Service Life & Cost Advantages of the ALM® 12V35 for Off-Grid Lighting and Signage Systems

SUMMARY

Off-grid signage and lighting systems provide critical functionality for construction crews, municipalities, and field personnel in remote locations. Typically, they are powered by fuel-based generation sets (gensets), solar PV panels, or both. Batteries are an integral part of these systems providing energy storage and backup power. A battery array in a lighting or signage system will support a load ranging from 20W to 500W, and run times from four to eight hours in a genset configuration, and eight to twenty-four hours using solar PV panels. These systems power cycle regularly, sometimes daily, and are used in outdoor locations with a wide temperature range and no climate control.

Most systems use lead acid batteries due to low initial cost. However, the frequent power cycling and varying depths of discharge (DOD) significantly reduce lead acid battery life. To overcome this, the battery capacity is often sized 2X – 3X greater than the power (load) and run time requirements. This adds cost, size, and weight to the system, with operating conditions that significantly shorten battery life to less than one year.

KEY TRENDS

Off-grid lighting and signage must operate for extended periods of time whether in mobile or stationary deployments. Utilizations are during dark or daylight periods. Construction or municipal projects deploy mobile lighting and signage to aid work crews or provide public messaging. Municipal and commercial entities are increasingly placing off-grid stationary lighting and signage to deliver public messaging and lighting. These stationary systems provide flexibility in deployment location, and minimize installation and use costs associated with a grid connection.

Sustainability is becoming a priority as organizations explore ways to provide "green" power to their lighting and signage systems. There is a growing need for configurations that use solar PV systems and other sustainable energy sources. “Green” solutions are enabled by LED lighting technology which consumes significantly less power versus other light sources, and operates directly on DC current.

Where fuel-based gensets are used, there is a need to reduce genset run time and fuel usage. Run time is associated with air and noise pollution, which can be issues at work sites. Reduction in the amount and frequency of genset refueling is also a key factor in keeping operating cost to a minimum.

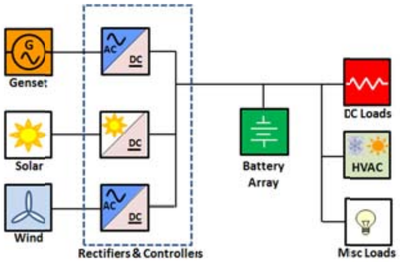


Figure 1

BACKUP POWER ATTRIBUTES & CHALLENGES

The block diagram of off-grid signage and lighting systems is shown in Figure 1. The genset and solar PV panels have different operational characteristics that influence the selection of battery type, nameplate capacity, configuration, and cost. The equipment use case and environmental conditions also impact the battery and system requirements.

For systems using a genset, the largest operational expense (OPEX) is fuel costs, including transportation. Lead-acid batteries have typical charge times from 6 - 15 hours, depending on how deeply discharged, resulting in long genset runtime and high operating costs to recharge the batteries. Genset operational efficiency usually occurs at a higher output power than most lead-acid batteries can be charged at. This further exacerbates costs and system inefficiency.

For solar PV systems, batteries are challenged by irregular or partial charging events from overcast days, with off-time during the night. Under these conditions, lead-acid batteries may not always be fully charged. Such “partial state of charge” operation can stress lead-acid batteries leading to unforeseen failure and costly replacement.

Lead-acid batteries generally face significant service life reduction if regularly discharged beyond 50% of their capacity. To address this, designers will oversize the battery systems to overcome the capacity derating. This increases the cost, size, and weight of the batteries. If a system cannot tolerate the extra size and weight, the lower capacity battery will degrade faster leading to more frequent and costly replacement.

Lighting and signage equipment are exposed to the elements and are not climate controlled. Battery calendar life at 25 °C degrades by ~50% with each average temperature increase of 10 °C. At 25 °C traditional lead-acid batteries have a calendar life of 5 - 10 years. The ALM® family of lithium ion batteries have a calendar life of over 20 years, providing over 10 years of service life at elevated temperatures.

The ALM® family of lithium ion batteries are robust and light weight, with a long service life over a wide range of operating conditions (figure 2). Under cycling applications, ALM batteries provide as much as 100X the cycle life of cycle-optimized lead acid batteries, even over temperature extremes. The ALM batteries charge up to 60X faster than equivalent lead acid batteries reducing genset fuel consumption by more than 80%.

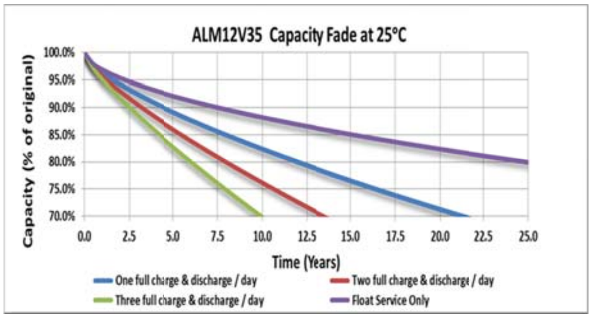
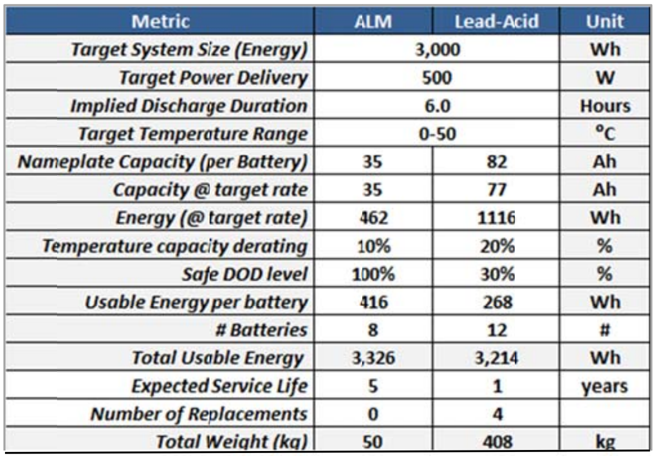


