



# Latest Technologies for Hybrid Plants

## Importance of Storage and Control for smart HPPs



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# Latest Technologies for Hybrid Plants

Importance of Storage and Control for smart HPPs

1. Company Overview
2. Introduction
3. Large-Scale Hybrid Systems – Case Study
4. Conclusion

# Company Overview

## About us

GP Tech is a leader company in the development of power electronic devices all over the world, which uses the state of the art technology to provide new solutions for the Energy Sector.



### Capacity

Advanced management systems that allow a more agile, predictable and controllable way to meet the needs of the network operators, regardless of the energy sources.

### Reliability

GP Tech offers a contrasted experience in grid integration under the hardest ambient condition and most demanded technical requirements.

### Profitability

Achieving the highest quality power signal with the best performance.

# Company Overview

Business Lines focused on Large Scale Renewable Power Integration

## SmartPv ■■■

Complete Inverter Stage Solutions for PV Large-Scale Plants with advanced control and power regulation capacities to meet any technical requirement

## GridCapabilities ■■■

Leaders in STATCOMs solutions for renewable signal enhancement and ancillary services.  
The key to reach the best power stability and superior performance

## EnergyReserve ■■■

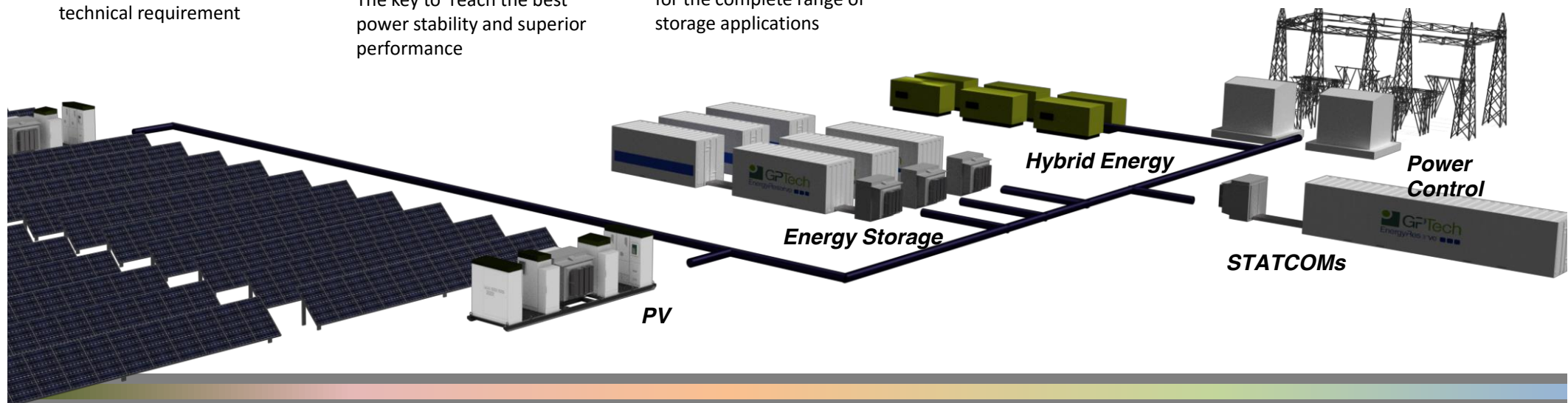
Storage turnkey products which solve all the technological aspects with a contrasted set of features for the complete range of storage applications

## EMSystems ■■■

A new generation of systems created to control the power to be delivered, configured for each individual case with our strong expertise

## DieselSolar ■■■

Optimized designs for Hybrid Renewable & Fuel to reduce the fuel consumption.



- Complete control of the generation chain to provide the best performance in utility-scale projects.
- Innovative products fully-developed by GP Tech and adapted to the different market requirements
- System Integrators with a huge experience in the global market
- Directly connected to the main players and entities in the utility segment



# Introduction

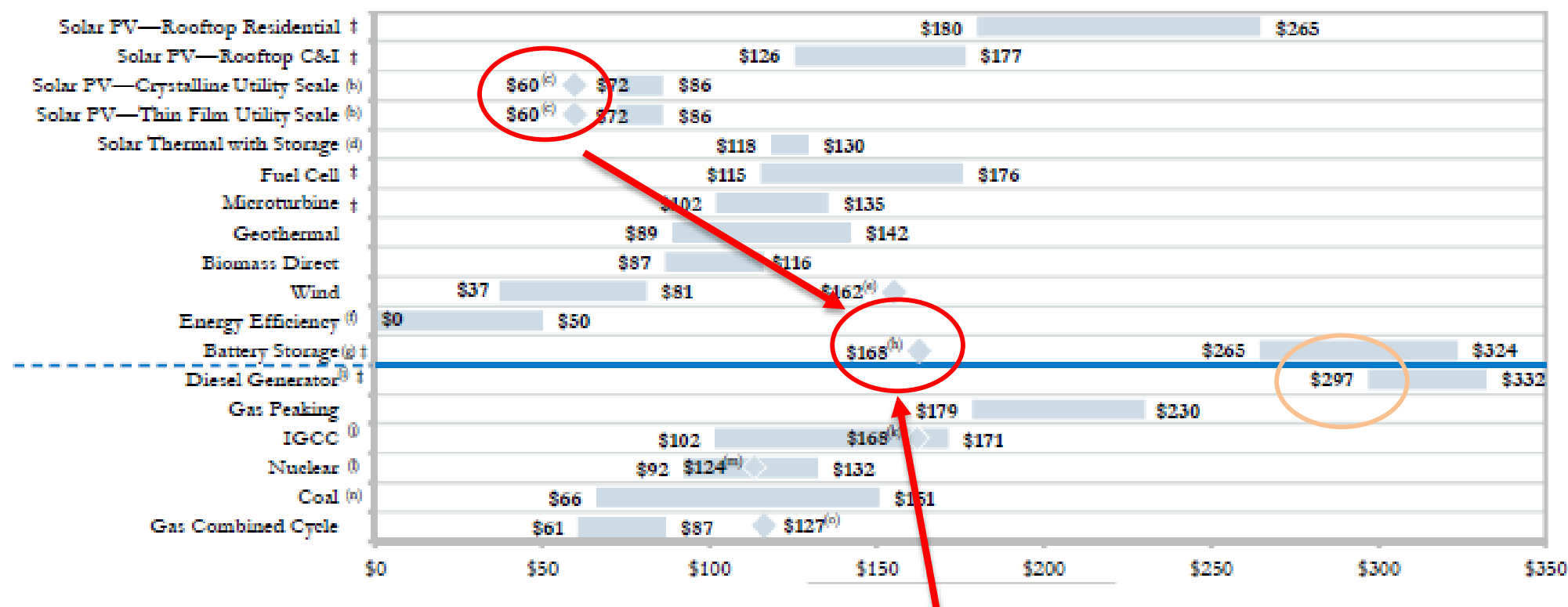
## Importance of Storage capability

1. If the decompensation between offer and demand is not balanced quickly (in a few seconds), a blackout of the system can be produced.
2. Due to the intermittent nature of the generation, one single wind facility or PV installation cannot power a significant population without any risk. An extra support to avoid this problem is needed.
3. Diesel generators, as energy backup, imply fuel energy dependence and increase the generation costs.
4. The use of energy storage technology enhances grid stability and supports the rise of intermittent wind and solar electricity capacity.



