ESA and ABAQUE Joint Webinar

August 27, 2015

Energy Storage Association

ABAQUE

Associação Brasileira de Armazenamento e Qualidade de Energia

Agenda

- *Energy Storage: Where We Are Today*
  - Matt Roberts, Executive Director, ESA
- *Insights into the Evolution of the Brazilian Marketplace*
  - Carlos Brando, Executive Director, ABAQUE
- *Needs of the Brazilian Electric Grid*
  - Francisco Artiero, Operation Planning and Scheduling Director, ONS

Energy Storage:

Where We Are Today

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www.energystorage.org


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UET UniEnergy Technologies
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ViZn ENERGY
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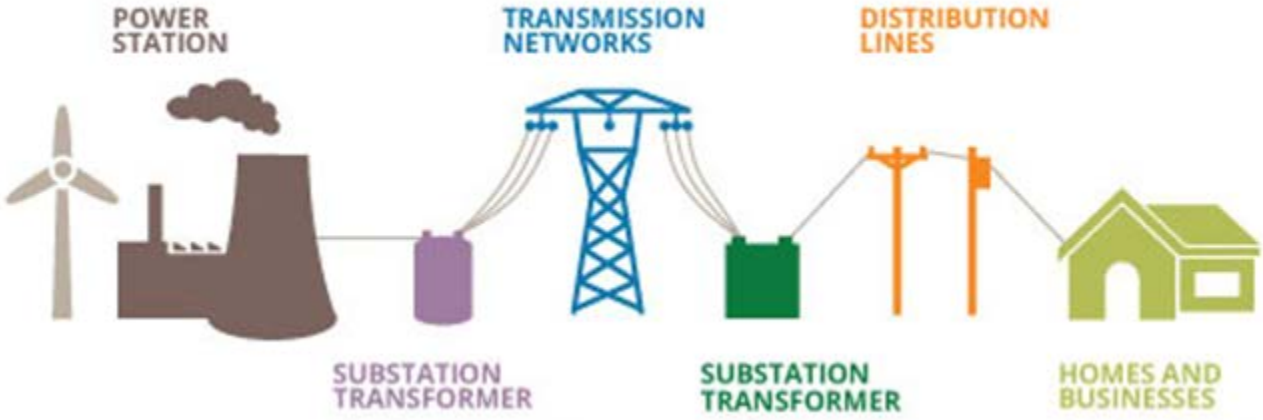
Younicos Let the fossils rest in peace.
ZBB

