ENGIE Impact

PPC – Aspectos Técnicos e Econômicos em UFVs Centralizadas

Experiência Internacional

Who We Are

ENGIE Impact

Accelerating sustainability transformation for corporations, cities and governments around the world

From Tractebel Advisory & Advanced Analytics to ENGIE Impact

Bringing together four organizations

ENGIE | ENGIE Insight	Unparalleled expertise in **resource data management** and data-driven **optimization of energy, water, waste and carbon**
TRACTEBEL Advisory & Advanced Analytics (ENGIE)	**Global engineering consultancy** specializing in energy infrastructure systems, energy economics, advanced analytics and data-science
RED (A company of TRACTEBEL, ENGIE)	Award-winning design and engineering services focused on **optimizing performance of hotels, data centers and digital infrastructure**
ecova®	Deep understanding of **energy supply management, renewables and compliance**

Legal Name
Tractebel Impact

ENGIE Impact

1,000 corporate, city and government clients

1,000,000 sites under management

2,000+ employees

20+ offices worldwide

We are an independent advisor aiming at helping Client accelerate decarbonisation

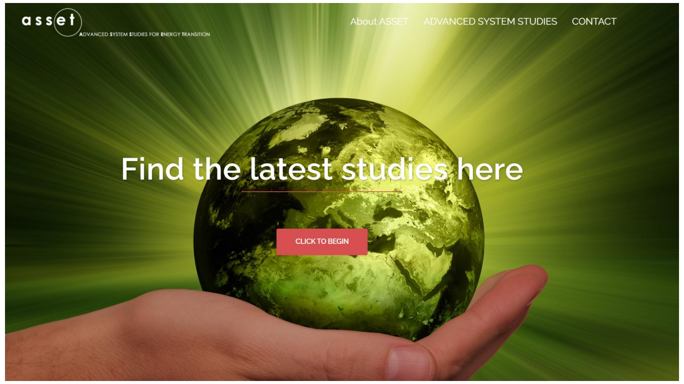
- ENGIE Impact is an independent legal entity. ENGIE Impact is part of ENGIE Group, but does not have any business links or obligations with other business units

- In our engagement we operate with Chinese walls, ensuring complete competition throughout the RFP management and project prioritization phase. ENGIE Impact is separate from ENGIE Group in terms of tools, data storage and location

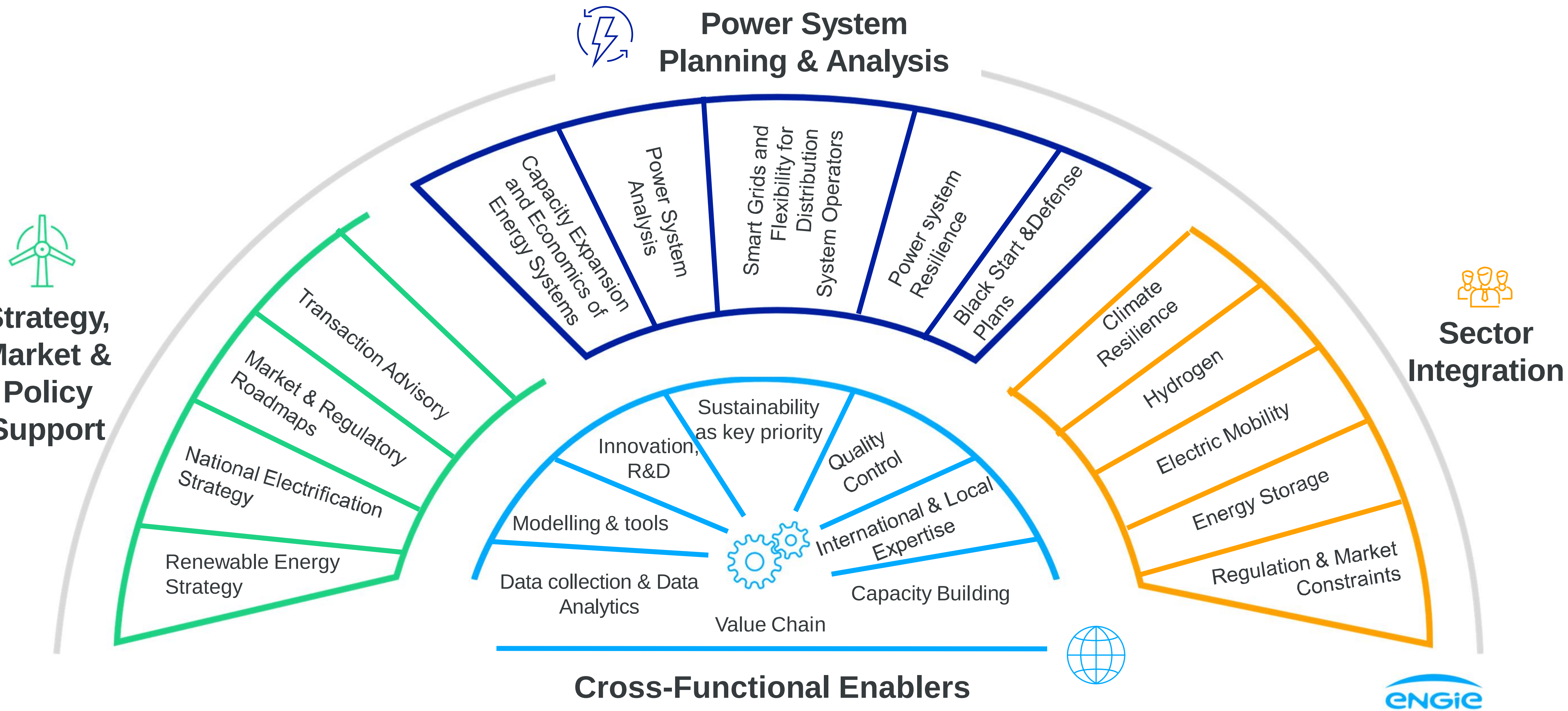
- The trust of our Customers is seen with highest importance and our studies are designed to be published if required. Transparency leads to no other option

