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SMART MICRO-GRID

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Definition of Micro-Grid

Definition given by Micro-grid Exchange Group of Department of Energy, USA:

"Micro-grid is a small energy grid
comprising interconnected loads
and distributed energy resources
(that is, distributed generation + energy storage),
within clearly defined electrical boundaries
and operating as a single controllable entity"

Major Components of Micro-Grid

Essential components of a micro-grid:

1. Power distribution system (PDS)
2. Distributed generation (DG)
3. Flexible or controllable loads
4. Micro-grid control centre (MGCC)

Optional components of a micro-grid:

1. Energy storage (ES)
2. Plug-in electric vehicles

Modes of Operation of Micro-Grid

Basically two modes of operation:

1. Grid-connected mode of operation
2. Isolated or Islanded mode of operation

Stimulants for Micro-Grid

Main factors stimulating the growth of micro-grids:

1. Increase in demand of energy
2. Reduction in cost of renewable energy generation
3. Increasing concern for environment
4. Complexities of design and operation of micro-grid and interconnection with main grid have been largely addressed.

Micro-Grid Types

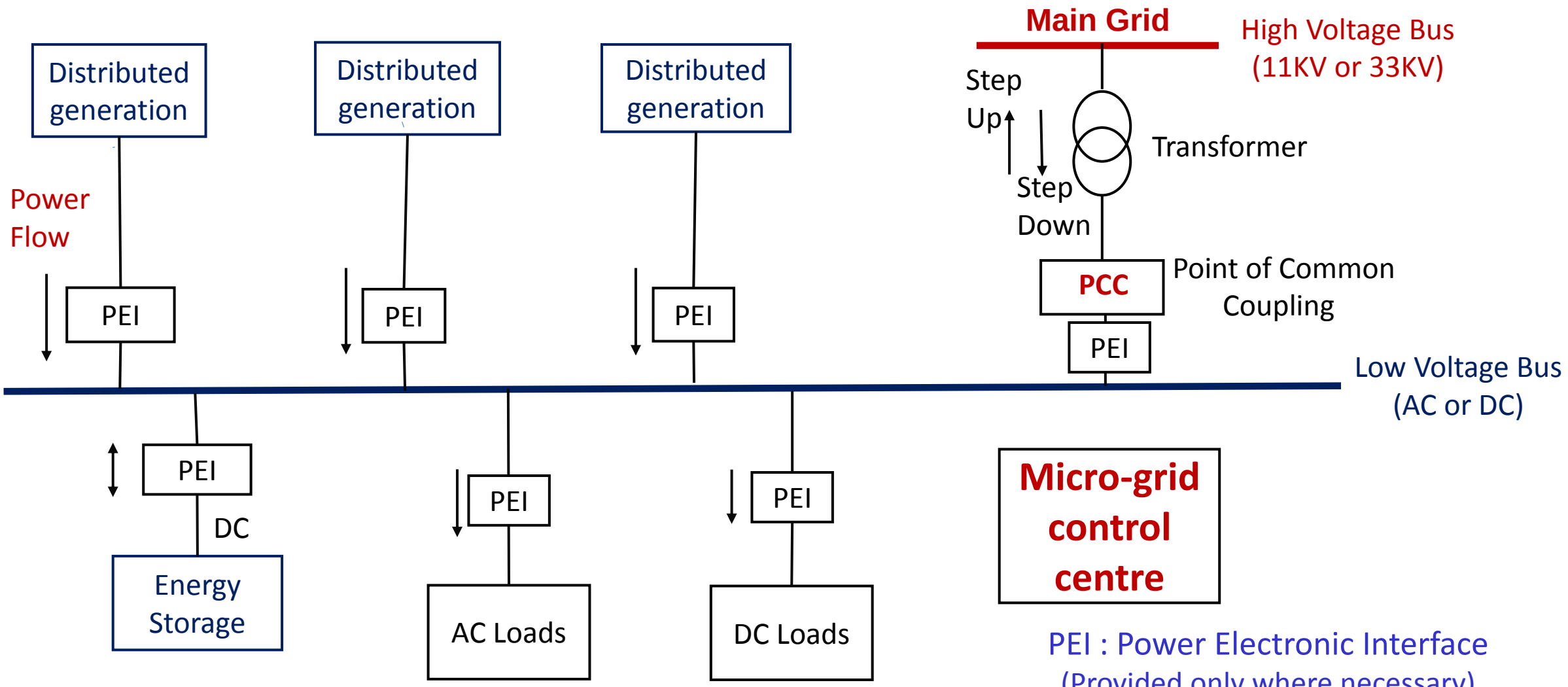
Types based on the power supply bus:

1. AC Micro-Grid
2. DC Micro-Grid
3. AC/DC Hybrid Micro-Grid

Types based on the distributed generation:

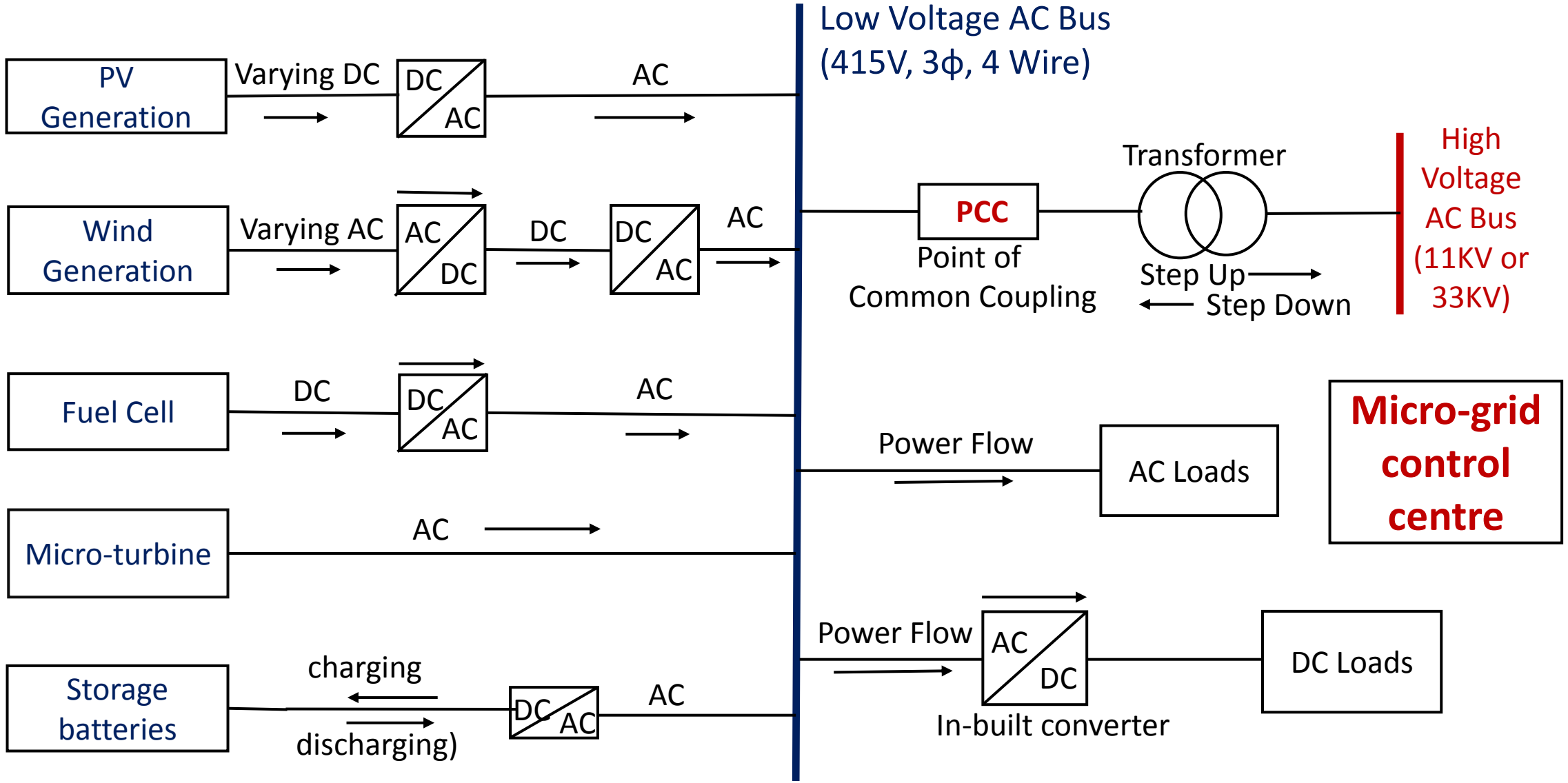
1. Single-DG Micro-Grid
2. Multiple-DG or Hybrid-DG Micro-Grid

General Architecture or Structure of Micro-Grid

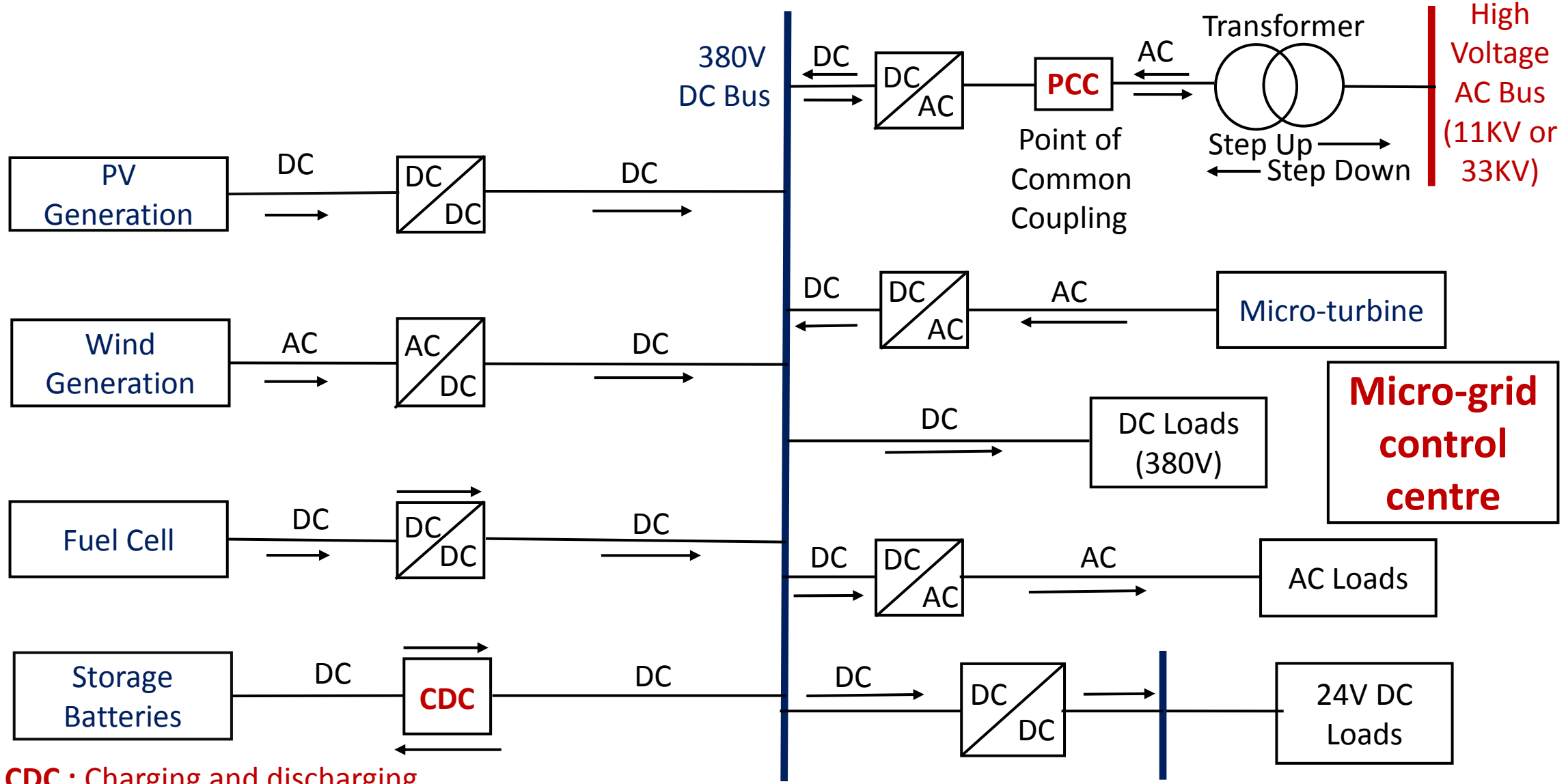


PEI : Power Electronic Interface
(Provided only where necessary)

