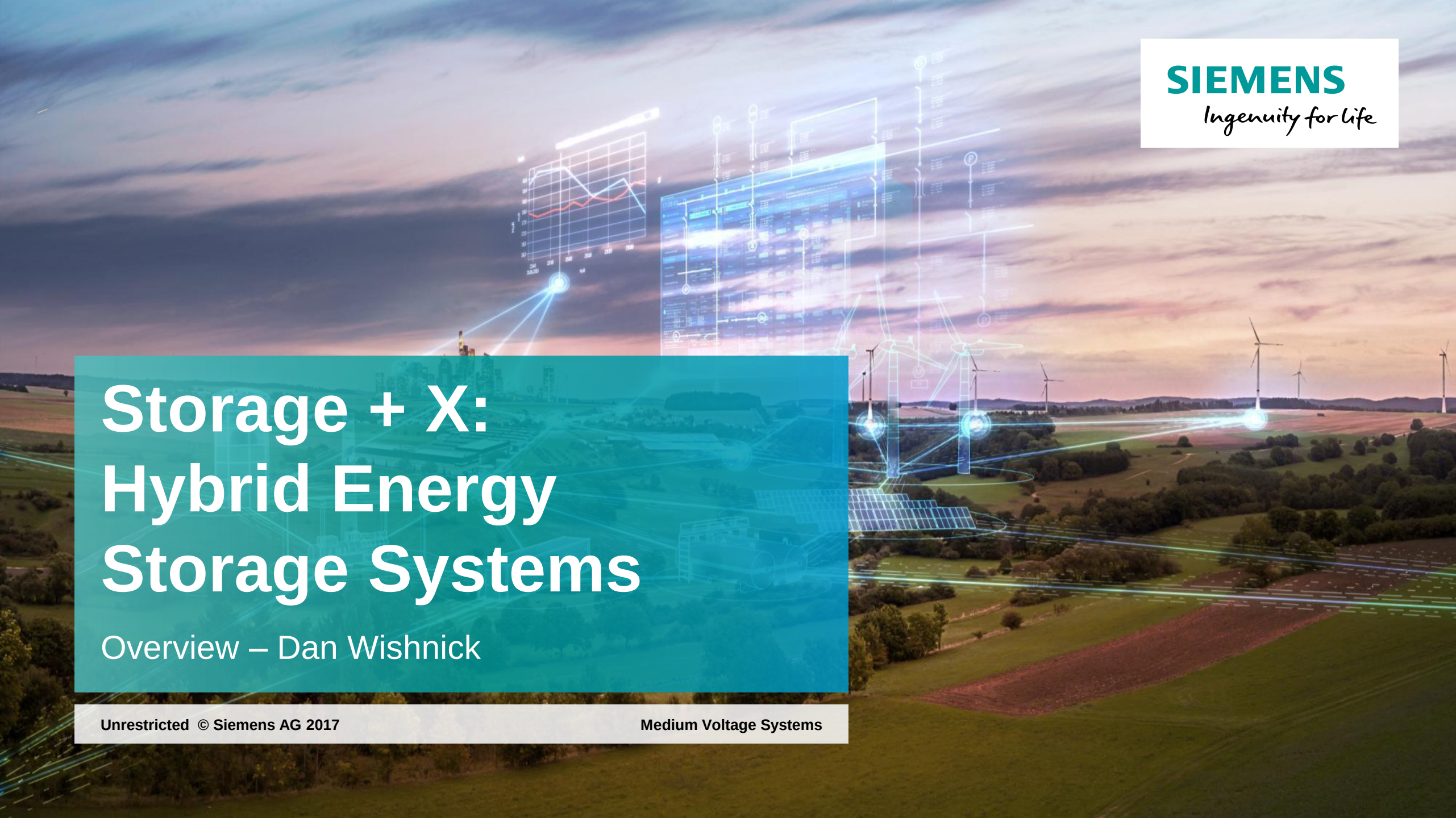

Storage + X: Hybrid Energy Storage Systems

Overview – Dan Wishnick

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Energy Transition…
What does it mean?

