SMART ENERGY MANAGEMENT FOR THE GRID CONNECTED SOLAR AGRICULTURAL PROSUMERS AND CONSUMERS

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ABSTRACT

Gujarat is a leader in the deployment of renewable energy and especially solar. The state has over 1,500no's of grid connected solar PV plants as on date and is among the top states in India for solar energy generation. The state has also given emphasis to distributed solar generation i.e. solar generation connected to the LT grid. The Gujarat Energy Development Agency (GEDA) has been implementing the rooftop solar program in lines with the central program of the Ministry of New and Renewable Energy (MNRE). Now, the state intends to extend the definition of distributed solar energy from rooftop solar PV systems to grid connected solar pumps or 'Farm-top' solar installations.

The central government has also planned to make an announcement to support and scale up this pilot project across the country through the **Kisan Urja Suraksha evam Utthaan Mahabhiyan (KUSUM)** scheme.

The state now envisions to dovetail the efforts through the KUSUM scheme and has announced the **Suryashakti Kisan Yojana (SKY)** scheme. The scheme is essentially a net-metering solar PV based pump set that is installed on the fields of farmers. The essential working of the scheme is similar to the rooftop net-metering policy in any location in the country. Farmers install solar powered irrigation pumps. The solar PV system provides day-time around 12 hours power to the farmers which is first used to meet the requirements of the pump. Any excess energy is fed into the grid for which the farmers are compensated by the power distribution company.

There are several benefits of such a scheme, which include (a) efficient use of water (b) additional source of revenue for the farmer (c) day time power for farmers (d) reduction of cross-subsidy burden on the DisCom (e) deployment of RE in a distributed and equitable manner (d) reduction of long-term power Subsidies for the state government (e) improved economy in rural areas.

1. INTRODUCTION

SKY Scheme is for grid connected Agriculture Consumers, farmers would be provided grid-connected solar photovoltaic (PV) systems in their farms adjacent to their pump-set. As per the scheme provision, 1.25 KW SPV system per HP of pump set will be installed. Such an arrangement would enable the farmers to inject the surplus generated solar electricity to the grid and will earn extra income from the sale of electricity to DisCom Farmers will get incentivized to pump water optimally, conserve ground water and help in energizing agricultural feeders and habitations. As being a generation at load point, reducing ATC losses, DisCom will save huge amount of money by minimizing energy purchase for Agricultural sector also will help to meet their RPO obligations. This would also reduce the subsidy burden on the State Government towards the farmer's electricity, as the State Government would be purchasing power from the farmer rather than selling power to them. But there are challenges to manage power in condition of Solarizes for the Non Solarizes consumes and Energy accounting is required at consumer, Transformer and Feeder input point. To meet these challenges Smart energy management system is developed by using Metering & communication solution and watchdog transformer with IoT technology.

Farmers who are the consumers of the DisComs and are connected to the distribution grid shall be the Beneficiaries. They shall be equipped with grid-connected solar photovoltaic (PV) systems in accordance to their existing contract demand. The feeder under the solarization i.e. the Agriculture feeder will be kept 'ON' during daytime, say from 7 am

