

# PV+ESS, Paves the Way for Future Renewable Energy World



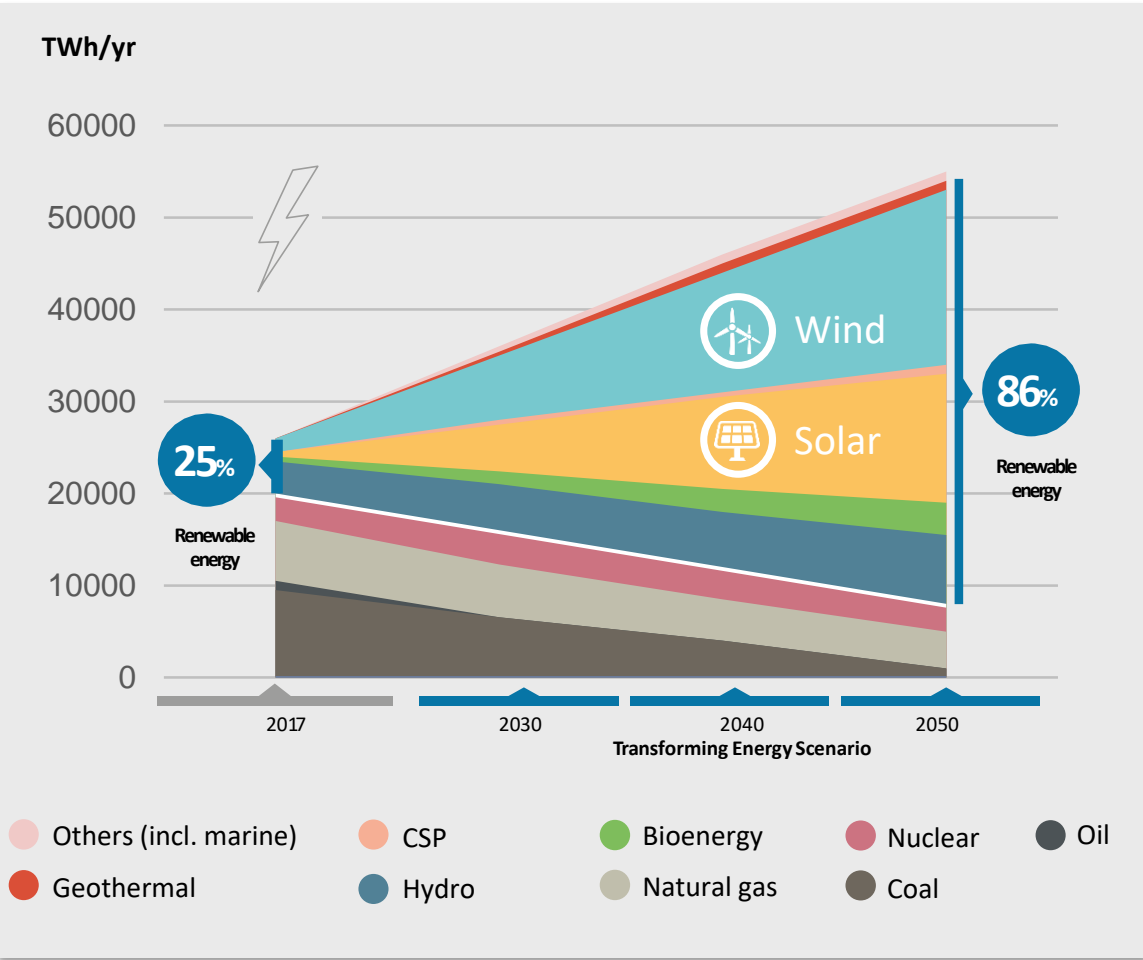
Dr. Miguel Ochoa Giménez, PhD  
Global Grid Technology Director



# World Energy Strategy Transformation

Promoting Solar & Wind to Become the Major Energy

## PV – The Major Energy Supply for Power Plant Installation



## The Government & Large Corporation specify low carbon targets continuously



**China**

Carbon neutral realized **in 2060**

Peak value **by 2030**, 20% renewable energy



**EU**

Carbon neutral realized **in 2050**

GHG emission reduced 60% **by 2030**, 32% renewable energy

Strategic transformation of energy giants  
Accelerate Carbon Neutral realized

Various Power consumption companies join RE100  
Promised to achieve 100% renewable energy power consumption



# Supporting Global Customers with String-based Technology

## Gulshat 40MW (Kazakhstan)

Highlight: Extreme cold temperature



## Monte Plata 33MW (Dominican Republic)

Highlight: Extremely high humidity



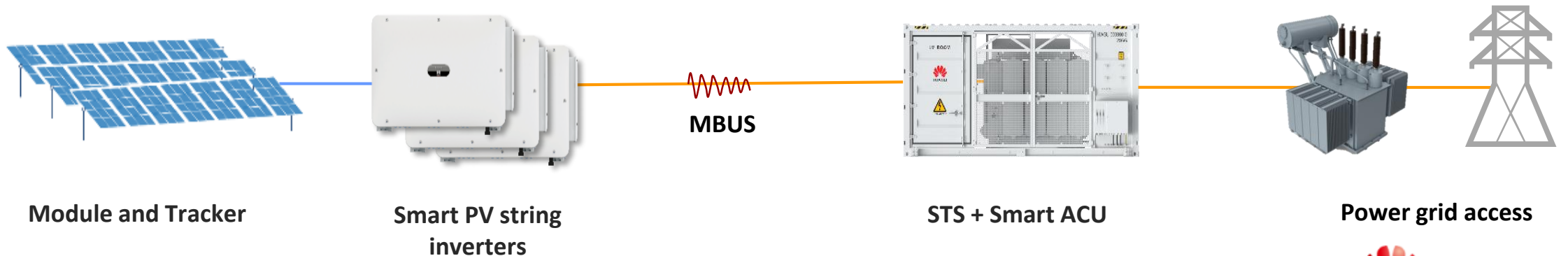
## Cauchari 315MW (Argentina)

