# Energy Storage Reshaping the Grid

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# Energy Storage Reshaping the Grid

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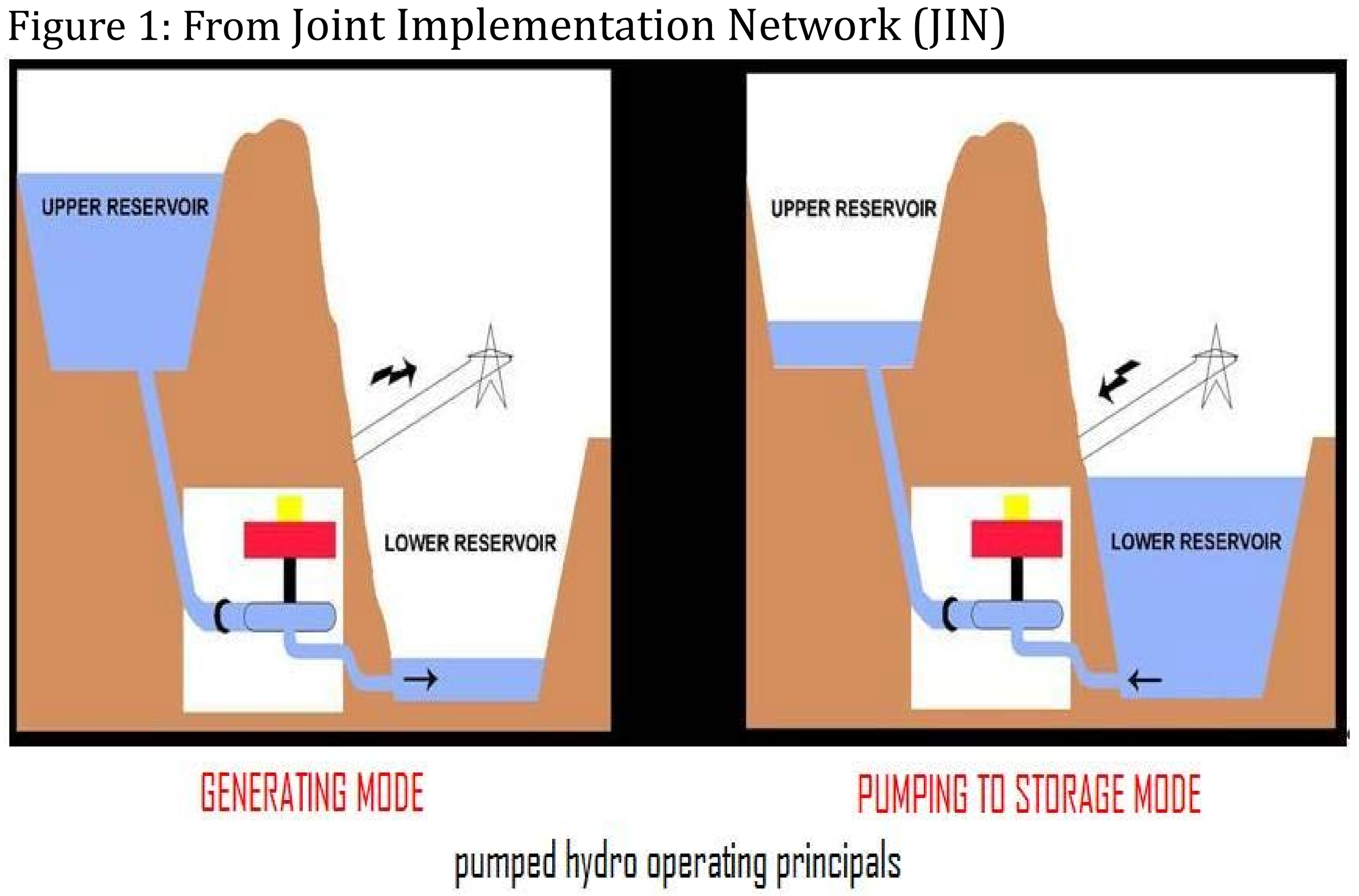
## OVERVIEW

This study examines the economic feasibility, implications, and benefits of implementing grid-scale energy storage. The focus will be on pumped hydroelectric storage (PHS) and its potential to function as a utility, and to stabilize grid-scale solar and wind energy. By applying discounted cash flow (DCF) analysis, the results show that PHS is feasible is grid applications.

