***ENERGY STORAGE RESHAPING THE GRID***

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**Overview**

This study examines the feasibility, implications, and benefits of large-scale energy storage integrated with the electrical grid. I will focus on the economic aspects of using high capacity, pumped hydroelectric storage and its ability to level production and enable a renewable power grid. Leveling production directly increases efficiency and ability to meet demand, while renewable energy is essential for sustainably producing energy into the future.

**Methods**

I will first analyze the economic feasibility and effectiveness of using pumped hydro storage (PHS) to increase efficiency by leveling production. To determine the feasibility of this investment I will conduct a discounted cash flow analysis and compare benefits with costs. To perform DCF analysis I will use cost estimates including capital, operation, and maintenance costs from *The Cost of Pumped Hydroelectric Storage* (Galvan-Lopez, 2014), which I then inflated to 2017 prices. By performing a DCF analysis, I found the total present value of costs from a PHS facility.

Revenue is generated by purchasing and storing low cost energy to sell when demand is high. These revenues are calculated by averaging peak and off-peak price variations and multiplying them by yearly MWh capacity. Revenues are then discounted over the lifespan of the facility, yielding the present value of benefits. With positive net benefits, the project would be feasible. The storing of energy allow power plants to generate electricity constantly at their most efficient production level, so I will estimate the production efficiency boost by examining an existing power plant with a PHS facility.

A similar concept to production leveling explains the potential for PHS to enable a renewable power grid. Renewable energy sources are inconsistent and unpredictable, but storing unused energy increases their ability to meet high demand. In determining the feasibility of renewable PHS energy I will use the levelized costing method to compare costs of renewables with costs of conventional energy, like coal or natural gas. The levelized costs of energy are given by the Lazard’s Annual Report 10.0 (Lazard, 2016). The levelized cost of solar and wind energy must be adjusted due to the efficiency loss from using PHS. I must then calculate the levelized cost of PHS using discounted cash flows and total lifetime energy generation estimates. This will be added to the cost of renewables to give me the total levelized cost of PHS stabilized renewable energy.

**Results**

 Using discounted cash flow analysis, I found that a project integrating PHS with a powerplant has a positive NPV and is therefore feasible. The PHS facility can act as a backup utility, increasing capacity to meet demand, and increasing value by over $290 million. With an increased capacity from the ability to store energy, powerplants can generate electricity about 20% more efficiently.

After using discounted cash flows method and total energy output, I calculated the levelized cost of PHS. I added this to the adjusted levelized cost of average renewable energy and found that the total levelized cost of renewable energy with PHS was less than that of coal and about the same as natural gas. The overall results imply that a reliable renewable power grid could be economically feasible using large-scale energy storage like PHS.

**Conclusion**

My study focuses on the economic feasibility and benefits of implementing large-scale energy storage, like PHS. This will improve value and efficiency of electricity generation and could enable a renewable grid. My analysis confirms that PHS could be feasibly integrated with power plants to help level production. In leveling production, the storage system will increase capacity, efficiency, and profits for power plants. My study also shows that PHS could be used to enable a renewable grid with a lower levelized cost than our current energy generation. The 2017 levelized cost of solar and wind energy, including the levelized cost of PHS, is lower than that of coal and natural gas. A renewable grid would be able to provide reliable energy for the foreseeable future without the depletion of resources. Energy storage is an essential part of having an adequate and efficient energy supply to meet our ever-growing demand.

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