

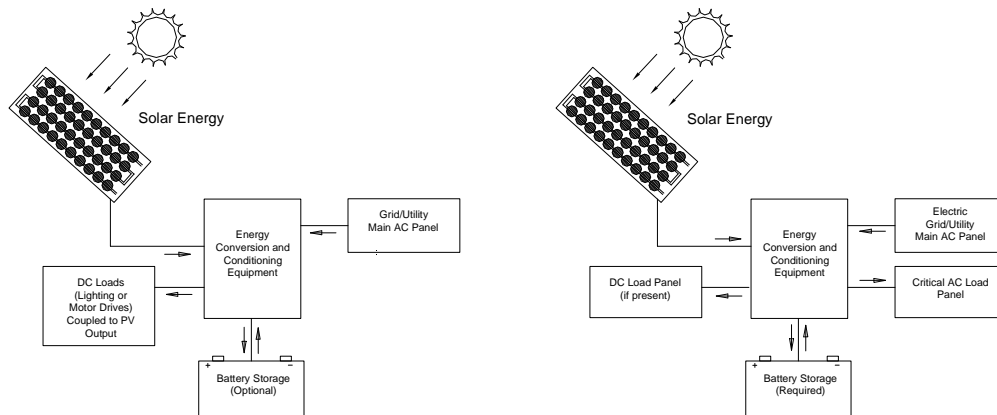
Non-Exporting Photovoltaic System Study

Prepared For

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1 Executive Summary

New Energy Options, Inc. (NEO) has been asked to survey the present state of photovoltaic systems which are incapable of back feeding electricity on to the utility distribution system. This report summarizes three different technologies, including a detailed description of the specific systems and their interaction with the utility distribution system.

2 Technical Overview

There are three different commercially available types or configurations of systems for utilization of photovoltaic energy which will not permit electrical energy to flowing back into the utility distribution system.

The first of these system configurations is the traditional Stand-Alone PV system, often used for off-grid applications. This system has no physical or electrical connection to the utility distribution system. It can be implemented in a location that has access to the grid in a manner that is identical to an off-grid application.

The second type of system is a Battery Backed Critical Load Panel PV system. This type of system has many permutations of operation and system sizing depending upon the site requirements. Some systems of this type may be programmed by the user not to feed energy back to the grid. Others are hardware configured at the factory to preclude back feeding into the grid.

The third type of system is a Direct Coupled PV System. This system directly utilizes the photovoltaic array without any power conditioning. This particular system has only one manufacture in the US and is still undergoing development.

