SERTP Energy Storage Overview

Energy Storage Association

www.energystorage.org

ESA MEMBERSHIP

AES we are the energy
ALEVO REDEFINING ENERGY
DUKE ENERGY
EASTPENN
EDF renewable energy
Invenergy
Johnson Controls

LG Chem Power Inc.
nationalgrid HERE WITH YOU. HERE FOR YOU.
NEXTera ENERGY RESOURCES
ONCOR
res powering change
S&C
stem

127 Energy
24m
Advanced Microgrid Solutions
ALTALINK
AMBER KINETICS
AMBRI
AMERESCO Green • Clean • Sustainable
AEP American Electric Power
AQUION ENERGY
Argonne National Laboratory

ATCO Electric
BlackRock
California ISO
Clean Energy Storage Inc.
current powered by GE
Customized Energy Solutions
crowell moring
CSA Group
DTE Energy
DOOSAN
Dynapower Company

e.on
EEI Edison Electric Institute
Edison Energy Solutions
Enel Green Power
Energport
engie
Enovation Partners
Entergy
eos
EnSync Energy Systems

Eversource Energy
EPRI Electric Power Research Institute
Exelon Generation
flex
FirstEnergy
Great Plains Energy
greencharge networks
GREENSMITH energy management systems
HIGHVIEW POWER STORAGE

HYDROGENICS SHIFT POWER | ENERGIZE YOUR WORLD
HYDROSTOR
ICE ENERGY
ICF International
IHI
Ingersoll Rand
Ingeteam
K&L GATES
KILPATRICK TOWNSEND
Landis+Gyr

LG Electronics
LOCKHEED MARTIN
LSis Industrial Systems
Maxwell Technologies Enabling Energy's Future
MITSUBISHI ELECTRIC POWER PRODUCTS, INC.
MORRISON FOERSTER
Mortenson construction
NRECA
NAVIGANT

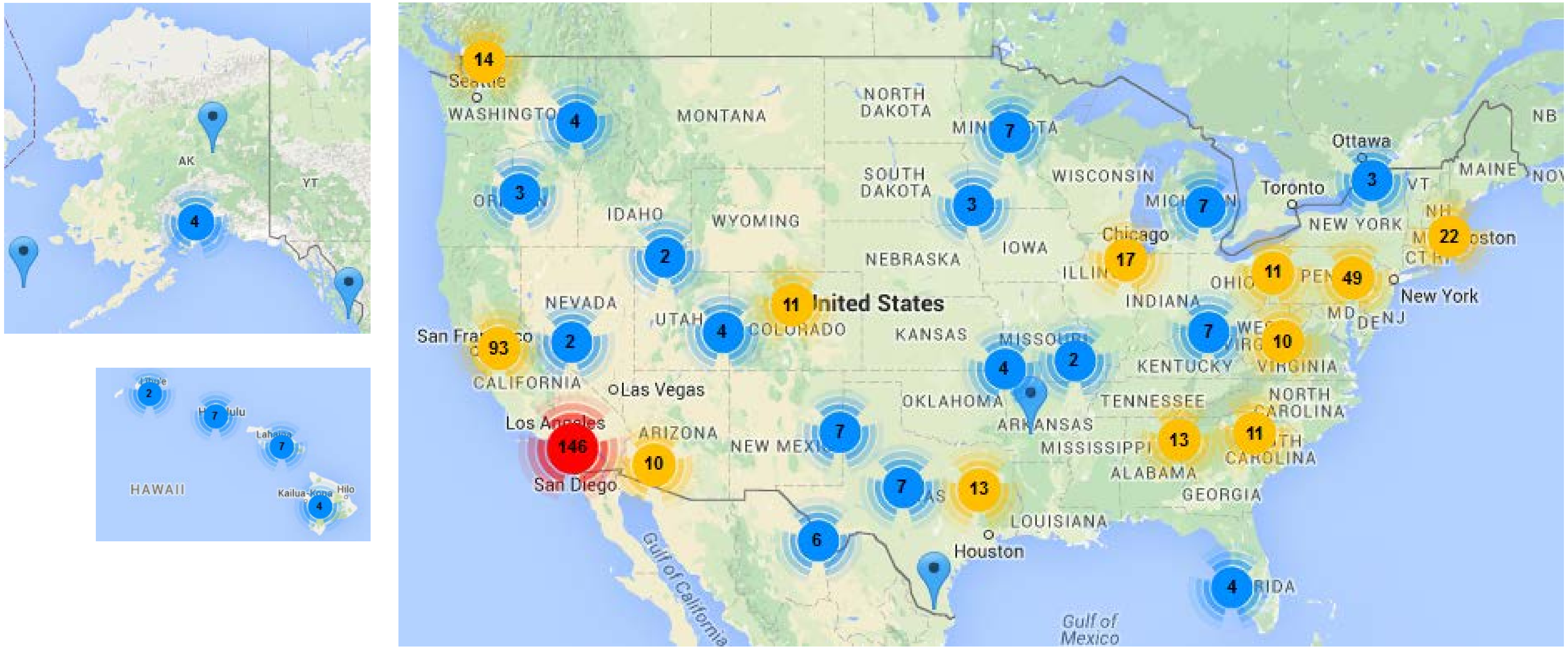
NEC NEC Energy Solutions, Inc.
Pacific Northwest National Laboratory
Panasonic
Parker
ORMAT
PEC
PG&E
PIERCE ATWOOD
PowerSecure Interactive Distributed Generation
PowinEnergy
PNM Resources

PSE Puget Sound Energy
PVHARDWARE
RECURRENT ENERGY
Saft
SDGE connected — A Sempra Energy utility
Sandia National Laboratories
Sempra U.S. Gas & Power
SAMSUNG SDI
SHARP
Sinexcel C&I PCS Provider
SOUTHERN COMPANY

SOLARRESERVE
SOUTHERN RESEARCH INSTITUTE
SOUTHERN CALIFORNIA EDISON An EDISON INTERNATIONAL Company
STARWOOD ENERGY GROUP
STEFFES CORPORATION
STORNETIC The Energy Storage Company
SUNVERGE
sunrun
SUMITOMO ELECTRIC

SUNWODA 欣旺达
SUTHERLAND
TVA
TEPCO
UET UniEnergy Technologies
UL
University of California San Diego
Vinson&Elkins
ViZn Energy
VIONX ENERGY
WANZEK
Younicos Let the fossils rest in peace.

Systems Operating Across the U.S.



Several MW-scale systems have 5+ years of operations

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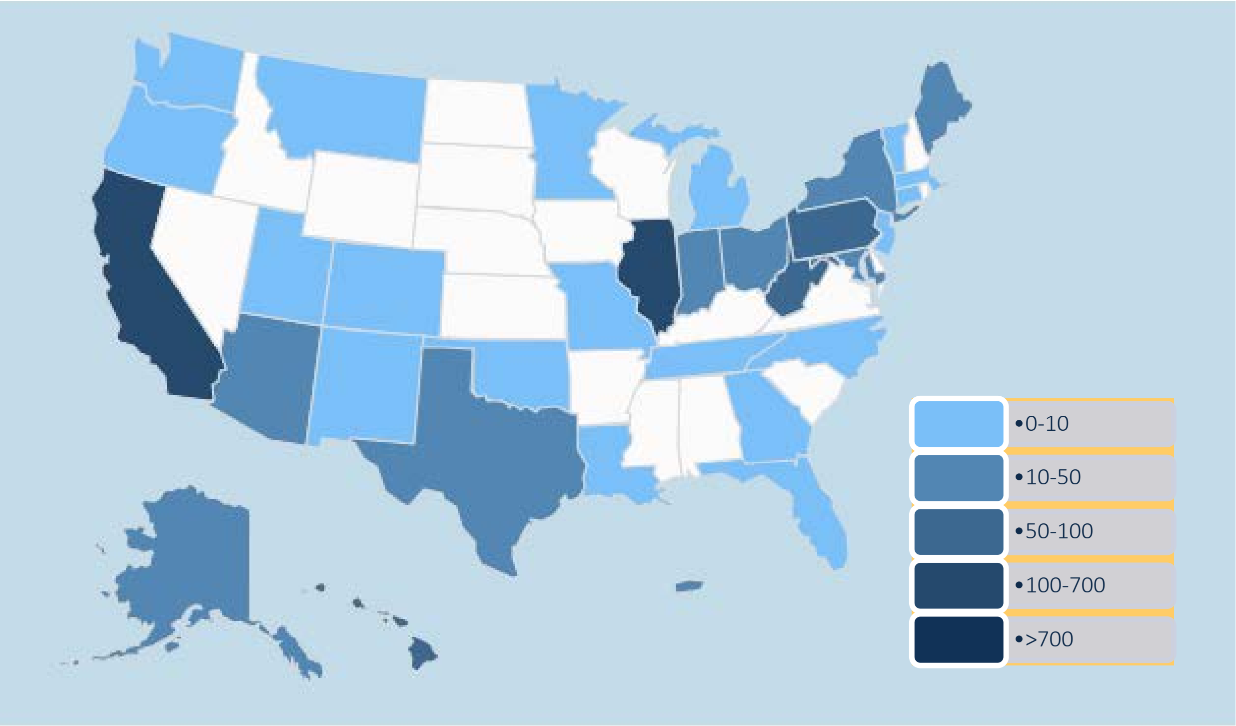
Deployments across states

Front of the Meter Deployments - MW



Source: GTM Research Energy Storage Data Hub

Behind the Meter Deployments - MW

State	Non-Residential	Residential	Total
Arizona	0.00	0.97	0.97
California	66.53	3.10	69.63
Hawaii	1.49	1.96	3.45
Massachusetts	0.00	0.18	0.18
New Jersey	1.89	0.04	1.92
New York	2.29	0.34	2.63
PJM (Excl. NJ)	2.25	0.05	2.29
Texas	0.00	0.14	0.14
All Others	4.21	4.16	8.38
Total	78.66	10.92	89.58

Source: GTM Research

CA will remain in lead, with **HI, AZ, TX, MA, & NY** vying for 2nd place through 2022.