Proof for our independence:

All studies led for the European Commission are freely available in the internet



Our capabilities on Energy Systems Analysis



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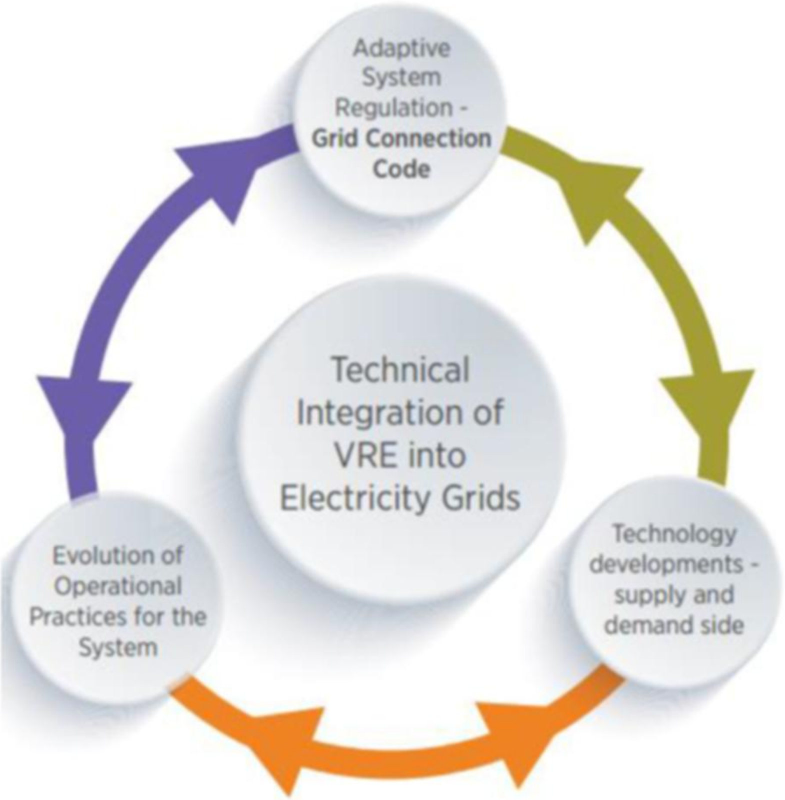
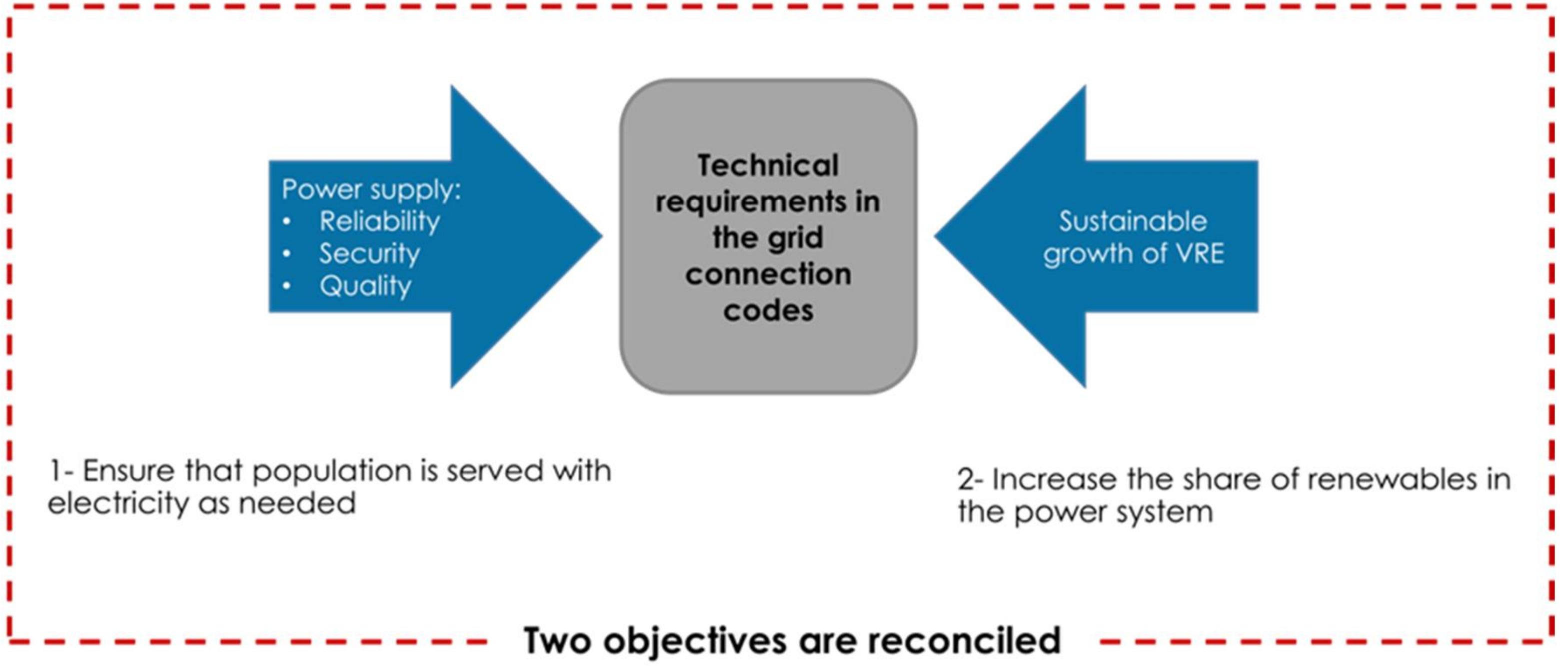
Power Plant Controller