# Introduction

## Levelized Cost of Energy Analysis



Source: LAZARD'S LEVELIZED COST OF ENERGY ANALYSIS

**168 \$/MWh NET LCOE for HPP (PV+ST) considering:**  
 LCOE PV **60 \$/MWh** from PV;  
 CAPEX **300 \$/kWh\_inst** from BATT;  
 OPEX **5 \$/kWh\_inst/year**, 13y lifetime batt

# Introduction

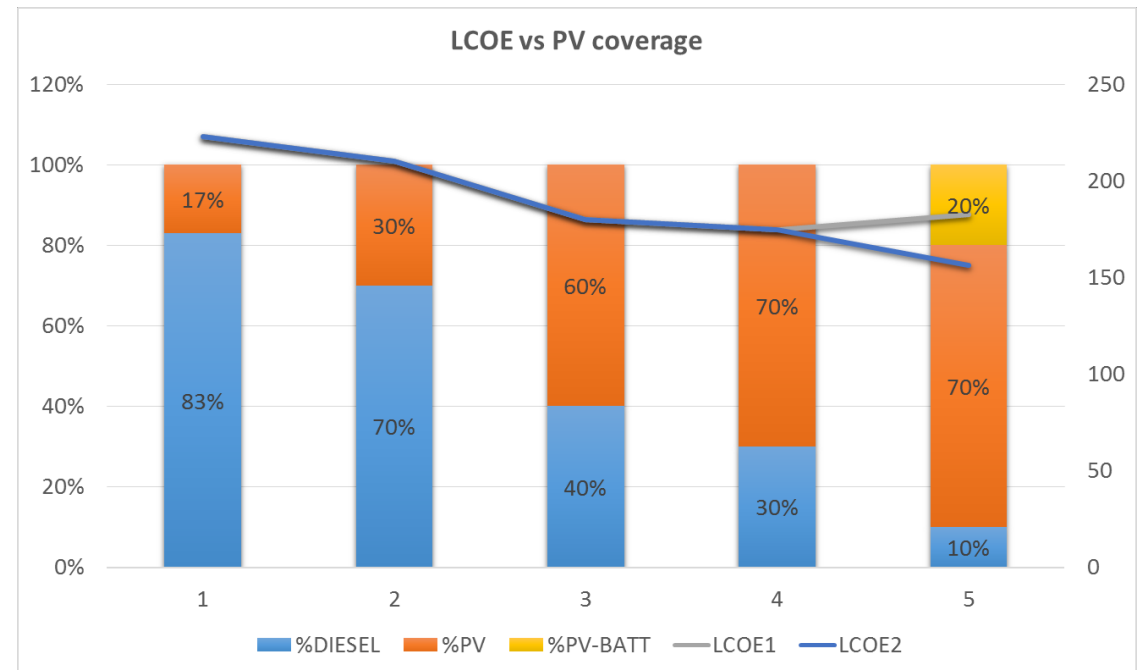
These solutions aim to reduce LCOE with incremental technological innovations

## ASSUMPTIONS

- LCOE DIESEL: 240 USD/MWh
- LCOE PV\*: 140 USD/MWh
- LCOE PV-BATT: 177 USD/MWh



- Engineering, device, software and hardware are design for the project to optimize LCOE for the customer
- All capabilities are together inside the team. Not working as an integrator but a solution designer
- Product marketing tools ready to commercialization



1. With standard PV-Plant technology
2. Engineering optimized for high plant factor (aprox. 30%)
3. Smart-Grid Technology and load management
4. Smart Weather Forecast System
5. Storage for Energy Shifting

\*PV system cost significantly depend on the country and the project specifications

# Introduction

## HPPs principal connection schemes

### ❑ Isolated systems

- Load energy by additional generation systems
- Insufficient and expensive consumption of the grid infrastructure as to be expanded
- Rural and remote sited installations, as development zones, natural reserves and protected environment

### ❑ Micro-grid systems combined to traditional grid

- Reserve of primary energy
- Decrease of external consumption
- Contribution to a green energy scheme
- Industrial installations, near to offices and residential buildings

