Unlocking the transition to a low-carbon, reliable electrical system with hybrid storage solutions

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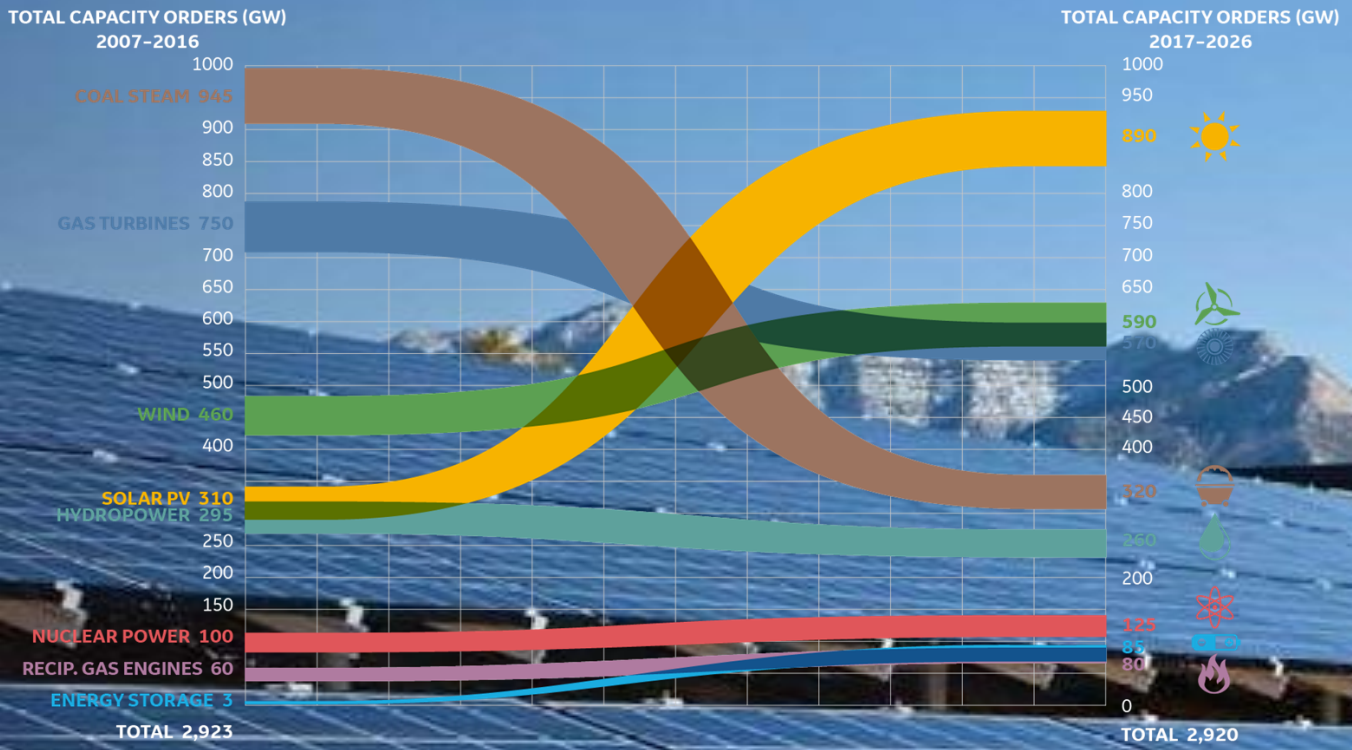
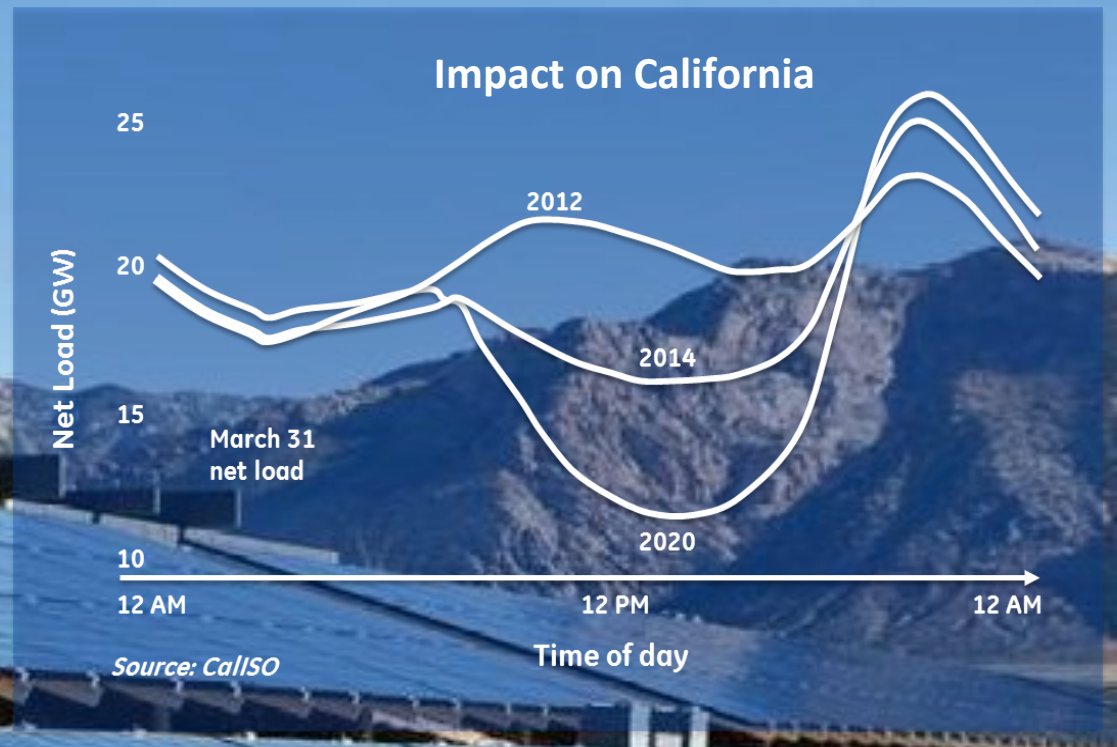
Transformation…at incredible speed



