Residential emergency solar power in western North Carolina

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Abstract – This paper provides a discussion of the costs, configurations and capabilities of small solar PV systems to provide lighting and minimal power for other uses during winter storm events in western North Carolina. Costs and benefits are compared to gasoline emergency generator systems. The paper identifies that it is affordable to combine solar photovoltaic panels with an automotive battery, suggesting an alternative to back-up electrical generators.

In western North Carolina, installation of solar photovoltaic (PV) arrays is becoming more popular for private homeowners. State and federal tax rebate programs currently allow North Carolina homeowners to recoup 65% of initial capital costs, and grid connected systems can even provide an income stream for owners. Even with these rebates and income streams, many systems do not have an acceptable rate of return. Finding a suitable site for PV arrays in the Smokey Mountains of western North Carolina is often a challenge for many home owners. Mountain and vegetative shading causes significant reductions in power output potential in PV systems eliminating acceptable financial benefits of a given system. In addition to avoiding electricity costs, non-grid connected solar PV may be used to provide emergency power for lighting. In North Carolina's mountainous, rural regions during the winter months, power outages are common, especially during heavy snows.

Keywords: solar photovoltaic, emergency power, emergency lighting, back-up power

INTRODUCTION

During the winter of 2010-2011, western North Carolina received three heavy snowstorms. Electrical power outages accompanied all three storms. Many residents with homes in the Sylva, North Carolina region were without power for periods of time between a few hours and a few days. Some of the most rural homes without gasoline or diesel powered generators were without power for three days during the worst, heaviest event. Back-up generators were the only source of power available. Generators can be expensive to purchase and difficult to maintain, and during many winters, back-up power is not needed frequently or for long durations. The purpose of this paper is to investigate the use of solar photovoltaic panels used in conjunction with automotive batteries and light emitting diodes (LEDs) as a cheap alternative to generators for back-up power and lighting.

DISCUSSION

Generators

Electrical power generators may be readily purchased during most times, but when bad weather is anticipated, available supplies of generators dwindles. A typical gasoline or propane powered 3500 watt generator costs between $250 and $500 at the Sam's Club (Sam's, 2012) in Asheville and will be adequate for most 2000 square feet and smaller homes. Installation of power connections, wiring, and transfer switches will cost about the same amount as the generator. Simple, permanent installation labor will add another $600-$800 dollars to the cost of a back-up power system, total including the generator, accessories and installation will typically amount to about $1500. A permanently installed system may be connected to the main service panel and allow home operations to occur almost as normal. Refrigerators, freezers, water heaters, electric stoves and heat pumps may be operated as

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long as the maximum load on the generator is below the power rating. Temporary generator installations may be made at a much lesser cost by most homeowners using drop cords, but larger appliances possibly may not be operated. For the purposes of this paper, an assumption will be made that a 3500 watts generator, temporarily installed will be used at a cost of $400 to provide lighting and some light appliance use such as a television or radio during a normal three day maximum power outage.

Batteries

Automotive batteries may be used to provide power for lighting. An eight year warranty battery may be bought at the local automotive parts store for $122. It is rated for 750 cold cranking Amps and 130 reserve minutes. The cold cranking amps is the current the battery will provide when it is new and fully charged at 0° Fahrenheit for 30 seconds, while maintaining a voltage of at least 7.2 volts (Battery FAQs, 2012). The reserve minutes capacity is the battery industry rating defining a battery's ability to power a vehicle with an inoperative alternator or fan belt. The rating is the number of minutes a battery at 80 degrees F can be discharged at 25 amps and maintain a voltage of 10.5 volts for a 12 volt battery (Battery FAQs, 2012). The reserve capacity is the rating of interest pertaining to emergency power. This battery will provide 130 minutes of capacity at 25 amps (at 80 degrees F) or 3250 amp-minutes or about 54 amp-hours. It will provide one amp continuously for two days at 12 volts without recharging. If we consider winter-time operation, we will assume the battery is located in a warm room, but lower temperatures will reduce this capacity.

Solar Panels

Small solar panels made to charge automotive batteries are readily available and may be bought for about $5.00 per watt (Northern Tool, 2012). A 15 watt panel is about $75.00. However, during the winter-time, experimentation has shown that solar panel output may be as much as six times lower than during the summer-time. A 15 watt panel may produce only about 2.5 watts peak output during these times. Full sun exposures on the southern sides of the mountains may allow better performance. A 15 watt rated panel may produce about 10 watts at peak during winter operation in this region. Based on output modeling for western North Carolina (PVWATTS, 2012), a 15 watt panel will produce less than one kilowatt hour per day (0.1Kw-hr actual) in December. If 24 amp-hours at 12 volts are used per day, this amounts to about 0.3 kilowatt hours, so about 4 panels (15 watts each) would be needed considering efficiency losses to replenish the batteries each day during the winter. The cost of these panels would be about $300 at $5.00 per watt (Northern, 2012). Coupled with the cost of a good quality battery, the cost of a solar emergency system will be about same as the cost of a small emergency generator, considering similar installation labor costs. Another assumption is that 12 volt light emitting diode (LED) lamps will be used. The alternating current to direct current (AC to DC) inverter usually needed in solar photovoltaic systems will not be needed in the system discussed in this paper. LEDs rated at 12 volts are readily available at local automotive supply stores. Separate low voltage circuits will be the primary disadvantage of a 12 volt solar/battery system, but is easily installed.