### ❑ Connected to weak grid

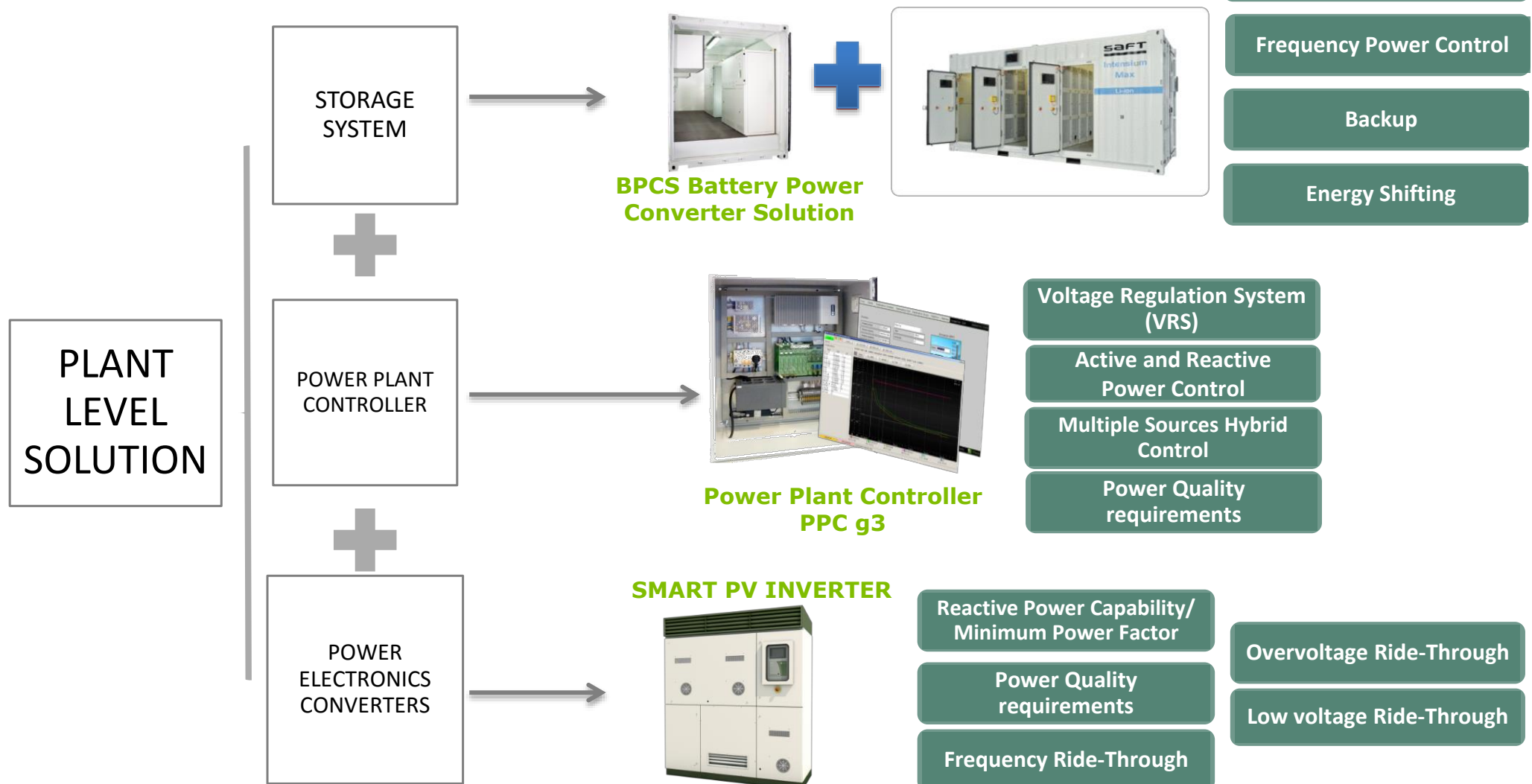
The topic of today

- Contributing to grid regulation (ancillary services)
- Needed to fit new quality and quick response requirements in renewables energies grid connection
- Controlling the entire power systems is a higher difficult issue
- Island Grids



# Hybrid Solutions with advanced technology

Proposed hybrid solution for different requirements



# Large-Scale Hybrid Systems: Case Study

## Large-Scale Hybrid System in Puerto Rico for grid integration

- An advanced hybrid solution with storage and integrating different power sources is required to comply with all the local requirements.
- The main objective is to avoid the potential quality degradation in the power injected to the grid in relation to voltage regulation and unbalancing, harmonic distortion, Flicker effect, Voltage and Frequency sags/interruptions and transients.
- **100% commercial project.** The CAPEX of the battery must be obtained from each kwh sold to the PREPA.



EMS POWER PLANT  
CONTROLLER

GRID CAPABILITIES  
STATCOMS

ENERGY STORAGE  
BATTERY POWER SYSTEM

# Large-Scale Hybrid Systems: Case Study

## Generation Structure of the island grid in Puerto Rico

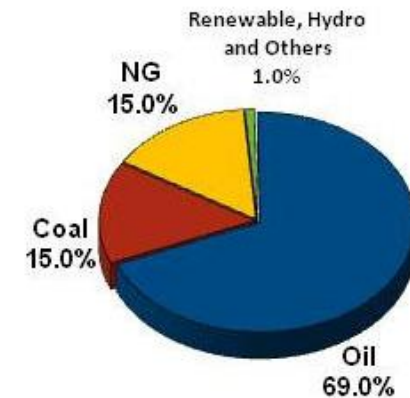


### Transmission and Distribution:

Transmission Lines:	2,444 miles
Distribution Lines:	31,446 miles
38 kV substations:	293
115 kV Transmission Centers:	41
230kV Transmission Centers:	10

