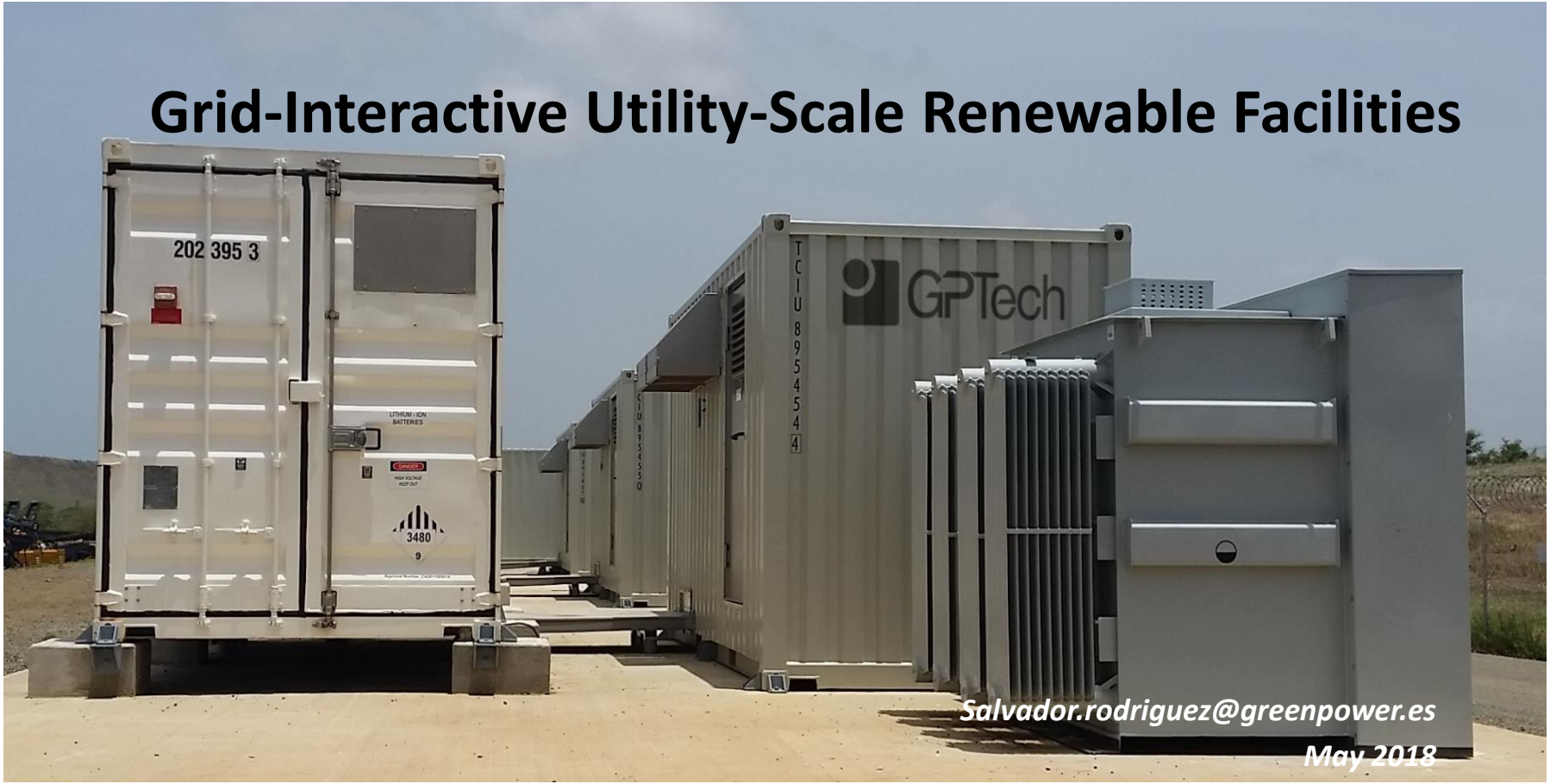
Grid-Interactive Utility-Scale Renewable Facilities



Salvador.rodriguez@greenpower.es

May 2018

GPTech

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- Case Study 3: Flexible Renewable Generation In Usa
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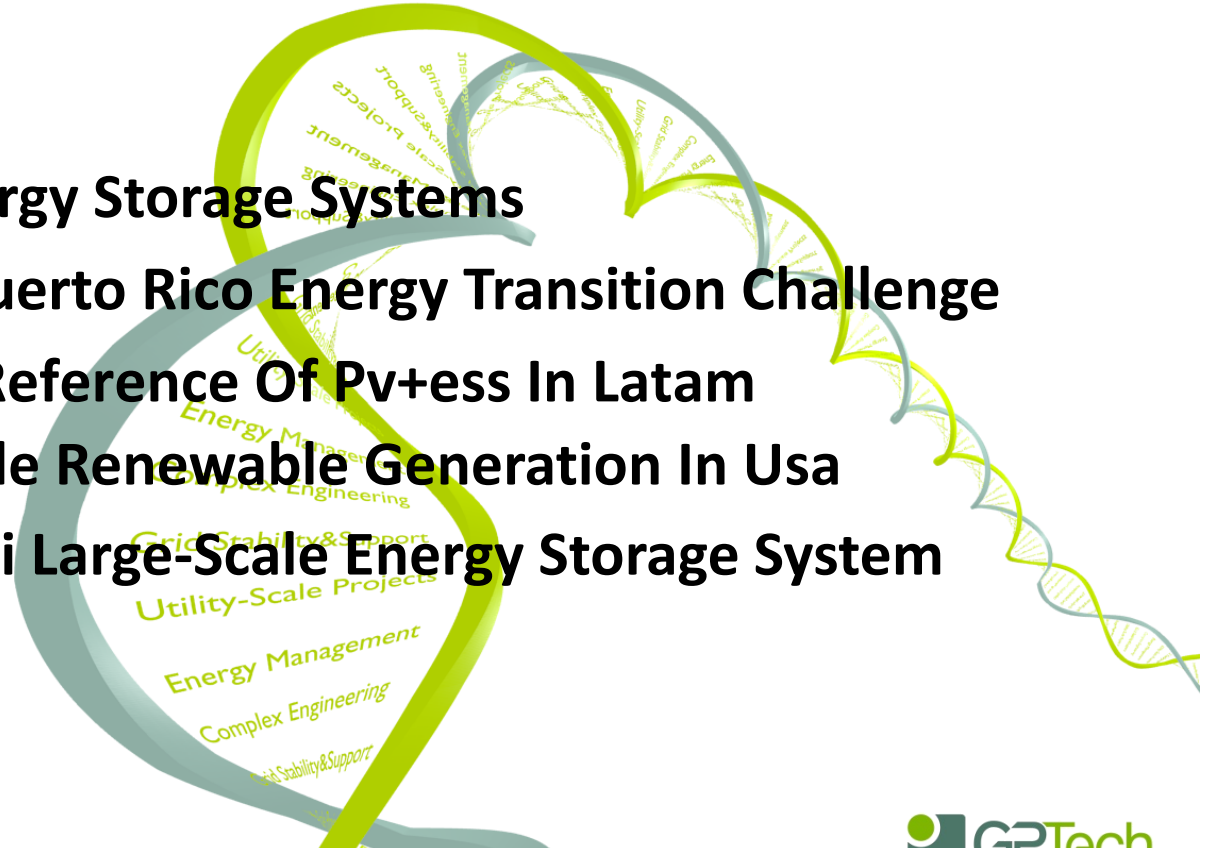
- Conclusions



GPTECH: FLEXIBLE RENEWABLE ENERGY

About us: Some Numbers & Milestones

GPTech is a leading Designer and Turn-Key Supplier of Energy Management Systems solving every integration challenge for Utility-Scale generation plants.