Comparison of the generator and the solar/battery system

The generator will be more versatile when in use. The generating capacity is greater than a solar/battery system of similar cost could provide. The household could operate nearly as it would normally. A pull-start generator does not require a battery to start. Batteries require periodic replacement. A generator set may also qualify for a tax credit under current North Carolina tax laws (US Dept of Energy, 2012). A typical generator set may be installed as shown in Figure 1.

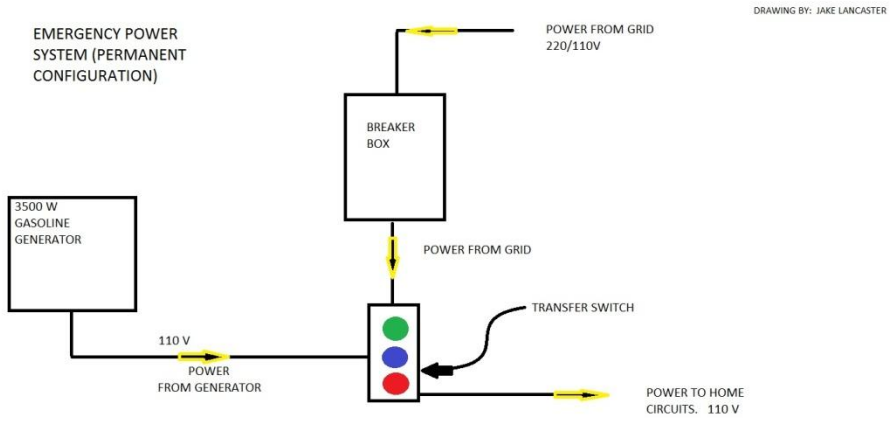

Figure 1. Typical residential generator installation

The solar/battery system does not require gasoline fuels nor will it require the maintenance of a generator. This fact is the primary advantage of the solar/battery system. Once installed, the solar/battery system could be used for lighting as needed, not just for emergencies. The power savings alone could not justify the installation, but when added with emergency use, a system may be justified, especially considering the tax credits currently available in North Carolina. A solar system may add more value to home resale due to consumer enthusiasm for green energy in the current market.

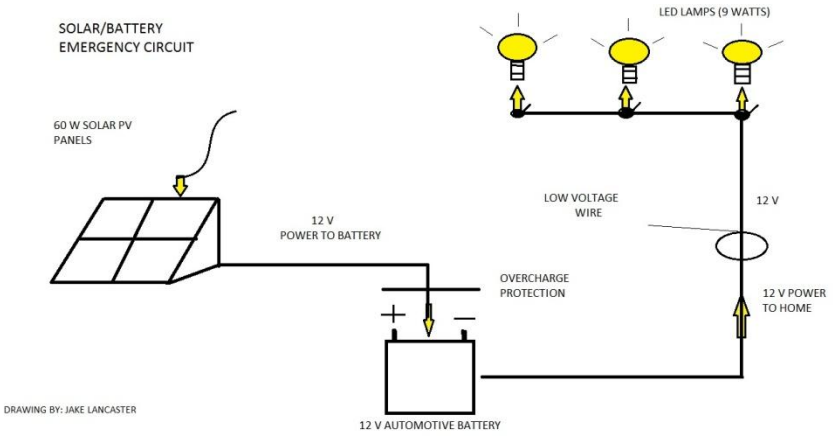

Figure 2. Typical residential solar/battery installation

Based on models (PVWATTS. 2012), as much as 0.23 kilowatt hours may be available for use daily during the summer with 60 watts of panel capacity, potentially enough power for all lighting needed during the long days, short nights of the summer. An over-current protector to protect the battery from overcharging will be needed and are available for $20-$30. As mentioned earlier, 12 volt LED lamps would be used with the solar/battery system. LEDs have extensive operating lifetimes typically in the range of 25,000 hours (Lowe's, 2012). The solar/battery system will be virtually maintenance free except for the expected battery replacements which will be needed. A typical solar/battery installation is shown in Figure 2.

CONCLUSION

Solar photovoltaic panels, used in conjunction with an automotive battery, 12 volt LEDs, and dedicated low voltage circuitry, may provide a typical homeowner in western North Carolina with a simple, low maintenance alternative to

back-up electrical generators for a cost of about $500. This cost is slightly higher than a temporary gasoline generator ($450), but cheaper than a permanent generator installation ($1500). Solar is currently popular socially, and may even help home resale value. Tax credits available under the current tax laws make solar systems even more desirable. A 12 volt system which is solar/battery powered used in conjunction with a grid powered 110 volt system will provide a homeowner clean, safe and reliable service with redundancy which could be valuable to a homeowner after a weather event such as a snowstorm or hurricane. The New York state victims of Hurricane Sandy would probably support redundant home electrical systems.

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