International Experience

The Role of Grid Code for VRE Integration





Source: [Scaling up Variable Renewable Power - The Role of Grid Codes (IRENA)]

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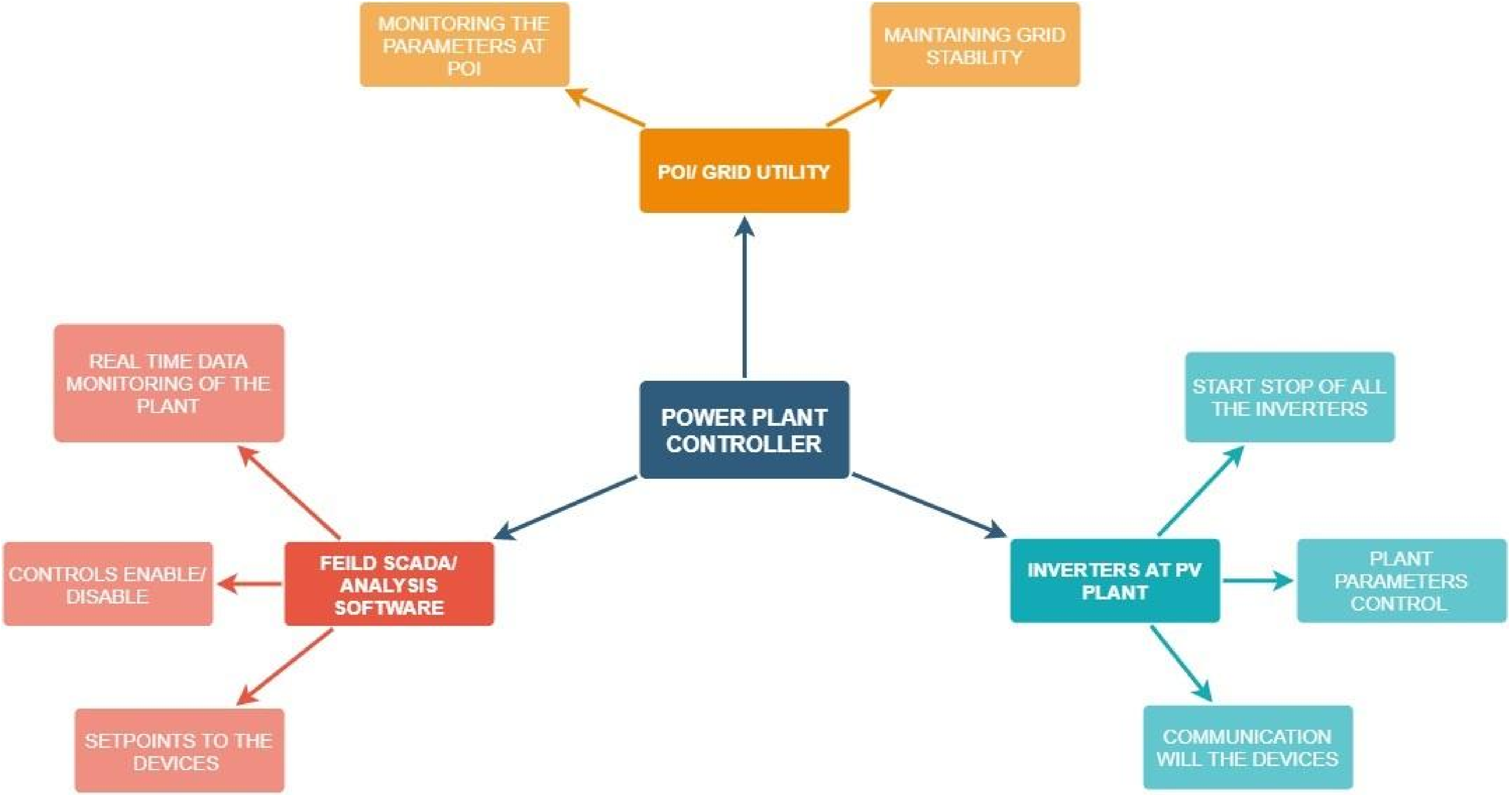
The role of PPC