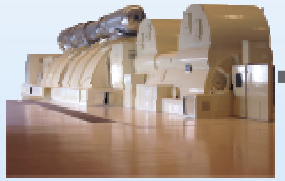


Growing scarcity in flexibility

Energy transitioning... the value of Renewable Hybrids

Thermal, Nuclear

Constant speed



50/60 Hz AC

Renewables

Variable speed

DC

- Synchronous
- Mechanical/Electromagnetic Conversion
- Centralized generation

- Asynchronous
- Electronic Energy Conversion
- More distributed grid

Powerful trends shaping the nature of electricity

DECARBONIZATION

By 2026, **RENEWABLES will represent 40%** of global **installed generation capacity***

IMPACT

- Growing share of renewables an increasing challenge to the traditional power system model

DIGITIZATION

EXPONENTIAL GROWTH of **connected devices** & **smart sensors**

IMPACT

- Real time decision making becomes possible … new software solutions open breakthrough optimization

DECENTRALIZATION

GROWING PENETRATION of **Distributed Energy Resources**

IMPACT

- End users become active actors of the power system (‘pro-sumer’) … growing grid complexity

ELECTRIFICATION 2.0

ELECTRIFICATION OF ENERGY-INTENSIVE USES

IMPACT

- Step increase in electricity consumption … accelerating Decentralization

Trends on Utility ESS for Renewables

Hybridization and Multiple Services

Increased Renewables Integration with Increased Energy Production

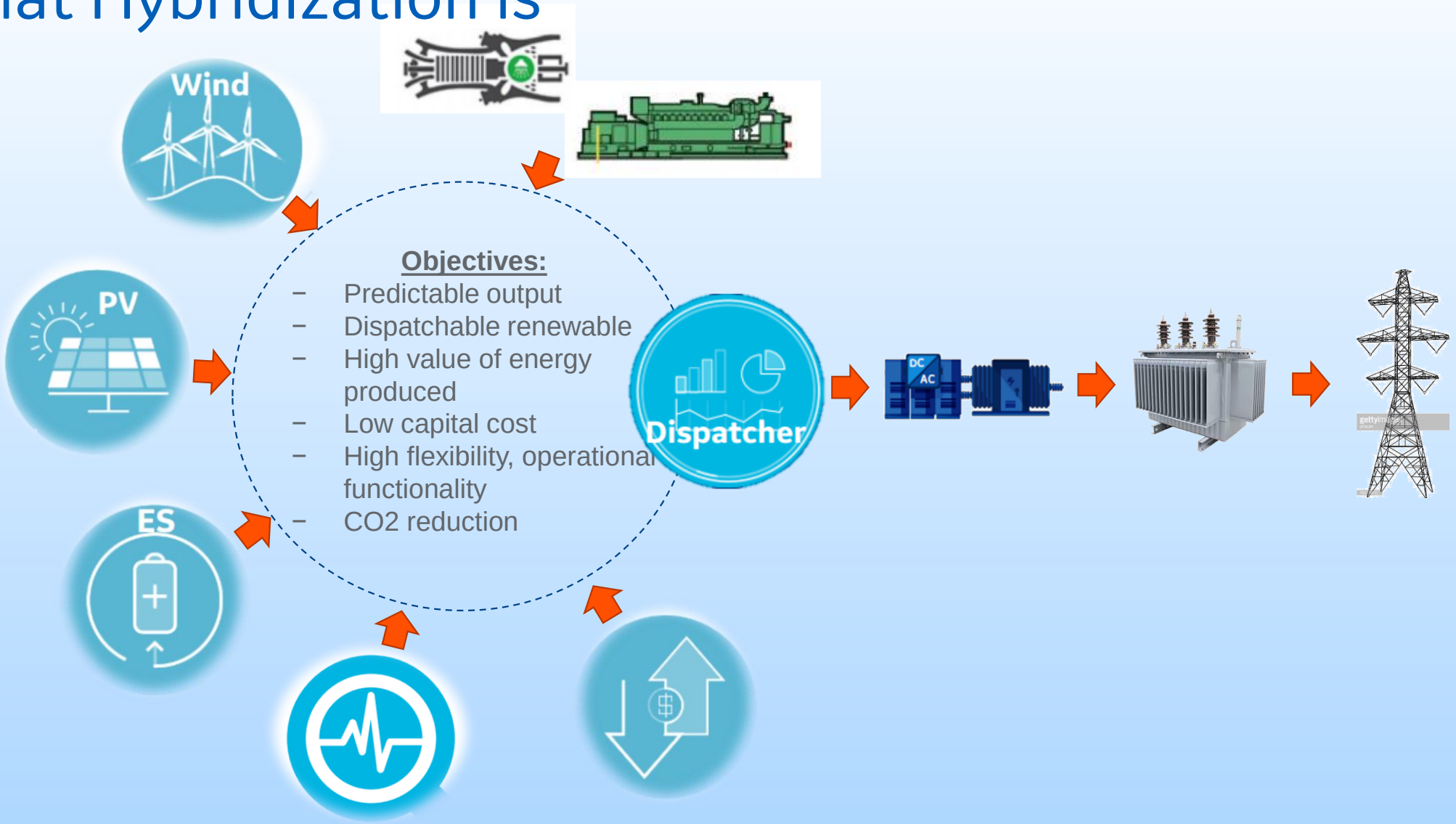
Renewables + ESS will further Optimize Electrical Grid

