

How to integrate Energy Storage System into large-scale PV plants

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Roberto González
R&D Department Manager. Solar PV
Ingeteam Power Technology S.A.
roberto.gonzalez@ingeteam.com

KEY FIGURES



Present in more than **22** countries and new markets.



3,700 employees around the world.



5.5% of turnover invested in R&D. 500 persons.



More than **75 years** in the electrical sector.

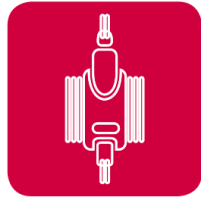


OUR BRANDS & BUSINESSES

Ingeteam

Indar

TECHNOLOGICAL CORE



Power conversion



Electric motors
and generators



Automation

SECTORS



Energy



Industry



Marine



Traction



Electric grids

Global footprint

INGETEAM AROUND THE WORLD



○ Manufacturing plants

Ingeteam

READY FOR YOUR CHALLENGES

ENERGY DIVISION



Wind

Accumulated Installed Power

40 GW



Solar

Accumulated Installed Power

9 GW



Hydro

Accumulated Installed Power

8 GW

PV & STORAGE PRODUCTS

Solar inverters

String Inverters



1Play TL M
2.5 - 6 kW

p. 10



3Play TL
10 - 33 kW

p. 18



3Play TL M
10 - 40 kW

p. 22



3Play TL U M
24 - 40 kW

p. 26



3Play TL
100 kW



PowerMax B Series
830 - 1800 kVA

p. 32



PowerMax U B Series
610 - 1800 kVA

p. 36



PowerMax Dual Inverter
1660 - 3600 kVA

p. 40

Central Inverters

Medium Voltage Solutions



PowerStation CON 20
1660 - 3600 kVA

p. 54



PowerStation CON 40 / Outdoor inverters
2490 - 5400 kVA

p. 58



PowerStation CON 40 / Indoor inverters
2490 - 5400 kVA

p. 62



INVERTER STATION
830 - 7200 kVA

p. 72



INVERTER STATION
830 - 7200 kVA

Battery Inverters (On- / Off-grid)



STORAGE 1Play
3 - 6 kW

p. 82



STORAGE PowerMax B Series
830 - 1640 kVA

p. 90



STORAGE PowerMax U B Series
610 - 1640 kVA

p. 94

Energy management solution



EMS Board

p. 102



EMS Plant Controller

p. 104

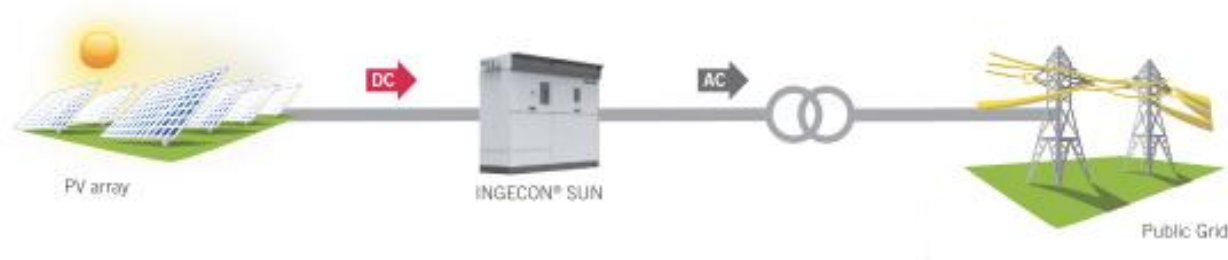
Accessories



String Box +
StringMonitoring Box

p. 118

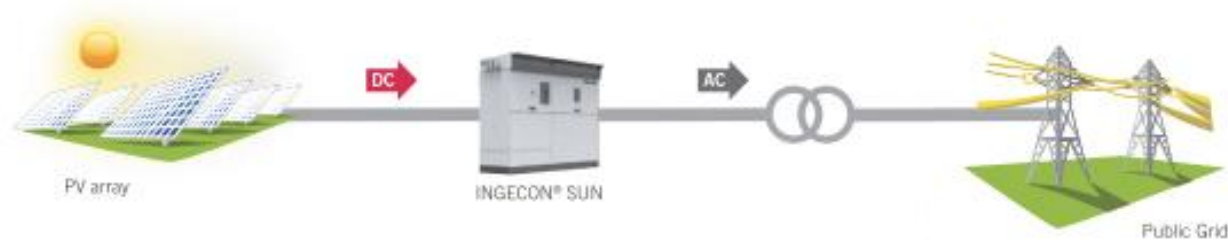
GRID INTEGRATION



Current requirements for PV Plants:

- ✓ Reactive Power control
- ✓ LVRT – HVRT
- ✓ Active Power Reduction

GRID INTEGRATION



Current requirements for PV Plants:

- ✓ Reactive Power control
- ✓ LVRT – HVRT
- ✓ Active Power Reduction

Requirements for a high PV penetration:

Grid stability? → Generation = Consumption

Fluctuating nature of PV power

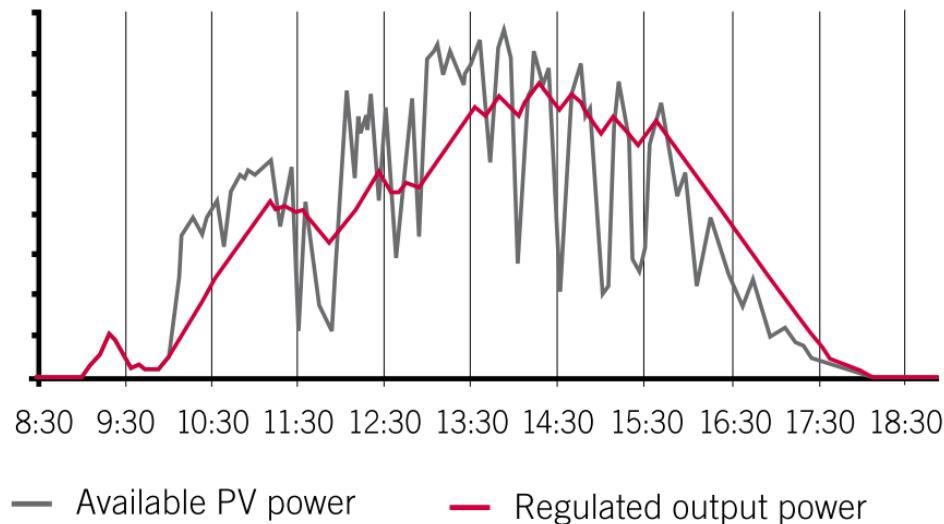
Storage is needed for **complete active power control**

ENERGY STORAGE IN PV PLANTS

Control options

- Ramp Rate Control

ΔP of PV Power Plant = ΔP of Conventional Power Plants



- Small battery capacity required (15 minutes. 4C battery)