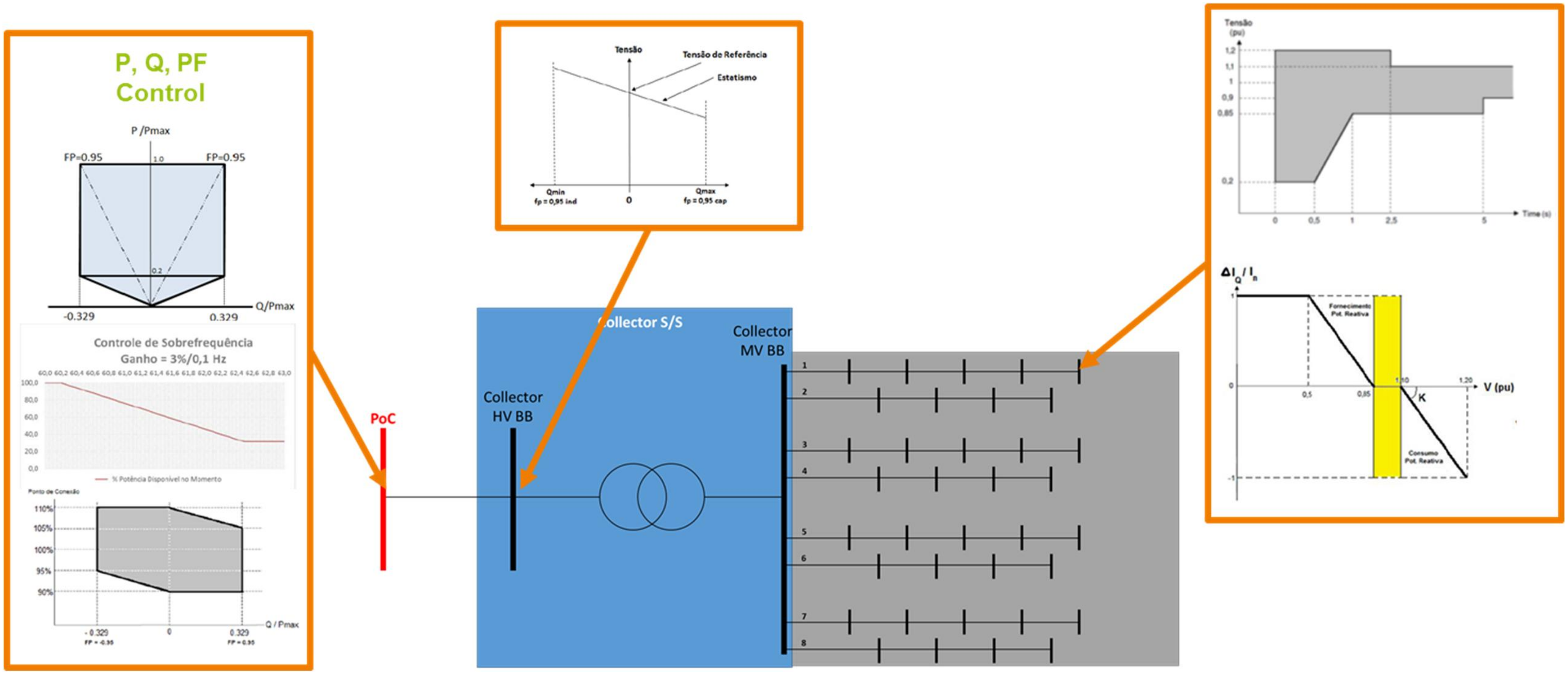
Source: [Power Plant Controller - Putting the Power back Into the hands of the Developer]

Typical Control Functions for PV Plants

- Voltage/var control:
  - Reactive Power Control
  - Voltage Control
  - Power Factor Control
- Frequency/MW control
  - Active Power Control
  - Frequency Control
  - Ramp Rate Control
- Fault ride-through & fast reactive current injection
- Special controls:
  - Power Oscillation Damping Control
  - Artificial Inertia
  - Black Start

Source: Power Plant Controller - Putting the Power back Into the hands of the Developer

Requirements Defined at Different Points



From PV farms to PV power plants

- Renewables are increasingly required to be more grid-friendly and provide regulation and flexibility to the power system where they are connected
- The massive penetration of VRE has raised the concern of system operators all around the world
- VRE power plants do not only generate power when the resource is available (farms), they must be operated as power plants supporting the power system

Trends

- Tighter performance, compliance tests and simulation model delivery requirements in modern grid codes
- Faster control response at the POI
- More and more requirements being defined at the POI
- Retrofit and hybridization of plants
- More and more “intelligence” added to the PPC (e.g. losses optimization, power quality management, etc.)
- Increased capacity of PV plants to provide ancillary services enabled by modern ancillary service market design

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System service provision per type of technology

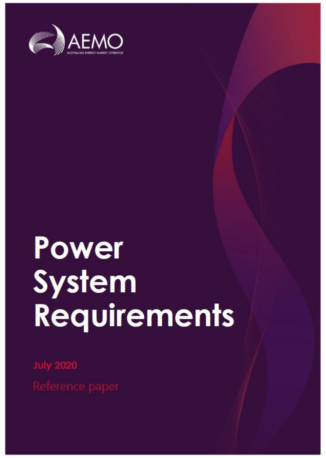
Figure 4 Summary of required system services, and capability of technologies to provide them