3 Stand-Alone PV Systems

3.1 Overview

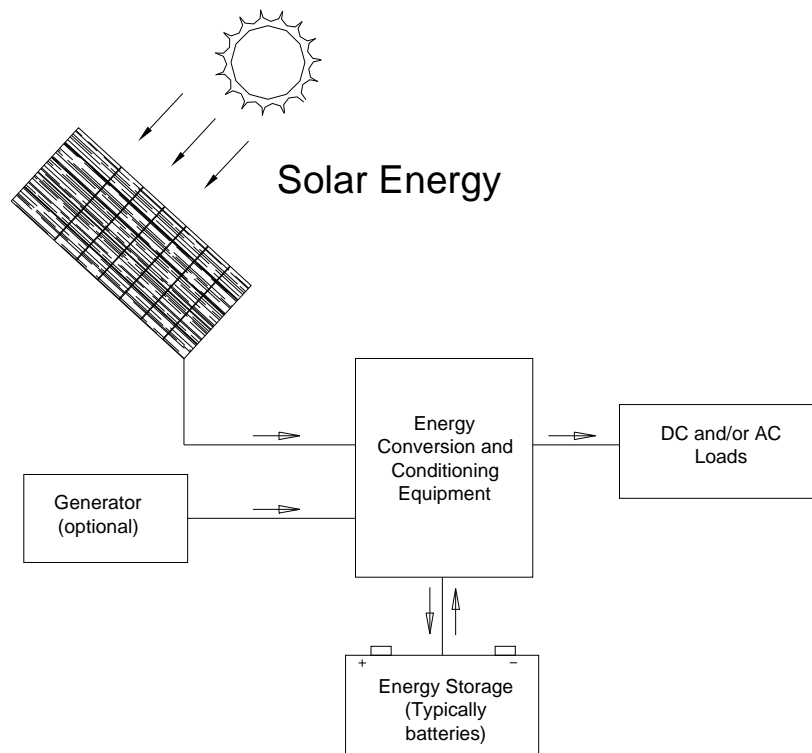


Figure 1: Block diagram of a typical stand-alone photovoltaic system

Stand-alone photovoltaic systems are independent of the utilities distribution system. These systems are typically installed in remote location where an electrical distribution system is not present. These systems are neither physically nor electrically connected to the utilities distribution system.

3.2 Theory of Operation

A typical stand-alone PV system involves a battery storage system, a photovoltaic energy source, an inverter if ac loads are present, a charge controller, and a generator if the load is to be supplied when the solar resource is scarce.

The theory of operation is to harness power from the sun and store the energy for later use in a battery system or use the energy as it is being produced. During times when the resources are low and the batteries have been depleted the system must run from a generator or the load will not be satisfied.

4 Battery Backed Critical Load Panel PV Systems

4.1 Overview

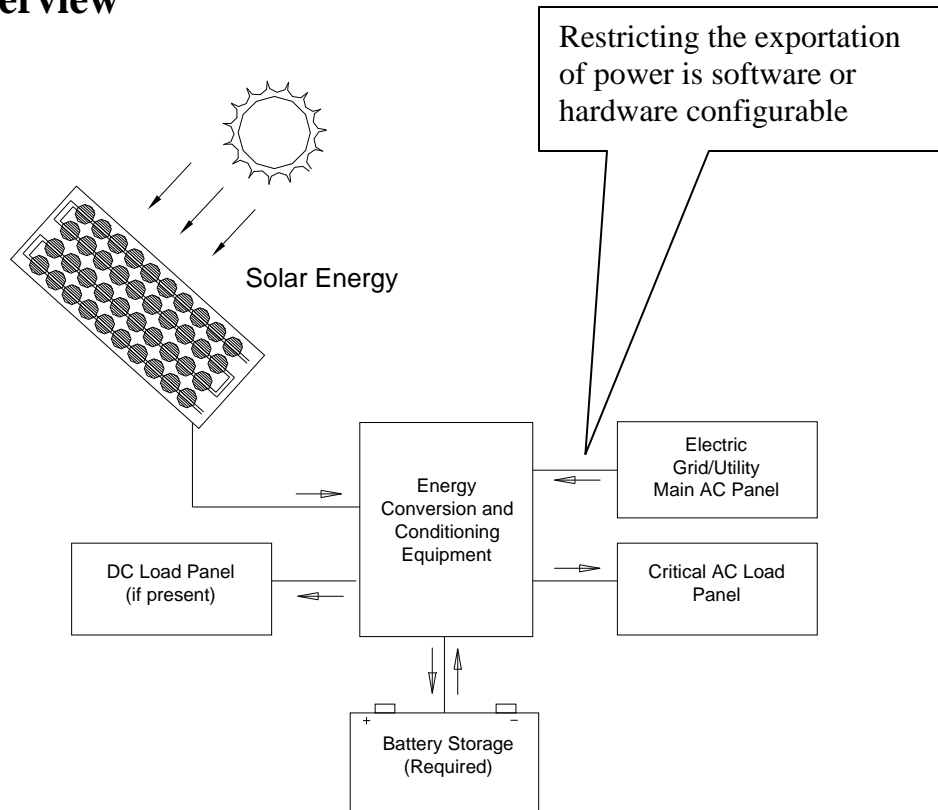


Figure 2: Block diagram of a typical battery backed PV system.

Photovoltaic systems with battery storage are often designed and configured as backup power systems with critical load panels. When the interconnection to the utility distribution system is de-energized, due to a power outage or other event, the PV system performs a UPS function. These systems can be configured to utilize photovoltaic energy source when the solar resource is present and use the utility grid at night and on days when the irradiance levels are insufficient to meet the load.