Source: PREPA, as of June 30, 2010

### Fuel Diversification-Production (2009)

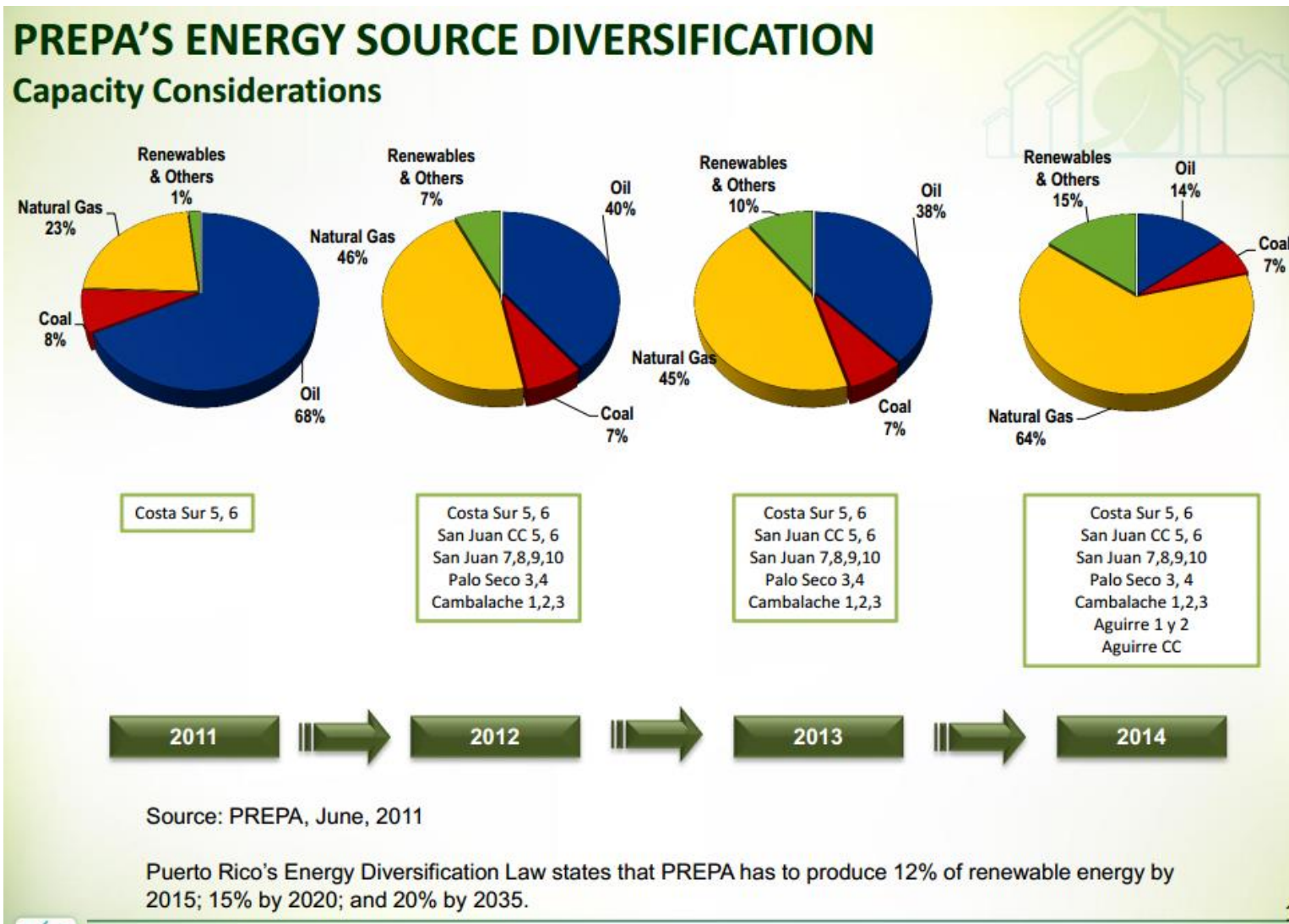


In addition, PREPA has 100 MW from 21 hydroelectric units and 8 MW from 7 Diesel Generators



# Large-Scale Hybrid Systems: Case Study

Former diversification plan for the power generation at the island



# Large-Scale Hybrid Systems: Case Study

New Grid Code designed to connect large scale PV plants to the grid

## Voltage Regulation System (VRS)

The PV facility shall contribute to the grid's voltage regulation, following the settings and reference of the utility's operator with a continuously variable and acting close loop.

## Frequency Ride-Through

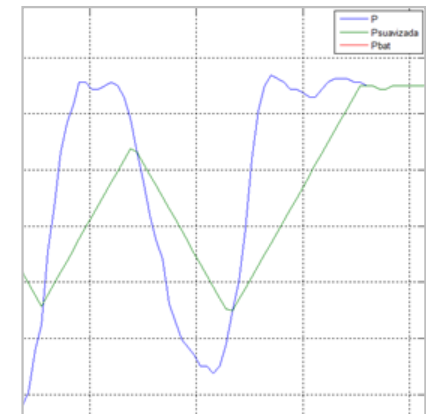
The frequency protection will be set under PREPA requirements.

## Voltage Ride-Through

The generators shall be online despite of the presence of 'voltage sags' (LVRT) and Overvoltage (OVRT) in the grid.

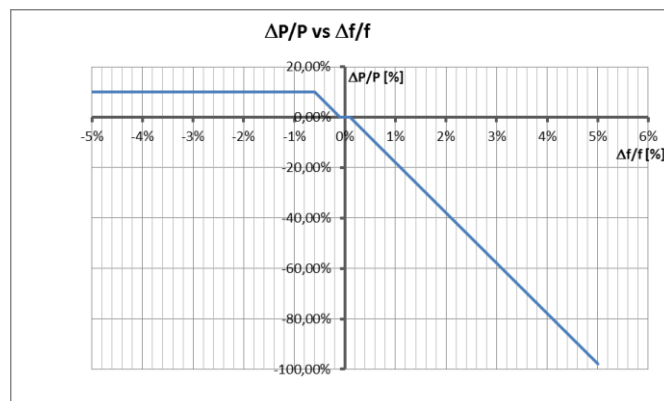
## Power Ramp Rate control

- The PV facility shall be able to **control the rate of change of power output** during some circumstances.
- The maximum change allowable is 10% of the rated power per minute. PV plant has to reduce power under utility demands (curtailment).



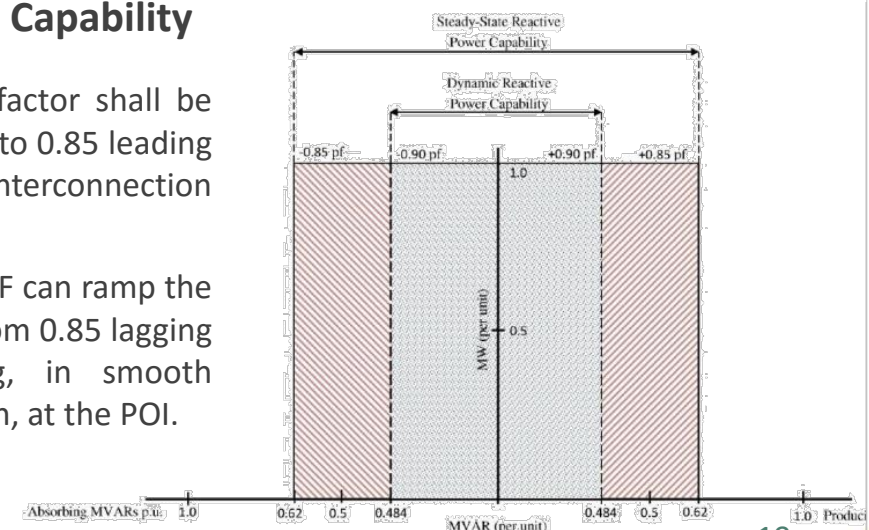
## Frequency response/regulation

PV facility should response like a classical governor due to primary frequency regulation.



## Reactive Power Capability

- The total power factor shall be from 0.85 lagging to 0.85 leading at the point of interconnection (POI).
- The aim is that PVF can ramp the reactive power from 0.85 lagging to 0.85, leading, in smooth continuous fashion, at the POI.





