ELECTRICITY STORAGE AND RENEWABLES FOR ISLAND POWER

Electricity systems in remote areas and on islands can use electricity storage to integrate renewable generation and help meet continually varying electricity demand. Electricity storage technologies vary widely in design, technological maturity and cost. There is no single best storage technology, and storage is not necessarily appropriate for all island electricity systems. This report will help electricity system planners, operators and managers to better understand what role storage can and should play in their electricity systems and to provide guidance on selecting and installing storage.

The mature technology of lead-acid batteries has moderate costs and high reliability. However, these batteries have a relatively short lifetime (typically, three to ten years) and must be disposed of or recycled properly. Lithium-ion batteries are common for mobile applications (such as cell phones and laptop computers) and may make their way into the electricity grid market in the next five years. They have higher first costs than lead-acid batteries but longer lifetimes and lower losses. Flow batteries (notably, vanadium-redox and zinc-bromine) hold the promise of long lifetimes and low operating costs. However, they are just entering the commercial market and thus do not have an established record of operation for electricity storage applications. Flywheels are best suited for short-duration storage (less than one minute), but they are still at an early stage of technical development. Compressed air energy storage (CAES) and pumped hydro are generally suitable only for large (500 MW+) electricity systems. There are numerous other storage technologies in earlier stages of technical development.

In addition to helping integrate renewables, storage can also contribute significant value by increasing the operating efficiency of diesel generators. These generators are much more efficient when operated at high load factors, and the addition of storage can significantly reduce the number of hours they operate at low or minimum load factors.

Storage can also be of value in systems that are transmission capacity–constrained or that suffer from low power quality at the end of the distribution system. Storage is generally not appropriate, in contrast, for solving problems such as chronic supply shortages or poorly performing transmission and distribution systems.

Detailed modeling of a typical diesel-based island electricity system shows that storage can be cost-effective even in the absence of renewables through its ability to increase diesel generator efficiency and thereby reduce diesel consumption. The rampant oversizing of diesel generators contributes to these potential savings. A combination of renewables, storage and diesel generators—all carefully sized and integrated—can yield the lowest cost solution (based on the levelised cost of electricity). However, such systems are complex. "Pure" renewable systems, such as photovoltaic (PV) plus storage, are relatively expensive due to the need for PV system and storage oversizing to meet loads during extended cloudy periods.

Acquiring storage for an electricity system has much in common with any large capital acquisition project. However, it does require that particular attention be paid to: (1) system integration, as storage must be carefully integrated with other electricity system components; (2) technical performance expectations, as many storage technologies are not yet technically mature; and (3) maintenance, as some storage options have critical maintenance needs.

Case studies of storage applications for island and remote locations point to several lessons learned from project experiences elsewhere, including:

- Pay close attention to system *design*, particularly ensuring that all system components are sized correctly and can work together.
- The more system components, the greater the complexity and challenge of system integration.
- Do not expect new technologies/pilots to be financially viable.
- Walk first, then run. Try to introduce one technical innovation at a time.
- Do not underestimate the transport costs, complexity and time requirements associated with getting equipment and expertise to rural/isolated locations.

- System monitoring and operation and maintenance (O&M) are critical to ensure system reliability/longevity.
- Test and debug system components *before* sending them out to rural/isolated locations.
- Diesel generator oversizing is rampant and contributes to high diesel consumption.
- It is critical to make systems financially sustainable. Even if subsidies cover first costs, operating costs (including battery replacement and O&M) will need to be covered by electricity sales/revenues or continuing subsidies.
- End-user buy-in (financially and politically) is critical.

The first step when considering storage is to conduct careful analyses of the costs and benefits of storage. Storage can help integrate renewables and reduce diesel use; however it comes at a cost that must be considered. If storage is desirable, further system design analysis is needed to determine the optimal type of storage. This can be done with free or low-cost system design and analysis tools, such as the HOMER modeling system.

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