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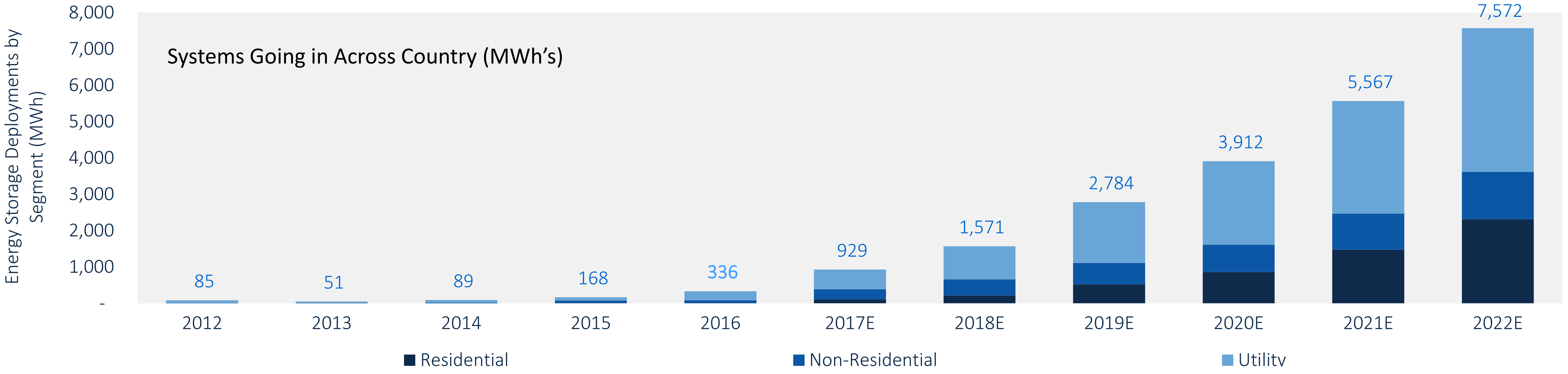
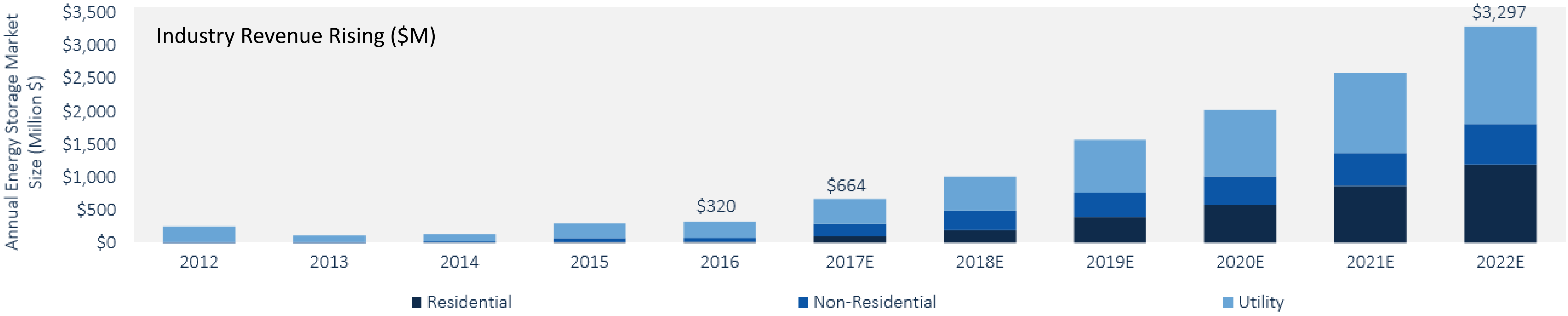


U.S. Annual Energy Storage Market Size, 2012-2022E (Million $)



Source: GTM Research

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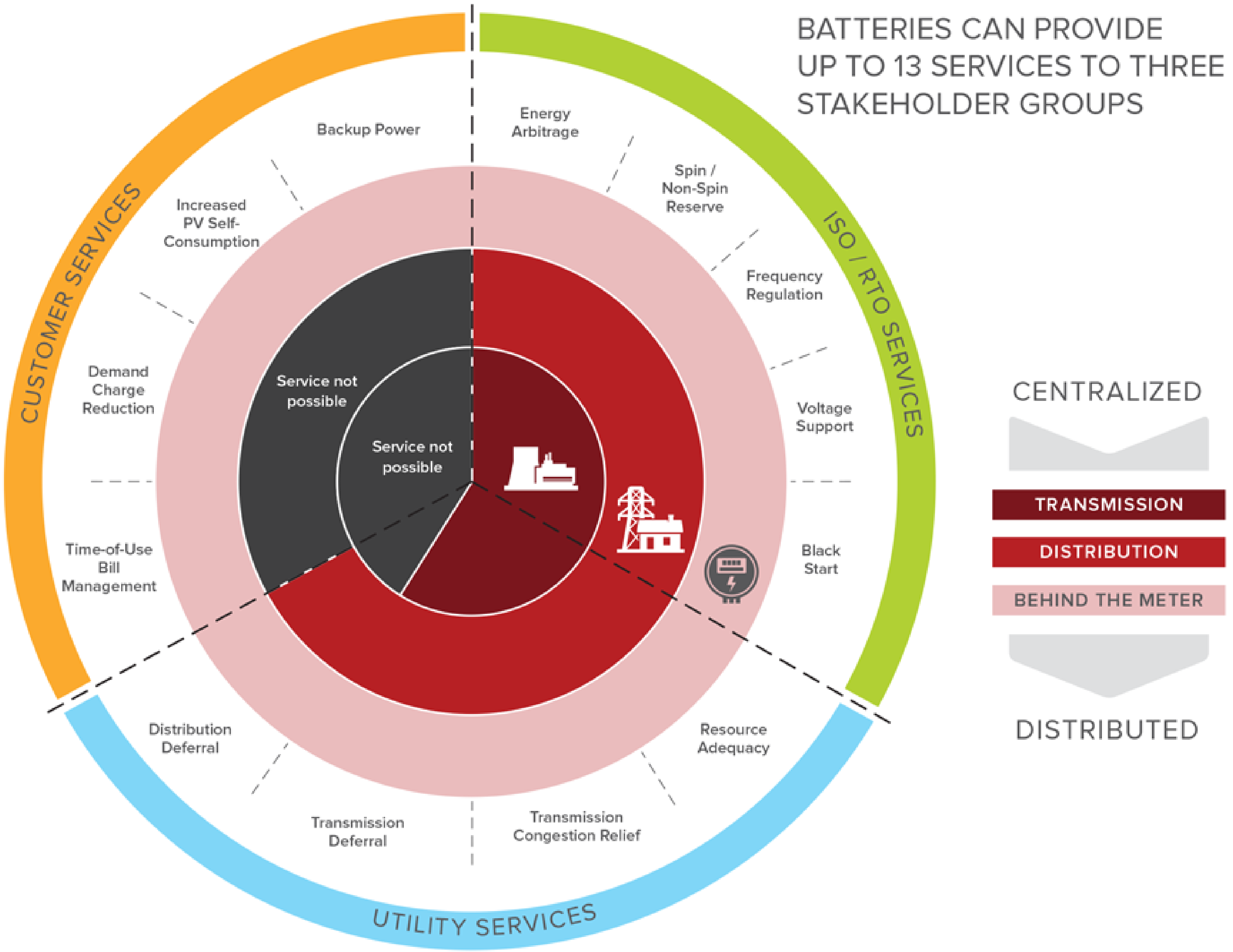
BATTERIES CAN PROVIDE UP TO 13 SERVICES TO THREE STAKEHOLDER GROUPS



Source: Rocky Mountain Institute

Why is storage important?

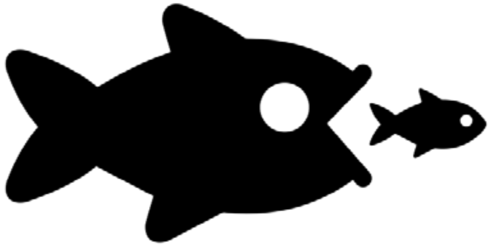
Storage optimizes use of the grid & enables system transformation

- **Saves households & businesses money** – reduce spending on excess capacity to meet peak system & local demands, optimize use of grid assets → lower rates
- **Makes the grid more reliable & resilient** – balance supply & demand fluctuations; mitigate supply disruptions and outages; manage planning uncertainty
- **Integrates more clean & distributed energy** – compensate natural variability of renewables and making them "dispatchable;" increase DER hosting capacity
- **Creates businesses & jobs** – new, growing industry offer investment and employment opportunities across the map

Policy Tools Fall Into Three Categories

Capture the full VALUE of energy storage

Ensure accurate market signals that monetize economic value, operational efficiency, and societal benefits



Enable COMPETITION in all grid planning and procurements

Storage can be a cost-saving and higher-performing resource at the meter, distribution, and transmission levels

Ensure fair and equal ACCESS for storage to the grid and markets

Reduce market and grid barriers that limit the ability for energy storage systems to interconnect

Policy Tools in the Toolbox

ACCESS

- DISTRIBUTION INTERCONNECTION
- TRANSMISSION INTERCONNECTION
- DISTRIBUTION TRANSPARENCY
- OWNERSHIP OPTIONS
- DER QUEUE MANAGEMENT
- MULTI-SERVICE CAPABILITY

COMPETITION

- NEW PROCUREMENT PROCESSES
- IRPs
- DISTRIBUTION PLANNING & GRID MOD
- RPS
- RESILIENCE PLANNING
- PROGRAMS NWA, EE, DR
- RESOURCE ADEQUACY QUALIFICATION
- RFPs
- RFIs

VALUE

- INCENTIVE
- TARGET
- FINANCING
- RATE DESIGN LOAD, DER
- PROGRAMS NWA, EE, DR
- COST-BENEFIT STUDY

CHARGING AHEAD

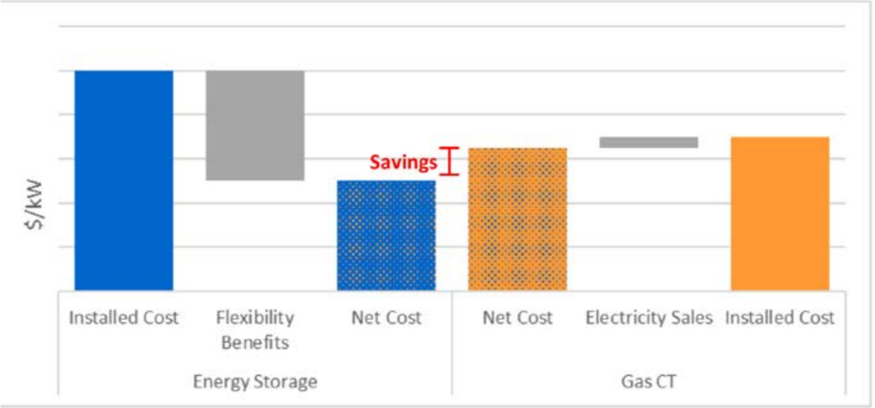
An **Energy Storage** Guide for Policymakers

- INVESTIGATE
- CLARIFY
- PLAN
- ENERGIZE

How Can Storage Be Included in IRPs?