# Large-Scale Hybrid Systems: Case Study

25 years PPA with Local Electric Authority (PREPA)

Year	Energy Purchase Price \$/kWh*	Green Credit Purchase Price \$/kWh**
1	0.1430	0.0350
2	0.1459	0.0350
3	0.1488	0.0350
4	0.1518	0.0350
5	0.1548	0.0350
6	0.1579	0.0350
7	0.1610	0.0350
8	0.1643	0.0350
9	0.1675	0.0350
10	0.1709	0.0350
11	0.1743	0.0350
12	0.1778	0.0350
13	0.1814	0.0350
14	0.1850	0.0350
15	0.1887	0.0350
16	0.1925	0.0350
17	0.1963	0.0350
18	0.2002	0.0350
19	0.2042	0.0350
20	0.2083	0.0350
21	0.2083	0.0350
22	0.2083	0.0350
23	0.2083	0.0350
24	0.2083	0.0350
25	0.2083	0.0350



## Financial Details (Estimated)

CAPEX	40 M\$
OPEX	0,3 M\$/y
Annual Irradiation	2,2 MWh/m2
Start of operation	2015
Operation period	25

\* The Energy Purchase Price for Agreement Years 2 to 20 shall be escalated in an amount equal to two percent (2%) per Agreement Year.

\*\* The Green Credit Purchase Price for Agreement Years 1 to 25 shall be equal to \$0.0350/kWh. The Green Credit Purchase Price shall not be subject to escalation.

# Large-Scale Hybrid Systems: Case Study

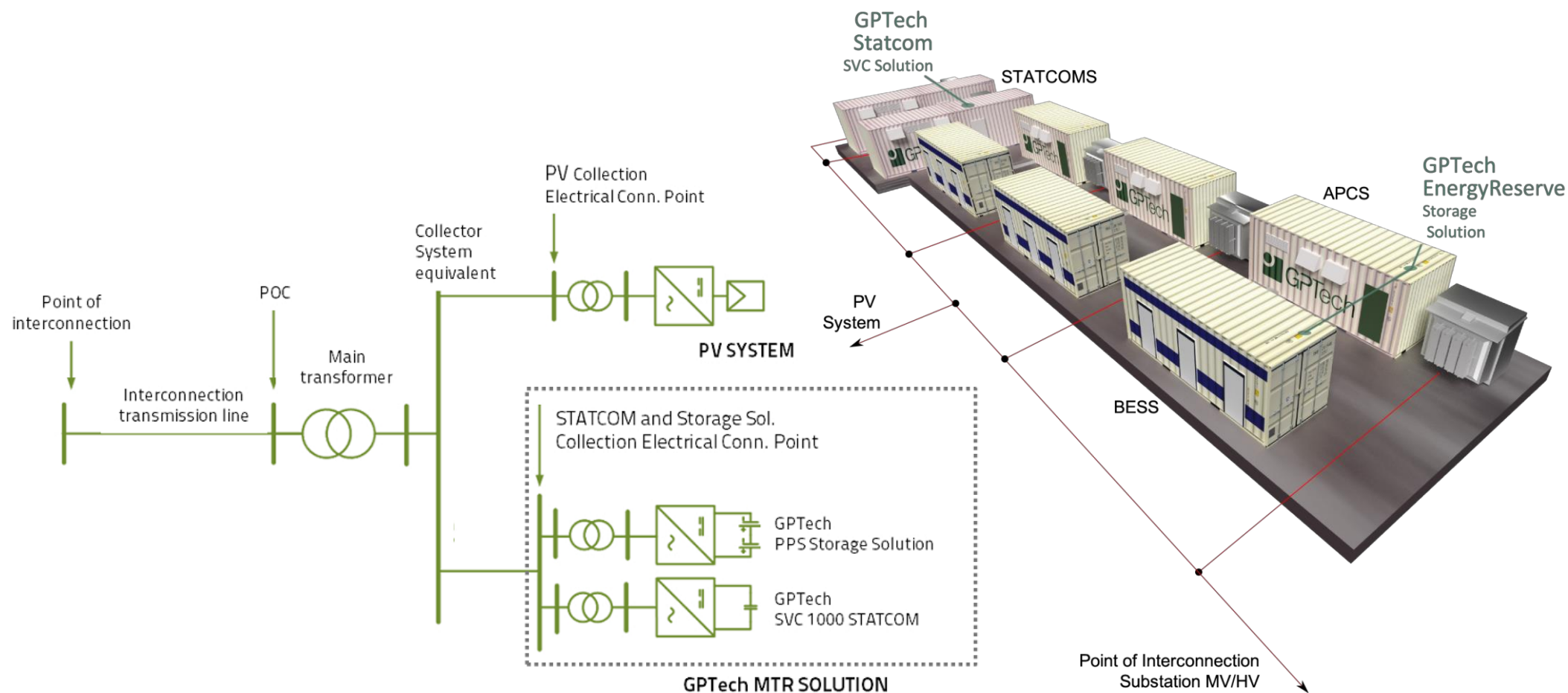
GP Tech's solution for connecting a 11MW PV plant and MTR compliance

System	Description	Tech. Data	Qty.
Batteries	Containerised ready-to-install Li-ion technology Intensium Max	<ul style="list-style-type: none"> <li>Voltage range: 600-800Vdc</li> <li>Peak Power: 1,8 MW</li> <li>Energy@BOL: 420kWh (40% DoD)</li> </ul>	3 containers of 1,1MW Continuous (1.8 MW peak, 1')
BPCS	GP Tech DC/AC BPCS, based on PVWD proofed technology	<ul style="list-style-type: none"> <li>Nominal Power: 5.1MVA.</li> </ul>	3 ContainersX 1700
FACTS	GP Tech DC/AC FACTS, based on SCV1000WD	<ul style="list-style-type: none"> <li>Nominal Power: 7MVA.</li> </ul>	1 container x 4MVA 1 Container x 3MVA