## BACKGROUND

Pumped hydroelectric storage stores energy by transferring water between upper and lower reservoirs. When demand is low, cheap electricity is used to pump water to the upper reservoir. When demand is high, the pump reverses, acting as a water turbine. As water flows through the turbine, back to the lower reservoir, peak electricity is generated and sold back to the grid. PHS has instantaneous electricity generation, meaning when addition energy is demanded, it can be produced immediately, with no additional variable costs. The technology scenario draws upon *The Northfield Mountain Pumped Storage Project* in Massachusetts, with a daily capacity of 8500MWh, 50 year life-span and efficiency of 80%.

Figure 1: From Joint Implementation Network (JIN)




## METHODS

To determine economic feasibility of a PHS facility, I perform the DCF analysis. I also examine economic benefits of PHS systems. Project costs are estimated in constant prices.

$$PV\ costs = capital\ cost + \sum \frac{Operation/maintenance\ Costs}{(1+r)^t}$$

$$P_v = \left(\frac{peak\ \$}{kWh}\right) - \left(\frac{offpeak\ \$}{kWh} * 1.2\right)$$

$$R_s = Summer\ P_v \left(\frac{1000kWh}{1MWh}\right) \times 8500 \times 30 \times 4$$

$$Off\ R_s = off\ summer\ P_v \left(\frac{1000kWh}{1MWh}\right) \times 8500 \times 30 \times 8$$

$$PV\ benefits = \sum \frac{total\ revenues}{(1+r)^t}$$

where $P_v$= Price variation; $R_s$- summer revenue

To account for PHS 80% efficiency, I adjusted levelized cost of energy (LCOE) for wind/solar based on Lazard's 10th annual report.

$$Adjusted\ LCOE\ renewables = \left(\frac{LCOE\ solar + LCOE\ wind}{2}\right) 1.2$$

