

PUBLIC

HITACHI
Inspire the Next

The future of grid forming inverters

John Glassmire and Marija Vujacic

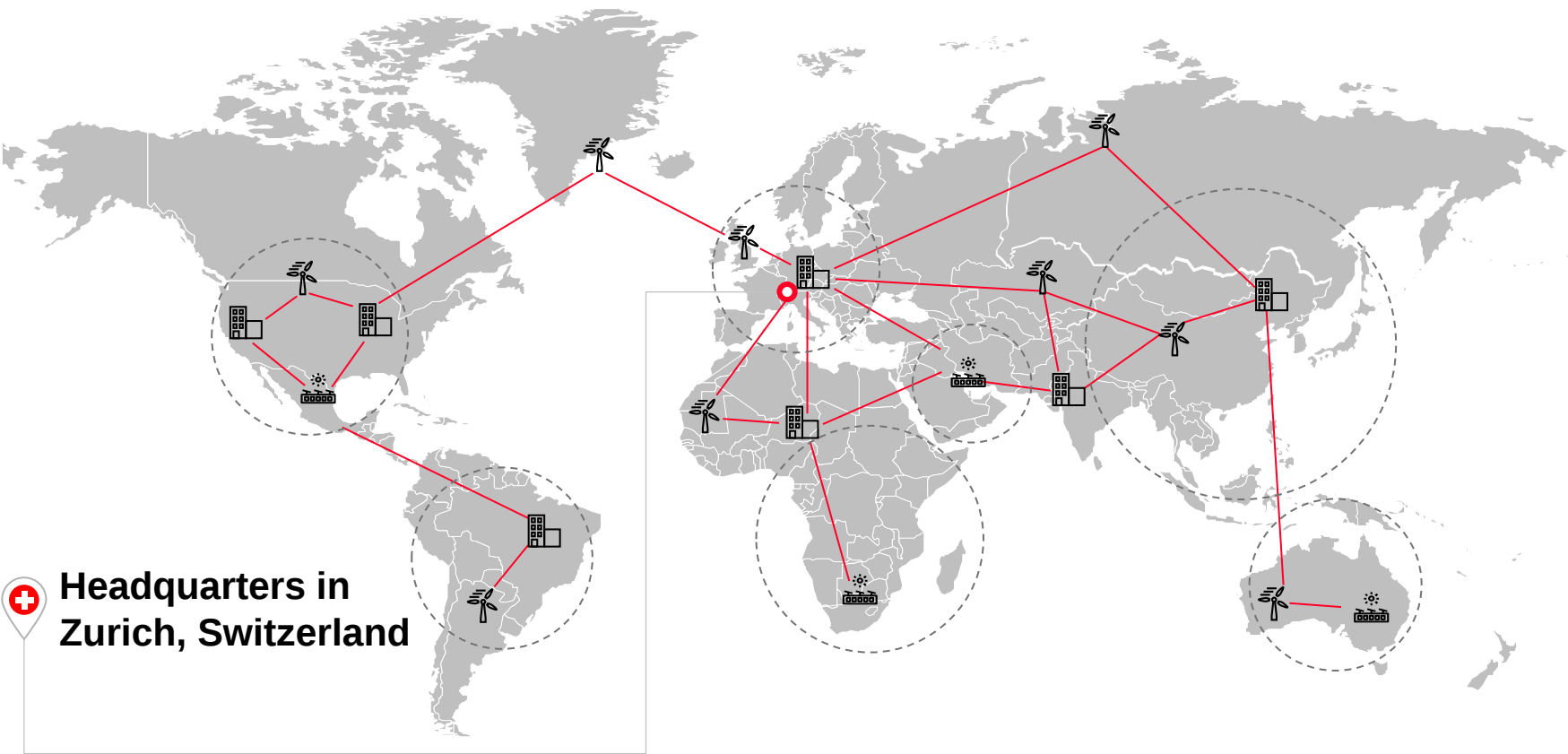
2022-06-08

© 2022 Hitachi Energy. All rights reserved.



Overview

Introduction	01
Hitachi Energy Heritage	02
Technology	03
VSM References	04
Key Takeaways	05
Q&A	06



