DEVELOPMENT OF A SMART MICROGRID R&D PLATFORM IN THE INDIAN CONTEXT

PART OF A PROJECT SPONSORED BY
THE MINISTRY OF POWER, GOVERNMENT OF INDIA
AND
INDIAN INSTITUTE OF TECHNOLOGY KANPUR, INDIA

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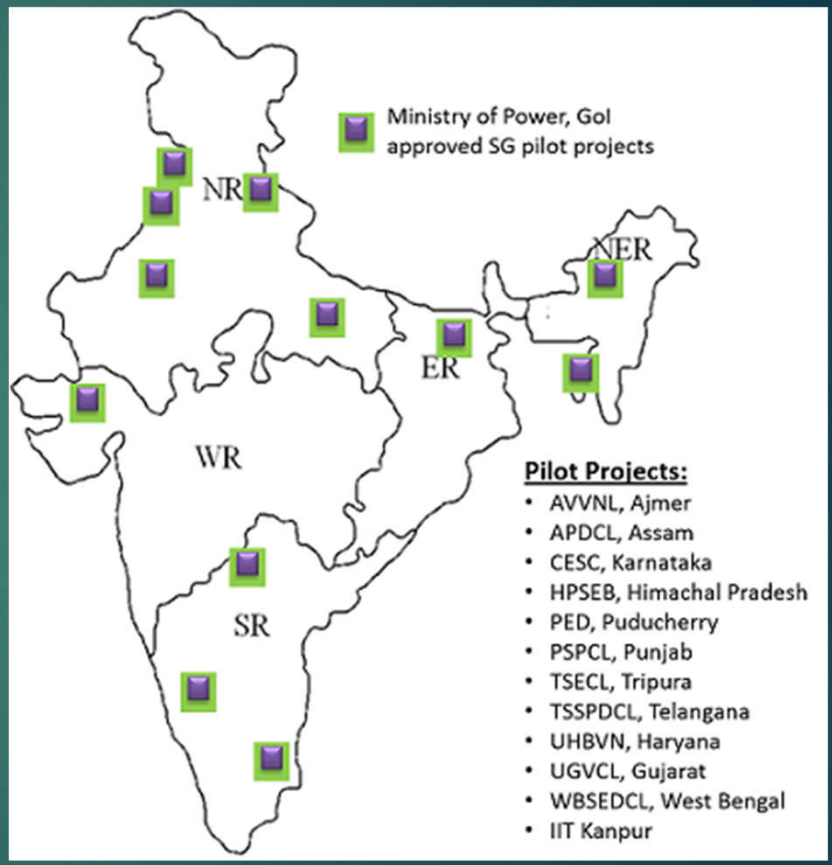
National Smart Grid Mission in India

- The Ministry of Power (MOP), Government of India established National Smart Grid Mission (NSGM) in 2015 to execute smart grid related activities in India
- 12 pilot projects were partially funded the MOP
- IITK 'Smart City' project is equally funded by the MOP and IITK



Project highlight

- IITK campus is chosen as the installation site
- The campus spans around 1000 acre (~4km^2), accommodating close to 10,000 people
- The project scope includes only the 'electrical' aspects of a smart city
- The electrical infrastructure of a prototype smart microgrid is installed using state-of-the-art technologies, keeping in mind typical Indian market and consumer behavior

Objective and scope

- Identification of key challenges in smart microgrid deployment, and development of innovative solutions
- Test-bed for future research in microgrid related areas
- Installation/upgradation of key enablers of smart distribution system: supervisory control and data acquisition (SCADA) system, advanced metering infrastructure (AMI), home automation (HA) system, and integration of household rooftop PV systems
- Training and demonstration for utilities, industries and academic institutions