- Should take proactive approach to include storage in resource planning
- ESA recommendations:
  - Ensure storage is included as eligible technology
  - Use latest cost/performance data
  - Match resource need with resource selection
  - Use sub hourly modeling
  - Ensure net cost of capacity (stacked benefits) are considered
  - Incorporate load-sited storage options as a potential resource
  - Check out www.EnergyStorage.org/IRP for more info!

Figure 1 Example Net Cost of Capacity Calculation

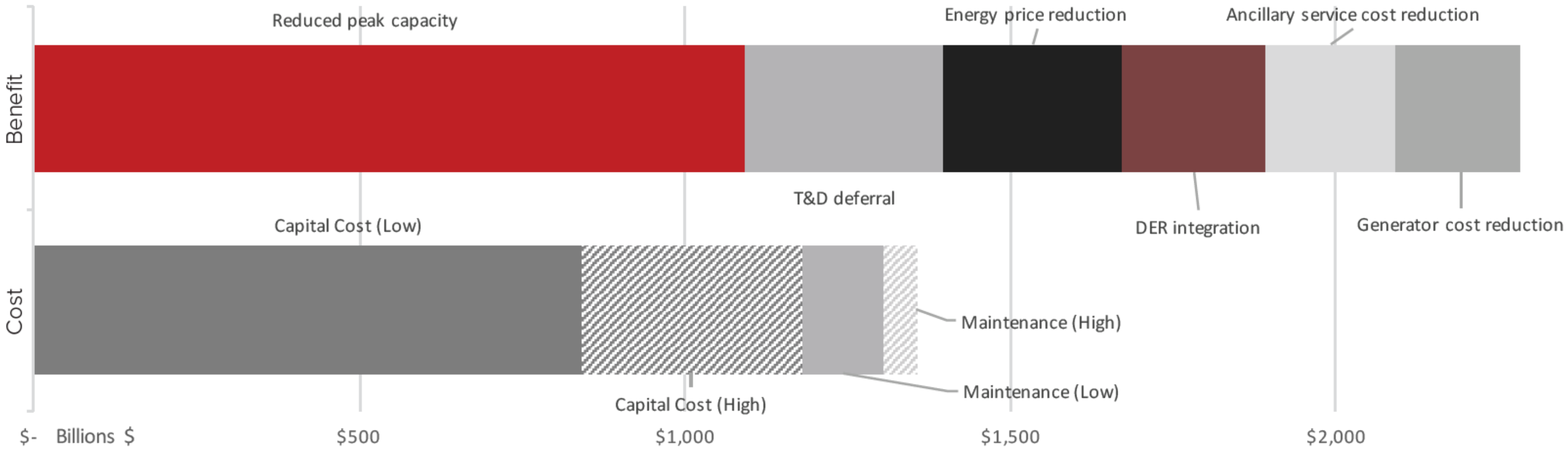


3

Net cost of capacity = Total installed cost – Operational benefits (flexibility operations & avoided costs)

Cost-Benefit Analysis

Massachusetts' State of Charge Report an excellent example of storage cost-benefit analysis



Source: MA DOER State of Charge Report, 2016. Note: Graph recreated from original "State of Charge" report.

Other states investigating storage include

Nevada, Oregon, and **North Carolina.**

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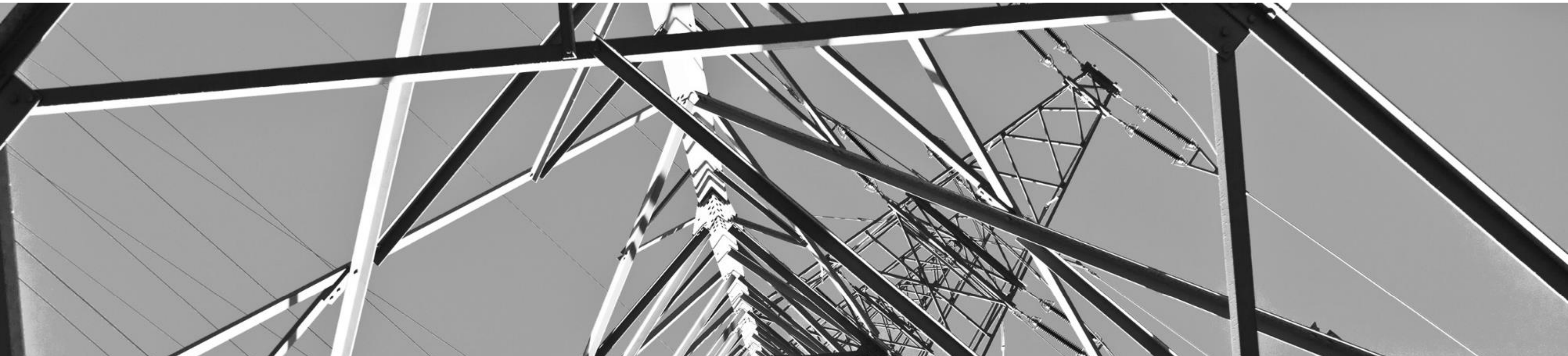
Conclusions

- It all comes down to **Value**, **Competition** and **Access**
- Investigative studies are useful, but only if they have an end goal of developing a procurement target
- Procurement targets are good tool to encourage learning by doing and jumpstarts process to include storage in utility processes
- Procurement targets and incentives not enough – need effective interconnection and rate design to make sure resources show up
- Many states are already designing policies for a robust storage market. Now is the time to act!



Storage Value Proposition in T&D Applications

Southeastern Regional Transmission Planning (SERTP) Webinar

AES Energy Storage

August 24th, 2017

Unlocking the full potential of the electric system.

The new energy network is emerging.

Electrify everything.

Accelerate renewables.

Transform the grid with energy storage.

About the AES Corporation:

Mission: Improving lives by providing safe, reliable and sustainable energy solutions in every market we serve.

6 MARKET-FACING STRATEGIC BUSINESS UNITS

4 CONTINENTS

17 COUNTRIES

AES Serves
9M
CUSTOMERS

7
UTILITY
COMPANIES

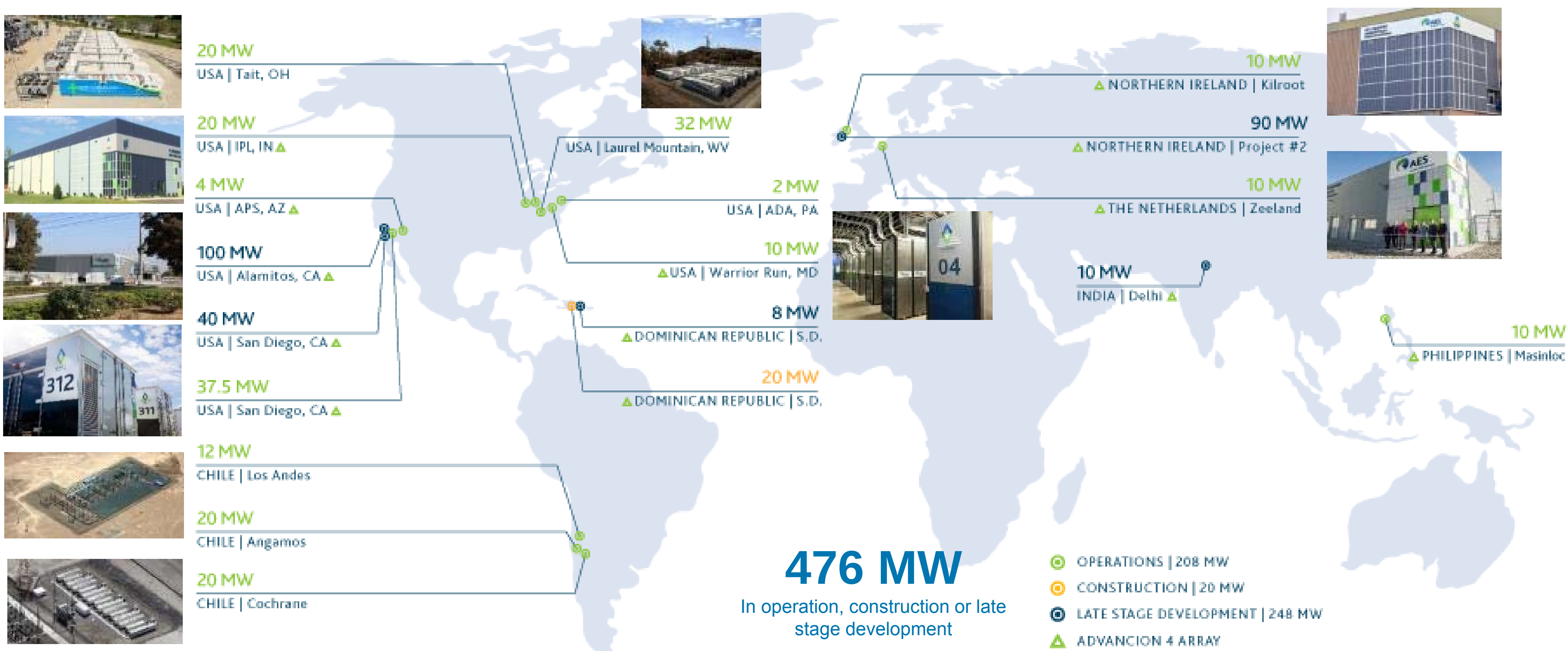
19,000
GLOBAL
WORKFORCE

$36B
TOTAL ASSETS
OWNED & MANAGED

$14B
TOTAL 2016
REVENUES

36,000 MW
GENERATION CAPACITY

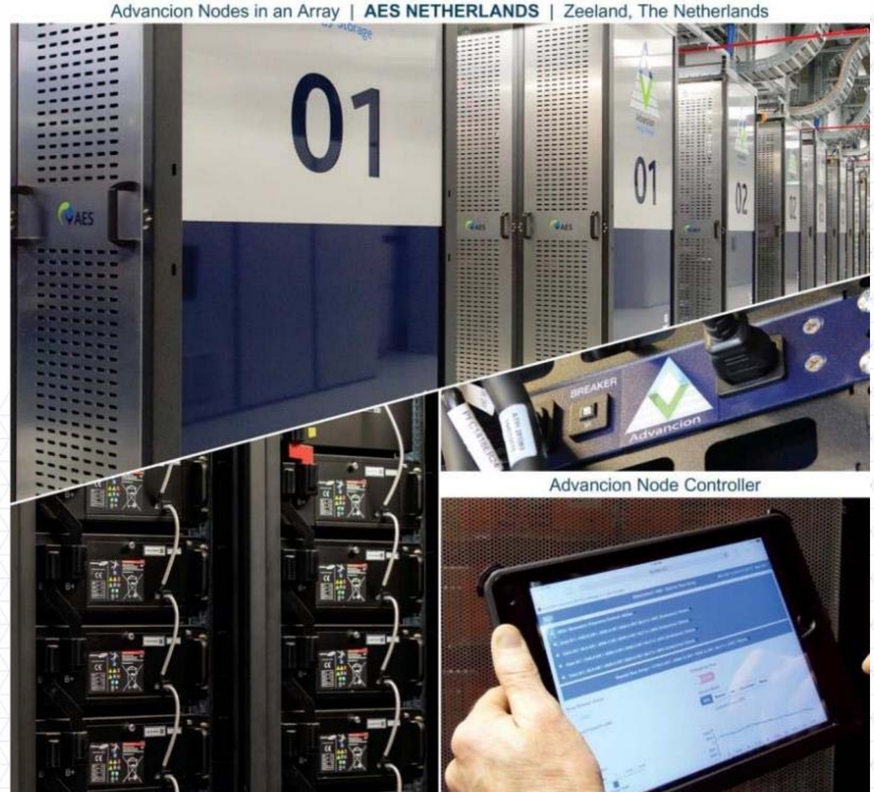
AES Energy Storage is the global leader in grid-scale energy storage solutions