4.2 Theory of Operation

A battery backed critical load panel typically involves a battery storage system, a photovoltaic energy source, an inverter, and a charge controller. The system is generally designed to supply power to critical loads from a battery storage system when the utility distribution system fails. If dc loads are present they can also be supplied. These systems require a means of charging the batteries through a charge controller and an inverter to supply the ac circuits from the dc bus. The charging source typically uses photovoltaic

modules and/or a wind turbine as the primary source of energy. A generator and/or the utility grid may be used in situations when other sources are scarce.

Some of these systems can be configured through user selectable program setting to disable export power to the utility grid. Others, due to their basic hardware design, are only able to draw power from the utility distribution system (they are physically incapable of exporting power.)

4.2.1 Inverters That Can Be Programmed Not to Export

Some of these systems (such as the Xantrex XW series inverter) have different modes of operation and can be programmed to not allow exporting power (sell) to the local utility distribution system. This mode of operation is user definable. There is no means to guarantee that an inverter will not be programmed to export in the future.

4.2.2 Inverters Which Are Incapable of Exporting

Other inverters (such as the Outback FX series inverter) are not built to export power and cannot be re-programmed or modified to allow exporting of power to the utility distribution system.

4.3 Inverter Manufactures for Battery Backed Critical Load and Stand-Alone PV System

Manufactures that can provide battery feed inverters and charge controllers:

Xantrex XW series power inverter

Outback FX series power inverter

SMA Sunny Island power inverter

5 Direct Coupled PV Systems

5.1 Overview

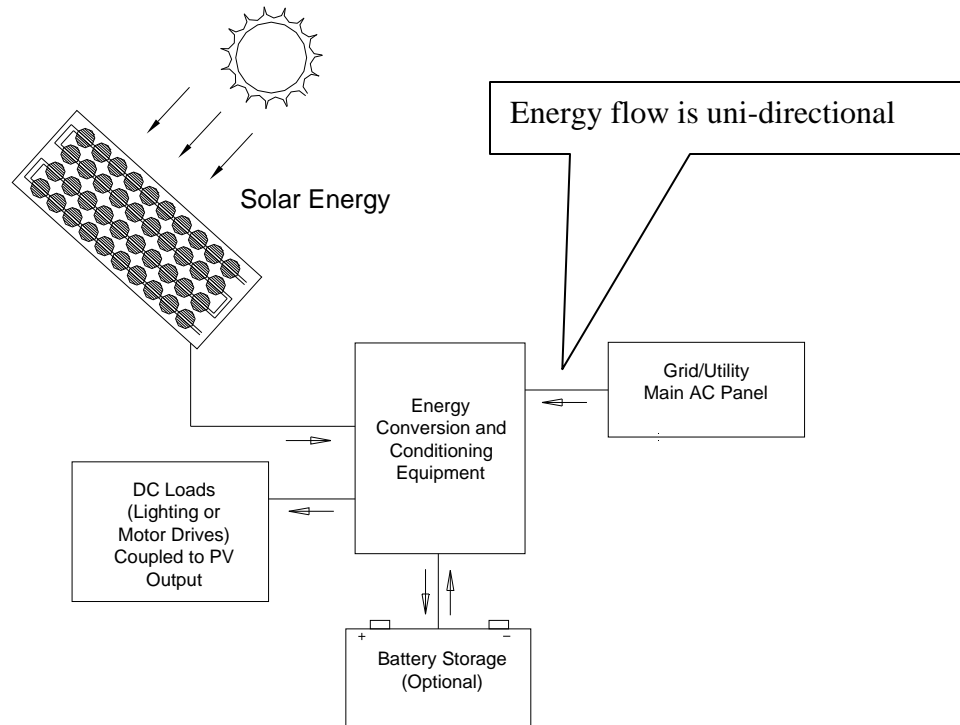


Figure 3: Direct Coupled PV System

The Nextek Power Systems 75kW Power Gateway is different from typical photovoltaic systems that are utility interactive. This type of system is designed to power a dc load directly from the photovoltaic source. In this configuration, the system eliminates the inverting of dc power to ac power, which typically connects to an ac panel, and eliminates converting ac power to dc power required by dc loads. This system connects the dc source directly to the dc loads and the result is to bypass inefficient power conditioning steps.

