University of Cyprus
PV Technology

WinPV

Guidelines for the Design of Residential and Community Level Storage Systems Combined with Photovoltaics (PV)

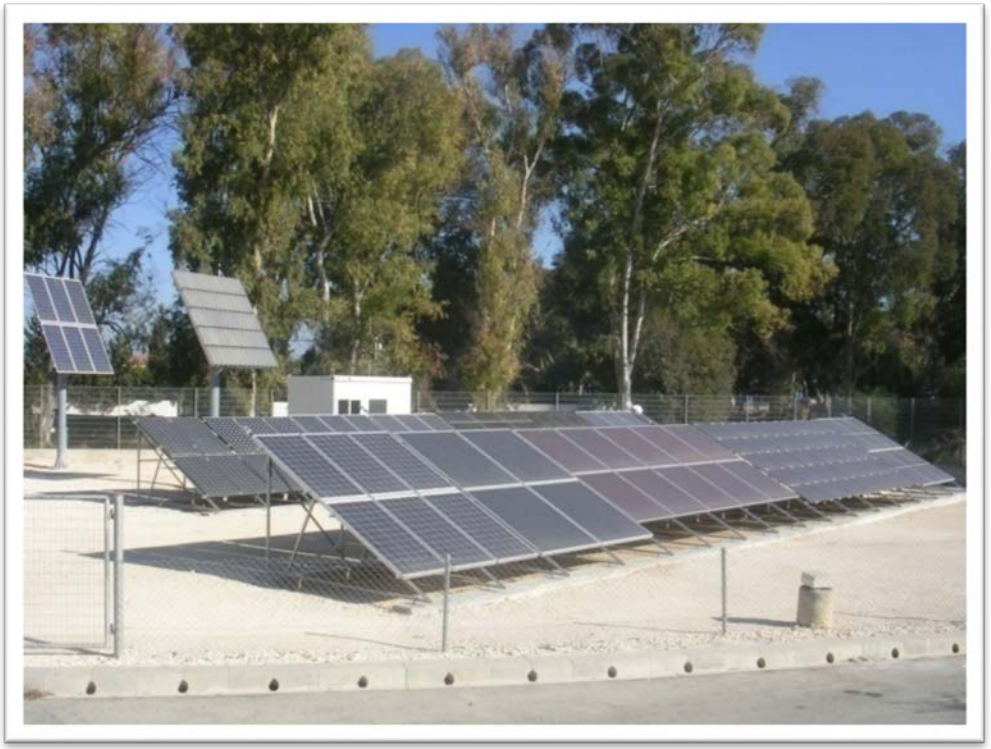
Stavros Afxentis
PV Technology Laboratory

University of Cyprus
PV Technology

WinPV

Outline

- Introduction
- Sizing of Battery Storage Systems
- Storage System Topologies
- Storage System Design
- Conclusions



Introduction

- Low-carbon or even zero-carbon energy generation
- **GREEN** and **RESILIENT** **Energy SYSTEM**
- Higher shares of renewables

- Intermittent nature of PV
- **Control** unobstructed deployment
- **Prevent** distribution grid issues

Introduction

ENERGY STORAGE

- Support operation of the grid
- Provide flexibility to the energy system
- Balance PV intermittency
- Achieve higher PV penetration

University of Cyprus
PV Technology

WinPV

Case Study

University of Cyprus
PV Technology

WinPV

Sizing of Battery Storage System

Typical household

- Annual energy yield of 1600 kWh/kWp
- Installed PV system capacity: 3 kWp
- Expected annual energy consumption of 5000 kWh