Storage Works on All Parts of the Grid



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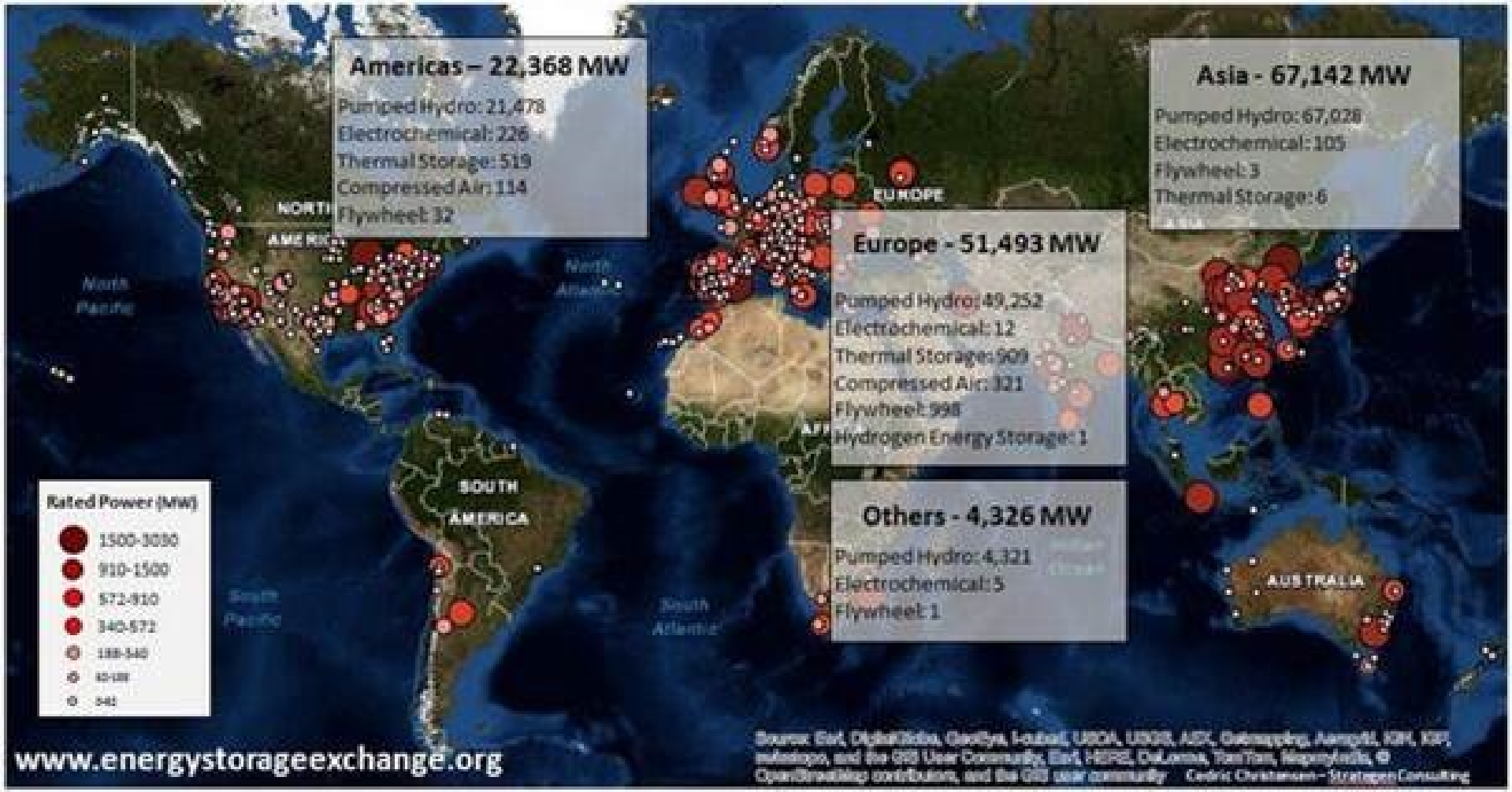
Over 1500 Grid-Scale Installations Globally