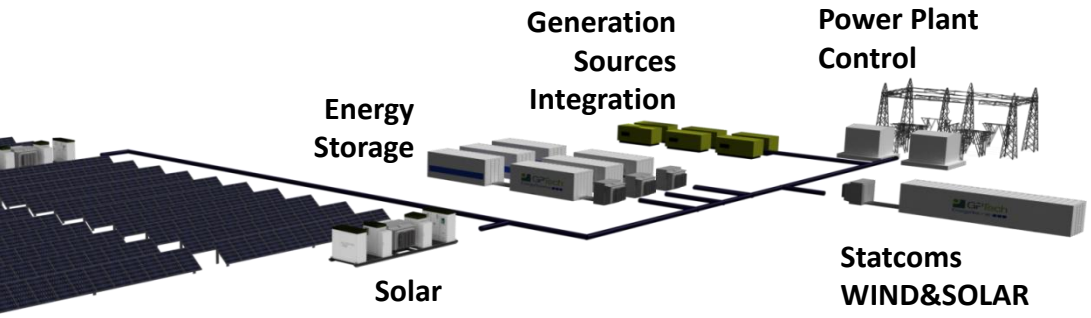
+2.7 GW INSTALLED

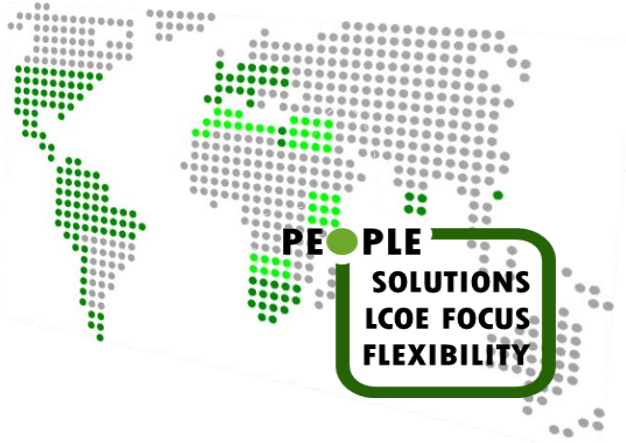
20 COUNTRIES

+15 YEARS EXPERIENCE

+1.5 GW/YR CAPACITY

ENERGY MANAGEMENT SYSTEMS

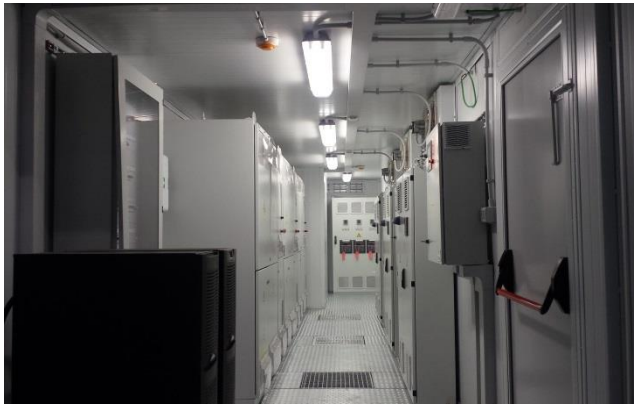




GPTECH: FLEXIBLE RENEWABLE ENERGY

About us: Challenging Grid Integration Environments

ESS - Salinas – Puerto Rico



PV - Santa Julia - Chile

STATCOMs +CAPACITOR BANKS
Quilapilum –Chile

PV - El Centro - California

ESS + PV - New Orleans

R&D Center - Spain

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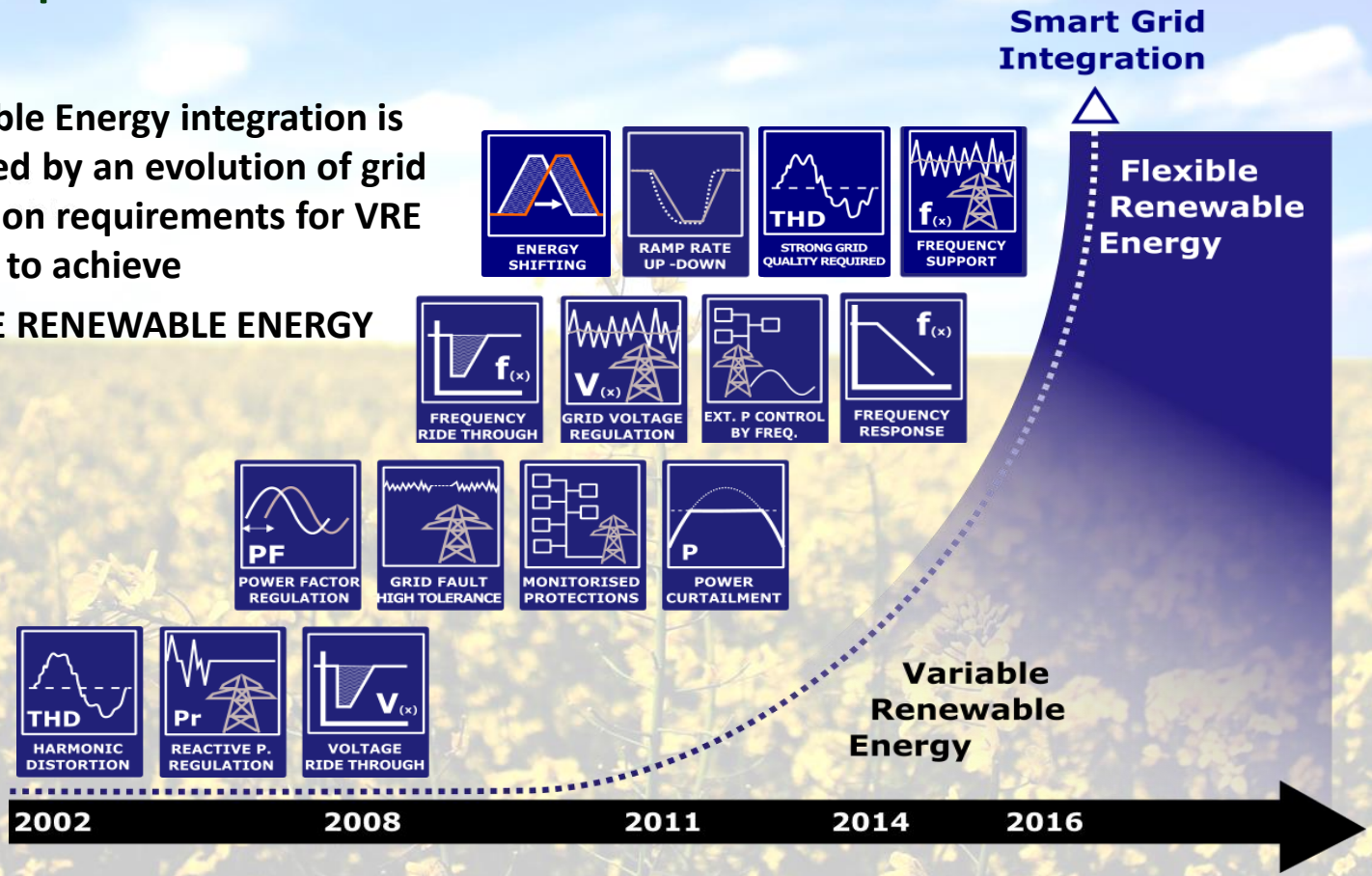
GRID-INTERACTIVE ENERGY STORAGE SYSTEMS

New Requirements for Renewable Grid Connection

Renewable Energy integration is supported by an evolution of grid connection requirements for VRE facilities to achieve

FLEXIBLE RENEWABLE ENERGY



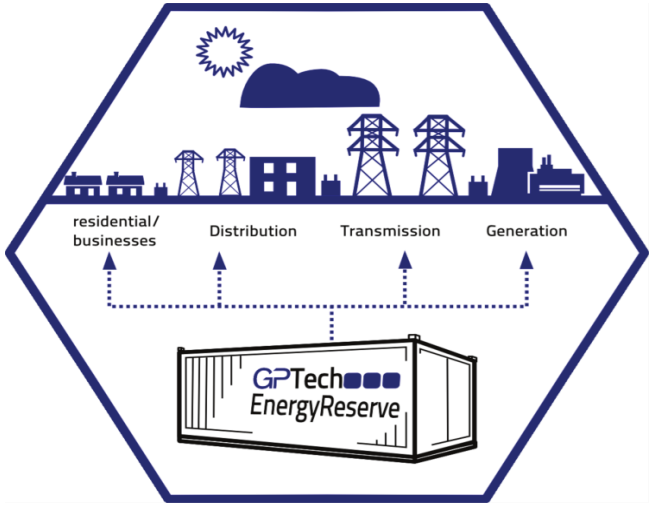
GRID-INTERACTIVE ENERGY STORAGE SYSTEMS

What services can batteries provide to the electricity grid?