Change in Regulatory and Financing Environment

Reduce Energy Costs

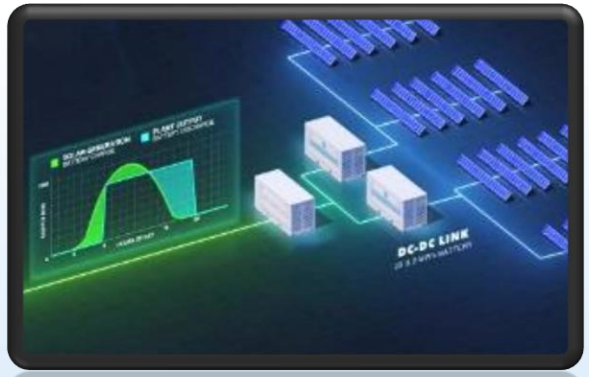
Higher DER proliferation

What Hybridization is



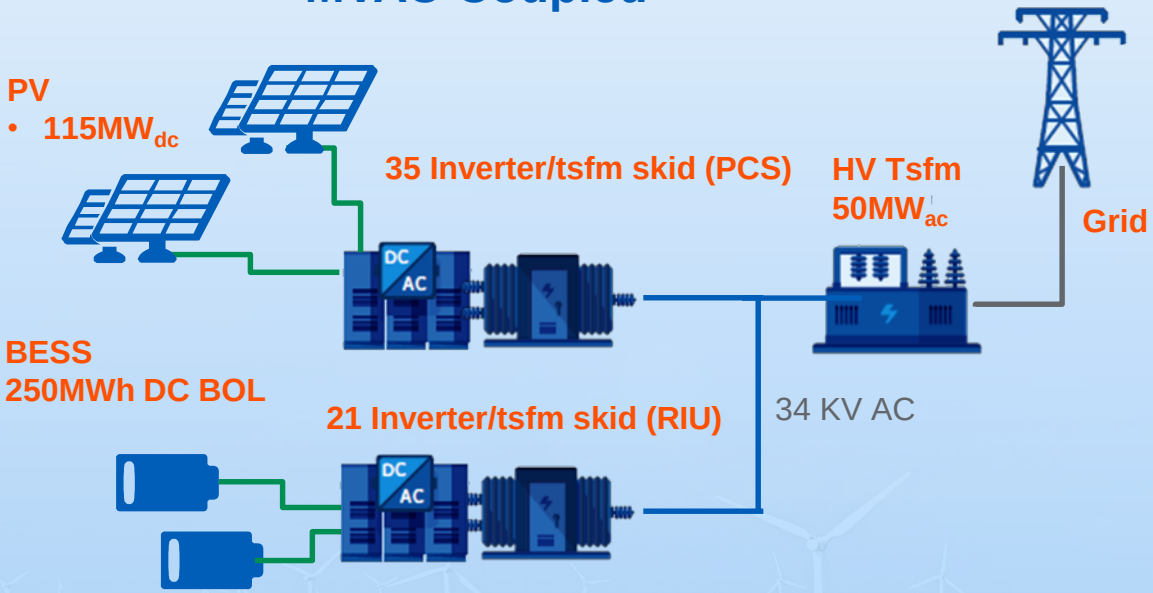
Optimization for maximum NPV/IRR or minimum LCOE

DC Coupled improve Solar Hybrid value

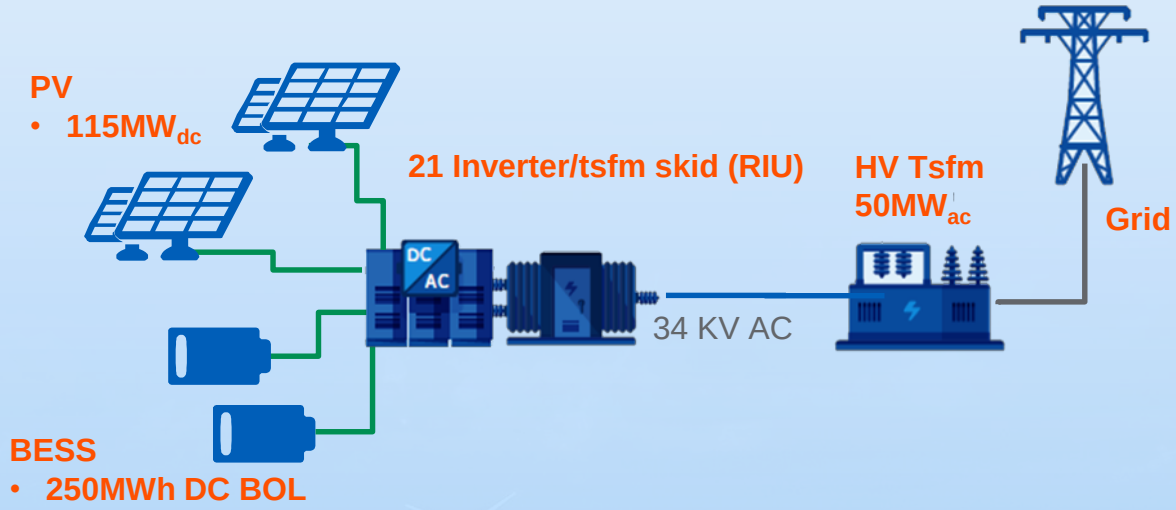


50MWac POI PV + 4hr BESS Dispatchable Power Plant
Location: Phoenix, AZ.