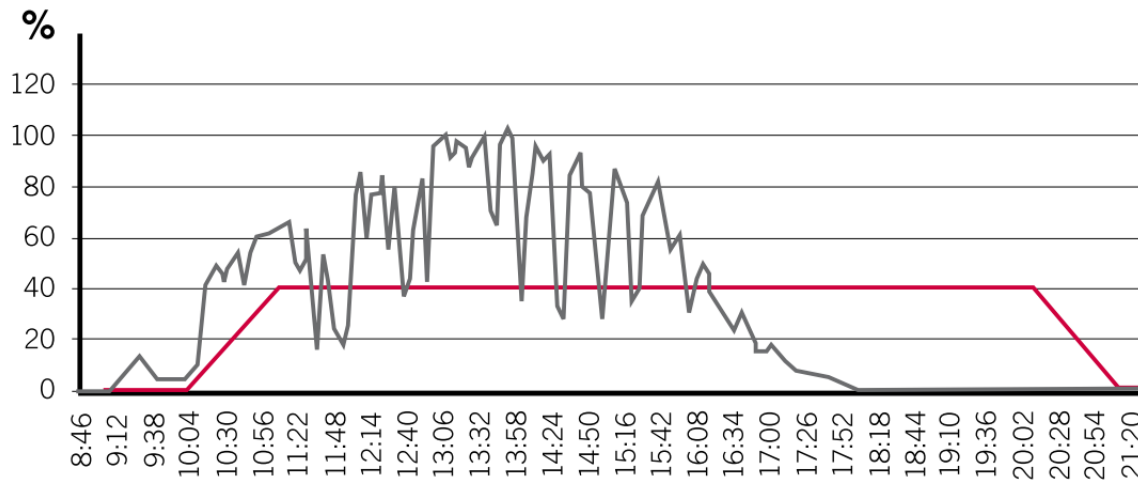
Requested in:

- Puerto Rico

ENERGY STORAGE IN PV PLANTS

Control options

- Ramp Rate Control
- **Energy Shifting. Constant Power Control**



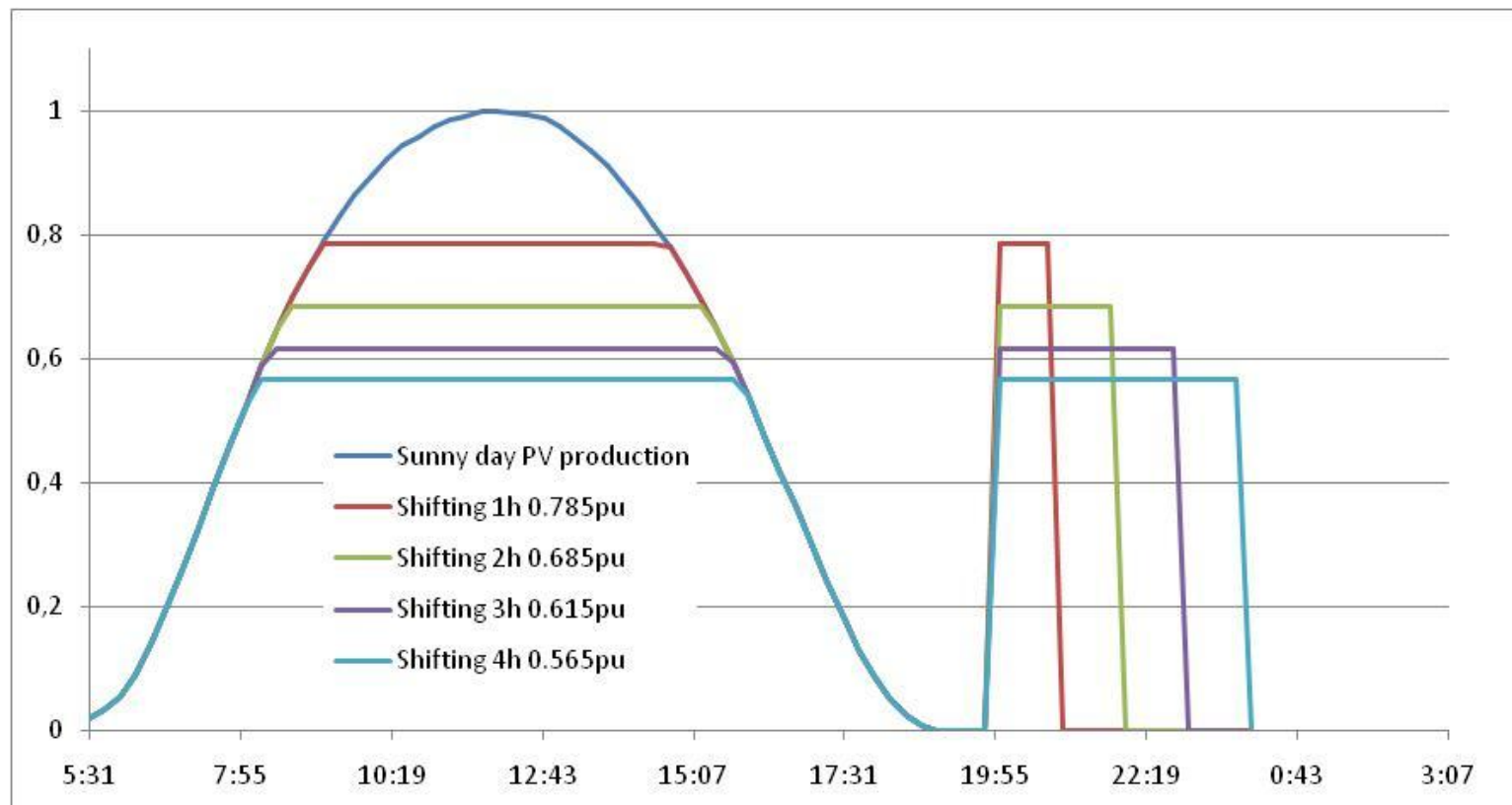
- Weather forecast day ahead
- Production forecast: power & time
- Big battery capacity required (1,5-2h. 0,5C battery)

Requested in French islands (CRE)

ENERGY STORAGE IN PV PLANTS

Control options

- Ramp Rate Control
- **Energy Shifting**

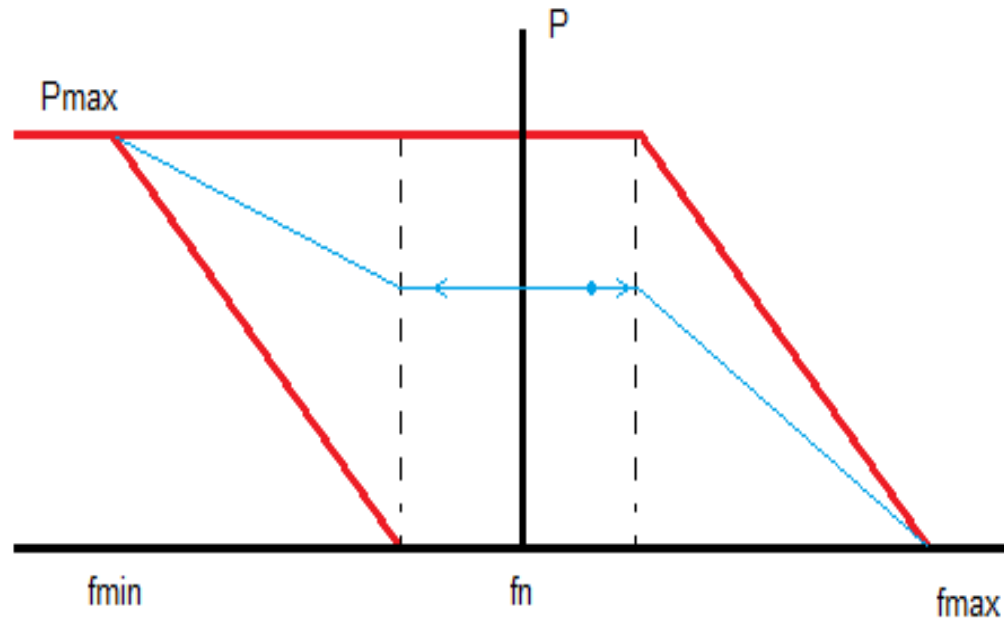


ENERGY STORAGE IN PV PLANTS

Control options

- Ramp Rate Control
- Energy Time Shifting. Constant Power Control

+ Frequency regulation (primary regulation)



