Poster Paper: Maximizing Renewable Energy Usage in Buildings using Smart Energy Switching Platform

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1. INTRODUCTION

Solar energy is slated to be an important energy source for reducing dependence in fossil fuels. Past few years have seen unprecedented deployments of solar energy in many countries of the developed world. However, solar energy uptake in developing countries is rather slow. This is particularly true for solar energy installations on buildings. Since buildings consume more than 40% of energy, it is important that greener buildings are encouraged through on-site production of renewable energy [2]. However, limited possibility of energy buyback programs in developing countries is one of the reason for less solar deployments. Also, in some countries the electricity infrastructure is so fragile that energy buyback programs at smaller scale are not feasible. Therefore, if the building owners like to go green then huge battery banks are needed to make the best use of solar energy. But battery banks add quite a bit of cost to the overall solar energy infrastructure in buildings. This extra upfont and maintenance cost is one of the reasons that hampers the growth of solar on buildings.

Hybrid solar energy systems are used when energy buyback programs are available [1]. In this work we make a case that traditional hybrid solar energy deployments are not feasible for places without energy buyback programs. Instead we propose an idea of a solar energy system for buildings that is somewhere between hybrid and off-grid solar energy systems.

Hybrid Solar Energy Systems make the coupling of the solar energy and grid energy at the main electricity distribution point of a building. This model of energy distribution works best when the grid is stable and energy buyback programs are available. In absence of the option of putting the energy back on the grid one would like the buildings to maximally utilize the solar energy. But the hybrid solar energy systems, while costing a fortune, do not utilize the maximum available solar energy. This is because the hybrid inverters charge the batteries from grid energy at night and when the batteries are fully charged in the morning the solar energy available is only utilized to run the needs of the buildings during daytime. Thus, the batteries are not charged from the solar energy, hence, maximum solar energy is not utilized. Also, the energy needs of buildings are not consistent with the solar insolation curve and about 30-50% solar energy is not utilized. Furthermore, there are other problems with the inverters that make them less efficient for places without energy buybacks. To this end in this work, we present a Smart Energy Switching Platform (SESP) that takes the coupling of the solar power and energy from the grid at device level for more fine grained utilization of solar energy. Our initial results show a reduction of about 42% in upfront and maintenance cost of SESP when compared with hybrid solar energy systems for the same building.

2. APPROACH AND ARCHITECTURE

Figure 1 shows the architecture of SESP. Selected devices in the building are connected with two sources of energy i.e. solar and grid using a Smart Switch. Smart Switch is placed with a single electrical device or a cluster of devices to control the source of energy. Smart Switches sense the live energy usage of devices. This live energy information is communicated to a Central Coordinator using Zigbee communication module. The central controller also receives live information on real-time solar energy production. State of charge in the batteries is also reported to the central controller. Energy information from the respective smart switches, information on solar energy production and the state of charge in the batteries are used for making the switch of a cluster between solar or grid energy based using user-defined preferences. User may set priorities on the state of charge in the batteries, or priorities on running clusters on solar or grid energy. Based on these priorities, SESP tries to maximize the usage of solar energy amongst the device clusters. SESP also has a weather forecaster that predicts the solar insola-

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tion of the next day and the next few hours using publicly available weather information[3].

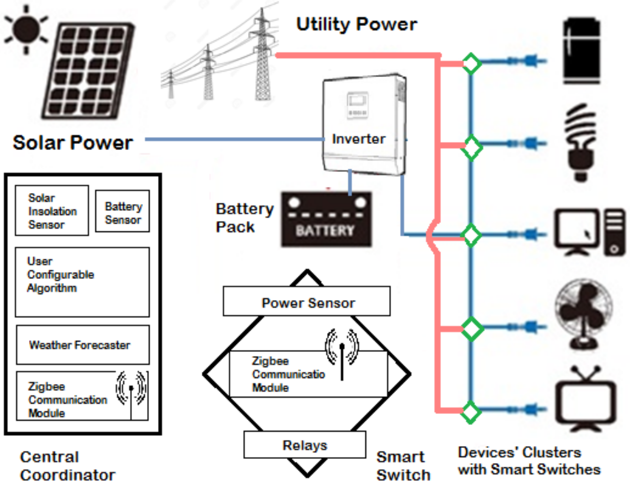


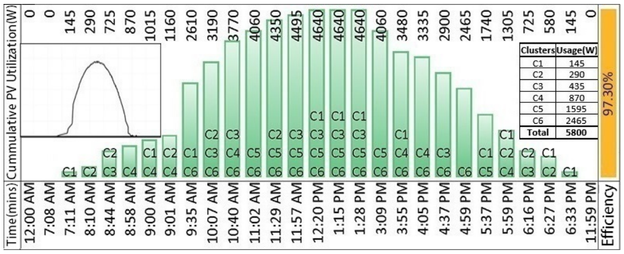
Figure 1: Smart Energy Switching Platform. (Diamond symbols are Smart Switches where energy from solar and energy from the grid is coupled)