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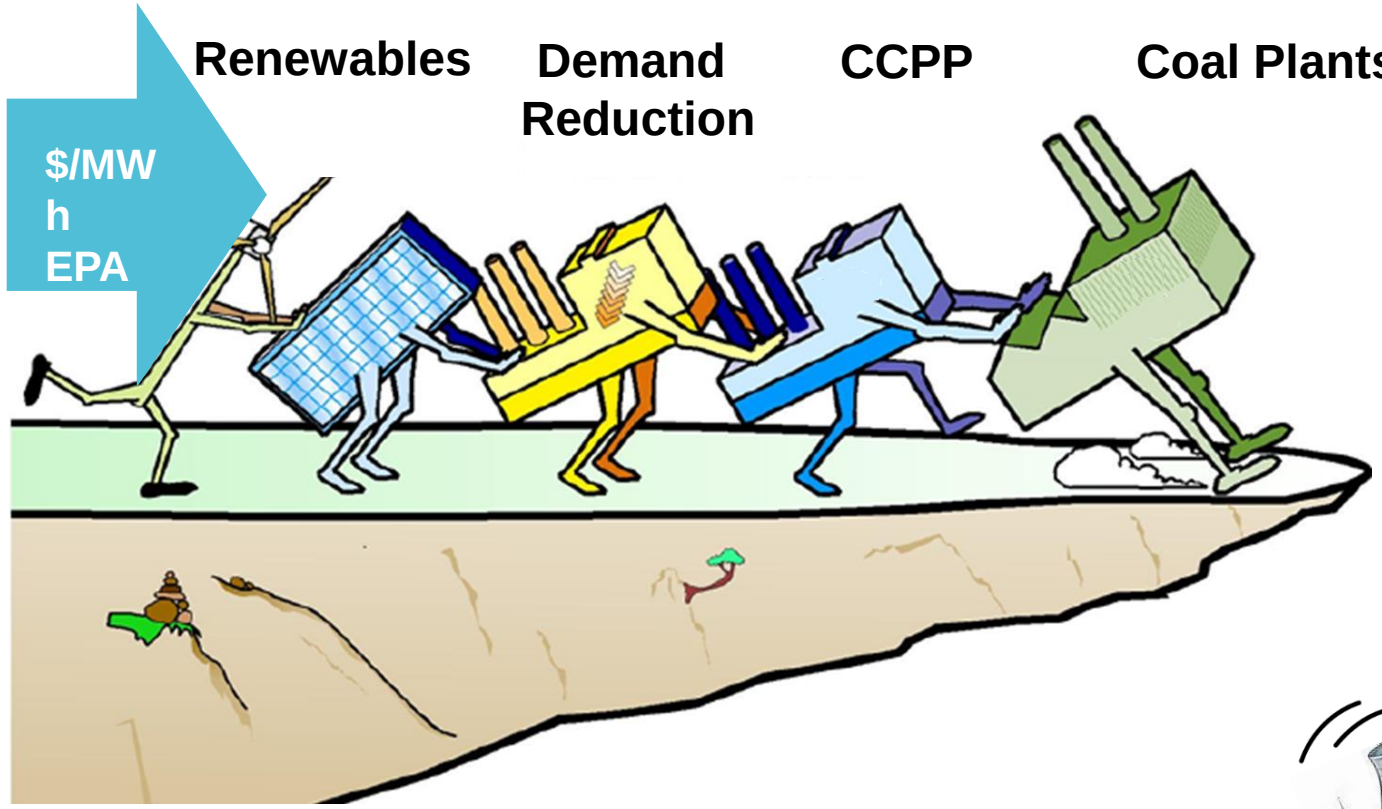
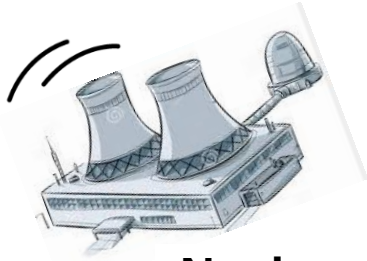


Retirement & Reduction of Conventional Power Generation

Who will fall next?

Challenges for Grid stability



Nuclear

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Hybrid Plants (Renewables + Storage + X)
New Technology for Reliable Renewable Penetration

