

# Reducing Microgrid Diesel Consumption with Aqueous Hybrid Ion (AHI™) Batteries

## INTRODUCTION

The world's economies are electrifying at an impressive rate. Between 2000 and 2008, the world electricity produced per capita has increased by over 30% percent. Much of this electricity, particularly in developing economies, has traditionally come from generators burning diesel fuel. This trend is beginning to change, however, as electricity users shift away from diesel and towards renewable energy. In addition to the environmental benefits of renewable power sources, recent cost-downs in solar panels and other renewable system components are further encouraging this trend. Hybrid microgrid systems that combine diesel generators with solar photovoltaic generation and batteries are a leading solution in this space because they can greatly reduce diesel costs, the levelized cost of electricity (LCOE), and the environmental impact of energy generation.

Aquion Energy's Aqueous Hybrid Ion (AHI) batteries are designed to meet the needs of this growing energy demand. These safe, reliable, and cost-effective batteries are optimal for stationary, long duration, daily cycling microgrid applications. In a microgrid, energy storage provides two main benefits. First, storage increases the amount of solar energy that can be used in the system. Without storage, the system can only use solar when the sun is available. Secondly, storage increases the efficiency of diesel gensets by allowing them to run at peak output, rather than simply following the load. Taken together, storage reduces the fuel use of both traditional stand-alone genset systems and hybrid solar/diesel systems.

## THE IMPACT OF STORAGE

### Generator-Only Microgrids

In many remote microgrid applications, a diesel genset is the go-to solution to provide continuous power. Generators operate most efficiently near their maximum output, but their efficiency decreases, and fuel use per kWh increases, as the load drops (see Figure 1). In situations where the genset is oversized relative to the average load, often because peak demand is much higher than the average demand, the generator will frequently operate at sub-optimal efficiencies, burning unnecessary diesel fuel.

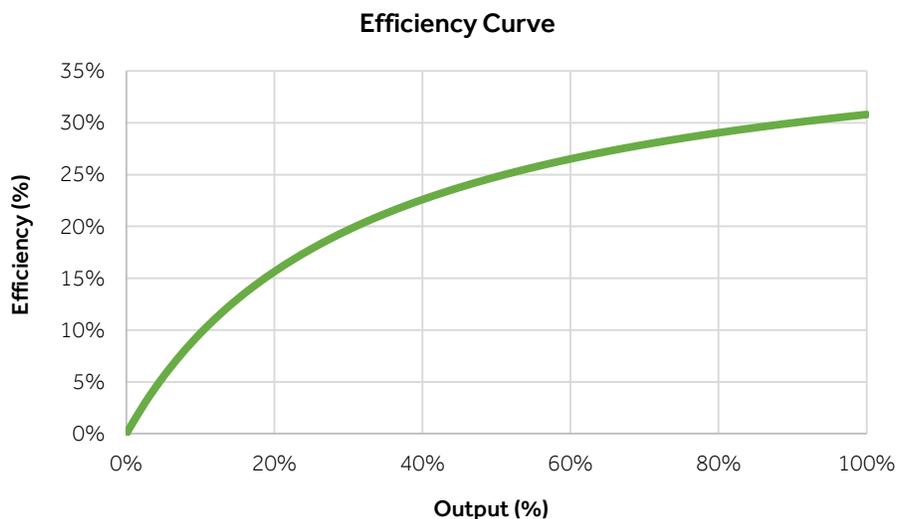


Figure 1: Typical genset fuel curve. Increasing the load from 20% to 80% doubles the efficiency of the generator, cutting fuel consumption per kWh in half.

With storage, the genset can run at maximum output and store excess energy, increasing the efficiency of the genset. The generator can then be shut off entirely, allowing the storage to serve the entire load, until it is completely discharged and the generator is turned back on. This can greatly reduce the energy demand of the system.

### Solar-Diesel Hybrid Microgrids

Microgrids that use both gensets and solar are becoming increasingly common in remote applications, particularly as the price of solar continues to decline. Depending on the size of the solar and storage systems installed, the storage can provide several benefits:

1. **Small renewable system (renewables supply <25% of energy):** In this scenario, the renewable system offsets diesel use during the day, and batteries mainly prevent the generator from rapidly ramping up and down with the renewable resource. This can also extend the lifetime of the generator.
2. **Medium to large renewable system (renewables supply >25% of energy):** In this scenario, storage not only prevents the diesel genset from running during the day, it also powers the system into the night, offsetting diesel use. The batteries can also help increase the efficiency of the genset during night time operation.

Any size storage system will help reduce diesel use, but the more solar and renewables installed, the greater the impact.

### Key Value Drivers

Storage can reduce diesel consumption for any system, but the magnitude of the benefit is tied to a few key metrics:

1. **Genset oversizing:** If the generator is often running below peak output, the system benefits considerably from storage, as it greatly increases the efficiency of the generator.
2. **Discrepancy between load and production:** If peak demand is at a different time than solar production, storage allows operators to increase the size of the PV system, greatly reducing fuel consumption.
3. **Price of diesel and solar:** The more expensive the diesel, the greater the benefits of storage, and the larger the renewable system should be. Cheaper solar, either due to less expensive panels or longer sun hours, also increases the value of storage.