Figure 2

COMPARING BATTERY ARRAY POWER SYSTEMS

Using typical requirements for an off-grid lighting system, NEC Energy Solutions' compares its ALM® 12V35 battery against a well-known lead-acid battery, optimized for partial SOC and deep cycling applications. The operating period is 5 years.

Load: 500 W / 3 kWh
Run time: 6 hours
Battery String Voltage: 12 V nominal
Operating temp: 0 °C to 50°C, average 35 °C
Diesel genset: 1 hour on, 6 hours off



Metric	ALM	Lead-Acid	Unit
Target System Size (Energy)	3,000		Wh
Target Power Delivery	500		W
Implied Discharge Duration	6.0		Hours
Target Temperature Range	0-50		°C
Nameplate Capacity (per Battery)	35	82	Ah
Capacity @ target rate	35	77	Ah
Energy (@ target rate)	462	1116	Wh
Temperature capacity derating	10%	20%	%
Safe DOD level	100%	30%	%
Usable Energy per battery	416	268	Wh
# Batteries	8	12	#
Total Usable Energy	3,326	3,214	Wh
Expected Service Life	5	1	years
Number of Replacements	0	4	
Total Weight (kg)	50	408	kg

Figure 3

SOLUTION

The ALM 12V35 uses lithium iron phosphate (LiFePO4) cells that provide excellent deep cycling capabilities, extended temperature, long service life and exceptional power and energy performance. The ALM 12V35 includes EverSafe™ protection technology as part of the Battery Management System (BMS) in each battery. This technology delivers fully redundant protection from internal failures or external abuse. It provides system-level protections for battery strings and power system operation, with automatic adjustments and recovery from system level faults or abusive application.

The ALM 12V35 has a number of advantages.

1.) Excellent power and run time performance
The ALM 12V35 can be safely charged and discharged across 100% of its capacity, whether operated with full or partial cycles, without significant loss of cycle life. Even though the lead-acid battery under comparison is optimized for partial SOC operation (which is often challenging), discharging to more than 30% DOD significantly reduces cycle life. Limiting operation to 30% DOD requires adding four more batteries to meet system energy requirements as compared to the ALM 12V35.This increases cost, weight, and volume.

2.) Service Life, Total Cost of Ownership
The lithium ion technology used in the ALM 12V35 has a cycle life of greater than 8,000 cycles at 100% DOD. The lead-acid battery cycle life is much less. Even when limited to 30% DOD, it provides less than one year of service life in this scenario. Over a five-year period, the complete lead-acid battery array needs to be replaced four times in order to provide proper energy storage to the lighting system. The ALM 12V35 has a service life of approximately 10 years, and therefore requires no replacement over the equipment service life of 5 years.

The total cost of ownership over the lifecycle of the batteries is shown in Figure 3. The costs shown are for the batteries only and do not take into account the cost of shipping replacement batteries (greater than 400 kg) to the site, labor to replace, and the cost of shipping dead batteries to recycling. These are omitted because the costs can vary greatly based on the location of the site, region, local ordinances and laws. The overall expenses can be considerable in many instances.

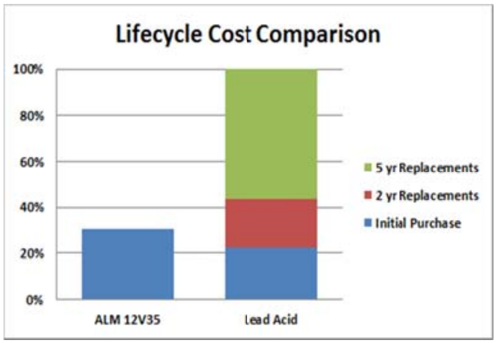


Figure 4

3.) Faster charging (by more than 10x) reduces OPEX
The ALM 12V35 can take advantage of high power genset efficiency. It can be fully charged in less than 20 minutes, compared to 300 minutes (5 hours) for partial SOC optimized lead-acid batteries. Running the genset for only 20 minutes provides more than 90% savings in diesel fuel costs. If more conventional lead-acid batteries are used, the charge time can be up to 15 hours.

4.) Significantly less weight than lead-acid batteries.
The ALM 12V35-based solution is ~1/8th the weight of the equivalent lead acid solution. This significantly eases installation and transportation of equipment from site to site.

The ALM12V35 is available in standard (s), intelligent (i), and High Power (HP) series to match application requirements. The i-Series offer integrated CAN bus or SMbus communications that provide remote monitoring and control of critical battery status, usage tracking, SOC, run time to empty, and other parameters.

NEC Energy Solutions ALM family of lithium-ion batteries undergo engineering construction, evaluation, and extensive testing to ensure international product safety conformity, as well as application specific certifications.

Visit **www.neces.com** for the latest information and data sheets.