By Marcus Wiemann
Alliance for
Rural Electrification

By Paul Bertheau
Reiner Lemoine Institut

By Massimo Bergadano
PHPower

» Energy storage increases access to electricity in Asia

Energy storage is increasingly becoming a hot topic in the debate on how to improve efficiency, reliability and price-competitiveness of electricity services, as well as on how to achieve deeper integration of intermittent renewable energies. Batteries per se cannot give access to electricity, but will play a key role in achieving the target of universal access to clean, reliable and affordable electricity services. The installation of decentralised grid back-up batteries also represents a solution for the additional billion of people living in rural and peri-urban areas that remain under-electrified suffering from regular black/brown-outs due to the poor quality of the grid.

Energy storage is increasingly becoming a hot topic in the debate on how to improve efficiency, reliability and price-competitiveness of electricity services, as well as on how to achieve deeper integration of intermittent renewable energies.

In grid-connected areas where there is poor grid quality, it is possible to install a battery that will use power supply from the grid or an autonomous renewable or oil powered generator to recharge. Energy stored will be delivered whenever there is a blackout or a brownout.

Application of batteries in diesel off-grid systems

Oil powered generators continue to be the most often used technology for off-grid systems, particularly regarding mini-grids. They have very low upfront costs, but high operation costs. Dependence on fuels exposes users to oil price shocks. Fuel scarcity, a common phenomenon in remote areas with difficult accessibility further undermines energy security of users. In this context, installing batteries in diesel off-grid systems will result in improved reliability and increased efficiency.

Adding small amounts of renewables to oil powered systems is not generally cost-efficient. Additionally, due to the intermittent nature of

alternative technologies, pure renewable energy systems can further aggravate the low load inefficiency of diesel generators. Despite the higher investment costs for renewables, the predictability of the price of renewables and the low running costs make it a good option for remote areas.

In this regard, a smart combination of renewables complemented with diesel and batteries can provide the solution in terms of reliability and affordability. The use of batteries will allow for savings in the use of diesel which could reach 50% and avoid the need to oversize the generator. Nonetheless, such systems are complex and technologically sophisticated. It is suggested to add new technologies one at a time, rather than all at once. Furthermore, although diesel prices are subject to high volatility making cost planning difficult, the implementation of batteries into small diesel fired systems can lead to significant cost saving.

To achieve universal electricity access off-grid solutions are key

Batteries per se cannot give access to electricity, but can ensure reliability of the electricity services. They can be applied for off-grid systems installed in rural areas where 84% of the world's un-electrified population (approximately 1.2 billion people in total) are concentrated. According to the Energy Access Practitioner Network, 40% of the additional generation that will need to be installed by 2030 to achieve universal electricity access will be off-grid. The installation of decentralised grid backup batteries also represents a solution for the additional billion of people living in rural and peri-urban areas that remain under-electrified suffering from regular black/brown-outs due to the poor quality of the grid. From a business perspective, developing and emerging countries represent a big potential niche for the battery market.

The potential of batteries on small islands in the Philippines

Researchers from the Reiner Lemoine Institut (RLI) analysed the potential for implementing solar and wind power into energy systems of global islands. Two scenarios were studied: the first one excluding batteries and the second one including lead-acid batteries as storage solutions. The scope comprised islands with a population of 1,000 to 100,000 inhabitants who rely mostly on diesel-fired mini-grids which are reflecting a very interesting field for hybridisation by photovoltaic (PV) and wind power.

Energy is provided with power generation by diesel generators on many small islands in the Philippines. This cost intensive and environmentally harmful energy supply hinders local development and increases the dependency on fossil fuel imports. As a consequence, energy is only supplied for short periods of 4 to 8 hours on many islands. These problems can be targeted by the implementation of renewable energy (RE) technologies as solar irradiation and wind is abundant on most islands. Nevertheless, reaching a high share of RE quickly requires battery storage and frequency stabilisation systems.

A combination of renewables with diesel and batteries can provide the solution

To understand the cost optimised configuration of PV, wind power, and batteries in a hybrid island system, a simulation for each island's energy system is performed by a software tool developed at RLI. The model simulates a one-node island energy system with hourly time steps for one reference year taking PV, wind power, diesel generators, batteries and a 20 year life time period into account. The output of the computation is the lowest levelised cost of electricity (LCOE) and the corresponding optimal system configuration.