Highlight: Extreme high altitude of  
~4,200m

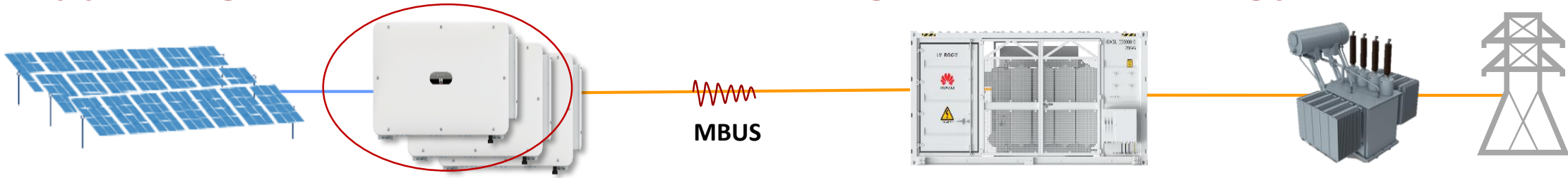


## SAKAKA 300MW (Saudi Arabia)

Highlight: Extreme dust & high temperature



# Supporting Global Customers with String-based Technology

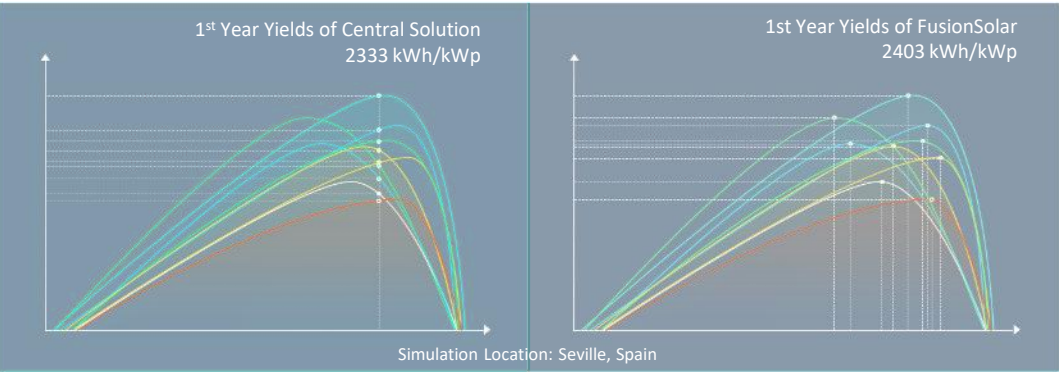
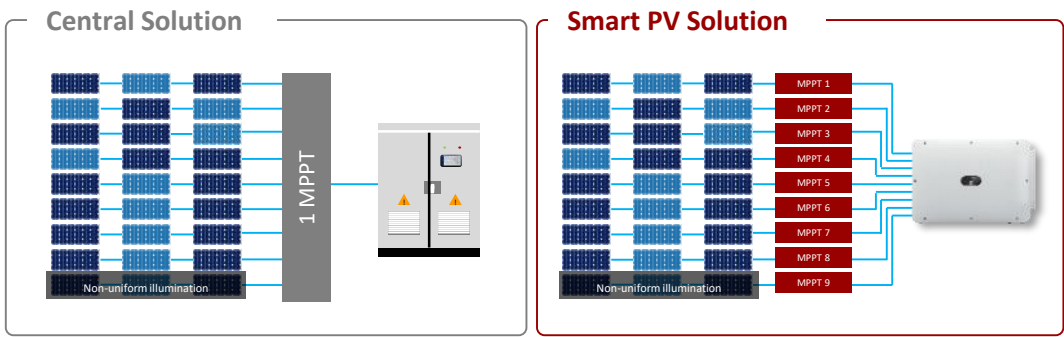