Service description				Supply side: Centralised generation		Network: Transfer between regions		Network: Transfer within regions	Network: Stabilising devices			Demand side: Load	Demand side: Decentralised resources	
System Attribute	Requirement	Service	Spatial level of need	Synchronous generator	Inverter-based resources	DC interconnection	AC interconnection	Transmission and distribution networks	Grid reactor, grid capacitor, static VAR compensator	Static synchronous compensator	Synchronous condenser[1]	Large industrial, residential, commercial	DPV	Battery storage
Resource Adequacy	Sufficient supply to match demand	Bulk energy	System wide	●	●	➡	➡	➡	○	○	○	●	●	●
Resource Adequacy	Sufficient supply to match demand	Strategic Reserves	System wide	●[2a]	◐[3a]	➡	➡	➡	○	○	○	●	◐[3b]	◐[3b]
Resource Adequacy	Respond to large changes in energy requirements	Operating reserves	Regional	●[2b]	◐[3a]	➡	➡	➡	○	○	○	●	◐[3b]	◐[3b]
Resource Adequacy	Transport energy generated to customers	Transmission & distribution services	Local	●[4]	●[4]	●	●	●	●	●	●	●[4]	◐	◐
Frequency Management	Maintain frequency within limits	Inertial response	Regional	●	◐[5]	◐[5]	➡	➡	○	◐[6]	●	○[7]	○	◐[5]
Frequency Management	Maintain frequency within limits	Primary frequency control	Regional	●	●[8]	➡	➡	➡	○	○	○	●	●	●[8]
Frequency Management	Maintain frequency within limits	Secondary frequency control	Regional	●	●[8]	➡	➡	➡	○	○	○	●	●	●[8]
Frequency Management	Maintain frequency within limits	Tertiary frequency control	Regional	●	●[8]	➡	➡	➡	○	○	○	●	●	●[8]
Voltage Management	Maintain voltages within limits	Fast response voltage control	Local	●	●	●	○	○	●	●	●	●	◐	●
Voltage Management	Maintain voltages within limits	Slow response voltage control	Local	●	●	●	○	○	●	●	●	●	◐	●
Voltage Management	Maintain voltages within limits	System strength	Local	●	○	○	⇨	➡	○	○	●	○	○	○
System restoration	Ability to restore the system	Black Start Services	Local	●	◐[9]	◐[9]	●	➡	○	○	○	○	○	◐[9]
System restoration	Ability to restore the system	Restoration Support Services	Local	●	●	●	●	⇨	●	●	●	●	◐	◐

Note: Classifications are indicative of general ability of each technology type. The extent to which technologies can provide each service must be assessed on the specifics of each individual system

1. This includes generators with ability to operate in synchronous condenser mode.
2a. While many synchronous generators can provide energy reserves, some less firm technologies (solar thermal or pumped hydro) will be limited by the amount of energy storage they include.
2b. There is a wide range of capabilities regarding synchronous generators ability to provide flexibility. Ultimately unit flexibility is a product of individual unit design and the economic circumstances around it's dispatch..
3a. Limited by duration for which service can be delivered.
3b. Limited by duration for which service can be delivered; existing controllability is limited.
4. The provision of local voltage support from generators and loads can improve the network transport capability near their respective connection points.
5. Some fast frequency response capabilities can be substituted for a portion of synchronous inertia, but are not considered equivalent.
6. Static synchronous compensators with energy storage devices are being trialled as an emergency provider of inertial response.
7. Except for load relief.
8. Includes fast frequency response capabilities.
9. Inverter-based resources can provide black start services, although none are currently contracted for SRAS.

Ability to provide service		
● Fully capable	◐ Partial or emerging	○ Unable
➡ Enables Delivery	⇨ Partial or limited Delivery	



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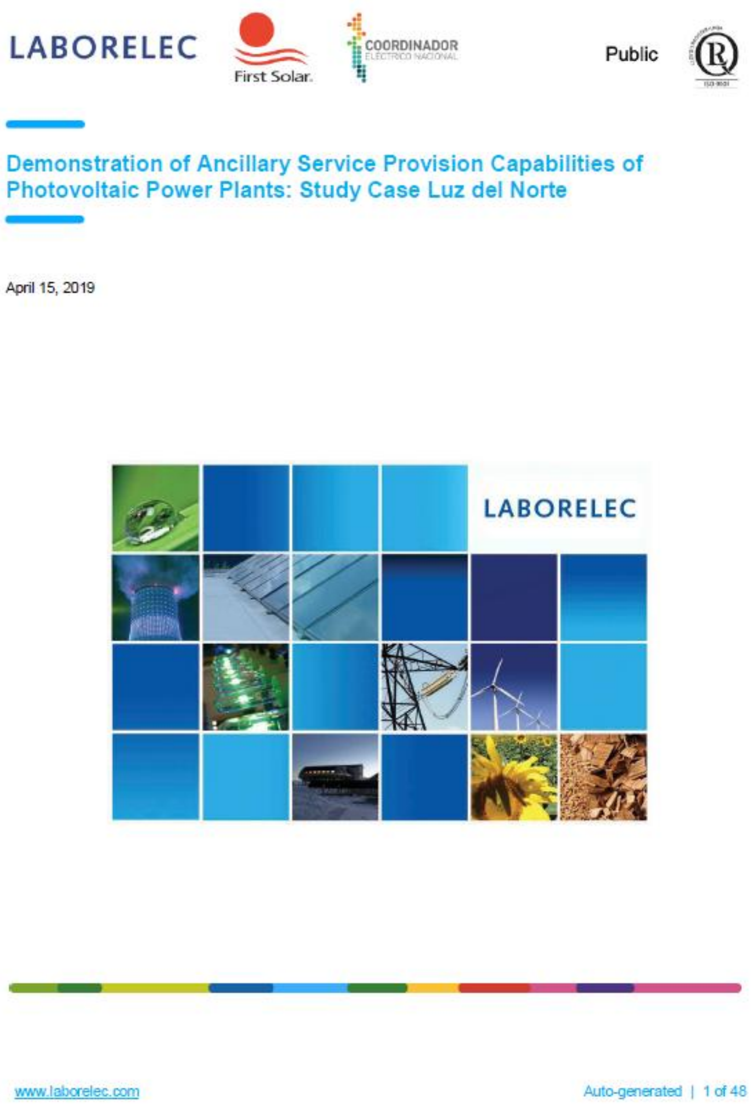
Chilean Example


LABORELEC First Solar COORDINADOR ELÉCTRICO NACIONAL Public

Demonstration of Ancillary Service Provision Capabilities of Photovoltaic Power Plants: Study Case Luz del Norte