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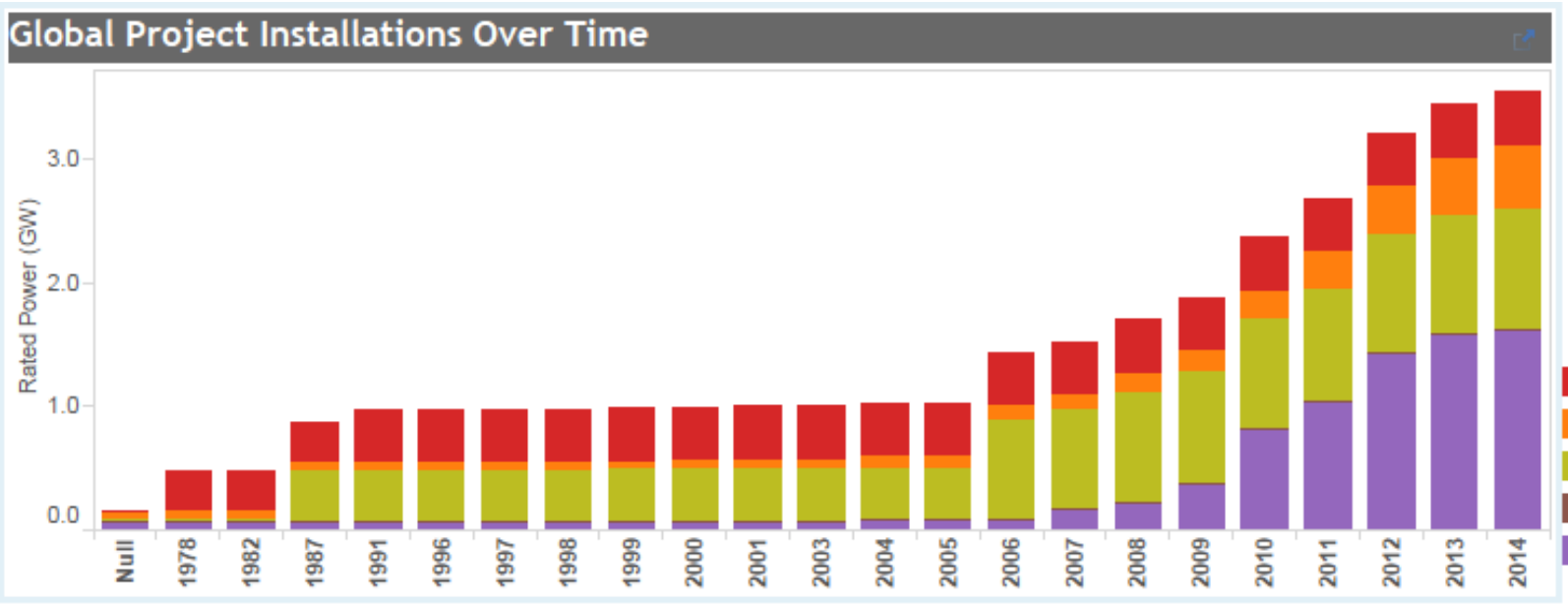
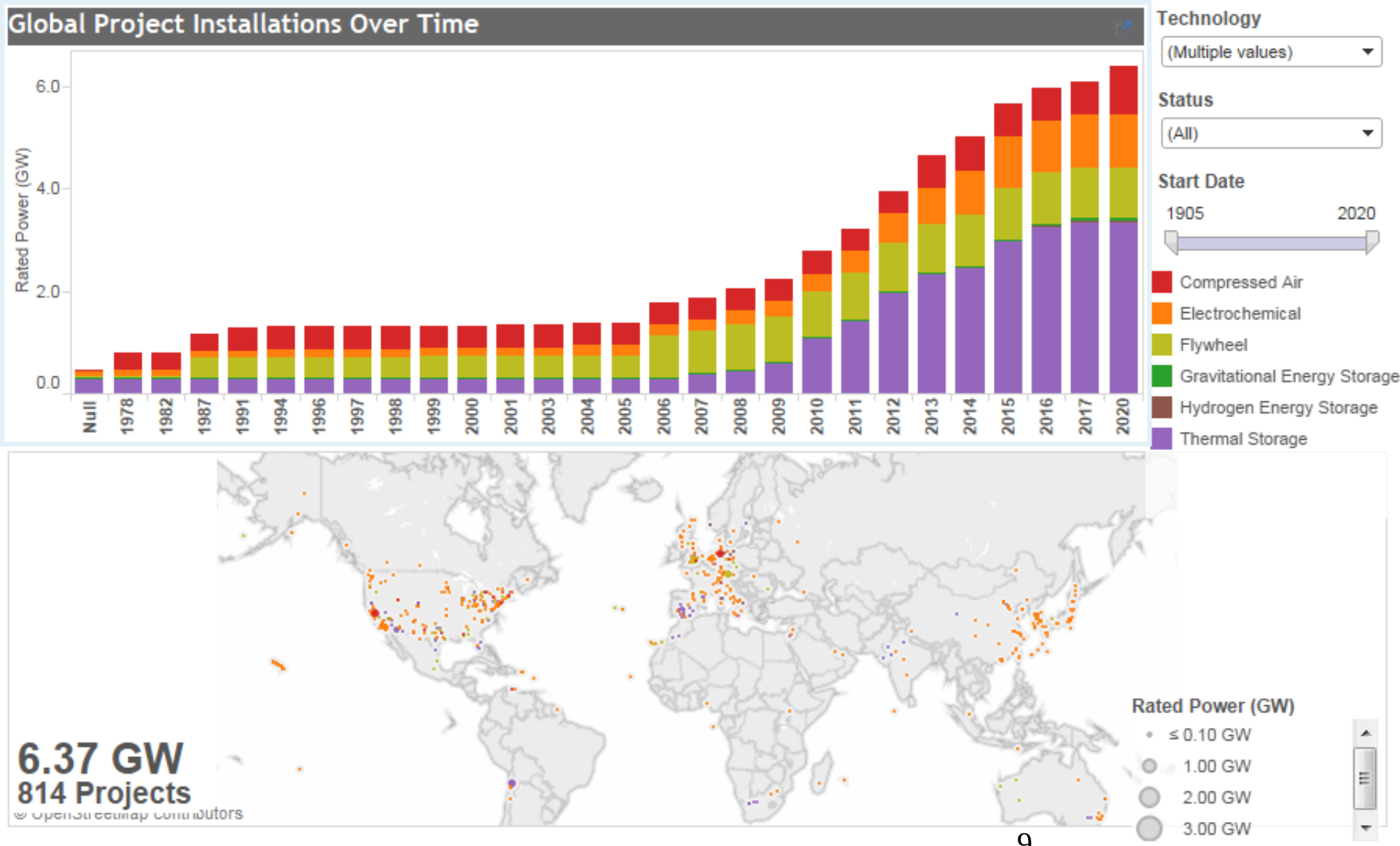
Operational Storage (Non-Hydro)