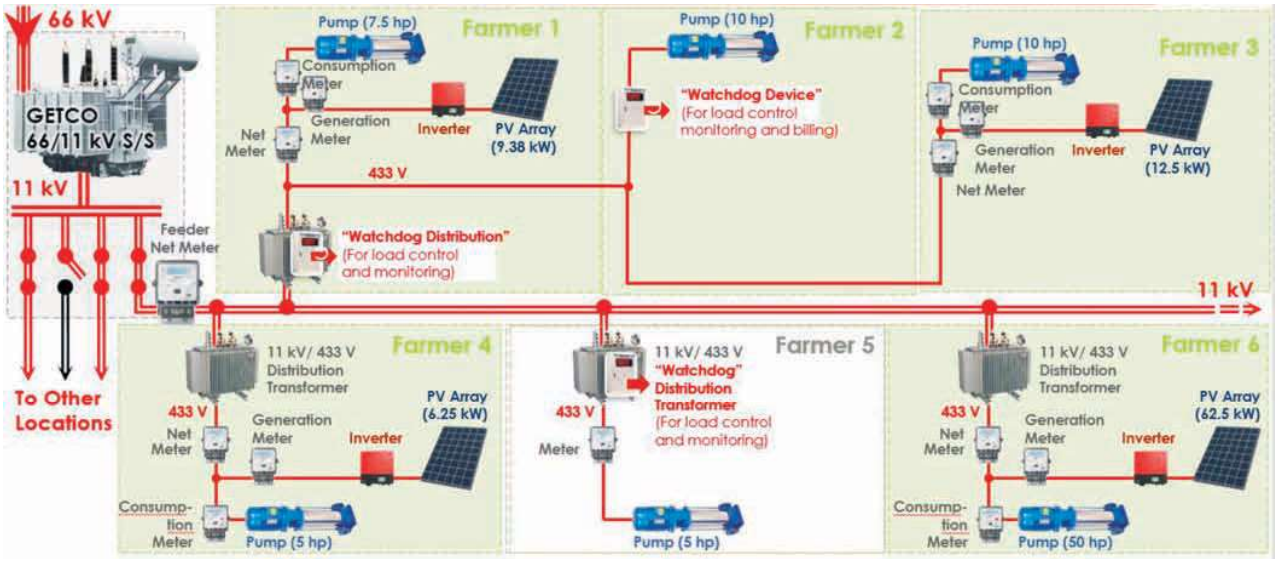

Fig.1 : Schematic diagram of SKY Scheme

to 7 pm. The timings may further be adjusted to maximize the solar energy generation. As shown in fig 1, multiple consumers are connected to one feeder. . It may, also, happen that some consumers do not opt to participate at the scheme. As the agriculture consumers is highly subsidized in tariff, the three phase power supply is restricted up to eight hours. For the remaining hours, single phase supply is catered for their lighting load through Special Designed Transformer called SDT/Planned Load Management Transformer PLMT

The Feeder, having solarized system consumers, say SKY consumers are producers and consumers, hence known as prosumers and some, who do not opt to participate, are normal consumers. For monitoring of consumption and injection of energy and for billing purpose, a Smart Energy management system is required. Also, Commercial loss shall be proportionately distributed amongst all the 'Solarized Agriculture Connections' of the feeder. To meet with all above requirements, feeder-level net-meter, the Distribution transformer net-meter and an individual farmers metering console is implemented with the IoT (Internet of Things) communication technology. The software is named as SEDM (Solar Energy Data Management)

Major two components are involved in the Smart Energy Management. As stated here under.

A) Metering and communication solution

B) 'Watchdog' transformer

2. METERING AND COMMUNICATION SOLUTION [METERING CONSOLE]:

The metering Console consists of 3 phase 3 energy meters, and one 1 phase energy meter as per requirement of domestic load and one IoT gateway, Solar System data collection software, server and analytics. A comprehensive '**Metering Console**' is prepared to house the energy meters, IOT device internal power and communication wiring, bus bars, auxiliary equipment, etc.

Key elements of meter console are as under:

- **Solar Generation Bi-directional Meter**, with RS485 port, compatible to communicate through MODBUS protocol for measurement of energy generated by SPV system.
- **Pump Motor Consumption** Bi-directional Meter, with RS485 port, compatible to communicate through MODBUS protocol for measurement of energy consumed by Pump-set. Energy measurement used by consumer pump motor.
- **Net Energy Meter Bi-directional Meter**, with RS485 port and compatible to communicate through MODBUS protocol for consumer net energy import and export for billing.
- **Domestic LT Energy Meter 1 Ph 2 Wire** Uni-directional with RS485 port and compatible to communicate through MODBUS protocol for energy used for their domestic load.
- **IoT-based DCU** to collect data from all four meters inside the metering console and from inverter at a