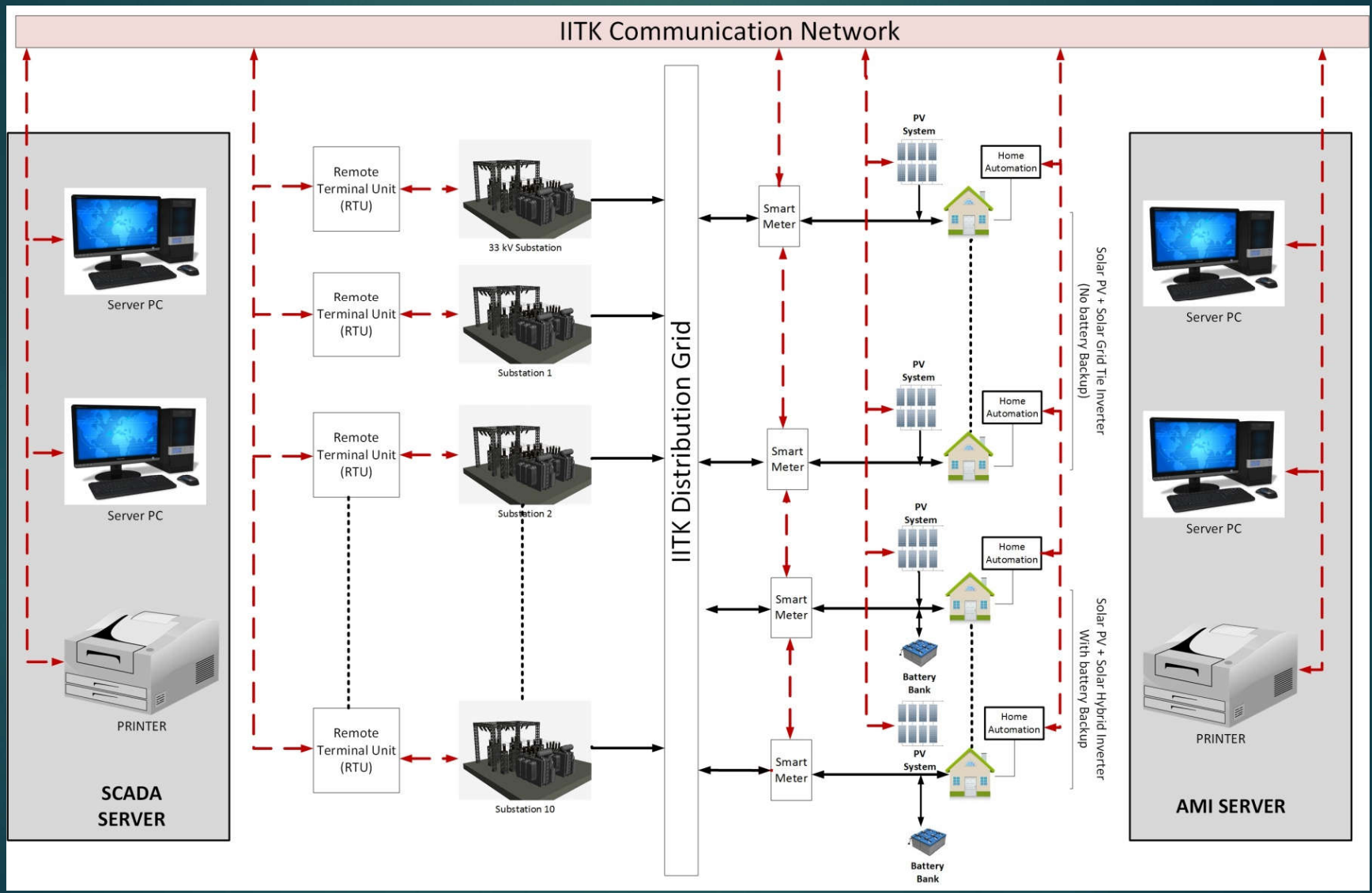
Electrical system

- IITK receives power at its main 33/11 kV substation
- Total sanctioned load: 10.5 MVA; 10 no. of 11 kV/415 V substations to distribute power in the campus
- Distribution system is mostly underground
- RTUs installed in all substations as part of the project, and the entire distribution network including LT feeders are now under SCADA
- 19 residential houses and the control centre have 5 kWp rooftop solar PV and home automation (HA) systems
- AMI includes these 20 locations, and also student hostels