Advancion® is a complete solution for Transmission Needs of the System

Available around the globe for third party users of Energy Storage assets

Advancion Nodes in an Array | **AES NETHERLANDS** | Zeeland, The Netherlands



Advancion Node Controller

Batteries in a Advancion Node | HMI Control Screen

Transmission Alternative

20 MW Advancion® Array
Indianapolis, Indiana

SERVICES

- Frequency response
- Capacity
- Voltage control

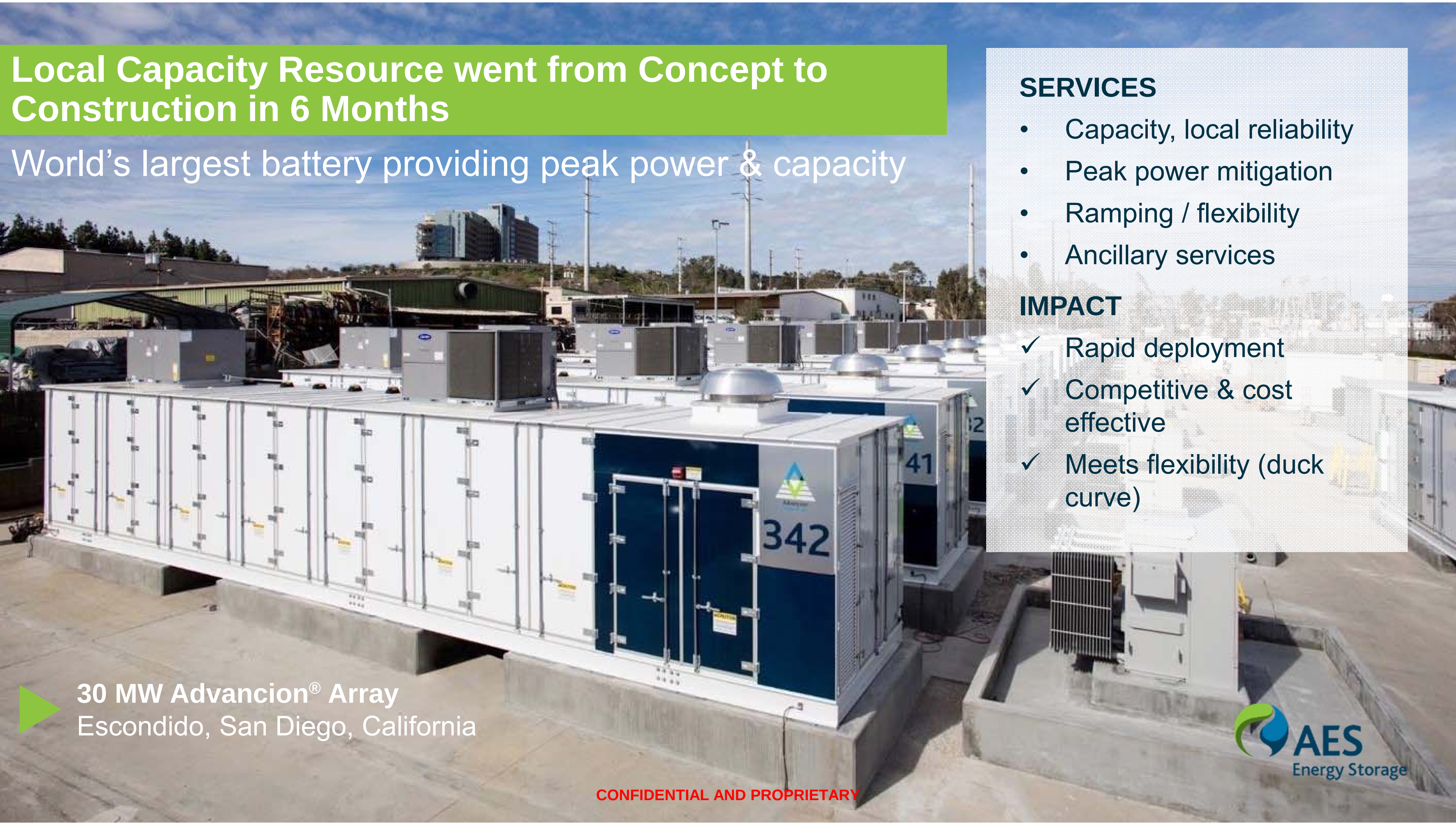
IMPACT

- ✓ Support rooftop solar growth
- ✓ Manage local feeder reliability
- ✓ Alternative to substation upgrades

AES Energy Storage

Local Capacity Resource went from Concept to Construction in 6 Months

World's largest battery providing peak power & capacity



SERVICES

- Capacity, local reliability
- Peak power mitigation
- Ramping / flexibility
- Ancillary services

IMPACT

✓ Rapid deployment

✓ Competitive & cost effective

✓ Meets flexibility (duck curve)

30 MW Advancion® Array
Escondido, San Diego, California

AES Energy Storage

CONFIDENTIAL AND PROPRIETARY

100 MW/400 MWh Energy Storage Project Under Construction

World's largest contracted energy storage project for local capacity in California

SERVICES

- Capacity, local reliability
- Peak power/off peak mitigation
- Ancillary services

IMPACT

✓ Competitive bid vs thermal peaker, cost effective

✓ Replaces environmental retired units

✓ Meets flexibility (duck curve)

100 MW Alamitos Energy Center
Long Beach, California

AES Energy Storage

Three T&D value plays for energy storage

1	**N-1 Capacity Release**	• Automatic power injection to support grid stability during contingency. • Increase the operational capacity of existing line (value creation from existing assets). • Arrests line overloads and frequency/voltage deviations until grid is redispatched
2	**Peak Load Relief (investment deferral)**	• Injects power downstream of thermal constraints during peak hours • Avoids or defers new transmission capex to meet load • Improves power quality and voltage conservation
3	**Feeder Reliability**	• Supports greater penetration of intermittent distributed resources • Injects real and reactive power to maintain voltage stability, improve power quality • Reduces wear and tear on existing equipment • Defers cost of traditional poles and wires solution

1 Capacity Release - Operational Construct

- Assuming Lines, X, Y and Z are rated at 500 MW capacity, N-1 limit across interface from A to B is 1000 MW.
- To increase throughput across the interface to 1500 MW, consider storage additions at nodes B and E that provide temporary post-contingency relief. These batteries are generally on stand-by – upon sensing a line-trip (through frequency or direct line flow input feed) they ramp to full output to provide counter-flows.

Figure 7

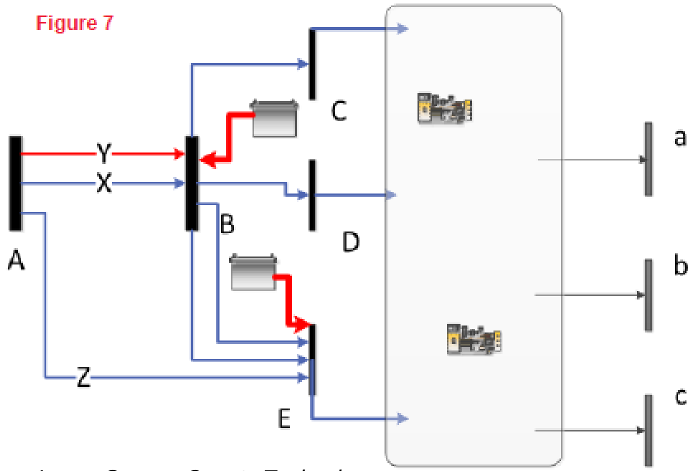
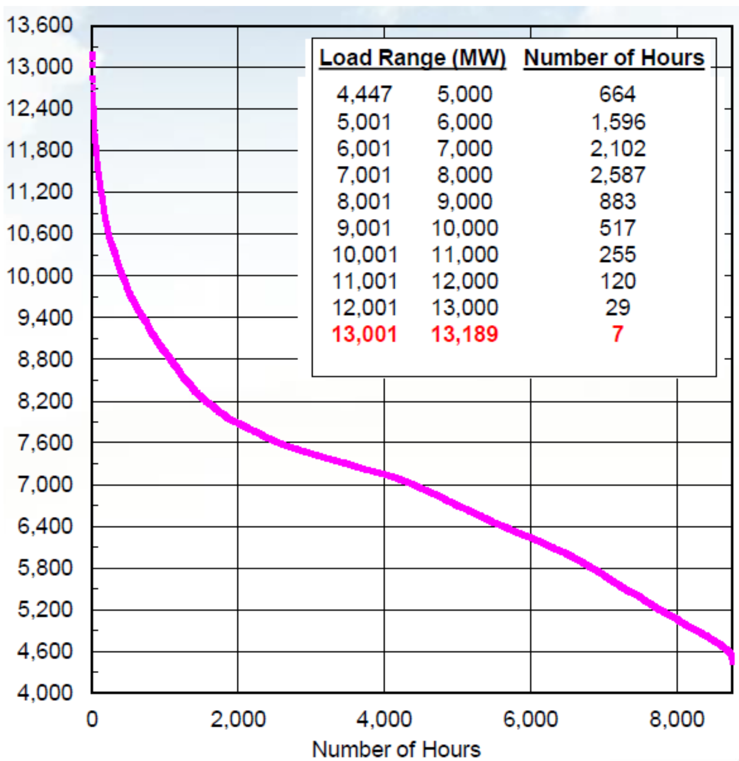


Image Source: Quanta Technology

2 Storage is well suited for peak load/congestion relief

ConEdison Load Duration Curve (Ilustrative)



Load Range (MW)		Number of Hours
4,447	5,000	664
5,001	6,000	1,596
6,001	7,000	2,102
7,001	8,000	2,587
8,001	9,000	883
9,001	10,000	517
10,001	11,000	255
11,001	12,000	120
12,001	13,000	29
13,001	13,189	7

Few hours where load is high – traditional T&D systems planning is performed based on deterministic power flow analysis for snapshot summer/winter peak conditions

↓

Consideration of Critical Load at which violations occur could provide indications of feasibility of non-wires alternatives

↓

Energy storage provides a unique capability to defer T&D investments

2

Transmission Alternative – Arizona Example

SERVICES

- Peak demand management
- Transmission investment deferral

IMPACT

- ✓ Defer or replace investment in 20 miles of transmission.
- ✓ *"We can take much smaller incremental steps to manage the need as it arises and not have to over-invest in some cases, as utilities have traditionally had to do in the past."*

APS Buys Energy Storage From AES for Less Than Half the Cost of a Transmission Upgrade

Photo Credit: lopez1441 / Panoramio

Punkin Center, known for its prominent pumpkin sign, will now also be known for pushing the vanguard of battery storage.

by Julian Spector
(https://www.greentechmedia.com/authors/julian-spector)
August 09, 2017

This is not a test.