April 15, 2019

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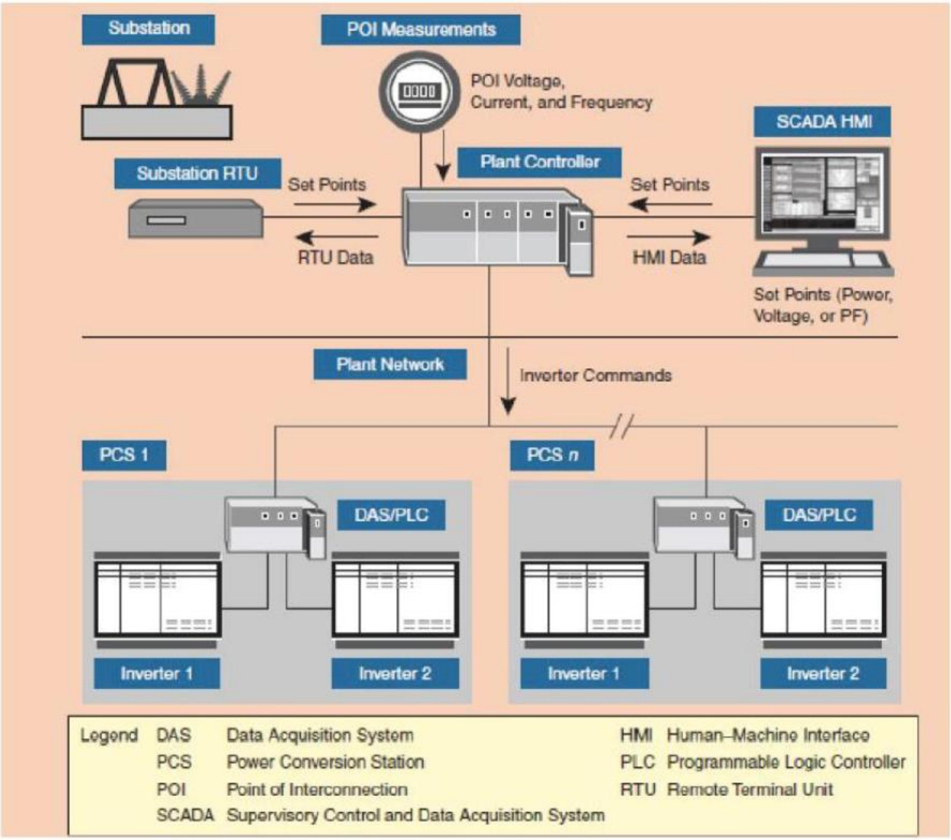

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Chilean Example (PFC)

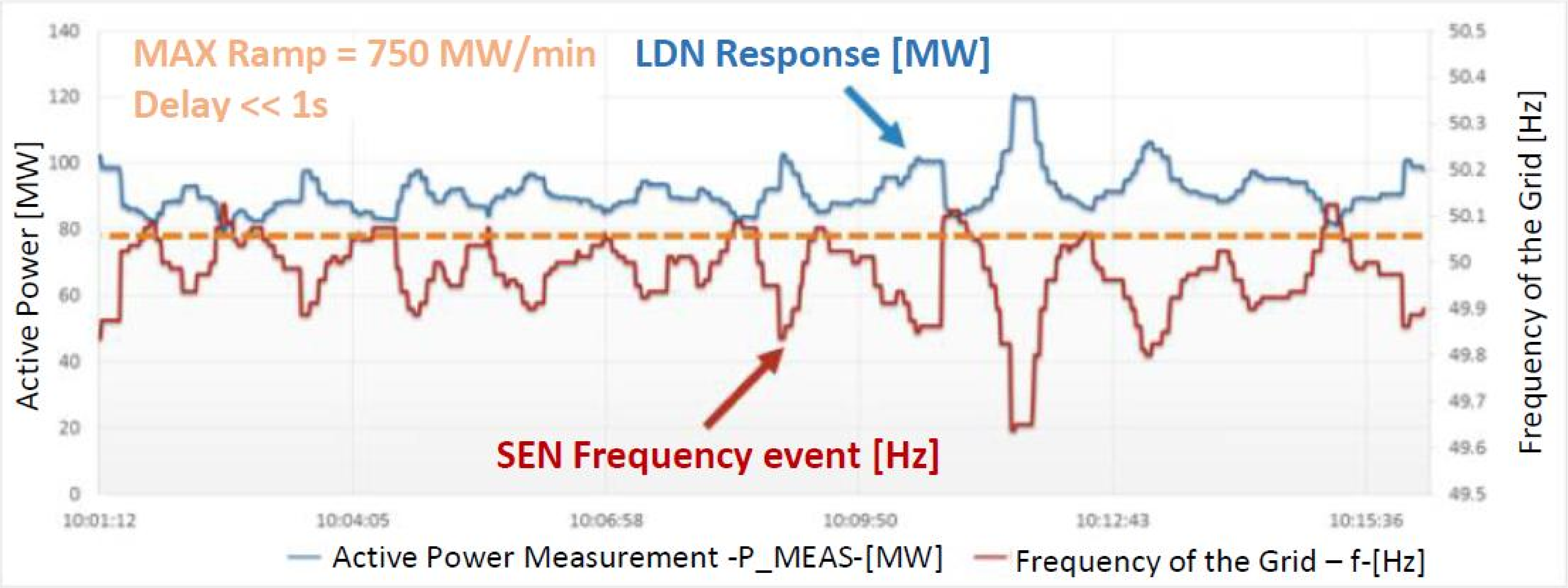

Figure 12: Luz del Norte´s response to under frequency event with 3% droop.