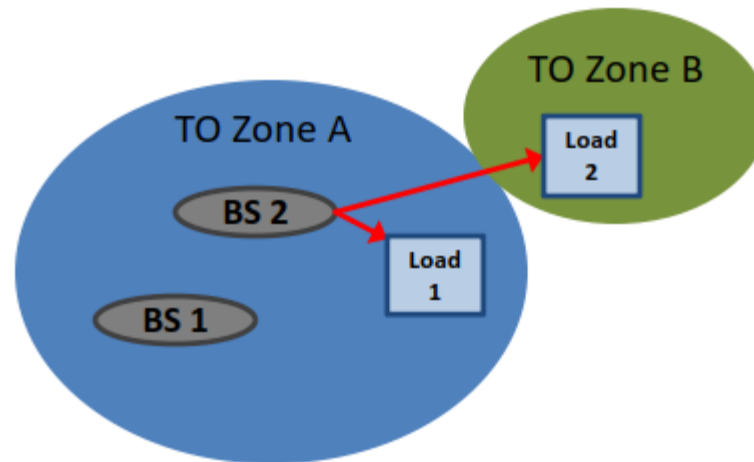
ENERGY STORAGE IN PV PLANTS

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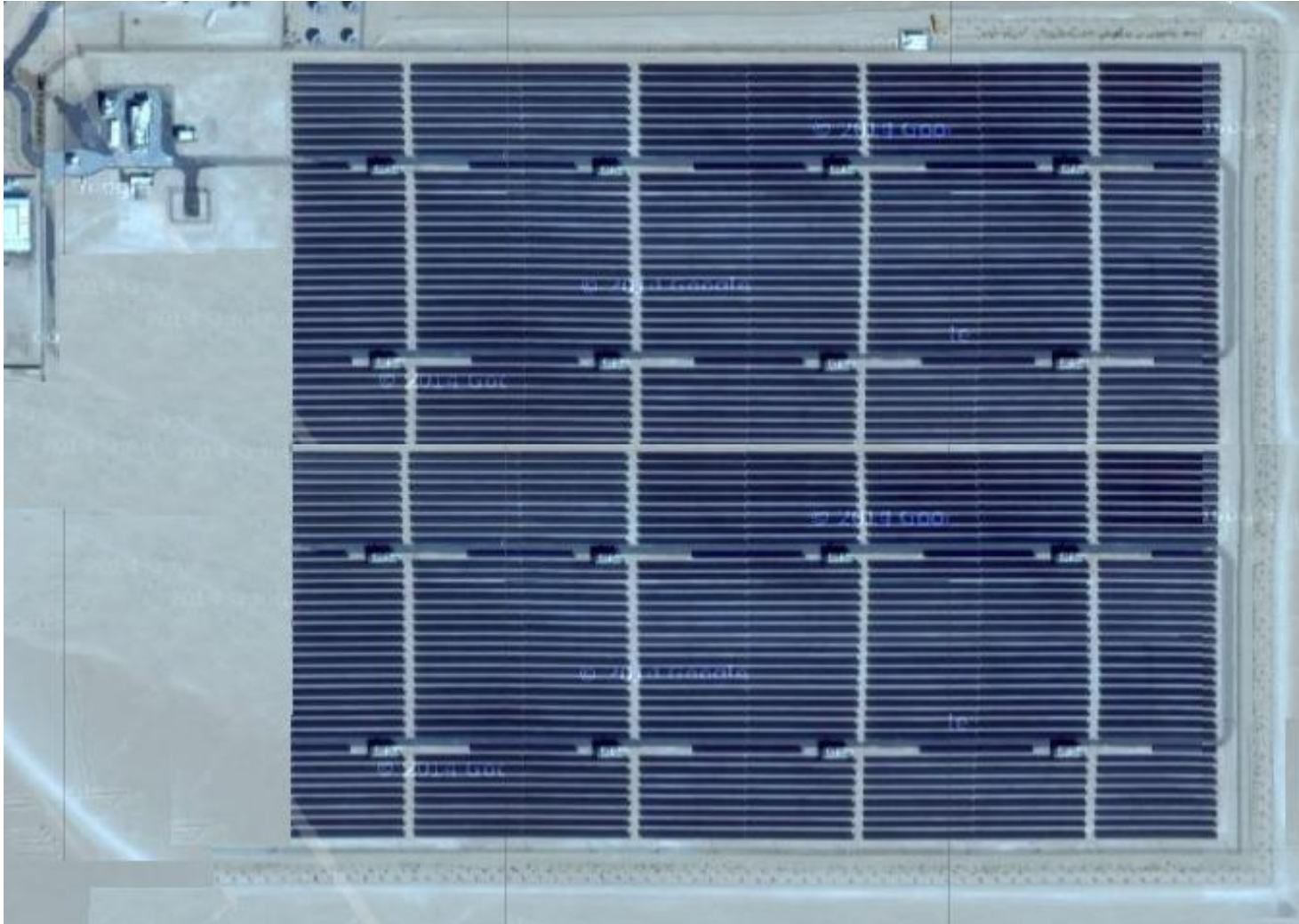
+ **Black Start Capability.**



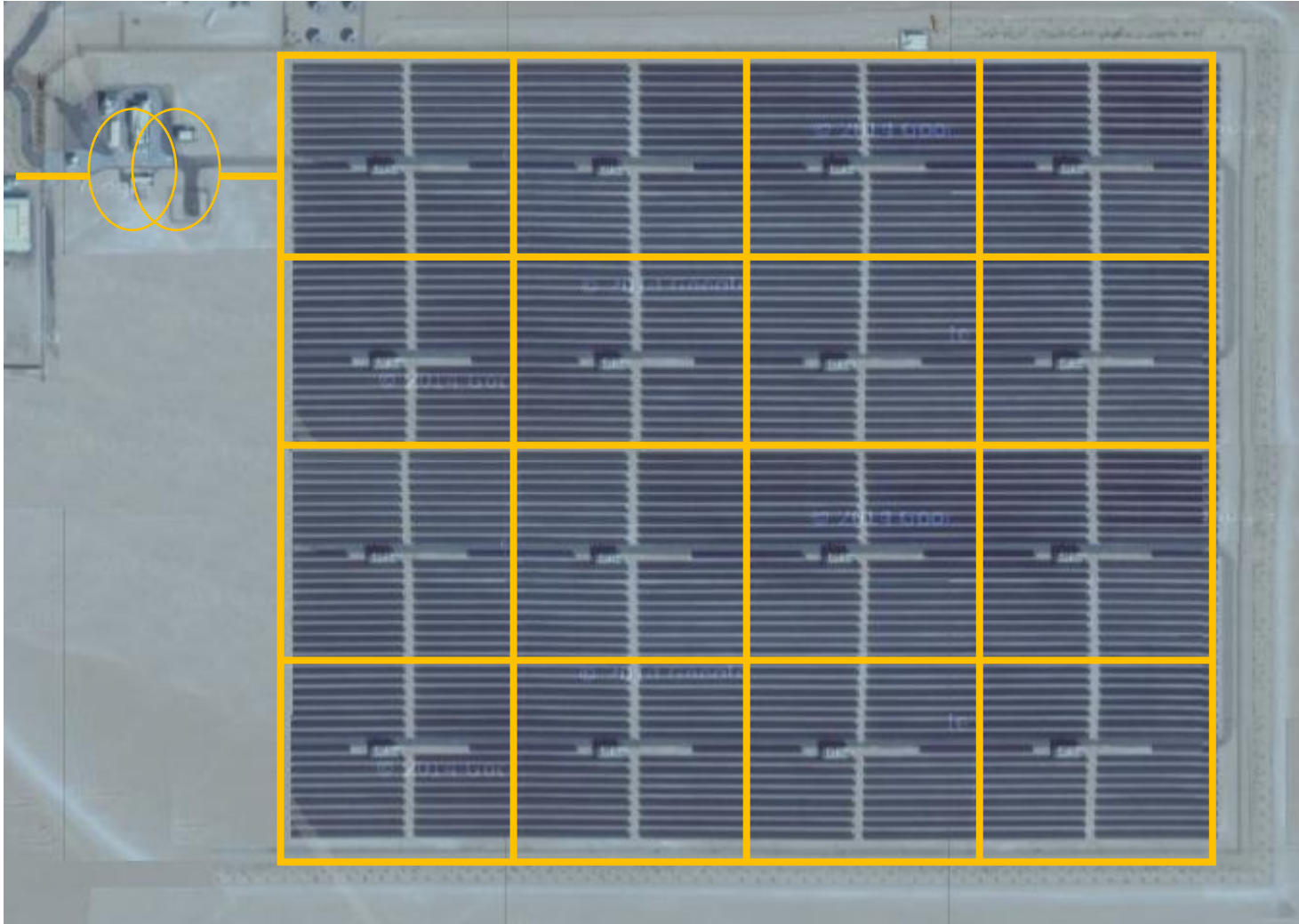
How to integrate an energy storage system into PV plants?