Final services provided by Battery Systems to the grid depend on many variables i.e. as the location where the system is installed or how the electricity authorities regulate the use of stored energy.

Grid support services

- Frequency regulation.
- Spinning reserve
- Peak shifting
- Black start
- VAR support
- Voltage regulation
- Load leveling



Renewables Integration

- Grid code compliance
- Ramp rate control
- Contribution to frequency regulation
- Voltage regulation
- VAR support
- Capacity firming

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Grid-Interactive Utility-Scale Renewable Facilities

Case Studies

CS 1: PUERTO RICO ENERGY TRANSITION CHALLENGE

SALINAS: (5.4 MWp/1.26 MWh) ESS + (10MWn) PV

- **An advanced ancillary services solution with ESS and PV as power source is required to comply with all the local requirements.**
- **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

ees AWARD 2016 finalist

GPTech Energy Storage Solution in Salinas, Puerto Rico

CS 1: PUERTO RICO ENERGY TRANSITION CHALLENGE

Project Development Market Framework

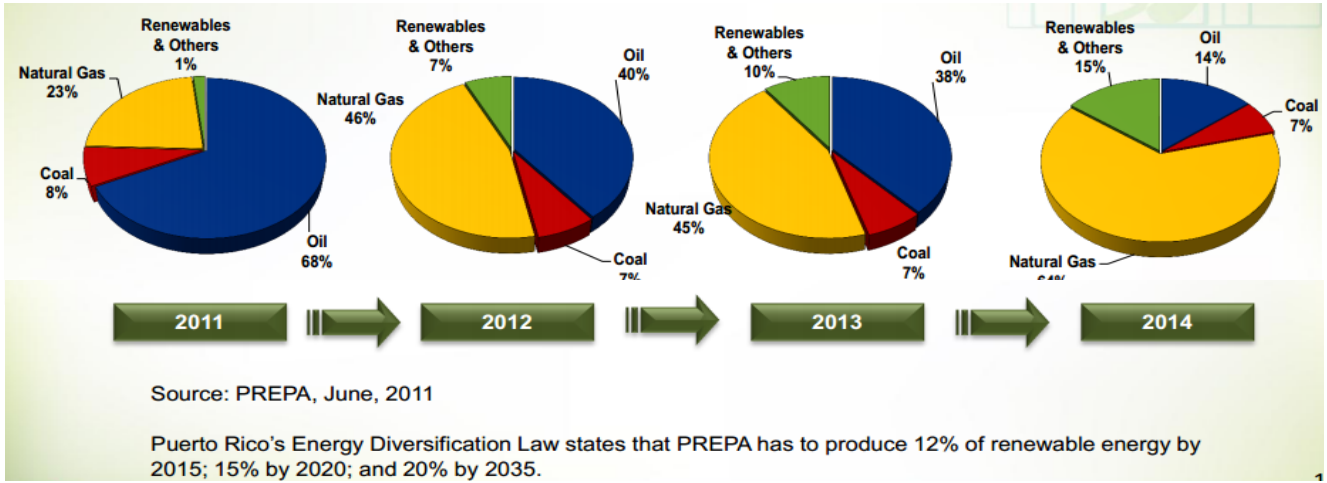
Electric System:

Generating Capacity:	5,839 MW
Peak Demand (in 9/05):	3,685 MW

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



Source: PREPA, June, 2011

Puerto Rico's Energy Diversification Law states that PREPA has to produce 12% of renewable energy by 2015; 15% by 2020; and 20% by 2035.

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CS 1: PUERTO RICO ENERGY TRANSITION CHALLENGE

Utility requirements: technical risks that seemed to threat IPP returns…..

GRID CODE REQUIREMENTS

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

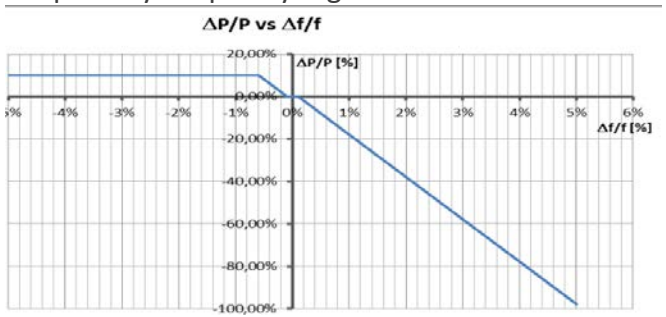
The generators shall be online despite of the presence of 'voltage sags' (LVRT) and Overvoltage (OVRT) in the grid.

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).

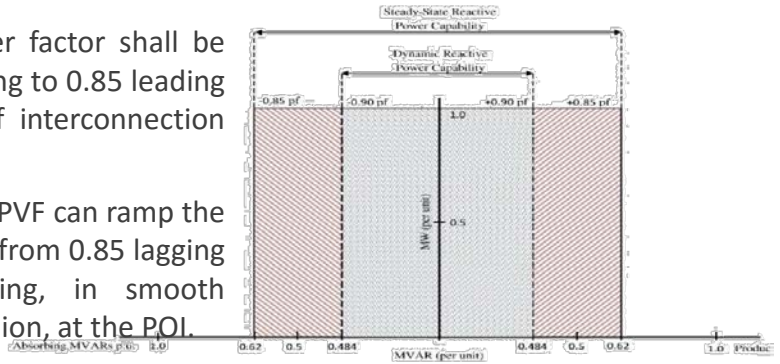
Frequency response/regulation

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



Reactive Power Capability

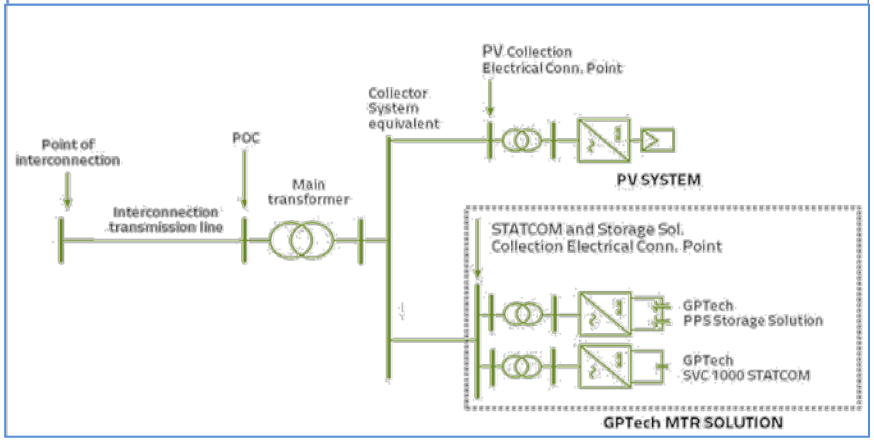
- The total power factor shall be from 0.85 lagging to 0.85 leading at the point of interconnection (POI).
- The aim is that PVF can ramp the reactive power from 0.85 lagging to 0.85, leading, in smooth continuous fashion, at the POI.

