European Journal of Scientific Research
ISSN 1450-216X Vol.56 No.1 (2011), pp.104-111

http://www.eurojournals.com/ejsr.htm

A Reliable Solution for JAWWAL's BTS Power Shortages in GAZA using a Photovoltaic System

Tamer Khatib
Department of Electrical, Electronic and Systems Engineering
National University of Malaysia, 46300Bangi, Malaysia
E-mail: tamer_khat@hotmail.com

Jehad Faddah
Department of Computing, Engineering and Technology
University Of Sunderland, Sunderland, UK
E-mail: jehadf@gmail.com

Samer AlSadi
Electrical Engineering Department, Faculty of Engineering and Technology
Palestine Technical University-Kadoorie , Tulkarm, Palestine
E-mail: samer_sadi@yahoo.com

Abstract

This paper presents an optimum Photovoltaic (PV) power system design for JAWWAL's mobile base station (BTS) in order to solve the problem of the frequent power cut offs in Gaza. The proposed PV system will work in parallel with the main electricity source as a hybrid system to charge additional backup batteries for the BTS. This will increase the up-time of the stations operation which already suffers from frequent power cut offs due to the critical electricity generation in Gaza. Finally, an installation configuration has been suggested in order to increase system's reliability and feasibly.

Keywords: PV systems; mobile stations; energy efficency improvement; BTS.

1. Introduction

The cost of energy produced by PV systems has dropped significantly since 1980. However, the cost of PV energy is still higher than energy bought from the local utility. Also, the initial cost of PV equipment is still higher than an engine generator. Yet, there are many applications where the low operation and maintenance cost of PV systems outweighs the low initial cost of the generator and makes PV the most cost effective long-term option, The number of installed PV systems increases each year because their many advantages make them the best option because of the following issues:

Fuel Supply: Supplying conventional fuel to the site and storing it can be much more expensive than the fuel itself. While solar energy is delivered free.

Environment: PV systems create no pollution and generate no waste products.

Maintenance: Any energy system requires maintenance but experience shows PV systems require less maintenance than other alternatives.

Site Access: A well-designed PV system will operate unattended and requires minimum periodic maintenance. The savings in labor costs and travel expense can be significant

Durability: Most PV modules available today are based on proven technology that has shown little degradation in over 15 years of operation.

Cost: For many applications, the advantages of PV systems offset their relatively high initial cost. For a growing number of users, PV is the clear choice [1-5].

Typically, the standalone photovoltaic power system consists of solar array, controller with maximum power point tracker, batteries, inverter and loads. Since the solar array is a sole energy source, the power of the system will change significantly with the variation of solar radiation, temperature, load conditions and battery state of charge (SOC). Thus, it is very crucial to optimize sizes of solar array and battery to meet the load demand (or load profile) under the desired loss of power supply probability (LPSP) at minimum system cost [6].

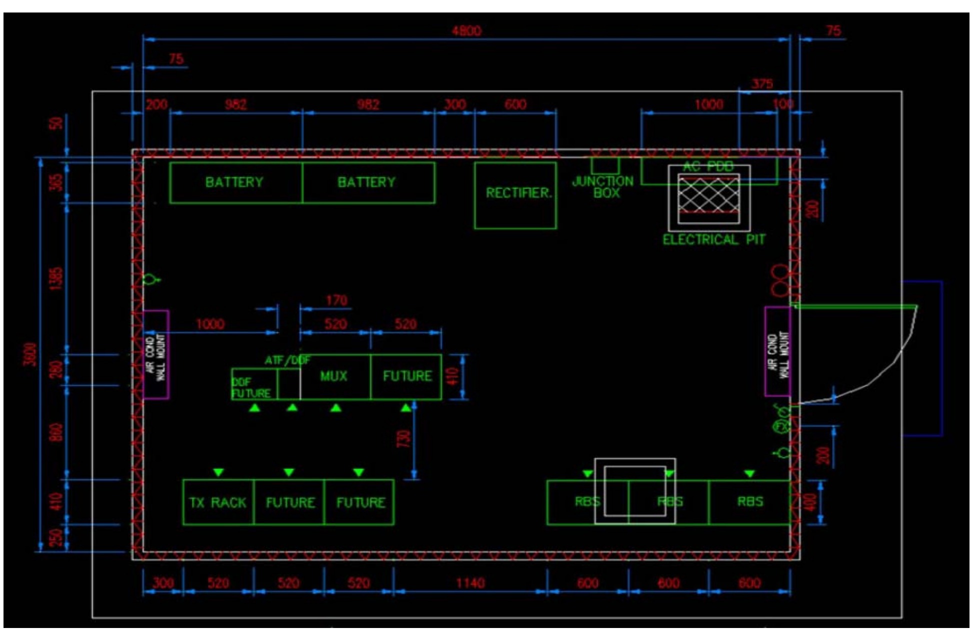
Currently, Gaza faces severe power shortages in its electrical sources, distribution and infrastructure. Usually, the power is out for 10 hours as a daily average and sometimes it is even worse which shorten the up-time of the BTS operation. The aim of this paper is to present an alternative solution using a PV system to increase the up-time BTS operation in Gaza.

