EXPORT AND IMPORT OF RENEWABLE ENERGY BY HYBRID MICROGRID VIA IOT

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Abstract—A hybrid smart grid, opens up new avenues for solar power based micro grids, to be controlled and accessed by Internet of things technologies. Also it makes possible new business models for export / import of generated and accumulated Solar PV. Integration with IoT allows micro grid systems to perform data logging over the cloud and provide remote control of the grid. This paper describes the approach to enhance the Hybrid power grid system in homes, and to connect them to a main grid connecting many other homes. The node owners can purchase or sell the generated/stored power at their homes, using a web interface.

Keywords— Hybrid Smart-grid, IOT (internet of thing), Monitoring, ACS758 sensor, Differential Op-Amp, Hybrid Capacitor, Cypress PSoc4, ESP8266;

Introduction

Hybrid smart grid is a system for enhanced micro grid, which comprises of solar energy generators, hybrid ultra-capacitors, home battery banks and a centralized server which controls the load as per power consumption.

Current central stations which control power grids, operate on update cycles that are about 15 minutes long. Every 15 minutes the central station estimates the power and adjusts its generators to meet the load. Unlike traditional source of energy, renewable power sources such as solar panels or wind turbines don't have a predictable output over the same time range which leads to solar panel being vulnerable to surges. Surges produced due to instant loads, like home appliances, cannot be borne by solar panel and are hard to predict. If grid drops below the needed power threshold, it can fail the entire system. Thus variable nature of renewable energy source is not suited for traditional power grid systems.

To prevent system failures on unpredictable output situations, as described above, we have alternatives such as adopting battery storage. However, this leads to deep discharge during surge and consecutively shortened life-cycle of the battery. On the other hand, if battery is coupled with a HUC (Hybrid Ultra-capacitor), HUC will take on the supply when the surge is encountered, thus safeguarding the battery.

Cost of installation of a micro-grid, can be overcome in few months due to its self-sustaining setup. The setup also enables a user to trade the leftover day's power, with his neighbours who are connected to the main grid. The transaction and information is to be exchanged on the Internet Of Things methodology [1]. Using lightweight publish-subscribe protocol over secure TLS, the users and micro grid system are able to communicate. Data is synced periodically from local cache of smaller hybrid micro grids to database of main grid. Using the Data collected overtime, the analytics engines provide real time statistics to all connected endpoints. To ensure sufficient power, the grid operators maintain extra power plants that are reserved for emergencies.

I. EASE OF USE

A. Hybrid Micro-Grid

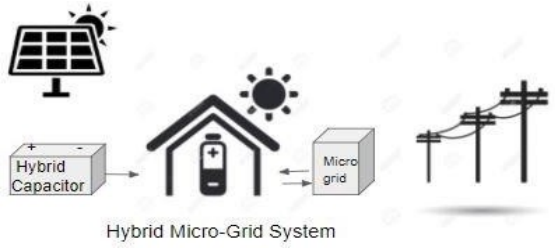


Fig.1. A Hybrid Micro Grid System

A hybrid micro grid system consists of solar panels, battery bank and a HUC (Hybrid Ultra Capacitor). Solar energy in stored in battery & HUC bank. A Hybrid micro grid system maintains 100% of battery's charge state. Any fluctuation in load is taken care of by HUC Bank.

B. Power Transmission

A main grid consists of individual hybrid micro grid systems, each of which contains solar power generation unit and battery storage units. This hybrid micro grid system of each home hereby referred to as node is connected via parallel bus to other homes with similar setup. This constitutes a grid, hereby referred to as Main-grid. [4] Since the nodes are capable of generating and storing power, they also have the capability to share power with other nodes in grid [2]. For example : If house A has more exposure to sunlight, it will generate more power than its daily consumption, while house B has guests arriving and requires more power today than usual production. House A can export power and B can import. The transaction can be initiated by user interface portals on mobile app or webpage and will be controlled by a centralized server.