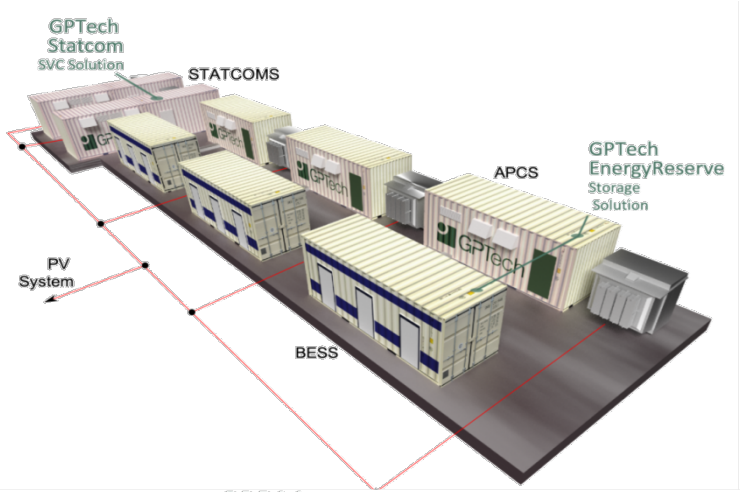


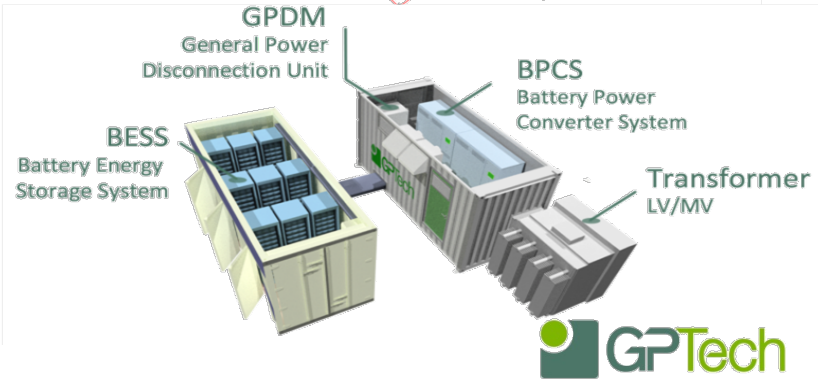
CS 1: PUERTO RICO ENERGY TRANSITION CHALLENGE

… resulting in a completed full-adapted solution to meet all requirements

System	Description	Qty.
Batteries	Containerised ready-to-install Li-ion technology Intensium Max	3 containers of 1,1MW Continuous (1.8 MW peak, 1')
BPCS	GPTech DC/AC BPCS, based on PVWD proofed technology	3 ContainersX 1700
FACTS	GPTech DC/AC FACTS, based on SCV1000WD	1 container x 4MVA 1 Container x 3MVA



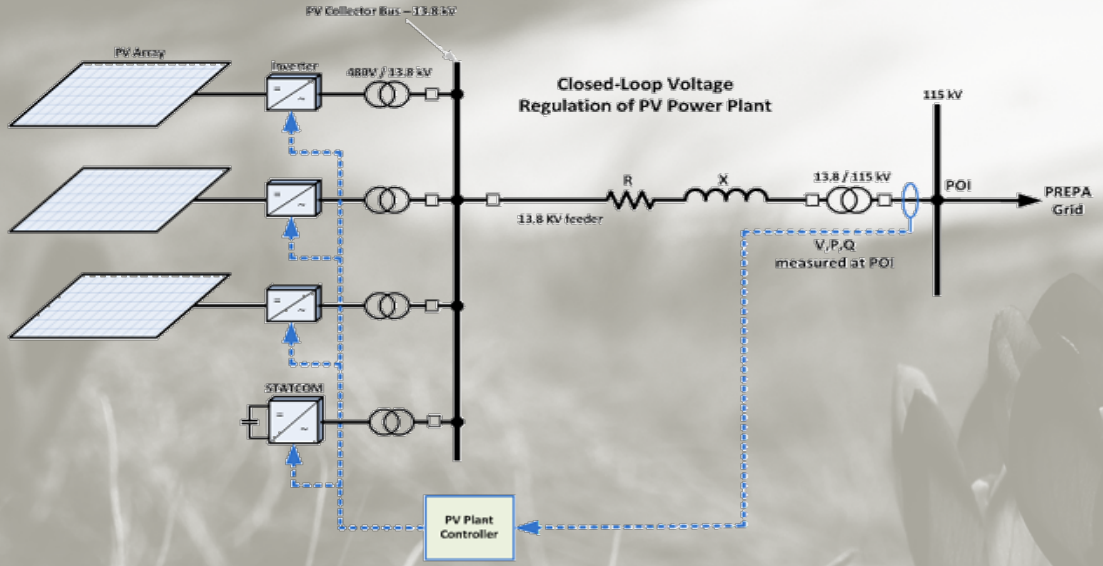




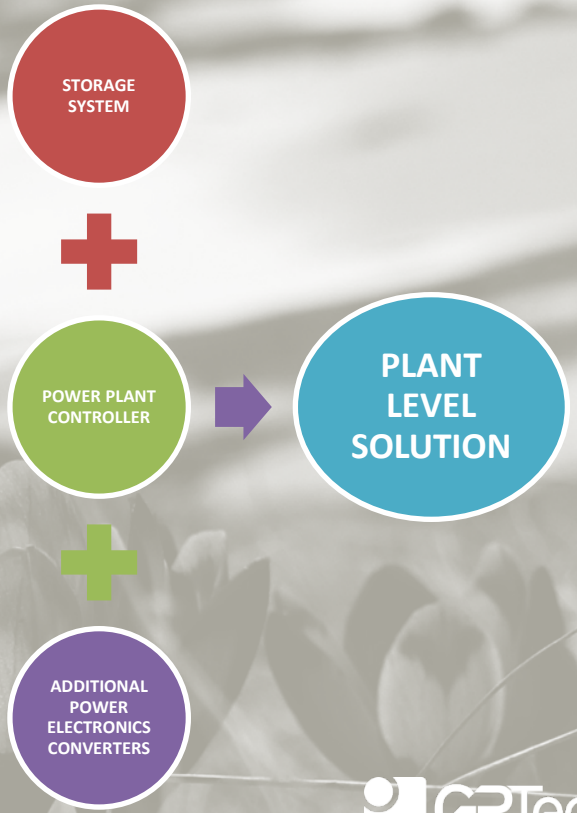
CS 1: PUERTO RICO ENERGY TRANSITION CHALLENGE

Plant level solution through a Controlling System

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



Source: NREL



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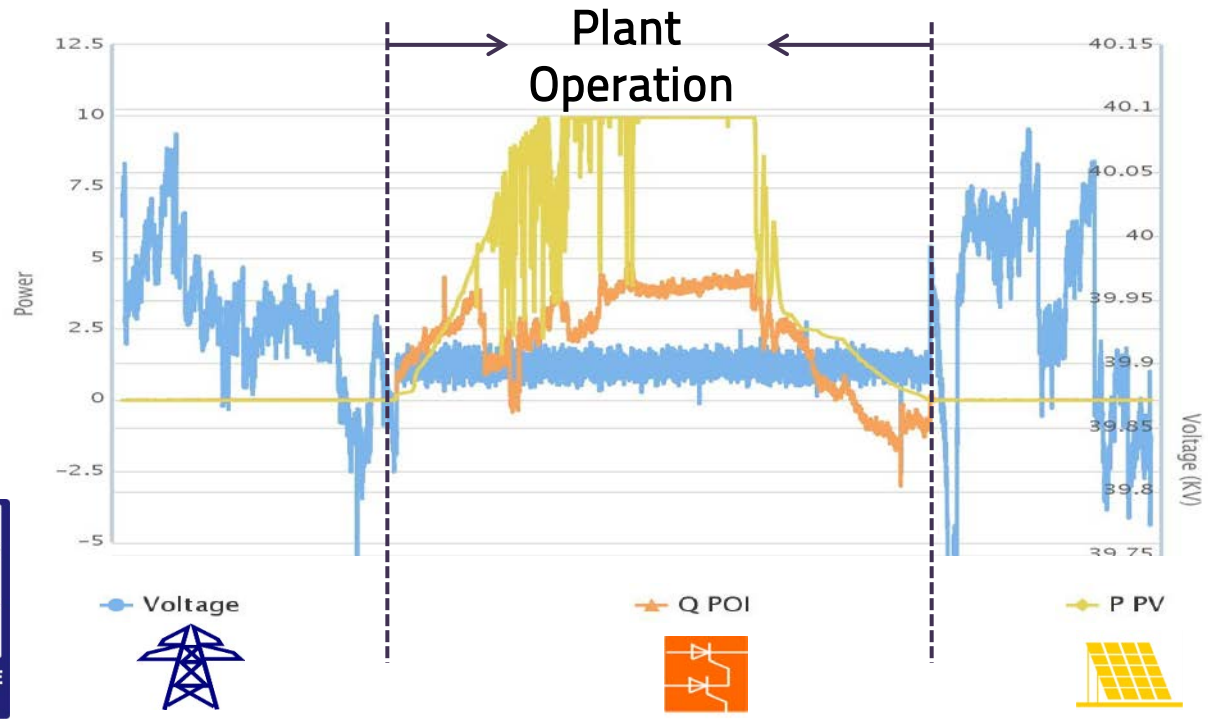
CS 1: PUERTO RICO ENERGY TRANSITION CHALLENGE

