University of Cyprus Battery Pilot Plan

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Outline

Introduction

- Absence of Energy Storage in Cyprus
  - Not included in the regulations yet
- Cyprus is heavily depended on conventional generation
  - About 90% of final energy comes from imported fossil fuels
- High solar irradiance
  - Increasing PV penetration to the power network in recent years
  - Residential PV systems under Net-Metering (common practise)
- High PV penetration may impose instability issues to the grid
- “Out-dated”, isolated power network
- Conventional power units to stabilise the network’s performance

Need for flexibility → Need for energy storage!

Current status

- First grid-connected Energy Storage Systems in Cyprus.
- Funded by the ERDF and national funds.
- Pilots include:
  - **9 Residential Battery Energy Storage Systems (BESS)**
    - Households in the wider area of Nicosia
  - **1 Laboratory BESS**
    - PV Technology Lab, University of Cyprus
  - **1 Social BESS**
    - Low Voltage Distribution Substation in Nicosia
  - **1 Public BESS**
    - New Nicosia Town Hall

UCY Residential & Laboratory BESS Pilots

- 9 2.5 KW / 9.8 KWh BESS installed
- Existing 3 KWp roof-top PV systems
  & Smart Meters
- System monitoring and data collection through
  manufacturer's online portal

from https://www.sma.de/en/

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University of Cyprus PV Technology

UCY Residential & Laboratory BESS Pilots

- Electricity power data
- In KW, 15-min averaged values, csv file format
  - Household electricity consumption
  - PV system production
  - Grid interaction (power import & export)
  - Storage performance (SoC, charge & discharge)
  - Direct PV consumption

from https://www.sma.de/en/

Interreg Mediterranean StoRES

Interreg Mediterranean Pegasus

Interreg Balkan-Mediterranean PV ESTIA

UCY Residential BESS Pilots

UCY Residential BESS Pilots

LG Chem RESU 10H

Battery **Lithium-ion**

- High Voltage (570 VDC)
- 9.3 kWh Usable Capacity
- Deep Cycle (95% DoD)
- Indoor & Outdoor (IP55)
- Temperature: -10°C to 4
- 10 years warranty

Images taken from https://www.sma.de/en/

SMA Sunny Boy Storage 2.5

Inverter **Bidirectional**

- AC-Coupled System
- 2.5 KW rated power
- Round-trip efficiency 97%
- Support HV batteries
- Indoor &Outdoor (IP65)
- Integrated Web Server

Image taken from https://www.lg.com

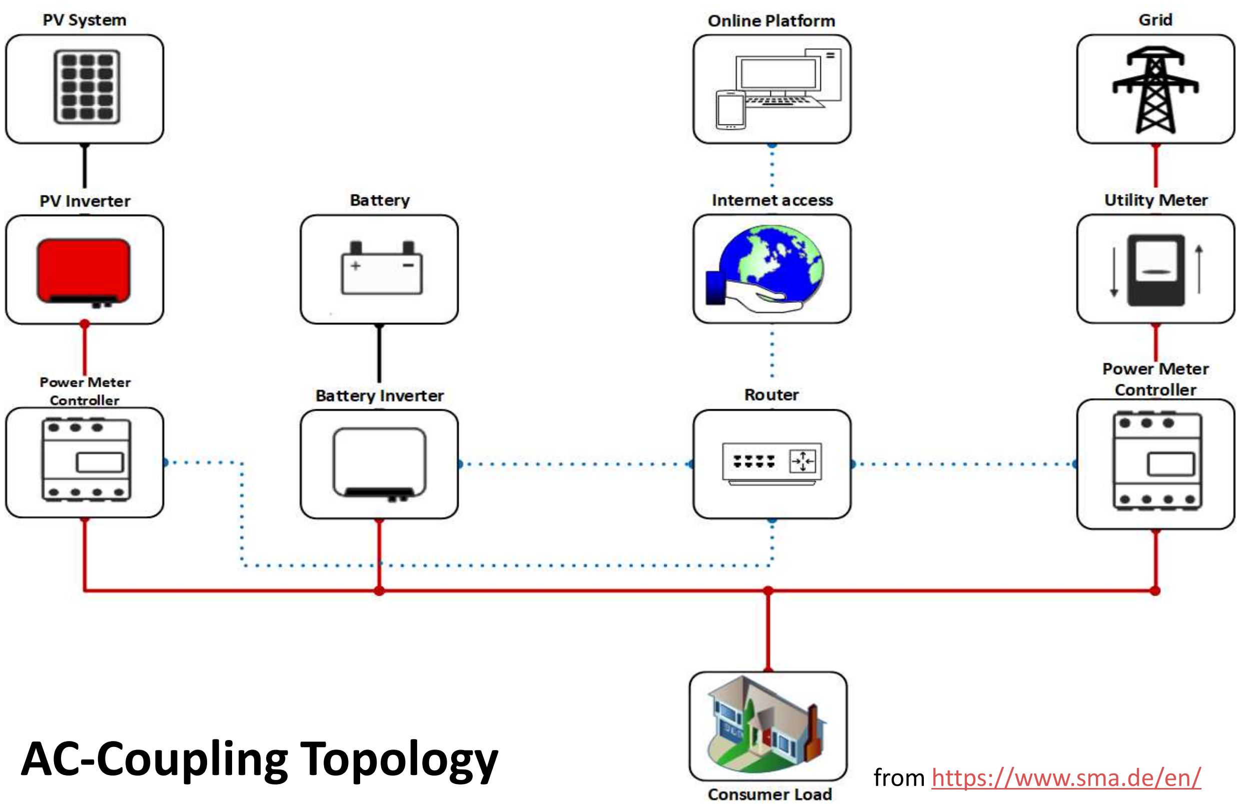
SMA Home Manager

Meters **PV & load meters**

- PV & Battery system monitoring
- External PV generation forecast (weather data and internal forecast)
- Energy consumption of house load
- Energy exchange with the grid
- Optimized battery control