Chilean Example (SFC)

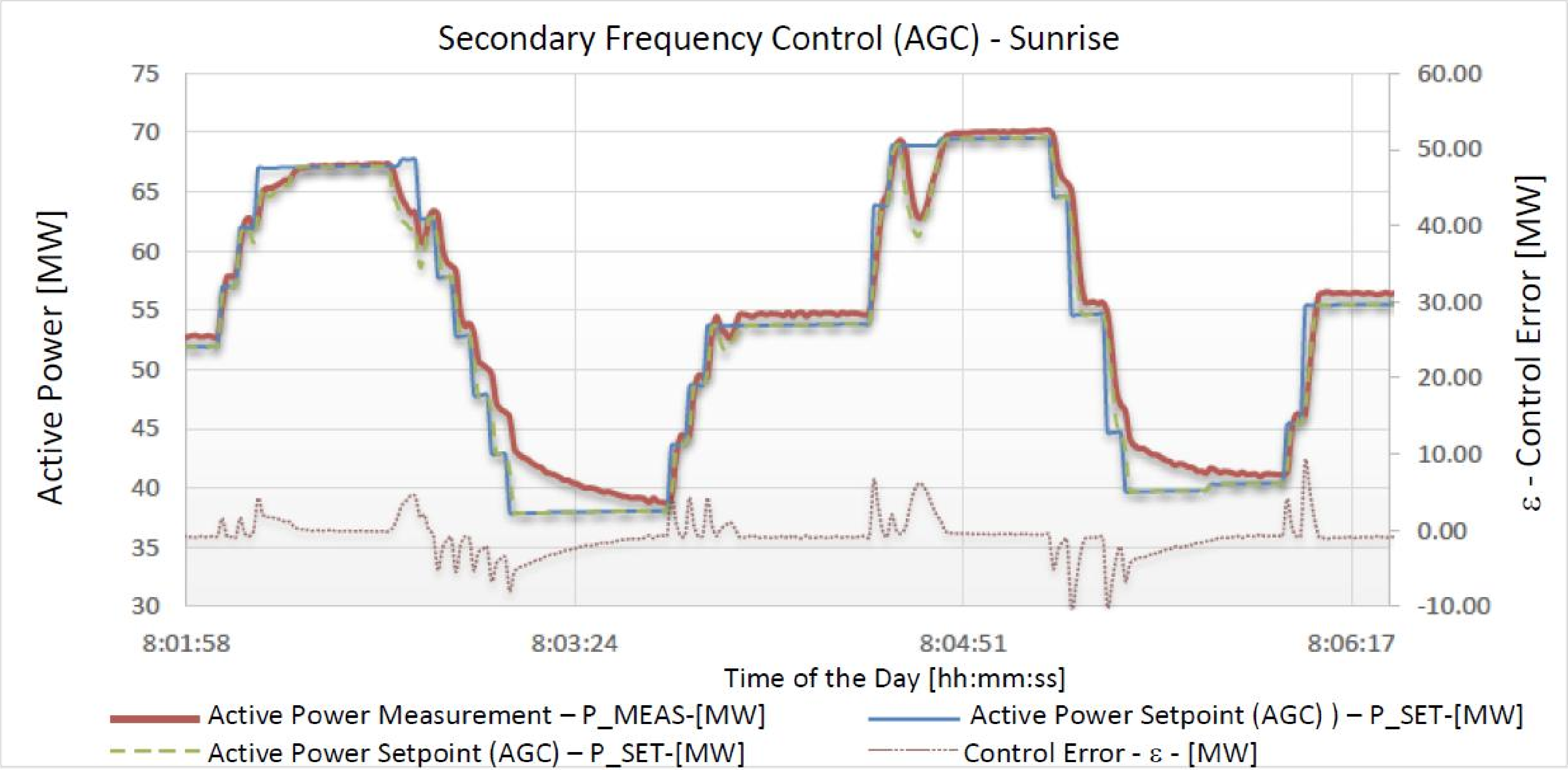

Figure 15: Response amplification at sunrise between 08:01 and 08:06.

Chilean Example (Voltage Control)