38,000 employees

90+
countries with
200 offices

~250
years' heritage
combined

5,500
sales employees
& field engineers

2,000
engineers &
scientists in R&D

Four Business Units

Grid
Automation

High Voltage
Products

Grid Integration

Transformers

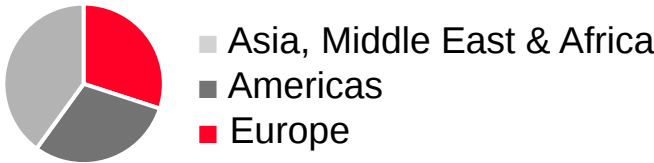
Customers



Offering

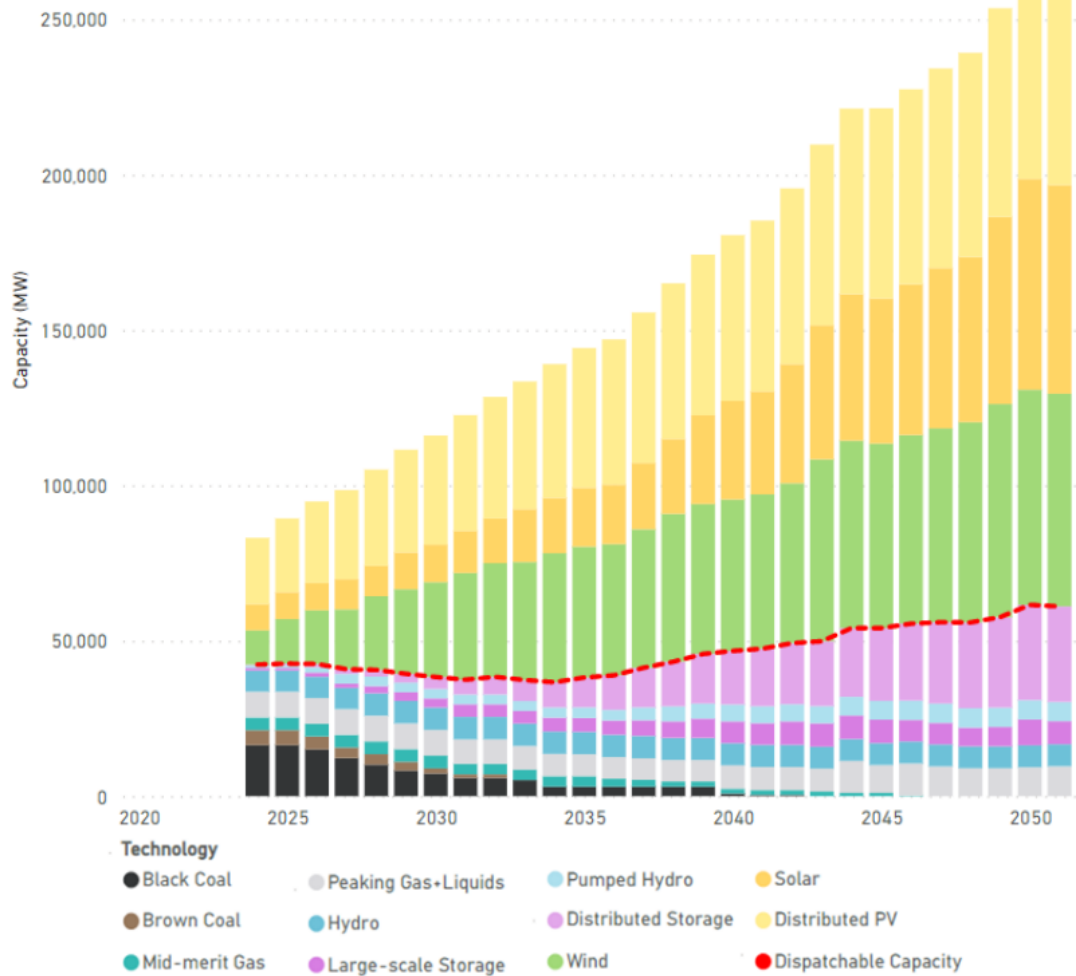


Geographies



Need to replace 14GW of Synchronous Generators in 8 Years

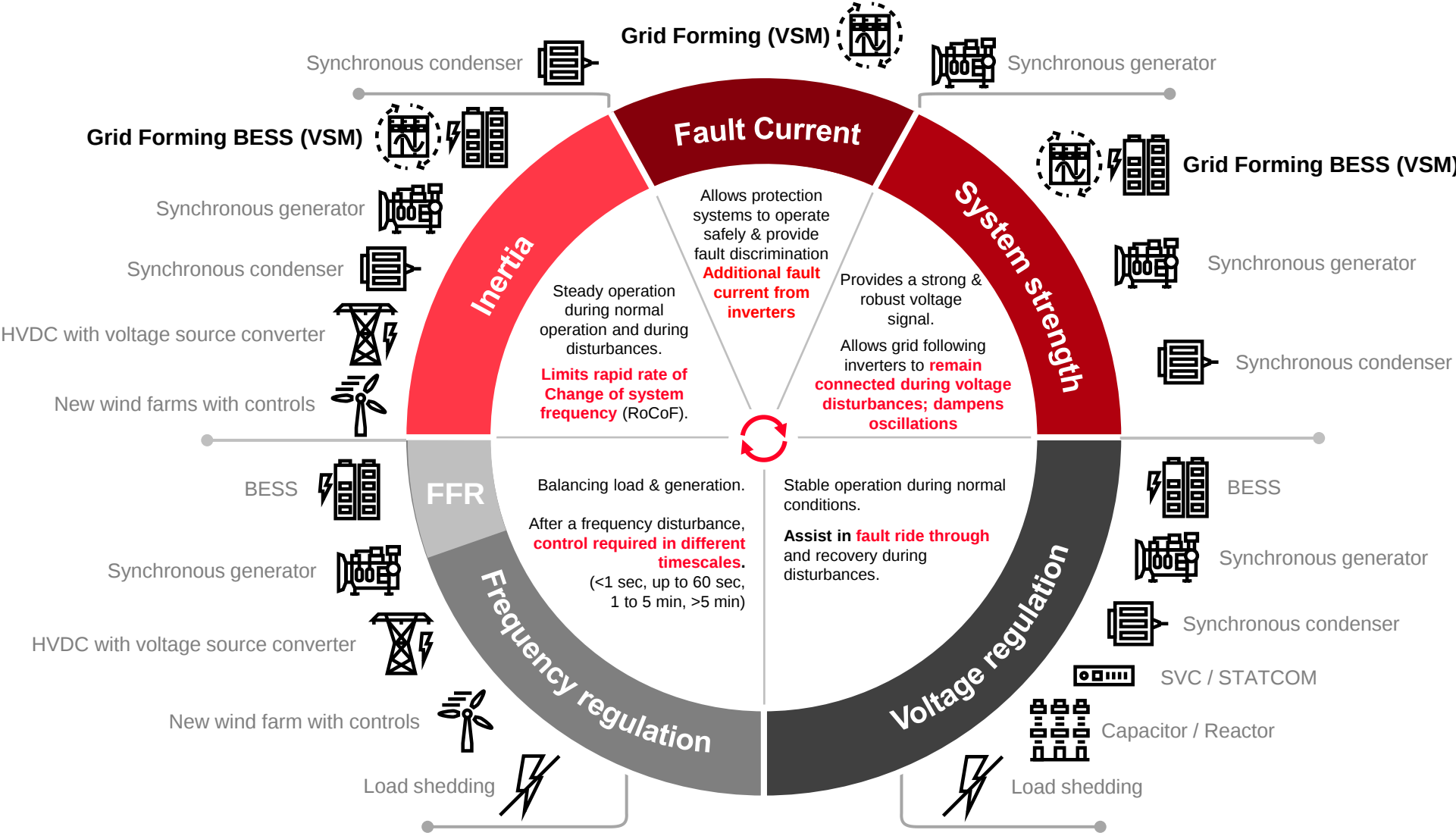
Renewable generation capacity to at least double every decade from now to 2050