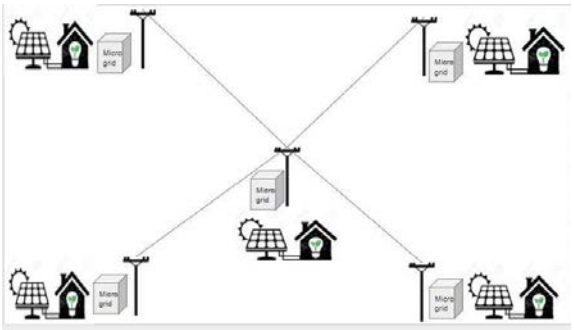


Fig.2. Power Transaction between Hybrid micro grid system nodes of Main Grid

II. DATA PROCESSING AND REAL TIME ANALYTICS

Each house that is connected to the micro grid system acts like a node in the grid. There is a publish/subscribe communication model between each node and server. Data is synced every 3 seconds using a lightweight protocol such as MQTT [3]. Every node publishes its updated information, regarding power generated and consumed, to the centralized MQTT server. The master client connected to the centralized server is responsible to update the collected information to the backend database for data persistence. An end user can view realtime status and performance statistics via MQTT on webpage using his designated account. [5]

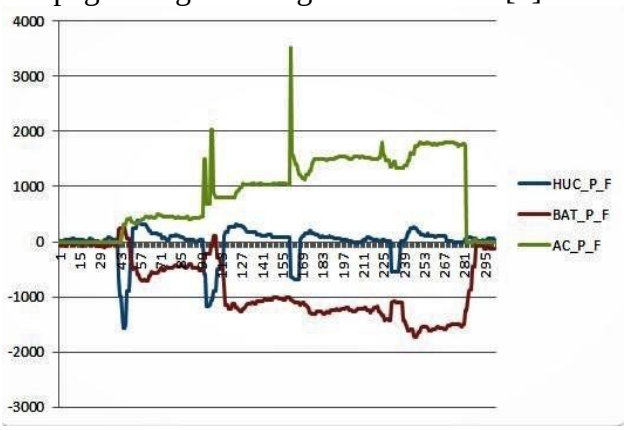


Fig.3. Time vs Power, battery and Current graph from data collected on a sunny day.

The information in the database contains output power against time. The graph (Fig.3) illustrates the condition when load generates surge and is absorbed by HUC. This process can be filtered and represented in various graphics models and views. An algorithmic system can also enable predictive analysis according to demographics and weather conditions. As described the flexibility and customizability is unbounded and can be used for further research as well.

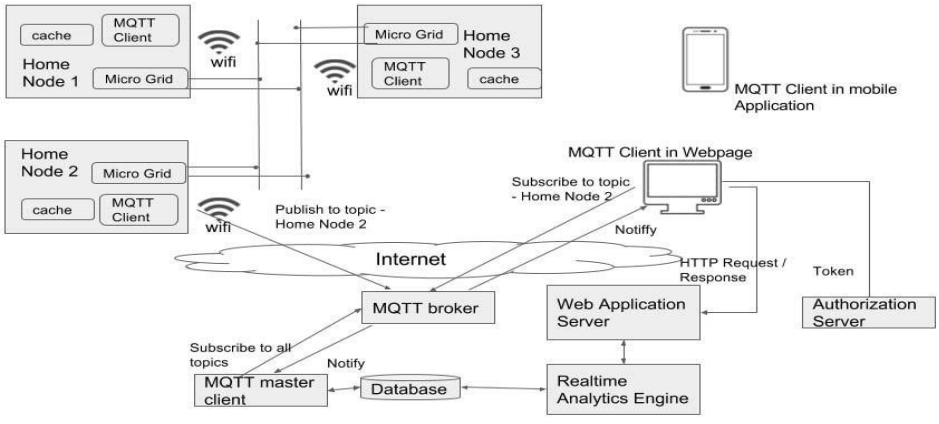
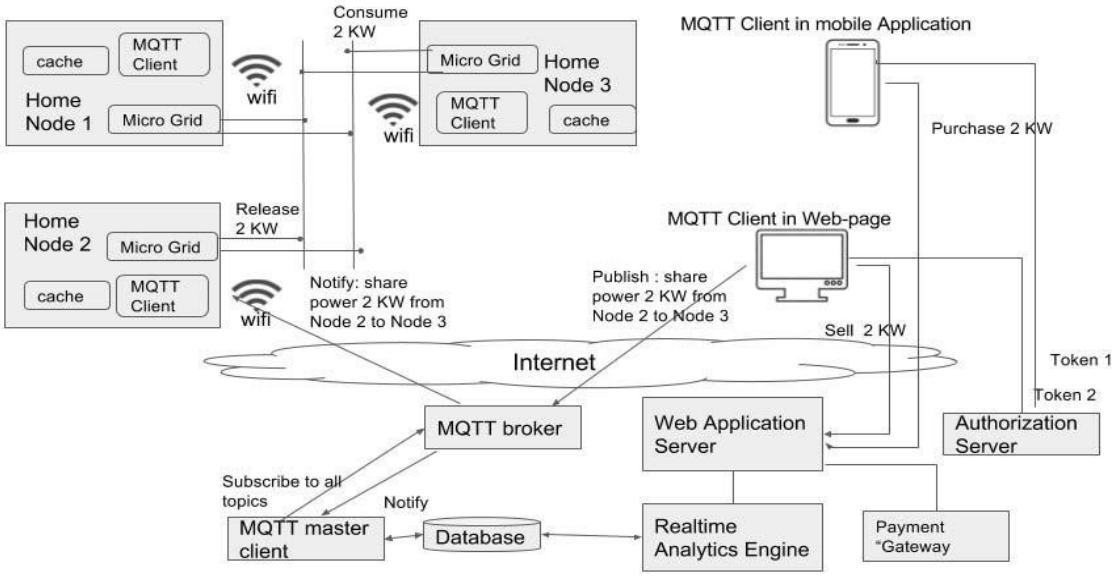


