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A Collaborative Approach to Operate High Powered Devices on Small-scale PV systems

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Abstract

The world needs renewable energy for the long-term future. One of the most promising renewable energy solar PV is ideal for buildings and rooftop. However, the uptake of solar PV in developing countries is rather slow. Mostly because it is expensive but also because heavy electrical appliances cannot be operated on small scale PV systems. In this paper, we present an approach to operate high powered devices on small-scale PV systems. In our approach, we have designed a platform called Smart Energy Switching Platform (SESP). A software layer on top of SESP allows the devices to follow a collaborative scheme where high power devices are moved to an on-state if enough power is available. With this approach, multiple high powered devices with transients can be operated with a smaller PV system. We have evaluated our approach using many simulation scenarios and has presented a case study to describe the working of the system.

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1. Introduction

Fossil fuel resources are depleting. Therefore, in the coming years, renewable energy resources will be needed on a greater scale to fulfill the energy requirements of the world. However, the renewable energy such as solar PV is still an expensive affair in the developing countries. Also, due to its limited capability to run heavy electrical devices such as air conditioners, solar PVs are not commonly in buildings as an energy source. To run this type of electrical devices the PV system has to be designed in a such a way that it can sustain the maximum power needed by them. The maximum power required by heavy electrical devices depends on their type. For air conditioners or other cooling devices such as refrigerators and deep freezers the maximum instantaneous power is determined by short transients. These short transients may occur for only a few seconds but require multiple times more power than the stable power requirement of a given appliance. Moreover, if multiple electrical appliances need to run using PV, then the cost of PV increases further.

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To us, the acceptability of PV systems would enhance if heavy duty electrical devices can operate on PV systems on buildings. However, the traditional PV architectures cannot readily run heavy electrical appliances on PV. Therefore, in this paper, we describe a newly proposed design of PV called Smart Energy Switching Platform (SESP). Using this platform we develop algorithms that would help us in operating heavy electrical devices on PV.

In the rest of the paper, we first describe the hardware architecture Smart Energy Switching Platform (SESP). This will be followed by a description of an algorithm that helps us manage heavy duty electrical devices on PV. This is followed by some case studies of the proposed solution. Finally, we conclude the paper with some future work.

2. Smart Energy Switching Platform (SESP)

Most of the rooftop solar PV installations use Hybrid PV systems. Hybrid solar PV systems tie the energy coming from PV and grid at the main electricity distribution point of the building. This model of energy distribution works best when the grid is stable, and energy buyback programs are available.

In the absence of the option of putting the energy back on the grid or when the feed-in tariff is not attractive, one would like the buildings to utilize the solar PV energy locally maximally. For this purpose, we proposed the Smart Energy Switching Platform (SESP) that takes the coupling of the solar power and energy from the grid at the device level for more fine-grained utilization of solar energy. Please note that this coupling does not mean tie off both sources. This means, changing-over and selection of PV or grid energy at a given time to power the device. Every single device is connected with SESP individually via Smart Switches. These separate change-overs of devices at finer level enables us to handle the transients in an efficient way without exhausting the available PV energy. These change-overs of both PV and grid energies are synchronized in such a way that the power requirements of devices are fulfilled during their startup cycle to cater the transient problem.

The architecture of SESP is shown Fig.1. SESP consists of two main components: 1) Smart Switch(es) and 2) Central Coordinator (CC). There is only one CC in an installation that connects multiple Smart Switches with itself. Using a Smart Switch(diamond shaped symbols) selected devices in the building are connected with two sources of energy i.e. solar PV and grid. Smart Switch is placed with a single electrical device or a cluster of devices to control the source of energy. For heavy electrical devices such as air conditioners or induction motors, a cluster will have one device only.

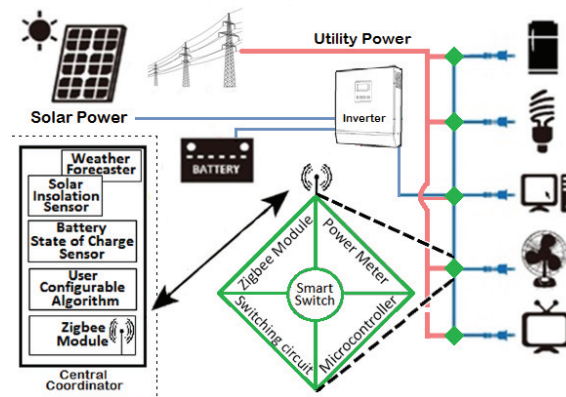


Fig. 1: Smart Energy Switching Platform. (Diamond symbols are Smart Switches where energy from solar and energy from the grid is coupled)

2.1. Smart Switch and Home Area Network

Smart switches are the change-over point that selects which energy(whether PV or grid) should be used to power-up the cluster/device. A smart switch consists of four main components: 1) Zigbee Module 2) Switching Circuit 3)

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