AC Micro-Grid Architecture

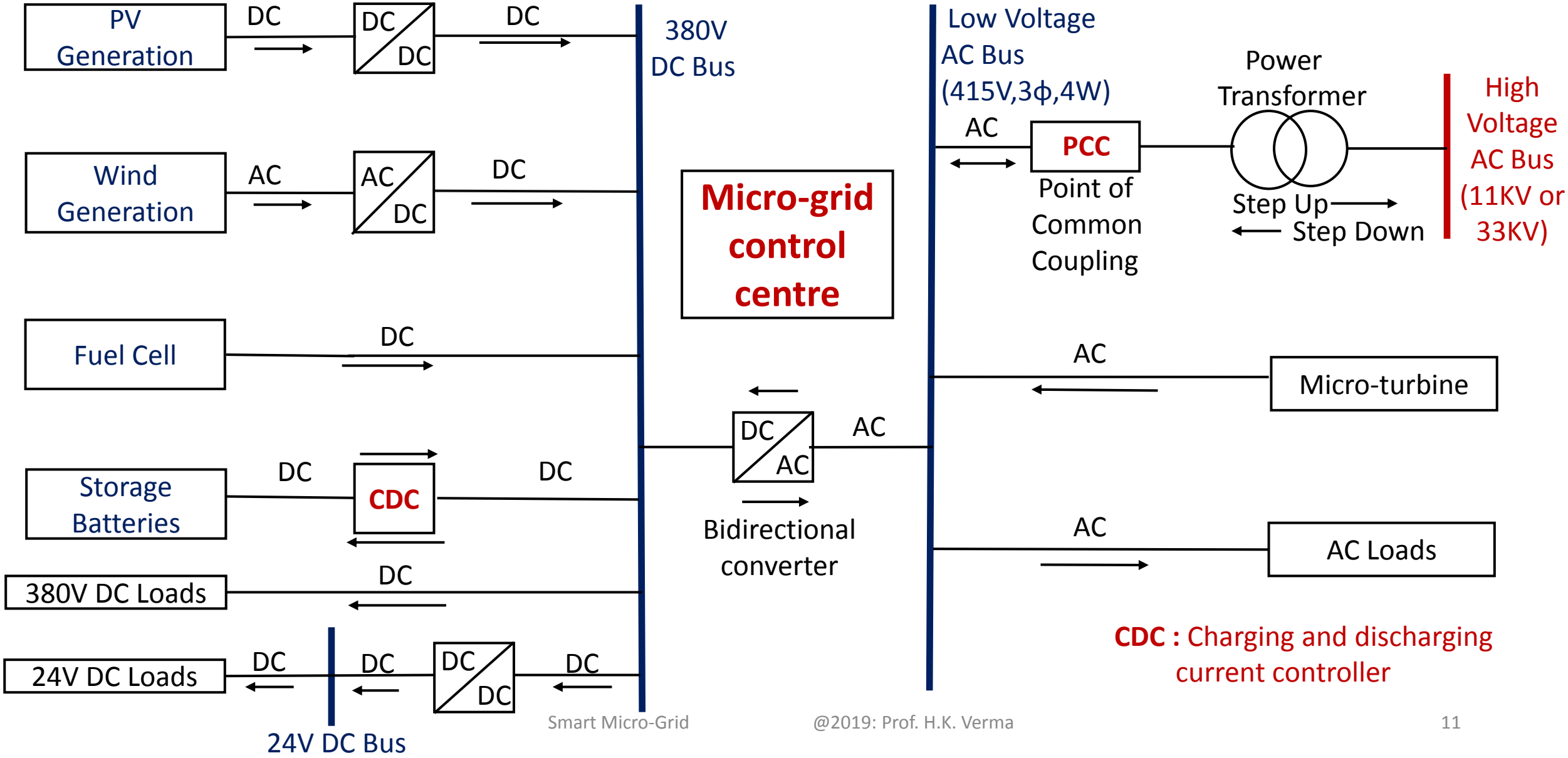


DC Micro-Grid Architecture



CDC : Charging and discharging current controller

AC/DC Hybrid Micro-Grid Architecture



Operation and Control of Micro-Grid

Challenges in Operation and Control of Micro-Grid (1)

Operation & control of micro-grid is more challenging than that of main grid for following reasons:

1. Two modes of operation (against a single mode of operation of main grid)
2. Different control strategies need to be implement in two modes of operation:

(a) Grid-connected mode

- If there is a short-fall of generation, then import power from main grid
- If generation is surplus, then export power to main grid

(b) Islanded mode

- If generation is surplus, then store surplus power
- If no storage or insufficient storage, then reduce generation
- If there is a short-fall of generation, then take power from storage
- If stored energy is not sufficient, then reduce the load.