Module and Tracker

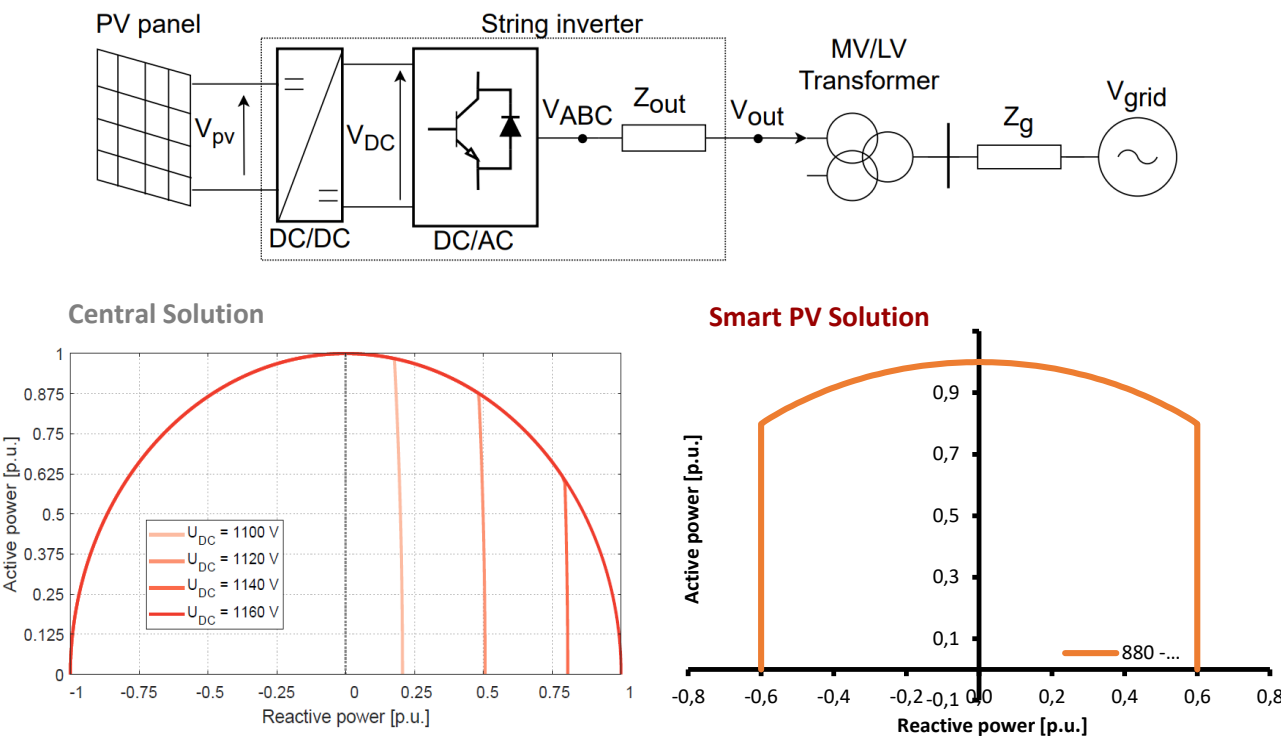
Smart PV string inverters

STS + Smart ACU

Power grid access



Huawei Confidential



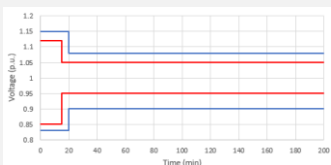
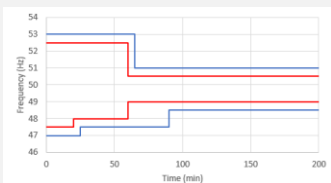
# Grid Code fulfillment thanks to the Smart PV inverters

Main grid code requirements:

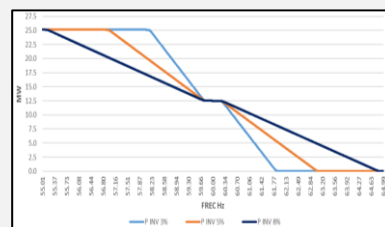
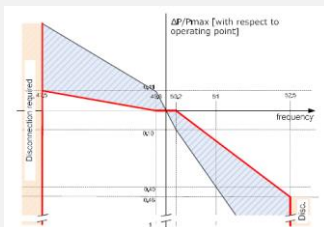
## Voltage and frequency protections

Voltage Range at 132kV-level and lower Voltage Levels	Voltage Range at 400kV-level	Minimum time period of operation
0.85 pu – 0.90 pu	0.85 pu – 0.90 pu	15 minutes in abnormal conditions for Non-Synchronously Connected Generating Units
0.90 pu – 0.95 pu	0.90 pu – 0.95 pu	15 minutes in abnormal conditions
0.95 pu – 1.05 pu	0.95 pu – 1.0375 pu	Unlimited
1.05 pu – 1.12 pu	1.0375 pu – 1.05 pu	15 minutes in abnormal conditions

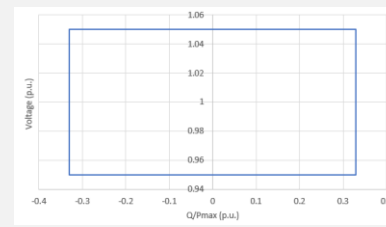
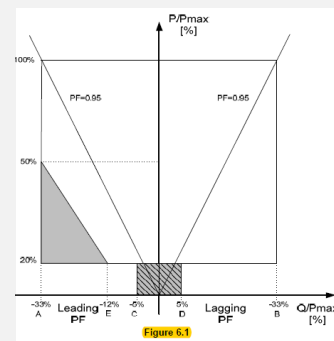
Frequency Range	Time period for operation (minimum)
47.5 Hz – 48.0 Hz	10 minutes
48.0 Hz – 48.5 Hz	20 minutes
48.5 Hz – 49.0 Hz	1 hour
49.0 Hz – 50.5 Hz	Unlimited
50.5 Hz – 52.5 Hz	1 hour



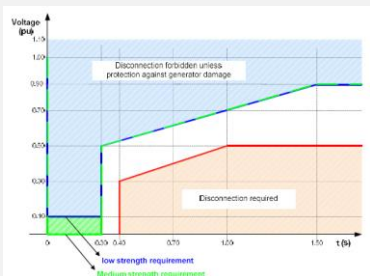
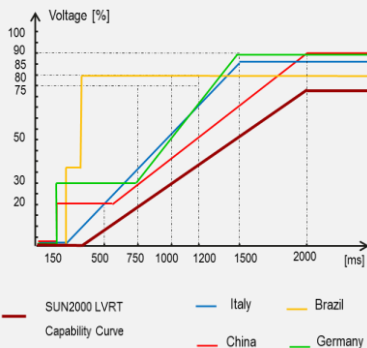
## Active power/Frequency regulation



