PUMPED HYDRO STORAGE ON ABANDONED MINE LANDS

AN OPPORTUNITY FOR INDIANA?

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WHAT IS PUMPED HYDRO STORAGE (PHS)?

CARTOON + LUDINGTON PUMPED STORAGE (MI)

Source: [Wikimedia Commons](https://commons.wikimedia.org/) and Toshiba Corp.
PHS BASIC FACTS

• 94% of U.S. energy storage is from PHS (23.6 GW, June 2018)
  • PHS plants have long lifetimes (50-60 years, 100+ years w/ investment)
  • PHS plants operate at 76-85% efficiency

• Most US PHS plants built in 1970s, many now being upgraded

• Recent interest and activity globally (esp Australia, Japan)
  • Since 2014, FERC issued licenses for three PHS projects
  • As of Feb 1, 2018, six licenses pending & nine preliminary permits pending
  • For recent US DOE interest and activity regarding PHS see:
    • https://www.energy.gov/eere/water/pumped-storage-hydropower
PHS CURRENTLY THE LEAST EXPENSIVE FORM OF GRID LEVEL STORAGE

• **Lazard’s Levelized Cost of Storage** Analysis
  • 2016: did not compare PHS to Battery Storage in 2017/2018 reports
  • Capital costs for PHS projects (global) range from $1.5 million to $2.5 million per MW installed
  • Capital cost of grid-scale battery solutions range from $3.5 million to $7.5 million

• **Weaknesses in estimates**
  • Assumes 40 year life span = undervalues longer-lived PHS
  • Potential underestimate of future battery cost = undervalues grid scale battery storage
KEY BARRIERS TO PHS EXPANSION:
ALL ARE BEING ADDRESSED
IN FUNDED R&D AND PROPOSED PROJECTS

• Geography (elevation)
• Proximity of good geography to transmission grid/demand
• Spark spread between peak sales and off-peak pumping requirements
• Facility size
• Environmental impacts
• Investment cost and time to completion
• Permitting delays and energy market rules
INDIANA ABANDONED UNDERGROUND COAL MINE PHS OPPORTUNITY

• Mine depth replaces mountains
  • Many mines potentially available, only some are deep enough

• Proximity to grid

• Integration of market available/market ready innovations to address key barriers

• Accommodating regional economic interest in face of declining coal demand

• Multiple collateral/synergistic economic opportunities
INDIANA PHS INNOVATIONS

• Hydraulic Wind mills pump water 24/7
  • Based on research by Prof. Afshin Izadian

• Closed loop design

• Filtration to manage debris & water quality

• Advanced variable speed turbines

• Design to reduce turbulence damage to mine walls

• Potential canopy to facilitate security, evaporation, water quality, synergistic uses
KEY FINDINGS
MULTIPLE STUDENT TEAM PROJECTS

• 8 hour 200 MW operation for $1,429/kW capital cost
• Designed, constructed, and commissioned in three years
• Primary concerns identified in interviews appear manageable
  • Condition of the subsurface void after being abandoned for so long
    • Common issue for mines: equipment and know-how to address are readily available
  • Concern for the water quality, some AMLs release acidic or metals-laden waters
    • Indiana Geological & Water Survey identified readily available remediation technologies
    • Widespread use of mine voids for drinking water
  • Other identified technical issues have mitigation strategies using mature, well-established solutions
• Multiple non-electric revenue opportunities
STUDENT PHS RESEARCH TEAMS

• Jared Davis and Manan Shah, Capstone SPEA MBA D.I.V.E., 2019
  • “Non-Electric Revenues from Pumped Hydro Storage using Abandoned Mine Lands”

• Aalan Miranda, Urvishkumar Patel, Han Shih, Joshua Woodward, Capstone ECE 487-488 IUPUI, 2017-8
  • “Power and Control using Abandoned Coal Mines for Pumped Hydro Energy Storage,”

• Macie’ Moore, Raymond Rummel, Brendan Smith, John Watkins, Capstone ECE 487-488 IU-Bloomington
  • “Policy Development and Stakeholder Outreach for the use of Abandoned Coal Mines for Pumped Hydro Energy Storage.

• Yogit Bhatt, Kokeb Gebre, Caleb Perkins, Dylan Wengerd, Mechanical Engineering capstone seniors
  • “Abandoned Coal Mine Energy Storage”

• Brayden Ratekin, for Peter Schubert/Richard G. Lugar Center for Renewable Energy
  • The Need for Coal Mine Underground Pumped-Storage Hydro Power Plants In Indiana, 4/29/2017
THANK YOU

DO YOU HAVE ANY QUESTIONS

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