Results: Voltage Regulation



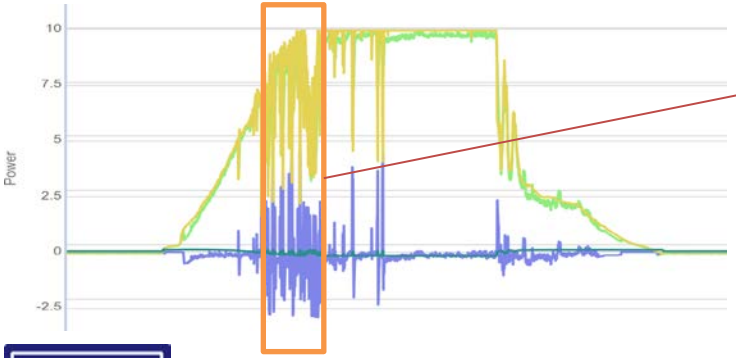
GRID VOLTAGE REGULATION

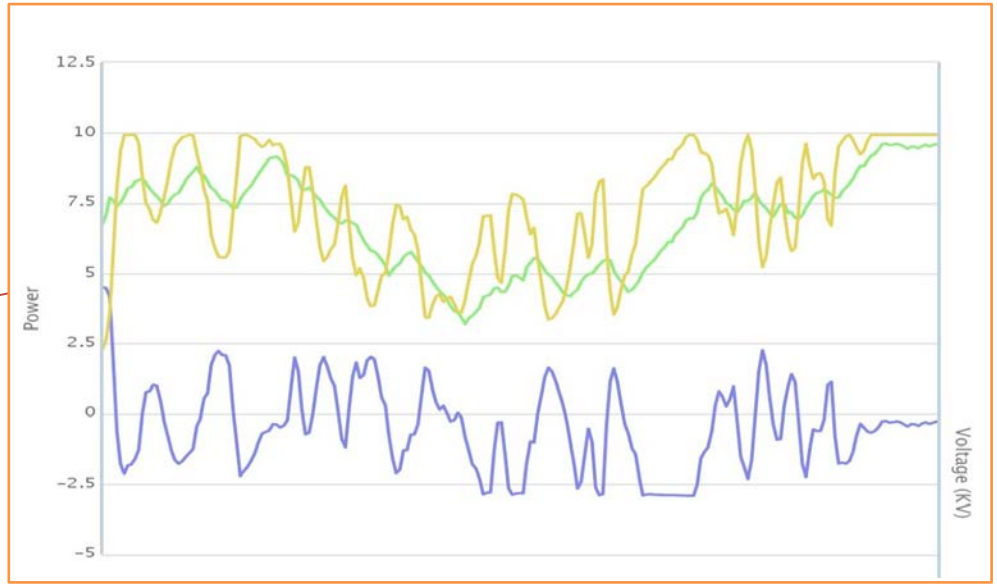
GPTech

CS 1: PUERTO RICO ENERGY TRANSITION CHALLENGE

Results: Response time < 250 ms

- Ramp Rate with Fast Dynamic Response
- In a Cloudy Day the Intermitency is solved with the Storage System





PREPA Minimum Requirements

PV ramp rate control: 10% per minute

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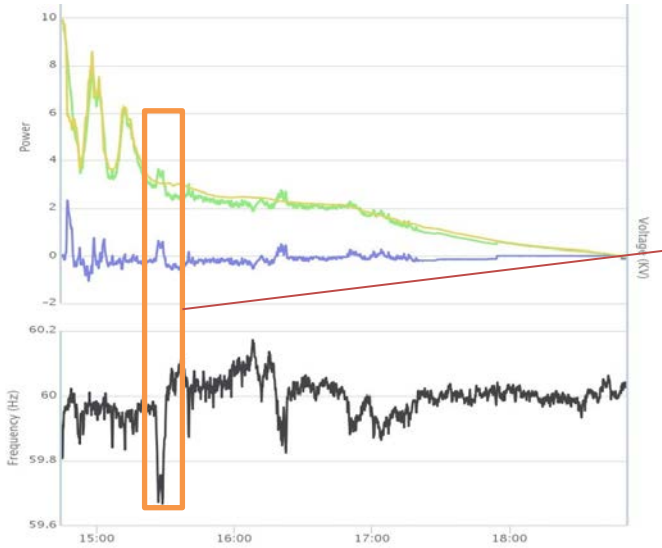
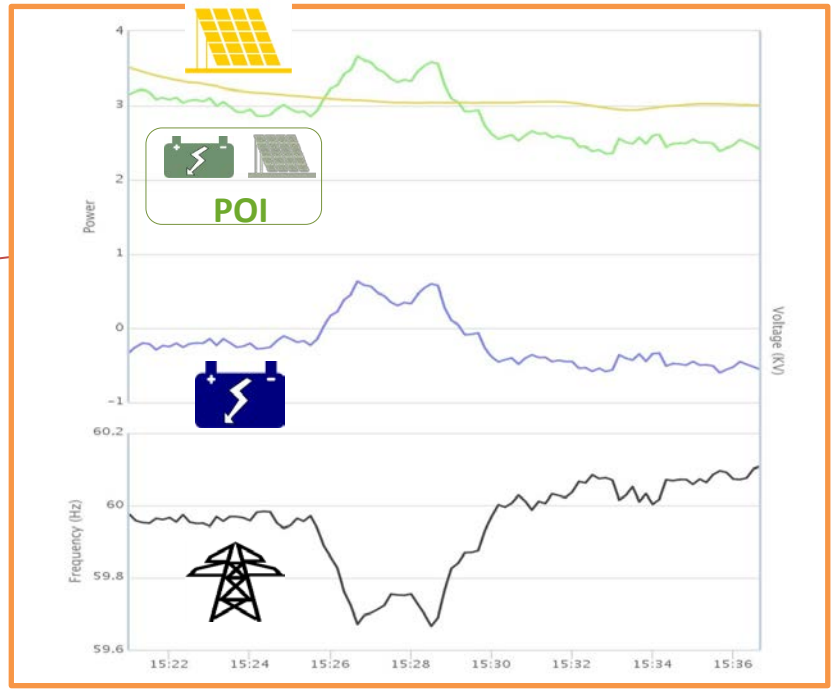
CS 1: PUERTO RICO ENERGY TRANSITION CHALLENGE

Results: Frequency Regulation





FREQUENCY REGULATION

PREPA Minimum Requirements

Frequency response with 5% droop , up to 1 MW for 9 minutes in case of large under-frequency events

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CS 2: ISABELA, NEXT REFERENCE OF PV+ESS IN LATAM

ISABELA: (21.6MW/5.04MWh) ESS + (55MW) PV

- The largest PV Plant in Caribean region combined with one of the largest ESS system in LATAM

CS 2: ISABELA PROJECT

ISABELA: (21.6 MW/4.2 MWh) ESS + (55MWp) PV

- This project uses the accumulated know-how in Energy Storage Integration in a huge scale.
- Time to develop is dramatically reduced compared to other projects in the region (< 1 year from start to comissioning)