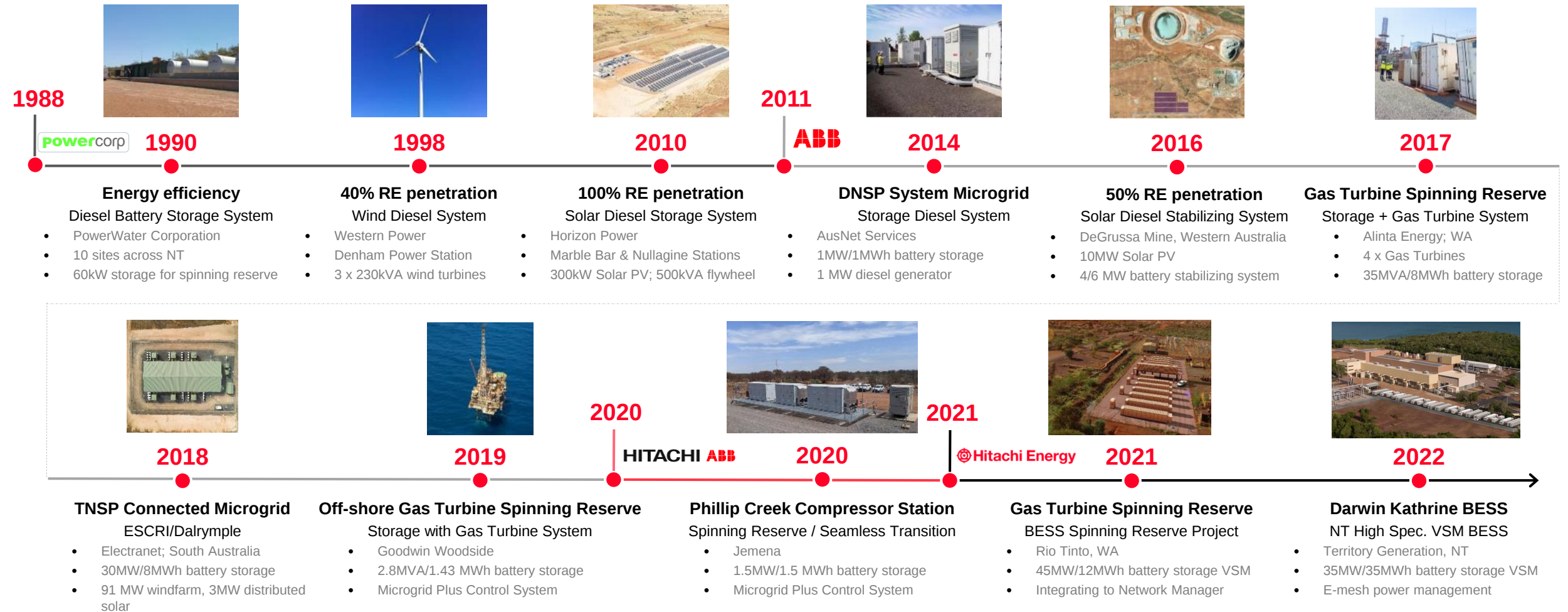
The Draft ISP 2022 highlights that **profound transformation** is anticipated that will rapidly cross uncharted operational conditions.

Fewer synchronous generators Coal capacity (GW)	Ubiquitous rooftop solar Installed DPV (GW)	Extensive VRE VRE capacity (GW)
Today 23	Today 15	Today 15
2025 21	2025 24	2025 23
2030 9.0	2030 35	2030 43
Widespread energy storage Storage (GWh)	Responsive demand VPP and demand response (GW)	Structural demand shifts Electric vehicles (number)
Today 13	Today 0.7	Today 26 k
2025 20	2025 1.6	2025 225 k
2030 400	2030 6.0	2030 2.3 m
Operational demand		
Maximum (GW)		Minimum (GW)
Today 32	Today 15	
2025 36	2025 9.4	
2030 38	2030 4.9	

What services are required to operate a stable and secure grid?



Our Heritage - Evolved Knowledge & Technology over 30+ years



Technology evolved from solving Power System Stability rather than Energy Conversion.

CUSTOMER CHALLENGES

Energy autonomy, reliability and resiliency; new economic opportunities; and effectively manage on increased portfolio of distributed energy resources (DERs).