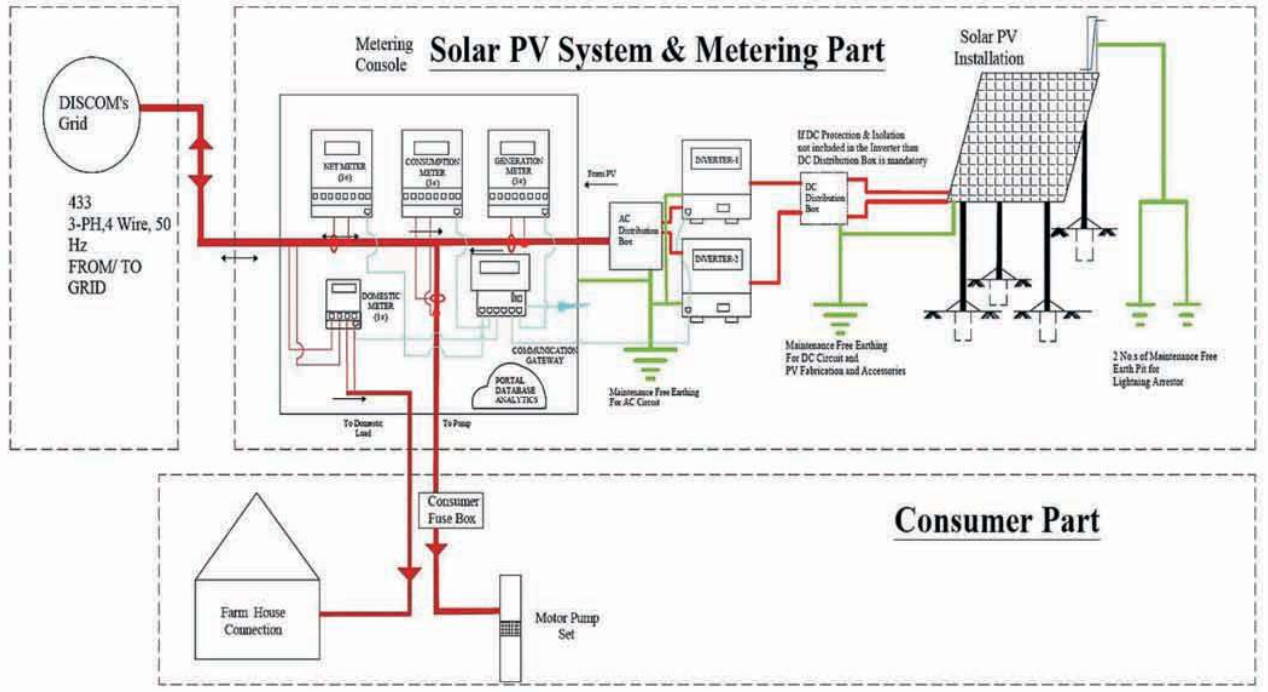

Fig. 2 : Schematic diagram of a Metering Console.

regular interval of 15 minutes (can be modified in the slab of 1 minute to 1 day, if required in future) using RS 485 port and MODBUS protocol and communicate with cloud server through secure communication protocol. Also, In case of other peripheral devices (e.g. Console box door open/ close indicator), the DCU may communicate based on appropriate digital or analog signals.

SEDM will be making communication with all energy meters and solar inverter. Also there is a provision to control the consumer load by connect and disconnect command from remote end through mobile App. Farmers can remotely make ON and Off the pump-set as an energy conservation aspect and Grid Demand Side management.

3. WATCH DOG TRANSFORMER (WDT)

This product is developed and patented by Gujarat Power Research and Development cell, (A Government Initiative), GUVNL, Gandhinagar, which will be installed at the premises of AG consumers who are not participating in the Scheme. The watchdog transformers is equipped with IoT based programmable smart device. There shall not be a direct access of uncontrolled Low Voltage (LV) terminals of The Transformer. It will limit the 3-phase power supply to non-participating AG consumers for a stipulated 8 hours, but may continue single phase power supply for residential purpose for the rest of the hours and also record the energy consumed by the consumer, the energy data and remote connect / disconnect shall be integrated with SEDM.

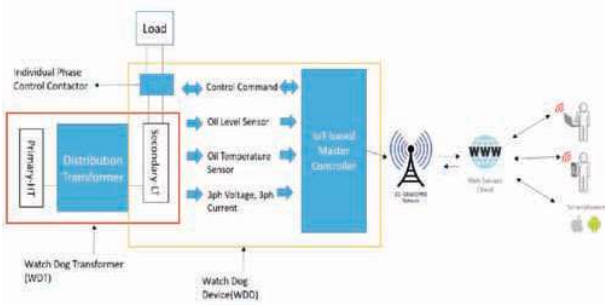

Fig. 3 : Schematic diagram of Watch Dog Transformer.

The Watch Dog Device (WDD) shall be an integral part of the Distribution Transformer. The WDD shall be fixed in a metal housing and whole unit with metal housing shall be fixed on LV bushing side via metallic adaptor so that there shall not be a direct access of LV bushing of DT (Distribution Transformer) to consumers. Here, a device is developed called Watch Dog Device (WDD) and same shall be mounted on a distribution Transformer. The Distribution Transformer with WDD is named as Watch Dog Transformer (WDT).