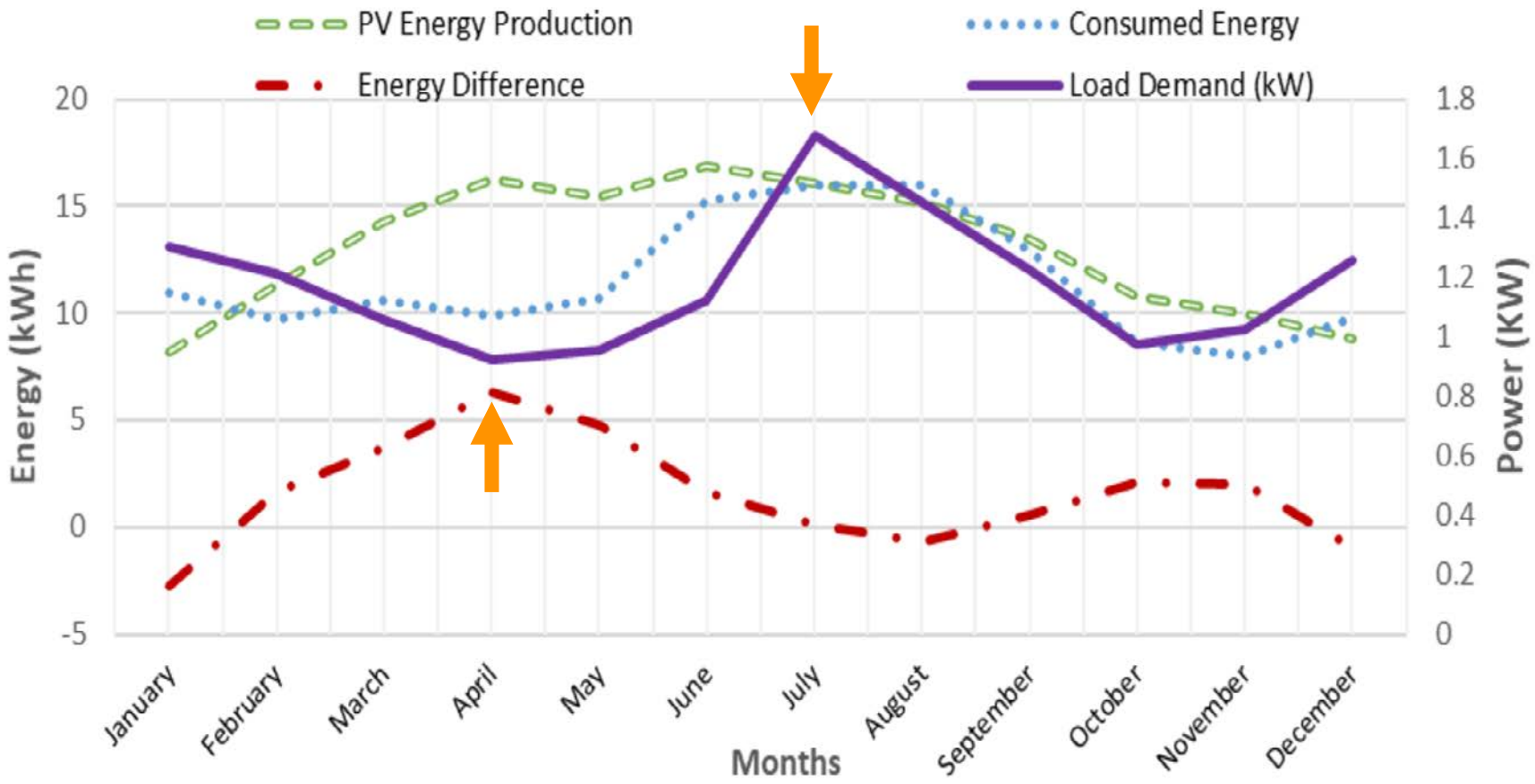
Battery Technology

- Deep cycle Lithium-ion battery

University of Cyprus
PV Technology

WinPV

Sizing of Battery Storage System



University of Cyprus
PV Technology

WinPV

Sizing of Battery Storage System

Residential Storage

- Maximum annual load power: 1.68 kW

Rated converter power: 2.5 kW

- Usable Battery Capacity: 6.4 kWh
- Recommended Battery DoD: 80%

Nominal Battery Capacity: 8 kWh

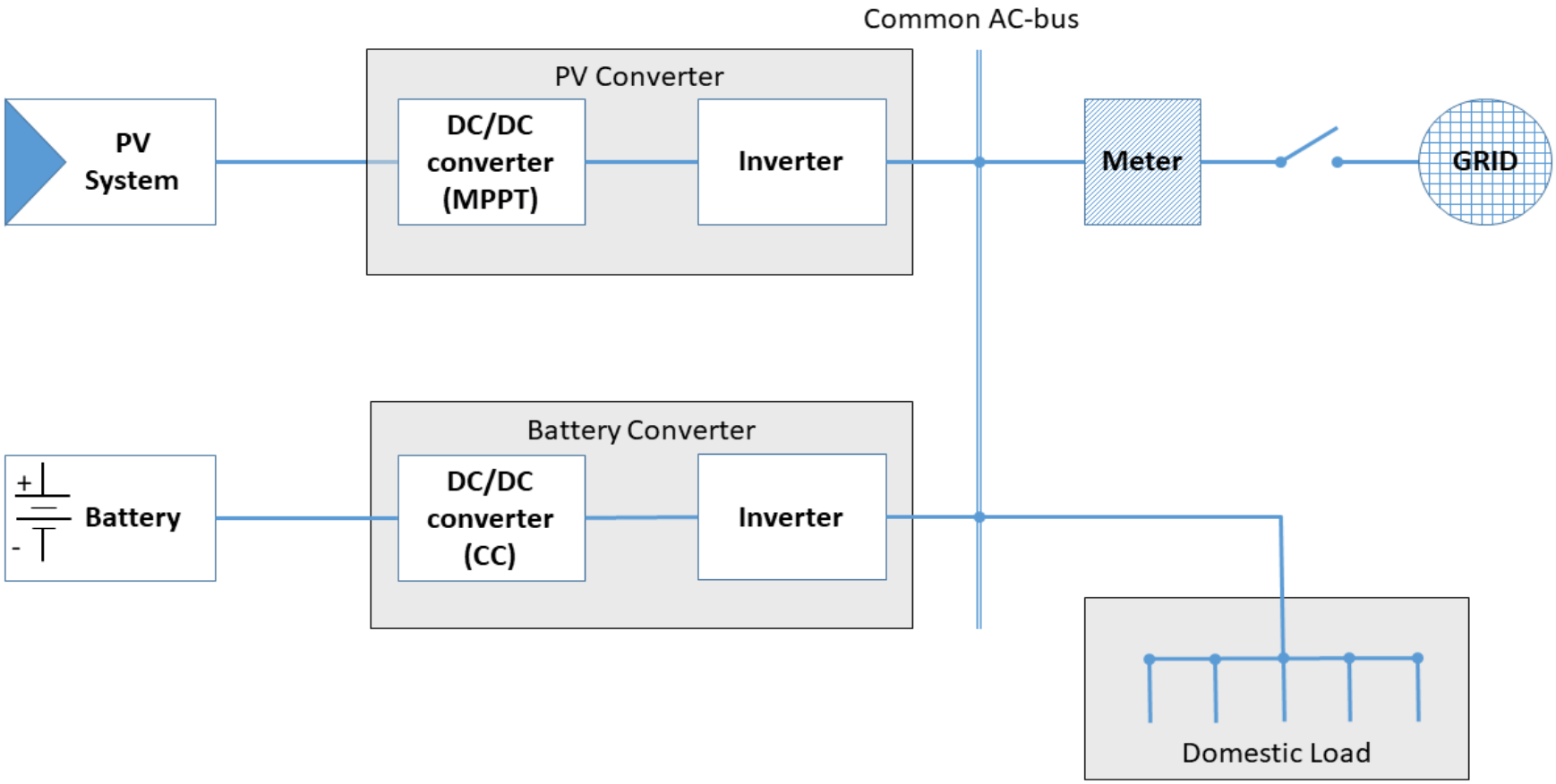
Community Storage

For example
10 Households
Same feeder

Converter power: 25 kW

Battery Capacity: 80 kWh

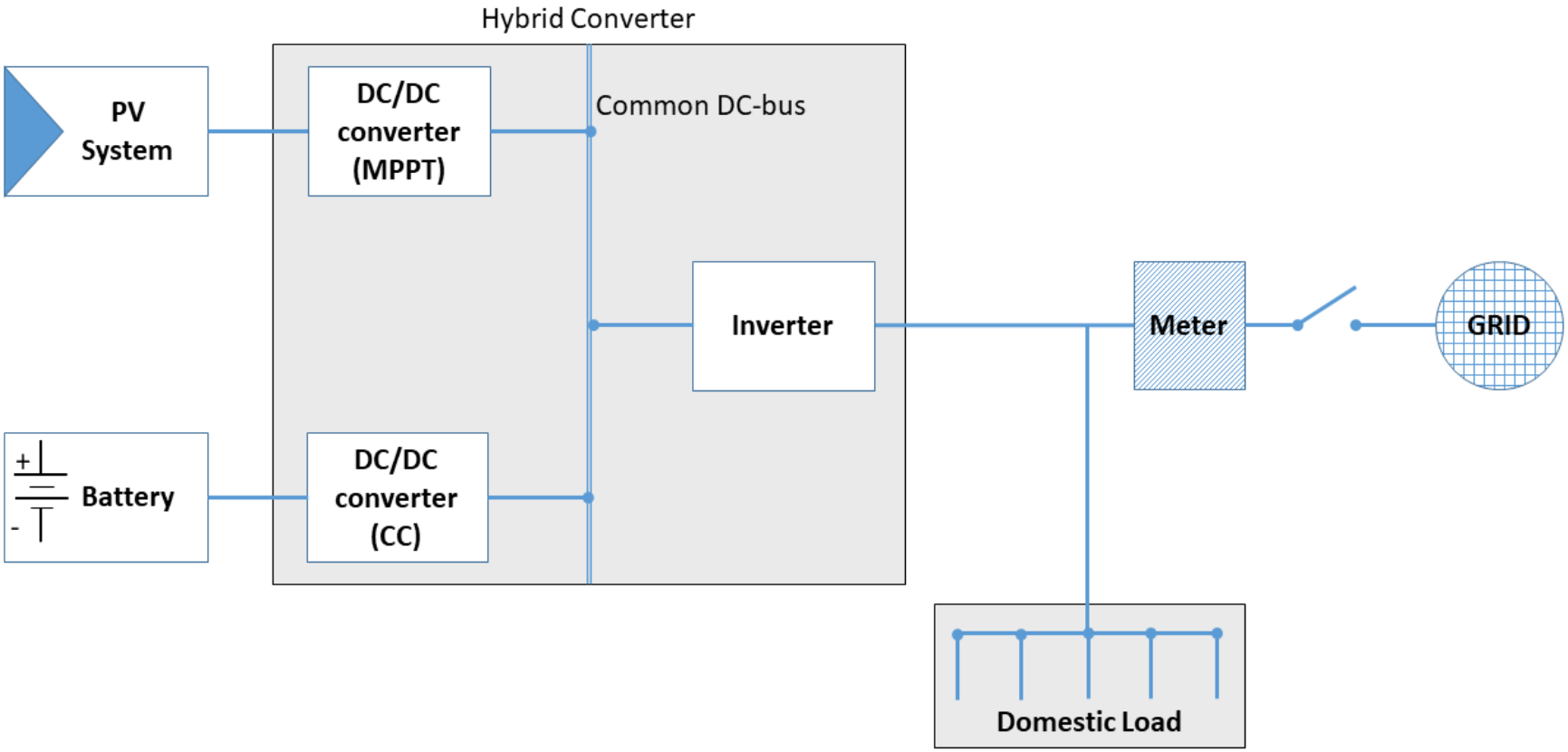
System Configuration – AC Coupled



University of Cyprus
PV Technology

WinPV

System Configuration – DC Coupled



Important Design Parameters

Electrical Parameters