## Reactive power/voltage regulation



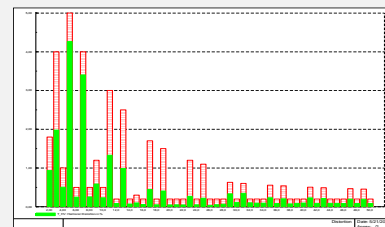
## Fault Ride Through



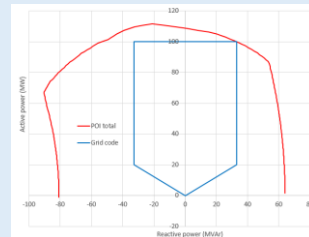
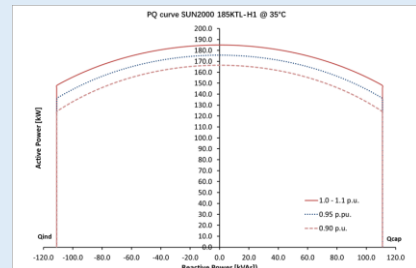
## Power quality

Planning Levels for Harmonic Voltage (in percent of nominal voltage) in the 230 and 400kV Systems					
Odd harmonics Non-multiple of 3		Odd harmonics Multiple of 3		Even Harmonics	
Order 'h'	Harmonic Voltage (%)	Order 'h'	Harmonic Voltage (%)	Order 'h'	Harmonic Voltage (%)
5	2.0	3	1.5	2	1.0
7	1.5	9	0.5	4	0.8
11	1.0	15	0.3	6	0.5
13	1.0	21	0.2	8	0.4
17	0.5	27	0.2	10	0.4
19	0.5			12	0.2
23	0.5			14	0.2
25	0.5			16	0.2
>25	0.2 + 0.3x25/h			>12	0.2

\* The above tabulated harmonic distortion levels are the total allowed in the IEC/IEEE Transmission System, hence harmonic emission allocations for individual Users will take into account the position of existing and prospective Users as indicated in Section 6.1.1.1.