The DOE Global Energy Storage Database (http://www.energystorageexchange.org/) is powered by Sandia Corporation (http://www.sandia.gov/) and Strategen Consulting , LLC (http://strategen.com/)

Planned Storage (Non-Hydro)



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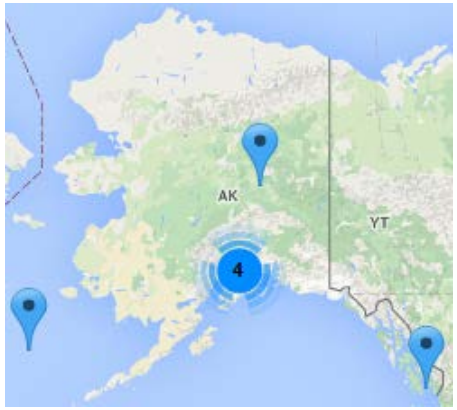
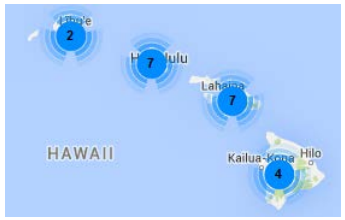
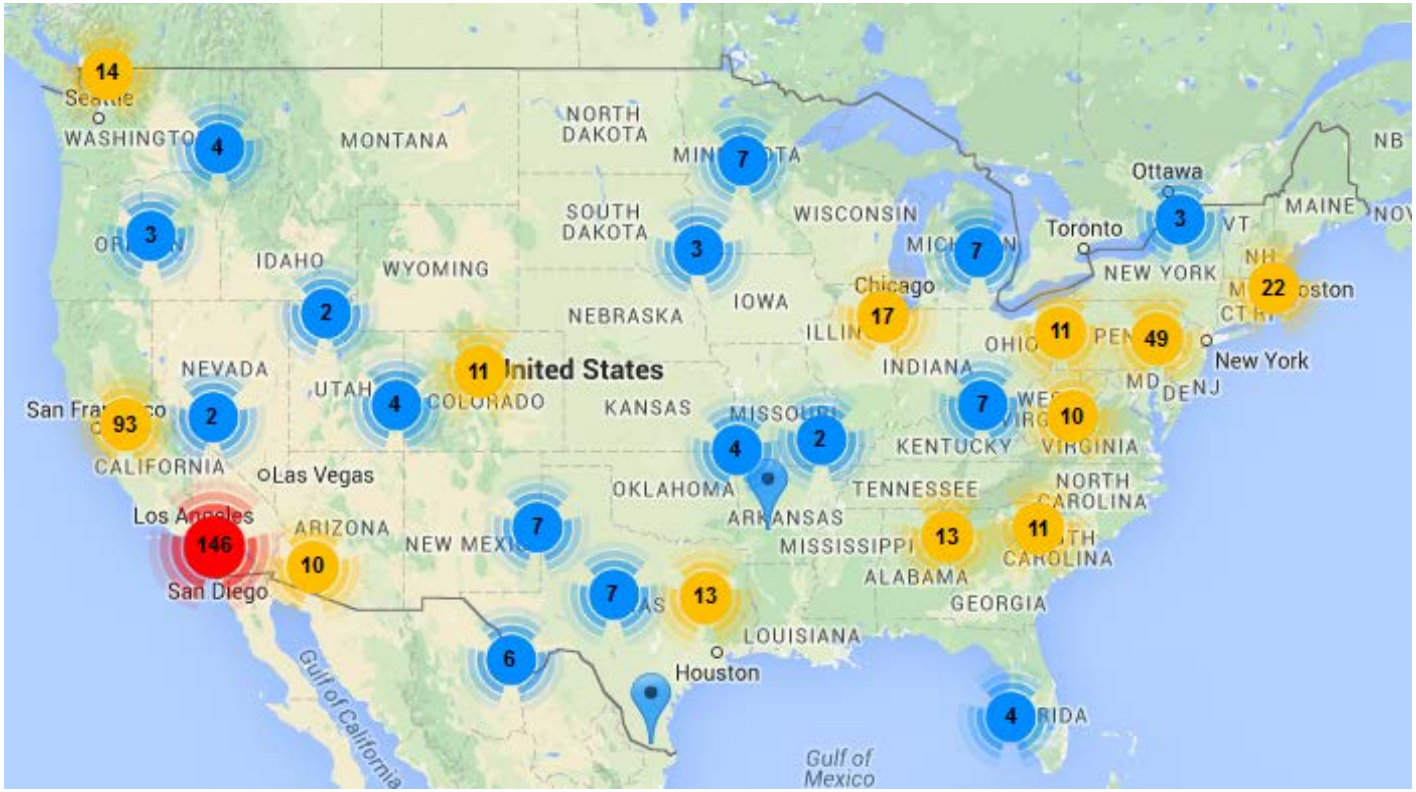
Projects Operating Across the U.S.







