ESS-30 HD |

BALQON Corporation
Lithium Batteries

Storing Nature

Energy Storage | HIQAP™

ESS-30HD lithium battery system provides 33 kWhr of battery storage energy to eliminate imbalance between supply and demand of energy generation by Solar Powered system. HIQAP™ battery storage system is equipped with lithium iron phosphate (LiFePO4) large format batteries, connected with Balqon's proprietary Battery Management System (BMS) and a master controller to monitor and protect batteries during daily charge and discharge cycles.

Solar Energy availability in certain regions or periods during the day can provide cost-free surplus energy that can be stored in batteries reducing electric costs and improving return on investment of Solar installations. In addition batteries can charged during off-peak hours and stored energy can be used during peak power periods to further reduce electricity cost. Model ESS-30HD with stored energy of 34 kWhr, is capable of running an average household electric power needs for up to a 24 hour period during emergency power network failures. In remote areas without power or grid connection, ESS-30HD can be used in conjunction with generators to efficiently store energy reducing generator fuel and maintenance costs.

Benefits | Battery Storage

Renewable energy output is undependable since it is effected by weather conditions. Renewable power generation in an on-grid system may cause issues with power grid due to fluctuation in the output, which makes frequency control difficult for electric Utilities. Use of battery storage systems can mitigate this output fluctuation by storing excess power locally. Large gaps in demand between peak hours and off-peak hours makes battery storage an ideal solution to store energy during off-peak hours for use during peak demand.

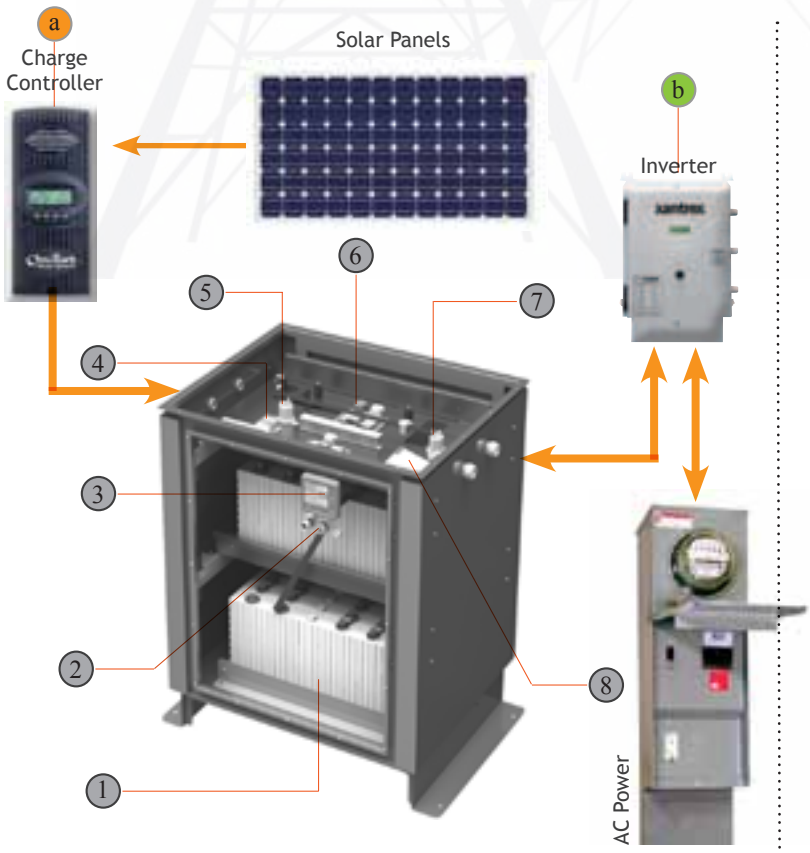
Power Utilities set time varying electricity prices, lower price at night and higher one during peak day hours to incentivize lower peak loads. Lithium battery storage can provide reduced grid power consumption during peak periods, thereby reducing electricity bills. In addition ESS-30HD can supply power continuity by instantly switching the load from grid to batteries during power outages.