Utility Arizona Public Service has contracted for a new grid-scale battery -- not to demonstrate the technology, but because it's a lot cheaper than the conventional alternative (https://www.greentechmedia.com/research/report/non-wires-alternatives-projects).

The company will purchase two 1-megawatt/4-megawatt-hour storage systems from AES for the small town of Punkin Center. This 600-person hamlet, 90 miles northeast of downtown Phoenix (and known for a bar with a prominent jack-o'-lantern sign (https://www.yelp.com/biz_photos/punkin-center-tonto-basin?select=uQBHmnXPP0wsWNHpqbdpUA)) is bumping up against the limits of its distribution grid.

The traditional approach, which APS considered, would be to upgrade the 20 miles of 21-kilovolt cables that service the town. That requires construction through hilly and mountainous terrain, with considerable expense and local disruption.

The utility decided that batteries would be cheaper.

3

AES delivered two 2 MW Advancion® arrays to Arizona Public Service (APS) to support distribution feeders with high RE penetration

- APS Solar Partner Program
  - 1,600 utility-owned home solar projects coupled with smart inverters
  - Evaluating high levels of distributed solar without compromising reliability
- APS using Advancion® to test how storage can support solar integration
  - Managing peak demand
  - Voltage regulation
  - Power quality improvement
  - Spinning reserves

Thank you

Kiran Kumaraswamy

Market Development Director

571-527-8498

Kiran.Kumaraswamy@aes.com

AES Energy Storage

Advancion Energy Storage

Siemens Energy Management lives up to future challenges with the most comprehensive portfolio

Large power generation | TSOs[1] | DSOs[2] and municipalities | Distributed generation | Oil and gas | Industries | Infrastructures / construction

Digitalization

Software/IT

Grid control – big data analytics – grid application

Automation

Communication, automation, protection, and field devices

Electrification

Electrification solutions

High-voltage direct current (HVDC) transmission – grid access – FACTS – air-insulated/gas-insulated substations – power systems solutions – microgrids / nanogrids

Products and systems

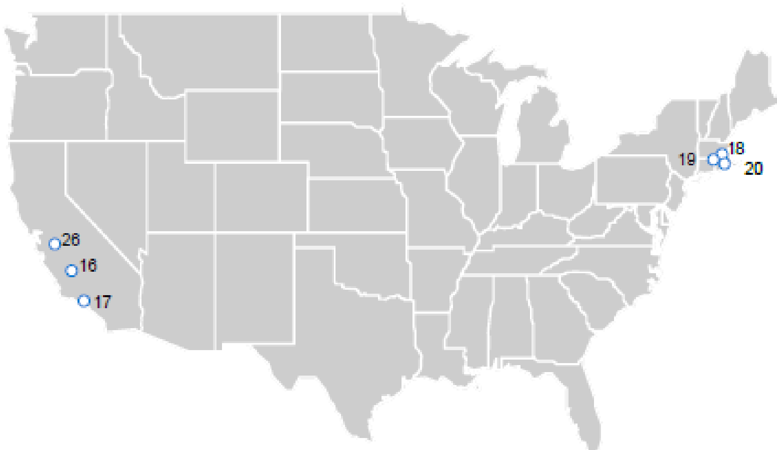
High-voltage switchgear and systems – power transformers – medium-voltage switchgear – distribution transformers – low-voltage switchboards and circuit breakers

Services and security

[1] Transmission system operators
[2] Distribution system operators

Siemens Energy Storage Systems Projects in the Americas

SIEMENS



#	kVA	kWh	COD	Country	Status	Application
16	1,260	1,000	May/14	CA/US	D	RI TS
17	120	45	May/15	CA/US	D	GS MG
18	500	3,000	Aug/16	MA/US	UC	RI MG
19	165	990	Oct/15	MA/US	D	RI MG
20	500	3,000	Aug/16	MA/US	UC	RI MG GS
21	620	300	Oct/16	Ecuador	UC	RI MG GS TS
22	165	660	Dec/16	**/US	UC	RI MG GS TS
23	165	660	Dec/16	**/US	UC	RI MG GS TS
24	250	1,000	Oct/16	**/US	UC	RI MG GS TS
25	250	1,000	Dec/16	**/US	UC	RI MG GS TS
26	9,600	4,000	Jan/17	CA/US	UC	RI MG GS BS

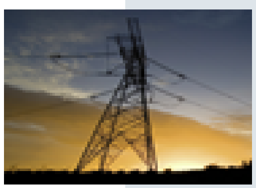
RI Renewable Integration
TS Time Shifting
GS Grid Support
MG Microgrid
BS Black Start

Challenges of the Future Grid

New Energy Mix
- Shifts in the energy mix with significant regional differences

Changing Economics
- Rising OPEX for fossil energy, falling CAPEX for wind and PV

Liberalization of energy markets
- Fluctuating prices and market integration of renewables



Weak / overloaded grids
- Little investment & high volatility through renewables

Environmental aspects
- Ramp-up of renewables accepted goal in all societies

1. **Increased Flexibility of Fossil Plants**
2. **Smooth integration of Renewables**
3. **Fleet Optimization (Economic Dispatch)**
4. **Hybridization Fossil + Renewables**
5. **Sizing the right mix of generation types**
6. **Services for Operations & Maintenance**

Maintaining Reliability in the Modern Power System
U.S. Department of Energy Report – December 2016

1. Power generation and transmission capacity must be sufficient to meet peak demand for electricity
2. Power systems must have adequate flexibility to address variability and uncertainty in demand (load) and generation resources
3. Power systems must be able to maintain steady frequency
4. Power systems must be able to maintain voltage within an acceptable range

Past: Conventional power plants delivering energy & ancillary services
Today & Future: VSC based solutions enable the evolving grid

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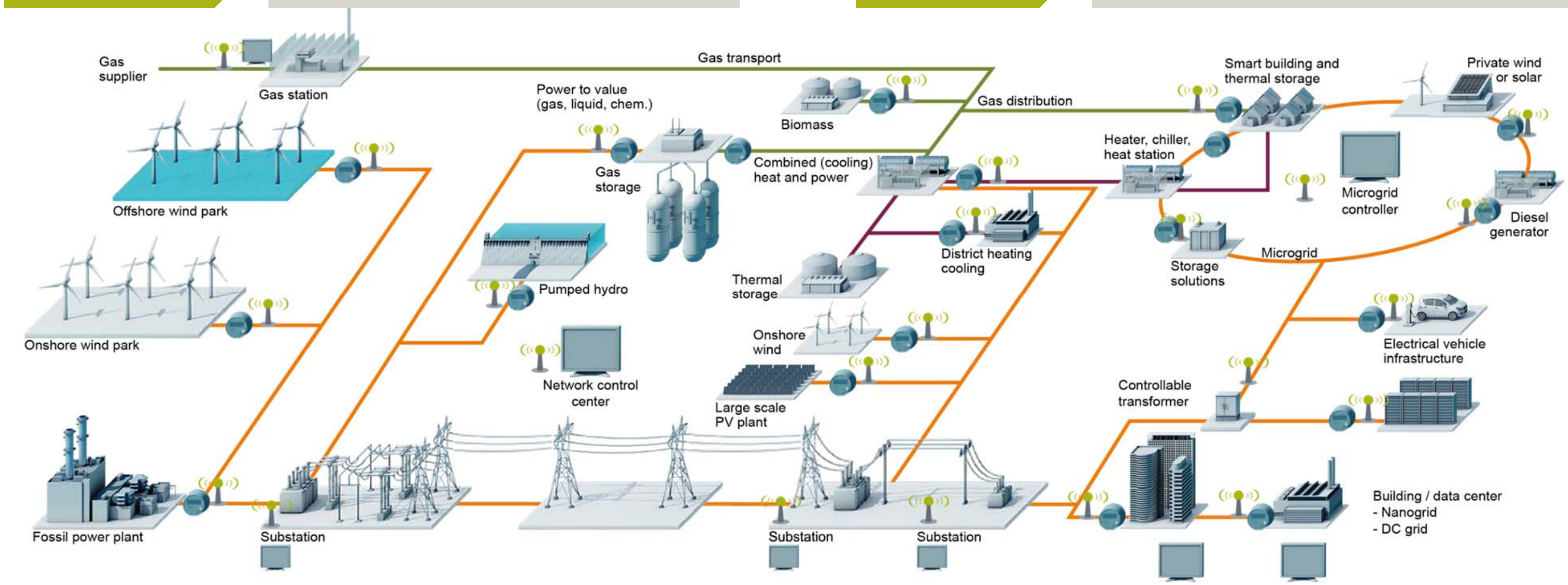
Advanced Power Electronics & Energy Storage – Enabling Alternative Grid Solutions