Whatever energy will come out from the DT, it will be measured, monitored and controlled energy. There shall be access to LV terminals of WDT only and not to the LV terminals of the DT. This will eliminate usage of unmeasured energy. The WDT and its remote data monitoring software will be continuously watching the energy recorded in WDT, and the energy recorded in consumer meters. If any less recording is found in consumer's meter comparing with the WDT, the WDT will be smart enough to disconnect the supply immediately, or it will give notification to the concern to take appropriate actions. The WDT will take local decisions also, in case of short circuit/over loading. It takes decisions to switchover the power supply from DT; from three phase to single phase and vice versa, locally as well as remotely. All the three phases or any one phase or two phases can be made ON/OFF as per prescribed schedule without any human intervention. The WDT will also monitor and control power staggering, three phase supply hours, single phase supply hours, no power hours etc. locally as well as remotely. The WDT will perform all the monitoring and control activities, including vigilance activities, without any human intervention.

Need of distribution transformer monitoring & Controlling System by WDT:

The Distribution Transformer is a critical equipment in the power system. The reliable operation of the power system depends upon the effective and successful functioning of the distribution transformer. Almost, the transformers used in the Utilities are having bare / open HT and LT terminals. The consumers are metered, but meters are installed in the premises of the consumers. The notorious consumers indulge with the meter and do not allow to record the energy consumed, properly. In so many cases, the consumers involved, are found strong headed. Under these circumstances, it becomes very difficult for any utility to control the theft of energy. The theft means unpaid usage of the electricity, and as per human psychology, it is misused which is ultimately misuse of scaring natural resources. This badly impacts the tariff of the electricity, cross subsidy and the National economy etc., which, ultimately increases burden on the honest customers and the Nation too.

Therefore the measurement, monitoring and control of the energy, which comes out of any transformer has to be done with a smart and intelligent device and such device should be an integral part of the transformer. Any energy comes out of the distribution transformer must been measured before it enters into any consumer's premises. The Other key parameters like voltage, current, power factor and temperature are also necessary for proper performance of the distribution transformer, which will be helpful to avoid or reduce disruption of the power supply, due to sudden unexpected failure. With the increase in renewable energy sources, distributed generation shall require to address the reactive energy management and imbalance. IoT based controller shall manage through the fix capacitors, as per the requirements of grid reactive energy.

Electrical energy is very costly, it has to be used very carefully and judiciously by its users. If it is not done then it has to be done using an intelligent device. Distribution transformer automation system provides a possible application for distribution grid self-healing. Based on intelligent switchers with functions of telemetering, remote signaling and remote control, it can realize real-time monitoring of the running status of distribution transformer, detecting and judging the fault timely.

4. SMART ENERGY MANAGEMENT FOR AGRICULTURE GRID

Smart Energy management done by Solar Energy Data Management System (SEDM) software, Dash-Board for monitoring, analysis and auditing, Billing Solution, WDT (Watch Dog Transformer) module, Mobile Application.

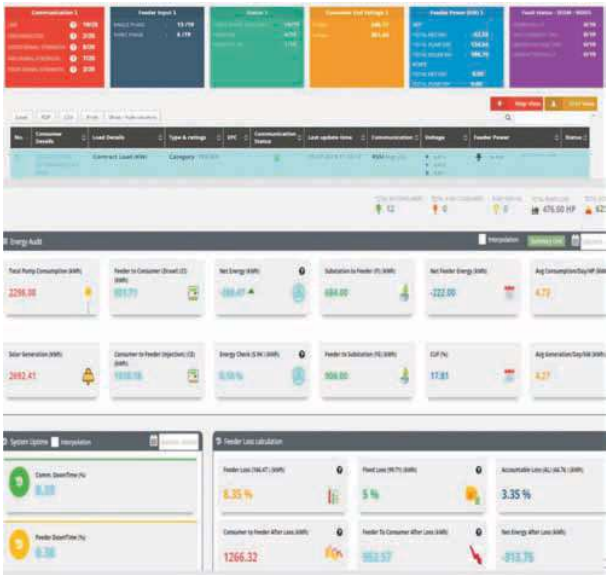

Fig. 4 : Real time data chart with solar generation, consumption, net export energy and status position of contactors Solar Energy Data Management System.

There will be an AMR system for meter readings of feeder panel meter as well as net meters of each consumer, the system will take energy data of Solar as well as consumption meters, also. DISCOM will make billing as per the net energy recorded in the feeder panel meter, after taking technical losses of the feeder into the account. DISCOM shall prepare a common statement of all consumers on a feeder, showing net energy exported/imported. System shall workout net amount payable or recoverable from the consumer.

IoT base device used in the meter console and the Watch Dog Transformer is intelligent enough to take decision as per the given logics as well as execute operation for smart energy management. Distribution automation system is an important approach to increase distribution network management level, increase power supply reliability and power supply quality, enlarge power supply capacity and achieve efficient and economic operation of distribution network.