1. **Converter Power:**
   - Maximum power derating of the PCS with ambient temperature (Typical specified ambient temperature is 25^{o}C)
   - Nominal PCS grid power scaled based on load demand
   - Max injected power to grid follow grid codes of each country
   - Withstand required reactive power exchange/active power
   - Nominal PV input at least equal to the max PV array power

Important Design Parameters

Electrical Parameters

2. **Nominal Voltage:**
   - DC Voltage range to handle maximum PV array voltage
   - AC Voltage follow grid codes
   - Allow for short voltage surges/dips
   - Off-grid voltage regulation at least as good as grid regulation

3. **Nominal Frequency:**
   - Follow grid codes
   - Allow frequency support

4. **Total Harmonic Distortion (THD):**
   - Affects power quality
   - Comply with relevant standards

Important Design Parameters

Electrical Parameters

5. **Power Factor:**
   - Adjustable within acceptable limits
   - Important for VAr control

6. **Inverter Design and Peak Efficiency:**
   - Transformer-less or with transformer
   - **Recommended:** Transformer-less – Higher efficiency (>95%)

Important Design Parameters

- Minimum Recommended Power Converter Standards:

Category	Number	Description
EMC	EN61000-3-2	Harmonic current emissions (≤ 16 A per phase).
	EN61000-3-12[b]	Harmonic current emissions (≤ 75 A per phase).
	EN61000-3-3[a]	Voltage changes, fluctuations and flicker (≤ 16 A per phase).
	EN61000-3-11[b]	Voltage changes, fluctuations and flicker (≤ 75 A per phase).
	EN61000-6-1 or EN61000-6-2	Immunity.
	EN61000-6-3 or EN61000-6-4	Emissions.
Electrical Safety	EN50178 [replaced by EN62477-1]	Power electronic converters and equipment.
	EN62109[c]	Power converters for PV systems.

a)Applicable to distributed household systems b)Applicable to centralised systems
c)Only required for PV and Hybrid converters.

Important Design Parameters

- Minimum Recommended Battery Unit Standards:

Category	Number	Description
Battery Safety	IEC62281 or UN/DOT 38.3	Transportation testing for lithium batteries.
	IEC62133 or UL1642	Safety test for lithium batteries.
	EN62619	Safety requirements for secondary lithium cells and batteries.
EMC	EN61000-6-1 or EN61000-6-2	Immunity.
	EN61000-6-3 or EN61000-6-4	Emissions.
Electrical Safety	EN50178 [replaced by EN62477-1]	Power electronic converters and equipment.

