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REPURPOSING OF ABANDONED MINES FOR THEIR USE AS GRAVITY ENERGY STORAGE SYSTEMS WITH SUSPENDED WEIGHTS

Joint Workshop EERA ES-e3s-CSP-DfE

SMART OPERATION OF ENERGY STORAGE TECHNOLOGIES IN FUTURE ENERGY MARKETS

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Challenges of VRES penetration

- “Fit for 55” package (2021) to reduce at least 55% of the CHG emissions by 2030.
- To achieve these goals, the use of Variable Renewable Energy Sources (VRES) is required.
- VRES penetration poses several challenges in reliability and operation of electrical grids.
- Energy storage systems (ESS) are essential to stabilize and support the grid
- Underutilization of conventional power plants and mines -> leading to their decommissioning.

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Energy Storage Systems (ESS) - Hybrid ESSs

- Energy storage systems can be used to increase reliability of VRES production.

- Many different energy storage systems, for both short-term and long-term storage.

- The Role of Hybrid Energy Storage Systems (Hybrid-ESS):
  - Grid challenges demand diverse storage capabilities that no single ESS can provide

  - Hybrid-ESS combine high energy-density and high power-density technologies

  - This synergy enables flexible, resilient, and efficient grid operation

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Circularity

- Traditional decommissioning processes often suffers from:
  - Focus on disposal.
  - Lack of upfront planning for circularity.
  - Economic barriers.

- Immediate material recovery is more expensive than disposal.

- Circularity in the decommissioning of conventional power facilities is aiming beyond simply disposing of assets.

- Circularity minimizes waste, reduces the need for new raw materials, creates economic benefits through material recovery, and conserves precious resources.

- Circularity promotes reuse, repurposing and recycling by:
  - Finding new applications for equipment, materials, and structures.
  - Modifying components to serve different functions.
  - Extracting valuable raw materials for new uses.

- Underutilization and decommissioning of conventional power plants
- Unlocks economic and environmental benefits through reuse
- Gravity Energy Storage (GES) as a Circular Solution:
  - Transforming abandoned coal plants and mines into GES facilities
  - Potential for low levelized cost of energy and grid support
  - Potential of hybridized with fast-acting ESS technologies

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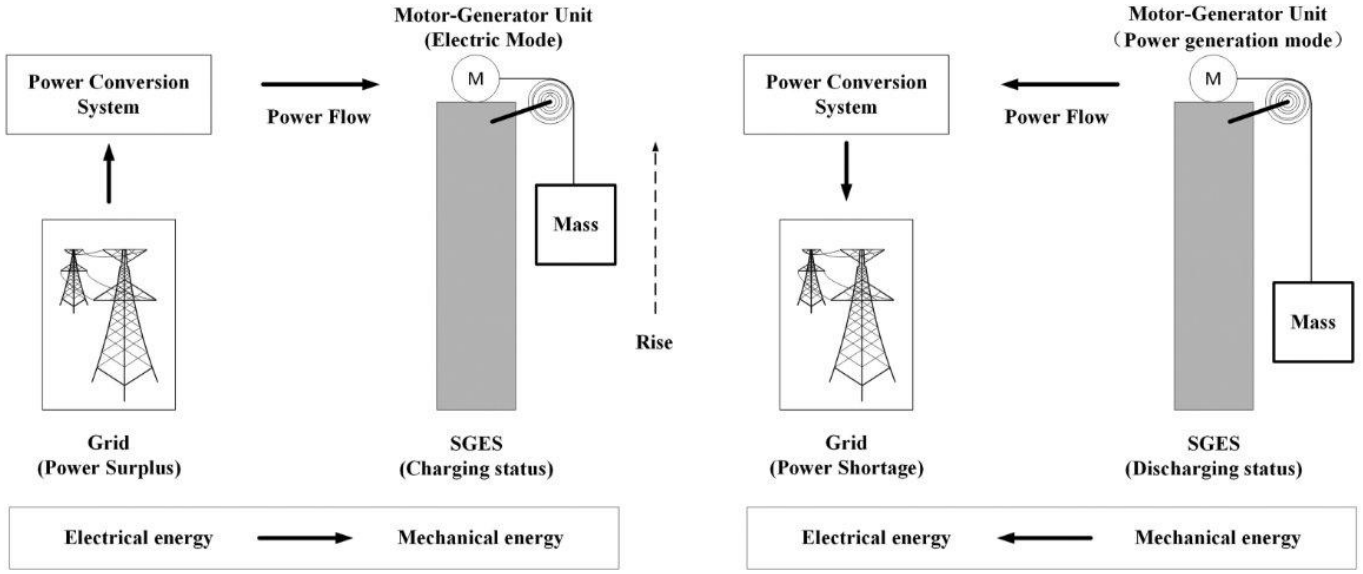
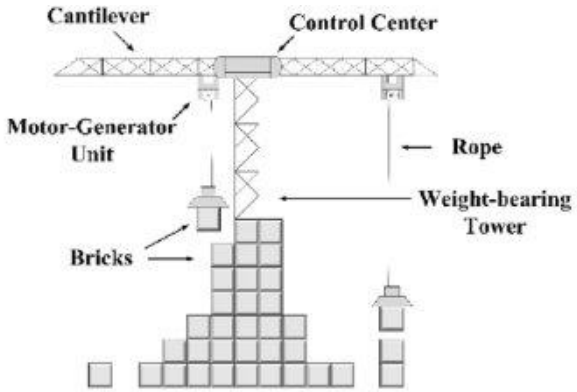
Gravity Energy Storage (GES)