2. A Review of Mobile Base Station Energy Consumption

The BTSs mainly contain three types of electrical loads which are transceiver, cooling units and back up batteries. The transceiver is supposed to be operational 24/7 while the cooling units are operated to keep the temperature within the allowed range. Backup batteries are used to supply the station in case of losing the main electricity supply. Fig. 1 shows a layout of a mobile base station cabin [7].

In general the mobile bas station's dimensions are 2.2m (W) x 2.2m (L) x 2.2m (H) where cabin constructed from PU panels with plywood sandwiched in between and fully insulated. The telecommunications equipment recommended operating temperature range is 5 to 35 deg C and operating humidity range is 15% to 80% RH, while Rectifier batteries system recommended operating temp range is between 20 - 25 deg C. The network equipment power load varies between 2,000W (Minimum) to 3,800W (Maximum) with different RBS cabin configurations and so the average monthly electricity consumption per cabin site is approximately 2,880 kWh, this means that the average monthly electricity bill per site is approximately 200$ – 2500$ [7].

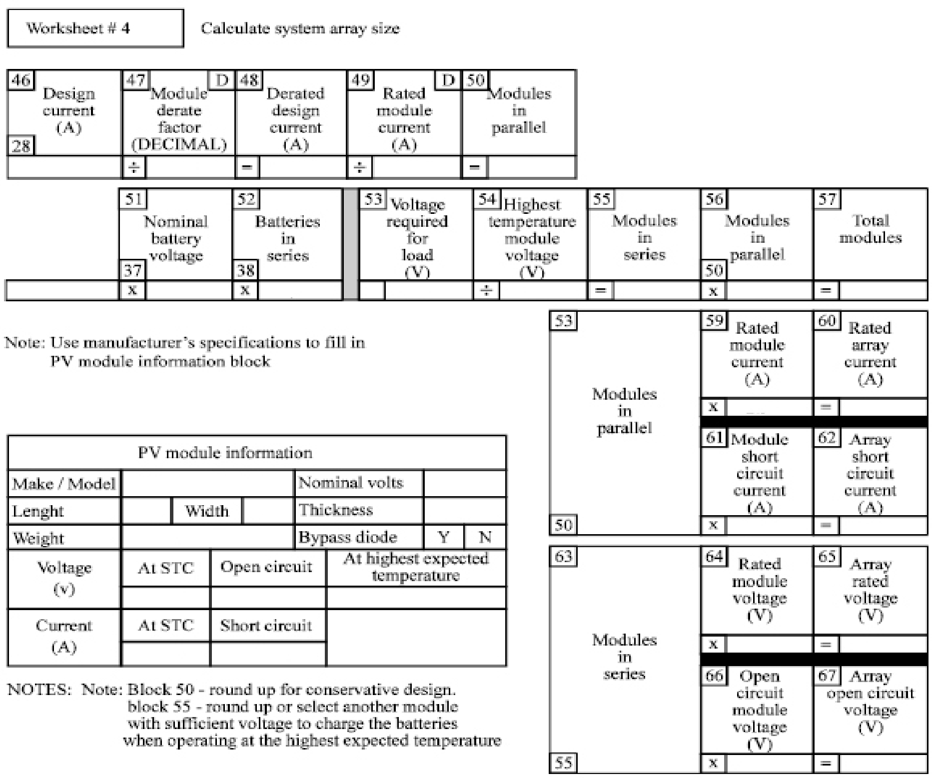
Figure 1: Mobile Base Station Layout



3. Design of the PV Power System

In this paper an average case will be taken as an example to design the proposed system based on its ratings. The stations power rating is 5700Watt including the batteries charging demand where the transceiver load is 1200 watt and the cooling units load is 2000 watt. The installed batteries ratings are 400 Ah/24V. However, the average solar irradiation for Palestine is 5.4 KWh/m^2 and the ambient temperature is in the range of 16-24 C [8]. In this paper KYOCERA, KC200GT 200 Wp PV module is supposed to be used. This module has a peak current and voltage 7.61 A, 26.3V respectively, where the efficiency of this module is about 20%.