In its default state, the SESP works in the following manner: At sunrise the system starts sensing the solar energy production. Central controller keeps a sorted list energy usage information from all clusters. As soon as the solar energy production is enough to switch the least energy consuming cluster its energy source is shifted to solar. The Central Coordinator sends a control signal to a Smart Switch to change the source of energy for the cluster. Based on a user-defined time interval the central controller checks the solar energy production and tries to match with a combination of clusters to maximally utilize the solar energy. Also the central controller keeps enough buffer in the batteries to meet any shortfall solar energy production for a brief time period.

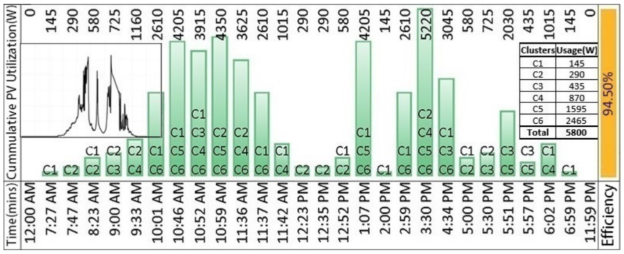
3. PRELIMINARY RESULTS

Figure 2a shows the result of SESP on a sunny day in a building with six clusters of varying profiles. In this figure, one can note that as soon as the solar energy is available at sunrise one or more clusters are shifted to solar energy. After a given time interval a new set of clusters are shifted to solar energy. This process continues until sunset. The solar energy usage is almost exactly the same as the solar insolation curve. Thus, at the end of the day the efficiency of solar energy production in this particular building is more than 97% of the available solar insolation. Figure 2b shows the same building with patchy sunlight. On this particular day the solar energy efficiency is more than 94%.

To summarize the SESP is able to bring the cost of the system down by about 42% even after adding the cost of Smart Switches and related electric wiring. Further the payback period of a solar energy system is down from nine to to seven years. This reduction in cost and payback period is possible by reducing the number of batteries required in the system which in turn reduces the maintenance cost of the system. Also, using SESP one does not need expensive MPPT Hybrid Inverters and can use the PWM Off-grid inverters which are available in half the price.



(a) Sunny



(b) Both Sunny Cloudy

Figure 2: SESP Solar Energy Utilization on a sunny day and in a day with partial overcast

4. CONCLUSION AND FUTURE WORK

SESP provides an alternate model for solar energy utilization at places where energy buyback programs such as net-metering or feed-in tariffs are not available. The design of SESP is deliberately kept simple to encourage its usage in developing countries. Moreover, one can install SESP with only two Smart Switches. By doing this, cost of the system will be reduce even further.

One possible future direction is to extend this system at neighborhood scale. Since some buildings have minimal energy needs during weekends and holidays the energy could be utilized in neighborhood buildings by making an energy co-op. Presently the system uses a simple bin-packing algorithm. However, for scalability this needs to be updated with a more sophisticated and scalable algorithm.

Another possible direction is to improve the algorithm to cater for planning power load shedding during the daytime. The battery needs to have enough storage to keep the high priority clusters energized during such outages. Another more challenging improvement in the algorithm is to plan for unplanned outages of varying durations.

Yet another direction is to cater varying power profiles of the clusters. Presently we are assuming the power profiles of the clusters to be constant. However, in reality power profiles vary all the time.

5. REFERENCES

[1] O. Erdinc and M. Uzunoglu. Optimum design of hybrid renewable energy systems: Overview of different approaches. *Renewable and Sustainable Energy Reviews*, 16(3):1412 – 1425, 2012.

[2] L. Perez-Lombard, J. Ortiz, and C. Pout. A review on buildings energy consumption information. *Energy and Buildings*, 40(3):394 – 398, 2008.

[3] N. Sharma, J. Gummeson, D. Irwin, and P. Shenoy. Cloudy computing: Leveraging weather forecasts in energy harvesting sensor systems. In *Sensor Mesh and Ad Hoc Communications and Networks (SECON), 2010 7th Annual IEEE Communications Society Conference on*, pages 1–9. IEEE, 2010.