Information Sheet #61

The ultimate solution for maintaining your nationwide generator network

Generator Systems & Energy Storage Using Lithium-ion Batteries

1.0 Introduction:

The traditional role of a standby generator system is to supply backup power when the utility power, or another source of prime power, goes off line. The emergence of renewable energy solar and wind power systems as the primary power source, with batteries used as backup energy storage when wind and solar is not available, is creating a new role for engine driven generator systems. This role is to recharge batteries used for energy storage within renewable energy systems during periods when there is insufficient wind or solar power to ensure the batteries are charged to the level as specified for the system.

This Information Sheet discusses the various methods of energy storage, in particular Lithium-ion batteries, the interface with an engine driven standby generator system, and the importance of ensuring fully charged batteries in an energy storage system:

2.0 Renewable Energy is Becoming a Significant Power Source:

While traditional power sources, such as fossil fuel, hydro-electric, and nuclear power, supply more than 90% of US power requirements, renewable energy over the years has found its place as an primary energy source, with wind providing 7.5%, and solar 1.3%, of the utility power generated in the US during 2017. As the US is a major consumer of power, this means a tremendous amount of energy storage is supporting renewable energy systems, and a new role for engine driven generator systems.

Engine Generator System in Standby Mode to Solar or Wind Power Supplying the Load

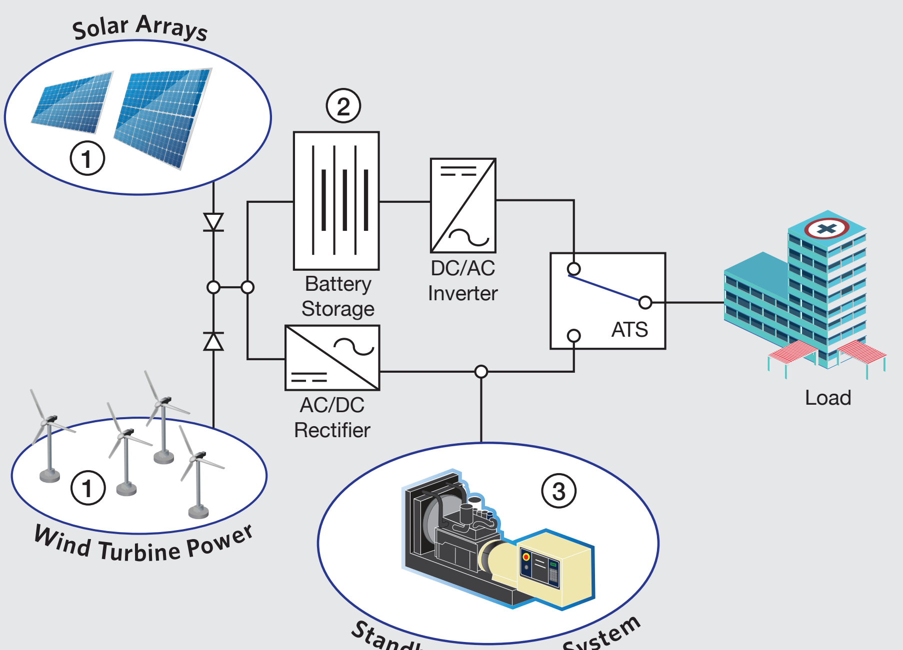

Diagram-one

KEY

1 - **Renewable Energy Source:** Battery Storage is used for backup power for Wind Turbine and Solar Array systems when wind or solar not available. A Micro-grid system may adopt wind and solar.

2 - **Battery Energy Storage:** The preferred batteries today are Lithium Iron Phosphate, see chart to right for details. The battery provides power when wind and solar is not sufficient. The system engineer will calculate the ampere hour capacity. However, for extended outages it is preferable to include a backup standby generator. A larger battery requires more wind and solar for charge.

3 - **Standby Generator System:** The generator will be sized to run the load and charge the batteries through a rectifier. Power from the renewable energy source can only flow one way. The AC load will be switched to the generator via an automatic transfer switch (ATS).

Features of Lithium Iron Phosphate batteries to other types

Chemistry	Lithium Iron Phosphate
Abbreviation	LFP
Cell Voltage	3.2V
Specific energy Wh/kg	90 - 125
Cycle Life	1000 - 3000
Charge Rate (C rate)	C/2 to 4C, charges to 3.7V
Discharge Time	IC but 30C on some cells; 2.5V cut off
High temp durability environment	High
Thermal runaway temperature	270°C (518°F)
Production Costs	Low

Wh/kg = watt hours per kg

To fulfill our commitment to be the leading network service provider in the Power Generation Industry, the USA, Inc. team maintains up-to-date technology and information standards on Power Industry changes, regulations and trends. As a service, our **Information Sheets** are circulated on a regular basis, to existing and potential Power Customers to maintain awareness of changes and developments in engineering standards, electrical codes, and technology impacting the Power Generation Industry.

3.0 Other Energy Storage Methods to that of Lithium-ion Battery Systems :

While currently renewable energy systems extensively use Lithium-ion batteries, other sources of stored energy are:

3.1 Mechanical - Uninterrupted Power System (UPS) have used the energy stored in a rotating flywheel to generate power when the utility goes off-line and the standby generator runs up to speed. This method is only practical for short periods measured in seconds.