MVAC Coupled



LVDC Coupled

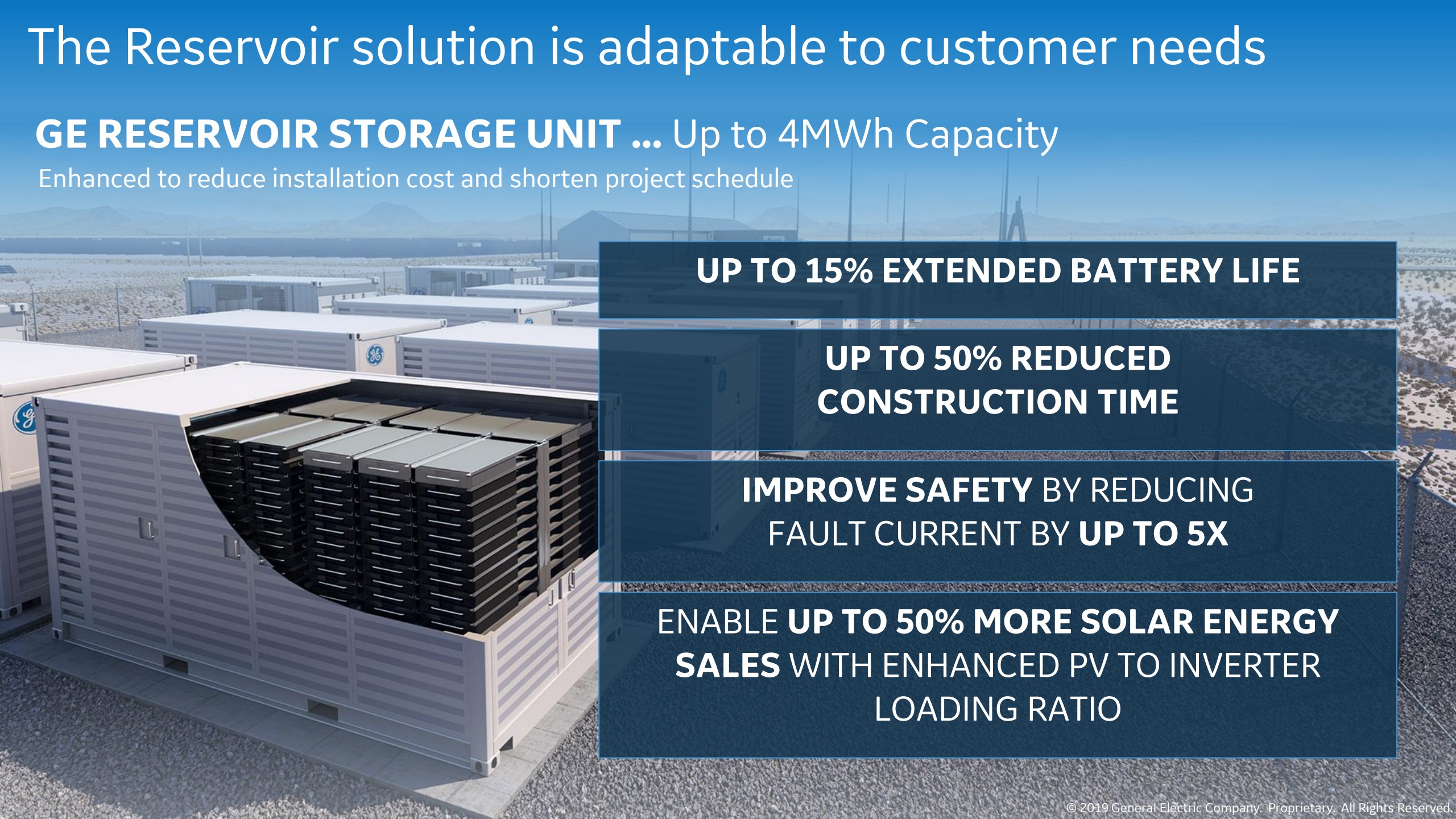


- ✓ Increase AC/DC Ratio
- ✓ Reduction of CAPEX and O&M Costs
- ✓ Reduction of -$4.3/MWh LCOE
- ✓ Increase of RTE up to 8% full plant