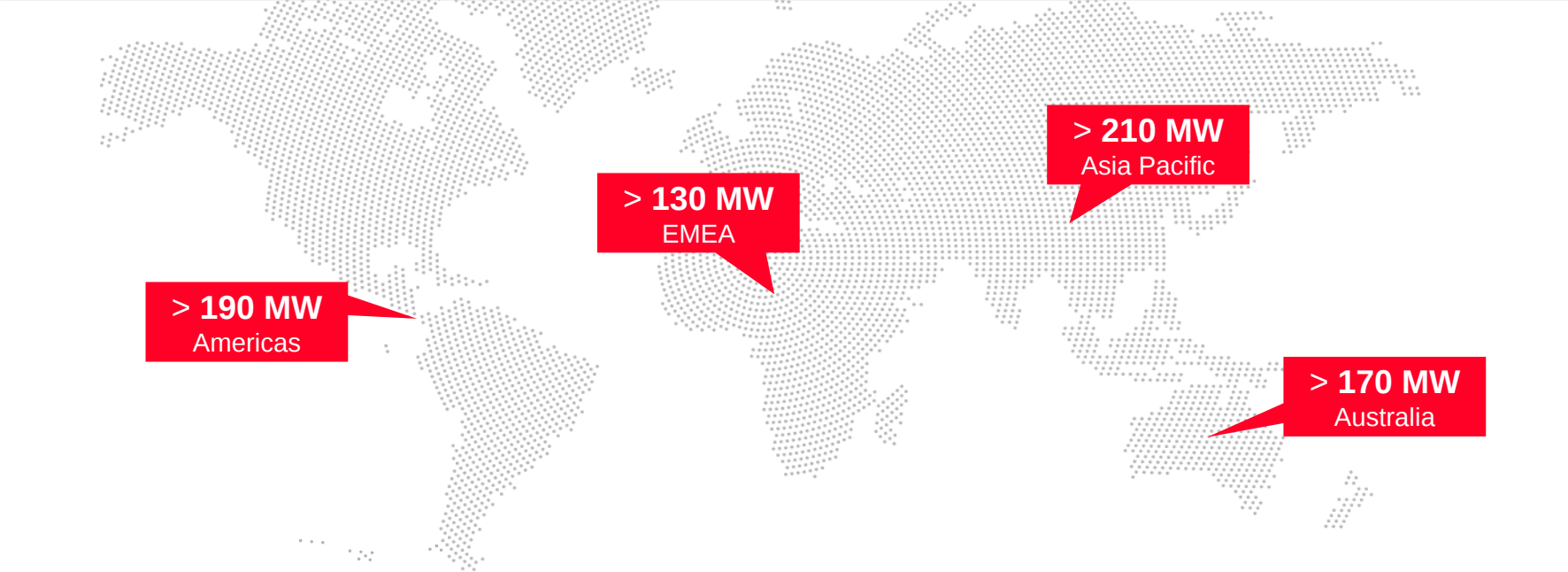
CUSTOMER OUTCOMES

- ✓ Improved reliability and resiliency
- ✓ Reducing energy cost & CO₂
- ✓ Unlocking new revenue streams
- ✓ Maximizing renewable integration

 **GLOBAL FOOT/PRINT**

 **VALUE PROPOSITION**

Grid Edge Solutions Regional references



220+
Projects delivered worldwide

30+
Years of experience

700+
MW of microgrids and BESS installed base

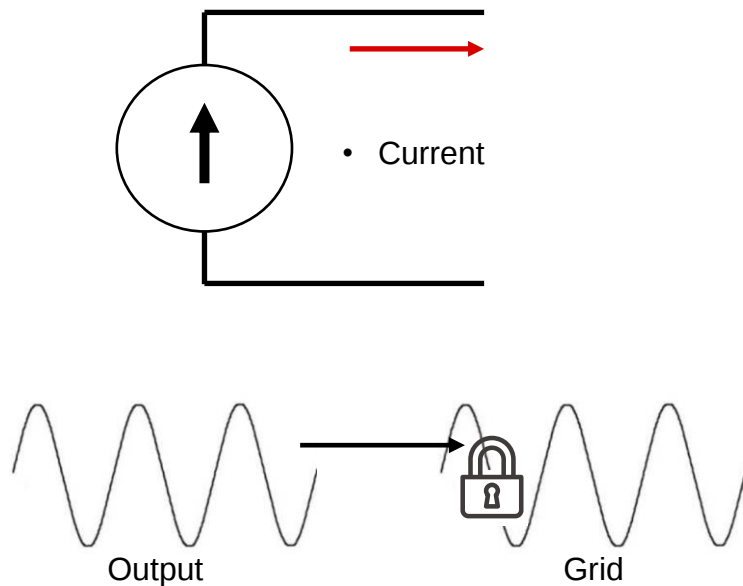
90+
Countries supported with Service and Sales organizations

e-mesh™ portfolio is a scalable, vertically integrated digital ecosystem managing & optimizing energy at all levels with wide range of applications from the field to the boardroom, on cloud and on premises.

How PowerStore digitally stabilizes grids

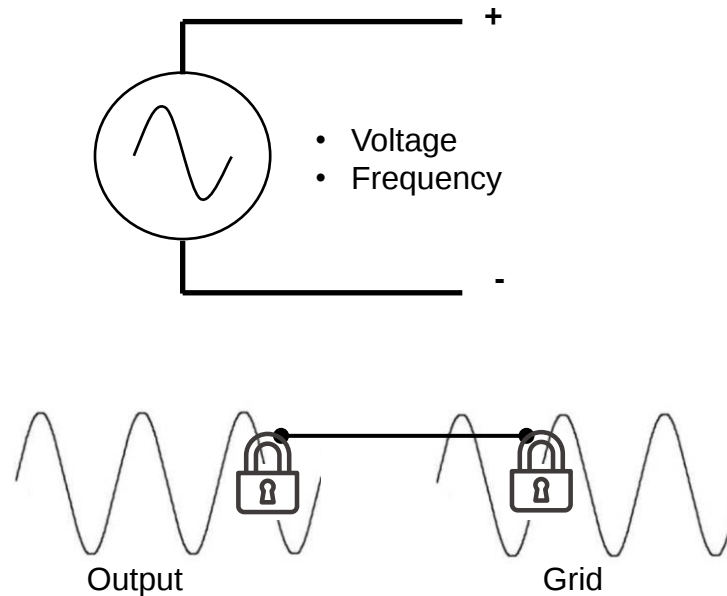
Grid following (GFL)

Current Source Inverter (CSI)