Images taken from https://www.sma.de/en/

UCY Residential BESS Pilots



AC-Coupling Topology

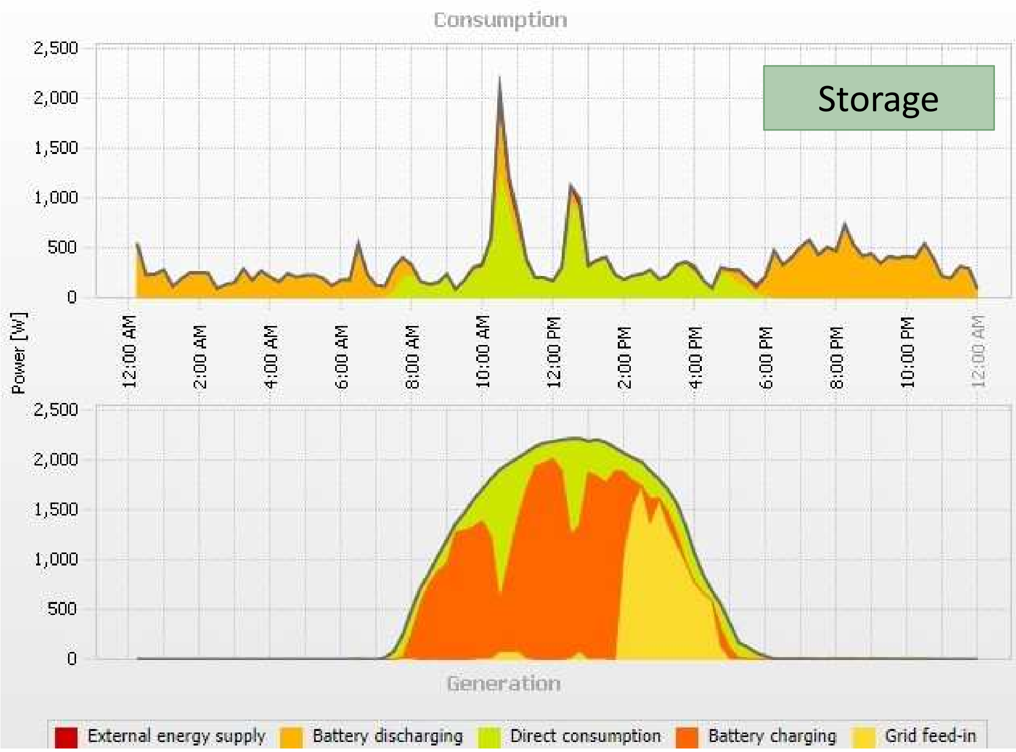
from https://www.sma.de/en/

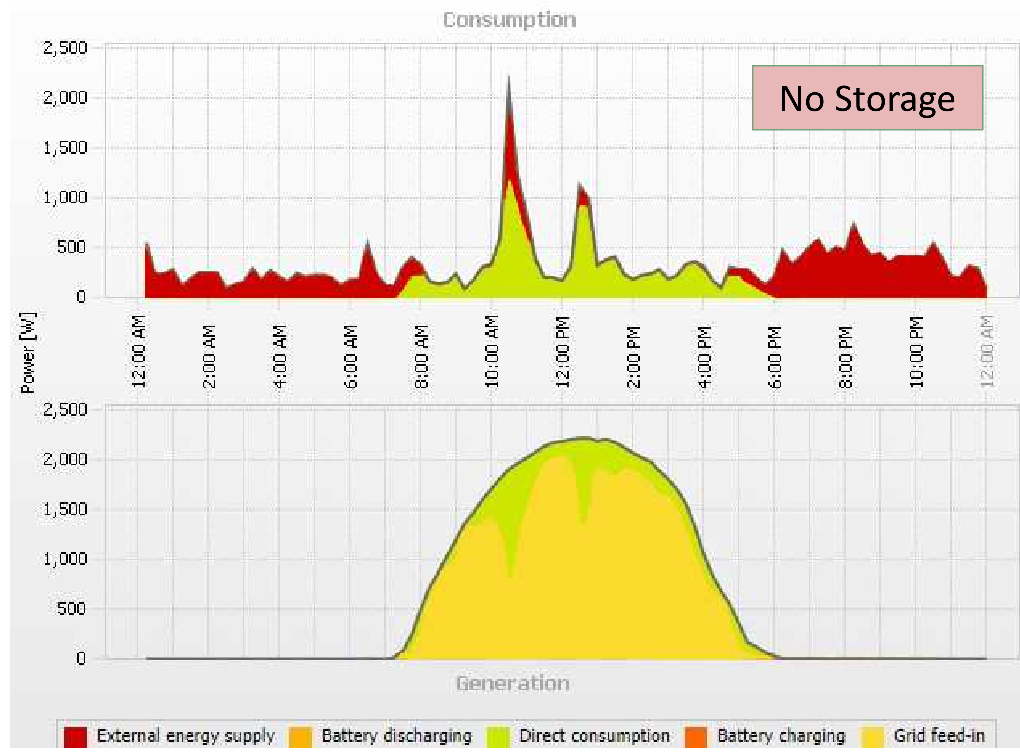
UCY Residential BESS Pilots

Two available modes

- “Increase Self-Consumption” mode
  - Storage of excess generation
  - Limit exported energy
  - Limit imported energy
- “Time-scheduled Charging” mode
  - Suitable for Time-of-Use Tariffs

