Total Energy Systems, LLC

KOHLER®

Your Reliable Guide for Power Solutions **Information Sheet # 140**

To fulfill our commitment to be the leading supplier in the power generation industry, the Total Energy Systems, LLC. team ensures they are always up-to-date with the current power industry standards as well as industry trends. As a service, our **Information Sheets** are circulated on a regular basis to existing and potential power customers to maintain their awareness of changes and developments in standards, codes and technology within the power industry.

Energy Storage Systems for Generator Systems

1.0 Introduction:

Energy Storage Systems (ESS) have always been an important component of generator systems. In a traditional engine-driven standby generator system, the ESS is the on-site fuel storage, usually diesel or gas. Should the utility grid go off-line, the standby generator's run time will be limited to the amount of fuel available at the site. ESS has a dual role as more renewable energy systems are applied to prime power applications, especially those with Grid-Tied systems. Not only to make sure the renewable energy source can supply power during a utility outage, but also to provide backup stored energy when the energy source is low or unavailable.

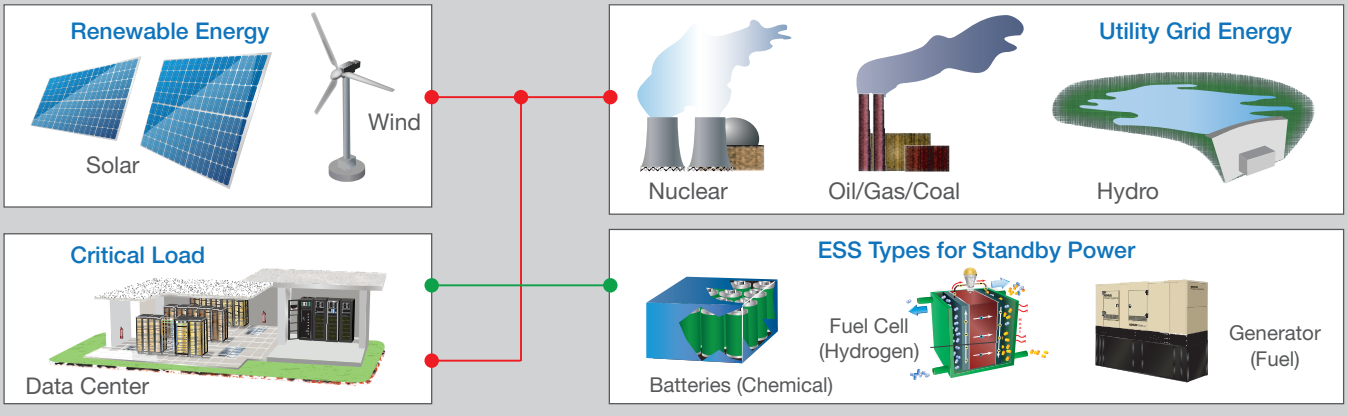
This information sheet discusses ESS for prime and standby power systems with a high renewable energy component within the application. Mainly wind and solar power systems supplying power in sync with the utility grid.

Use and Types of Energy Storage Systems (ESS)

Figure 1 ESS Used for Power Generation Applications

Type of ESS & Example	Mechanical	Electrochemical	Nuclear	Electrical	Hydrogen Based
Type	Gravity/Kinetic	Lithium-ion	Uranium	Super Capacitors	Fuel Cells
Use Example	Hydroelectric	Backup to Renewable Energy, and Grid Power	Nuclear Power	UPS	Peak and Backup power
Type	Pumped Hydro	Lead Acid			Compressed Gas
Use Example	Storage for Peak use period	Starter Battery			Generators
Type	Flywheel	Nickel Cadmium			Fossil Fuel
Use Example	(UPS)	Back-up Power Telecoms			Engine Driven Generators

Figure 2 Example of Where ESS is Used for Renewable and Traditional Grid Power



2.0 What is Energy Storage:

Energy storage is when the energy produced at one time is stored for future use. Energy stored bridges the gap between energy production and energy demand. Often, energy demand constantly cycles up and down, whereas energy production is more constant. The energy produced comes from multiple sources, including but not limited to radiation, chemical, gravity potential, electrical, and heat. There are two storage requirements, short and long term:

2.1 Long-term:

Long-term examples include bulk storage of water stored for hydroelectric dams (gravitational energy). And the extensive electrical grid network with many connected forms of power generation using stored energy from nuclear and fossil fuels.