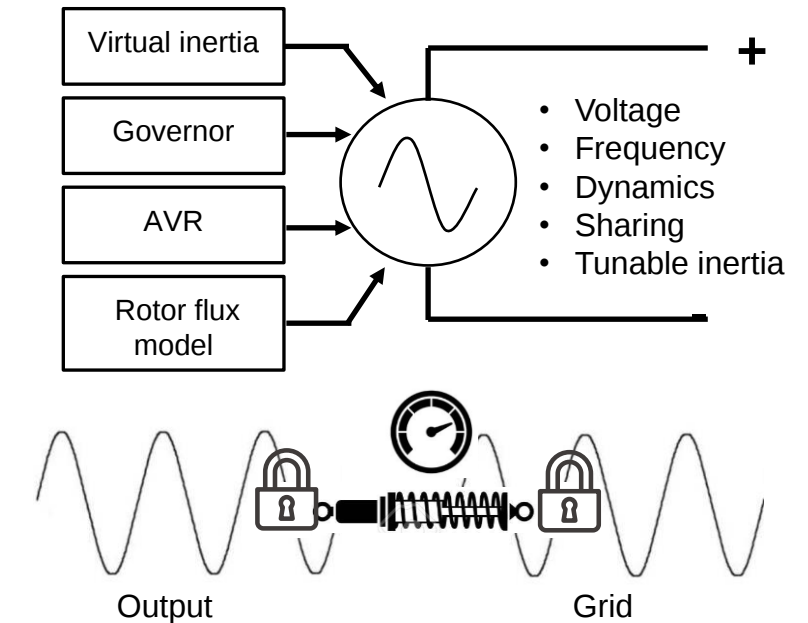
Grid forming (GFM)

Voltage Source Inverter (VSI)



Virtual Synchronous Machine (VSM)

PowerStore GFM BESS in VGM



The key to stabilizing grids and unlocking new revenue streams is digital automation and smart controls intelligently applied to grid forming (GFM) converters

Monetized Virtual Synchronous Machine Services (today)

No	Service Functions	Description	ISO/RTO/NEM	Microgrid (0.1-10 MW)
1	Sinewave	Voltage Harmonic Filtering		\$
2	System Strength	Strengthen Weak Grids		\$
3	Static Inertia	Inherent frequency support		\$\$\$
4	Short Circuit Current	Activating Protection System		\$\$\$
5	System Restoration	Energizing network sections		
6	Starting from black	Blackstarting a dead bus		\$\$
7	Stabilising frequency (fast)	Fast Frequency Response		\$\$
8	Stabilising frequency (reserve)	Contingency Frequency Support	\$\$	\$\$
9	Stabilising frequency (regulation)	Secondary Frequency Regulation	\$	\$
10	Support Voltage	Voltage regulation		\$
11	Standalone Operation	Grid reference for islanded Operation		\$\$\$
12	Seamless Transition	Disconnection and reconnection of network sections without interruption		\$\$\$

Monetized Virtual Synchronous Machine Services (future?)

No	Service Functions	Description	ISO/RTO/NEM	Microgrid (0.1-10 MW)
1	Sinewave	Voltage Harmonic Filtering	?	\$
2	System Strength	Strengthen Weak Grids	\$\$	\$
3	Static Inertia	Inherent frequency support	\$\$	\$\$\$
4	Short Circuit Current	Activating Protection System	\$\$	\$\$\$
5	System Restoration	Energizing network sections	?	
6	Starting from black	Blackstarting a dead bus	?	\$\$
7	Stabilising frequency (fast)	Fast Frequency Response	\$\$	\$\$
8	Stabilising frequency (reserve)	Contingency Frequency Support	\$\$	\$\$
9	Stabilising frequency (regulation)	Secondary Frequency Regulation	\$	\$
10	Support Voltage	Voltage regulation	?	\$
11	Standalone Operation	Grid reference for islanded Operation		\$\$\$
12	Seamless Transition	Disconnection and reconnection of network sections without interruption	?	\$\$\$

VSM References

Inertia, Strength, and Security for Grids

Virtual Synchronous Machines & BESS in Australia

Hitachi Energy has over 200MVA operating or in construction since 2014

HITACHI
Inspire the Next

Goodwyn (Woodside)

- 2.8MVA/1.43MWh VSM
- Offshore Platform
- Commissioned 2019



Northstar/Soloman (FMG)

- 30MVA/8MWh VSM &
- 20MVA/5MWh VSM
- NWIS/Private Network
- Commissioning 2022



Newman (Alinta)

- 35MVA/8MWh VSM
- NWIS/Private Network
- Operating since 2017



Kalbarri (Western Power)

- 5MVA/2.5MWh VSM
- SWIN
- Operating since 2021



Tom Price (Rio Tinto)

- 45MVA/12MWh VSM
- Private Network
- Commissioning 2022



De Grussa (Sandfire)

- 6MVA/2MWh VSM
- Private Network
- Operating since 2017



DK BESS (TGen)

- 35MVA/35MWh VSM
- NT
- Commissioning 2023



Goodwyn (Woodside)



Newman (Alinta)



Northstar / Soloman (FMG)



Tom Price (Rio Tinto)



De Grussa (Sandfire)



Kalbarri Microgrid (WP)



ESCRI (ENet)

ESCRI/ Dalrymple

- 37MVA/8MWh VSM
- NEM
- Operating since 2018



DK BESS (TGen)



Hitachi ABB VSM, existing & under construction



Other Supplier BESS, existing



Other Supplier BESS, under construction



GESS (AusNet)