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Challenges in Operation and Control of Micro-Grid (2)

3. Distributed generation is obtained from renewable sources:
   - Generation is intermittent, not continuous
   - Generation keeps on varying
   - Generation is partially controllable

4. Spinning reserves are much limited:
   - Real spinning reserve: Storage batteries
   - Virtual spinning reserve: Flexible loads

Three-Level Control

Complete control and automation of a micro-grid can be split into three hierarchical levels:

1. Primary or Local Control
2. Secondary or Centralized or Global Control
3. Tertiary or Optimization Control.

"A micro-grid provided with centralized control, by using computers and communication network, is considered as a **Smart Micro-Grid"**

Primary or Local Control

1. Strategy: Local controls by individual controllers (converters)
2. Controls are based on local measurements
3. Communications not required
4. Objectives: Power-flow control, voltage control , frequency synchronization
5. PV Generation: Controls performed by inverter:
   - Frequency control
   - Voltage control
   - Maximum power point tracking (MPPT)
6. Wind Generation: Controls performed by converters:
   - Voltage control (AC-DC converter)
   - Frequency synchronization (DC-AC converter)
7. Storage Battery: Controls performed by bidirectional converter:
   - Charging current control
   - Discharging current control

Secondary or Central Control

1. Strategy: Microgrid is treated as a single system
2. Control is based on the system-wide measurements
3. Communication Requirements
   - Two way communication is essential
   - It should be fast
   - It should be reliable
4. Objectives:
   - Active-power sharing among different distributed generators
   - Reactive-power sharing among different distributed generators
   - Supply voltage regulation
   - Power quality control
5. Control Technique : SCADA

Tertiary Control or Optimization

Two optimization strategies have been suggested:

1. Economic optimization alone
   - Strategy: minimization of the cost of energy
   - Consider dynamic pricing of electricity and accordingly carry out demand response.
2. Multi-objective optimization
   - Strategy: minimization of a multi-objective cost function
   - The cost -function may include:
     - Micro-grid construction cost
     - Operational costs of distributed generators
     - Start-up and shut-down costs of distributed generators
     - Costs of interrupted loads
   - May also include minimization of gas emissions.

Application Areas of Micro-Grid (1)

1. Private organizations
   - ➢ Industrial and commercial organizations
   - ➢Privately owned
   - ➢Microgrid is operated by facility managers
   - ➢Limited interaction with utility
   - ➢ Focus on economic and reliable power
2. Government organizations
   - ➢ Microgrid operates closely in parallel with main grid

   (a) City or municipal micro-grid
   - Usually works as a driver of SMART CITY vision
   - Focus on economic and reliable power

   (b) Military-base micro-grid
   - Focus on reliability and safety

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Application Areas of Micro-Grid (2)

3. Electric utilities
   - Vertically integrated with utility's distribution system and customer-base
   - Focus on service quality and power quality
4. Educational institutes
   - Called campus micro-grid
   - Focus on
     - "Economic and reliable power" and/or
     - "Innovation and research in smart grid technologies / microgrid"
5. Remote village or village-cluster
   - Where main-grid connectivity is not viable
   - Ownership may be with village community / Village Panchayat / utility
   - Focus on electrification of remote / rural areas

Major Benefits of Micro-Grid

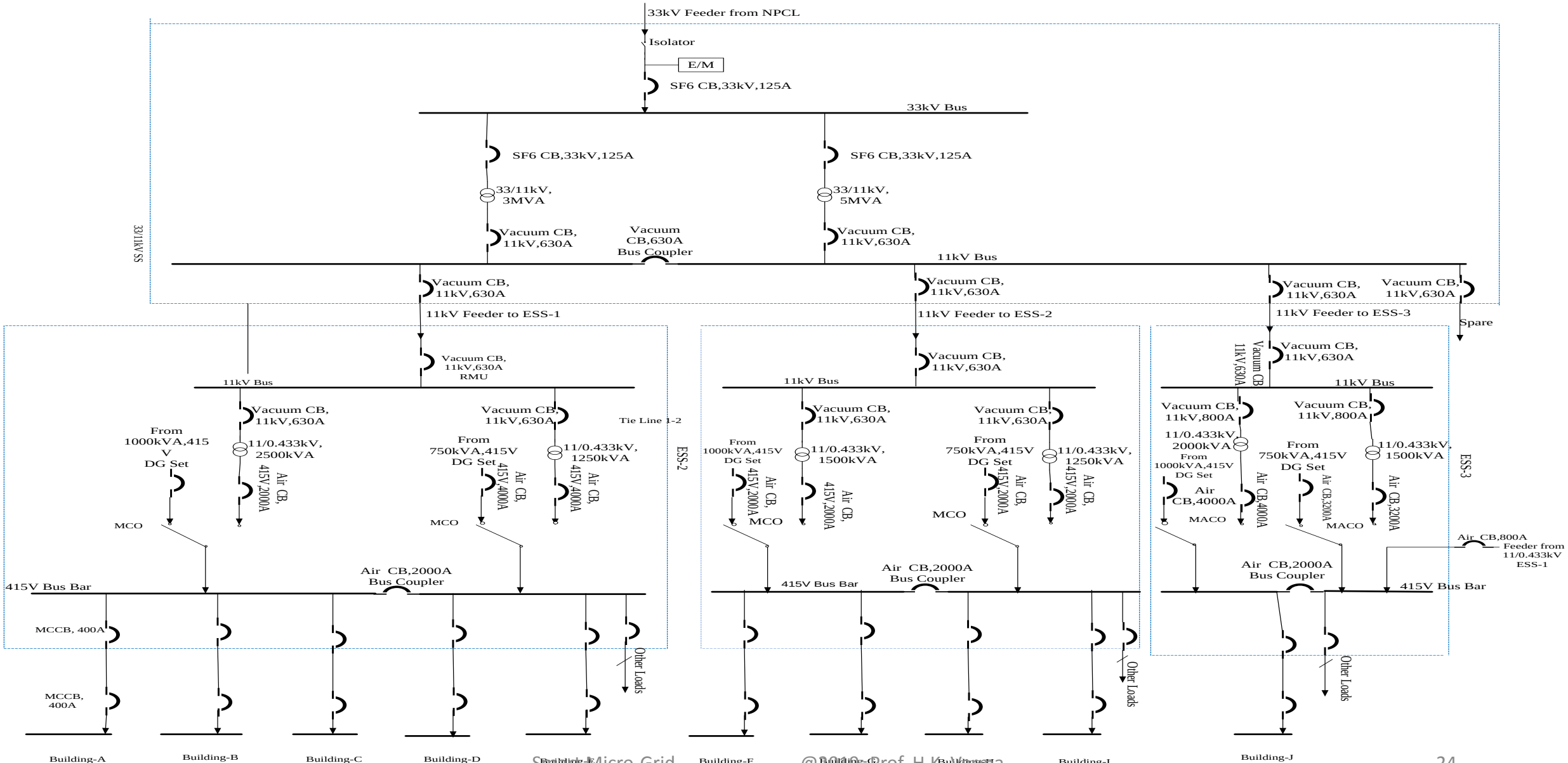
1. Enables smart grid implementation.
2. Promotes distributed renewable energy generation.
3. Enhances energy security because of local and distributed generation.
4. Improves voltage regulation because of local and distributed generation.
5. Enhances energy efficiency of supply system by eliminating transmission losses and minimizing distribution losses.
6. Enables supply-load optimization.
7. Supports main grid by providing power generation.
8. Enables electrification in rural and remote areas.