ESS-30 HD	Specification
Nominal Capacity	34 kWhr Stored Energy
Battery Type	Lithium Iron Phosphate
Battery Voltage	48 Vdc Nominal
Operating Voltage	42 Vdc - 60 Vdc
Cycle life	3,000 Cycles @ 80% DOD
Charge Voltage	52.5 Vdc Bulk Charge |57.0 Vdc Absorption Charge | 55 Vdc Float Charge
Discharge Voltage	45 Vdc max
Max Discharge Current	500 Amps DC @80% DOD 1000 Amps DC @50% DOD
Max Charge Current	700 Amps - Bulk Charge mode [@52.5 max output voltage]
Operating Temp	-45 deg C to +65 deg C
Warranty	Five years (prorated)

System | Battery Management & Safety

Balqon ESS-30HD, HIQAP™ lithium battery storage unit contains integrated battery management system that monitors each battery cell voltage and temperature during charge and discharge cycles. Balqon proprietary QANBUSS™ battery management system controls charging, discharging, balancing of lithium battery cells with intelligent functionality that extends battery life. QANBUSS™ functionality allows ESS-30HD to be charged or discharged by standard charge controllers and inverters.

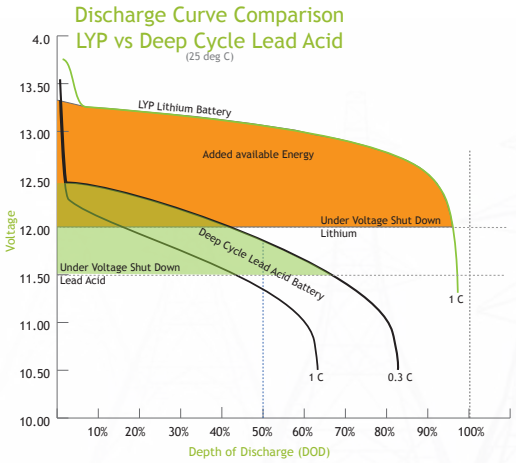
The safety and life of lithium battery pack greatly depends on operating conditions such as charge/discharge rate, State of Charge [SOC%],load characteristics and temperature. The crucial role of battery management system is to ensure that each individual cell is operated within safe limits to extend battery life.

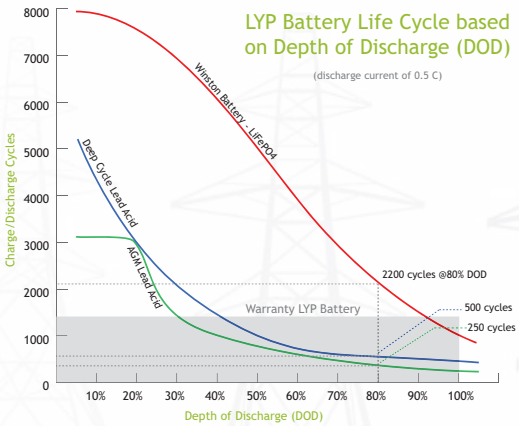


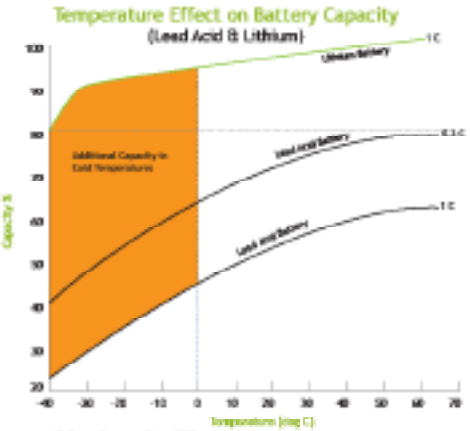
There are three key factors that determine safe reliable operation of lithium battery storage system: Pack Voltage |Cell Voltage|Temperature. Pack Voltages for Charge and Discharge cycles are user adjustable on most leading Charge Controllers and Inverters in the market. Prior to connecting with ESS-30HD, Solar charge controller and Inverter must be programmed to match specifications. Once ESS-30HD unit is powered "ON", QANBUSS™ will automatically monitor each cell voltage and temperatures during daily use. ESS-30HD is equipped with contactors on charge and discharge side of the circuit that protects the batteries in case of a failure in the system. In addition the system is equipped with four relay outputs that can be used to control external equipment, such as charger, inverter, buzzer,generator etc.

Adding ESS-30HD to a current solar installation or replacement of a existing lead acid energy storage is as easy as connecting four cables to external power studs mounted on side of the battery enclosure. Simple program changes to the Solar Charge controller and Inverter, and ESS-30HD is installed and operational in minutes.