The Reservoir solution is adaptable to customer needs

GE RESERVOIR STORAGE UNIT … Up to 4MWh Capacity

Enhanced to reduce installation cost and shorten project schedule



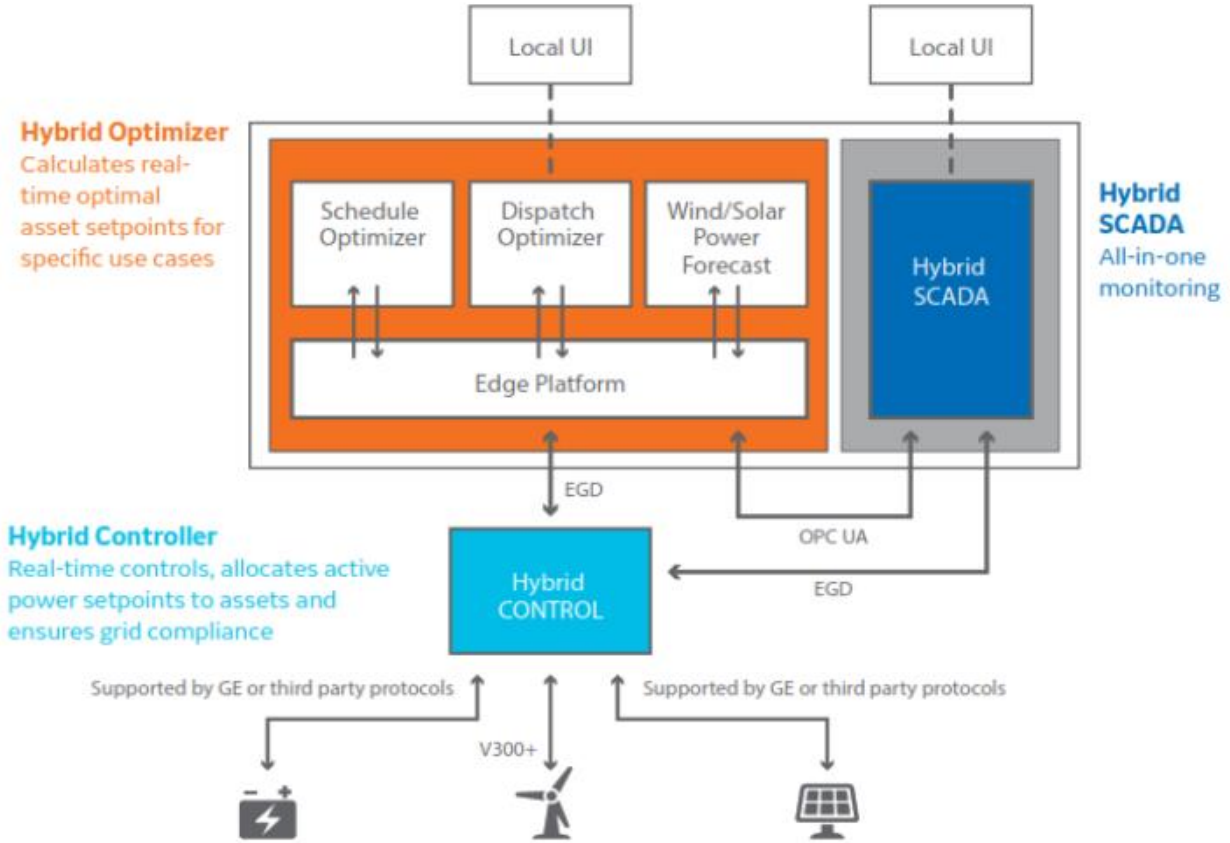
UP TO 15% EXTENDED BATTERY LIFE

UP TO 50% REDUCED CONSTRUCTION TIME

IMPROVE SAFETY BY REDUCING FAULT CURRENT BY **UP TO 5X**

ENABLE **UP TO 50% MORE SOLAR ENERGY SALES** WITH ENHANCED PV TO INVERTER LOADING RATIO

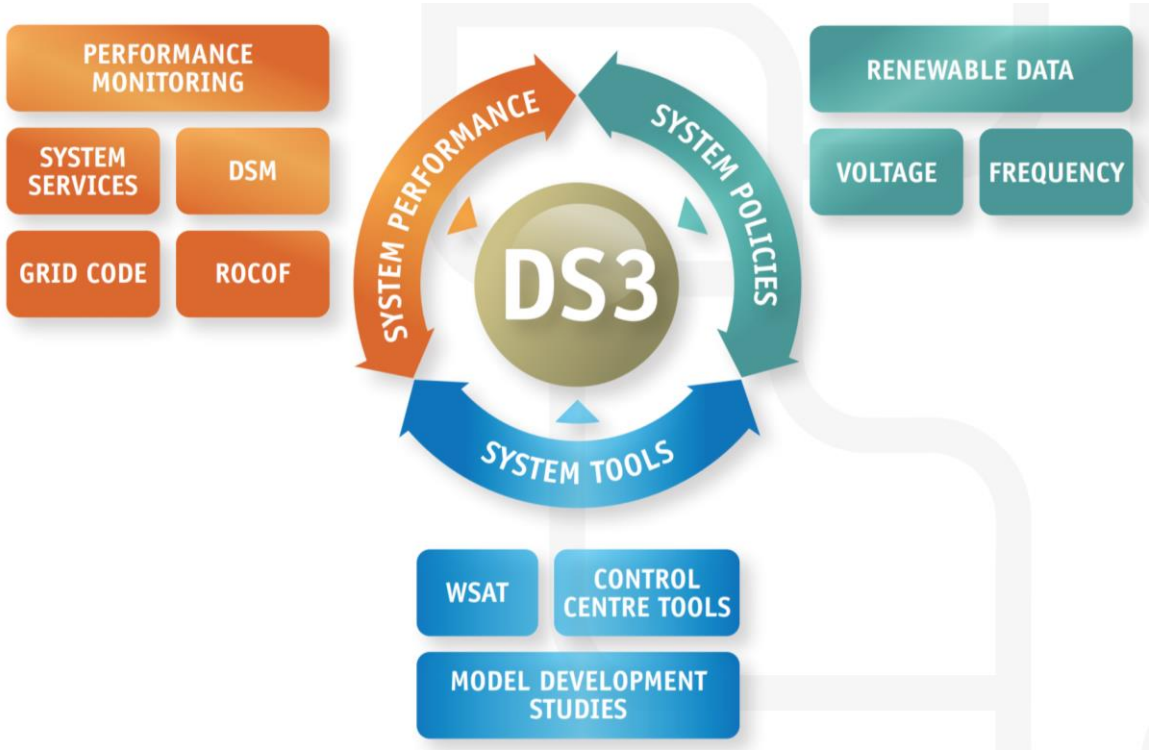
Renewable Hybrid Control Systems



- Multi-layer supervisory controller by which co-located wind, solar, storage and/ or other generation assets are integrated at the farm-level
- Utilizes an Edge-based **Hybrid Optimizer** that calculates desired asset setpoints for specific use cases, such as power firming, load following and energy shifting… These set points are communicated to the **Hybrid Controller**, to send active power set points to assets