2.2 Short-term:

Short-term storage examples include chemicals, as with a battery, and food for consumption. Other short-term types include capacitors in an electrical circuit, kinetic energy stored in a flywheel (UPS systems), and latent heat for storage heater units.

3.0 Energy Storage System (ESS) Associated with Fossil Fuel Power Generation:

Residential, commercial, and industrial electrical power consumers connected to the electrical utility grid are connected to the grid's bulk storage capacity in the form of nuclear, fossil, and hydro plants stored fuels. However, their combined connected load is not constant; it cycles continuously, with the grid pulling down from its stored energy components as required. However, the grid itself cannot be relied upon to constantly produce power without interruptions. Standby generator systems have been developed to provide short-term power when the grid goes off-line. *See figure 1.*

Short-term power requires short-term ESS. The following are the traditional standby generator systems applied to applications that's primary power source is the utility grid:

3.1 Engine Driven Standby Generator System:

When the utility goes off-line the generator starts, and a correctly sized engine turns a correctly sized generator to produce the electrical current the connected load requires. Energy for this application is stored in the form of fossil fuel, either diesel, NG, or LPG. Fuel is stored on-site or piped, depending on the application. Without an Uninterrupted Power System (UPS), there will be several seconds with out power as the generator runs up to speed.

3.2 UPS Standby Generator System:

Many critical applications have no tolerance for power interruptions while the generator runs up to speed. To meet the requirements of these applications, UPS systems have been developed that tap into two varieties of stored energy. First, chemical electrical energy stored in a battery, and second, kinetic energy stored in a flywheel. See the information sheet on UPS.

4.0 Renewable Energy Systems and the Constant Requirement for On-Site ESS:

A high percentage of utility grid power uses stored energy from fossil fuels, such as coal and natural gas. For over a hundred years, this has been a very convenient source of stored energy that can be easily tapped into as the load cycles up and down. However, fossil plants are one of the principal emitters of Carbon Dioxide CO2 that contributes to global warming. As such, there is a drive to be less dependent on stored energy in the form of fossil fuels and using more renewable energy sources.

The utility grid has used hydro-electricity for more than a hundred years using gravitational stored energy in the form of water stored behind dams. For 60 years, nuclear power plants have heated steam for turbines using the stored energy in nuclear fuel rods. Hydro and Nuclear are large infrastructure projects with all associated costs and regulations.

While both hydro and nuclear are well-proven power plants with minimal CO2 output, the direction has been to generate more power with solar and wind as renewable energy. The only problem with solar and wind is that the bulk energy source that powers them is not constantly available. As the connected load varies, there must be some means to store the wind and solar energy when the wind doesn't blow and the sun doesn't shine. Therefore these types of energy generators will always require on-site short-term energy sources.

5.0 Renewable Energy Systems and the Constant Requirement for On-site ESS:

Currently, many solar energy systems at the consumer end are configured as Grid-Tied systems. This means the DC power generated from the solar panels, via inverters is synced to the AC voltage sine wave of the utility grid. To avoid "Island Mode" (*see the information sheet on this subject*), solar power is also shut down when the grid goes off-line. This same applies to wind turbines that are connected to the grid via inverters. It is a safety procedure to protect utility workers working on the line.

Grid-tied renewable energy systems are popular because of tax incentives applied to them for environmental reasons. When the connected load is lower than the wind or solar power produced, any surplus energy is forced into the utility grid and the meter will run backwards to lower the consumers utility bill.

As long as the consumer is also connected to the grid, power is available without sunshine or wind. The problem is what to do when the grid is off-line and when solar and wind energy sources are unavailable. The solution has been to use various stored energy sources, including chemical energy in the form of batteries, fuel cells with hydrogen-based fuels, and engine-driven generator systems with on-site fossil fuel storage *See figure 2*

6.0 Adapting Grid Tied Renewable Energy Systems to ESS Back-up Power:

The principal ESS solution to provide on-site back-up power for solar and wind is batteries. Battery technology has developed as an economic and technical solution, particularly in the form of Lithium-ion batteries. During normal operation, the load will cycle up and down, and any surplus DC power will maintain the battery in and fully charged state. The battery is sized when the system designer has determined the battery power that is required and what critical load amperage will be connected. For longer durations, an engine-driven generator will be applied.

If the installation in the normal state is operating as a Grid-Tied system, NEC and UL codes specify that there has to be a switching mechanism to move from the Grid-Tied to Island Mode operation, (see *Information Sheet When Solar Power Systems Require Standby Power*). Some data centers and healthcare facilities use fuel-cells as backup power as an alternative to batteries.

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