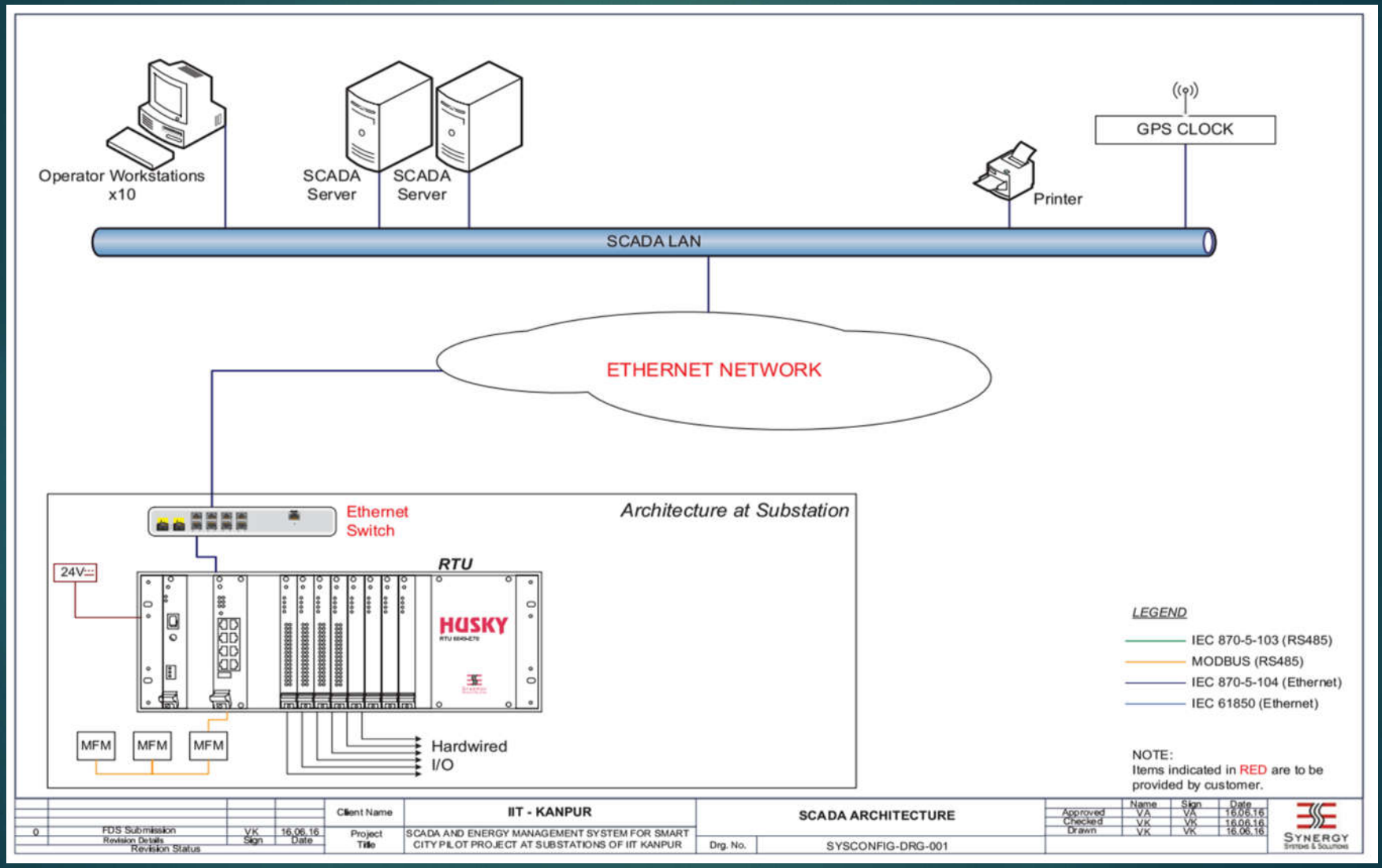
Key functionalities

- Smart microgrid substation
- Smart homes
- Renewable integration
- Advanced Metering Infrastructure (AMI)
- Smart control centre
- Advanced IT infrastructure
- Battery storage management

