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Research Article

A Study on the Implementation of a Monitoring System to Solar-Powered Houses

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ABSTRACT

The study involves the implementation of a solar power monitoring system to solar-powered houses to help owners keep watch and make preventive maintenances to respective solar power systems installed at home.

Keywords*: solar power, monitoring system, off-grid*

Background

Electrical power plays an important part in the lives of countries today. Electricity can now be said as the lifeblood of today's businesses, households, and forms of communication. Without it, we won't be able to run our digital gadgets, computers, mobile communication devices, lights, appliances, elevators, radars, and other things that depend on electrical power.

In relation to electrical power, the high cost of using one at home or in businesses has spurred a new growth in the power industry: solar power. Solar power is mostly implemented by household owners to alleviate fluctuating prices of electricity and sometimes even going off-grid as to not depending on corporate subscription to power distributors. Large commercial corporations are also converting some of their properties to accommodate a large volume of solar panels to minimize their dependence on power-generating companies.

In such things most use of electrical power needs in monitoring the consumption of power including the performance and durability of the components being used to distribute power. The aspect of monitoring should also encompass not just the money involved in consuming power but also the potential expenses in buying, maintaining, and repairing the equipment involved.

With this comes the idea of a solar power monitoring system with a design and aim to track power consumption and power output of the solar panels, including the output and remaining contents of batteries. Also, it will alert the owner for any non-functioning section so that an immediate troubleshooting check and repair can be done outright.

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Existing System and Design

Most solar power systems and their built-in monitoring modules are quite limited. Only the total power and remaining power stored by the system is shown.

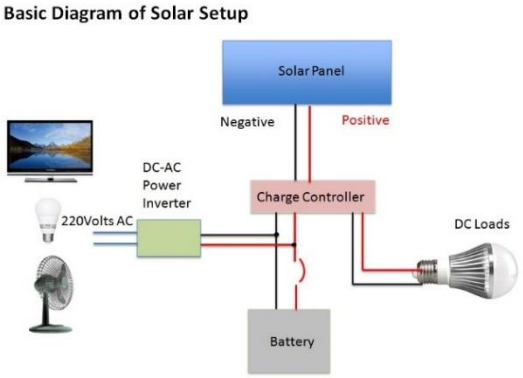

Figure 1. Basic solar power setup with power inverter as a primitive status monitoring system

Problem Areas

The problem of the current system in place is that the components being monitored are quite limited. Including the fact is that there is no suggestion from any system which area might need to be checked when the power being supplied is inadequate or there is a power shutdown.

The requirements analysis (problem areas) for the homeowner was presented through the PIECES Framework which was the following:

Performance

A solar panel system with unknown performance statistics may hide a defect until it's too late to conduct preventive maintenance on the equipment. It is possible that one or more of the panels are not properly absorbing the correct amount of sunlight due to physical damage. Without the correct statistics, it might overlook some power generation loss and attribute it to other causes outside the solar panel setup.

Information (and data)

A very crude and basic status indicator lacks additional data that may help decide whether a part or section of the solar power system is or is not functioning correctly. Every part of the power generating equipment installed is important and should also be monitored.

Economic

Lack of data may eventually lead to overhead expenses. Lack of information can trigger situations such as buying replacement equipment when they just need some small fixes.

Control

The homeowner will always be at the mercy of unscrupulous individuals out to make money by selling the equipment even if the power setup does not require it.

Efficiency

A crude monitoring system will not be able to show a complete picture on why the entire setup is not performing efficiently. For example, it is possible that a panel is not entirely damaged except for a few power cells, but that will also incur less power absorption capabilities for the entire system. One is supposed to squeeze every bit of available solar power especially on cloudy and stormy weather since clouds block sunlight.

Service Problem

If defects or discrepancies are not detected early, it is possible that the system may collapse at a time that the homeowner will not be able to do anything to get it working again. For example, the power setup halting because of damaged equipment and the owner has no replacement material or cash to buy a new replacement for it.

Research Objectives

This research is aimed for solar panel system owners to have a more enhanced and capable status monitoring system by interfacing with Microsoft .NET framework. The current system does provide some status, however, is severely limited and does not provide a better bird's eye view of the systems' health. This study will also extend the efficiency of the solar power system, decreasing the owners' expenses on equipment replacement.

The general objectives of this study are to create an automated monitoring system that will help the homeowner make key decisions in maintaining his solar power system. Also, to give advanced notifications so it can wisely

conduct preventive maintenance on the hardware installed.

The specific objectives of this study are the following:

- Monitor the health on most parts of the power system, if not all.
- Alert or notify the homeowner of problems or potential problems in the setup.
- Provide statistics on the performance rating of the entire system.