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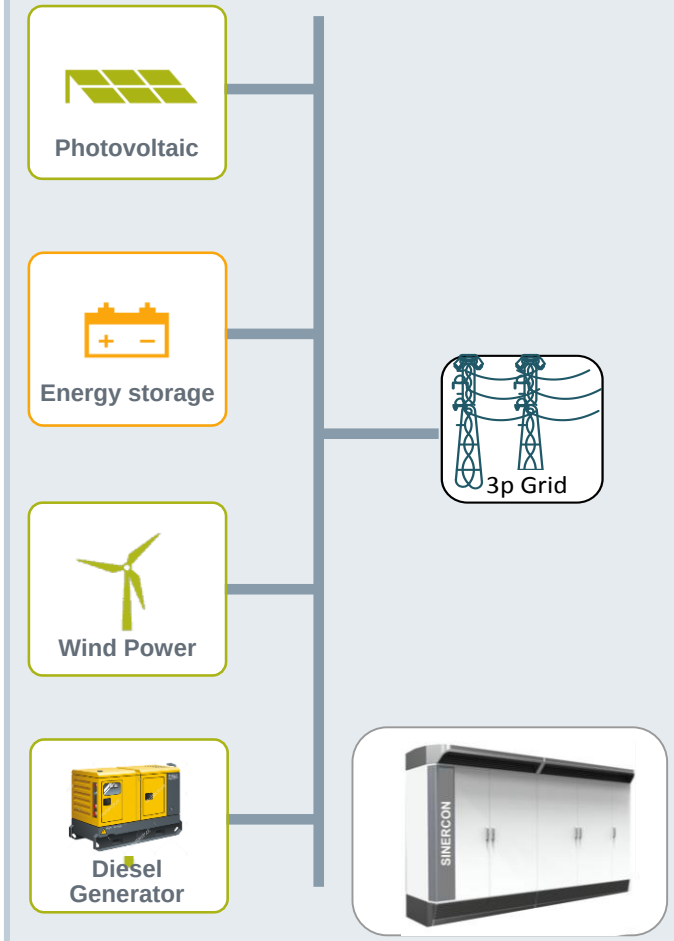
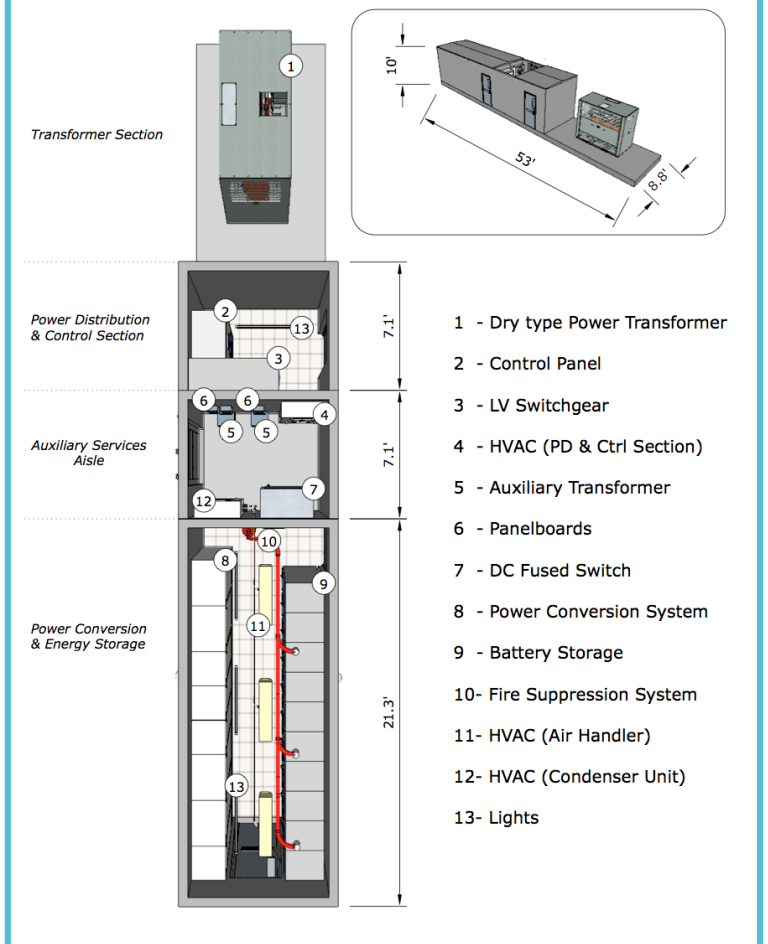
Fuel Dependency ↓

Grid Stability ↑

Greenhouse Gas Emission ↑

Energy Usage Optimization ↑





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Siestorage Energy Management System (EMS)
Overview of applications and functionalities

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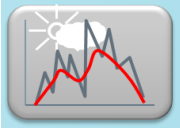
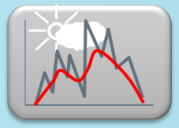
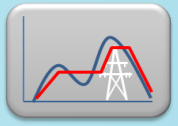

Ramp Rate Control


Renewable Smoothing

Frequency Regulation / Support


Renewable Capacity Firming

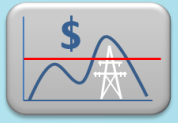
Voltage Regulation (V,Q Set-points)


Time Shifting

Power Factor Control

Arbitrage – Energy Trading


Load Following



Peak Shaving

Microgrid Operation

- Island Operation
- Grid Paralleling
- Black Start

Time of Use (TOU)

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Grid Attached Storage
Energy Storage Co-located with Gas-fired Power Plants