System Architecture



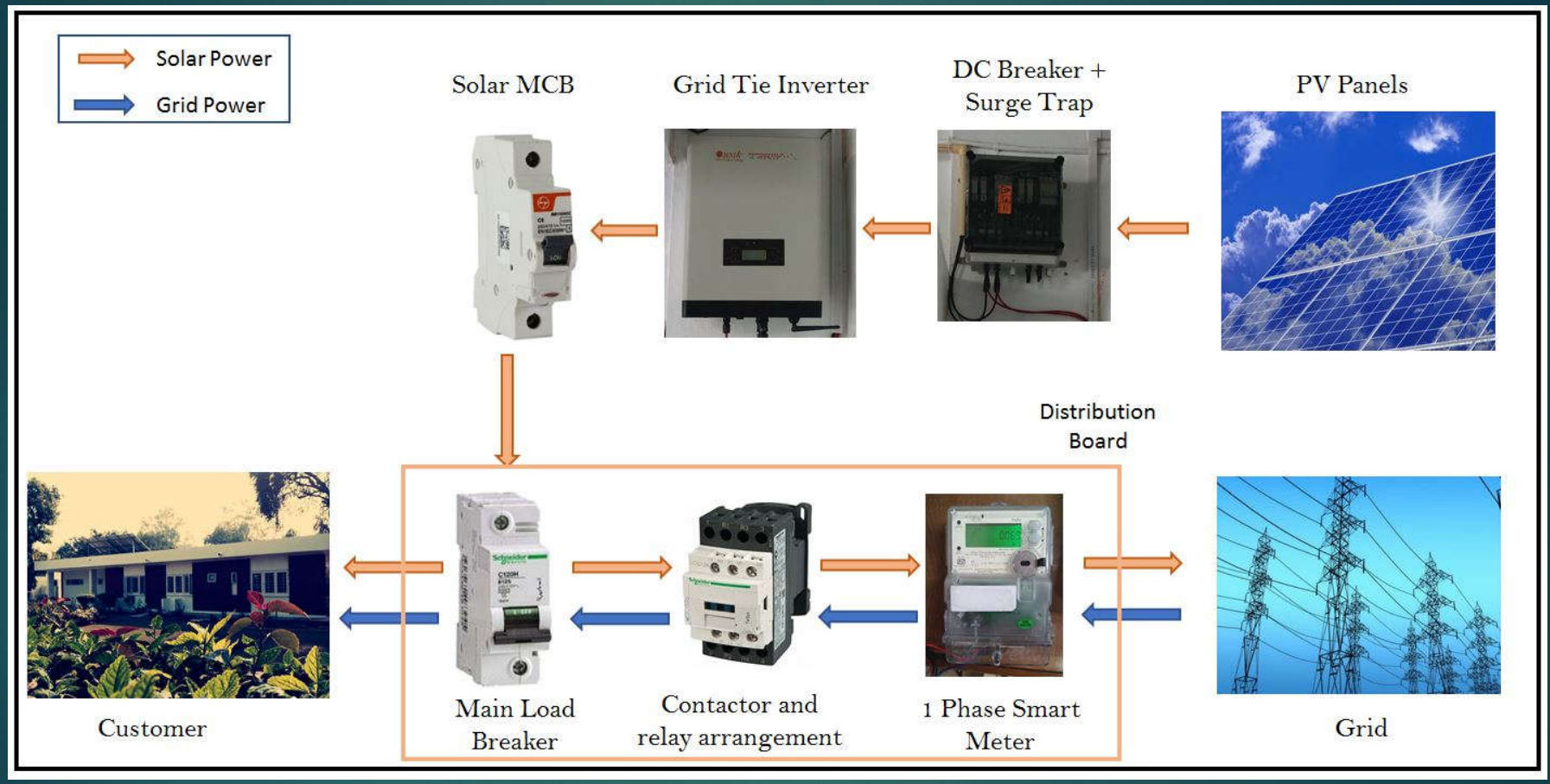
SCADA Structure



SCADA: Implementation challenges

- Unavailability of circuit diagrams and potential free contacts for old circuit breaker control panels … contact multiplier relays (CMRs) had to be used
- Very short time window for power shutdown at substation for upgradation and installation work…DG backup had to be arranged for critical labs, HPC etc.
- Significant effort went into motivating existing operators/staff at IITK substations to learn and operate SCADA and troubleshoot.
- Customizing and integrating in-house solutions to the SCADA software was a big challenge.

Renewable integration



Renewable Integration… contd.

- Solar PV system of capacity 5 kWp each, installed on the rooftop of 19 houses and the control centre.
- 16 houses have Grid Tie Inverters and the rest 4 have Hybrid Inverters and battery storage.
- The design of the hybrid inverters is unique in the Indian market.
- These battery-connected solar PV systems can feed to the grid, as and when required.