Case Study:
A Campus Micro-Grid

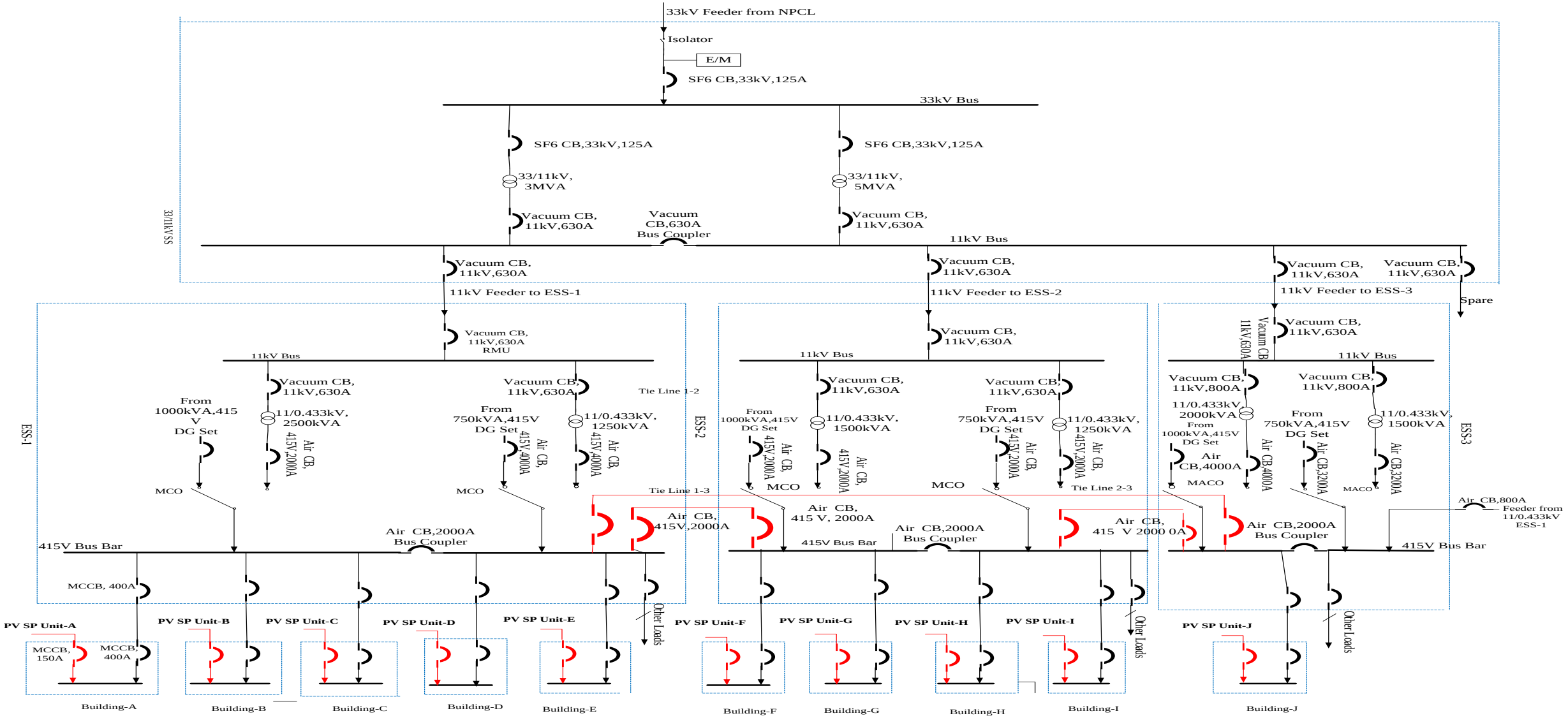
Upgradation of Campus PDS to Smart Campus Micro-Grid

1. Add renewable distributed generation (DG): (Distributed roof-top PV solar power plant)
2. Integrate the distributed PV solar power plant with PDS at major load points
3. Add inter-substation links
4. Add SCADA system for centralized control of Campus Micro-Grid from control station
5. Add advanced metering infrastructure (AMI) for acquiring meter data in control station
6. Develop and install software modules.