Figure 2: Designing Work Sheet [9]



3.1. Design of the Solar Array and Batteries

The designing procedure is detailed in the worksheet in Fig.2 which proposed by [9]. Based on the mentioned information, the load current is 50A (Transceiver load divided on the Transceiver rated voltage) where the module's derate factor is supposed to be 0.*8*. The voltage required by the load is 24 V and the module's voltage at highest expected temperature is 25.5 V. Following the previous data the number of needed modules in parallel are *8* (KYOCERA, KC200GT 200 Wp) where one module in series is needed.

As for the needed capacity of batteries, it is given by,

$$C_{AH} = \frac{E_{Load}}{V_B \, DOD \, \eta_{charging}} \qquad (1)$$

where E_{Load} is the energy which supposed to be consumed by load. V_B is batteries rated voltage, DOD is the depth of charge and $\eta_{charging}$ is the charging efficiency. Whereas, the designed system is supposed to supply the load for 6 hours, thus the energy consumed by load is 7.2 KWh. The DOD and charging efficiency are supposed to be 0.8 and 0.9 respectively. Based on equation (1) the needed capacity is 400 Ah [7].

3.2. System Analysis

The charging time (CT) of the batteries can be given by,

$$CT = \frac{C_{AH}\, V_B\, DOD}{N_m\, A_m\, E_{sun\ average}\, \eta_m \eta_B} 12\,h \tag{2}$$

where C_{AH} is the battery capacity, V_B is the battery rated voltage, DOD the allowable depth of charge, N_m is the number of PV modules in the array, A_m is the PV modules area $E_{sun\ average}$ is the average daily solar irradiation fall on one meter square, η_m and η_B are PV modules conversion efficiency and batteries charging efficiency respectively[7]. Using equation (2) and suppose that the charging efficiency and the allowable DOD are 90% and 80% respectively, the charging time needed to make the batteries fully charged is 8.5 hours.

The discharge time (DT) can be calculated as follows [7],

$$DT = \frac{C_{AH}\, DOD}{Load\ current} \tag{3}$$

Based on equation (3) the discharging time is 6.5 hours.

3.3. System Configuration

As a fact, the batteries cannot being charged and discharged at the same time, thus, to avoid losing the sun's power during the day while the batteries are supplying the load, the system (PV modules and batteries) will be divided in two identical systems each is 4 modules and 200Ah batteries. The charging and discharging time will be 4.25 and 3.25 hours respectively for each system. This configuration will allow half of the batteries to be charged while the other half is being discharged and this will increase the reliability of the system and its feasibility as well.

3.4. System Installation

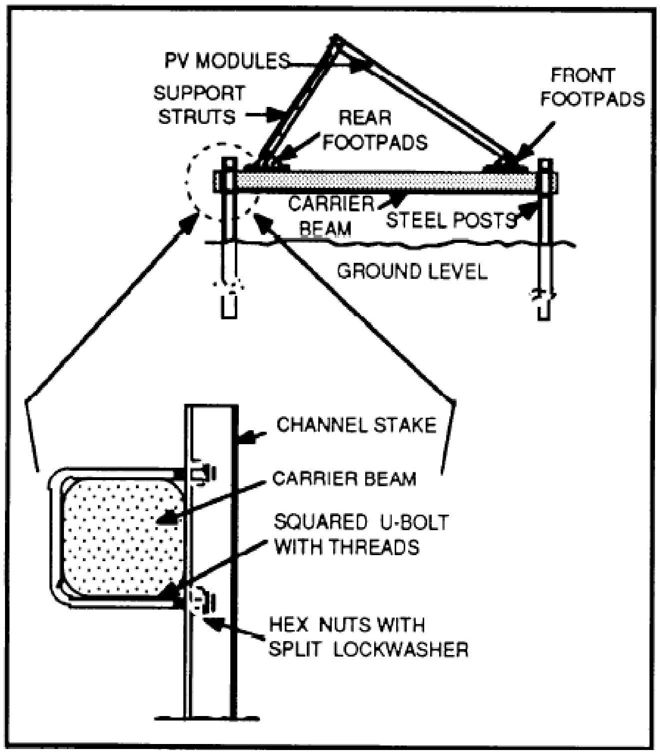
Stand-alone PV systems will be reliable power producers for more than two decades if properly sized for the application, engineered well, and installed carefully.