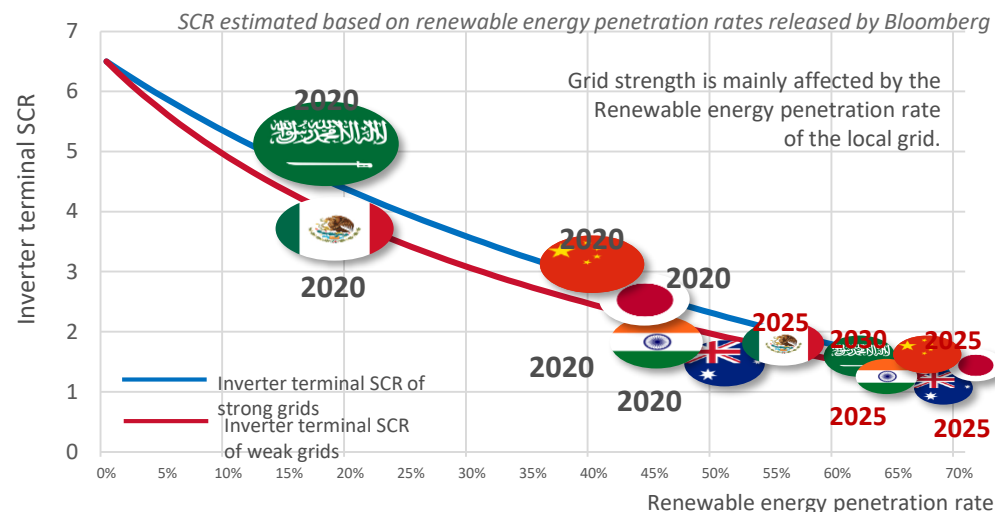


## Huawei's inverter capability

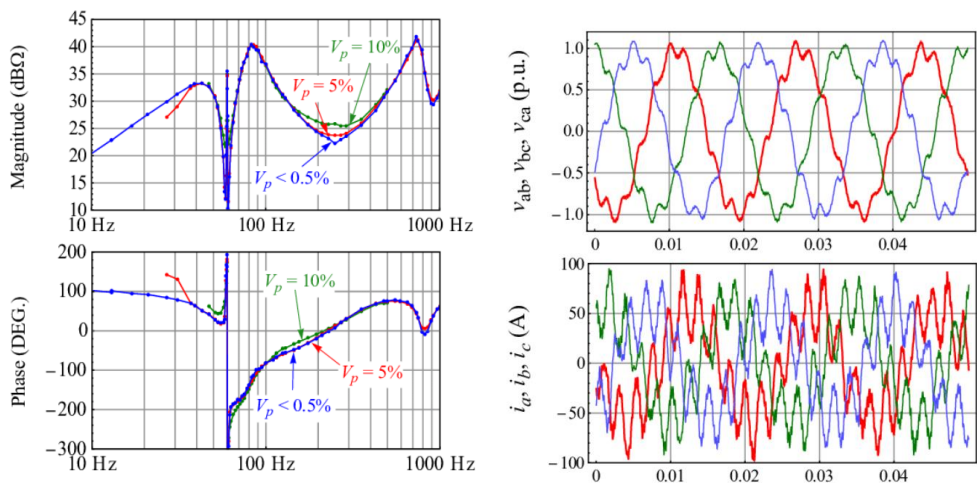


# Increasing Renewable Energy Penetration Rate Causing Grid Challenges

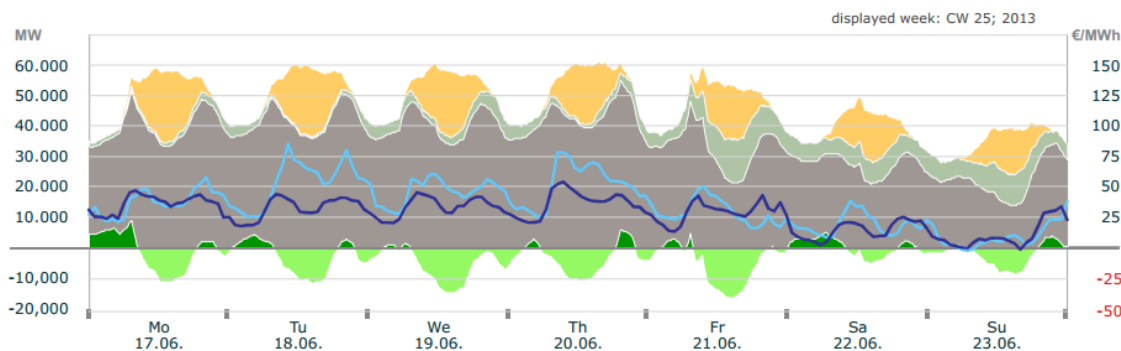
## Grid-strength weakened



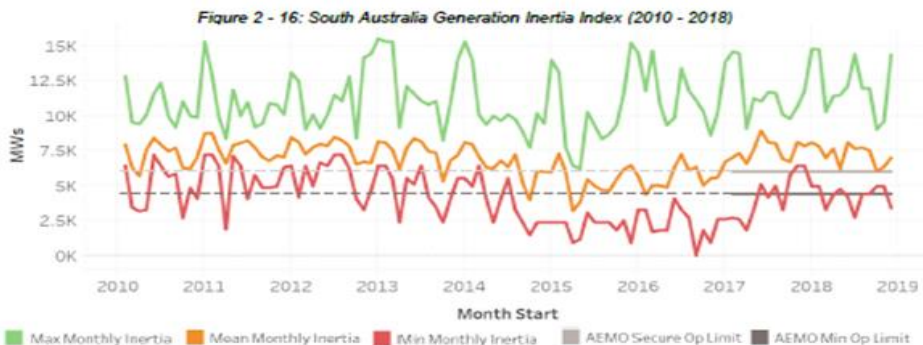
## Increase of resonances and voltage harmonic distortion



## Reduction of the grid inertia



## Intermittent power generation based on PES



# Storage - Necessary Enabling Technologies

## Promoting Renewable Energy from Grid Following to be Grid Forming

### PV



IGBT Drive



DSP



### Current Source

Grid following  
Passive acceptance

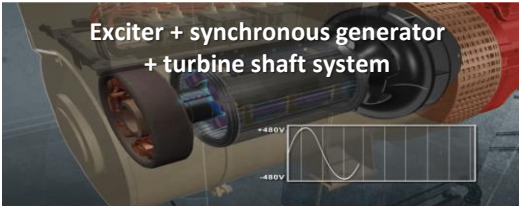
Solar energy:  
**Cannot be stored**  
Generated electricity:  
**Difficult to control**

### PV + ESS + Algorithm



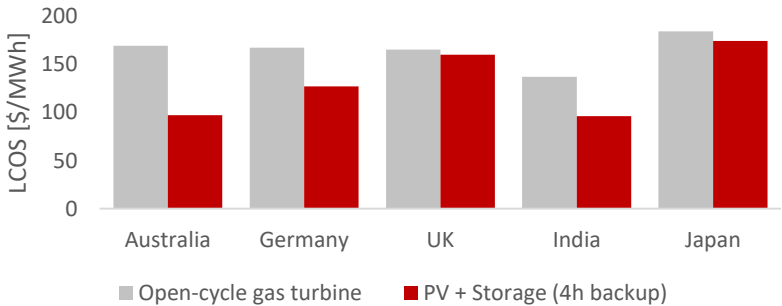
### Voltage Source

Grid Supporting  
Proactive integration



Solar energy:  
**Can be stored as electricity**  
Generated electricity:  
**Easy to control**

The electricity cost of solar/wind storage will **be close to or even lower than** current mainstream peak-shifting methods



Main reasons for choosing PV + storage & wind + storage

- Low power supply costs  
Energy can be **directly absorbed from PV or wind systems**, reducing power transmission and distribution costs.
- Reduced initial investment  
Storage and PV/wind share the step-up station and external transmission line, reducing system investment and ROI period.

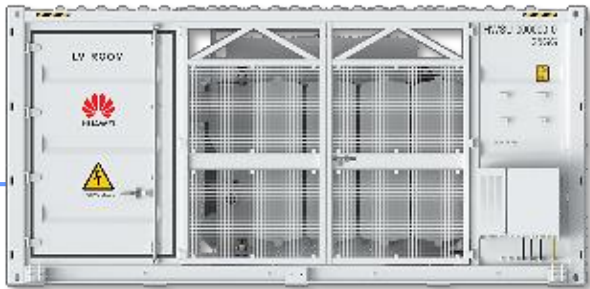
# Smart String ESS: Optimal LCOS, Active Safety