UCY Residential BESS Pilots





from https://www.sma.de/en/

UCY Residential BESS Pilots





EMS

Specifications

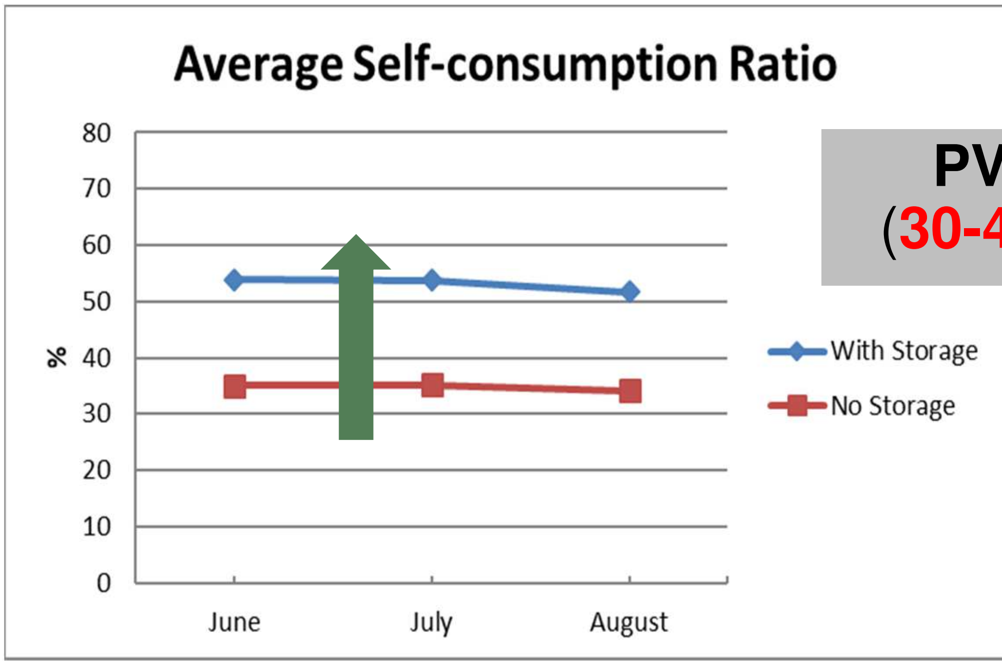
- Intelligent energy management
- PV power meter
- Bidirectional load meter
- Integrated web-server

Functionalities

- Increase Self-consumption
- Time-of-Use Tariffs
- Limit export electricity
- Scheduled Battery Charging

Residential Pilots Preliminary Results

Approx. **20%**
Self-Consumption increase during summer 2018.

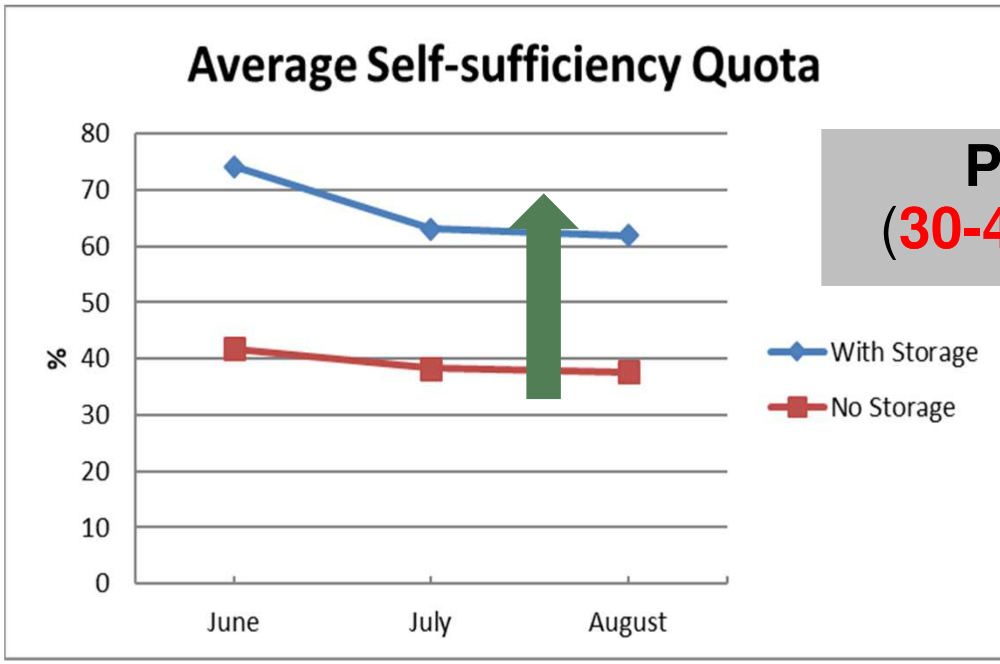


PV Self-Consumption boost
(30-40% → 50-60%, as expected)

Self-Consumption:
on-site consumption of PV generation

Residential Pilots Preliminary Results

Approx. **30%**
Self-Sufficiency increase during summer 2018.

