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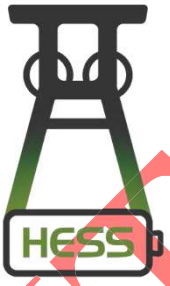
Hybrid energy storage system using post-mining infrastructure (HESS)



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Energy router software

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Document authors	**Marcin Jura (KOMAG)** **Joanna Rogala-Rojek (KOMAG)** **Jan Biela (KOMAG)** **Sławomir Bartoszek (KOMAG)** **Jakub Bernatt (KOMAG)** **Jerzy Jagoda KOMAG)** **Sebastian Jendrysik (KOMAG)** **Wiktor Markusik (KOMAG)** **Dorian Markusik (KOMAG)** **Michał Głatki (KOMAG)** **Michalak Dariusz (KOMAG)** **Orzeł Bartosz (KOMAG)** **Rozmus Magdalena (KOMAG)** **Szewerda Kamil (KOMAG)** **Tokarczyk Jarosław (KOMAG)** **Daniel Kowol (KOMAG)** **Piotr Matusiak (KOMAG)**
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1 Introduction

Energy storage systems are important to modern efforts to stabilize power grid, integrate variable renewable generation, and improve energy reliability. This project investigates a specialized energy storage system architecture that leverages post-mining underground and overground infrastructure as a host for energy storages and an energy router — a control and power-conversion hub that mediates flows between storage and the grid. By combining multiple storage technologies (pumped-storage hydroelectricity, compressed gas energy storage and thermal energy storage) with an energy router located within repurposed mine workings, the system aims to provide flexible, scalable, and cost-effective energy services while reusing otherwise idle civil assets.

The project is motivated by the need to integrate high shares of variable renewable generation while providing reliable, dispatchable energy services. Repurposing abandoned mine workings for large-volume storage reduces civil-works costs and embodied carbon compared with new excavation, making long-duration storage economically and environmentally more attractive. Using post-mining infrastructure transforms legacy liabilities into productive assets, supporting local economic regeneration through construction and operations jobs and creating opportunities for new industrial or community energy services. It creates flexible revenue by combining different storage types into one controllable plant that can do energy arbitrage, sell capacity, and provide grid services.

Technically, the energy router optimizes dispatch to minimize degradation and maximize value. Overall, the motivation combines decarbonization goals, cost reduction through asset reuse, enhanced grid stability, local economic benefits, and the opportunity to demonstrate integrated control and safety strategies for subterranean hybrid storage.

To develop the algorithm for the energy router, several additional tools were required. For that reason the following were also developed:

- Test bench - a platform to house the energy router, provide HMI visualization, and simulate energy storage systems before access to real ones.
- Next-day price API - supplies the algorithm with necessary market price forecasts for scheduling and arbitrage.
- HMI visualization - local human-machine interface used on the test bench for control, monitoring, and manual override.
- Web visualization - remote dashboard to monitor system status and performance on different devices.