- ✓ Distributed
 - DC Coupling
 - AC Coupling
- ✓ Centralized

ENERGY STORAGE IN PV PLANTS

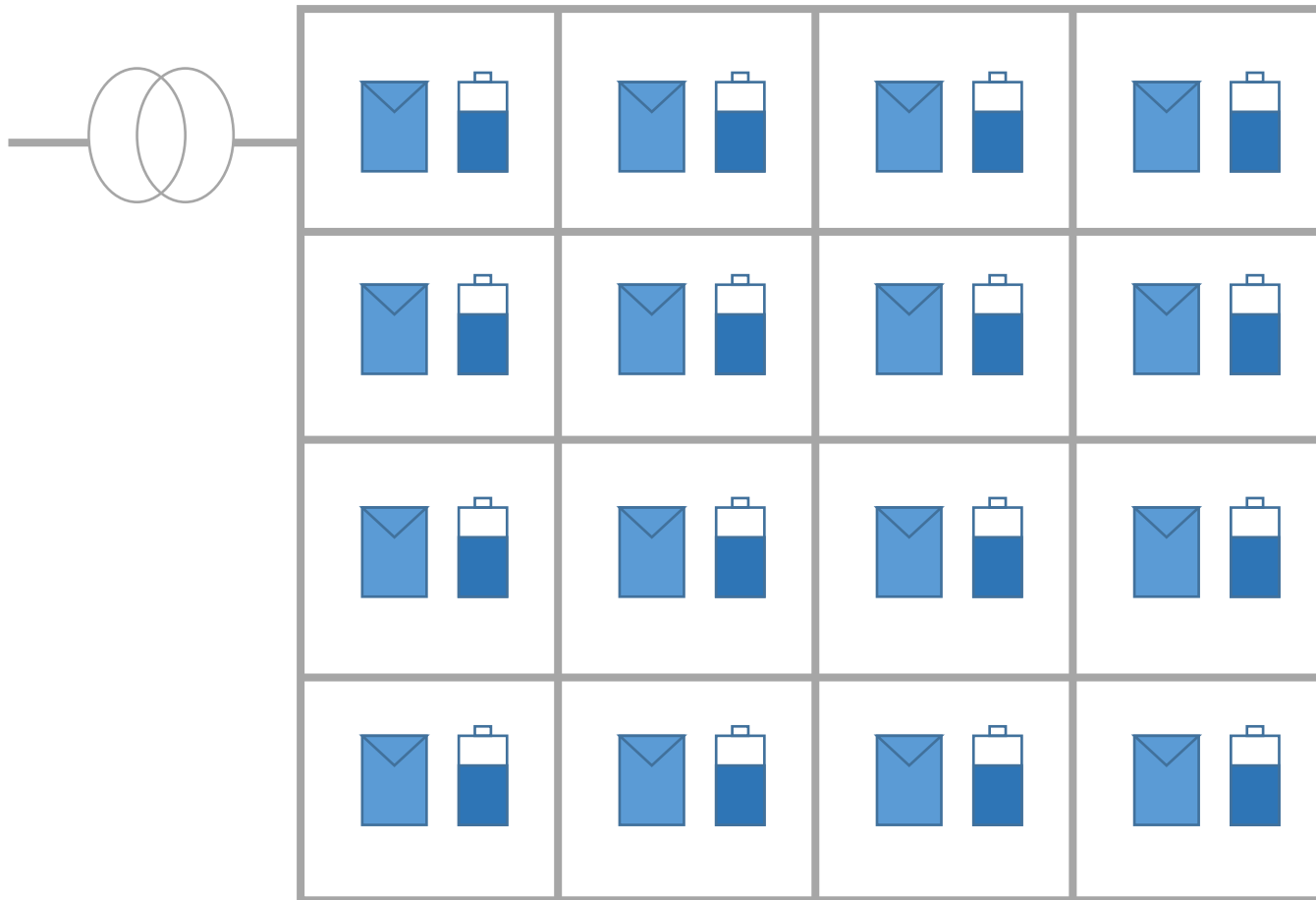


ENERGY STORAGE IN PV PLANTS



ENERGY STORAGE IN PV PLANTS

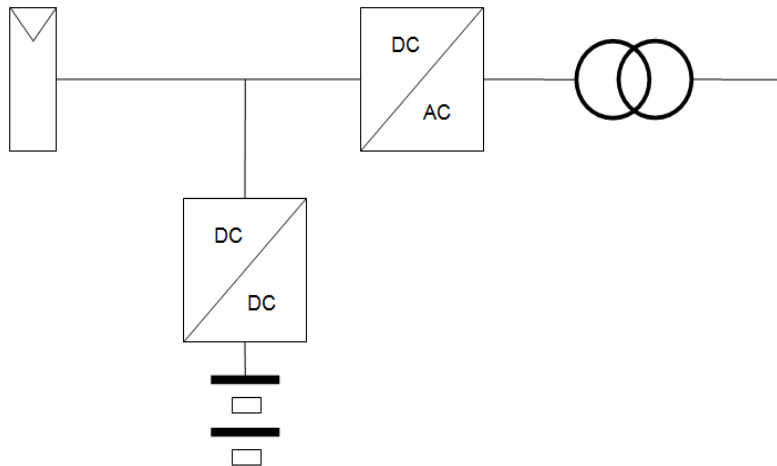
Distributed



ENERGY STORAGE IN PV PLANTS

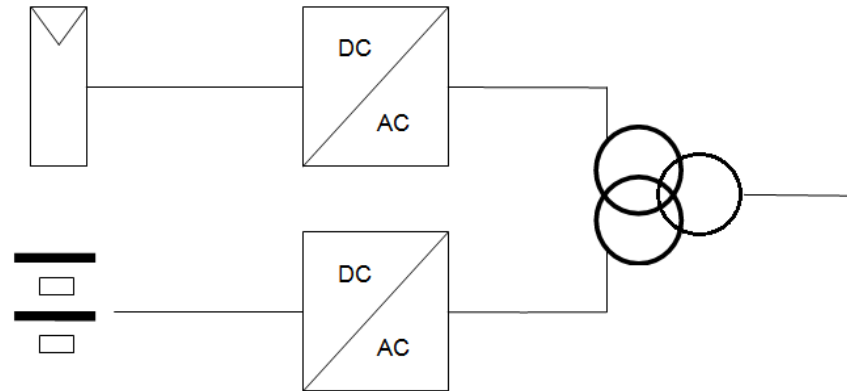
Distributed

DC COUPLING



- ✗ Buck - boost DC/DC required
- PV: 870-1500V
- Batteries: 900-1100V
- Larger PV input line needed