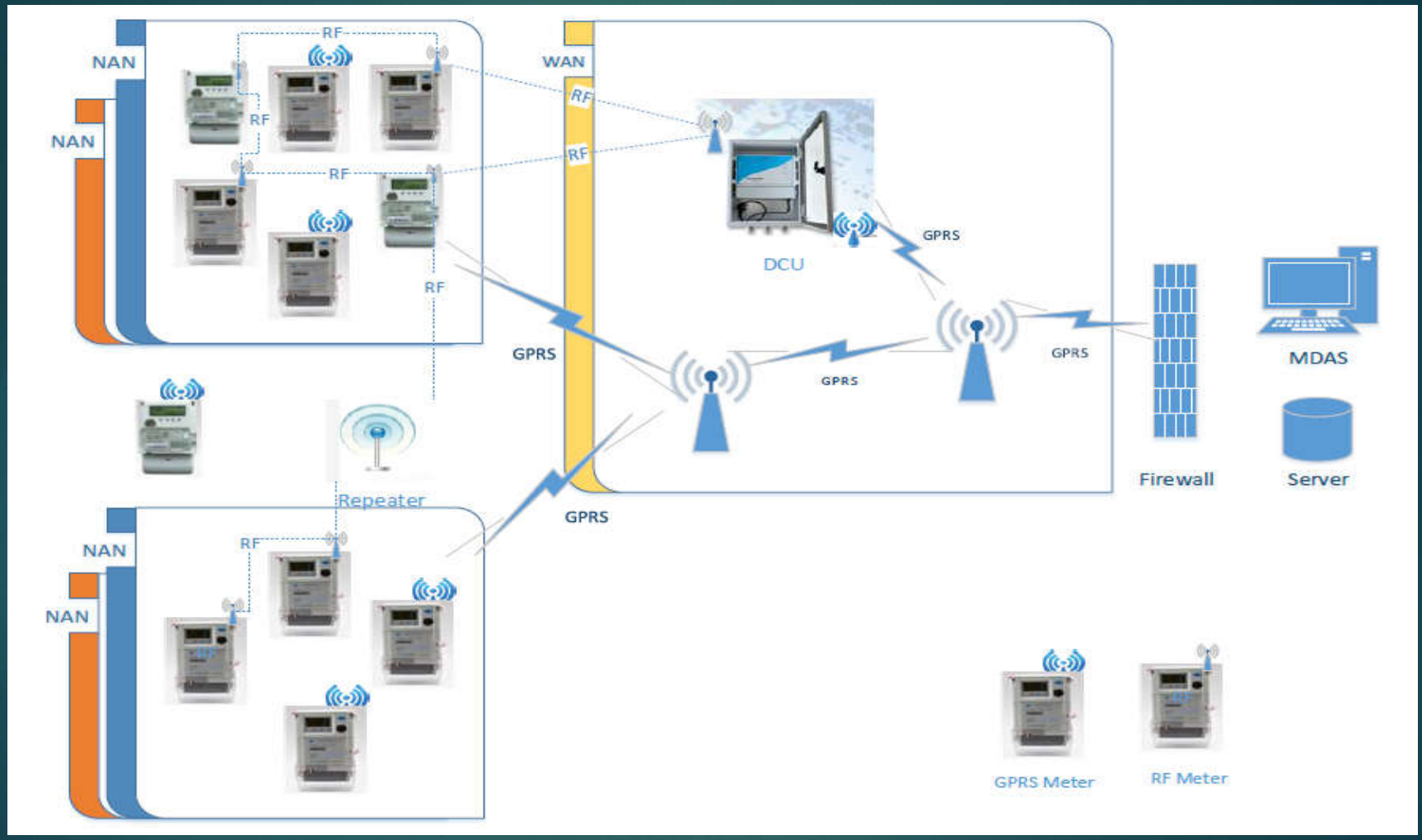
Solar PV: Challenges

- Getting consent of the house owner…had to explain the benefits
- Getting environmental clearance to cut or trim trees surrounding the panels
- Uneven or irregular rooftop…had to customize the mounting structure
- The rooftops are specially treated for heat and rain in IITK campus…concrete blocks were used to avoid drilling on the rooftops.
- During light load in the campus, the grid voltage at the houses are typically higher than usual…the range of operating voltage of the inverters had to be adjusted

Advanced Metering Infrastructure

- Smart meters (1 phase, 3 phase)
  - IS 15959 certified and IS 16444 compliance
  - Net metering, trivector, tamper-proof, remote connect/disconnect
  - GSM/WiFi/Ethernet connectivity
- Smart meter network
  - RF/Ethernet network
  - DCUs communicate to smart meters through RF
  - Ethernet communication between DCU and server
- Meter data management system (MDMS)
- Integration of MDMS with SCADA
- IT infrastructure for the MDMS