## REAL WORLD APPLICATION

### Situation

An island resort in Southeast Asia currently uses diesel generators to power an average of 10 MWh per day. The average load is just over 400 kW, and the yearly peak reaches 1,300 kW. They currently use three 500 kW generators, which operate according to the standard efficiency curve from Figure 1. The resort has historically paid between \$1 and \$1.40 per L of diesel, and are looking to see the impact of storage on their electricity expenses under both scenarios.

### Solution

The resort would like to add solar panels and Aquion's Aqueous Hybrid Ion (AHI) batteries to their system, and are considering several different scenarios:

1. **Daytime solar:** A PV system that would provide solar whenever it was available, with no storage. This requires 800 kW of solar.
2. **Small storage:** A PV/storage system that would use energy storage to eliminate genset runtime during the day. This would require 800 kW of solar and 1200 kWh of storage.

3. **Medium storage:** A PV/storage system that would eliminate genset runtime during the day and store excess solar energy for nighttime use, providing 50% of energy demand from the solar panels. This requires 1,600 kW of solar and 2,400 kWh of storage.

They estimate the solar will cost \$2 per watt installed, and are using a 10% discount rate over 20 years.

**Results**

We analyzed the impact of solar and AHI energy storage in this system for both \$1 and \$1.40/L diesel using HOMER (www.homerenergy.com), a standard modeling tool. We looked at four metrics: the levelized cost of electricity (LCOE) of the system, the renewables fraction, or percent of energy from renewables, and the diesel use per year. The results show that storage is beneficial in both systems, regardless of diesel cost or system configuration:

	System LCOE at \$1/L Diesel	System LCOE at \$1.40/L Diesel	Renewable Fraction	Diesel Use (L/Year)	Solar Size (kW)	Battery Size (kWh)
All-Diesel	\$0.43	\$0.59	0%	1,400,000	0	0
Daytime Solar	\$0.40	\$0.52	25%	1,100,000	800	0
Small Renewable	\$0.38	\$0.49	25%	960,000	800	1,200
Medium Renewable	\$0.40	\$0.48	49%	770,000	1,600	2,400

Table 1: System results at \$1/L diesel and \$1.40/L diesel

AHI energy storage reduces system-level LCOE, increases renewables penetration, and reduces diesel use. At \$1.40, it is optimal to put in a medium-sized renewable system, because it offsets more diesel and reduces the LCOE by 11 cents per kWh. At \$1, the smaller renewable system becomes more optimal on an LCOE basis, saving 5 cents per kWh (Figure 2).

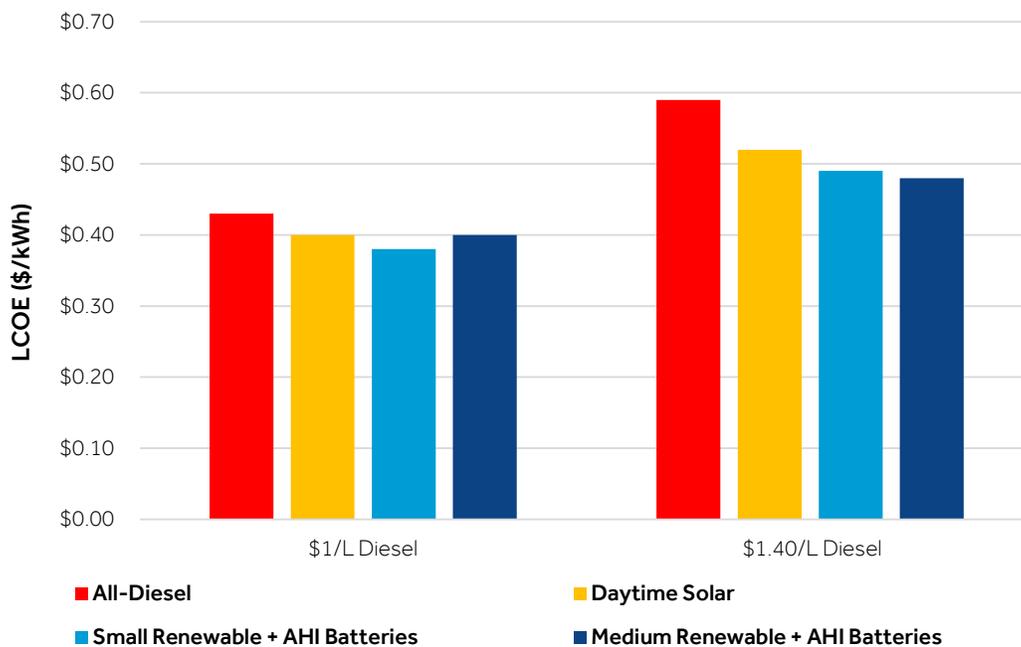


Figure 2: LCOE reduction due to the introduction of AHI batteries.