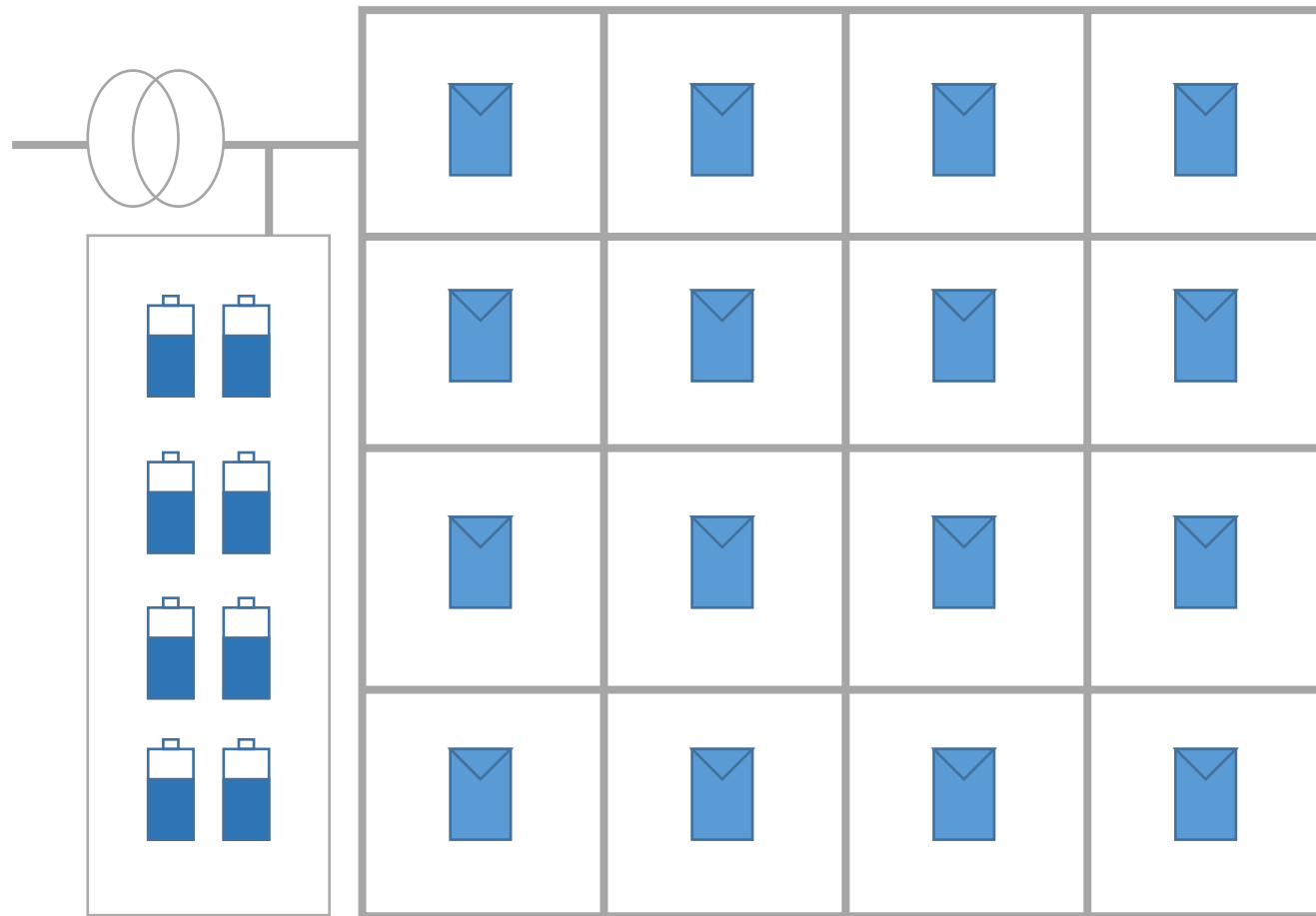
AC COUPLING



- ✓ Standard inverters

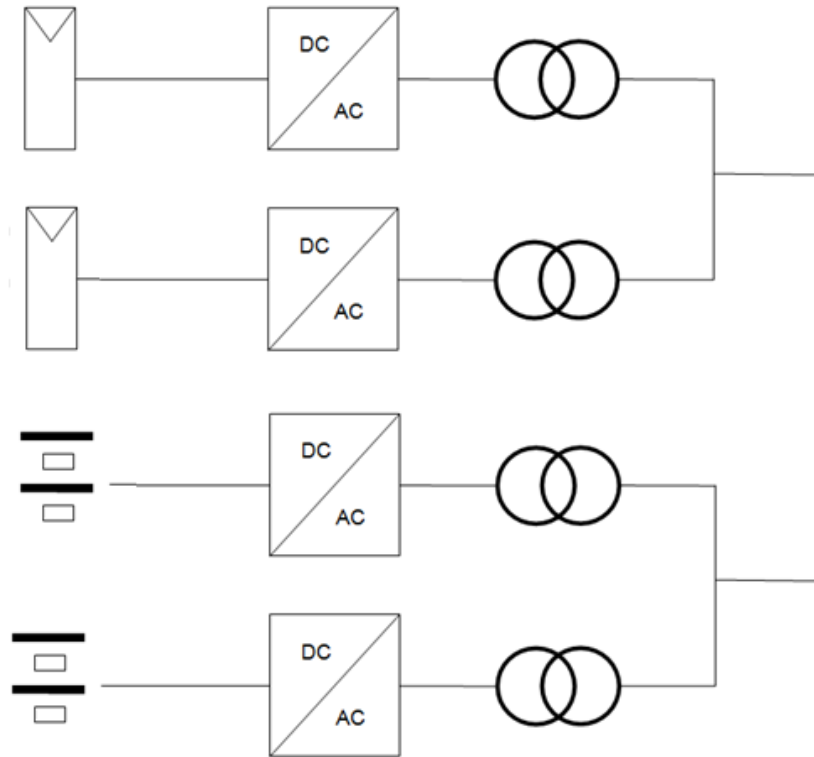
ENERGY STORAGE IN PV PLANTS

Centralized



ENERGY STORAGE IN PV PLANTS

Centralized



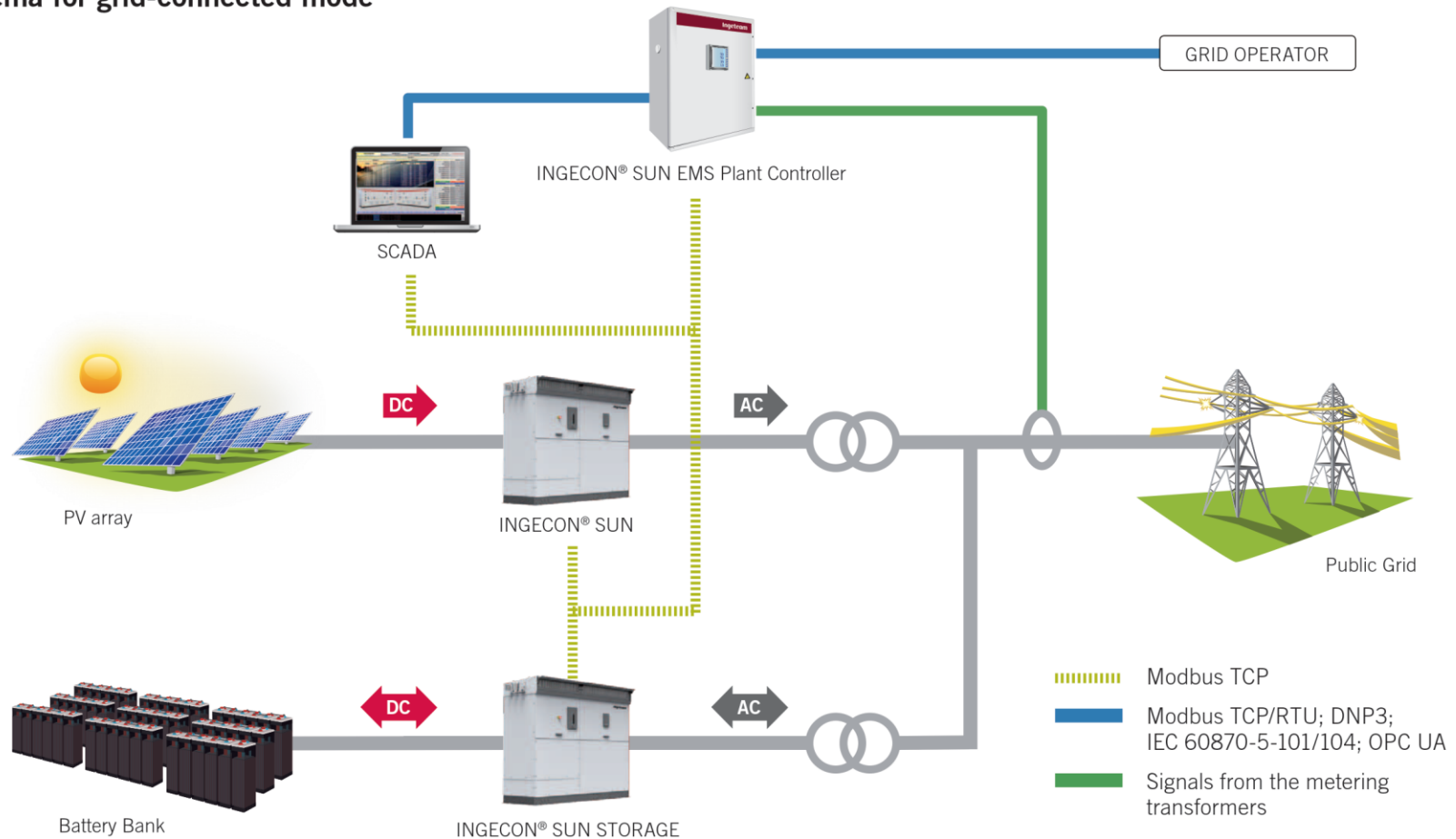
✓ Standard inverters

ENERGY STORAGE IN PV PLANTS

	Distributed DC coupling	Distributed AC coupling	Centralized AC coupling
Ramp Rate Control	Good	Good	Excellent
Energy Time Shifting	Good	Good	Good
Frequency control	Good	Excellent	Excellent
Economies of scale - Inverters	Good	Excellent	Excellent
Economies of scale - Batteries	Good	Good	Excellent

SOLUTIONS FOR AC-COUPLED SYSTEMS

Schema for grid-connected mode



✓ Valid for distributed and centralized systems