Scope and Limitation of the Study

The scope is based on what the current market offers to the public for monitoring solar power systems. This study will encompass:

1. Panel availability and solar energy absorption rate.
2. Battery health and power storage.
3. Current total load from appliances or total power consumption rate.
4. Status notifications to user.
5. Check-up suggestions by application when a problem has been encountered.
6. Storage of aggregated measures for historical data with daily, weekly, monthly, and yearly reporting.
7. Printing of reports

Please take note that the inclusion of some technical capabilities listed above might depend on what the manufacturer of the inverter has allowed to be accessible via USB interface. This study is limited to:

1. Inverters with RS-232 and USB interface only.
2. Running the application under Windows OS platform. Compatibility for android or iOS devices is not provided.

This study will not include:

1. A gateway or login portal to enable remote monitoring outside the owners' home network.
2. Multi-user capability for the application.
3. Feasibility computations for electrical costs savings and solar equipment expenses as this should have been computed and projected prior to the owner installing a solar panel system.

Significance of the Study

The study is intended to benefit the following:

- Homeowner: Being the primary user of the system, the owner does not need further technical know-how on diagnosing solar panel setup and configuration problems as the monitoring system is designed to give him an early notice on potential problems and estimated fault spots.
- Technical Staff: Serving as the support crutch of the homeowner, the monitoring system makes pinpointing the root cause of the problem much easier as the monitoring capability already gives the actual status of the system or at least give out which section is not functioning. The staff can immediately work on that isolated area instead of figuring out which part broke down or which part is processing inefficiently

Conceptual Framework

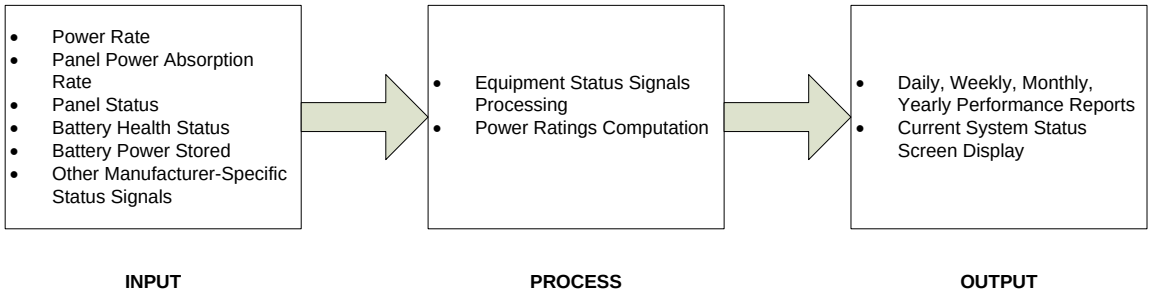

Figure 2. Conceptual Framework of the Proposed Monitoring System

Figure 3 expounds on the monitoring systems' displays the current health status and power readings of the solar power setup. The systems take all of the digital readings from the various equipment connected and are all processed, computed, and interpreted to statistical information. Once this is done, the said aggregations are displayed in terms that an owner can understand and as an option, it can be printed as reports.

Methods

The system will include an application to draw running statistics from the inverter device. This includes solar panel data, battery status information, and other indicators as provided by manufacturer through their design.

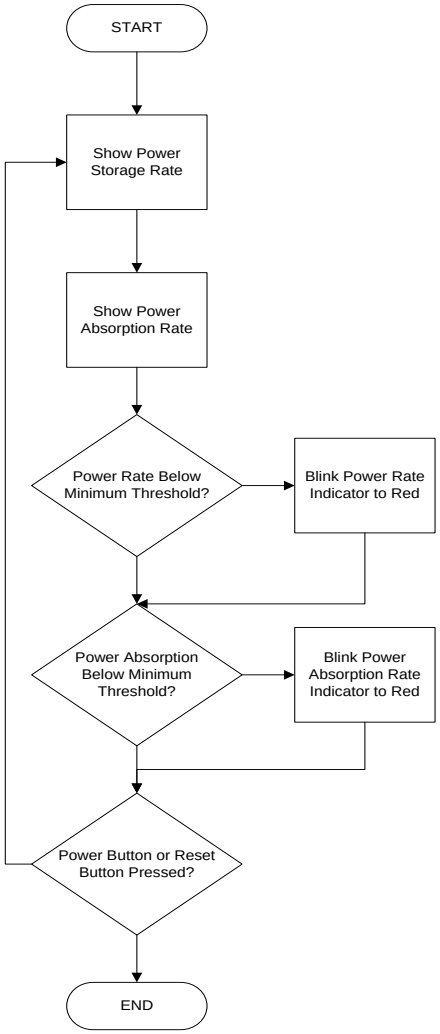

Figure 3. Flowchart of a basic inverter status monitoring system

Figure 3 show the process of the implementation of a basic inverter status monitoring system.