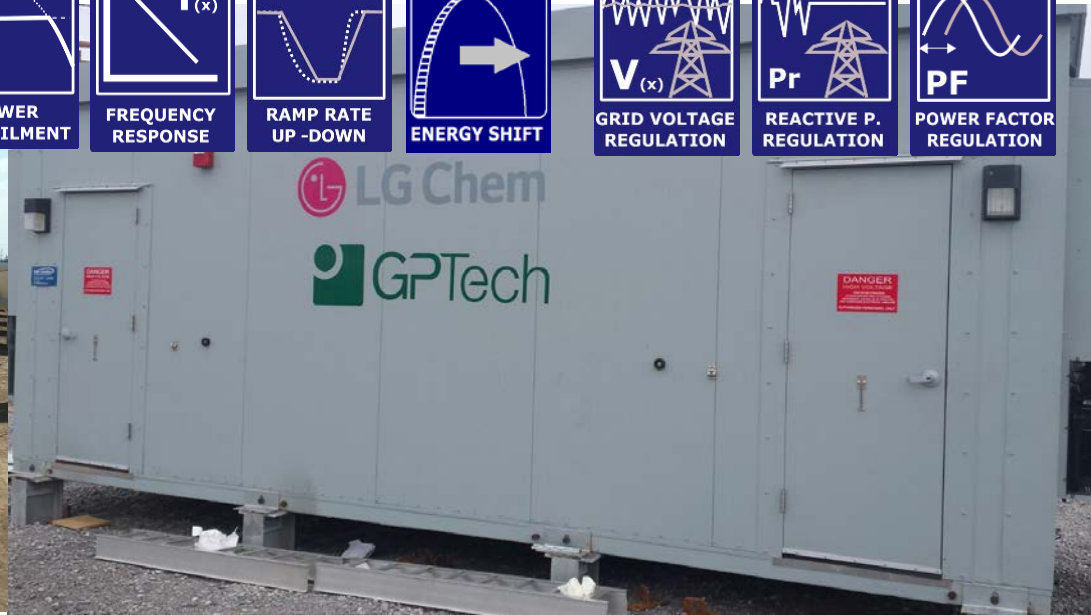
System	Description	Tech. Data	Qty.
Battery System	Containerised ready-to-install Li-ion technology Intensium Max	▪ Voltage range: 600-800Vdc ▪ Peak Power: 2,2 MW ▪ Energy@BOL: 420kWh (40% DoD)	10 containers x 1,35MW Continuous (2,2 MW continuous peak, 1')
BPCS	GPTech DC/AC BPCS, based on PVWD proofed technology	▪ Nominal Power: 21.6 MW	10 EnergyReserve IS20 Containers x 1700
FACTS	Capacitor Banks	▪ Nominal Power: 4MVA.	2 container x 2 MVA

GPTech

CS 3: FLEXIBLE RENEWABLE GENERATION IN USA

NEW ORLEANS: (5.4 MWp/1.26 MWh) ESS + (10MWn) PV

- Utility-scale solar generation, battery storage and state-of-the-art Power Plant Control technology
- Creating a standard for utility-scale solar generation performance in New Orleans



GENERAL

START/STOP

ACTIVE POWER BASED

P
POWER CURTAILMENT

$f_{(x)}$
FREQUENCY RESPONSE

RAMP RATE UP -DOWN

ENERGY SHIFT

REACTIVE POWER BASED

$V_{(x)}$
GRID VOLTAGE REGULATION

Pr
REACTIVE P. REGULATION

PF
POWER FACTOR REGULATION

CS 3: FLEXIBLE RENEWABLE GENERATION IN USA

NEW ORLEANS: (5.4 MWp/1.26 MWh) ESS + (10MWn) PV

System	Description	Tech. Data	Qty.
Battery System	Containerised ready-to-install Li-ion NMC technology	▪ Voltage range: 588-823Vdc ▪ Peak Power: 500 kW Energy@BOL: 500kWh	1 containers x 0,5 MW Continuous
BPCS	GPTech EnergyReserve APCS, based on WD proofed technology	▪ Nominal Power: 500 kW.	1 SKID Container
PV	GPTech APIS 1000, based on inverters PVWD500 UL	▪ Nominal Power: 1,008kW AC.	1 SKID container

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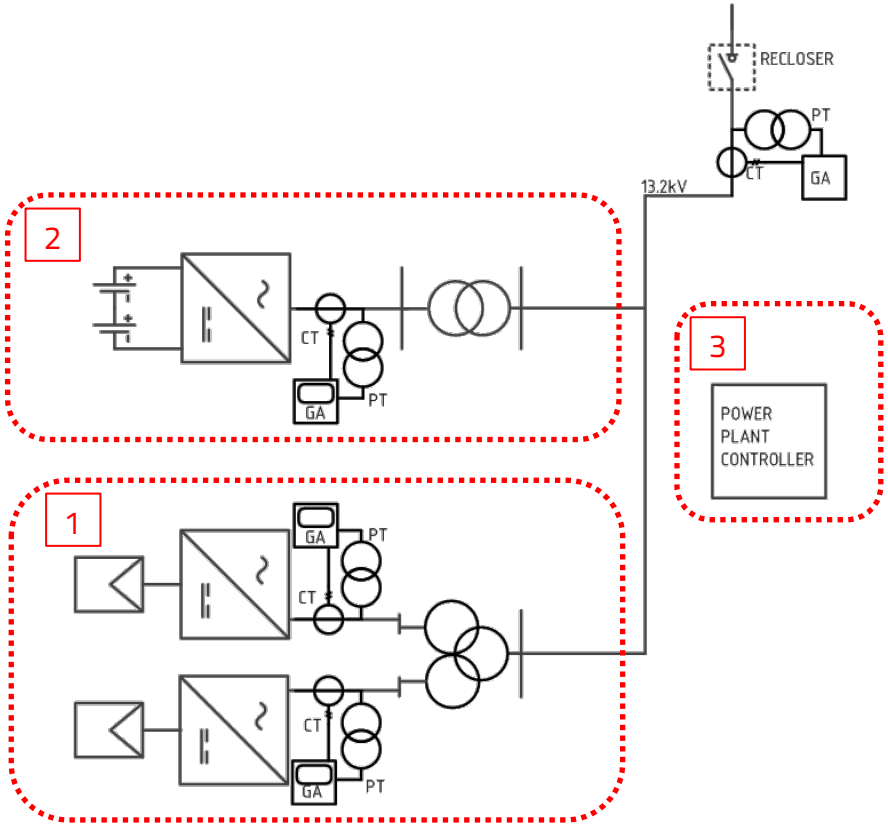
CS 3: FLEXIBLE RENEWABLE GENERATION IN USA