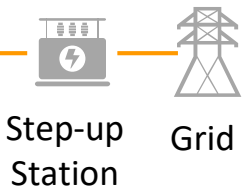
**LUNA2000**  
Smart String ESS



**LUNA2000**  
Smart PCS



**STS**  
Smart Transformer Station



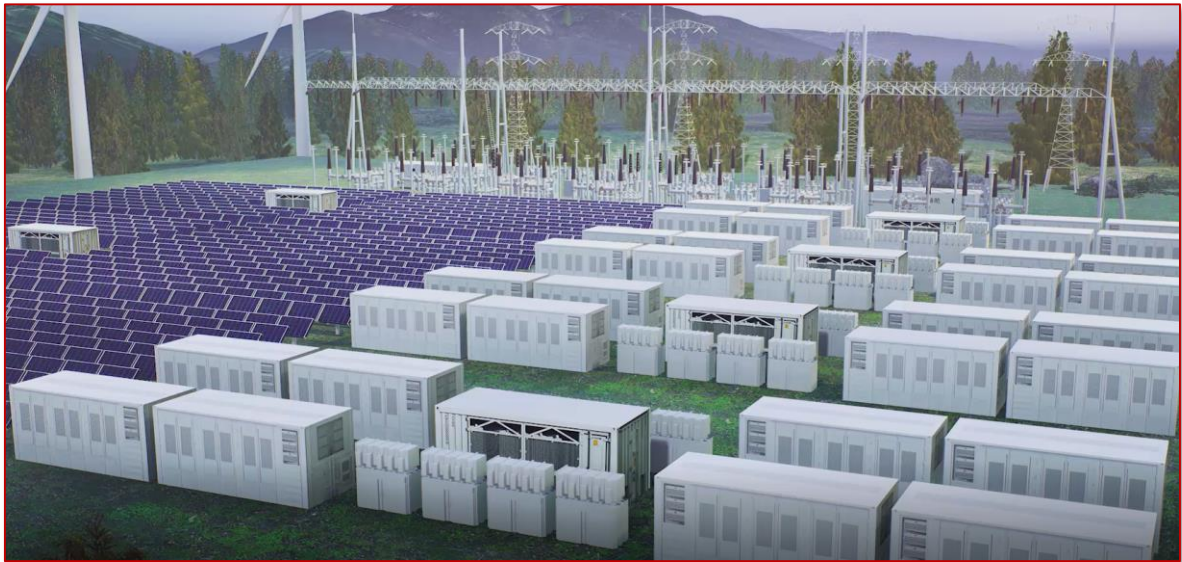
**Smart PCS**  
LUNA2000-200KTL-P0

## Smart PCS

Rated AC Capacity: 200KW  
Rated Input Voltage: 1200Vdc  
Rated Output Voltage : 800Vac  
Efficiency: DC-AC Max 99%  
AC-DC Max 98.7%

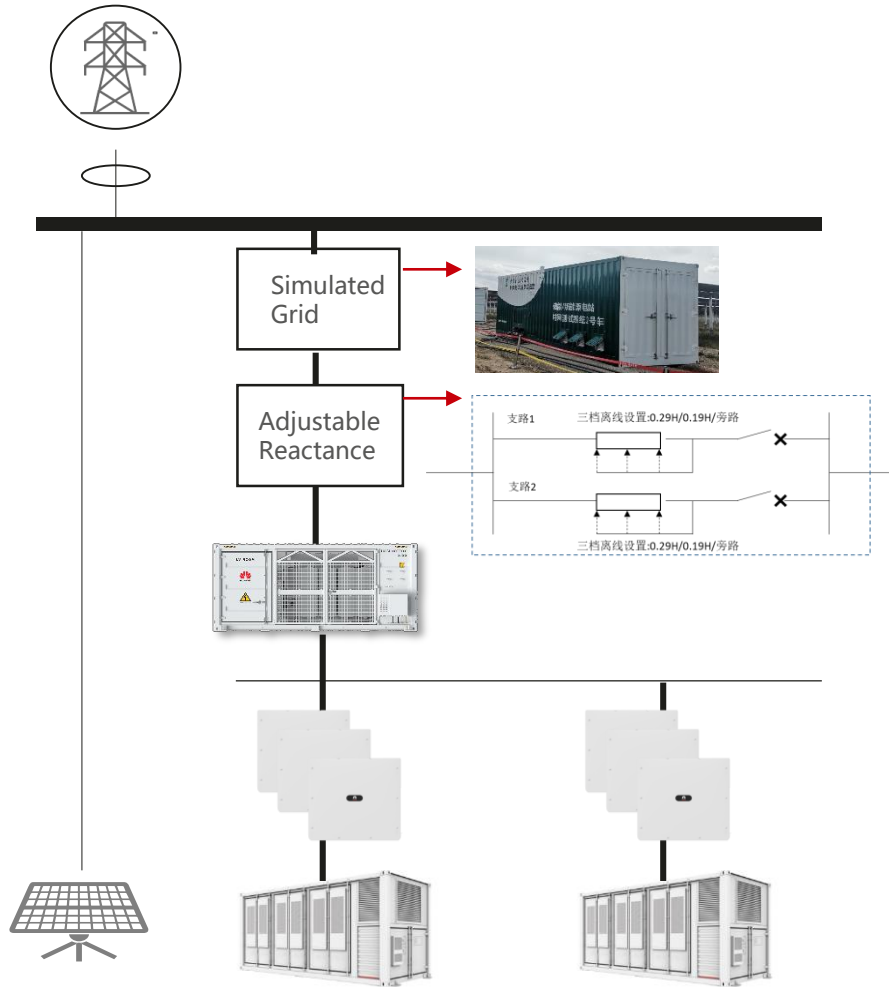
Protection: IP66  
Corrosion: C5M  
Weight: < 90kg

Control: Grid-forming/following cap.



