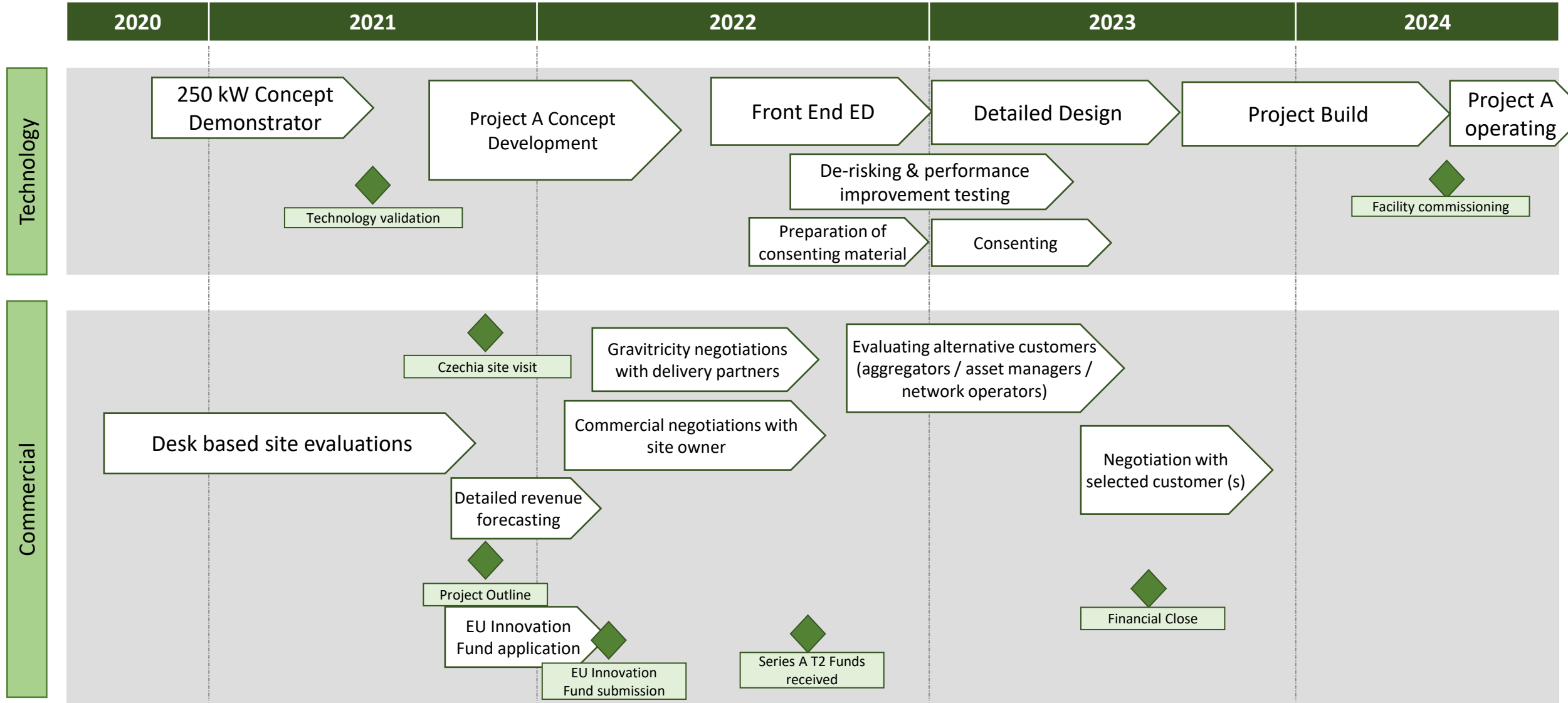
- Potential Lease or revenue share contribution to CERKA (dependant on ownership structure)
- Ability to install more solar or other renewables through addition of flexibility from storage facility
- Energy Storage Services agreement (possibly via partitioned energy storage system with multiple revenue stacks)
- Permanent office lease for prototype staff and innovation team
- Significant Press visibility for CERKA Village