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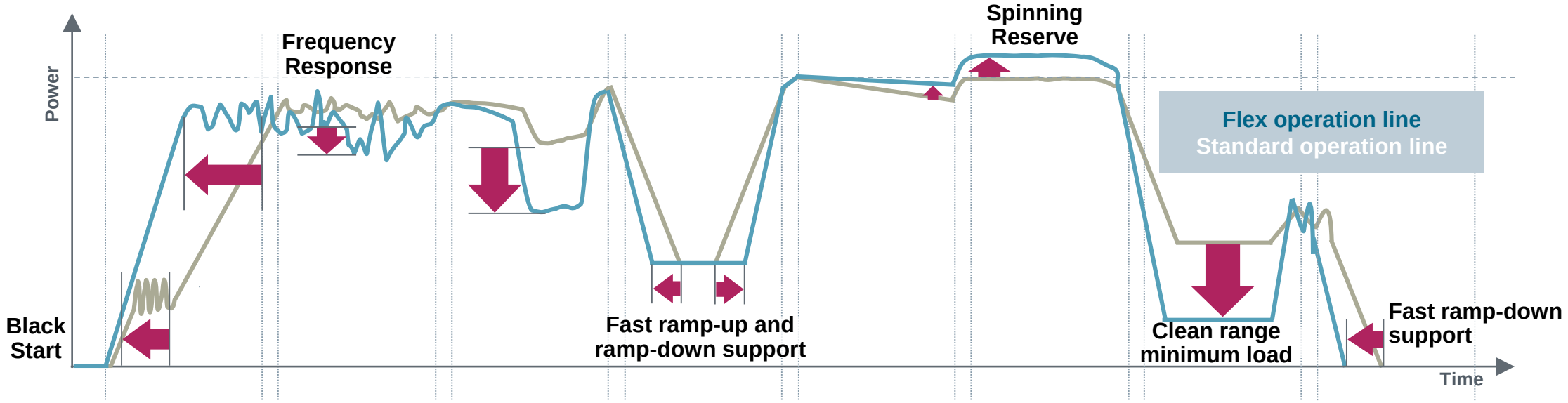

Time to Sync	Fast Start Up	Primary Frequency Response	Secondary Frequency Response	Manual Operation	BLOC	Peak Power	Part Load	Fast Shut Down
5 min	Purge after shutdown 35 MW/min GT start up gradient, also for cold start	3%/s GT Gradient 10% rated load jump	55 MW/min and higher transient load gradient	55 MW/min and higher transient load gradient	Grid Sustaining at under-frequency	Extra power by ▪ Evap. cooler ▪ Inlet chilling ▪ Suppl. firing	Lower Minimum Turndown	55 MW/min transient gradient

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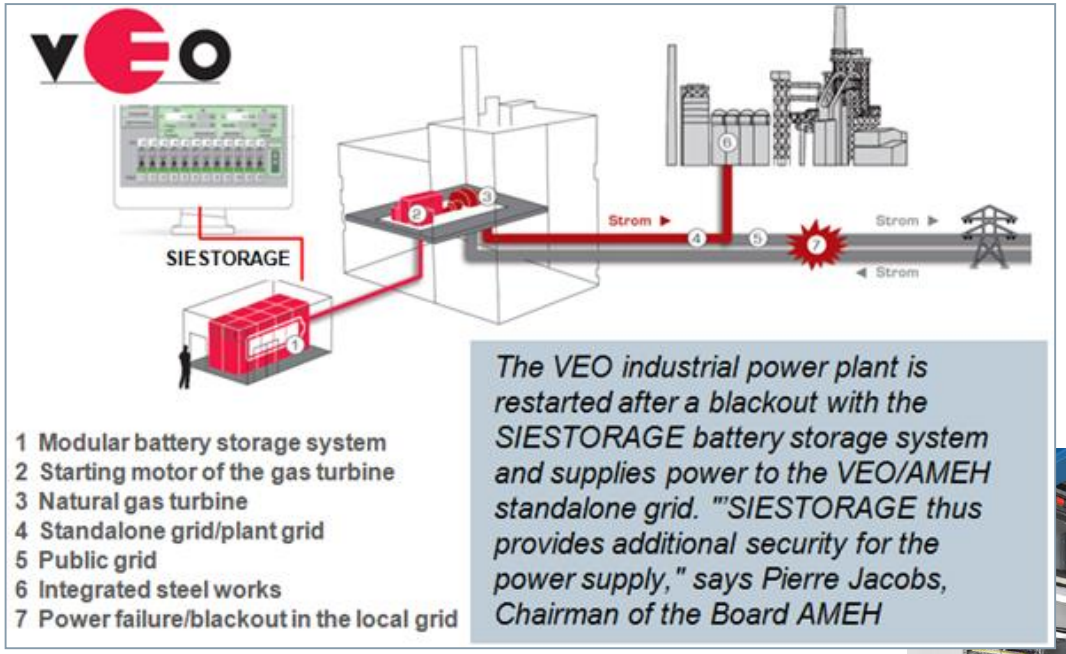
Black Start Capability at an Industrial Power Plant



1 Modular battery storage system
2 Starting motor of the gas turbine
3 Natural gas turbine
4 Standalone grid/plant grid
5 Public grid
6 Integrated steel works
7 Power failure/blackout in the local grid

The VEO industrial power plant is restarted after a blackout with the SIESTORAGE battery storage system and supplies power to the VEO/AMEH standalone grid. "'SIESTORAGE thus provides additional security for the power supply," says Pierre Jacobs, Chairman of the Board AMEH

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Microgrids or Hybrid Systems
Right Mix of DER to provide Grid Stability and Energy Savings