The proposed system is intended to expand the usual function of the inverter which is only limited to monitoring power output and panel power absorption status. It allows extended monitoring capabilities that can result to a more properly maintained solar panel setup and fully exploit the benefits twenty-four hours around the clock every day.

There are existing systems that have already been developed. With this, it is also being proposed that the system to be created should have a similar look, feel, and contents as compared to those existing applications.

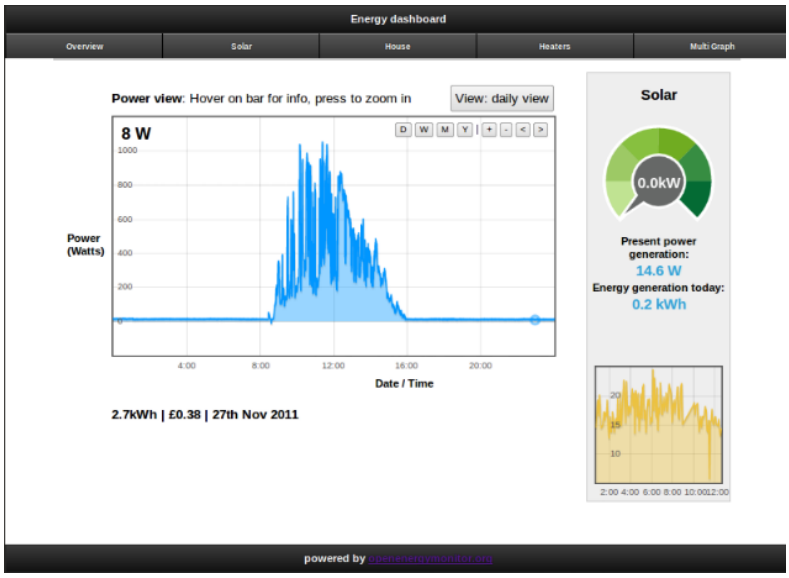

Figure 4. Existing Advanced Monitoring System Screenshots

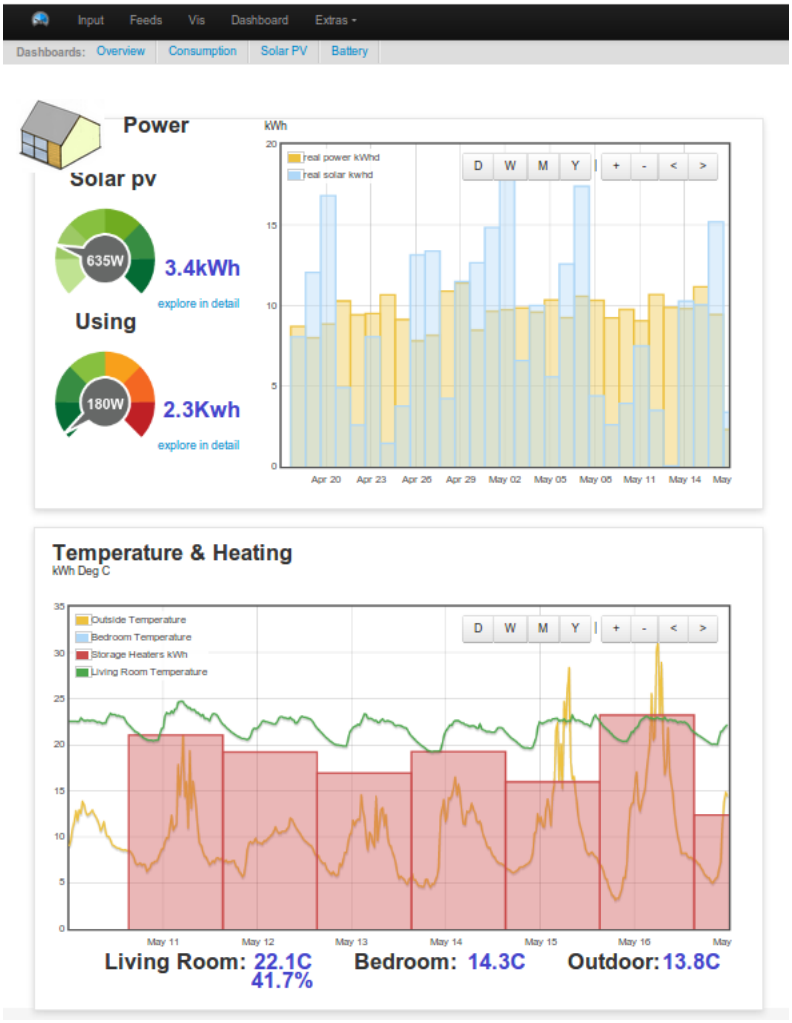

Figure 5. Additional Screenshots of an Existing Advanced Monitoring System

Results and Discussion

With the possible implementation, the study has resulted in the following requirements and actions for the success of the proposed project:

Hardware Requirements

Developer and User:

- Minimum of Dual Core or Core 2 Duo Processor Motherboard that can accommodate a Dual Core / Core 2 Duo Processor with RS-232 interface
- At least 1GB RAM
- 500GB and up hard drive space
- 14" LED Monitor
- RS-232 cable and/or USB cable for data connection
- Power Inverter
- Power Regulator, Keyboard, and Mouse

Software Requirements

Developer:

- Operating system of MS Windows 7 version and above
- Visual Studio 2008 and above
- SQL Server 2005 Express and above
- Microsoft .NET 4.0 to 4.5 Framework
- API or software for the target Power Inverter

User:

- Operating system of MS Windows 7 version and above
- SQL Server Express and above
- Microsoft .NET 4.0 to 4.5 Framework
- API or software for the target Power Inverter

The assumption is that whatever software version the developer installs, the user should have either the same version or a higher version. Compatibility issues may crop up if the user will have lower versions of the applications that the developer used.

Testing

The testing will be conducted through parallel use of the status screen of the inverter against the developed .NET power monitoring system hooked to a computer. Since the primitive monitoring system is limited, manual computations for some data will be done to compare against the other health status indicators from the new system.

Implementation

The trial implementation of this new, advanced monitoring system will be done at a house with an existing solar power setup with the assumption that the required solar power equipments are also existing and currently functioning.

Human Resources

Once the software is used, there will be no need for the homeowner to hire an additional staff just to monitor and run the software. A technical staff however should be on standby to provide technical support and on-site repair if the need arises. The technical staff could either be separate personnel or the researcher of this study.

Installation

Hardware configuration and software installation will be done by a technical staff. The staff will just be deploying the application with the package installation file stored in a flash drive or DVD-R. No copies of the installer file will be left in the target client computer.

Training

Training will be conducted through a one-day session with the owner of the house. The training will encompass proper use of the application and output of reports. The training to use a laptop or a PC in knowing how to power up the computer and activate the application will also be included in the training if the beneficiary is computer-illiterate.

Documentation

The documentation on how to use the application will be provided to the owner of the house. The system design, entity-relationship diagrams, and other technical documentations will not be given to the owner.

Benefits

The study results in the following benefits that will impact direct users once implementing the proposed solution:

Tangible Benefits

- More statistics stored enable performance monitoring for most attached hardware.
- The system will store signals coming from the equipment and stored for future viewing of the homeowner and further evaluation of their health.
- Reports can be printed out and the owner can be able to compare the performance of the solar power system on a daily, weekly, monthly, and yearly basis.
- Better tracking of power panel absorption and power output.
- The owner will be able to tell discrepancies between the supposed power stored as against the load of appliances that the batteries can run during day and night.

Intangible Benefits

- A more informed homeowner.
- The homeowner does not need to frantically worry if there are certain problems, or the solar power system is interrupted as he already has clues or indicators when and where it stopped functioning.
- Less time spent in troubleshooting equipment.
- The technical staff will have a good amount of idea what repairs or fixes to implement since operational data is available for them to check on.

Conclusion

Based on the study it can be concluded that developing additional monitoring capabilities can be developed on top of some existing solar power systems.

Based on the results of the study the following can also be inferred:

- Additional monitoring statistics can benefit the homeowner economically and produce fewer worries whenever his power setup is online.
- This also includes less dependency on power-producers and power distributors that charge a hefty amount of cash for electrical power.

Based on the results of the study it is recommended that:

- The homeowner makes an informed selection first of equipment prior to even availing of the development or installation for this software. Not all inverters support functionalities for them to draw out more data or performance statistics from the associated hardware within their power setup.
- Future capability for the system to be accessible also even if the homeowner is far away from his home.

Additional security setup using firewalls if the said monitoring system will have remote access features.

Recommendation

The researchers would like to extend their appreciation to their respective organizations for their undying support in giving opportunities including this research. Without their valuable inputs and treasured assistance on the information of the study and the design and development of the application, this study would not be possible.

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