# Large-Scale Hybrid Systems: Case Study

GP Tech's solution for connecting a 11MW PV plant and MTR compliance

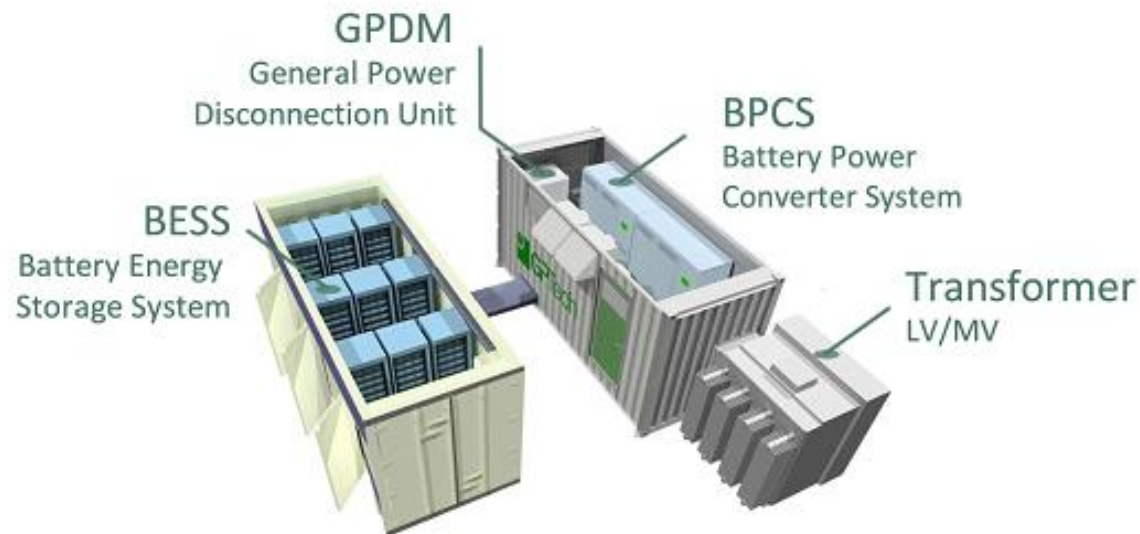




# Large-Scale Hybrid Systems: Case Study

## Storage system

**GP Tech EnergyReserve:** BESS system with modular GP Tech Battery Power Conditioning System.



**GP Tech STATCOM:** Integrated Solution using modular electronic converters for VAR support.

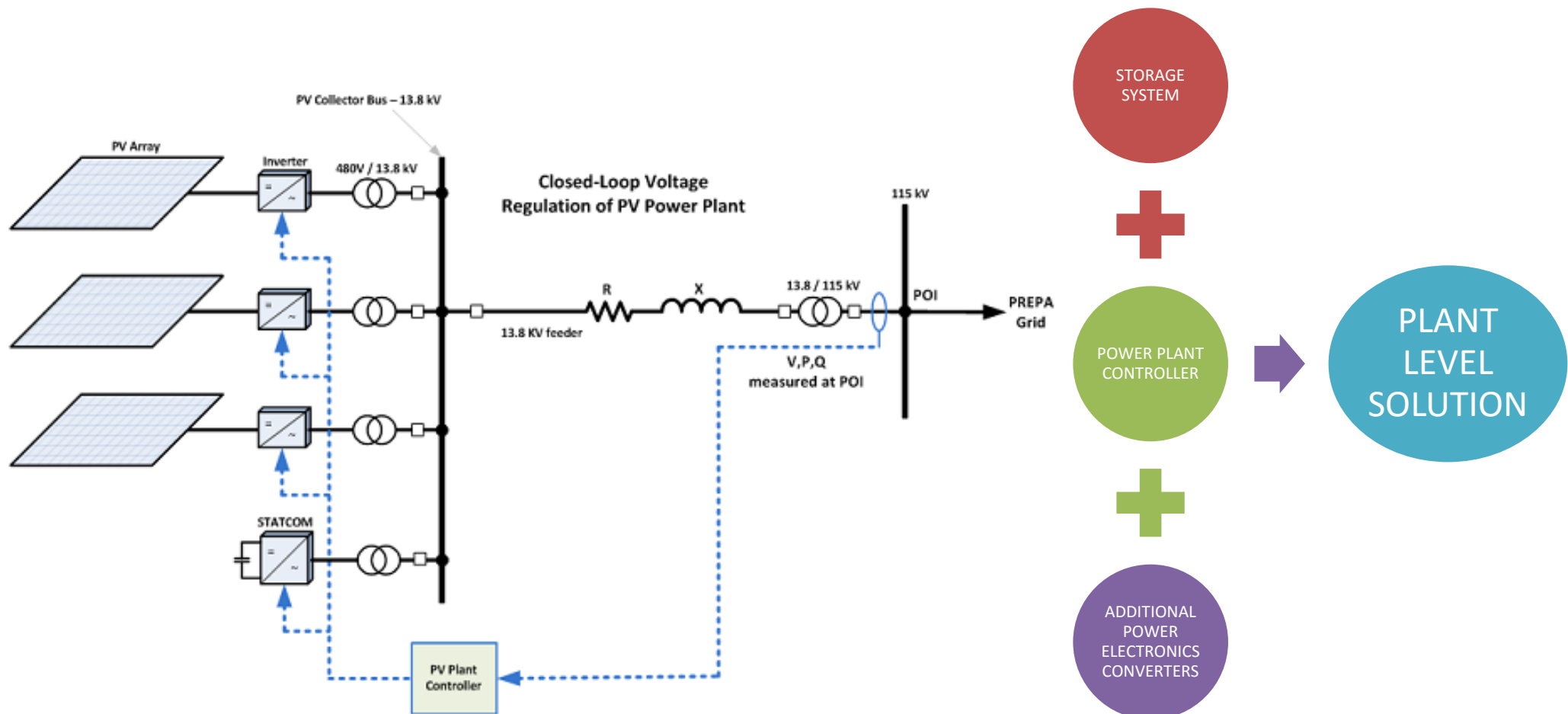
**GP Tech EMSysystem PPC:** Power Plant Controller for centralised management of the Power Regulation.



# Large-Scale Hybrid Systems: Case Study

Plant level solution for Control : EMS

The full compliance requires a plant level solution with additional systems a central control