3.2 Compressed Air - Stored compressed air through a turbine blade can be used to generate power. However, it requires a considerable amount of stored compressed air to generate power for any period of time, requiring costly storage vessels.

3.3 Thermal Energy - Certain volcanic geographic locations can supply thermal energy, and heat pumps can use stored ground heat energy. While these systems are not time limited they can be very costly to install.

3.4 Hydro Energy - The US already has tapped into most suitable topographical areas large enough to generate hydro-electric power economically for long periods of time.

3.5 Tidal Energy - Using the movement of water through major tidal areas to generate power has been considered for many years. Large scale projects would be expensive and it has yet to be implemented.

3.6 Stored Battery Energy - Before the introduction of Lithium-ion batteries, Lead-Acid and Nickel Cadmium batteries were the batteries of choice in UPS systems and telecommunication systems. Their use is still extensive, but the advantages of Lithium-ion batteries as a more efficient electrical storage method means renewable energy systems are choosing Lithium-ion.

4.0 The Advantages of Lithium-ion Batteries:

While the initial costs of Lithium-ion batteries are 1.4 times that of alternative batteries, the total ownership costs (TOC) are driving users and designers of renewable energy systems to Lithium-ion. The characteristics of different batteries can also dictate the size of generator system.

The following is are examples of the TOC:

4.1 Lighter Weight - Being one third the weight of lead-acid results in less expensive mounting arrangements for large systems.

4.2 Low Failure Rate - Much lower failure rate with longer lifespan and lower maintenance requirements (10-year TCO savings of 10 to 30%, with almost non-existent failure).

4.3 Reduced Maintenance - Built-in Battery Management System (BMS) providing auto status and fault monitoring, etc. whereas a single bad (defective) battery can take down the entire string of lead-acid batteries.

4.4 Longer Lifespan - Up to 15 years (lead-acid have to be replaced every 3-4 years).

4.5 Operational Temperature Range - Can operate at temperatures of 86°F (30°C) – almost 10°F higher than lead-acid.

4.6 Time to Recharge - Can fully recharge in about 2 hours vs. 24 hours for lead-acid.

4.6 Less Environmentally Invasive - One third the carbon footprint of lead-acid.

5.0 Recommended Type of Lithium-ion Batteries:

The ideal lithium chemistry to use in UPS batteries for data centers is lithium iron phosphate (LFP) – see Diagram 1 overleaf. Compared to other chemistries, lithium iron phosphate offers the best mix of safety, performance, longevity, and cost effectiveness:

5.1 Stable Chemistry:- Lithium iron phosphate is a very stable chemistry making it safer to use as a cathode (cobalt is chemically unstable).

5.2 Reduced Thermal Runaway:- Provides significantly reduced chance of thermal runaway. Early versions of Lithium batteries gained a reputation for catching fire, hence the move to lithium-ion.

5.3 Rapid Charge and Discharge:- The chemistry permits a very rapid discharge and recharge period without generating too much heat.

5.4 Fire Suppression:- Should a fire occur with a LFP battery, it can be extinguished by ordinary water sprinkler system.

6.0 Typical Battery Storage Systems Utilizing Engine Generator Standby System:

Engine driven generator systems are used to recharge battery energy storage systems in a variety of off-utility or micro-grid systems including:

- **Wind power -** Batteries are the energy storage to sustain power when no wind is available. During excessive periods of no wind, standby generators are used to recharge the batteries.
- **Solar Power -** As above, but the primary power is solar arrays instead of wind generators.
- **Battery Energy Standby to Utility Grid -** Some systems utilize batteries as the standby power when the utility is off-line. If the battery storage is insufficient to supply power through extended power-outages, an engine driven generator supplies power to the batteries. The generator installation can be permanent or have a mobile generator connected to the system via a docking station.

7.0 Generator Specifications for Charging Lithium-ion Batteries:

The following details specification considerations when applying a generator system tp supply power to a battery storage system:

- **Alternator -** As batteries are DC volts and engine generator systems are AC volts, generator power input to the battery when recharging will be through an AC/DC rectifier. Rectifiers use diodes that can produce harmonics that effect the wave form of the AC power. This can be troublesome for Automatic Voltage Regulators (AVR) controlling a generator, therefore the generator specified should be able to withstand a high component of Silicon Controlled Rectifiers (SCR) loads.
- **Auto-Starting -** Usually a sensor detects the battery has fallen to a certain ampere hour capacity and a signal is transmitted to a 2-way contact for the generator to automatically start. It will shut down when the sensor detects the battery is fully charged.
- **Connection of Generator System -** The battery storage system outputs DC power that is fed to an invertor to transform the power to AC. The AC generator is connected to the AC side of the system via a by-pass isolator switch if manual, or Automatic Transfer Switch (ATS) if automatic. (See diagram-one front page)

USA
ULTIMATE SERVICE ASSOCIATES
A NORTH AMERICAN SITE SERVICES CO.

Ultimate Service Associates, LLC.
5514 South Lewis Ave.
Tulsa, OK 74105

Ph: 918.836.8701
Fx: 918.835.2748

www.usa-svc.com