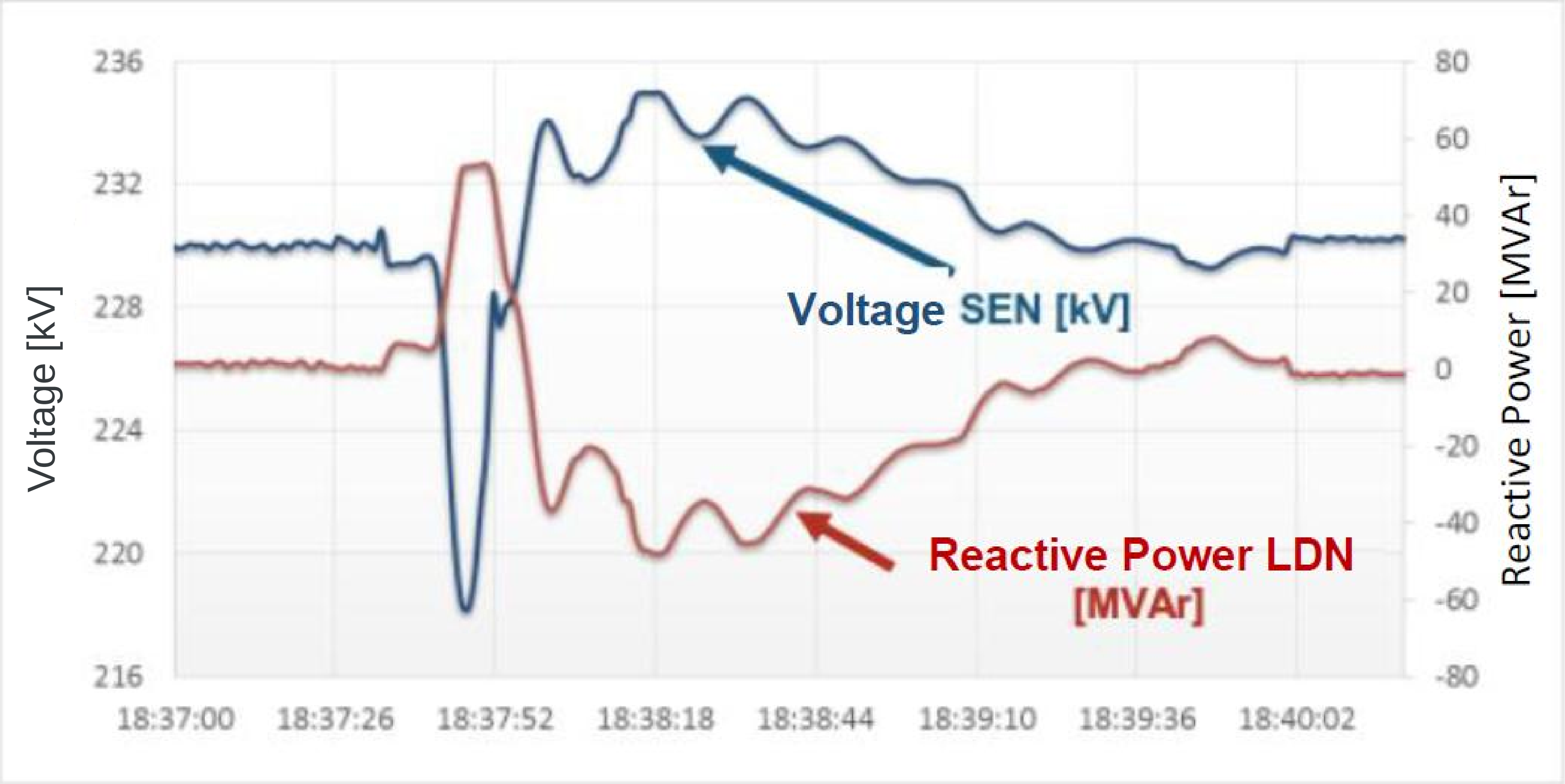

Figure 17: Luz del Norte´s response to voltage variation – 1999 MVAR/min – 3% Droop.

Puerto Rico Example

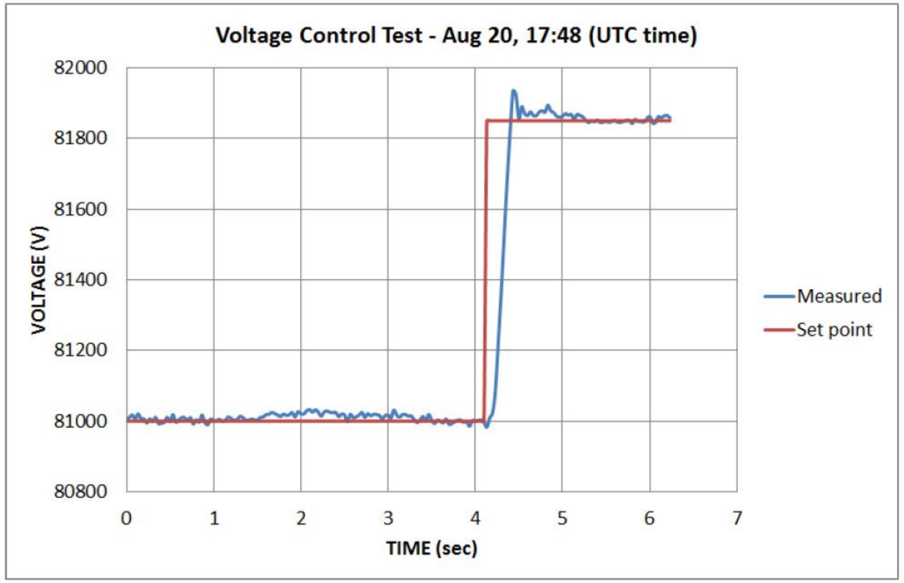

Figure 78. Voltage control test

Advanced Grid-Friendly Controls Demonstration Project for Utility-Scale PV Power Plants

Vahan Gevorgian and Barbara O'Neill
National Renewable Energy Laboratory

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

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Breaking news!

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European TSOs successfully managed the solar eclipse

Jun 10, 2021

Today, a solar eclipse took place affecting the majority of countries in Europe between 10:10 to 13:45 CEST. TSOs were prepared for this special event.

The PV infeed in the most affected countries in Continental Europe reached a maximum of 56 GW. The maximum decrease caused by the solar eclipse was 4.9 GW. This was in line with the prognosis made by TSOs. The frequency did not show significant deviations from the target value of 50 Hertz. The PV infeed was back to normal at 13:45, after the solar eclipse was over.

The 10 June 2021 was successfully managed by the European TSOs through adequate preparations in advance and permanent coordination during the solar eclipse. Lessons will be drawn to best prepare for a more challenging eclipse foreseen next year on 25 October.


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Thank you!