5.2 Theory of Operation

Nextek Power Systems 75kW Power Gateway is a unit that directly couples photovoltaic dc power to the dc input of dc lighting ballasts or dc motor drives of air handling units. The 75kW Power Gateway passes dc power directly to a load. If the photovoltaic output is insufficient to supply the load, then the Gateway will supply in the remaining unsatisfied load with rectified ac energy from the utility.

The 75kW Power Gateway has an optional battery backed storage system for continuous power during utility failure.

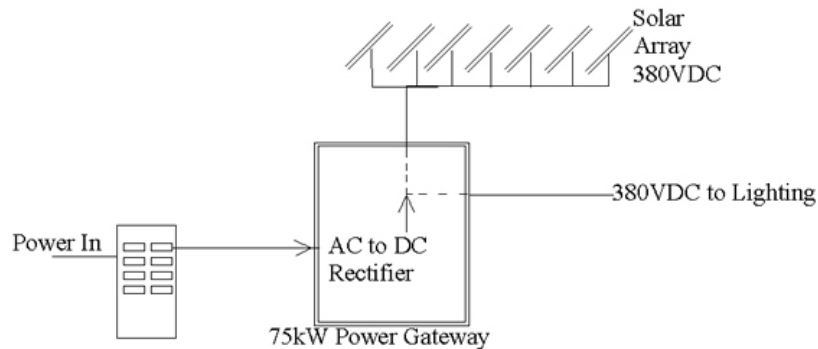


Figure 4: Power Gateway Direct Coupled PV System with Lighting Load.

The current Nextek Power Gateway prototype rectifies utility ac power to dc power. This process works in parallel with the photovoltaic system output to supply the load. The Gateway's IGBT bridge can only supply power in one direction to the dc output bus supplying the load. In this configuration the unit has no ability to invert dc power and feed back to the ac side. In future models of the Power Gateway there will be a plug-in control module which, when installed in the unit, will give the system inverting functionality. This control module will detect excess power on the dc bus and switch the same bridge into an inverting function.

5.3 UL listing Considerations

The Nextek Power System is UL listed in Canada but currently not UL listed in the United States. The UL listing in the US is currently underway but at present there is no approximate date of the listing. However, there are installations in America.

- 1) A 10kW STC PV system is installed on Hempstead's Town Hall Facility in Long Island, NY. This system directly couples PV output to two motor drives in there HVAC system.
- 2) Rochester, NY has a PV system directly couples to there dc lighting system.

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6 Building Installation Considerations

6.1 Battery System Financial Considerations

Battery-based systems have efficiency losses in the inverter and some efficiency losses in the battery storage system. The installation cost of such a system is generally more than a typical utility interactive system due to the battery storage system and increase in power conditioning equipment and BOS components. In most cases battery systems will require consideration of ventilation in the design.

Cycling power into and out of a battery system with lead acid batteries has a round trip efficiency of approximately 80%. This value is highly dependent on the specific application. Furthermore, typical lead acid batteries require replacement approximately every five years when used in standby applications. The life of a battery is also highly dependent on the applications and specifically the charging/discharging cycling patterns.

These systems have a greater number of components and maintenance routines than a typical utility interactive photovoltaic system which simply feeds the ac source in parallel with the local utility distribution system. This is primarily due to operation and control of a large battery bank. Systems that have battery storage will require ongoing maintenance.

6.2 Facility Circuit Distribution Considerations

The physical and electrical arrangement of circuits and load centers will determine the ease of reconfiguring the system for a photovoltaic installation. For all three of the approaches and technologies described here some level of segregation of facility branch circuits will be required for their efficient implementation. A site inspection will be the first step in determining the complexity of the circuit arrangement within the facility and the applicability of any of these options.