3.4.1. PV Array

PV arrays for stand-alone systems are installed in many unique and innovative ways, However, there are common issues involved in any installation, whether the array is fixed or tracking, mounted at ground level, or on a pole or building. The objective is a solidly mounted PV array that will last for many years and withstand all kinds of weather. Regardless of whether you buy or build the mounting structure make sure it is anchored and the modules are restrained. Many module manufacturers and distributors sell mounting hardware specifically designed for their modules. This hardware is intended for multiple applications and different mounting techniques and considerations like wind loading have been included in the design. Using this mounting hardware is the simplest and often the most cost effective. Customized array mounting structures can be expensive.

Fig. 3 shows one mounting technique that has been used for small PV systems. Aluminum or galvanized angle can be used for the support struts, steel fence posts can be driven into the ground and the cross-beam can be made from treated wood, metal, or concrete. Galvanized Ubolts can be used to hold the crossbeams. Stainless steel bolts and nuts are recommended because they will not rust and portions of the array can be removed if future maintenance is required. The foundation for the array should be designed to meet the wind load requirements of the region. Wind load depends on the size of the array and the tilt angle [9,10].

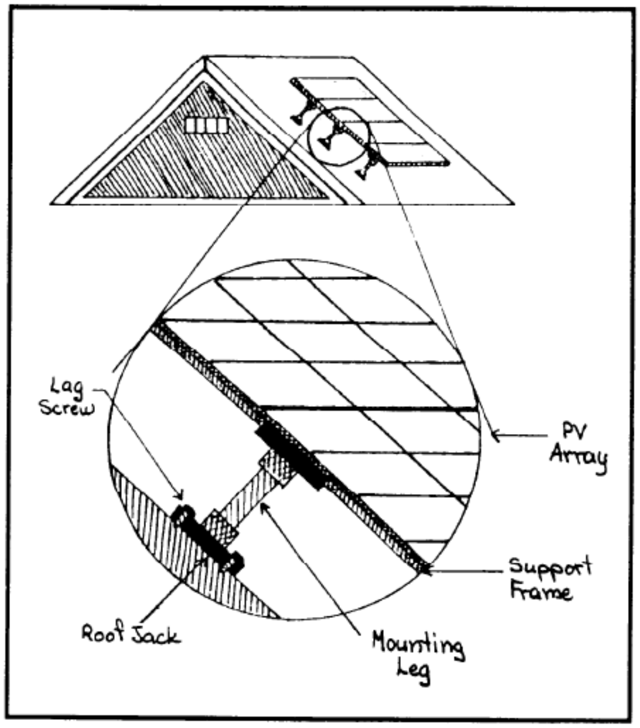
Figure 3: Simple Ground Mount for a PV Array



Changing the tilt angle of an array to account for seasonal changes in sun altitude is not required. For mid latitude locations, a tilt angle change every three months is estimated to increase energy production about 5 percent on an annual basis. For most applications, the additional labor and the added complexity of the array mount does not justify the small increase in energy produced. If tracking of the flat-plate array is desired, the recommended trackers are single axis units that require little control or power. These are passive trackers driven by a closed Freon system that causes the tracker to follow the sun with adequate accuracy for flat-plate PV modules. In high wind areas a powered tracker may be preferred.