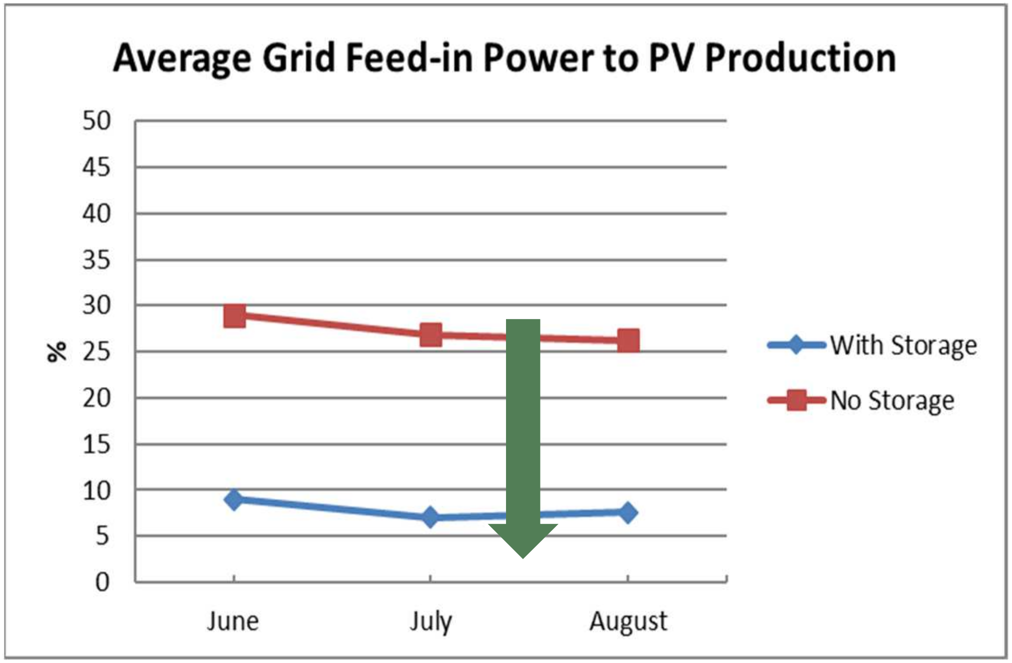


PV Self-Sufficiency boost
(30-40% → 60-70%, as expected)

Self-Sufficiency:
contribution of PV generation over total demand

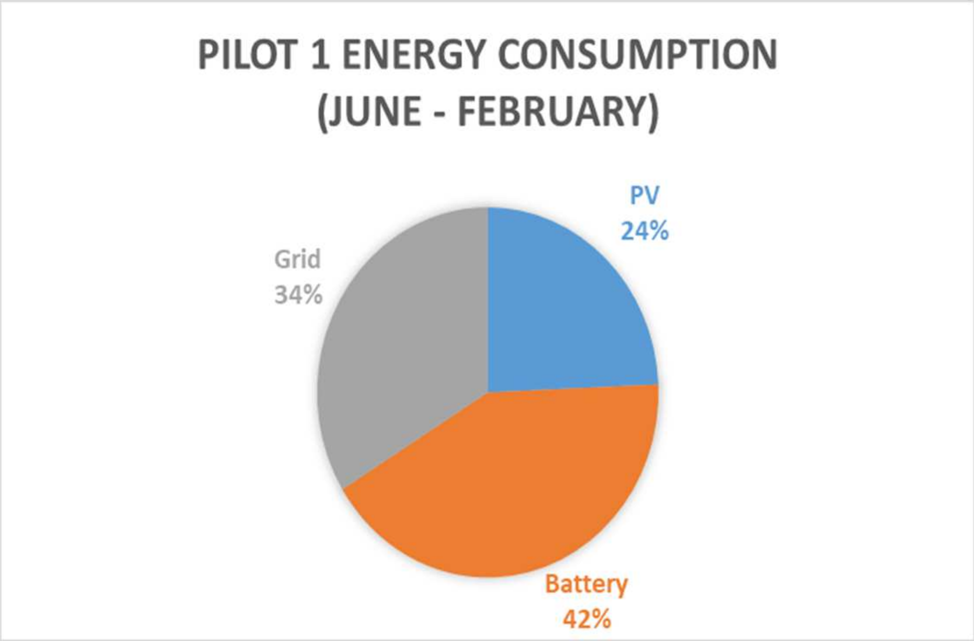
Residential Pilots Preliminary Results

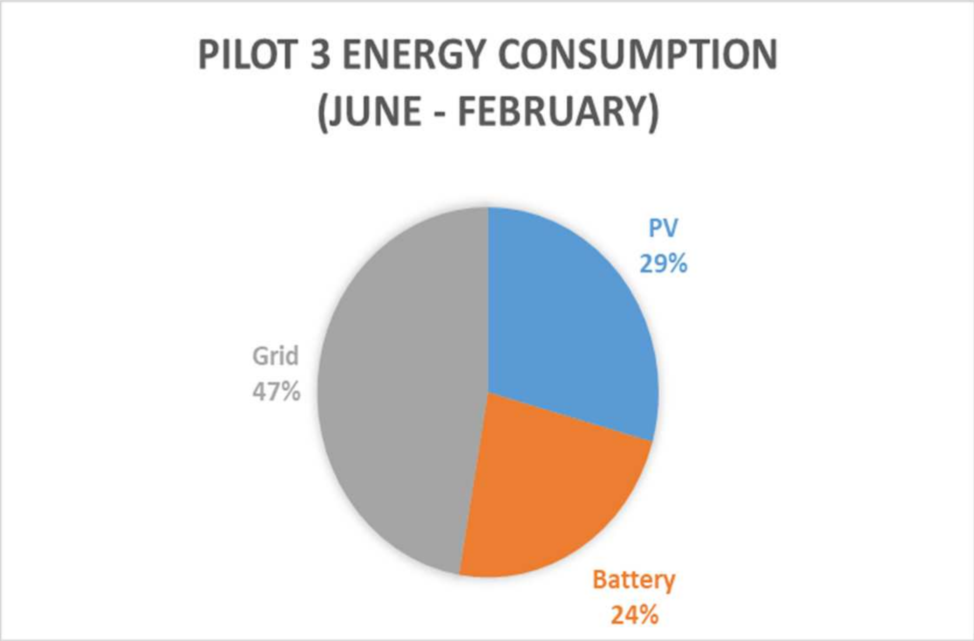
Approx. **20%**
Grid Feed-in reduction during summer 2018.