Fig.4. Communication between Nodes via MQTT and Real-time Analysis



Buying and Selling Power between nodes in Hybrid Microgrid system

Fig.5. Buying and selling power between nodes

V. Security and Scalability

A. Hardware and Access network security

A traditional transmission system is subjected to various theifs and fraudulent behavior. Government losses about 23% due to distribution and transmission losses, while some remote states even approach to a number as high as 50%. According to Wikipedia the highest losses due to electricity were in India ($16.2 billion).

In a hybrid micro grid system the solar energy output is monitored autonomously with real time analytics and theft is nearly as difficult as stealing the sunlight. There exists a system of trackers and notifies to contact each node user and operator immediately as and when an intrusive behavior is detected within the grid.

Additionally, anytime a node is found operating unorderly, it can be remotely disconnected from the grid. In the event of doing so, user can also consume his own solar power output but cannot do any transaction of power with others in the grid. There is an option to perform remote diagnosis in case any problems occur to do root cause analysis with immediate implementation in rerouting traffic.[6]

B. Communication and Data Security

The communication between nodes is TLS/SSL encrypted. By implementing authentication and authorization, security is provided at network, transport and application levels. The end points such as mobile and web pages use trusted CA certificates to download data and/or update parameters in configuration.

The database will be read-only restricted to all clients except the MQTT master.

C. Scalability and High Availability

A minimum of 2 nodes is required to create a smart grid network. The system can be scaled by adding more nodes or removing existing ones. The main grid can scale from few houses in locality to entire metropolitan cities if required. A centralized database system maintains the count of nodes and performance statistics of each.

Since the nodes regularly sync up information with the main server, any node level failure does not harm the backed up data. The database servers are also clustered to provide data duplicacy and load sharing. In event of a main server or database system going down, the clustered arrangement will ensure that others server handle its role and do not create service disruptions.

VI. HARDWARE COMPONENT

The following hardware components constitute a hybrid micro grid system to collect the data from system:

Circuit required major component are ACS758LCB-100B high current bi-directional current sensor, LM358-Single Supply Dual Operational Amplifiers, ESP8266 -12e Wifi module and CY8CKIT-044 PSoC® 4 M-Series Pioneer Kit.

VII. OPERATIONAL AND MONETARY BENEFITS

The hybrid micro grid system is self-sustainable as well as profitable in the long run.

The system will prevent the long distance transmission losses A solar PV system has a lifespan of around 25 years. However, same is not in the case with the solar inverters. Most inverters come with a life-expectancy of ten years.

VII.CONCLUSION

This paper provides a complete, self-sustaining and opensource solution for renewable energy utilization via power grids. Solar power based hybrid micro grids should be deployed to locally generate energy and share with other members of grid. It will intercommunicate over the backbone of Internet of things technologies. According to all research carried out for the proposed project, solar power is a cost-efficient and robust source of energy which is underutilized in today's times. If integrated with intelligent grid systems, it can provide power to not only homes but also localities on sharing basis. Data loggers will sync information with distributed database systems on cloud while real time analytic engines will provide notifications and reports to visualize data for predictive and statistical analysis. This robust model even provides business avenues for home owners to harvest and commercialize generated solar power. It will also help governments to regulated power generation and consumption for a healthier and greener environment.

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