Reinforced concrete with anchor bolts is recommended. The foundation and frame should be designed to withstand the worst case wind expected in the area. The movement of the array should be checked to make sure the path is clear of obstructions. In general, roof mounting of PV modules should be avoided. They are more difficult to install and maintain, particularly if the roof orientation and angle are not compatible with the optimum solar array tilt angle. Penetrating the roof seal is inevitable and leaks may occur. Also, it is important to achieve a firm and secure attachment of the array mounting brackets to the roof. Attaching the mounting brackets to the rafters will provide the best foundation, but this may be difficult because module size and rafter spacing are usually not compatible. If there is access to the underside of the roof, 2 x 6-inch blocks can be inserted between the rafters and the attachment made to the blocks. Attaching the array to the plywood sheathing of the roof may result in roof damage, particularly if high winds are likely. If a roof mount is required, be sure to allow a clear air flow path up the roof under the array as shown in Figure 4. The array will operate cooler and produce more energy if it stands off the roof at least 3 inches, Flush mounting PV modules to the roof of a building is not recommended [9,10].

Figure 4: Roof Mount for a PV Array



3.4.2. Control Center

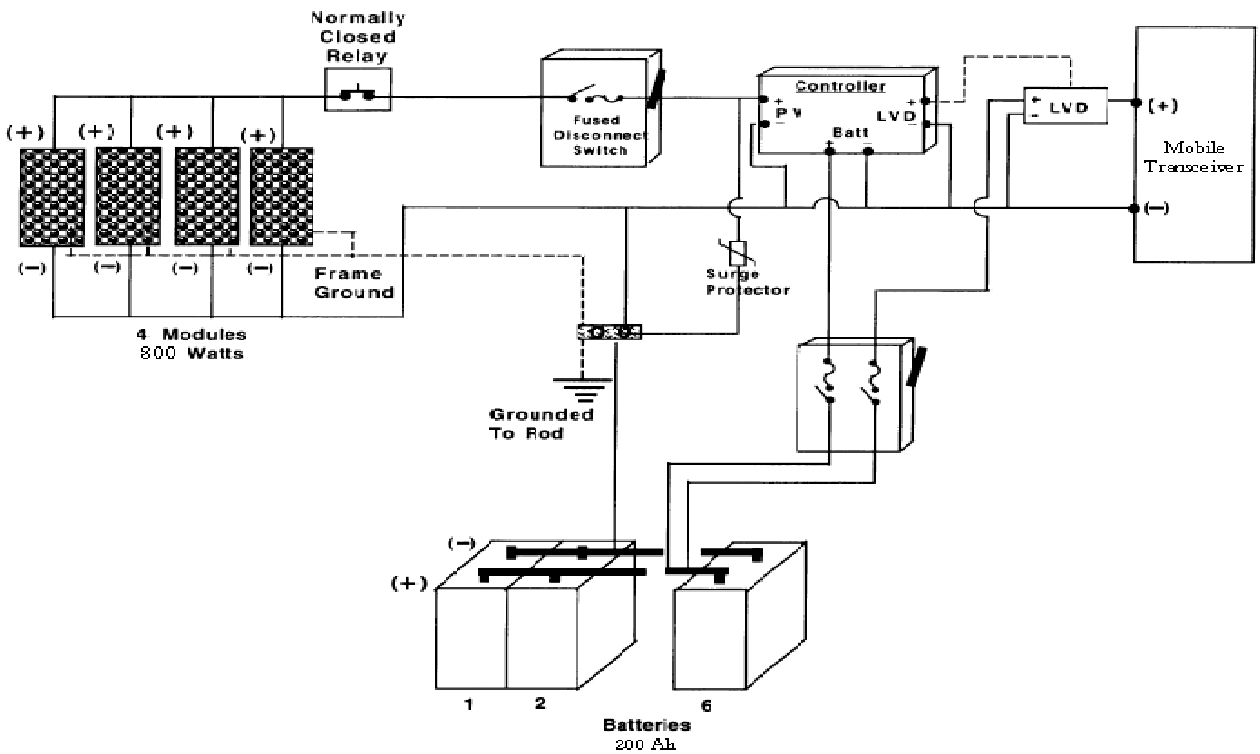
Electronic controllers, converters, or inverters are often installed in the control center along with switches, fuses, and other BOS. Electronic components must be able to withstand expected temperature extremes in both operating and non-operating states. Any printed circuit boards in these units should be coated or sealed to protect the electronics from humidity and dust. Certified electrical service boxes should be used. High temperatures will shorten the life of electronic equipment. Dust can be a problem in a well-vented enclosure. Some boxes have filters at the air access points.