- 1MVA/1MWh VSM
- NEM
- Operating since 2014

Dalrymple substation: Unplanned Islanding

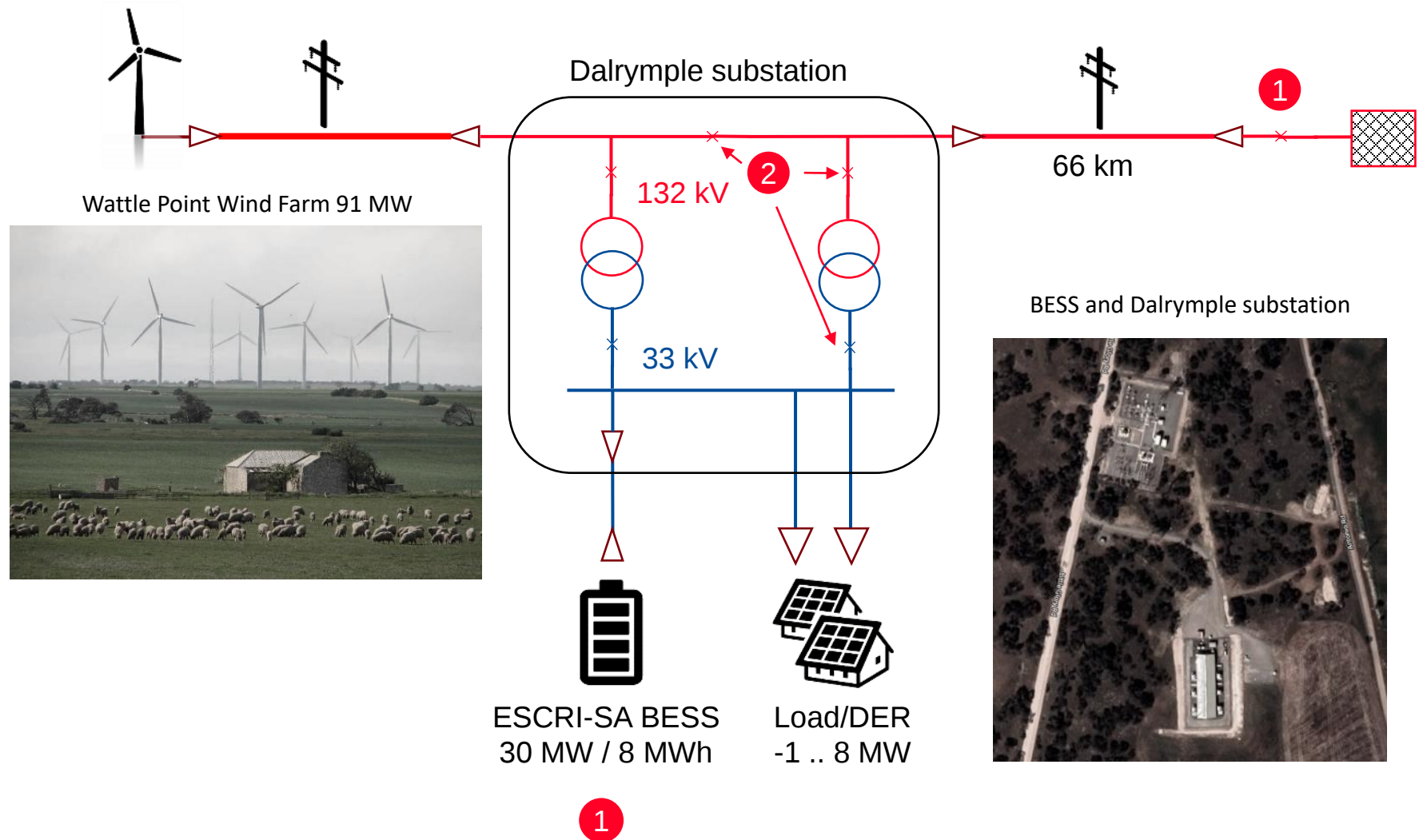
Sequence of events

Pre-event conditions

- Wind farm offline
- BESS running unloaded on the NEM
- Local load ~ 4 MW
- All breakers closed

Event

- 1 132 kV breaker at the upstream substation opens
- 1 BESS becomes the only grid forming source in the now islanded microgrid and instantaneously supplies the area
- 2 Some 80 msec later the protection system at Dalrymple disconnects the upstream line