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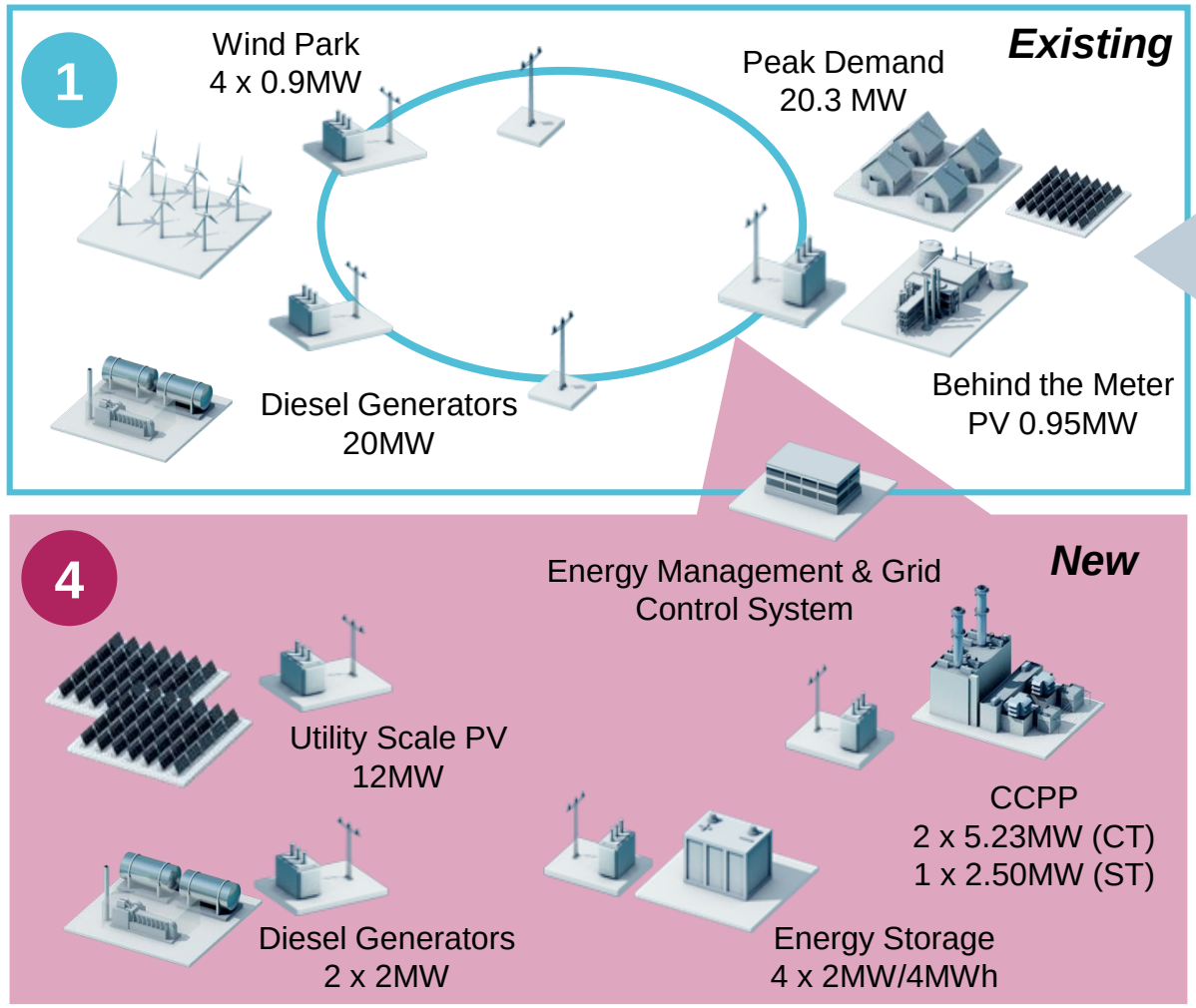


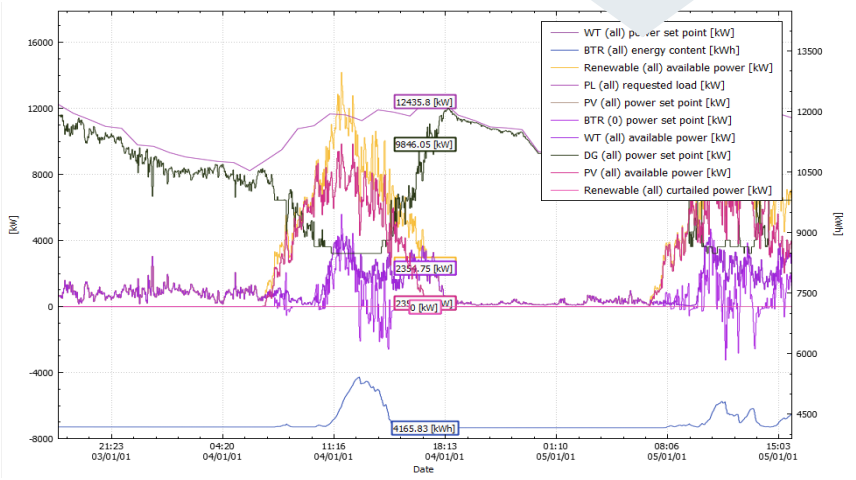
Simpson

2

Input
Demand Profile
Generation Asset Profile
Technical Requirements
Fuel and Oil Price
Weather Forecast