Grid Feed-in:
excess PV generation
injected to the grid

Residential Pilots Preliminary Results





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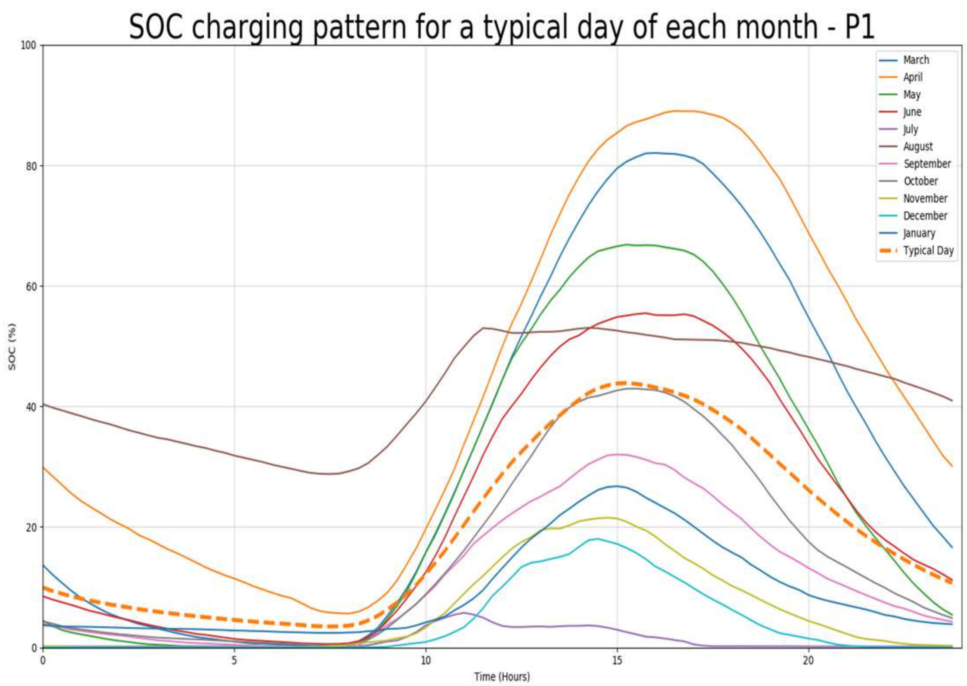
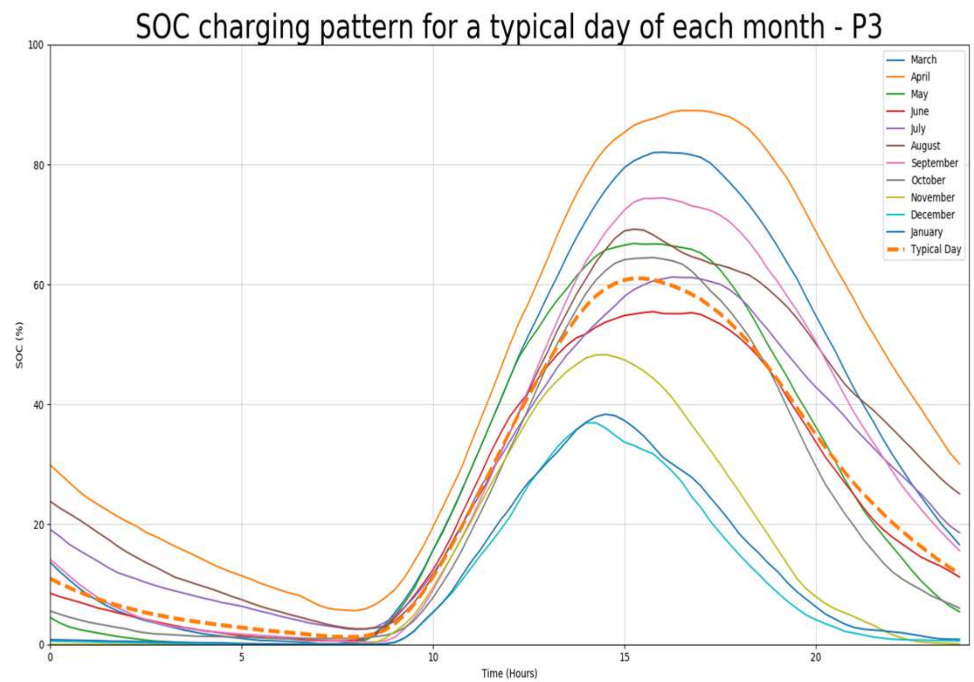