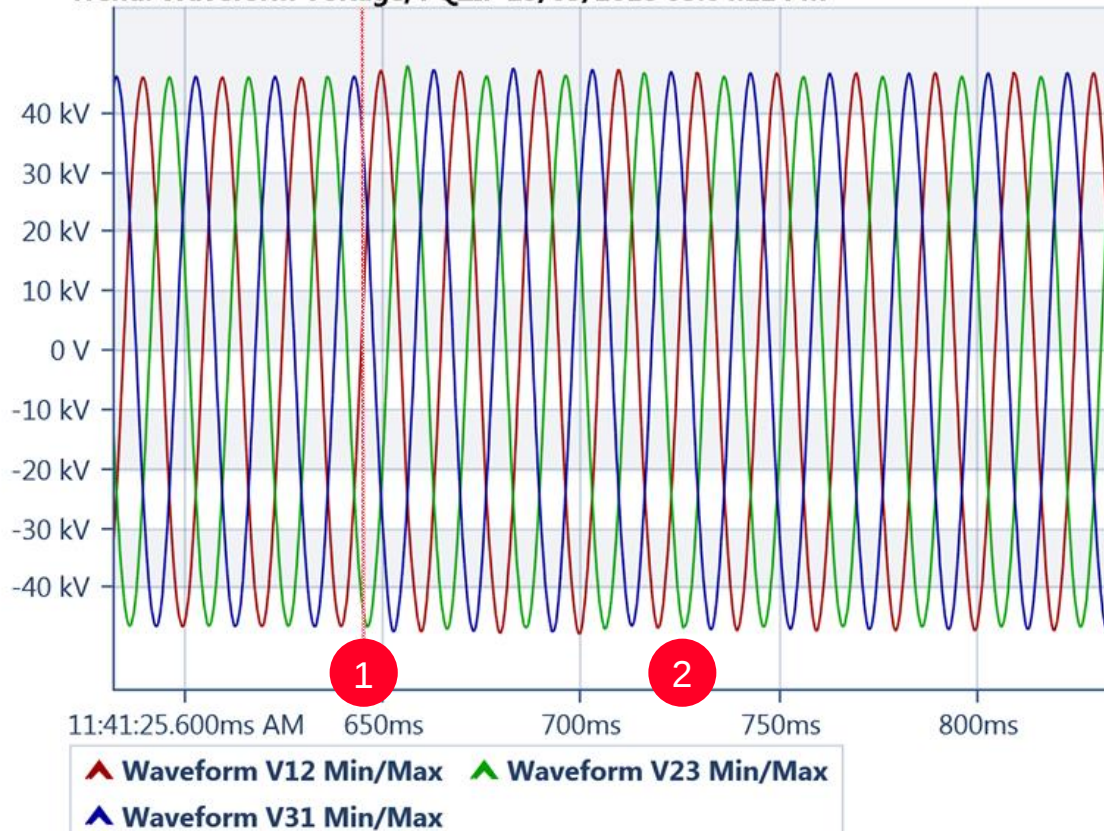


ESCRI/Dalrymple: Unplanned Islanding

The islanding instant – BESS voltage and current waveforms

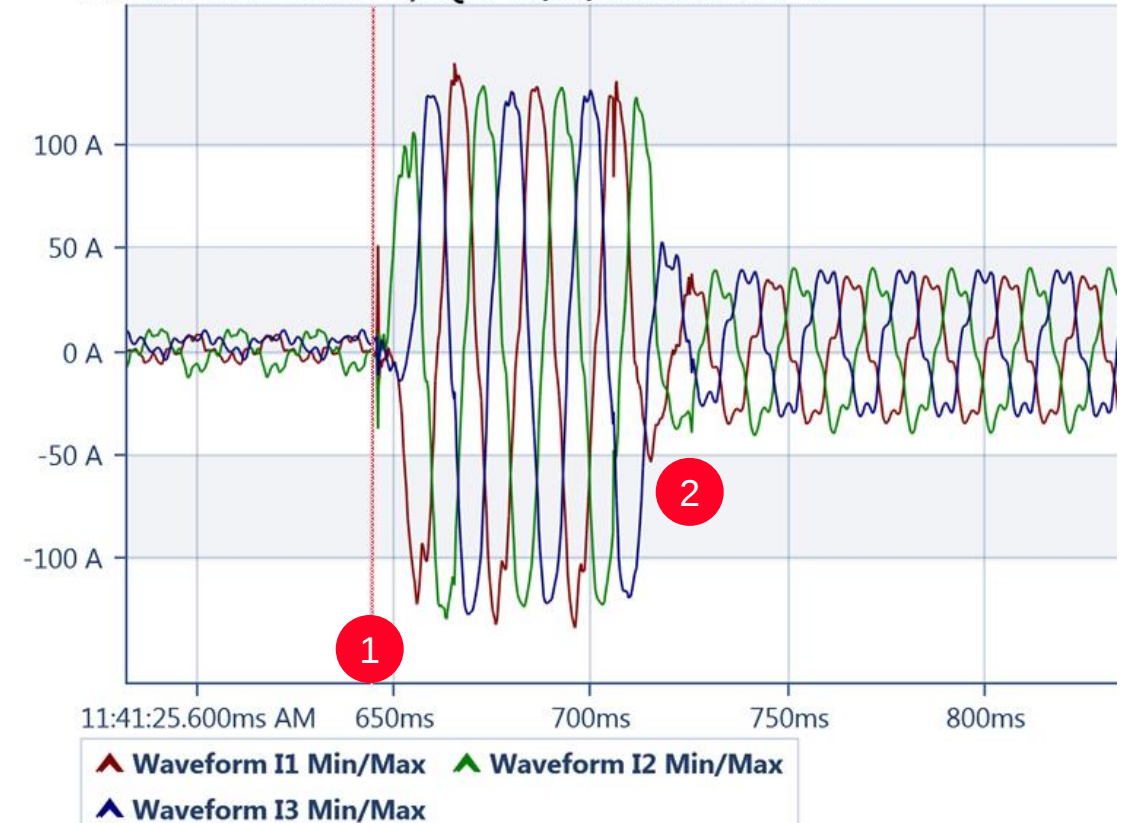
1 132 kV breaker at upstream substation opens = islanding takes place