#	Description
a	Solar Charge Controller|48 Volt charge controller with modified bulk/absorption/float voltage configuration; power cables connected to bulkhead connectors on battery enclosure.
b	AC Inverter| 48 Volt input to 110 VAC or 230 VAC output with modified under voltage shutdown specifications; input power cables connected to bulkhead connector on battery enclosure.
1	Lithium Battery|Lithium Iron Phosphate batteries connected in series and/or parallel configuration; nominal voltage 48 volts; each cell connected to Battery Management System and Cell balancing circuit
2	Power "ON" | "STOP" | Manual system control buttons; independent control of charge and discharge circuits for maintenance or replacement
3	Battery Monitor/Display |Optional display shows each cell voltage, temperature, SOC and user controlled adjustable parameters; Kwhr meter; input charge and output discharge current
4	Accessory Relays|Four 12 Volt relays for accessory controls - external chargers, generators, fault lights etc.
5	Charge Contactor Control|12 Volt contactor controlled by BMS system, contactor opens if one cell voltage reaches above 3.8 Vdc or pack voltage reaches above 52.5 Vdc; requires manual reset
6	Battery Management System|15 Cell battery management system, monitors individual cell voltage, pack voltage, input and output current; calculates SOC%, Kwhr stored and used; cell temperatures
7	Discharge Contactor Control| 12 Volt contactor controlled by BMS system, contactor opens if one cell voltage reaches below 2.8 Vdc or pack voltage reaches below 45 Vdc; requires manual reset
8	QANBUSS™ Battery Control Unit|Multiplexer unit monitors cell voltages, temperatures, provides relay and contactor controls|diagnostic tools







Value|Energy Density|Discharge Rate|Cycle Life|Transfer Efficiency

Emerging role of Energy Storage in both off-grid and on-grid applications has led to development of new battery chemistries with increased cycle life and transfer efficiency ideal for renewable Energy Storage System (ESS). Balqon ES-30HD, HIQAP™ battery storage uses Lithium Iron Phosphate battery with Yttrium (LYP) batteries, which is known to be the safest in Lithium-Ion group of batteries.

Lithium Iron Phosphate batteries have been used in electric vehicles for over a decade and are known for their high energy density (wh/L) and specific energy (wh/kg) when compared to lead acid batteries. In addition to these features, LYP delivers longer cycle life, efficient energy transfer and higher performance in both cold and hot environments.

Energy Density of LYP battery is approximately 1/2 the size, and 1/3 the weight of an equivalent lead acid battery. Higher discharge capability of LYP battery (80% DOD) allows use of lower amp hour LYP battery compared to an equivalent lead acid battery.

Discharge rate is a critical consideration in determining the battery capacity for use in Energy Storage System (ESS). Combination of high discharge rate and higher depth of discharge % (DOD) of a LYP battery, only 54% of lead acid ahr capacity equivalent is needed for LYP replacement battery. ESS application requiring 100 ahr (12.5 amps/hour) discharge during eight hour period will require 125 ahr LYP battery or 230 ahr capacity lead acid battery.

Cycle life is a measure of battery life expressed in terms of number of charge and discharge cycles after which the battery becomes unusable. In lead acid batteries, sulfation is the leading cause of battery end of life. Since most lead acid energy storage is not equipped with battery cell management, imbalance in lead acid cells leads to sulfation and end of battery life. This condition is particularly true when cells are connected in large series configuration. In addition high ambient temperatures and/or high charge and discharge rate increases speed of chemical reactions which leads to development of undesired molecules. These molecules increase chemical impurities in a battery changing cell morphology which leads to slow degradation in battery capacity leading to end of battery life. In sealed lead acid batteries higher temperatures can also result in increased internal pressure inside the battery leading to mechanical failures. Higher energy density of active material in lithium batteries provides over 4 times the cycle life of an equivalent lead acid battery. ESS-30HD is equipped with sophisticated battery management systems that monitors and balances individual cells during its lifetime. Under similar charge and discharge rate, lower internal resistance of the LYP battery keeps internal temperature significantly lower than a lead acid battery. Lower internal temperatures reduces development of undesired molecules and impurities resulting in longer cycle life of LYP battery.