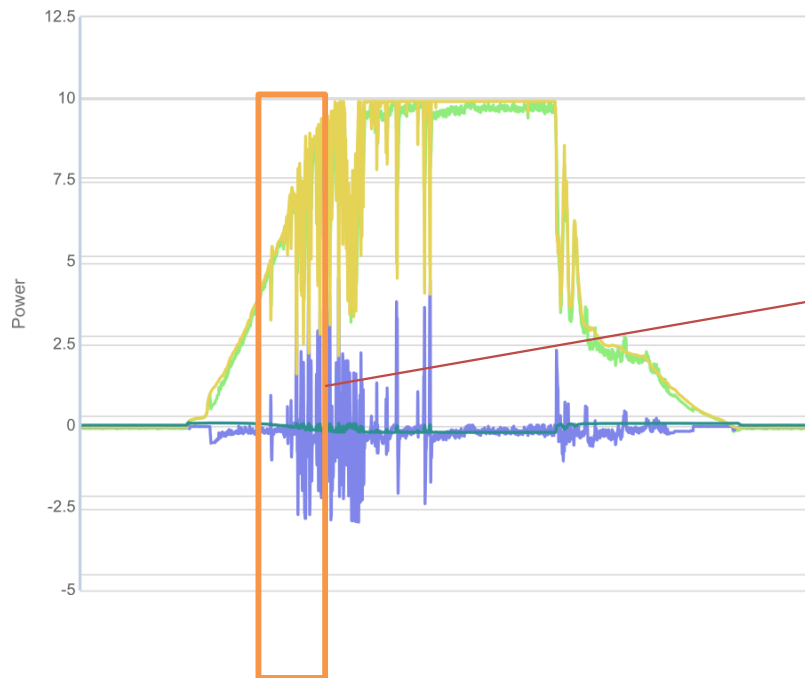
Source: NREL



# Large-Scale Hybrid Systems: Case Study

Results: Fast Dynamic Response

- PPC Response time < 250 ms

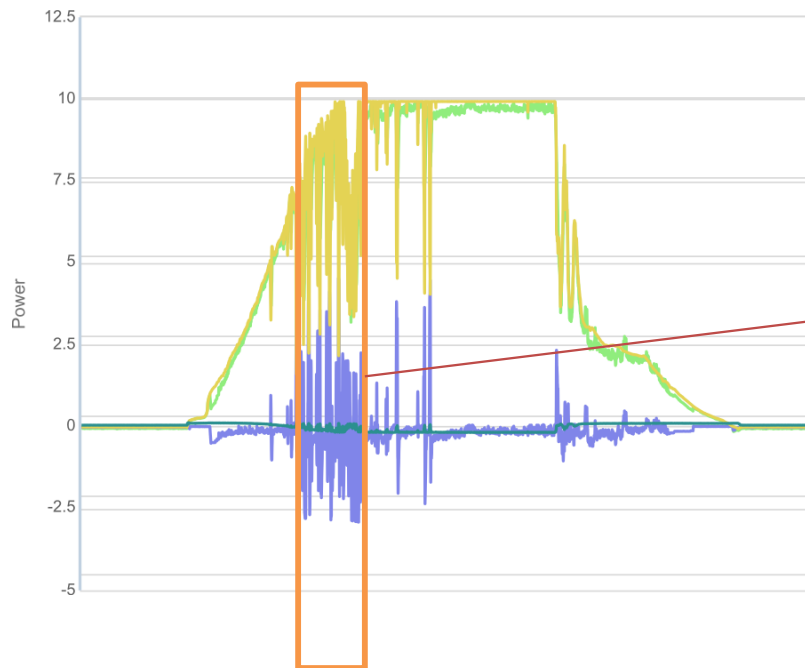


# Large-Scale Hybrid Systems: Case Study

Results: Ramp-Rate Behaviour

## PREPA Minimum Requirements

PV ramp rate control: 10% per minute

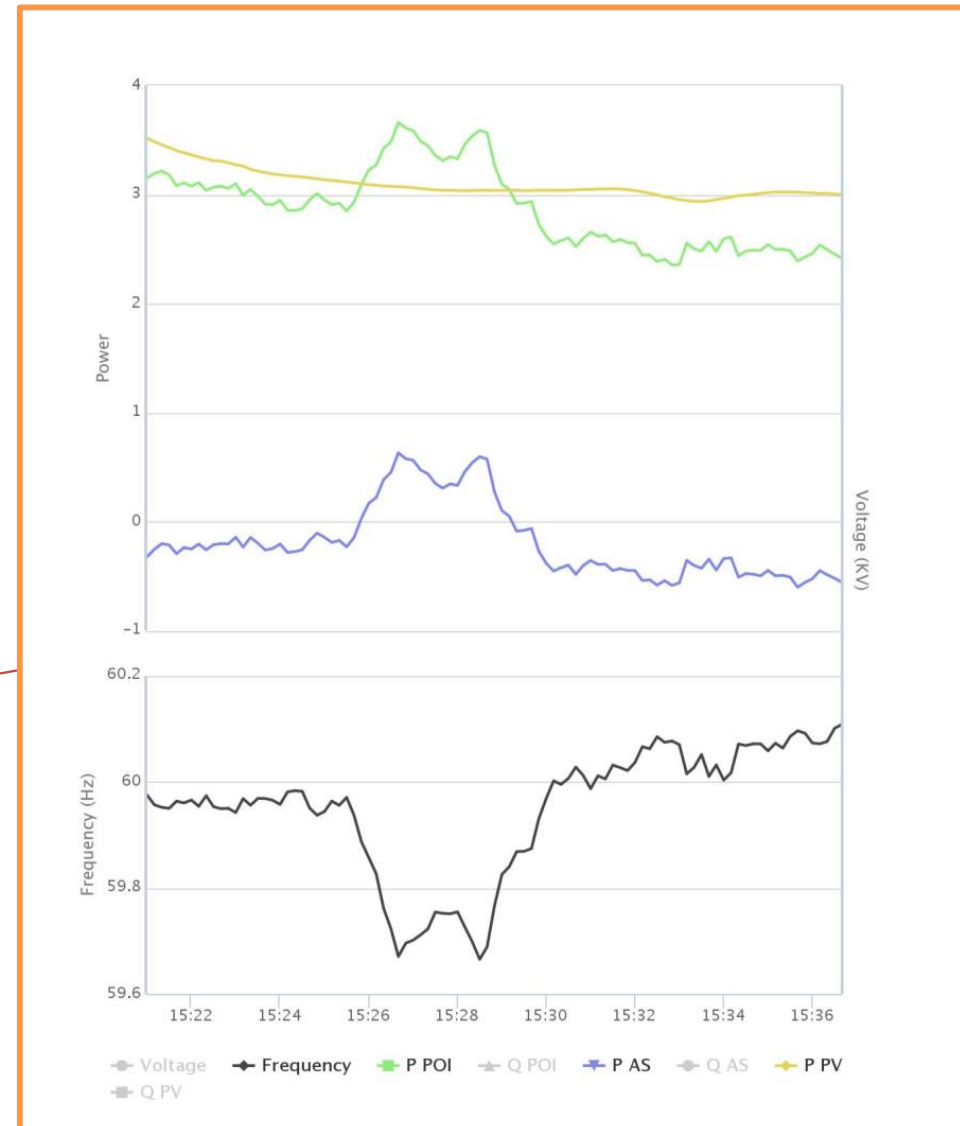
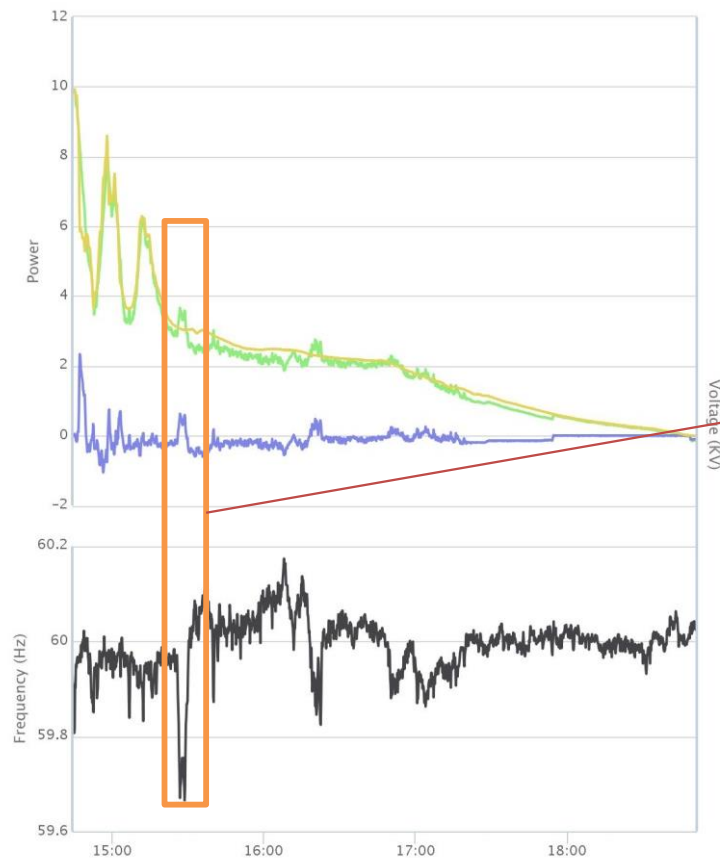