Flexible AC Transmission Systems

- STATCOM
- Dynamic Voltage Control

Energy Storage

- STATCOM + ESS
- Frequency Stability

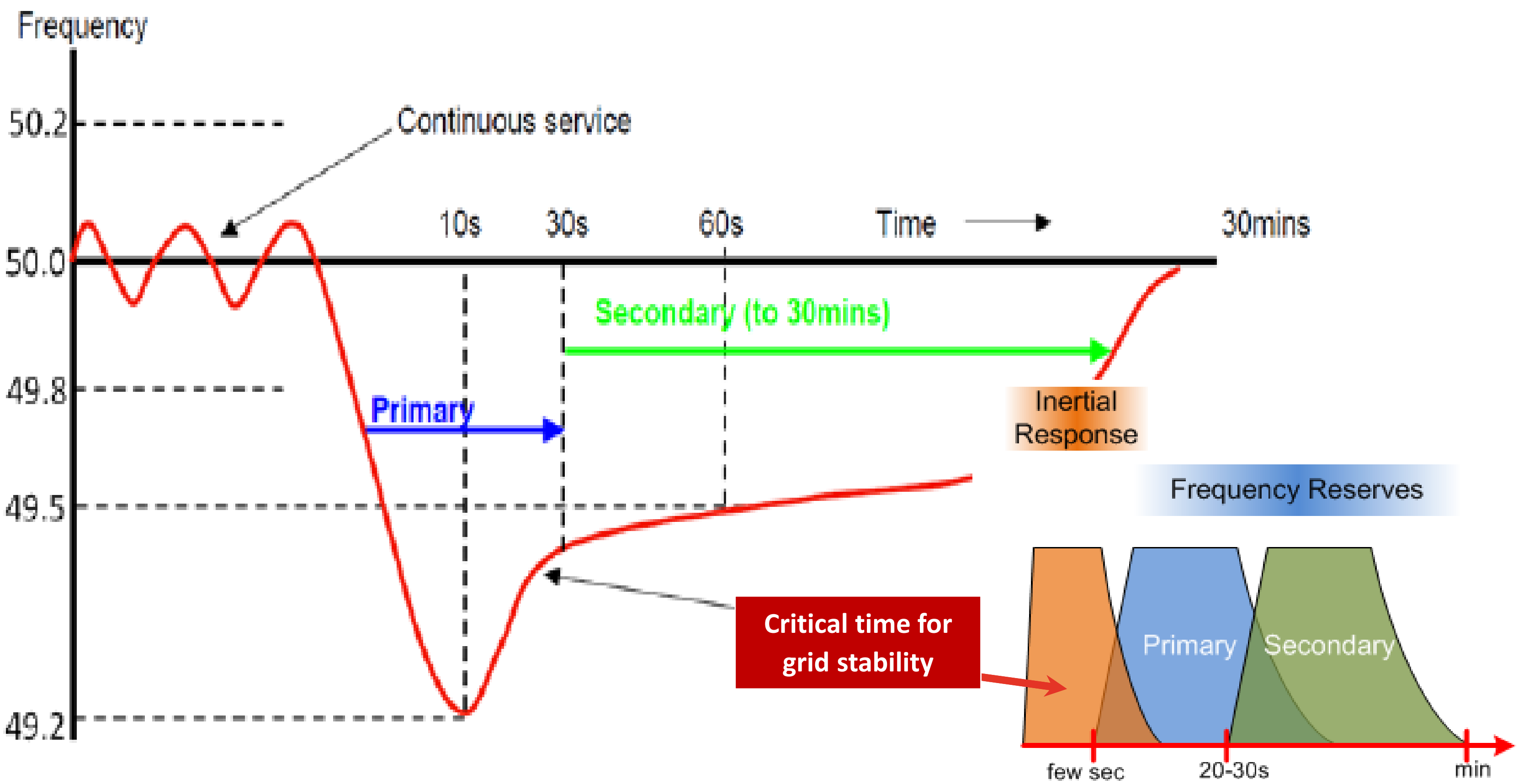


Enabling Alternative Solutions to Supplement or Replace Conventional Solutions

IEEE PES Power & Energy Society®

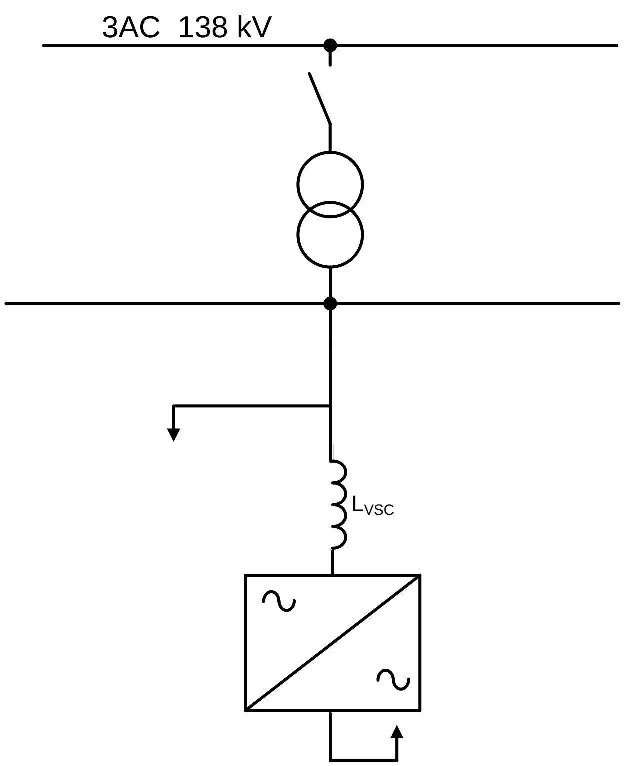
IEEE

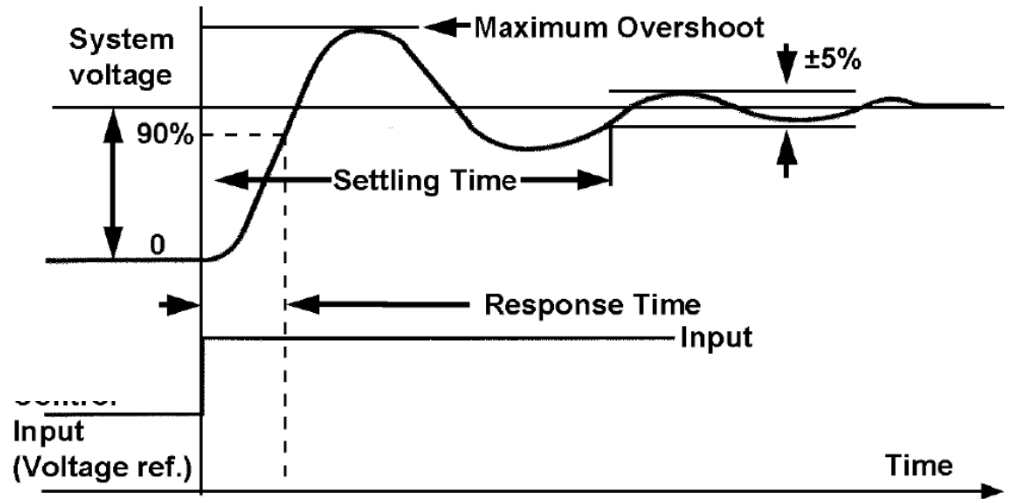
Maintaining a Reliable Grid – Frequency Stability



Past: Conventional generation providing stability and reserves
Today & Future: VSC based solutions enabling renewables, DER, storage

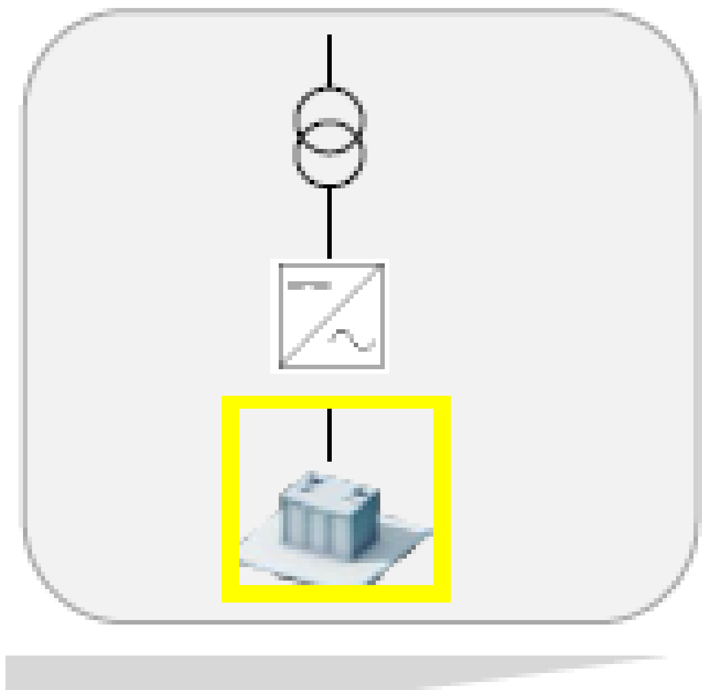
Maintaining a Reliable Grid – Voltage Stability





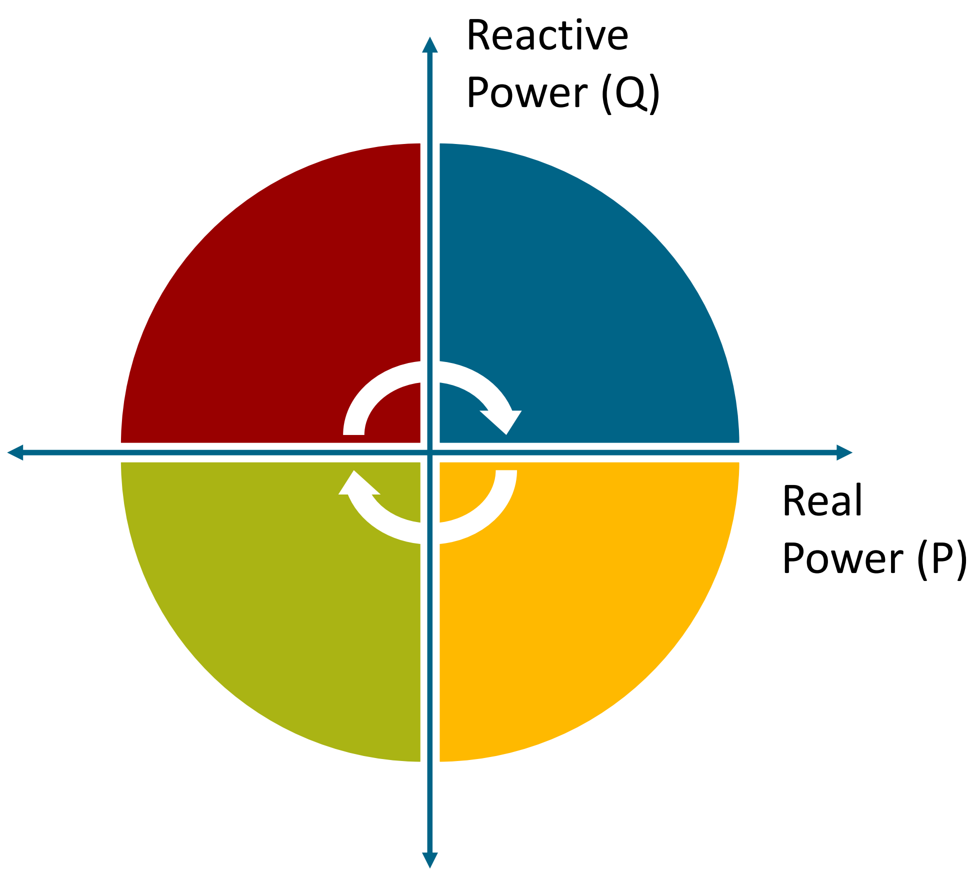
Conventional generation, T&D, and Flexible AC Transmission System (FACTS) Solutions

Advanced Power Electronics & Energy Storage – Enabling Alternative Grid Solutions



- Fully dynamic four-quadrant real and reactive output capability
- Advanced control systems that enable them to 'mimic' conventional generators (voltage source)
  - AVR, frequency response, inertia
- Tunable to the application:
  - Speed of response
  - Real vs. Reactive
  - Unbalanced/balanced
  - Droop, deadband, etc.