Project Configuration

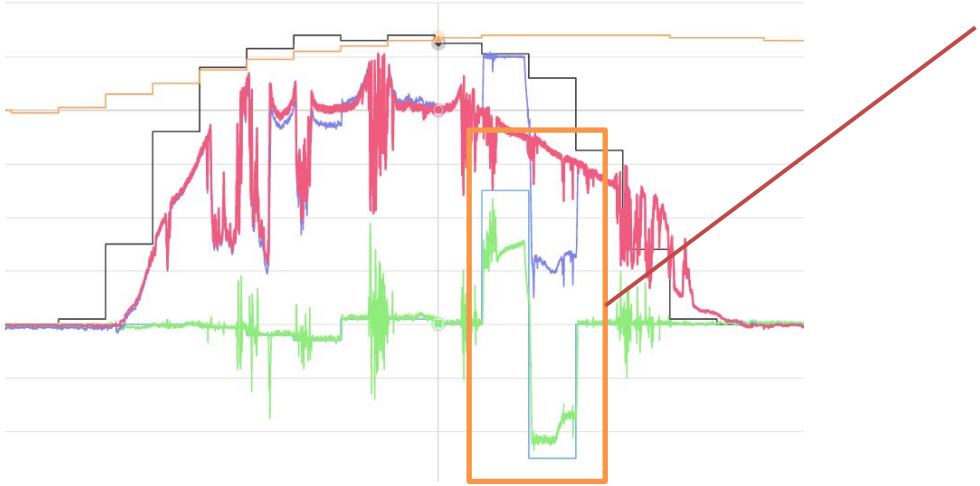


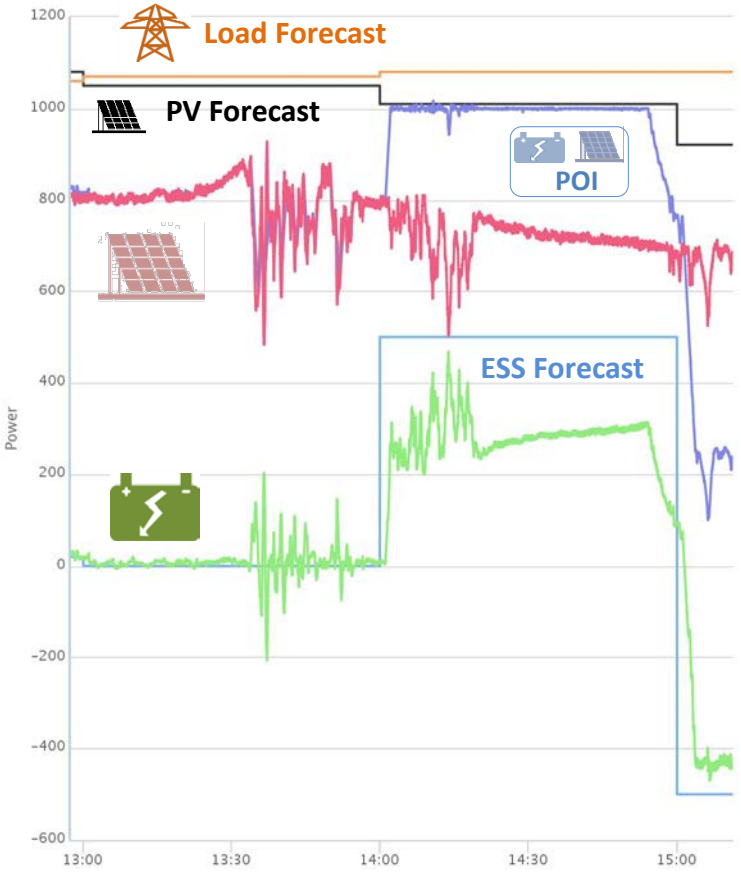
1. PV System (1.34MW_{DC}/1.08MW_{AC}):
   - **PV Field**
   - **1 x APIS or PV Power Station**
2. **Energy Storage System (ESS):**
   - **Battery Energy Storage System**
   - **1 x APCS or ESS Power Station**
3. Power Plant Controller
4. Communication System

CS 3: FLEXIBLE RENEWABLE GENERATION IN USA

Energy Shifting

- A portion of PV production is stored within ESS in order to be injected a most convenient hour, based on a schedule reference, which itself is based on a specific criteria.
- Based on PV production forecast and line load (24h ahead)





Energy Storage System supplied in Hawaii

DC Connection for the ESS

GPTech

INTRODUCTION

Main Objetives

Energy Storage System supplied by End Client (ESS) together with an Advanced Control, Communication and Monitoring Solution (CCMS: Management System + Advanced Supervisory System) in order to connect a Flexible Solar Power Plant, rated 20MWac - 28 MWdc located in USA.

The design will ensure the fulfilment of the grid requirements, while improving the power generation stability and the dispatchability of the plant by the use of BESS (Batteries Energy Storage System).

INTRODUCTION

Why us?

The optimal combination of technologies and interfaces proposed by GPTech allows turning an intermittent energy source into a flexible generation plant that improves the grid quality and adds true utility value.

Complexity associated to the combination and interaction of several coexisting subsystems and the highly complicated technical requirements by the Electrical Authorities have been taken into account in the design of the solution supported by the broad expertise of GPTech in Puerto Rico and other international references.

FINAL SOLUTION

Main Requirements

Intention to build a PV Plant of 20 MWac, 28 MWp with a dispatchability capacity of 100% of power for 5 hours. The sizing a distribution of power and energy during the year has been done by our customer. Additionally, the dispatchability other requirements related with the batteries operation are:

- - Ramp rate (up and down) remotely adjustment.
- - Under & over frequency response. Remotely adjustable droop.
- - Frequency response in a time lower than 50 ms.
- - Remote BESS four quadrant kVA control.

DC/DC converter for the BESS and a single DC/AC inverter to connect the batteries and BESS to the grid. This configuration improves the maximum output power of the DC/AC converter at the same time is improving the efficiency of the charge/discharge cycle.

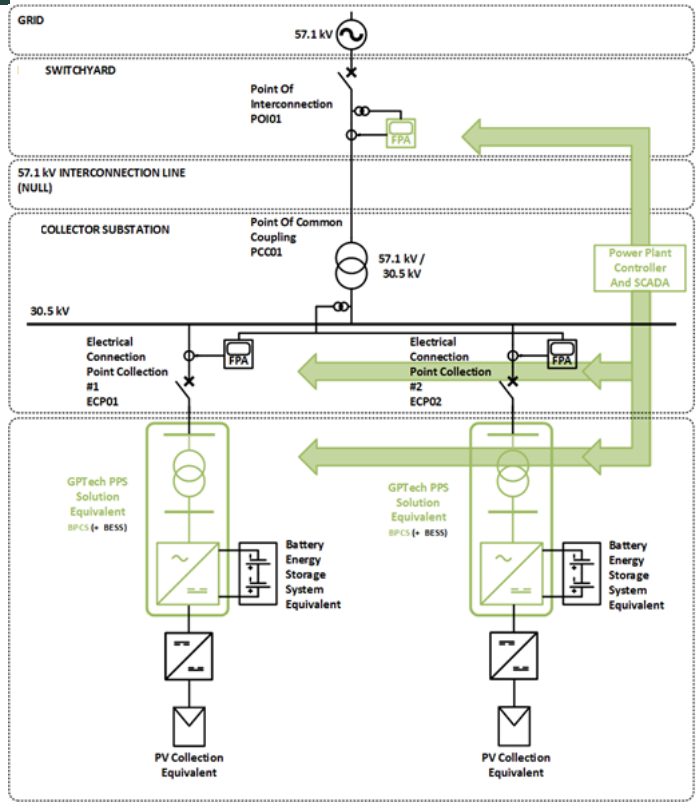
Operation day target is 2018. The expected operation time is 25 year.

Scope: Turnkey Proposal. Design, optimization, engineering, procurement, installation-construction, integration, commissioning and start-up.

BESS Supply not included.

FINAL SOLUTION

Description



The system consists on the following key subsystems:

Advanced Multi-port Power Stations (AMPS).
Energy Storage System (BESS) (it will be supplied by Client).
Power Plant Controller (PPC).

The Plant Operator is provided with an Advanced Supervisory System composed by:

EMS Monitoring Module (EMS-MM).
SCADA system.

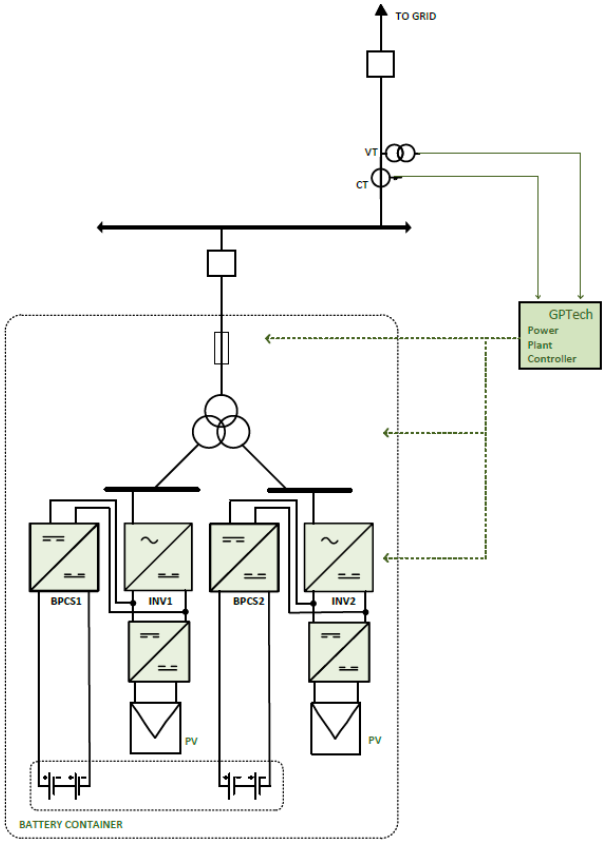
PPC and Plant Supervisory System are optimally integrated so that:

The PPC manages the working points of the power electronics to ensure the fulfilment of the grid requirements, while improving the power generation stability and the dispatchability of the plant by the use of BESS.