For the Philippines, 193 islands with a population above 1,000 and below 100,000 were identified. For each of the considered islands, input parameter such as solar and wind resources, local diesel costs, energy consumption and load profiles are derived according to a special methodology. Average values found for the considered islands are 1,490 full load hours of PV contrasted by 617 full load hours of wind, diesel costs of €0.93 per litre and an energy consumption of 1.54 GWh/year.

Batteries increase the share of renewable energies

For the business as usual scenario, a solely supply by diesel generators is simulated resulting in average LCOEs of €ct 37,0 per kWh. By implementing the cost-optimised share of solar and wind power without batteries, LCOEs are lowered by €ct 5.92 per kWh. The optimised implementation of 40 MWh battery capacity (lead-acid) would then lead to a reduction by €ct 7.69 per kWh. Although the implementation of batteries is not leading to a high reduction in LCOE compared to the first scenario their implementation leads to a dramatic increase in renewable shares achieved in the island energy systems. Without batteries, the renewable share in the systems averages at 34% whereas with batteries the renewable share averages at 81% of the total energy supplied.

Larger PV capacities (+95% compared to scenario 1) are installed in the second scenario as the batteries enable the shift of generated PV power to evening hours. Wind power capacities are decreasing with the implementation of batteries (-28% compared to scenario 1) as their potential is lower compared to solar PV throughout the Philippine islands.

The study shows that the implementation of battery technologies in combination with renewable energies can reduce power generation costs and thereby contribute to alleviating energy poverty. In the Philippines, batteries can be seen as enablers for the installation of large shares of solar PV.

Implementation of batteries leads to large environmental benefits

Furthermore, the implementation of batteries leads to large environmental benefits as diesel power generation is mitigated through a shift to PV power generation in the evenings. With further cost reductions for PV technology and rising diesel fuel costs, the economic viability of injecting PV combined with batteries into diesel systems will become an even more viable option.

Integrating sodium-nickel technology to design rural villages

Designing for flexible and extensible systems is a key factor when dealing with small infrastructures such as when rural villages face changes in energy use patterns due to rising peak loads, thus affecting energy storage too. These systems allow not only for time-shifted renewable energy consumptions but also for better peak load management, an important feature for low-budget infrastructures where surges in power become overwhelming.

The Long Semadoh Village project, designed by PHPower, is an example of a project that uses Sodium-Nickel technology to provide a best-effort solution for household demand management. Located about 80 km from Lawas, on the northern side of Sarawak (Malaysia), the village of Long Semadoh is a cluster of nine small villages, stretching along 20 km on both sides of the upper Trusan River. The project targeted the integration of hybrid sources to lower down expensive fossil fuel consumptions and the promotion of responsible energy use through managed energy allowances.

Maximise renewable energy consumption over gen-set production

As one of the innovative solutions selected to maximise the project outcome brought to the local population, the Sodium-Nickel batteries technology was expressly chosen to maximise renewable energy consumption over gen-set production. It also grants long-lasting and low-maintenance installation thanks to extended life cycles. Finally the Sodium-Nickel technology brings along environment friendliness, as the batteries are recyclable, safe and gas emission-free.

The storage systems (12 Sodium-Nickel 48V 8 kWh) have been conceived to grant lighting and base appliances use during standard climate periods. Without the need for battery sheltering (for explosion hazards and/or over-temperature protection) and due to their high energy density and small sizing, the units have being inserted directly into common power boxes. Moreover, a micro-grid application will allow villagers to acknowledge battery SoC and act responsibly to avoid unwanted discharges.

The storage systems used in the project have proven to fit very well with the strict requirements for energy provisioning where the grid is absent or faulty. Despite their high upfront costs, if properly designed and maintained, batteries will improve the system's performance and lead to economic savings over its lifetime. «

Author Marcus Wiemann is the Secretary General at the Alliance for Rural Electrification (ARE) and is responsible for the policy sector and outreach. ARE has become a pioneering actor in the field of sustainable development, supporting and bringing together renewable energy companies who are passionate about rural electrification through off-grid renewable energies.

Author Paul Bertheau is working as a researcher at the off-grid research group of the Reiner Lemoine Institut. The research group is focused on assessing the economic feasibility of renewable based hybrid systems.

Author Massimo Bergadano is Founding partner of PHPower. The Italian company fosters sustainable development and progress by promoting distributed generation and a conscious, responsible use of energy and resources.