$$Level\ cost\ of\ PHS = \frac{PV\ costs}{8500 \times 365 \times 50}$$

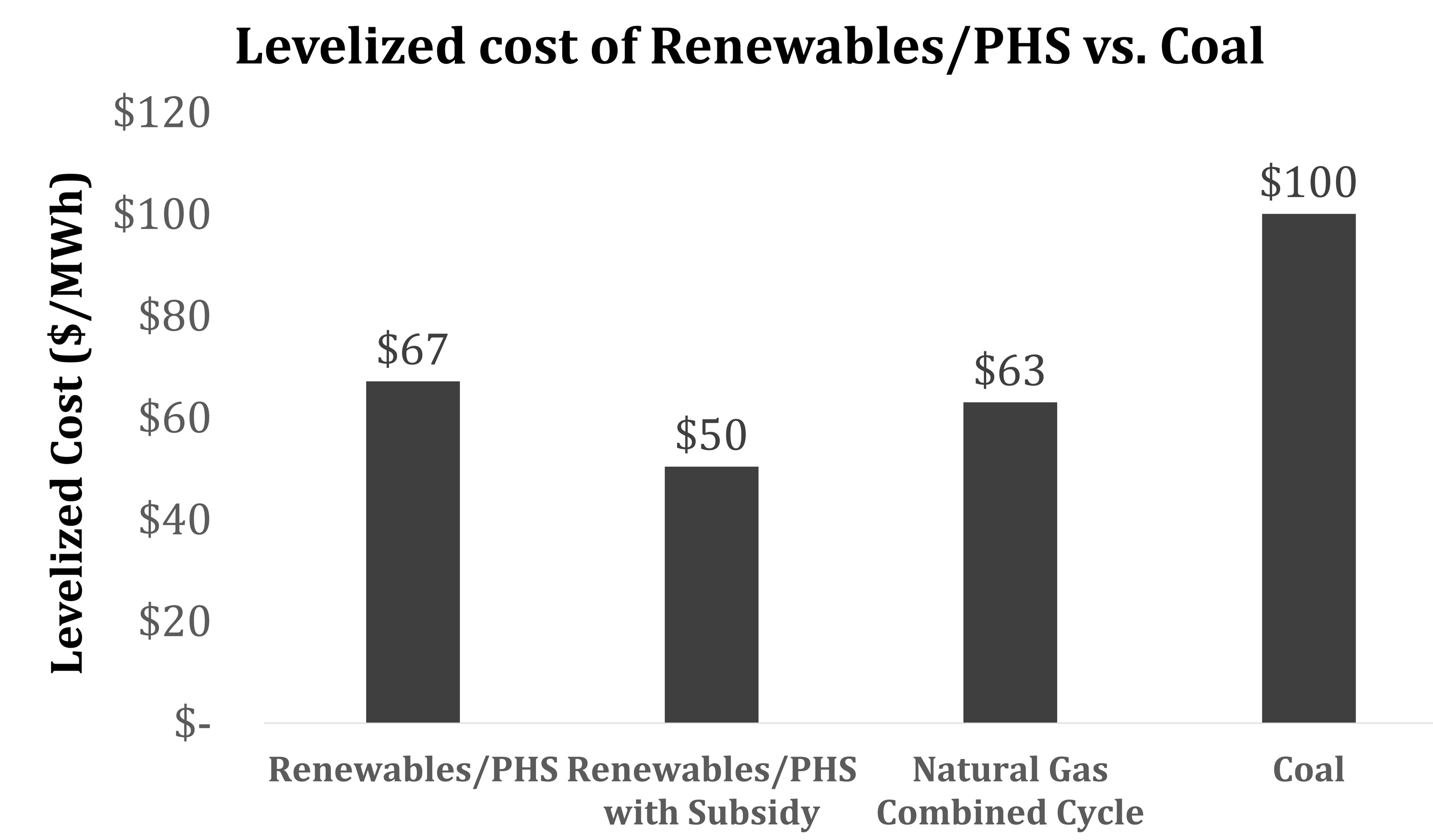
## RESULTS

Using DCF analysis, I found that PHS has a NPV of $299 million, discounted at 5%. PHS facilities can act as independent utilities, buying and reselling electricity, to generate profit. It can also be integrated with existing utilities to increase capacity.

| Cost and Revenues | Millions of Dollars | |
|---|---|---|
| Capital cost | $782 | |
| PV O/M costs | $139 | |
| PV total costs | | $921 |
| PV summer revenue | $624 | |
| PV off-summer revenue | $596 | |
| PV total benefits | | $1,220 |
| **NPV** | | **$299** |

## RESULTS (CONT.)

PHS can also be used to stabilize otherwise unreliable energy from renewables.
With the levelized cost of renewable energy now lower than that of other conventional energy sources, PHS implies the potential for cheaper grid energy.
PHS facilities add about $6/MWh to the levelized cost of renewables, and another 20%, due to the efficiency loss. This puts the levelized cost of PHS stabilized renewable energy at $67/MWh and $50/MWh with government subsidy. As you can see in the graph below, the levelized cost of renewables with PHS is less than that of conventional sources.




## CONCLUSIONS

My study shows that pumped hydroelectric storage facilities are economically feasible and profitable. PHS facilities have a NPV of $299 million over 50 years, and further imply an increase in capacity and efficiency for utilities. PHS stabilized renewable energy costs are lower than that of conventional energy, validating that PHS can be integrated to enable solar and wind powered grid energy. Integrating PHS with renewable energy systems will result in improved reliability and energy sustainability of the grid.

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