INGECON SUN EMS Plant Controller

Ingeteam's Power Plant Controller



Main Control Features:

- ☐ On-Demand Production
- ☐ Ramp Rate Control
- ☐ Active Power Reserve
- ☐ Fast Frequency Regulation
- ☐ Digital Q Compensation
- ☐ Power Factor Control
- ☐ Automatic Voltage Regulation
- ☐ Voltage Control
- ☐ Power Oscillations Damping

PV & STORAGE INVERTERS

1,000
Vdc

1,500
Vdc

Central Inverters (610 – 1,800 kW)



INGECON SUN STORAGE PowerMax – B Series

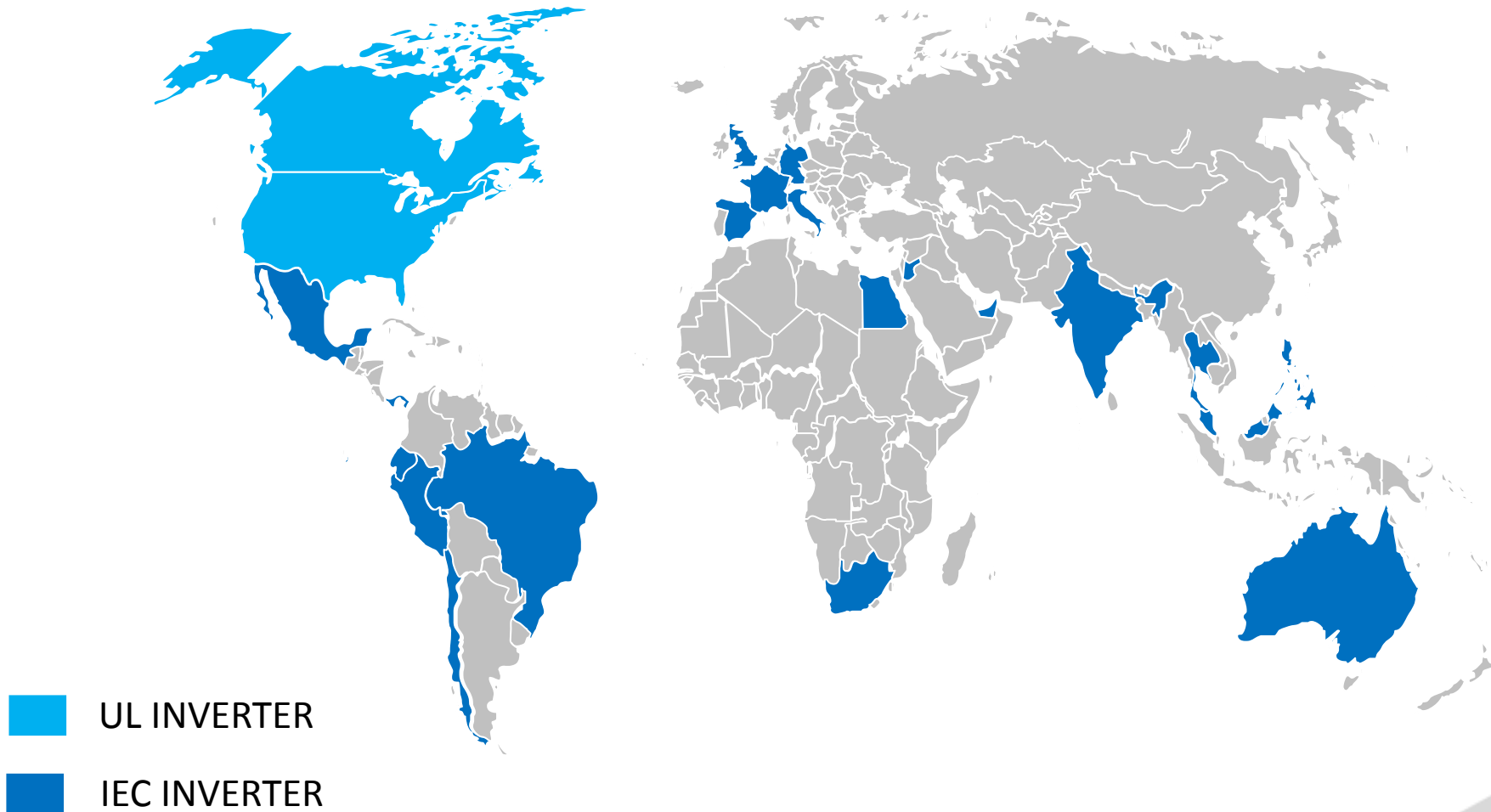
- ❑ Three-phase battery inverters
- ❑ IEC and UL version (1,000Vdc & 1,500Vdc)
- ❑ AC voltage ranging from 220V up to 690V
- ❑ MV power stations also available up to 7.2 MVA
- ❑ AC power range: from 610 to 1,800 kVA
- ❑ 26 MWh supplied worldwide