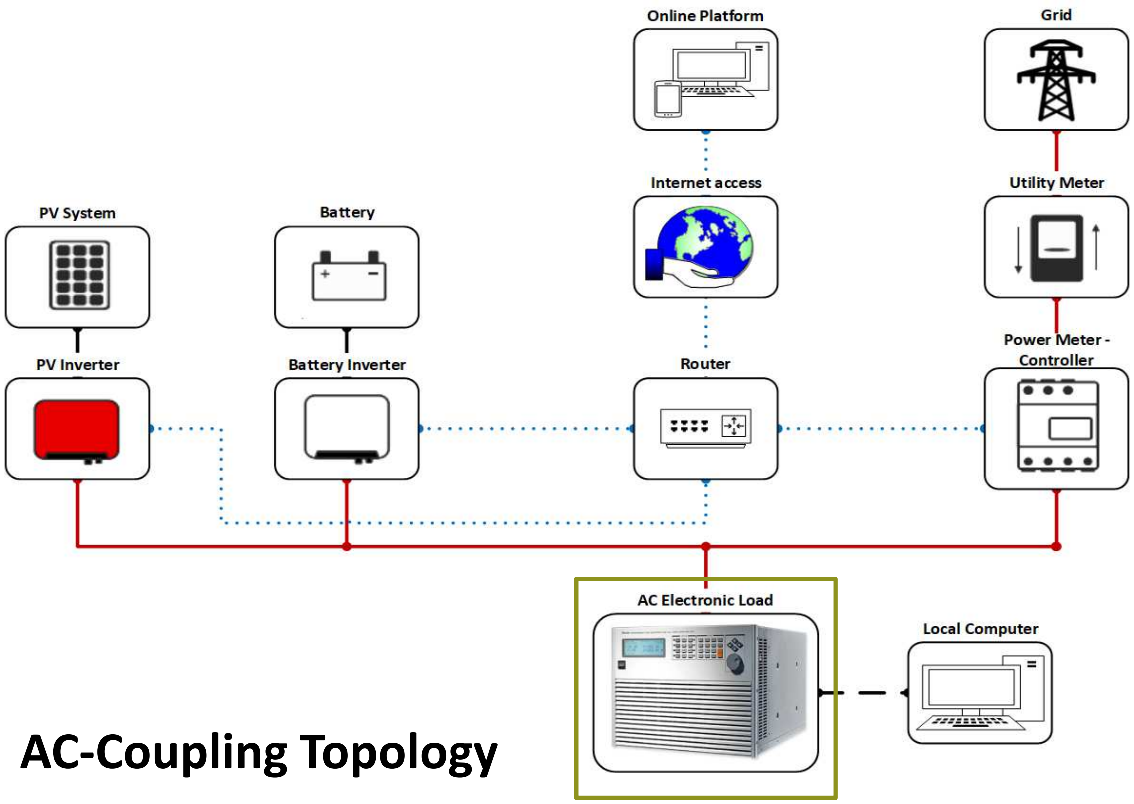
UCY Residential BESS Pilots

- Installation of additional monitoring equipment
  - Temperature & humidity monitoring
  - Thermal consumption monitoring





UCY Laboratory BESS Pilot



AC-Coupling Topology

UCY Laboratory BESS Equipment

- **Battery:** LG Chem RESU 10H
  - 5 KW maximum power, 9.3 KWh usable energy capacity
- **Battery inverter:** SMA Sunny Boy Storage 2.5
  - 1-ph, 2.5 KW rated power at 230 V, 50 Hz

Battery **Lithium-ion**

- High Voltage (570 VDC)
- 9.3 kWh Usable Capacity
- Deep Cycle (95% DoD)
- Indoor & Outdoor (IP55)
- Temperature: -10ºC to 45ºC
- 10 years warranty

Images taken from https://www.sma.de/en/

Inverter **Bidirectional**

- AC-Coupled System
- 2.5 KW rated power
- Round-trip efficiency 97%
- Support HV batteries
- Indoor &Outdoor (IP65)
- Integrated Web Server

Image taken from https://www.lg.com

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UCY Laboratory BESS Equipment

- **Load emulator:** Programmable AC Electronic Load
  - Power Rating: 1.8/3.6/4.5 KW
- **PV system:** 3 KWp PV system
  - Installed at 30 deg. (common practice in Cyprus)