- GES is a technology for storing potential energy with solid materials at various elevations

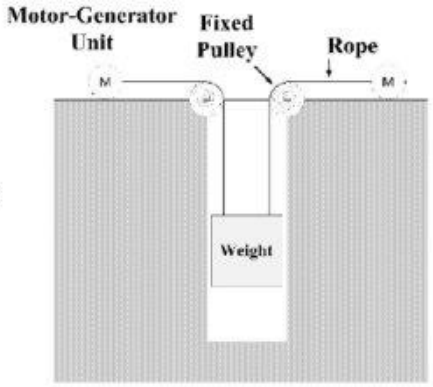
- E.g., the gravitational potential energy is stored by absorbing power to drive the electromechanical equipment to lift a weight, when there is a power surplus in the grid and lowering the weight to return power to the grid, when there is power shortage



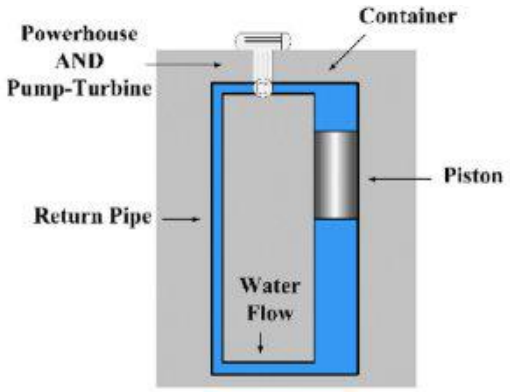
SWOT analysis of GES:	
Strengths: Easy to scale Long service life (30-50 years) High cycle efficiency (80-90%) Low cost of electricity Environmental friendly Good geographical adaptation	Weaknesses: Lack of attention Lack of technical maturity Uneconomical in small scale scenarios
Opportunities: Rapid rise in installed RES capacity Rapid development of the energy service market	Threats: Other large-scale energy storage technologies Related policies and systems still need to be improved



