Hybrid, Micro-inverter and Battery based Standalone System for Rural and Urban Water Delivery

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ABSTRACT: The work describes a solar powered micro-inverter and battery operated hybrid electrical energy source implemented at the University of the District of Columbia’s Experimental Farm. The goal of the project is to provide round the clock electricity for maintaining specified temperature in a series of green houses as well as supply irrigation water to a variety of crop systems including sustainable agriculture projects comprising hydroponic, aquaponics, specialty and ethnic vegetables and fruits production and urban forestry, hydroponic crop systems at the Farm. The advantages and shortcomings presented by a micro-inverter based system, when combined with the traditional battery storage/inverter are analyzed. The system is proposed to be a model for a self-powered, standalone small scale hybrid system, ideal for semi-rural and rural farming.

Keywords: Stand-alone PV systems, Water Pumping

1 INTRODUCTION

The University of DC, which is a land grant institution, has a research farm, located in the suburb of Washington, DC, the Muirkirk Farm in Beltsville, Maryland, which serves as a research site for some of the Agricultural Experiment Station projects, undertaken by the College of Architecture, Urban Sustainability and Environmental Sciences (CAUSES), jointly with the School of Engineering and Applied Science (SEAS) of the University. The farm site has greenhouses, crops and a couple of administration buildings. A solar tracking photovoltaic system is currently present on the farm with enough power to activate two-900W submersible pumps [1]. This system is a traditional battery/inverter based system. The proposed project described in this paper is an additional 1.2KW photovoltaic solar based energy source which combines a battery/inverter system and a microconverter based system. The new design is expected to reduce the battery consumption and provide a round the clock power delivery for six greenhouse inflation blowers.

2 MICROINVERTER TECHNOLOGY in BRIEF

2.1 Basic concept

A solar micro-inverter, or simply microinverter, is a device used in photovoltaics to convert direct current (DC) generated by a single solar module to alternating current (AC). The output from several microinverters is combined and can be fed to the electrical grid. Microinverters contrast with conventional string and central solar inverters, which are connected to multiple solar modules or panels of the PV system through a battery storage system.

Microinverters have several advantages over conventional inverters. The main advantage is that small amounts of shading, debris or snow lines on any one solar module, or even a complete module failure, do not disproportionately reduce the output of the entire array. Each microinverter harvests optimum power by performing maximum power point tracking for its connected module. Simplicity in system design, simplified stock management, and added safety are other factors introduced with the microinverter solution. Microinverters produce grid-matching power directly at the back of the panel. Arrays of panels are connected in parallel to each other, and then to the grid. This has the major advantage that a single failing panel or inverter cannot take the entire string offline.

The microinverter maximizes energy production from your photovoltaic (PV) array. Each Microinverter is individually connected to one PV module in the array. This unique configuration means that an individual Maximum Peak Power Point Tracker (MPPT) controls each PV module. This ensures that the maximum power available from each PV module is exported to the utility grid regardless of the performance of the other PV modules in the array. That is, although individual PV modules in the array may be affected by shading, soiling, orientation, or PV module mismatch, the Enphase Microinverter ensures top performance for its associated PV module. The result is maximum energy production from your PV system.

2.2 Microinverter connection

A microinverter is connected directly to the solar module as depicted in Fig. 1.

Each microinverter is attached to the PV racking. A terminator and AC junction box are required to complete the connection. The combined AC voltage generated by each microinverter is then fed to the “grid” through a bidirectional meter. The microinverter will not generate AC power unless it is matched to an AC voltage from the grid. This feature is useful during power failure occurring on the grid. On such occurrence the voltage generated by the microinverters will not transfer to the grid and cause electrocution of maintenance staff working to restore
power on the grid.

Figure 1: Microinverter connection (from Enphase Energy Manual [2])

2.3 Connection to the grid through AC coupling

AC coupling allows use of microinverters with off-grid and battery-based photovoltaic systems. These applications require a battery-based inverter to create a “micro grid” that the microinverters can then be connected to. This is generally referred to as AC coupling because the microinverters and the battery-based inverters are “coupled” on their AC outputs.

In our design, we emulate the AC coupling with a 3-phase rotary converter, which converts a single phase 240V into a three phase 120V, 60Hz system.

3. PROPOSED HYBRID DESIGN

3.1 Description

The proposed hybrid system shown in Fig. 2 consists of the following components:

- Four SW 285W solar modules;
- Four EnPhase 250 microinverters;
- A MAGNUM 2.8KW inverter;
- A bank of six, 8G8D gel batteries;
- An optional communications gateway; and
- A rotary inverter.

Figure 2: Microinverter and battery-based power system

3.2 Implementation

The PV modules are placed on the roof top of a shelter and the other components are placed inside the shelter as depicted in Picture 1.

The power generated by the hybrid system is currently used to activate, 24/7 a bank of six inflation blowers as shown in Picture 2, which also shows four of the six greenhouses of the farm where the blowers are installed.

Picture 1: Roof top installation of solar panels and microinverters

Picture 2: Inflation blowers mounted in six greenhouses

The batteries and the “traditional” inverter as well as the
rotary inverter are placed inside the shelter as shown in Picture 3.

![Picture 3: Battery/Inverter and Rotary inverter](image1)

3.3 Performance

Up until the writing of this paper, the system is not fully operational due to a faulty MAGNUM inverter which is under repair. However, the proof of concept is considered to be valid until a trial run reveals unforeseen difficulties.

4 CONCLUSION AND ACKNOWLEDGMENTS

The hybrid microinverter and battery based system seems to have a good potential as a viable and cost effective alternative to a single battery/inverter based solar generated power delivery system. This system AC coupling scheme proposed in this project may however be impractical for remote rural areas where grid access is limited. The rotary inverter approach is well suited for semi-rural applications where a single phase grid line is available.

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8. REFERENCES

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