CC = Constant Current
CP = Constant Power
CR = Constant Resistance

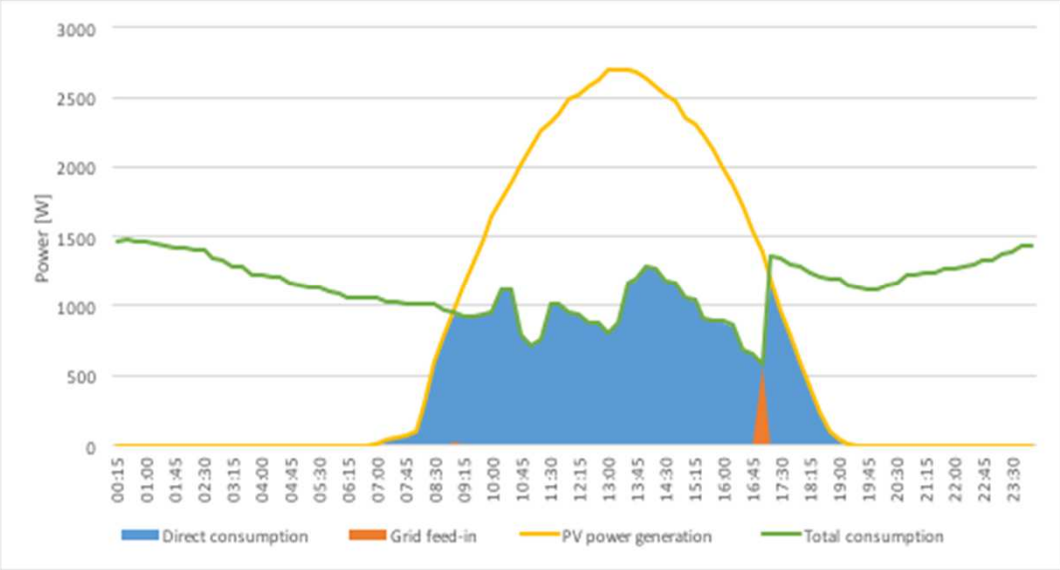
Load — **AC Load emulation**

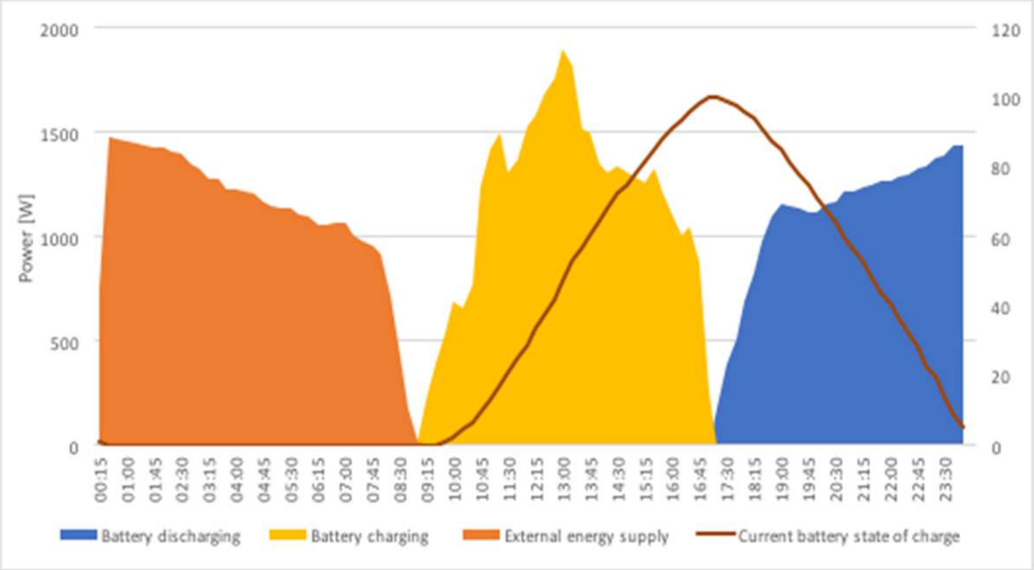
Image taken from https://www.chromausa.com

- Rated Power 4500W
- Real and accurate simulation capabilities
- Prevents overstressing the instrument
- Reliable and unbiased test results
- GIPB&RS232 interface for remote control & monitoring
- Modes of operation: CC, CP, CR *

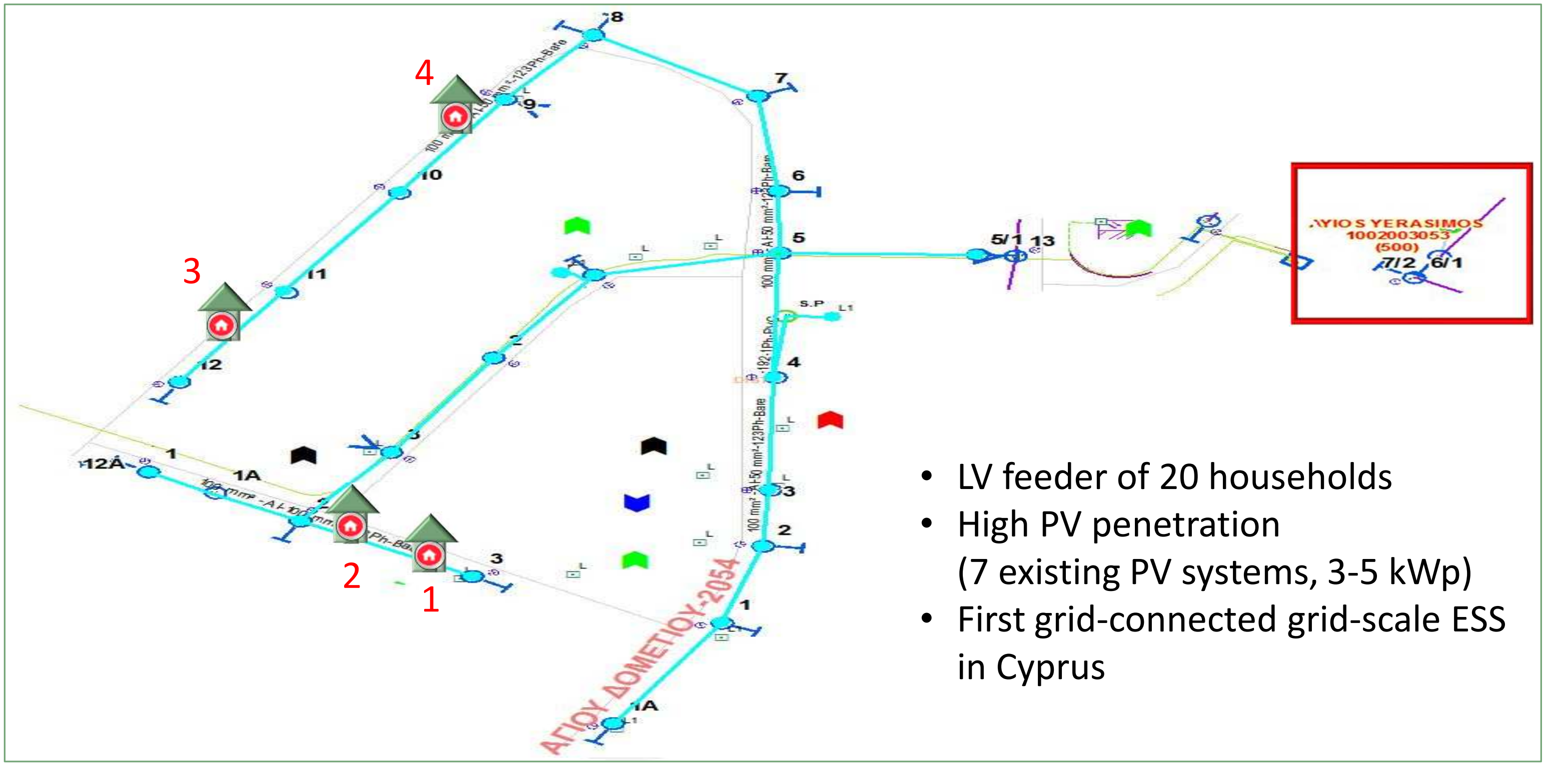
UCY Laboratory BESS Pilot

- Figures show real load consumption data emulated to the AC Electronic Load and the energy balance and behaviour of the BESS over a period of 24-hrs.
- Constant Power (CP) Mode / Emulate typical residential load / 24-hrs period