The Plant Supervisory System provides the operator with real time information on plant performance, as well as with the data and analysis needed to assess overall system performance as well as detecting and diagnosing abnormal system behaviors.

FINAL SOLUTION

List of Services



Systems Engineering and Documentation.

- Manufacturing and Project Management.
- System Integration, Test & Commissioning, included Pre-Initial Synchronization Day integration and coordination works.
- Site Acceptance Test with Utility.

GPTech´s EMS Subsystems

The Energy Management System supplied consists of the following components, listed in table below:

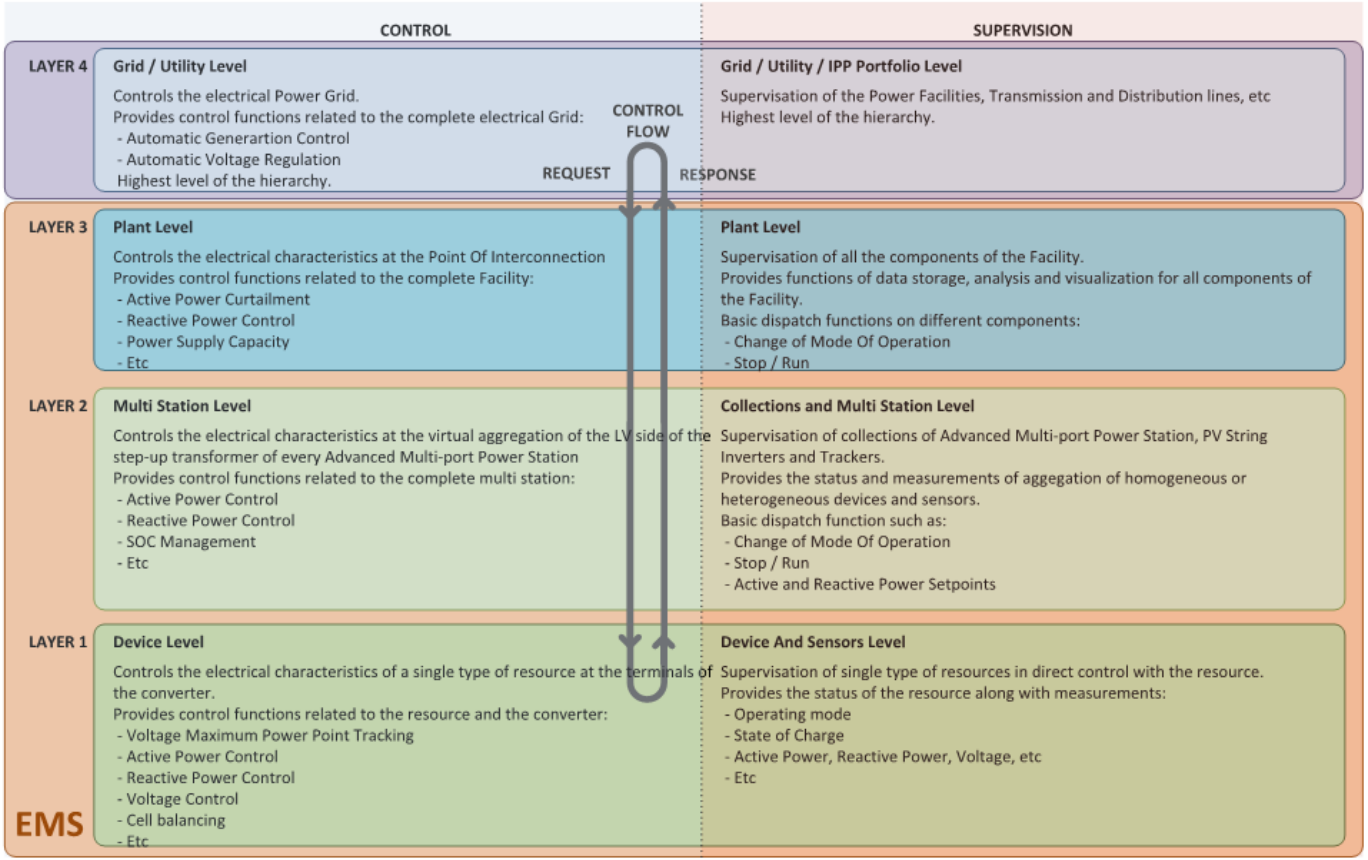
System	Equipment
Advanced Supervisory System	1 x EMS-MM 1 x SCADA
Management System	1 x Advanced Power Plant Controller (PPC)
Advanced Multiport Power Station (AMPS)	8 x AMPS2800WD3-HV690/DC1200
Energy Storages System of 116 MWh Batteries (ESS)	It will be supplied by Client

Notes:

Each Advanced Multi-port Power Station includes 2 DC/AC bidirectional WD3 module with rated power 1400 kVA and 2 DC/DC bidirectional, booster WD3 DC module with a rated power of 1300 kW.

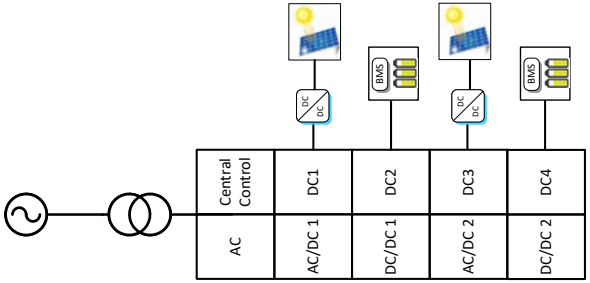
FINAL SOLUTION

Control Architecture



EQUIPMENTS & SYSTEMS

Advance Multi-Port Power Station: AMPS2800WD3-HV690/DC1200



WD3 family is an evolution of the World-Wide Design Converters manufactured by GPTech. AMPS2800WD3-HV690/DC1200 is based on devices prepared to work as an electrical conversion unit. AMPS2800WD3-HV690/DC1200 is made by the next modules:

(1) MP2800WD3-HV690/DC1200 Converter:

- 2 DC/AC bidirectional WD3 module with rated power 1400 kVA
- 2 DC/DC bidirectional, booster WD3 DC module with a rated power of 1300 kW.
- AMPS Control & Communication Panel (APIS Controller)
- Standard Ancillary Services System for its own functioning
- AC/DC Disconnection Modules
- Internal Grounding Network
- Internal UPS up to 1 kW 5´ for control and communication system. (optional)

(1) 2800 kVA Pad Mounted transformer:

- Two LV windings of 690 V and 1400 kVA each one (*)
- One HV switch configuration, one for transformer to loop-bus and one at outgoing bushing.
- Short circuit fuses

(*) Transformer configuration could be change to only one winding depending on the batteries isolation to ground.

The AMPS is available to include as options:

(1) External customizable UPS

(1) Customize Ancillary Services System

Low voltage AC panel, DC boxes and the Control & Communication Panel are included inside the Converter.

Physical distribution of the components has been chosen considering the working spaces and minimum security distances, according to IEC regulations. Footprint and positions of UPS and Advance Auxiliary Services System shown below are intended only as an example, and they could differ from the definite final agreed distribution.

CONCLUSIONS

1. Each Utility Scale Integration of a Renewable Generation Technology in a weak grid present a distinct challenge with a number of one-off attributes…
2. The temptation to go to the “fall-back” solution of “inverter stretching” is strong…..
3. The combination of a Systems Approach, Know-How and flexible SW/HW platforms allows to turn the challenge into opportunity…
4. …creating tangible multiple-value and predictability for utility and IPPs

GPTech


THANKS FOR YOUR ATTENTION,
QUESTIONS?
GPTech

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