Campus Power Distribution System

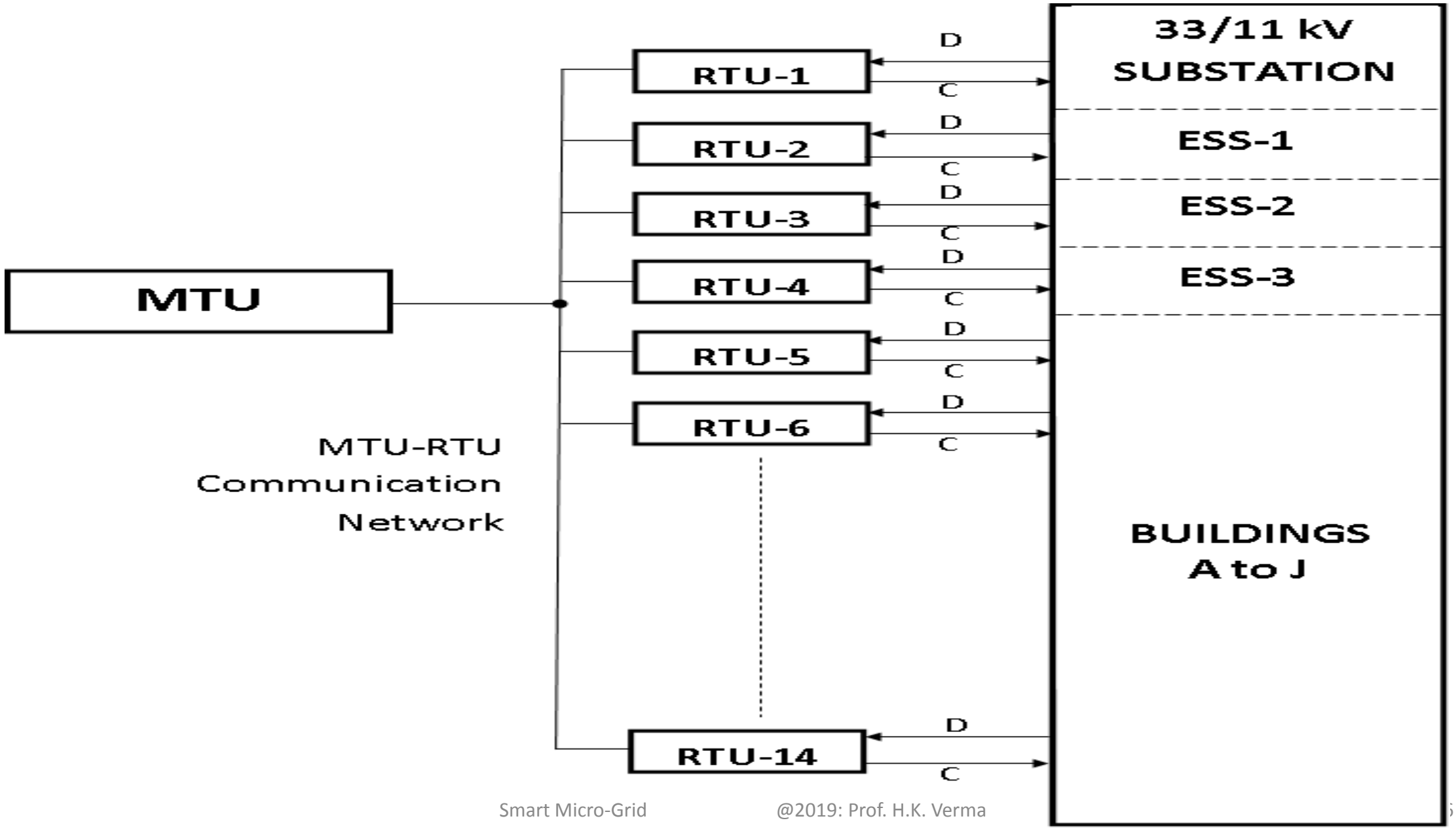


Micro-Grid : PDS with Distributed Generation and Tie-Lines

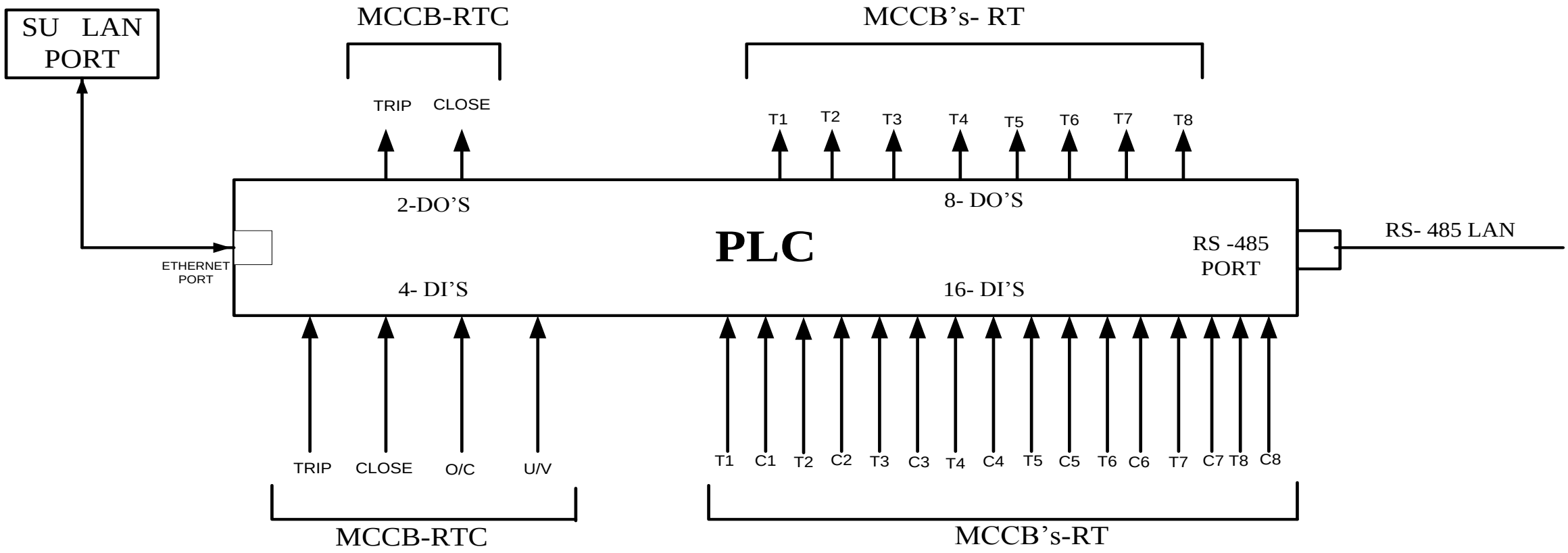


LEGEND-
MCO: Manual Change Over Switch, 1000A
MACO: Both Manual & Auto Change Over Switch, 1000A