# Large-Scale Hybrid Systems: Case Study

## Results: Frequency Regulation

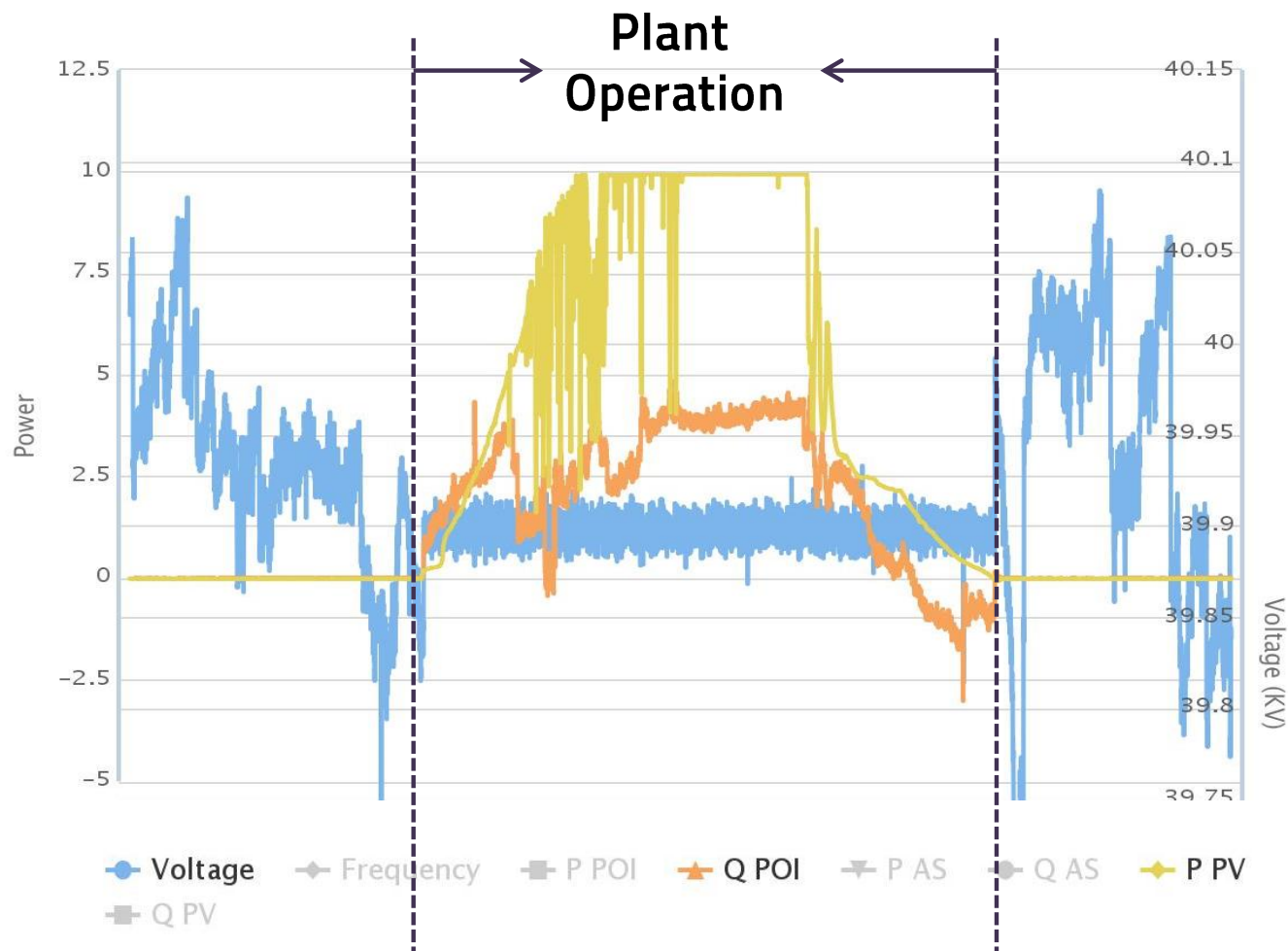
### PREPA Minimum Requirements

**Frequency response** with 5% droop, up to 9 minutes in case of large under-frequency events



# Large-Scale Hybrid Systems: Case Study

Results: Voltage Regulation with STATCOMs



# Conclusion

1. We are involved in an Energy Revolution
2. The storage will be a key technology to make the change feasible
3. The cost of the new energy mix, using renewable energy, will be competitive.
4. We don't have to compromise the grid quality in this new scenery, moreover, we must demand its improvement by using new technologies like smart grids.



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