# Prototype Grid Forming BESS Test

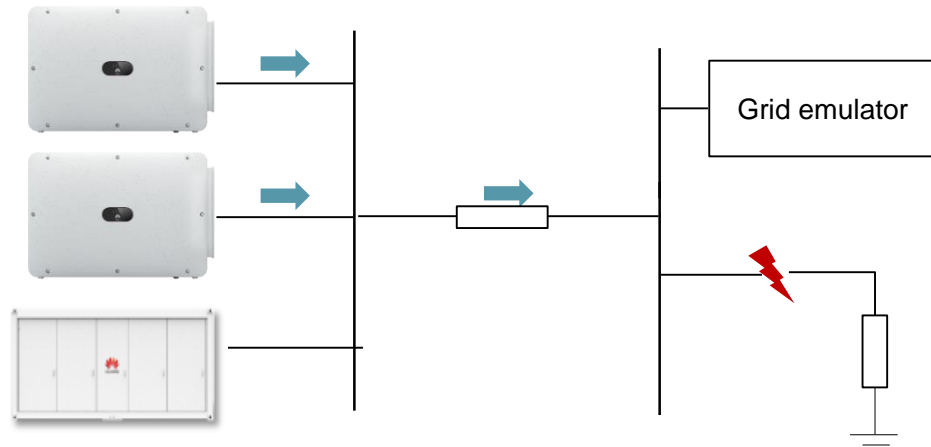
Grid company and Huawei plans to demonstrate grid forming effectiveness using a 1MW/3MVA BESS.



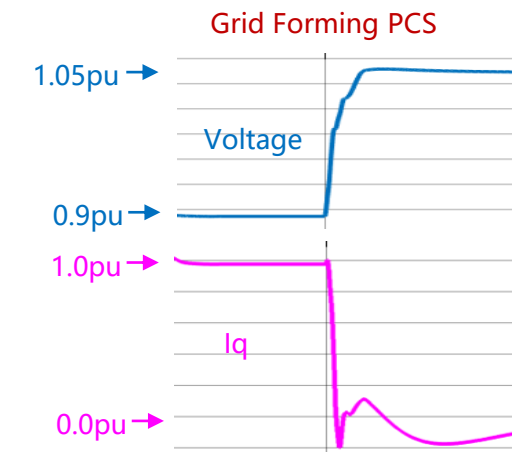
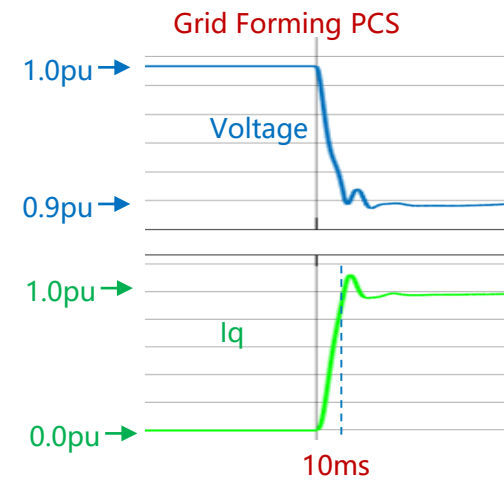
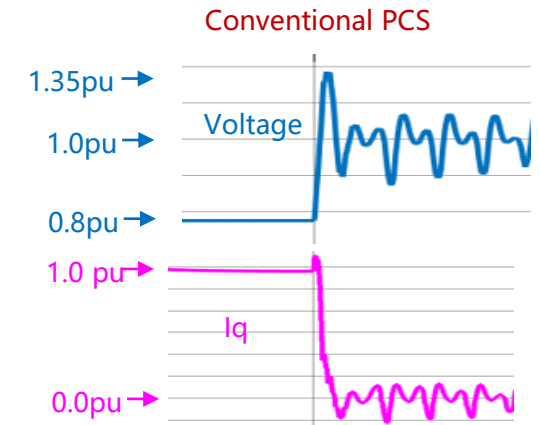
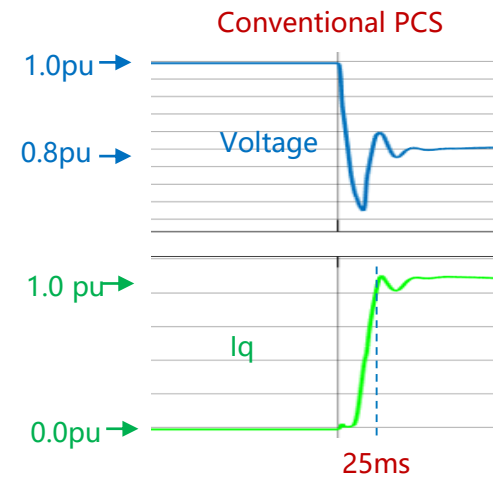
	KPI		Conventional BESS	Prototype
Voltage source In parallel			--	20 PCS same bus
Short Circuit Loading			100%	300%
Frequency	inertia	Reaction time	~200ms	5ms
		Time constant	4-12s	4-12s
		ROCOF	No active power overloading	1C Battery for 0.5C application 1Hz/s ROCOF
Reactive power capability			SyncCon: - 50%Sn~+100%Sn	±100%Sn
Voltage control	Response time		30-60ms	<10ms
Voltage stability support	Phase jump		SCR 1.5, ±30°	SCR 1.5, ±60°
	Over-excitation		--	1.X terminal voltage
FRT	L-H FRT		0pu*120ms 130*100ms	[(0pu-200ms) + (1.3pu- 100ms)]* 3
	Active power during HVRT		P change > 10%	P change <10%
	V+F joint FRT		--	[Fault->0.9/1.1pu, ±1Hz/s] * 140ms