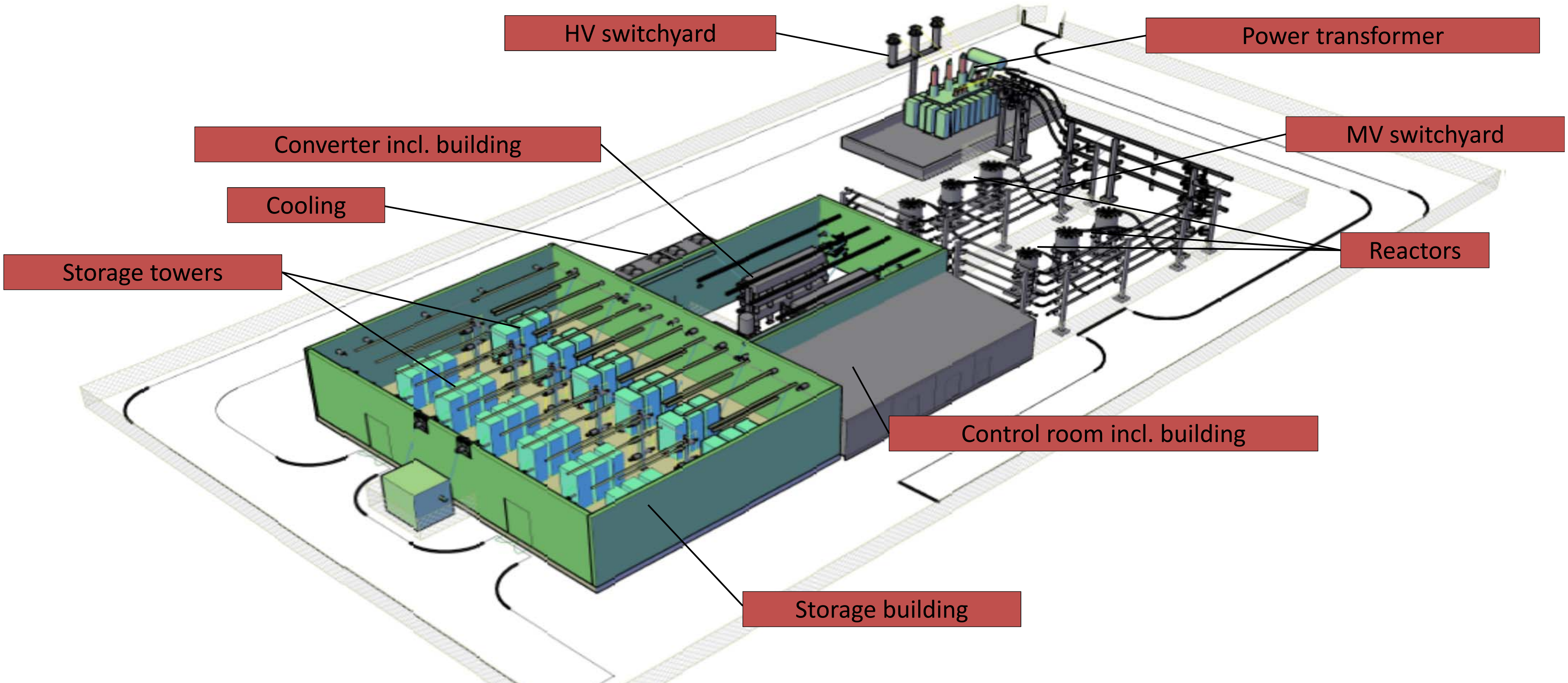
Advanced Power Electronics & Energy Storage – Enabling Alternative Grid Solutions



Full Real & Reactive Power Output Capability

- Dynamic Stability
- Transient Stability
- Voltage Support
- Frequency Regulation
- Power Quality
- Power Flow Improvement
- Oscillation Damping

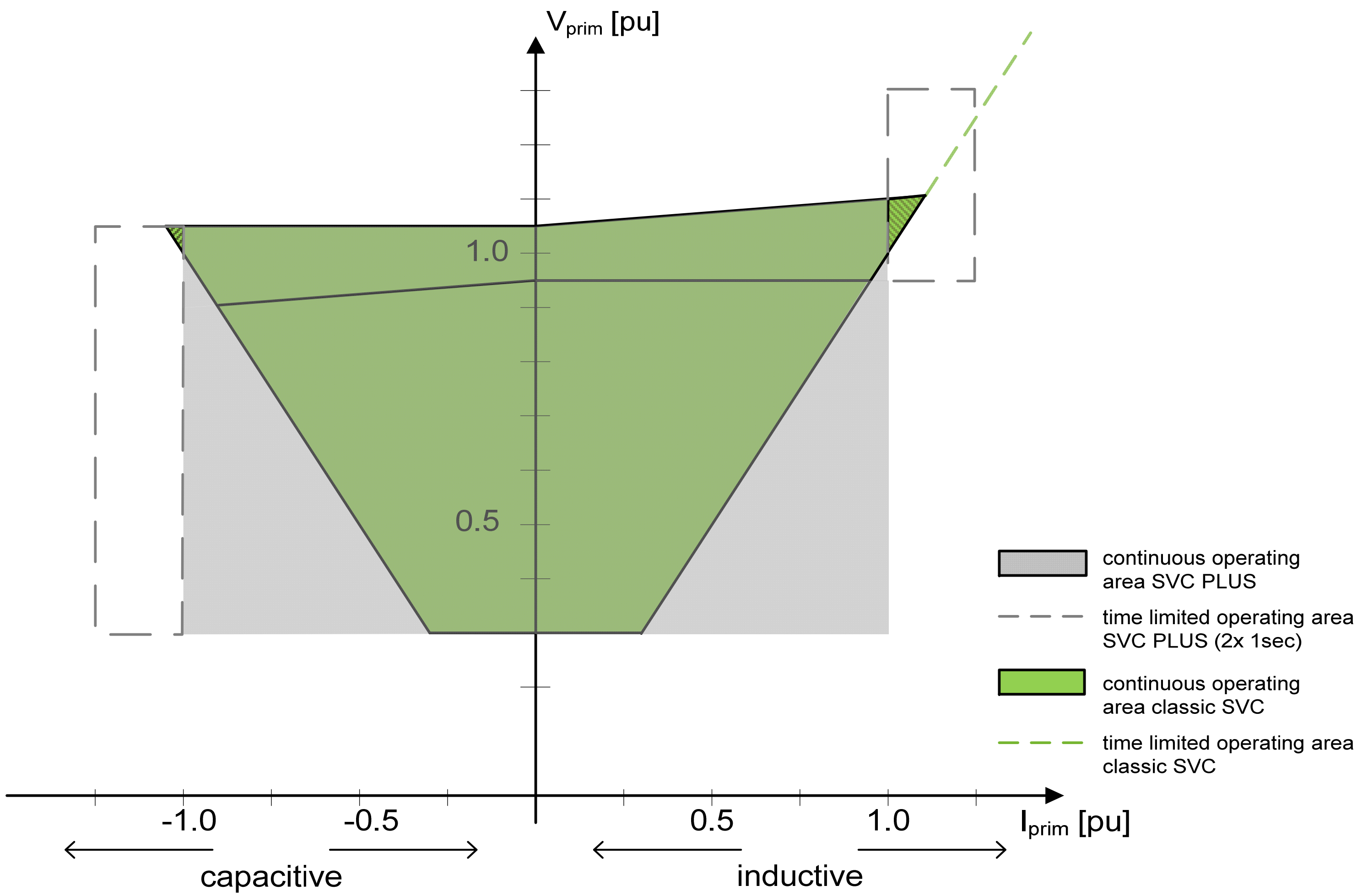
Siemens SVC Plus Grid Stabilizer
Energy Storage with STATCOM Capabilities



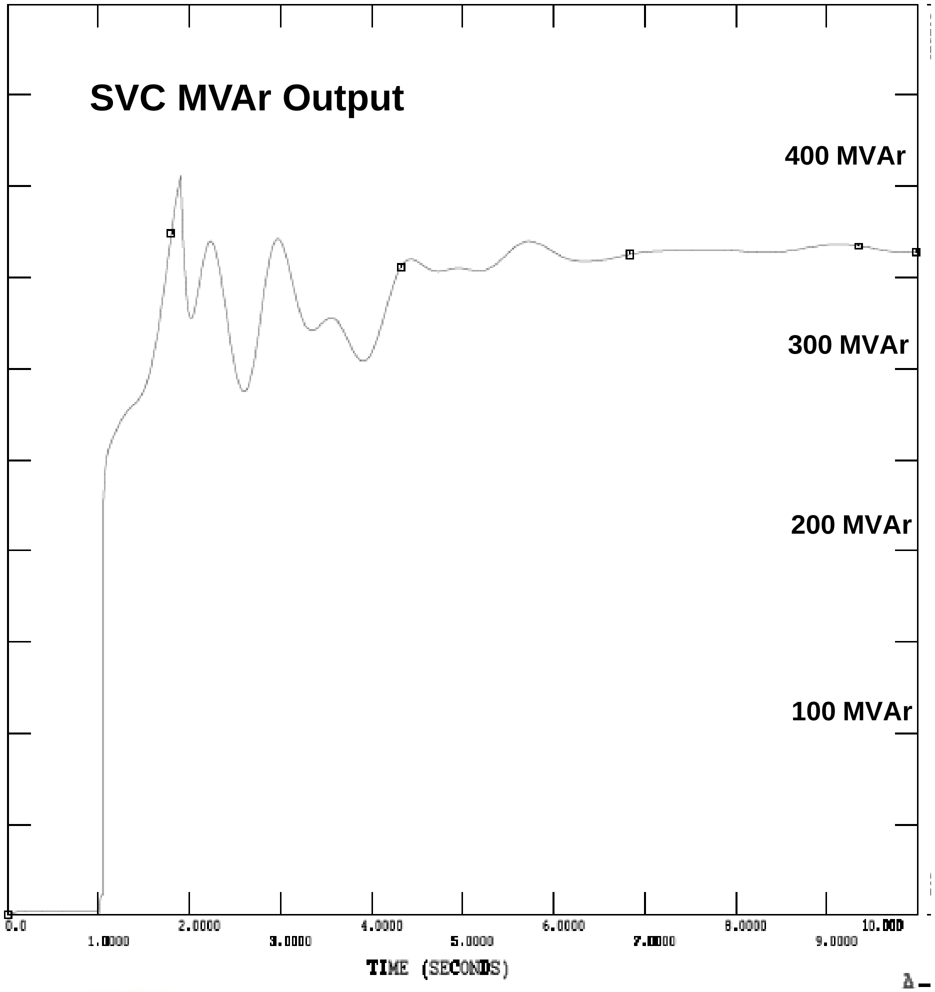
Optimized Solution: Co-locate Dynamic Reactive Power + Energy Storage