## 6. Project Detail

# Technology & commercial development timescales: Single weight, prototype schedule, 4MW / 2MWh



# Project Funding

## **DEVELOPMENT PHASE – Gravitricity (and partners)**

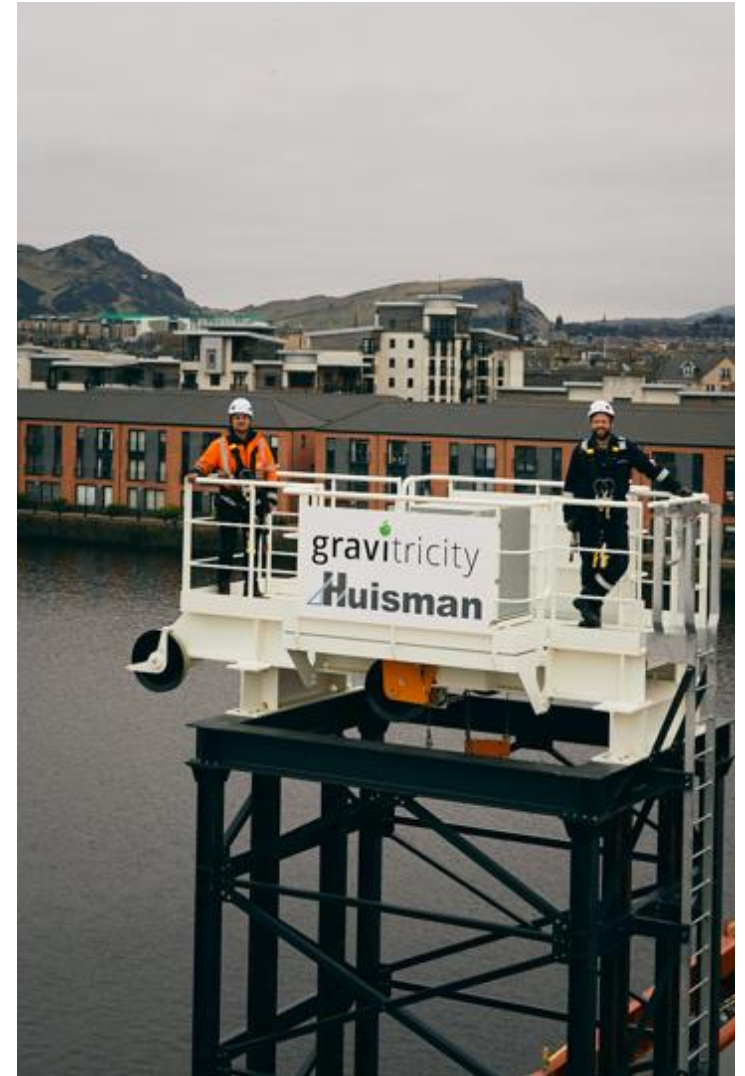
- Gravitricity Board has authorised project development activity plus Front end engineering design – underway. (Needs project clarity to proceed.)
- Gravitricity also receiving EUIF Project Development Assistance, led by European Investment Bank

## **CONSTRUCTION PHASE – 50% Innovation Grant / 50% Project Partners**

- EUIF application submitted early 2022 (Staric or Frenstat). Gravitricity and Huisman with UGN. Other applications will be prepared.
- Match funding from project partners. Provisionally 25% Gravitricity; 25% Huisman Equipment BV.
- Financial Close 2023

## **OPERATION PHASE – 20+ Years. Revenues to project partners**

- Revenues must be bigger than annual costs for project to go ahead. FCR base case – options for stacking additional revenues.
- Rent expected to be paid to mine owner. Also additional office-space, etc, for first-of-a-kind project.
- Shaft maintenance costs need to be allocated sensibly





An aerial view of a Gravitracity facility. The facility consists of a large building with a blue roof and a concrete base. Inside the building, several large spools of material are visible, some with blue components. A white van is parked on the concrete base next to the building. The facility is surrounded by a green field with a fence. In the background, there is a city skyline and mountains under a sunset sky.

# Questions?

**Chris Yendell**  
Project Development Manager

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