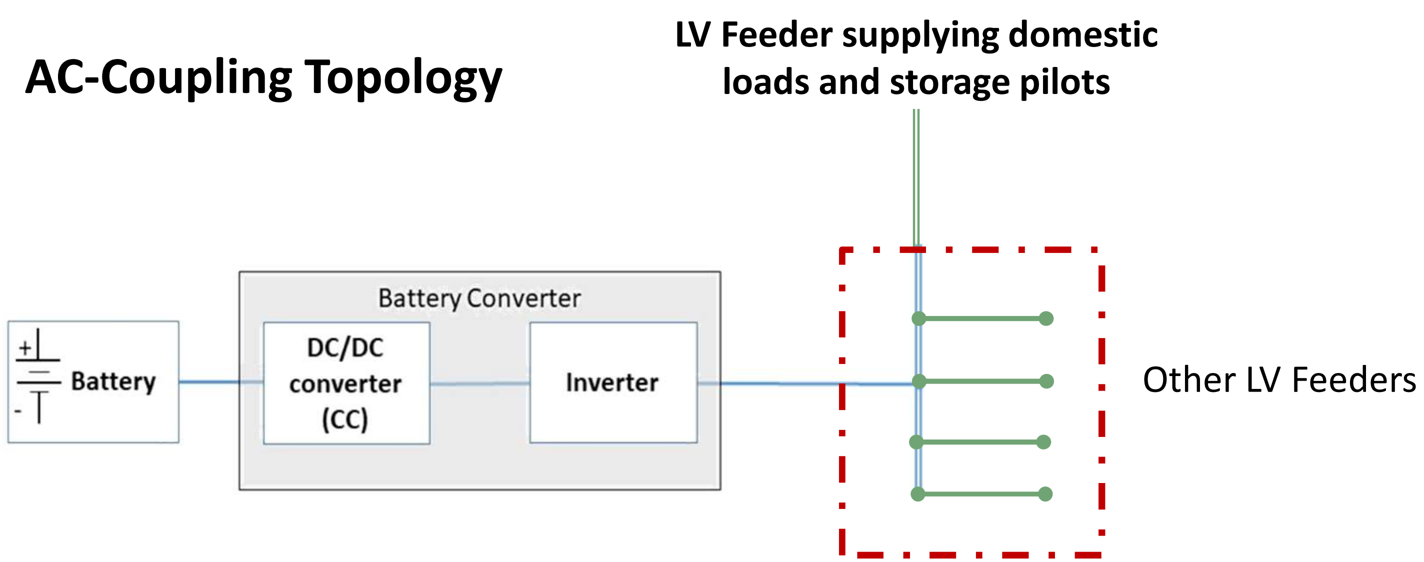


UCY Social BESS Pilot



- LV feeder of 20 households
- High PV penetration (7 existing PV systems, 3-5 kWp)
- First grid-connected grid-scale ESS in Cyprus

UCY Social BESS Pilot



UCY Social BESS Pilot

Battery — **Lithium-ion Technology**

- High Voltage (800 VDC)
- 50 kWh Usable Capacity
- Regulated Air Cooling
- 10 years warranty

Inverter — **Bidirectional Technology**

- 30 KW / 30 KVar power
- Efficiency up to 96%
- Support HV batteries
- Integrated Web Server

EMS — **Integrated Web Server**

- Optimal Power Balancing
- Frequency Control (P[f])
- Support of SCADA
- Target SoC
- Voltage Control (Q[u])
- Control & Monitoring via UI

Images taken from http://www.autarsys.com/

- Outdoor installation
- Insulating container
- Local and remote control
- AC-coupling topology
- Coupled with LV feeder
- Power analyser at PCC
- Monitor grid operation (P, V, I, f)
- EMS to perform power balancing and grid ancillary services

UCY Social BESS Pilot

System Parameters	
Rated power	30 KW
Nominal AC Voltage/Freq.	400V, 50Hz
Nominal Current	43.5A
THD	<2%
Inverter efficiency	>96%
Weight	2 tones
Storage Battery	
Cell Chemistry	NCM
Life cycles	6000
Efficiency @ 0.5C	>96%

Interface	
Data Monitoring	SCADA
Communication	Ethernet Modbus GPRS/Satellite

UCY Social BESS Pilot

- Turnkey solution possible for integration of Off-grid & On-grid applications
- Ancillary grid services:
  - Frequency Control (P[f]) – Active Power Compensation
  - Voltage Control (Q[u]) – Reactive Power Compensation
  - Harmonic compensation
  - Peak shaving and Peak shifting
  - Fault ride through ability

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UCY Public BESS Pilot

- New Nicosia Town Hall, 12 KWp roof-top PV system

UCY Public BESS Pilot

LG Chem RESU 10H x3

SMA Sunny Boy Storage 5.0 x3

SMA Home Manager x3

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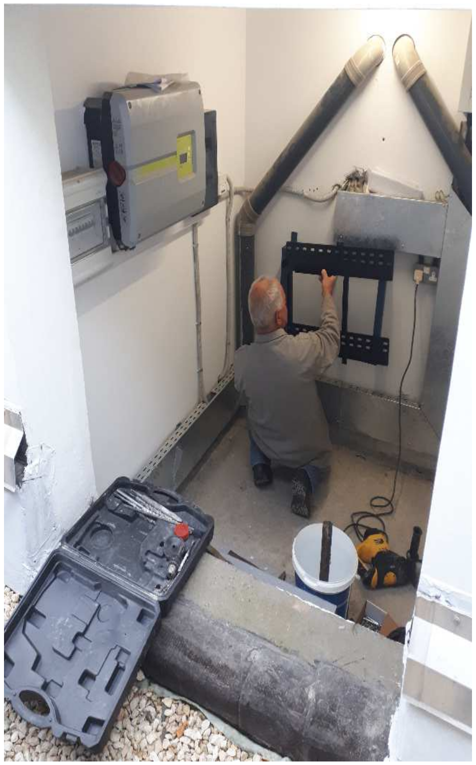

Thank you for your attention!

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