Output
Recommended Energy Mix
Cost Benefit Analysis
Performance Guarantees
Control Strategy

3



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Complex Hybrid System

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Highlights

- Full turnkey supply of complete hybrid power plant (including ESS, PV plant, Gen sets, plant automation and grid control)
- Guaranteed minimum renewable share, and capability to work with 100% renewable penetration during sunshine hours (diesel off)
  Economic optimized operation of hybrid power plant (e.g. diesel vs. ESS)

Project Size

- ESS: 305KW / 620 kWh
- Biodiesel Generators: 5 x 325kW
- PV Plant: 922 kW
- Controls: T-3000 Siemens Controller

Location

- Isabela Island, Ecuador

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Hybrid Plants (Renewables + Storage)
Capacity Firming to Stabilize Renewable Production

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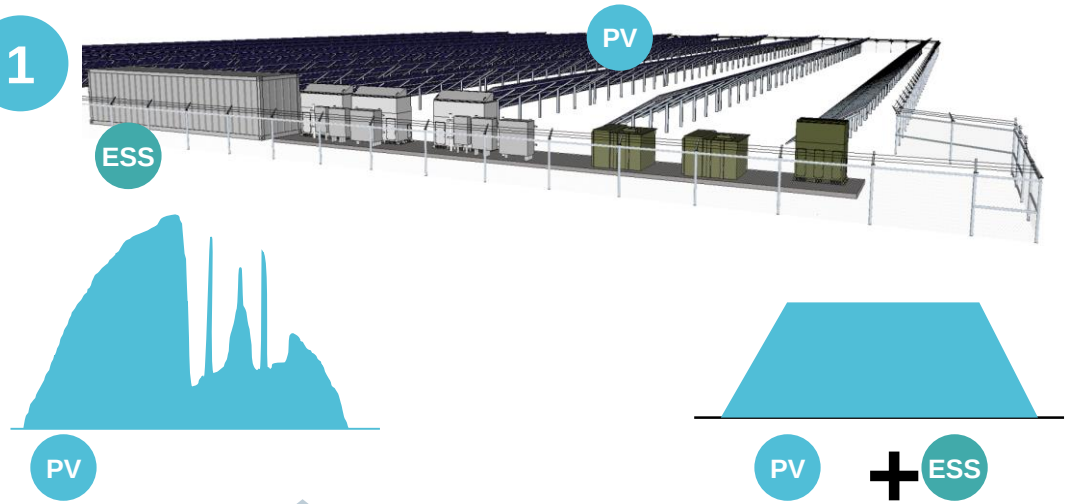
1