AMI implementation



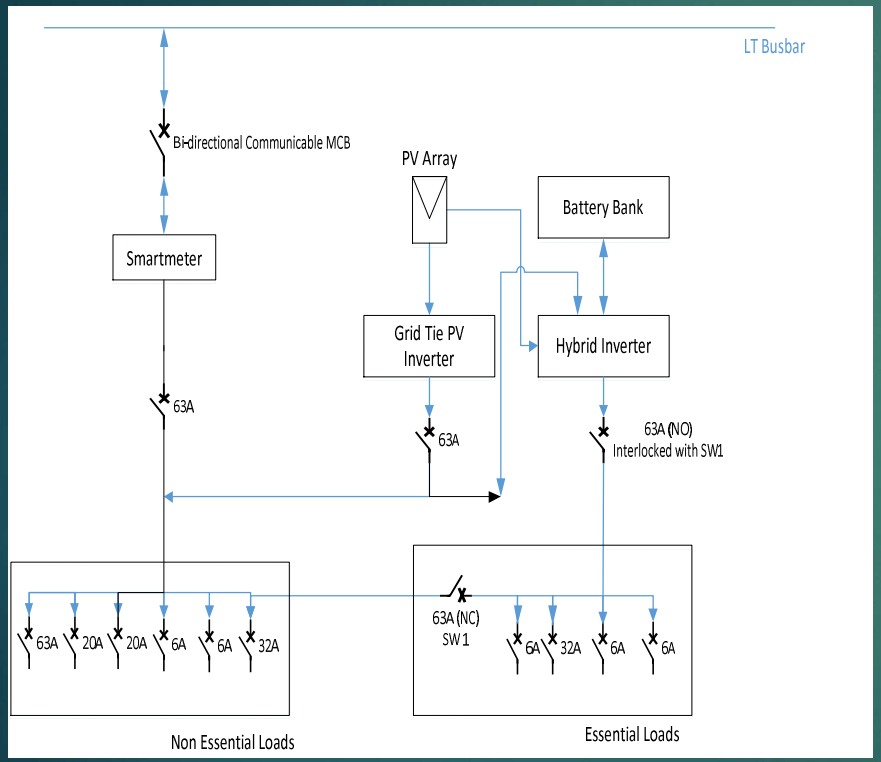
Smart home

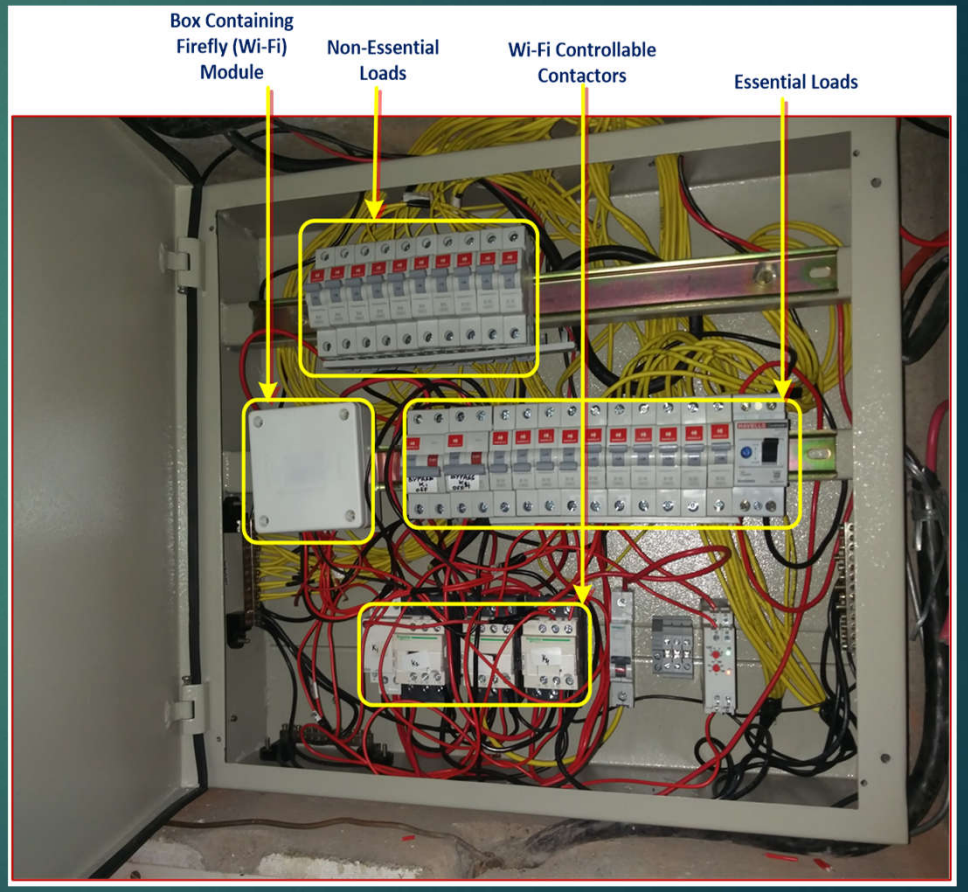
- Home Area Network
  - Wifi/Zigbee/Z-wave based network within house
  - Sensors for monitoring and control
  - Smart lighting and cooling system
  - Remotely controllable electrical appliances
- Central controller of smart home
  - Run energy efficiency applications
  - Facility to do peak load clipping
  - To provide real time energy usage details

System Integration (SI) & Home Automation (HA)