# Prototype Grid Forming BESS Test

Test circuit

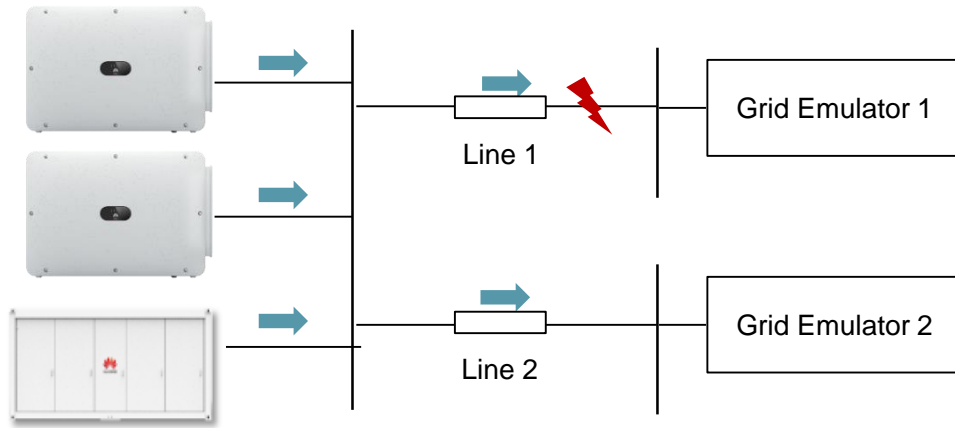


1. PV terminal SCR = 1.5
2. Grid-side fault



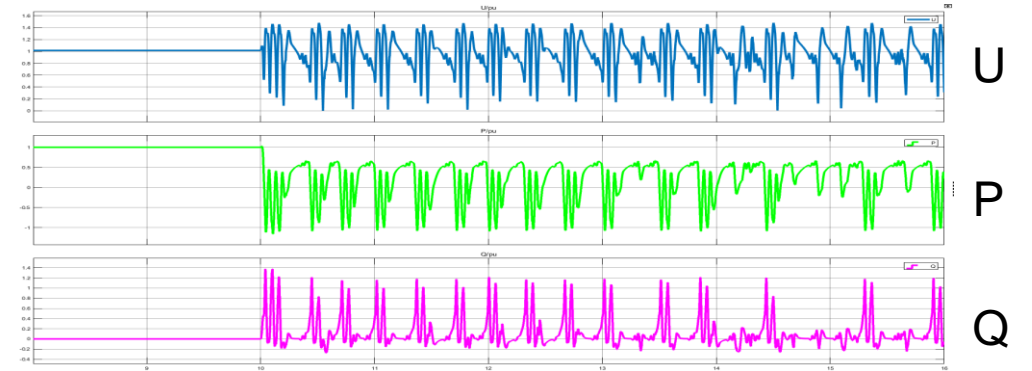
# Prototype Grid Forming BESS Test

Test circuit

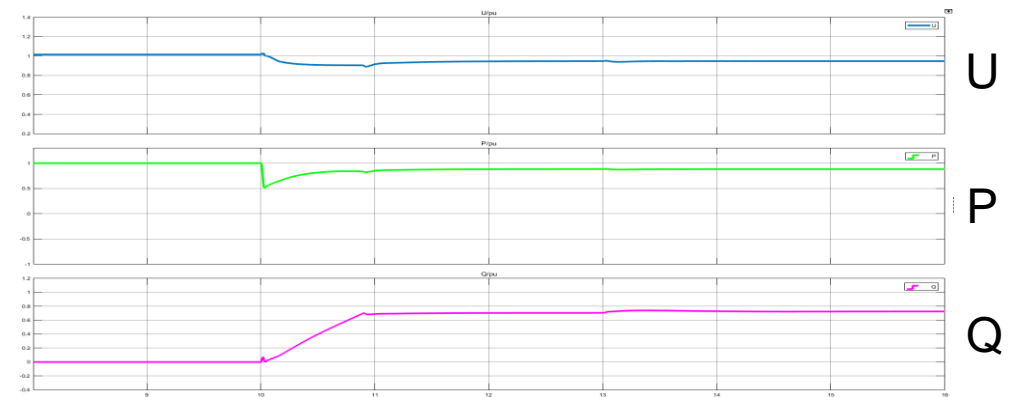


1. PV terminal @ SCR 1.5
2. N-1, causing PV terminal SCR drop to 0.75 (voltage instable)

## 1. Conventional PCS + PV



## 2. Grid Forming PCS + Grid Following PV



# Thank you.

把数字世界带入每个人、每个家庭、  
每个组织，构建万物互联的智能世界。

Bring digital to every person, home and  
organization for a fully connected,  
intelligent world.

**Copyright©2022 Huawei Technologies Co., Ltd.  
All Rights Reserved.**

The information in this document may contain predictive statements including, without limitation, statements regarding the future financial and operating results, future product portfolio, new technology, etc. There are a number of factors that could cause actual results and developments to differ materially from those expressed or implied in the predictive statements. Therefore, such information is provided for reference purpose only and constitutes neither an offer nor an acceptance. Huawei may change the information at any time without notice.

