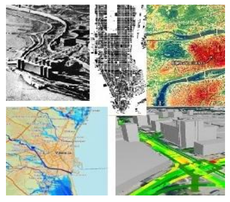

Unconventional Energy Storage: Paving the Way for Renewables

Robert N. Amundsen
New York Institute of Technology, U.S.A.

NEW YORK INSTITUTE OF TECHNOLOGY
College of Engineering & Computing Sciences

INTRODUCTION

Electricity is a unique commodity, since it must be produced at the same time as it is consumed. This is an especially difficult problem, because electric loads can change rapidly within a few minutes. The solution is to develop energy storage technologies. This is easier said than done, due to the complexity and expense of large-scale energy storage systems.

Renewable energy sources increase the need for energy storage. Wind and solar production can change quickly and unpredictably, due to local weather conditions. Since electric loads and renewable energy production are both fluctuating, sufficient energy storage is essential for reliability.

Electricity prices increase during high demand and decrease during low demand. Significant cost savings can be achieved by purchasing and storing energy during low demand and releasing energy during high demand. Energy storage systems are often cost effective since they can “buy low” and “sell high”.

Pumped storage, compressed air, flywheels and gravity batteries are some examples of unconventional alternatives to batteries.

ENERGY STORAGE OPTIONS

Pumped storage uses two reservoirs to store energy. Water is pumped from a lower reservoir to a higher reservoir when demand is low. When power is needed, water is released from the higher reservoir and generates electricity by flowing through a turbine on its way to the lower reservoir.

Compressed air energy storage uses underground caverns or tanks to store pressurized air, which can be released to turn a turbine and generate electricity when needed.

Flywheel energy storage uses a large, spinning wheel. Electricity powers a motor to add energy to the flywheel during off-peak hours. Later, a generator extracts energy from the flywheel during peak hours.

Gravity batteries store energy by lifting heavy weights on a tower during off peak hours, then allowing the weights to move downward and turn a generator during peak hours.

RENEWABLE ENERGY SOURCES

Renewable energy sources, such as solar and wind, are highly variable. Wind is highly dependent on weather conditions. Sunlight can be blocked by clouds and is completely unavailable overnight.

Traditional power grids were designed for large fossil-fueled powerplants, which can operate at steady levels, day or night. Renewable sources are distributed throughout the grid and their output fluctuates. Sometimes there is too much power; sometimes there is too little power.

Energy storage enables grid operators to capture excess energy during peak output, and release energy when there is a shortfall. Combining renewable energy sources with energy storage opens a pathway to reliable power generation with significant environmental benefits.

FIGURES

Figure 1. Pumped Storage

Figure 2. Compressed Air Energy Storage

Figure 3. Flywheel Energy Storage

Figure 4. Gravity Battery

Figure 5. Smart Grid

RECOMMENDATIONS

Energy storage systems can save money by satisfying peak loads with inexpensive off-peak power. They enable greater use of renewable energy sources, so they reduce pollution. They can increase reliability of the power grid by providing extra capacity when power is needed the most.

Costs of energy storage systems can be reduced further by standardization, economies of scale and funded research. Smart Grid technology can allow integration of energy storage and renewable energy while preserving reliability.

Effective communication with stakeholders is necessary to accelerate approvals, secure financing and prevent delays. Demonstration projects are essential for building trust and inspiring innovation.

REFERENCES

Areola, R., Adebiyi, A. & Moloi, K. (2025, April 6) Integrated Energy Storage Systems for Enhanced Grid Efficiency: A Comprehensive Review of Technologies and Applications. Energies. Retrieved from https://www.mdpi.com/1996-1073/18/7/1848

Castillo, A. & Gayme, D. (2014, November) Grid-scale energy storage applications in renewable energy integration: A survey. Energy Conversion and Management. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S0196890414007018

Staadecker, M., et al. (2024, November 3) The value of long-duration energy storage under various grid conditions in a zero-emissions future. Nature Communications. Retrieved from https://www.nature.com/articles/s41467-024-53274-6

Unattributed (2023, April 5) Adding capacity to the electricity grid is not a simple task. The Economist. Retrieved from https://www.economist.com/technology-quarterly/2023/04/05/adding-capacity-to-the-electricity-grid-is-not-a-simple-task

Worku, M. (2022, May 15) Recent Advances in Energy Storage Systems for Renewable Source Grid Integration: A Comprehensive Review. Sustainability. Retrieved from https://www.mdpi.com/2071-1050/14/10/5985?utm_source=researchgate.net&medium=article