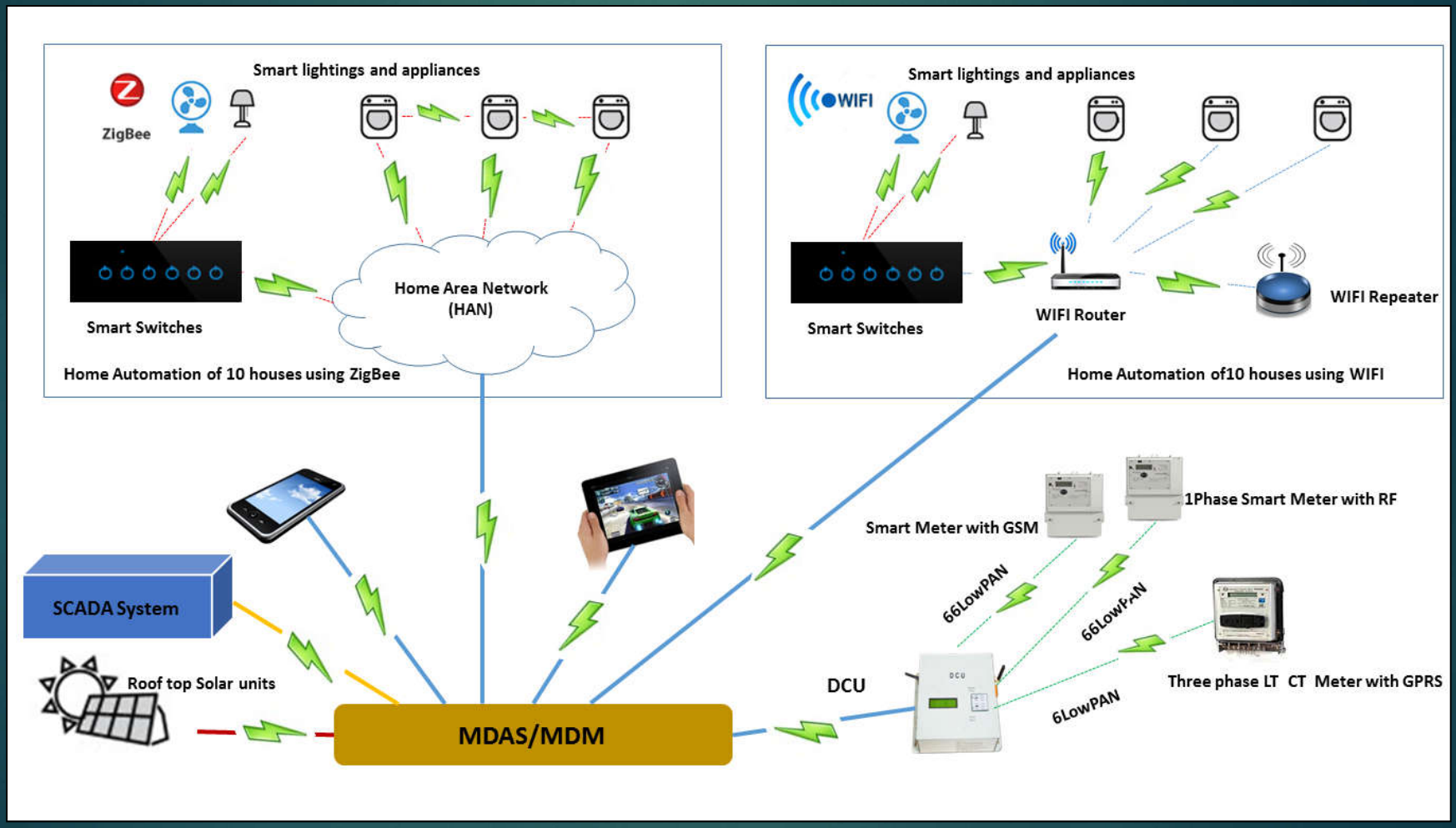
- SI software installed in control centre: integrates data coming from SCADA, AMI, HA, and solar inverters
- Functionalities: meter data management, automated billing, peak load management, and demand response
- HA communication technologies: wi-fi, Zigbee and Z-Wave
- Home appliances are controlled through the SI software or mobile apps.
- Customized distribution boxes (DBs) designed and installed in smart houses
- Non-essential and essential loads are segregated, and controlled through communicable MCBs placed in the DB