Layout of SCADA System for Smart Micro-Grid



Remote Terminal Unit

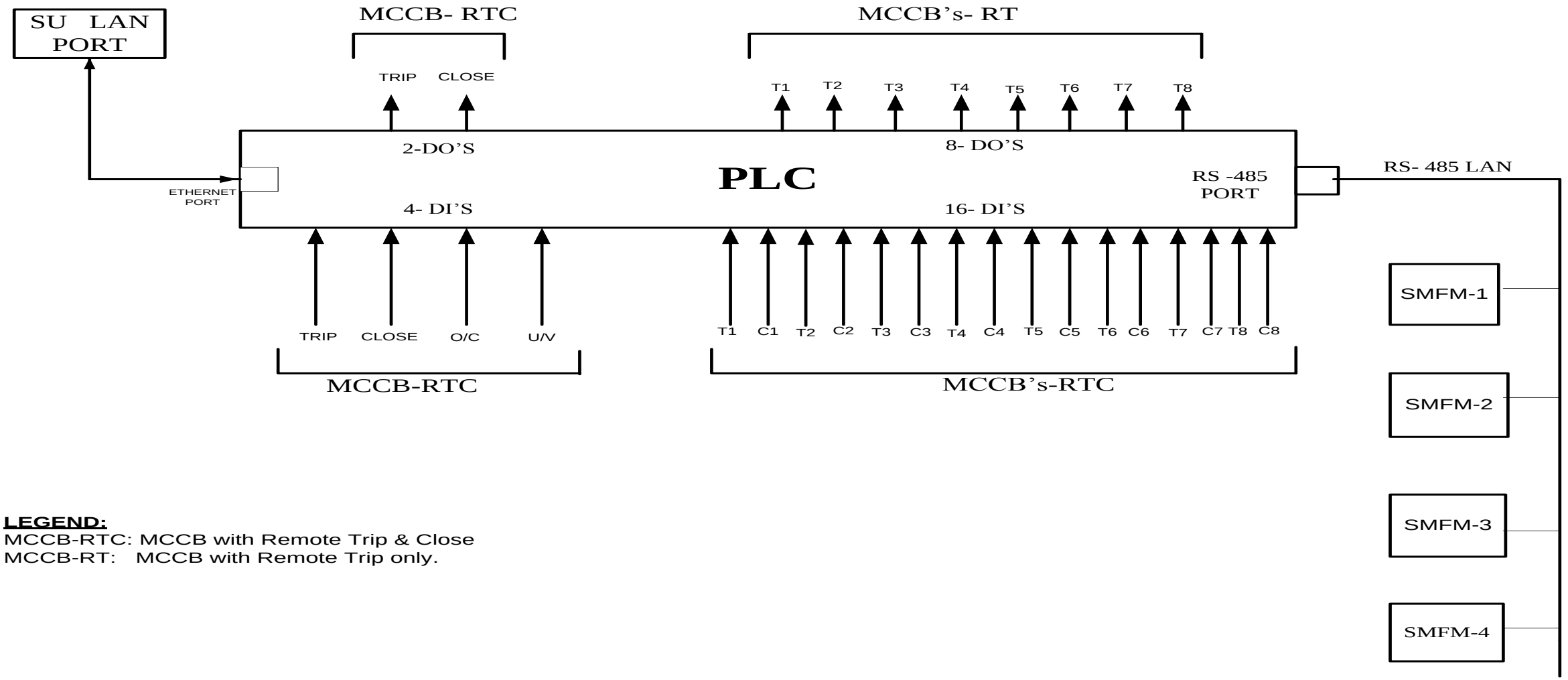


Legend

MCCB-RTC: MCCB with Remote Trip & Close.

MCCB-RT: MCCB with Remote Trip only.

RS485 LAN for Advanced Metering



LEGEND:
MCCB-RTC: MCCB with Remote Trip & Close
MCCB-RT: MCCB with Remote Trip only.

Software Modules

RTU software:

PLC ladder program for data acquisition, control and data transmission

MTU software modules :

1. HMI screens
2. Communication
3. Operation and control
4. Data collection and storage
5. Data analysis and trend curves
6. Alerts and alarms
7. Energy management
8. Peak-demand management,
9. Outage management
10. Report generation

Some Screen Shots of the Operation of SCADA System of Smart Campus Micro-Grid


SCADA
SHARDA UNIVERSITY
Beyond Boundaries
SHARDA UNIVERSITY SMART MICRO-GRID
Energy Management - SCADA System
Overview of Campus Micro-Grid
SCADA System
Data Acquisition & Monitoring
Operation & Control
Energy Management
Peak Demand Management
Report Generation
11-04-2018 17:16:08
Current User : rajat
Login
Logout
Exit
Concept and Guidance
Prof. H. K. Verma
Distinguished Professor
and
Ms. Ranjeeta Singh
Assistant Professor
Department of Electrical & Electronics Engineering
Sharda University
Student Contributors
Rajat Singh (2017)
Faizan Kabir (2016)
Gaurav Sharma (2015)
Bimenyimana Theogene (2015)
Display main
Clear
Clear All
17:16
11-04-2018