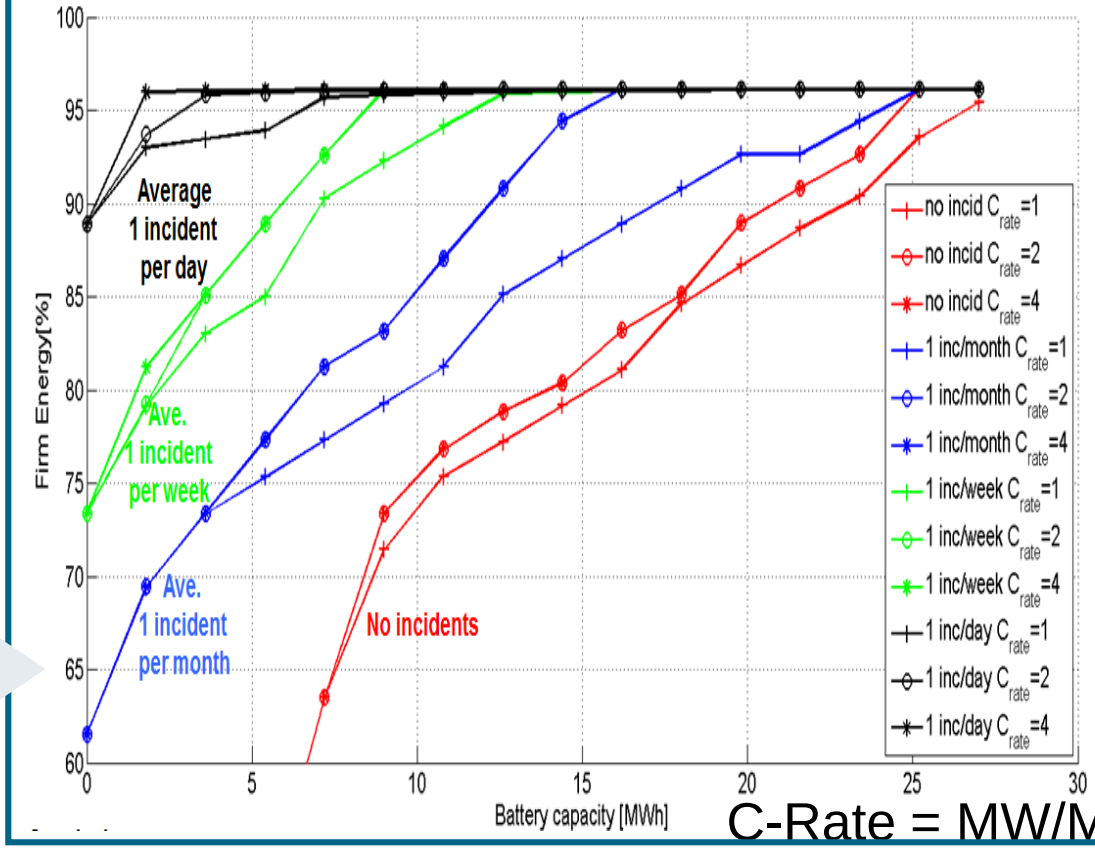
Simpson

2

Input
PV Plant Size
PV Plant Location
Technical Requirements
Penalties & Contract Terms

Output
ESS Size Options
Cost Benefit Analysis
Performance Guarantees
Control Strategy

3



C-Rate = MW/MWh

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Solar/Storage Project

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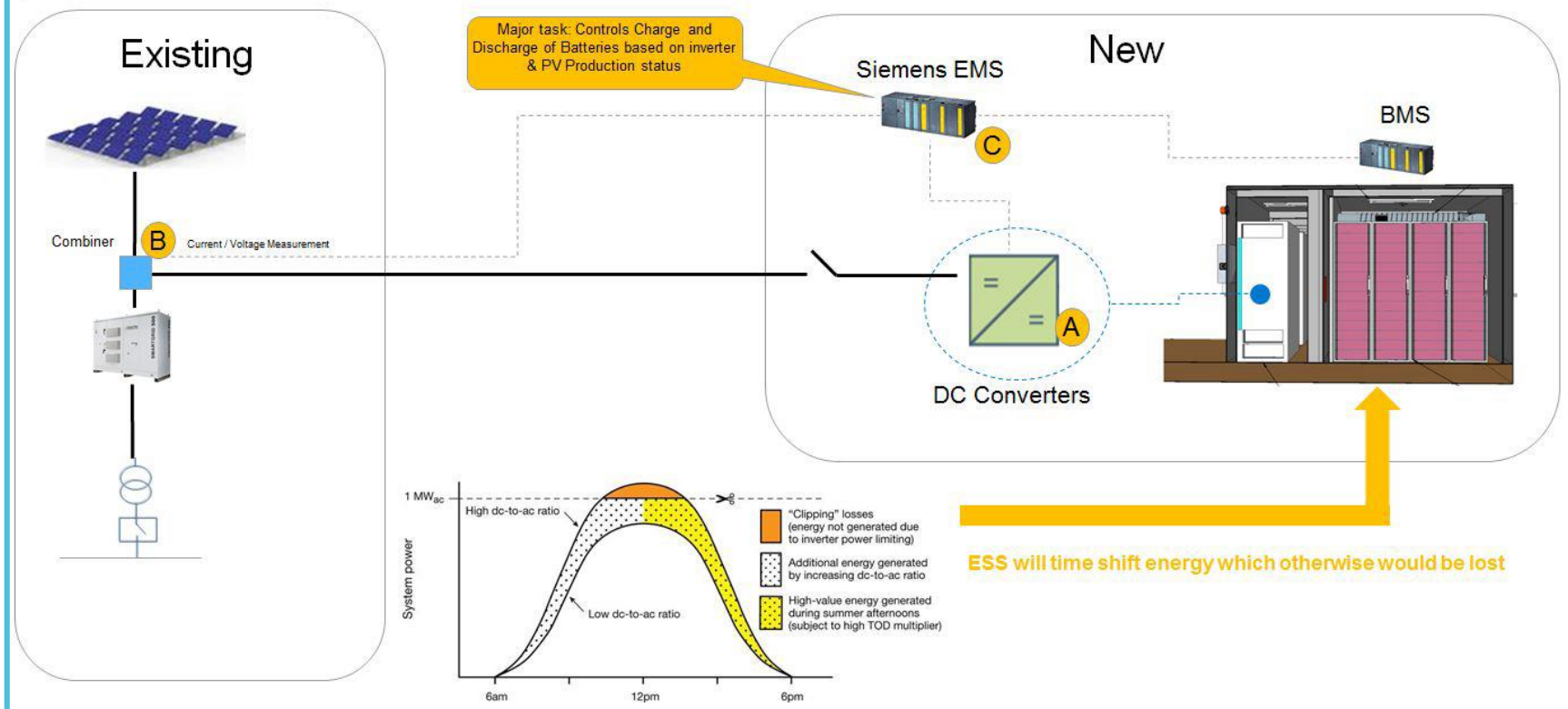
DC Coupled System – Clipped Energy



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US Energy Storage Market
Lessons Learned and Market Trends