Important Design Parameters

Mechanical Parameters

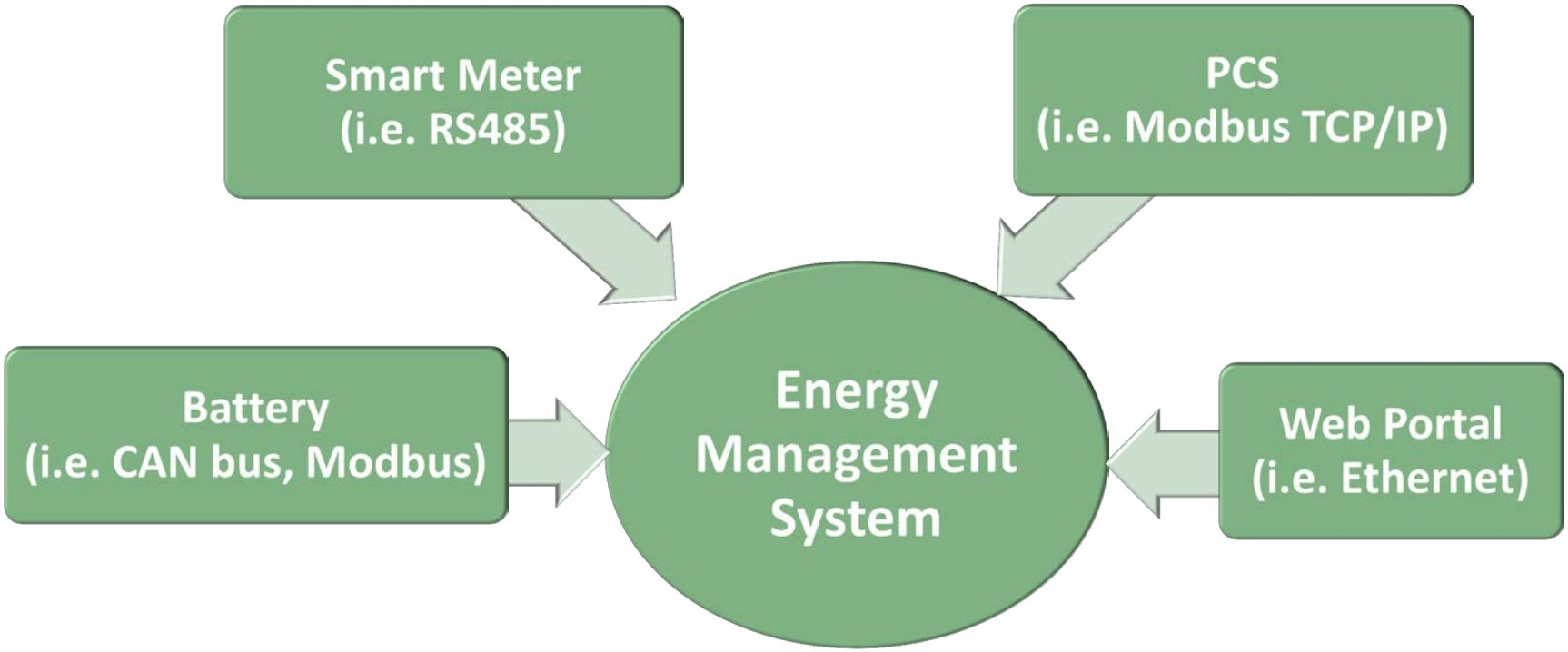
1. **Ingress Protection (IP):**
   - Minimum IP20 indoor use, IP65 outdoor use

2. **Ambient Temperature and Relative Humidity:**
   - Power Converter: -40^{o}C to 50^{o}C , 5% to 95%
   - Battery Unit: 25^{o}C ± 10^{o}C

3. **Cooling:**
   - Natural Convection (Indoor), Forced Air (Outdoor)