5. BENEFITS

Benefit to Farmer

- Farmers receive reliable daytime power.
- Farmers are incentivized to use judicious power for agriculture, thereby becoming efficient in terms of both, energy as well as ground water usage and depletion.
- Farmers shall have a substantial secondary source of income by selling surplus power to the DISCOMs.
- Help farmers become self-reliant for their power requirement.
- Create employment opportunities for rural areas.

Benefit to the DISCOMs

- Huge energy drawl will get eliminated.
- Huge and manageable burden on system in case of rain shortage will get eliminated.
- Distribution loss minimize technical and non-technical losses in power systems
- Watch Dog transformer eliminate theft, unauthorized usage and failure of the transformers, due to over loading.
- Cross subsidy will reduce or will get eliminated in phase manner.
- IoT base DCU in meter console, works as an intelligent device for energy storage, accounting, and alert for abnormal event and demand side management.

Benefit to the Government:

- Reduce the financial burden of DISCOMs and the State Government by reducing the subsidized for power to farmers.
- Help the DISCOMs promote renewable energy and meet their solar renewable purchase obligation (RPO).
- Provide good quality day time power supply to farmers
- Farmer gets an opportunity to earn additional income
- Promote social welfare by encouraging agriculture sector
- Encourages energy and water conservation
- Farmers will get motivated to use energy efficiency pump sets as well as micro-irrigation system.

6. CONCLUSIONS

The SKY has a power to make revolution in rural sector by creating additional income to farmers. The scheme promotes energy conservation as well as water conservation. The current burning issue of continuously depleting ground water level will get automatically addressed because farmers will get motivated to adopt micro irrigation system against traditional flood irrigation system. In future, as prices of fossil fuels will be increasing, this will the best option, as there will be additional earning by the farmer after meeting the pumping needs.

Use of the IoT for monitoring of a solar power plant is a key step as day by day the renewable energy sources are getting integrated into the utility grid. Thus automation and intellectualization of the solar power plant monitoring will enhance future decision making process for solar power plant and grid integration of such plants. For the IoT based remote monitoring system for solar power plant, the approach is studied, implemented and achieved the remote transmission of data to a server for supervision, successfully. IoT

based remote monitoring will improve energy efficiency. The Web Console based interface will significantly reduce time of manual supervision and energy billing & accounting.

Using, WDT in place of normal Distribution Transformer, the theft, unauthorized usage and failure of the transformers due to over loading will get almost eliminated. However, a remote monitoring of parameters of distribution transformer like Oil Temperature, Winding Temperature etc. will also be done with a smart way, which will help to reduce transformer failure.

7. REFERENCES

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BIODATA

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RB Patel is a graduate in Electrical Engineering and later he passed examination of Energy Auditor First class with Distinction in 2009 through BEE. He has more than 30 Years of experience of power Transmission & Distribution and also monitoring of the different electricity schemes. Presently he is serving as a head of the Gujarat Power Research and Development (GPRD) Cell, Gandhinagar and In Charge Chief Engineer (Tech), GUVNL, at Vadodara.

He worked as a team member for development of technical specifications in many items related to the DISCOM business, like Transformers, Energy Meters, RMUs, 11KV Capacitor Banks with communication, Cables, Solar System with its communication software. He has developed various equipment independently, like Special Designed Transformer (SDT), Planned Load Management Transformer (PLMT), HT Metering Cubicle, HT-ABS. He has awarded by IUCAN National Award in 2014 for Invention of Special Design Transformer for single phase power supply to Agriculture Farm.

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Rohit Patel is a graduate in Electrical Engineering, Masters in Business Administration (MBA) and later he passed examination of "Advance Certificate in Power Distribution Management" & "Executive Certificate Program in Power Management" through PDPU, Gandhinagar. He has a total of 21 years' experience with an electrical distribution company, Gujarat.

He performed admirably in his projects expertise as a Project Implementer in GeoUrja (Enterprise GIS System), as a Nodal Officer in ERP (Enterprise Resource Planning), as a Project Coordinator in SCADA (Supervisory Control & Data Acquisition System) and as a Quality Manager in NABL Meter Testing Lab. He has an in-depth knowledge of the electricity distribution system and has played a significant role in improvement of power system with GIS, SCADA, System Studies, MDAS-MDM, AMR and Smart Grid etc. Presently he is serving as a senior R&D Engineer in Gujarat Power Research and Development (GPRD) Cell (GUVNL), Gandhinagar.