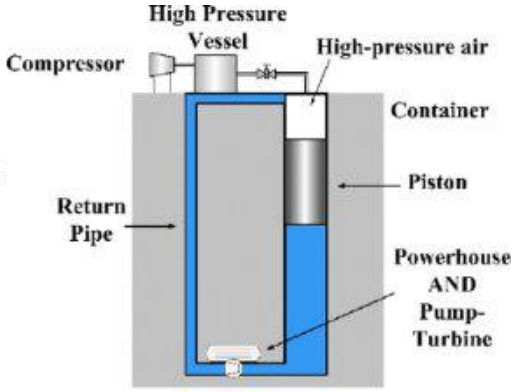
Tower GES



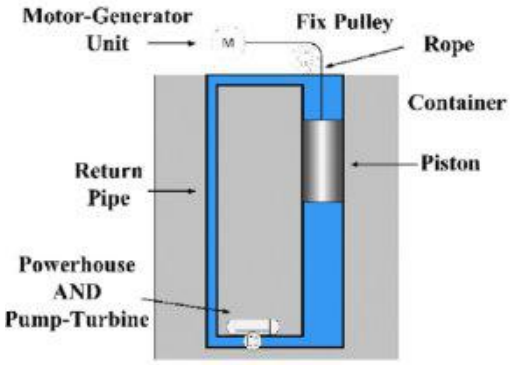
Shaft GES



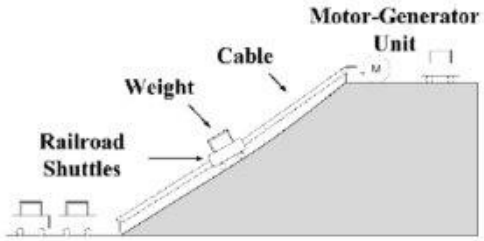
Piston GES



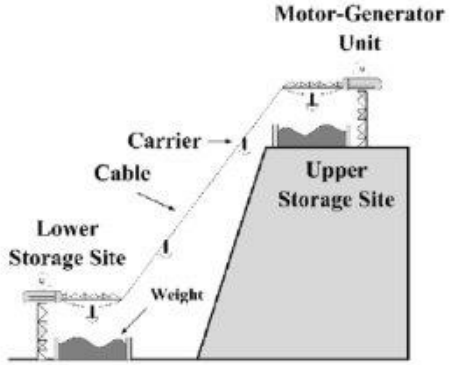
Compressed Air Piston



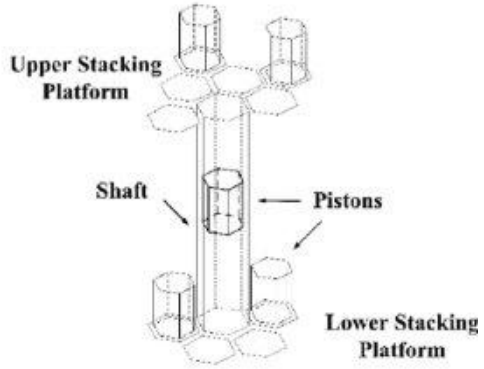
Rope-hoisting GES



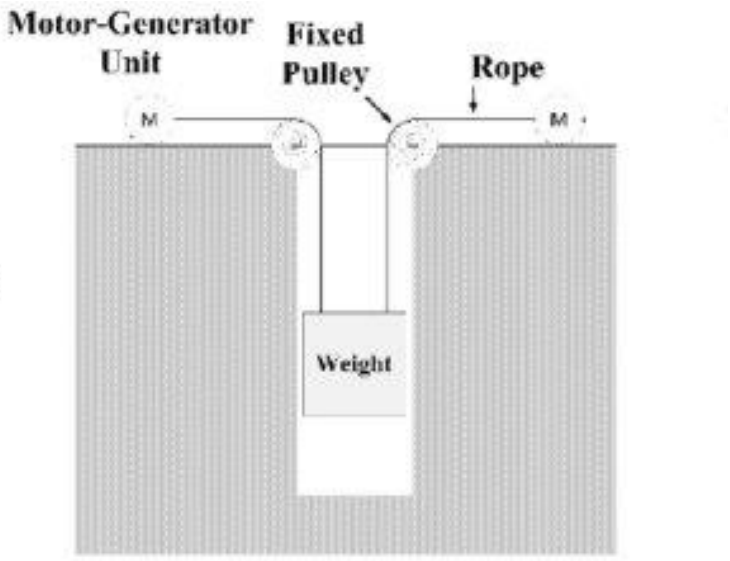
Mountain Mine-car



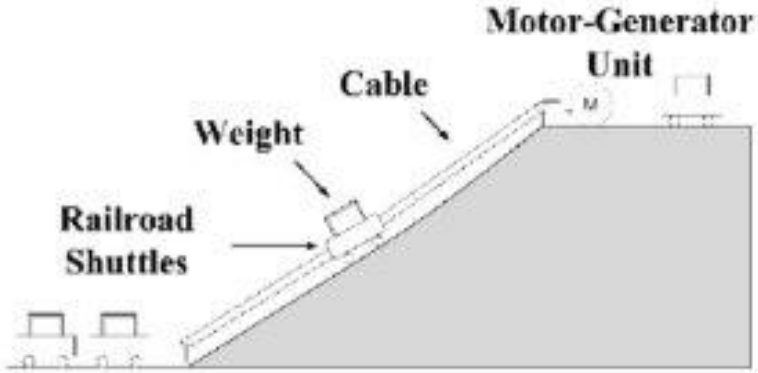
Mountain Cable-Car



Linear Electric Machine-based



- Indicatively abandoned equipment from coal power plants/mine can be used for Shaft GES:
  - Shaft mine
  - Hoisting system
  - Generator/Motor