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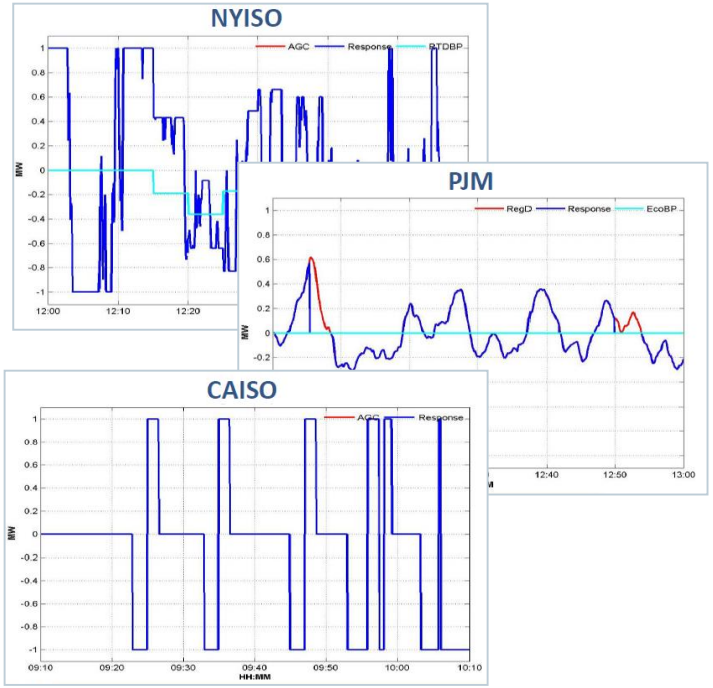
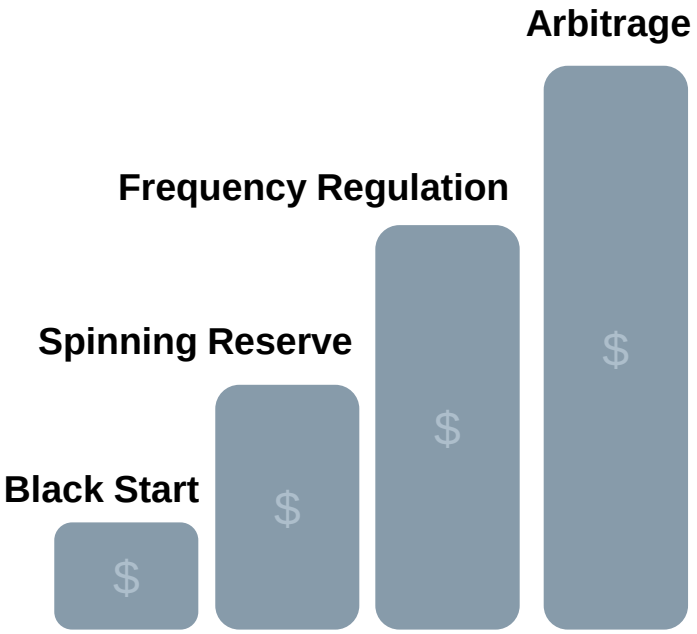
Solutions across ISOs



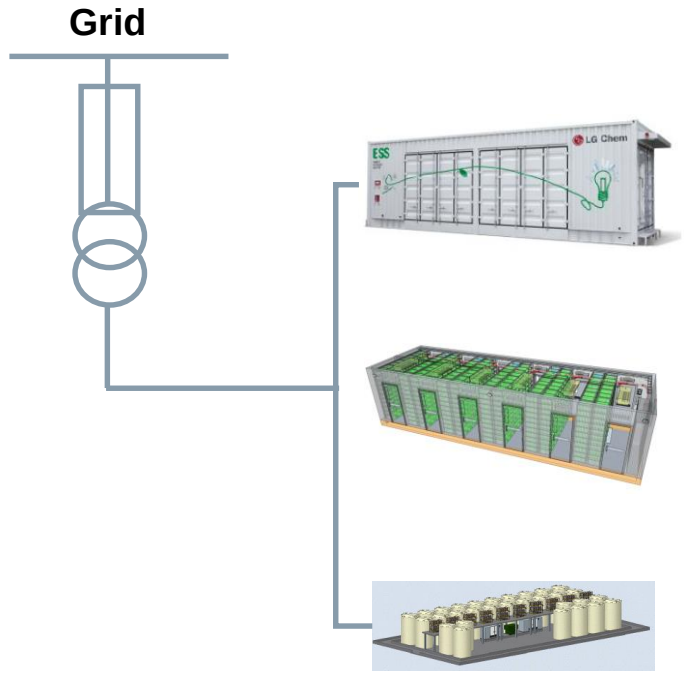
There is no "one-fits-all solution" across all ISOs in the country

Multiple Revenue Streams



Maximization of profitability by optimization of assets' usage in the various markets

Hybrid Energy Storage Solution



Li-ion for short-term and Flow Battery for long-term applications might present the right mix for many customers

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