4. **Installation:**
   - Proper ventilation, Adequate thermal parameters

Data Acquisition – Residential ESS

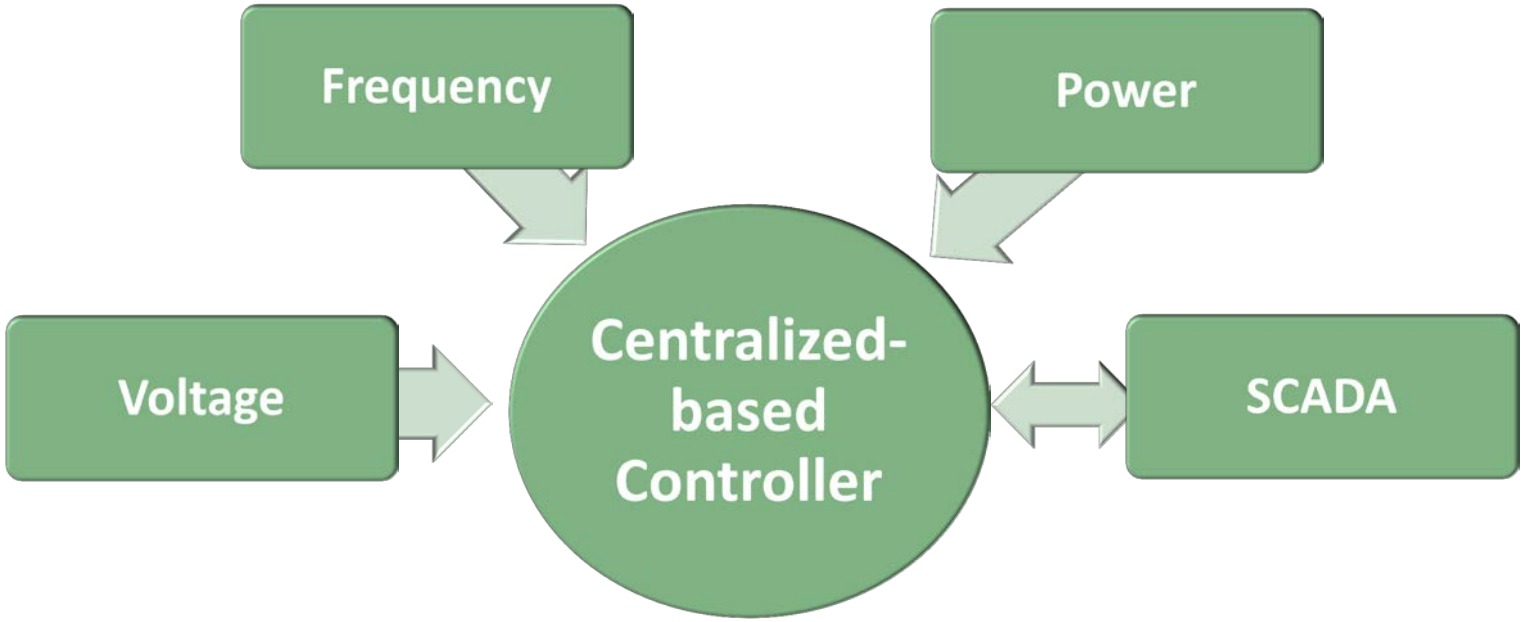


Electrical Sensors – Residential ESS

Smart Meters (SM)

- Measure import and export energy
- Regulate energy flow
- Embedded communication
- Usually equipped with serial communication (i.e. RS485)
- Fast and reliable data transfer over long distances

Data Acquisition – Community ESS



- SCADA or Battery Converter: Voltage, Frequency, Power
- **SCADA recommended for Frequency measurement**
- **SCADA for future communication with the DSO**