Transfer Efficiency of energy produced from renewable energy sources to storage batteries can significantly influence cost of the overall system. Poor transfer efficiencies of lead acid require 20% larger solar installations when compared to LYP lithium storage systems. Lead acid batteries due to their high internal resistance have a transfer efficiency of 72 - 76% compared to 96% transfer efficiency of the LYP battery. A 50W, Solar panel installation can produce 400 whr of energy during an 8 hour period, but only 304 whr of this energy will be stored by lead acid batteries, meanwhile a 40 watt solar panel installation with LYP batteries would store the same amount of energy during an eight hour period.

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Battery Management System

The ESS-320HD energy storage system is equipped with Balqon Proprietary QANBUSS™ battery management system with intelligent functionality that extends battery life. Balqon QANBUSS™ has undergone over four years of field testing in electric vehicle and energy storage applications ranging in voltage from 12V to 700V. Each QANBUSS™ module monitors up to twelve (12) lithium battery cells and can be connected in series to monitor unlimited cells via J1939 Can Bus communication.

QANBUSS™ monitors each battery cell during charge and discharge cycle and transmits the following information every 100 ms (millisecond):

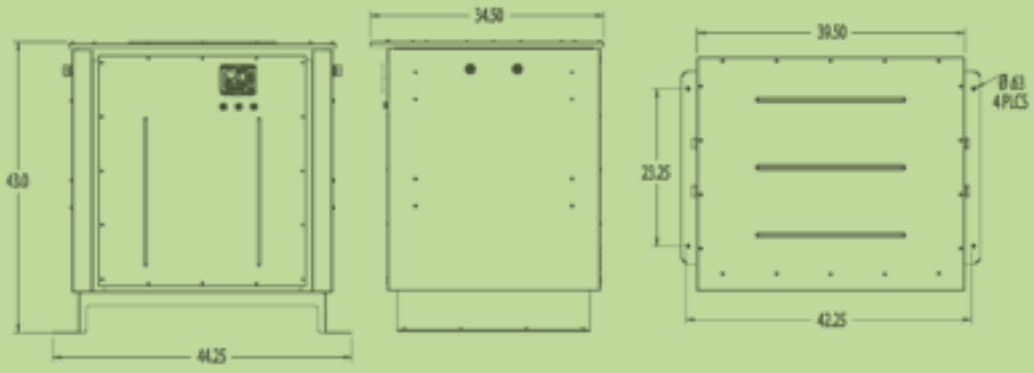
Lowest Cell Voltage	Highest Cell Voltage
Temperature Sensor #1 (T1)	Temperature Sensor #2 (T2)
QANBUSS™ Board Temp (TB)	# Cells reporting (1-12)
# Cells balancing (1-12)	Total Bank Voltage (Vdc)

During charge and discharge cycle of batteries, above information is transmitted from all QANBUSS™ modules via J1939 Can Bus to the Battery Controller Unit (BCU). BCU is designed to be highly flexible and field programmable for both automotive and energy storage applications. To protect batteries from over charge/discharge, BCU is programmed with set points and limits customized to the application needs. Listed below are key controls and protections of BCU:

Under Cell Voltage (UCV) Warning/Fault	Over Cell Voltage (OCV) - Warning/Fault
Under Cell Temp (UCT) - Warning/Fault	Over Cell Temp (OCT) - Warning/Fault
Low Pack Voltage - Warning/ Fault	Low STATE OF CHARGE SOC - Warning/Fault
Cell Not reporting - Warning/ Fault	Charge Command - Bulk/ Float
Cell Balance Current	Energy Used/Stored in Kwhr
Charge Enable/Disable	**Discharge Enable/Disable**

QANBUSS™ BMS system is designed to operate in environments with high electrical noise. J1939 system communication provides seamless integration and noise immunity with other automotive components (ECU's) used in electric and hybrid vehicles. QANBUSS™ BMS uses passive balancing to balance the cells during charge cycle. Each cell is connected to 8 watt passive shunt resistor, which helps dissipate up maximum of 2 amps per cell during balancing phase. When connected to a CAN Bus capable charger, charge current is reduced during balancing phase to ensure efficient pack balancing.

QANBUSS™ system is designed with wide range of voltage sensing capabilities, from 0.3V to 5.0 V which makes it compatible to any lithium battery chemistry available in the market today. Each QANBUSS™ module monitors pack temperature via two (2) thermistors. During charge cycles, charge rate is automatically reduced if temperature reaches certain programmed thresholds.



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