PV & STORAGE INVERTERS

EMC, Safety and Grid Code Certification

1,000
Vdc

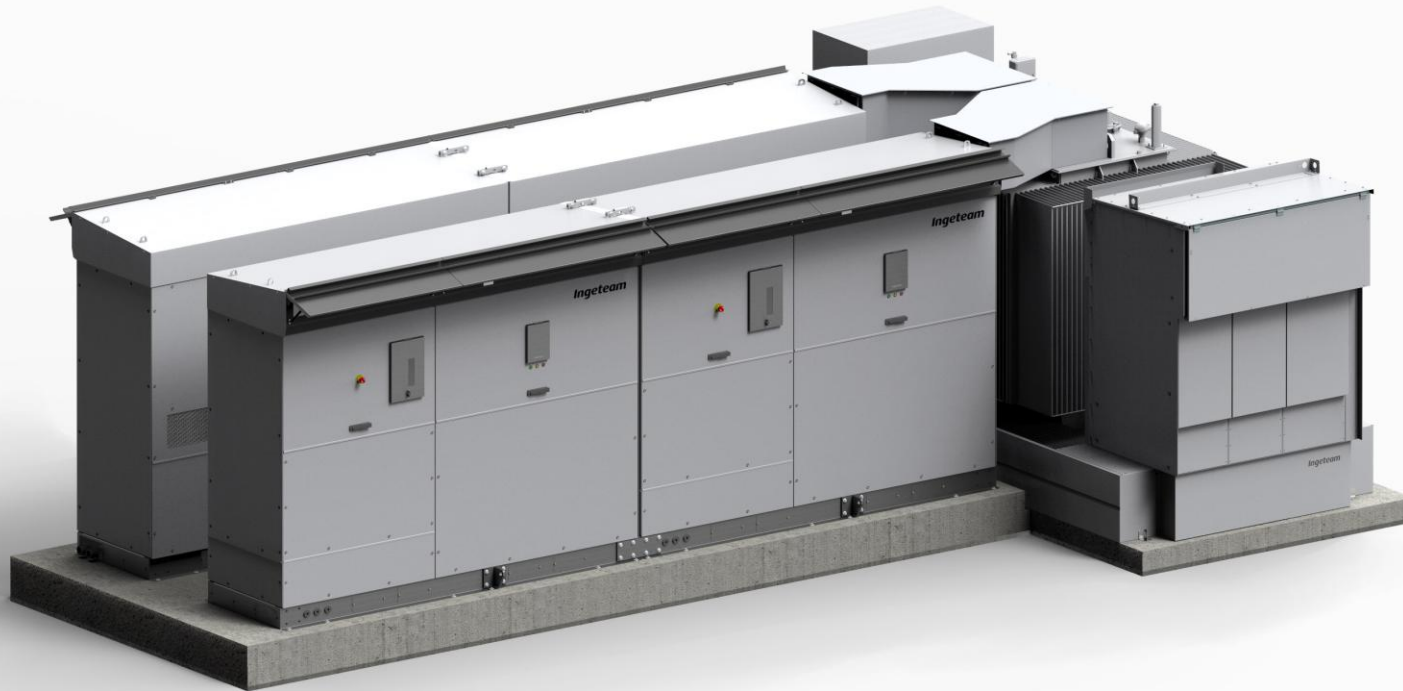
1,500
Vdc



STANDARD MV SOLUTIONS

Double dual inverter

- ❖ Turnkey solution up to **7.17MVA @30°C / 6.45MVA @50°C – 1,500Vdc**
- ❖ Turnkey solution up to **5.10MVA @35°C / 4.69MVA @50°C – 1,000Vdc**



17-foot-long skid integrating the LV and MV cubicles and the MV transformer.

INGECON SUN STORAGE PowerMax

References

Coto Laurel (Puerto Rico)

- 15 MW PV with INGECON SUN PowerMax
- 5.3 MW Storage with INGECON SUN STORAGE PowerMax
- SAFT Li-ion Batteries