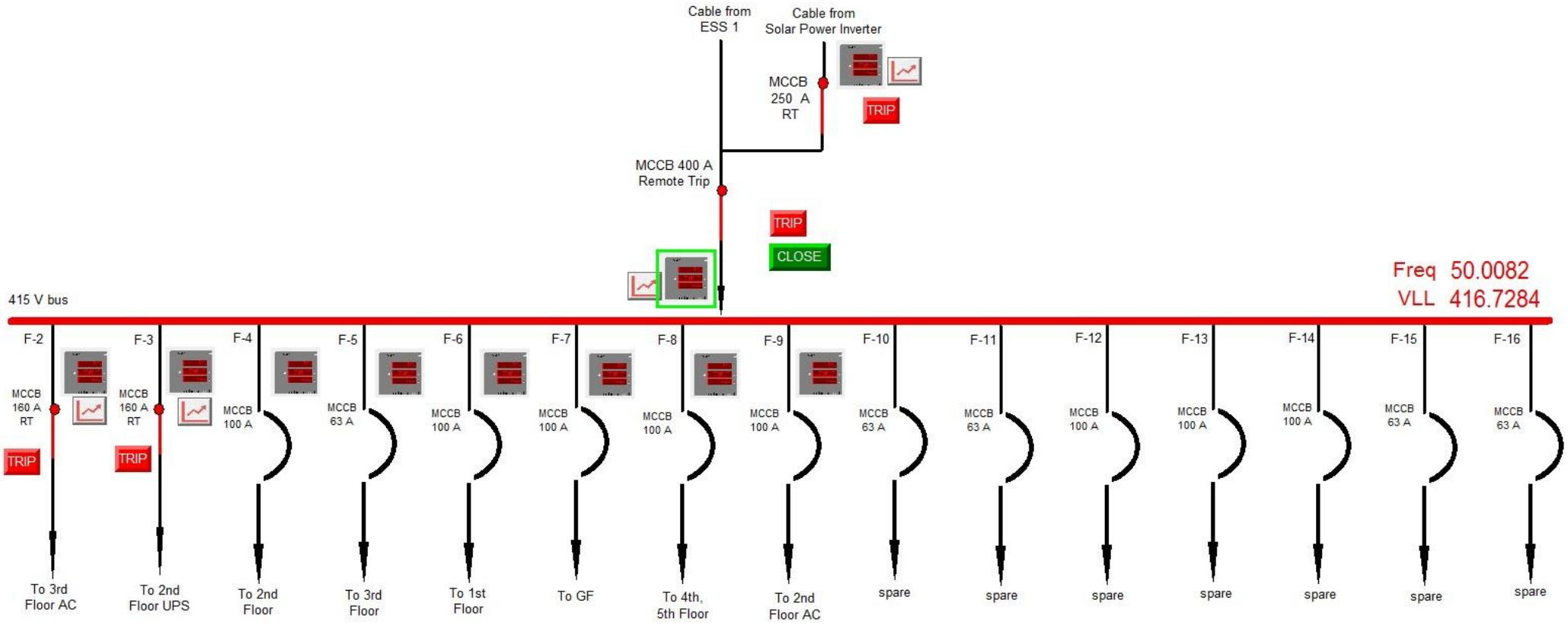
SCADA

Operaion and Control

Block 3 A , Main Distribution Panel (Ground Floor)

11-04-2018 17:21:04

Current User : rajat



Block 3A Schemetic Diagram

Block 3A Trends

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Home

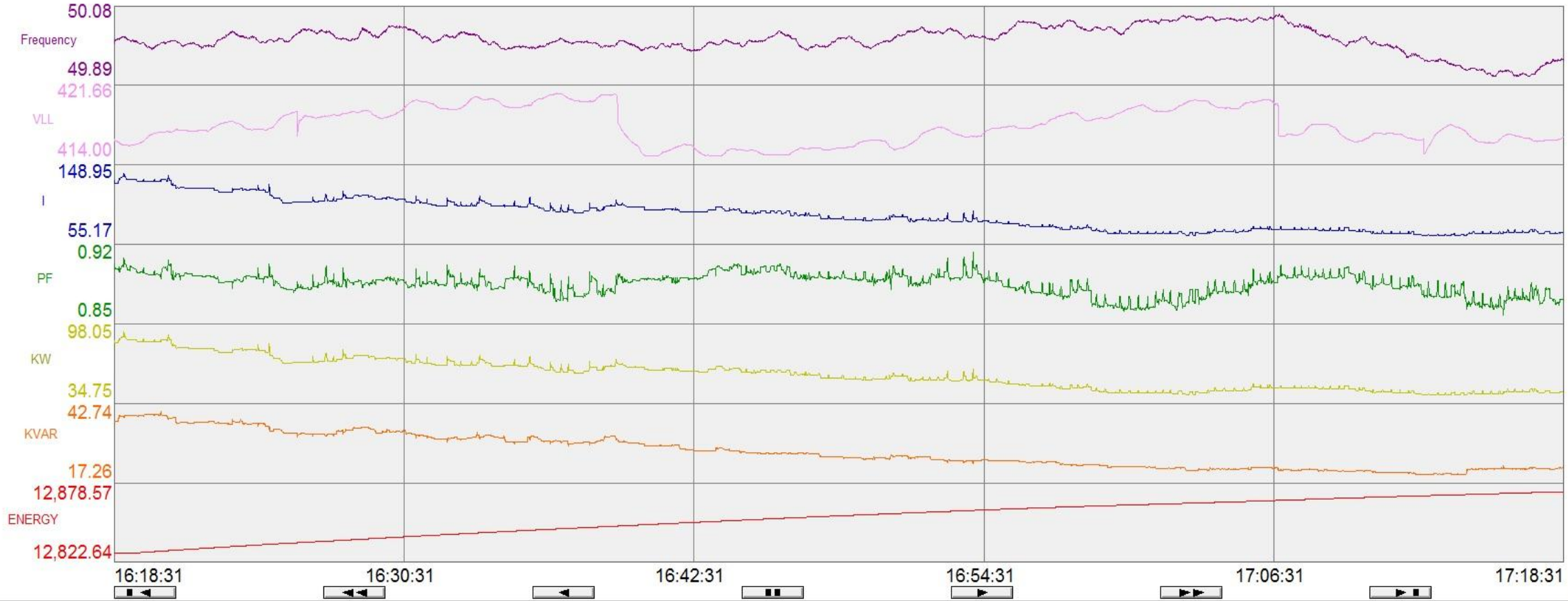
Display "Block 3a OnC"

Clear Clear All

17:21
11-04-2018

SCADA

FEEDER 1 BLOCK 3A 11 April 2018



Caption	Value	Min	Max	Units
Frequency		49.89	50.08	Hz
VLL		414.00	421.66	V
I		55.17	148.95	A
PF		0.85	0.92	
KW		34.75	98.05	KW
KVAR		17.26	42.74	KVAR
ENERGY		12,822.64	12,878.57	Units

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