Customized distribution box for houses with Hybrid Inverters

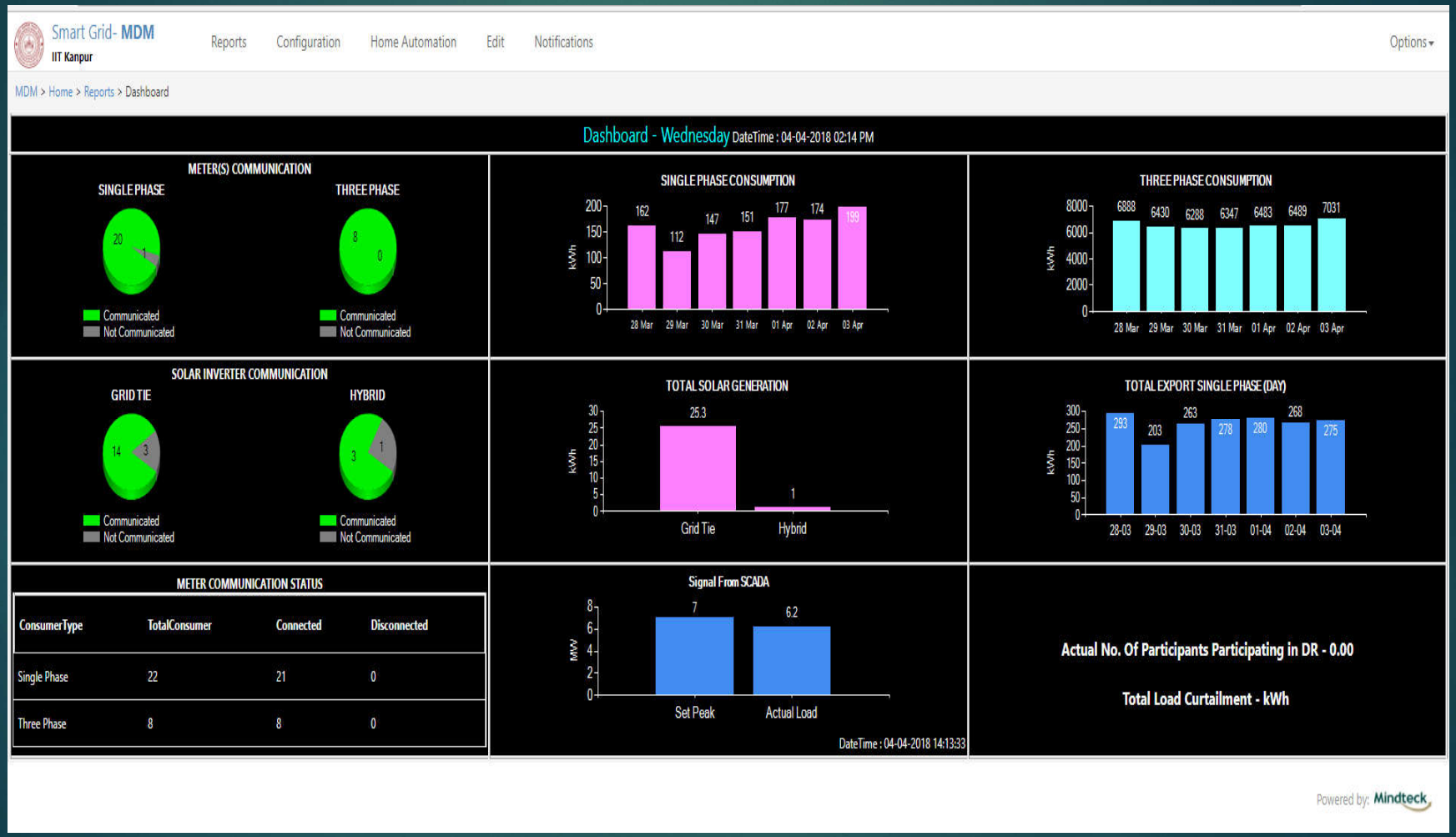




SI scheme


Smart lightings and appliances
ZigBee
Smart Switches
Home Area Network
(HAN)
Home Automation of 10 houses using ZigBee
Smart lightings and appliances
WIFI
Smart Switches
WIFI Router
WIFI Repeater
Home Automation of10 houses using WIFI
SCADA System
Roof top Solar units
MDAS/MDM
DCU
Smart Meter with GSM
1Phase Smart Meter with RF
6LowPAN
6LowPAN
6LowPAN
Three phase LT CT Meter with GPRS

SI software dashboard



Challenges in AMI and SI

- Long que in smart meter certification agency
- Distance between DCU and meter, hindrances such as walls and trees, data loss, were critical concerns
- The locations were changed for some DCUs as they were unable to receive data from the meters. In some cases, signal repeaters were used.
- Access to houses and availability of house owner for installations was the most challenging problem.
  - Schedules prepared several days ahead, and permissions had to be taken from the inmates for these visits.
  - To minimize the duration of interruption, the devices were tested in lab, before installation in the houses.
  - The best solution, of course, was choosing the houses where inmates were yet to shift.

Challenges…contd.

- The SI platform in IIT Kanpur is the first of its kind in the Indian scenario in the sense that four different sub-systems, viz., SCADA, AMI, solar PV, and home automation system, are integrated. The SI vendor had to thoroughly customize its solution in close consultation with the project team in the development, testing, and validation phase of the SI platform.
- Practical implementation of DR scheme is challenging; the consumers had to be made aware of its purpose and importance. The project team is working on creating the required awareness.

Research activities

- Remote monitoring & control applications for smart homes
- Distribution state estimation
- Load forecasting
- Distribution reconfiguration
- Fault detection, isolation, and restoration
- Intelligent billing system
- Demand response management
- Power extraction control from solar PV during grid-connected and off-grid operation

Thank you!