Trend: Waveform Voltage, PQZIP 25/09/2018 05:04:11 PM



2 Upstream line is disconnected

Trend: Waveform Current, PQZIP 25/09/2018 05:04:11 PM

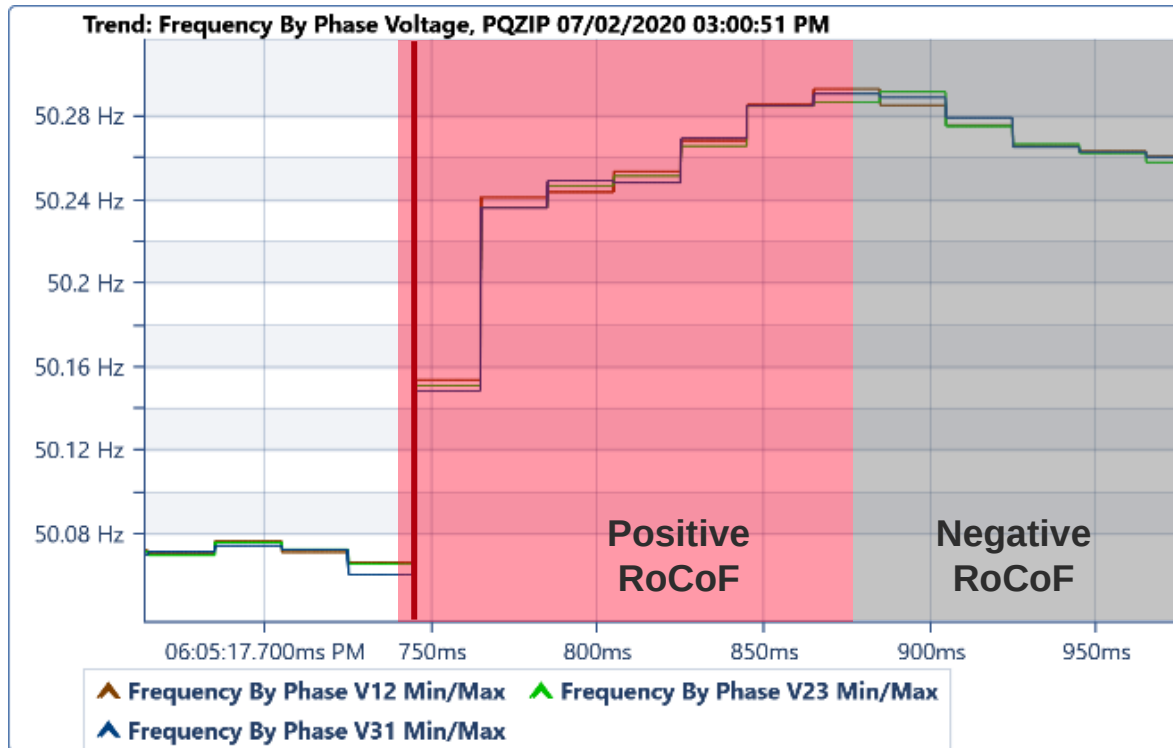


Misconception: Dalrymple BESS does not switch modes from grid connected to islanded – it is always Grid Forming

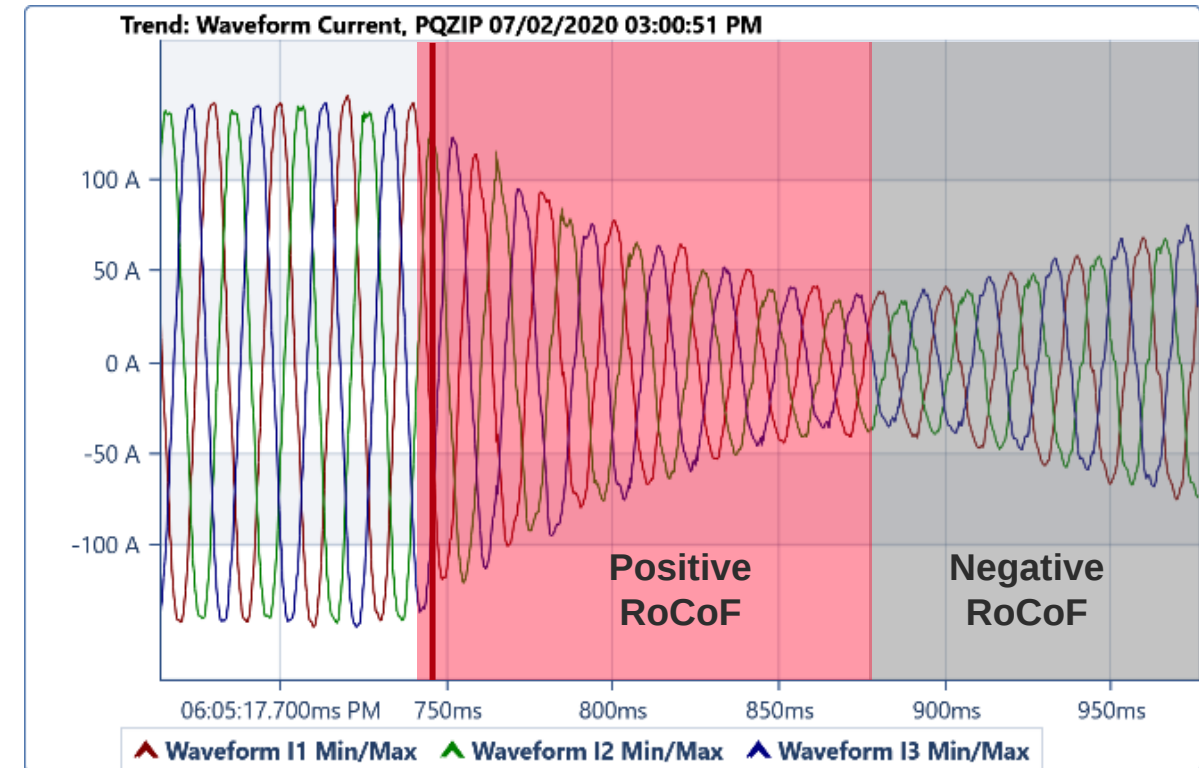
South Australia Islanding Event: Inertia Response

VSM responds to frequency change prior to high-speed data recorder

Frequency Measurement by high speed data recorder over 300ms



VSM Response – Current responds prior to frequency measurement (red vertical line) and the output (below) mirrors the grid frequency (left) as it resists the change in frequency



Selected NAM projects – from small/isolated to large-scale systems



2003

Gas Turbine Spinning Reserve

Ni-Ca Battery Storage System

- Golden Valley Electric Association
- 40MW / 10MWh battery storage
- Outages reduced by over 60%



2014

RE integration

Li-ion Battery Storage System

- Southern Cal Edison
- 8MW / 32 MWh
- Contingency support, V support



2019

Gull Bay Microgrid

Solar Diesel Storage System

- Gull Bay First Nations community
- 300kW / 555 kWh BESS
- 300kW Solar PV; 1 x 450kW, 250 kW, 180kW Diesel



2019

Cordova Microgrid

Hydro Diesel Storage System

- Cordova Electric Cooperative
- 1MW / 1MWh
- 2 MW diesel generator; 7.5 Hydro



2021

SnoPUD Arlington Microgrid

Solar EV Diesel Stabilizing System

- Snohomish Public Utility District
- 1MW / 1MWh
- V2G; Grid stabilization; RE integration; RE back-up



2021

Magens Junction Microgrid

Storage + PV + CHP System

- E-Finity
- 500 kW / 820 kWh
- Power quality & RE integration

Transitioning towards inverter-based grid by leveraging Microgrids know-how



Summary

- **Virtual Synchronous Machines (VSM) are a proven technology to run grids on renewables.**
 - **VSM is the new grid**
- **VSM's have been successfully operating for over a decade**
- Hitachi Energy, the partner of choice and lowest risk option
 - Installed first Australian NEM connected VSM in 2014
 - First large-scale VSM registered on the NEM in 2018 (perhaps in the world)
 - Executed more than 200MW VSM projects globally



HITACHI
Inspire the Next 