- **Hybrid Controller** is built on the architecture of GE's legacy farm controllers (WindCONTROL , SunIQ, BESS Controller), leveraging decades of experience to ensure grid compliance with increasingly stringent regulations
- Response of these assets can be monitored via a consolidated **Hybrid SCADA** interface. The system can communicate with assets from various OEMs via V300+ communication protocol

Wind Storage

Delivering a Secure Sustainable Electricity System (DS3)



Shades Of Green: Wind-Battery Hybrid System Debuts In Ireland

Wind + Solar + BESS, transmission connected

CUSTOMER CHALLENGE

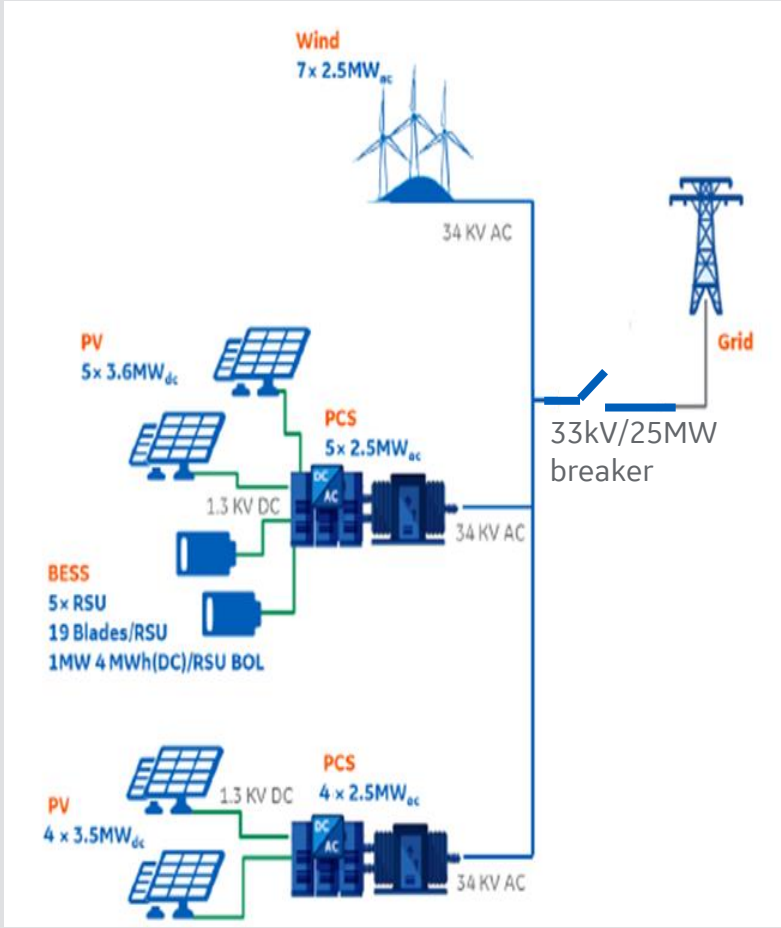
- Matching a specific load profile (Cement plant or local utility end customer)
- Reduce transmission charges
- Interconnect limited to 25MWs of capacity

PROJECT DESCRIPTION

- 17.5 MW Wind, 25 MW solar AC and 20MWH/5MW battery

APPROACH

- Analyze best technical and economic hybrid system
- Design controls and optimization architecture