- Indicatively abandoned equipment from coal power plants/mine can be used for Mountain mine-car GES:
  - Tracks/Railways
  - Generator/Motor

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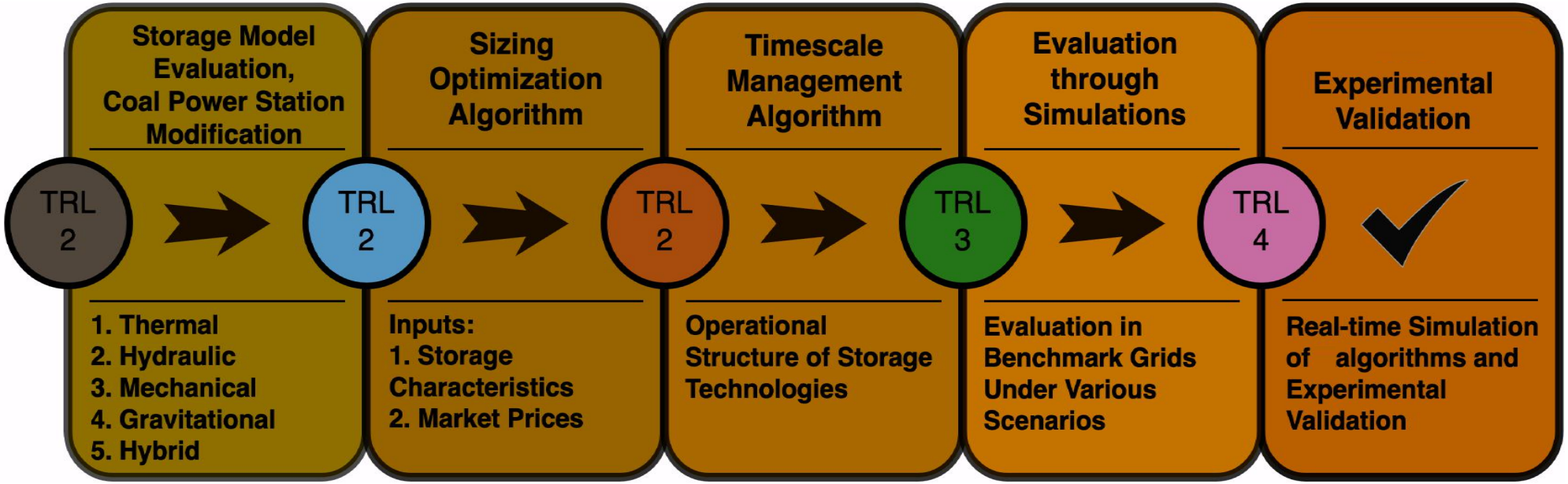
GRAVITEQA Project

➢ The GRAVITEQA project has received funding from the European Union's Horizon programme

➢ GRAVITEQA will go beyond the current SoTA by

- ➢ designing a methodology to find the optimal GES size from abandoned coal power plants/mines
- ➢ examining the hybridization of different storage types,
- ➢ take into consideration elements and data from the energy market for credible sizing
- ➢ enhance cyclic economy by considering reusing/repurposing existing equipment



- GRAVITEQA Methodology includes the development of two algorithms:

- Optimization algorithm-sizing of the solutions
  - **Role:** Determines optimal size and mix of GES system

  - **Objective:** Profit maximization.

- Development of different timescale management algorithm

  - **Role:** Managing hybrid storage configurations across different timescales

  - **Objective:** Orchestrating diverse storage technologies for effective grid service provision.

  - **Overall target:** Enabling long-duration discharges using the integrated storage solution.

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Conclusions

- The VRES penetration:
  - Impact the grid operation
  - Increase the need of installing ESSs
  - Hybridization of ESSs for addressing issues

- Underutilization and decommissioning of coal power plants
  - Opportunity for repurposing the abandoned infrastructure
  - GES as a Circular Solution for repurposing coal power plants/mines.

- GRAVITEQA Project focus on:
  - Circular-by-Design methodology for abandoned infrastructure
  - GES systems
  - Hybrid ESSs

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Thank you

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