3.4.3. Grounding

A good ground will provide a well-defined, low-resistance path from the stand-alone PV system to earth ground. This path is expected to carry fault current if system malfunctions occur so the ground wire must be as large as the largest conductor in the system. Two types of grounding are needed in PV systems. For the system ground, one of the current carrying conductors, usually the negative, is grounded at a single point. This establishes the maximum voltage with respect to ground and also serves to discharge surge currents induced by lightning. Any exposed metal that might be touched by personnel should be grounded. This includes equipment boxes and array frames. This will limit the risk of electrical shock should a ground fault occur. A low-resistance earth ground requires good contact between the ground rod and earth. Subterranean water lowers the resistivity of the contact. If the system is in an area with rocky soil, a good ground may be difficult to achieve. Consult a local electrician for suggestions.

A PV array can attract lightning, especially if located at a high elevation relative to the surrounding terrain. Current surges can be caused by a direct lightning hit or by electromagnetic coupling of energy into the PV system's conductors. There is little that can be done to protect the PV system equipment from a direct lightning strike. Surges caused by near strikes occur more frequently and the severity of possible damage depends on the distance from the strike to the array. Commercially available surge protection devices (movistors and silicon oxide varistors) are reasonably priced and their use is recommended. They are normally installed in the array output and at the dc input to any electronic device. If an inverter is used, surge protection devices should be installed at the ac output as well as the dc input. Installing the wiring in grounded, buried metallic conduit will decrease susceptibility to lightning [9,10].

Figure 5: One of the Two Systems Layout



It would have been more cost effective to make use of the existing sites back-up batteries, however, the choice of adding a new independent system was made to ensure old system reliably and to increase overall up-time.

4. System Cost

Table I shows a detailed system cost, the major share is for the PV modules in way that every KW costs 3.5 $.. The salvage value of the PV systems is usually 20% of the capital cost. However, The Installation item includes fuses, contactors and wires.

Table 1: PV System Cost

	PV system cost		
	Item	***Price***	***Life Time cycle***
1)	8 x PV modules (200Wp)	5600 $	25 years
2)	2 x Charge Controller	200 $	10 years
3)	Chargable Battries 400Ah/24	2000 $	10 years
4)	Mounting Hardware	200 $	25 years
5)	Installation	200 $	-
	Total cost	8200 $	
	Salvage value	1640 $	25 years

5. Conclusion

A Reliable solution using a PV power system has been proposed to solve JAWWAL’s BTS power problem in Gaza. The PV system designed to supply the backup batteries in parallel with the main electricity source because of the frequent power cut offs. The system has been introduced in an installation configuration that increases the BTS up-time and its reliability as well. It is expected to get back the investment within 2 years maximum because of the huge losses caused by the failure of the stations.

References

[1] Tamer Khatib, , Azah. Mahmoud and Nowshad Amin. 2009. A New Controller Scheme for Photovoltaic Power Generation Systems, European Journal of Scientific Research, 33(3): 515–524.

[2] Thomas, M. G. and G. J. Jones, 1988, The design of residential photovoltaic systems, Sandia Laboratories.

[3] Peter , P. G. and P. George,1983, Optimal sizing of stand alone photovoltaic system. ERC-R07

[4] Hasti DE. 1994, Photovoltaic power system applications. IEEE Power Eng Rev;18–9.

[5] Gavanidou ES, Bakirtzis AG. 1992 Design of stand-alone system with renewable energy sources using trade off methods. IEEE Trans Energy Convers;7(1):42–8.

[6] Shrestha GB, Goel L. 1998 A study on optimal sizing of stand-alone photovoltaic stations. IEEE Trans Energy conver;13(4):373–8.

[7] Khatib, T.T.N., Azah Mohamed, Marwan Mahmoud and Nowshad Amin. 2010. An Efficient Maximum Power Point Tracking Controller for a Standalone Photovoltaic System", International Review of Modeling and Simulation, 3(2):129-139

[8] M.M. Mahmoud, I.H. Ibrik. (2003). “Field experience on solar electric power systems and their potential in Palestine”. Renewable and sustainable energy reviews.7:531-543.

[9] Tamer Khatib, 2010, A Review of Designing, Installing and Evaluating Standalone Photovoltaic Power Systems, Journal of Applied Sciences, vol.10, issue 13, pp:1212-1228.

[10] Chapman RN.,1987, Sizing handbook for stand-alone photovoltaic/storage systems, SAND87-1087. Sandia National Laboratories, Albuquerque, New Mexico; April 1987.