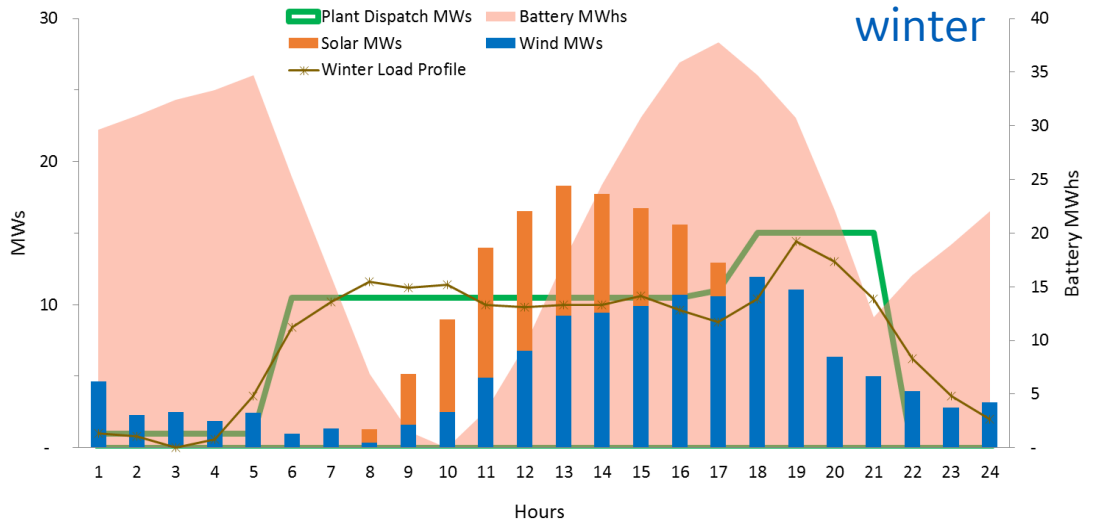


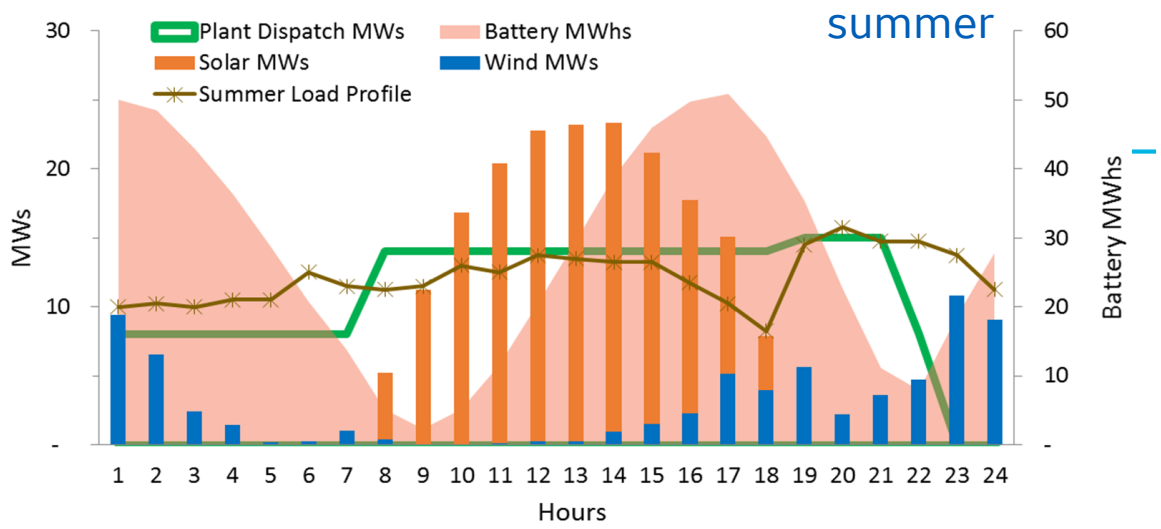
BUSINESS CASE

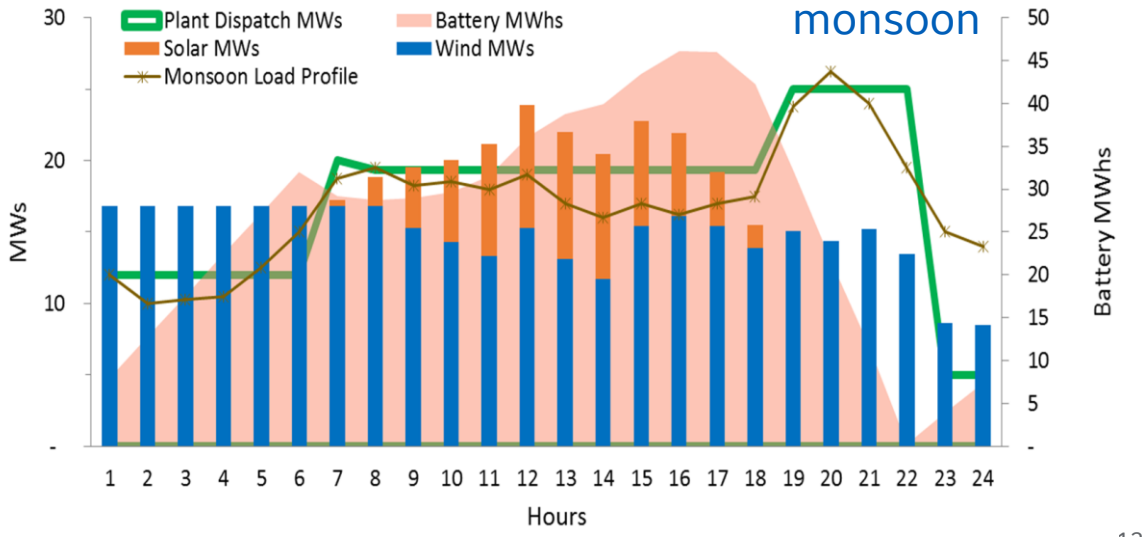
- CF increase
- **CAPEX**
  - Savings on substation
  - MWs of inverters and unit transformers removed
- **OPEX**
  - Avoided transmission charges, reduced Opex and cost of night charging for solar plant