University of Cyprus
PV Technology

WinPV

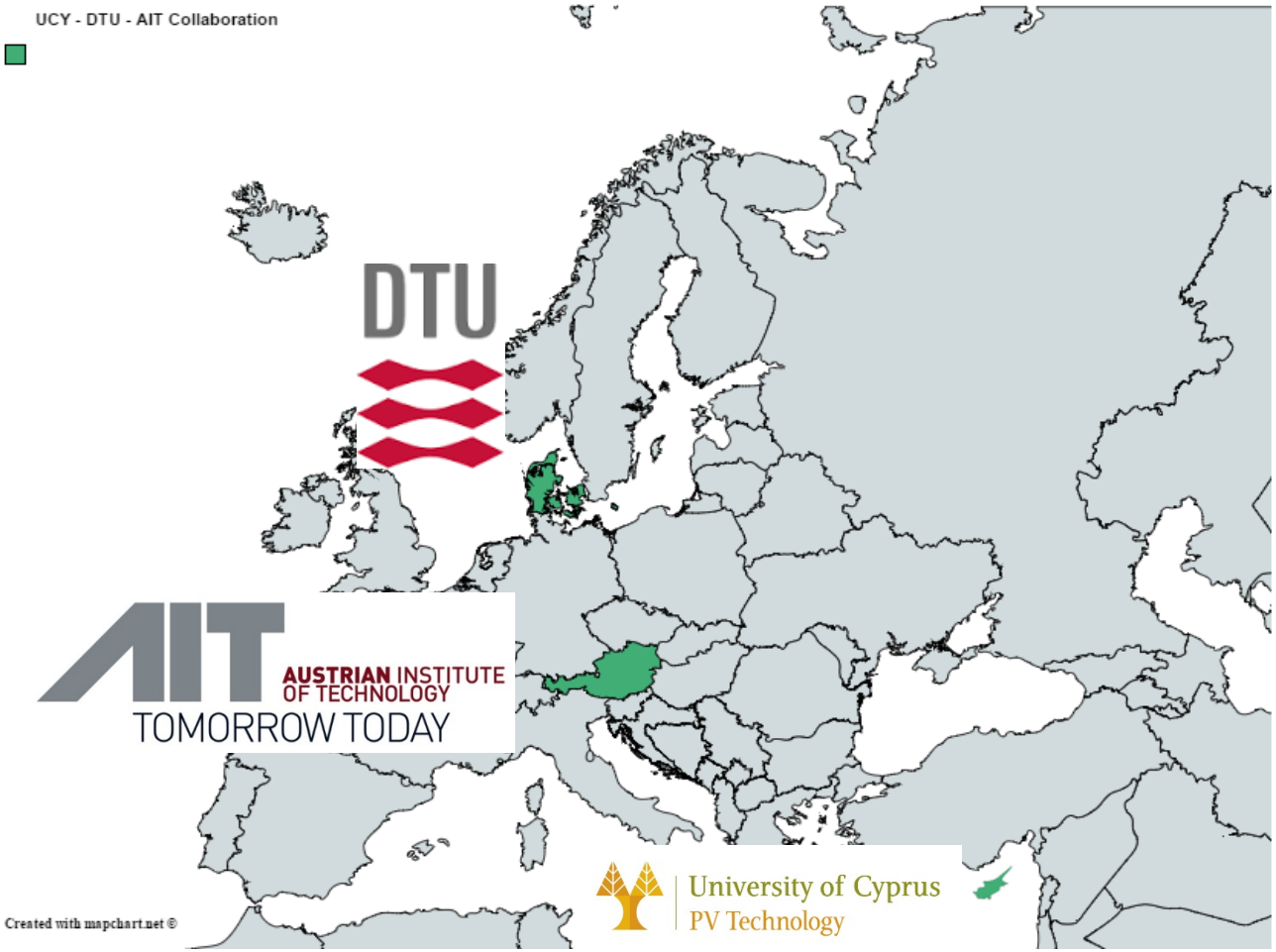
Electrical Sensors – Community ESS

- Distribution feeder voltage
- Grid frequency
- CTs to measure the 3-PH line current (usually analogue output)
- Battery Converter compatible with CTs
- Additional A/D converter may be required

Conclusions

- Methodology for sizing Battery Energy Storage Systems
  - Power Converter Power: 150% of the maximum demand
  - Battery Unit: 80% DoD
  - Strongly depend on the load profile and PV production
- Electrical and Mechanical Parameters
- Electrical Sensors for Data Acquisition
- Communication Protocols (i.e. RS485, web-server, SCADA) for secure transfer and remote supervision

Together we do more for PV and Smart Grids



Team

- 3 countries
- Over 100 Expert Researchers, Trainers
- One stop shop (cells to modules to Grid)
- Training, Testing, Research

Mr. Stavros Afxentis

University of Cyprus
PV Technology Laboratory
FOSS Research Centre for Sustainable Energy
1 University Avenue
New Campus
P.O. 20537
1678, Nicosia

Tel: +357 22-892272
Email: afxentis.stavros@ucy.ac.cy
Website: www.pvtechnology.ucy.ac.cy

Thank you for your attention

Questions?