Implemented control: Ramp Rate Control and Frequency regulation



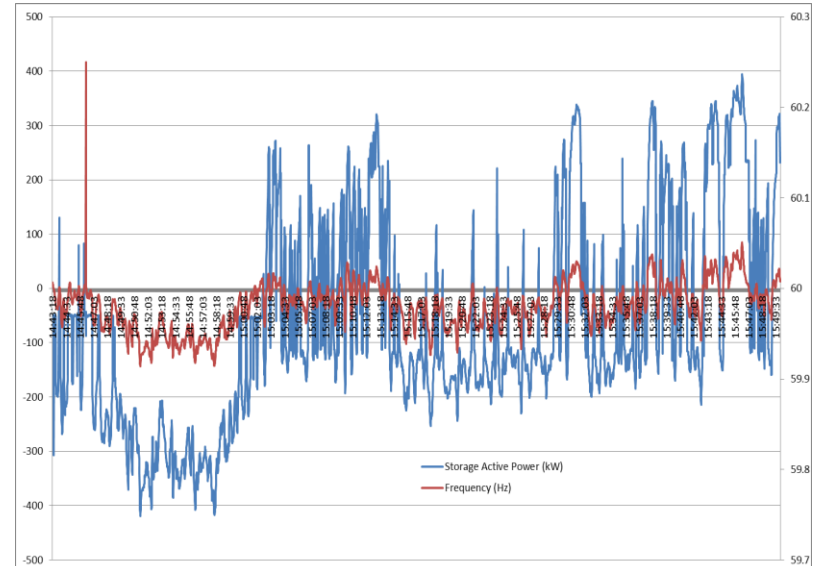
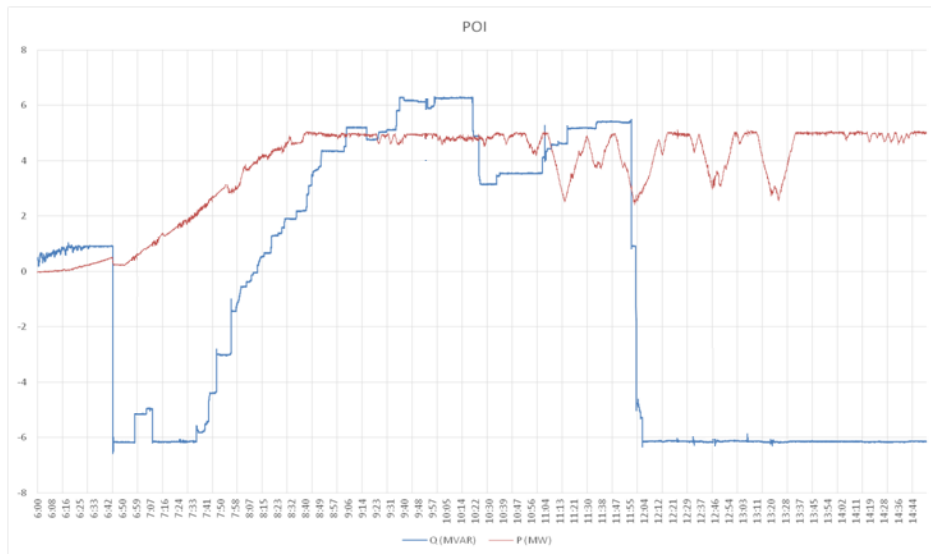
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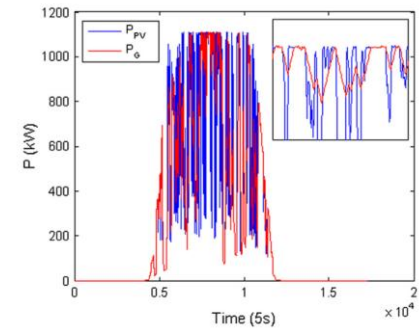
INGECON SUN STORAGE PowerMax

References

ILIS Project. Montes del Cierzo, Tudela (Spain) 2013

- INGECON SUN STORAGE 1000TL X400 Indoor
- Li-ion Batteries. SAFT Intensium Max 1.1MW / 560kWh

Implemented control: Ramp Rate Control, Energy Time Shifting.



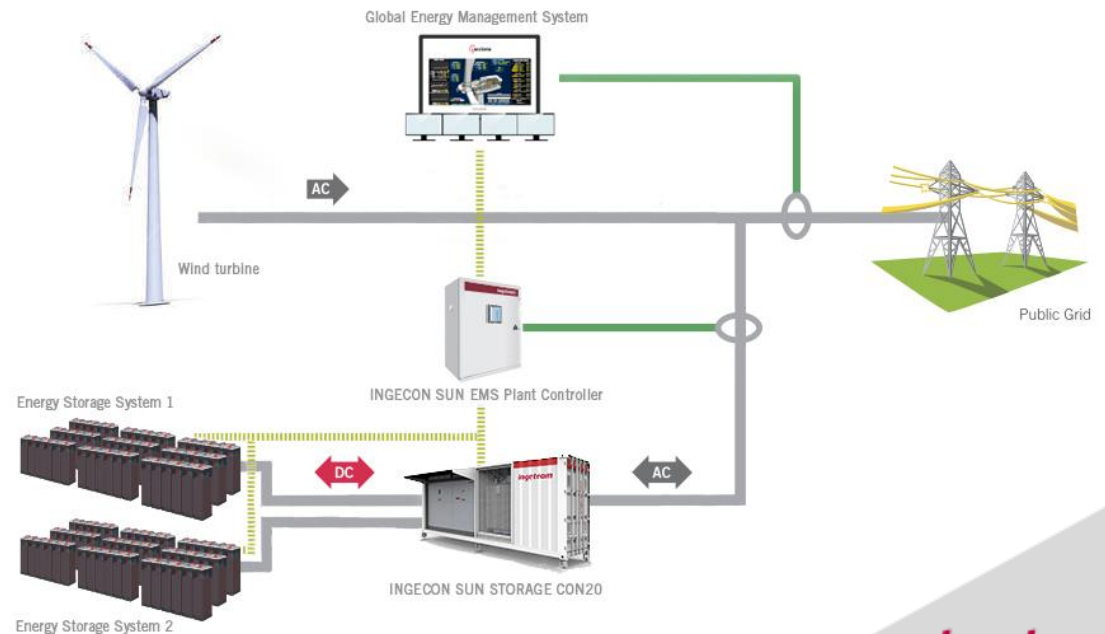
INGECON SUN STORAGE PowerMax

References

HYWINDESS Project. Barasoain (Spain)

- 2 x INGECON SUN STORAGE 1220TL B470
- SAMSUNG Li-ion Batteries, Power
- SAMSUNG Li-ion Battery, Energy

Implemented control: Ramp Rate Control, Energy Time Shifting.



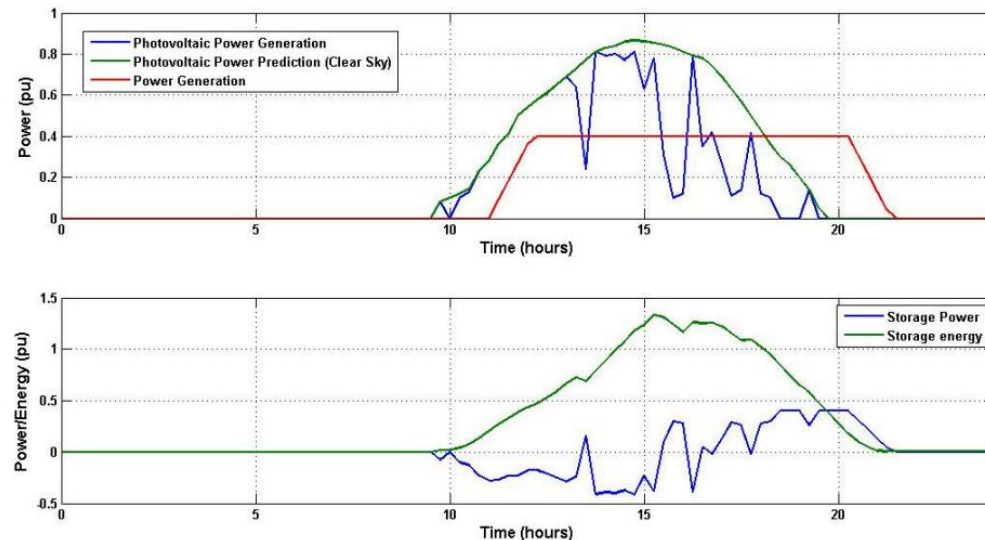
INGECON SUN STORAGE PowerMax

References

Barzour (La Reunion, France)

- 9 MW PV with INGECON SUN PowerMax
- 9 MW Storage with INGECON SUN STORAGE PowerMax
- 9 MWh SAFT Li-ion Batteries

Implemented control: Energy Time Shifting



CONCLUSIONS

- ❑ AC coupling allows the use of standard inverters and reduce the price of the systems, thanks to the economies of scale.
- ❑ Centralized solutions allow an optimization of the battery size and costs.
- ❑ Ingeteam provides compact, Plug&Play, standard MV solutions that reduce the engineering costs and increase the quality of the overall system.

Ingeteam

READY FOR YOUR CHALLENGES

www.ingeteam.com