Source: USTDA Report

Plant Dispatch Profile: Example

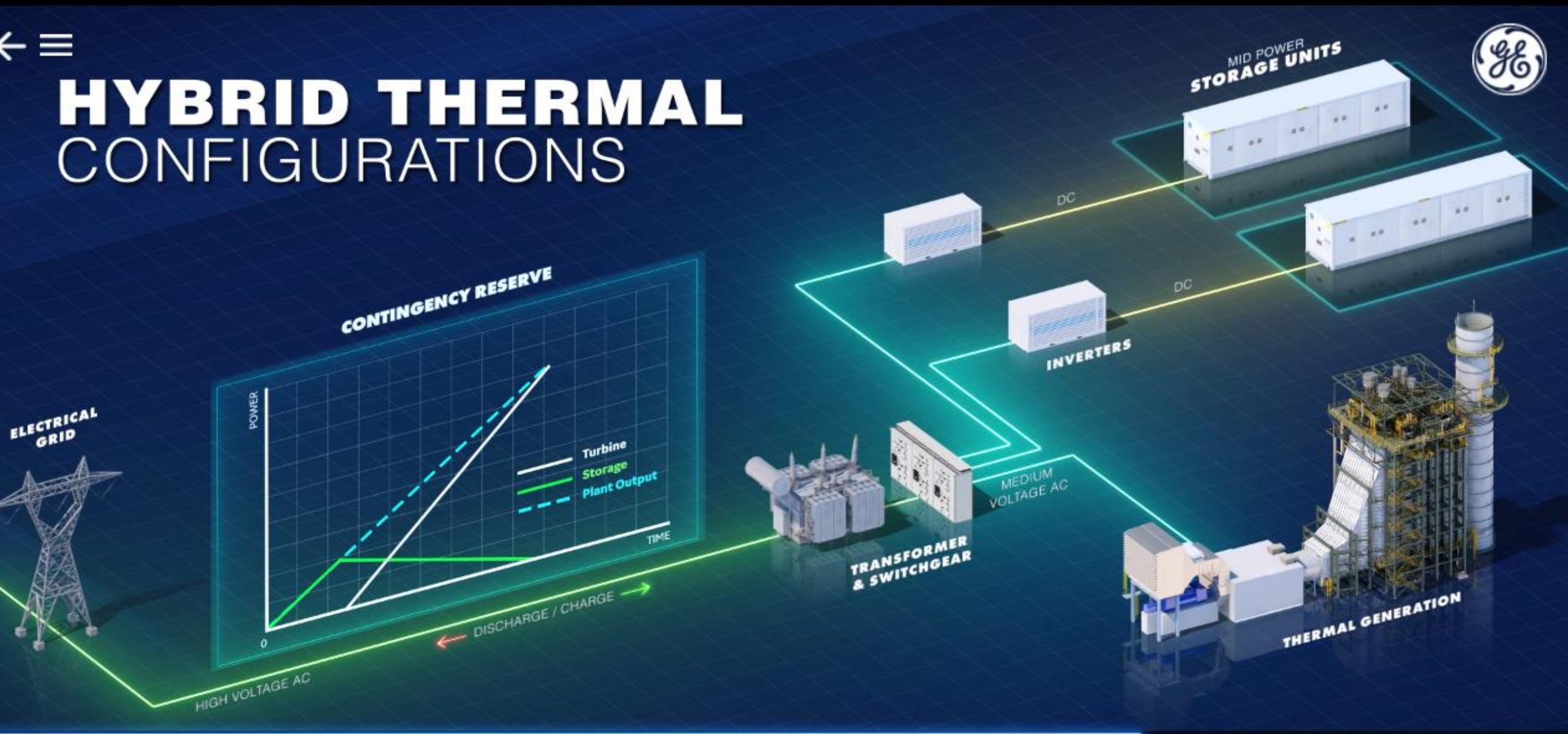






- Interconnect capacity reduced -leading to optimum utilization of transmission system
- Increased Plant Load Factor
- Significant savings in capex due to Hybridization
  - Optimized Storage sizing
  - DC level integration between Solar and Storage – common BoP
- Improved production efficiency due to DC integration
- Optimum land utilization and Savings in O&M Cost

HYBRID THERMAL CONFIGURATIONS



HIGH POWER
SYNTHETIC INERTIA

HIGH POWER
FREQUENCY RESPONSE

MID POWER
CONTINGENCY RESERVE

MID POWER
IMPROVED OPERATIONS

0 MINUTE DISCHARGE

6+ HOUR DISCHARGE

Grid Forming Batteries

BESS projects are usually not Grid Forming

Key GE Grid Forming BESS Projects:

- Metlakatla Power & Light 1MW/1.4MWh- 1995 [1]
- Vernon CA 5MW/2.5MWh- 1996 [2]
- Battery Energy Storage System of 30MW/22MWh- IID 2017 [3]

Projects under design/execution

- Inverter rating optimizations
- Large drives fed from BESS

Imperial Irrigation District (IID)
30MW, 20MWh BESS project -2017

Lessons Learned & Recommendations

1. **Stacking of services**

   Allows for more cost-effective solutions

2. **Stimulate hybrid technologies (solar, wind, batteries, gas, …)**

   Allows to solve issues closer to the source and more cost-effective solutions

3. **Mix shorter and longer duration services**

   Allows more cost-effective solutions

4. **Integrated expansion and operations planning**

   One deals with more granular events, defining which assets to use, and the other defines the new assets needed by the grid

5. **Be open to all technologies**

   Build an open market environment so all technologies can compete, and let the most efficient technology win