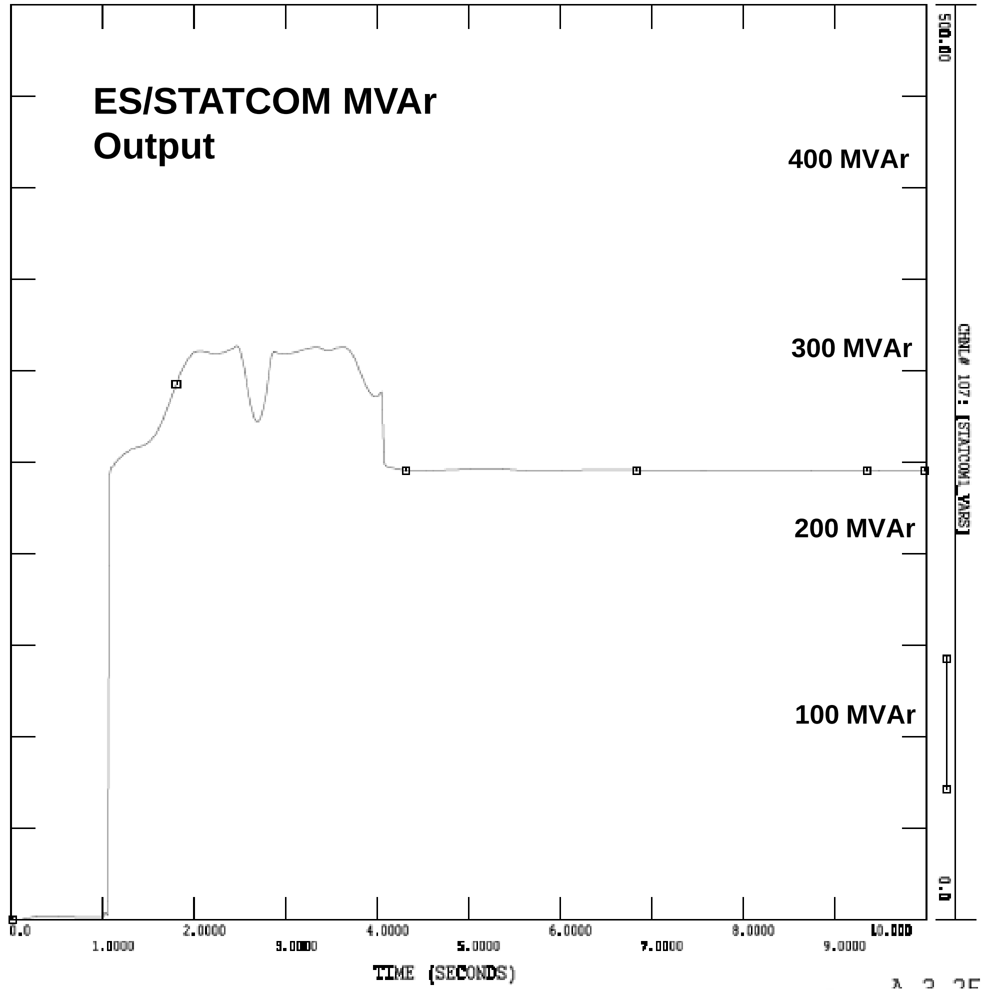
SIEMENS

Inverter Based vs Impedance Based – Performance Characteristic

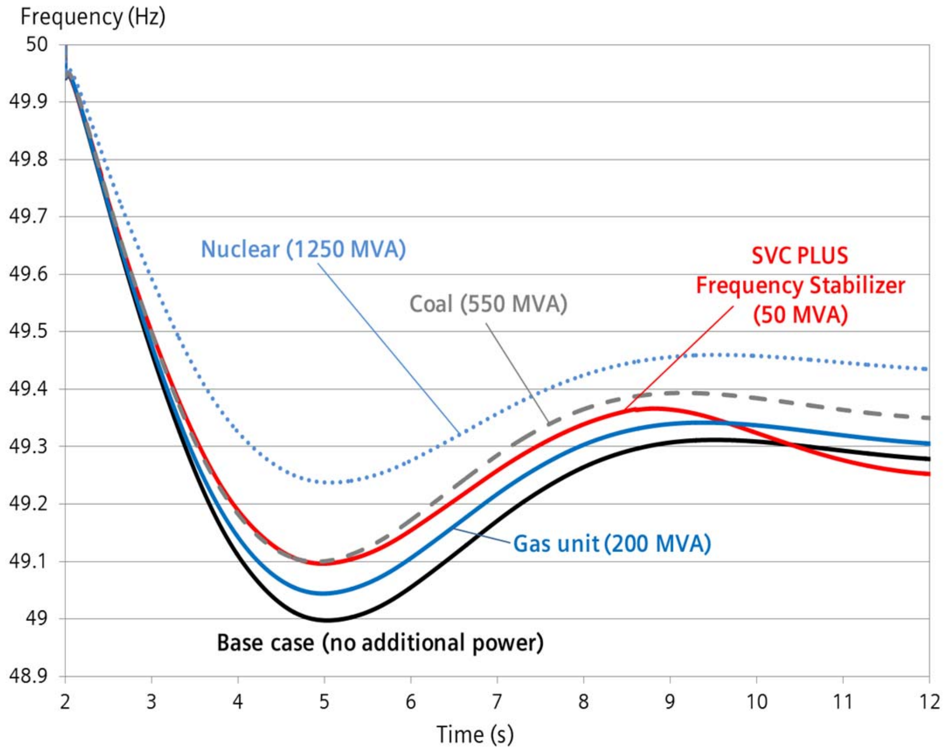


Dynamic Simulation of Critical Contingency - MVAr Output – SVC versus ES/STATCOM





STATCOM with Energy Storage
Impact on primary reserve and possible benefits



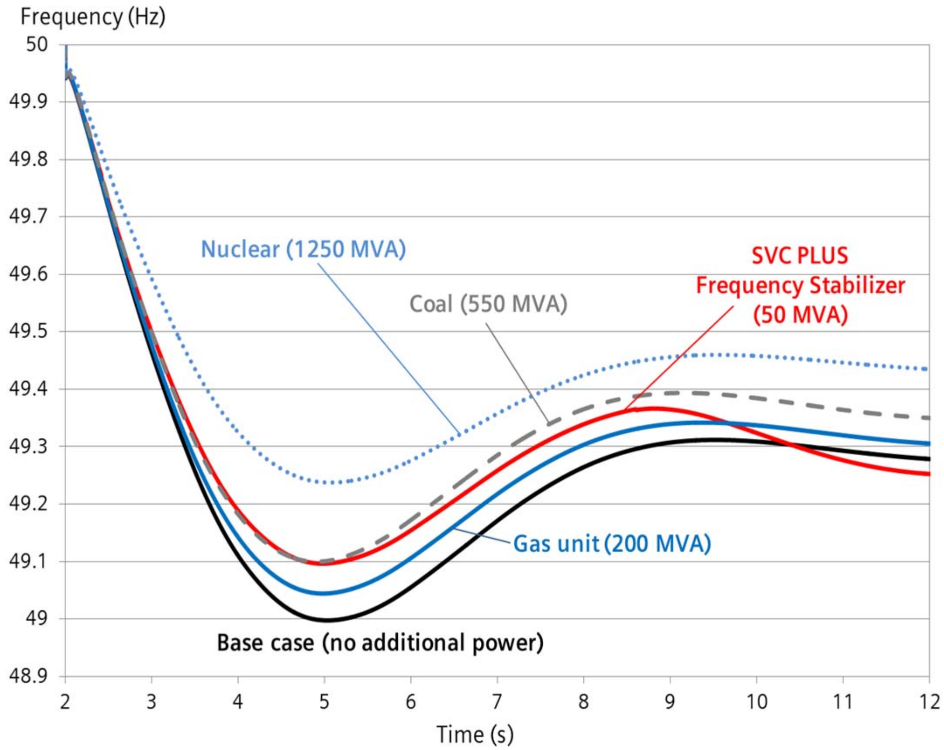
High renewable show-case for Ireland (All-Island – 2022):

- Low load (~2500 MW)
- High share of renewables (65%)
- ~ 23 GWs inertia online
- Trip of 500 MW unit

A 50 MW SVC PLUS FS solution has an equivalent impact on frequency as an additional 550 MVA coal power plant or approx. 2 x 200 MVA gas units.

Energy Storage with VSC can reduce level of "must run" units (required for secure operation of the system) and reduce primary reserve

STATCOM with Energy Storage
Impact on primary reserve and possible benefits



Potential savings under given assumptions*:

$\dot{€}_{gas}$ = **2,31 Mio €/year**

$\dot{€}_{coal}$ = **2,89 Mio €/year**

Potential savings of CO_2 emissions**:

16,9 Mio tons CO_2 for gas

73,6 Mio tons CO_2 for coal

Energy Storage with VSC can reduce level of "must run" units (required for secure operation of the system) and reduce primary reserve

* Not considered: start-up costs, CAPEX and OPEX. Made assumptions are under revision.

** 0,93 kg CO2 per 1 kWh from coal, 0,55 kg CO2 per 1 kWh from gas

Summary

The Grid is Evolving

- Proliferation of renewables, DER, new technologies are changing the traditional construct

But the Objective Remains the Same – Maintain Reliability

- Peak Demand, Flexibility, Frequency, Voltage

Voltage Source Converter Technology Provides Alternative to Conventional Solutions

- STATCOM, Energy Storage

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https://www.energy.siemens.com/hq/en/power-transmission/facts/

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