Several MW-scale projects have 5+ years of operations

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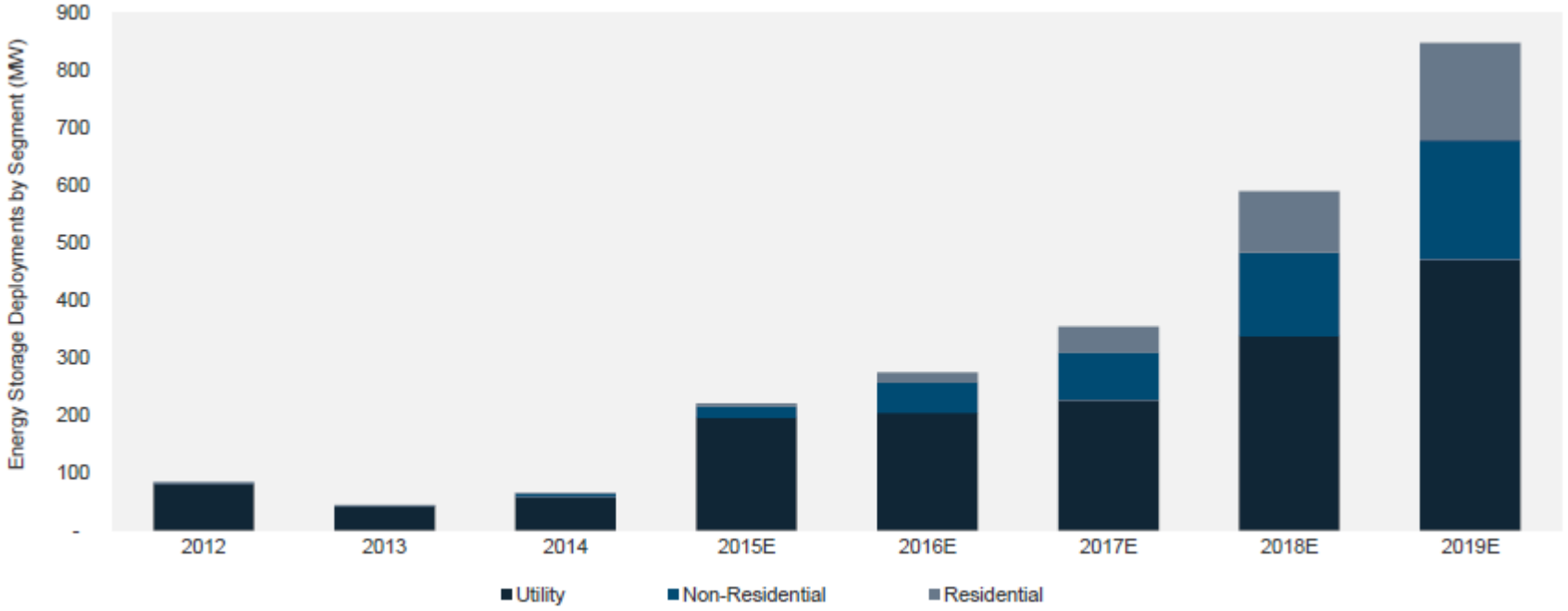
Energy Storage Installs Are Growing

IN THE U.S. annual installation in 2019 expected to be ~850 MW, quadruple estimated annual installation in 2015. (GTM-Research)



GLOBALLY expected to grow from <1 GW in 2013 to 6 GW by 2017 and over 40 GW by 2022. (IHS)

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- According to market research firm IHS, energy storage growth will “explode” from .34 GW in 2012-2013 to 6 GW by 2017 and over 40 GW by 2022.

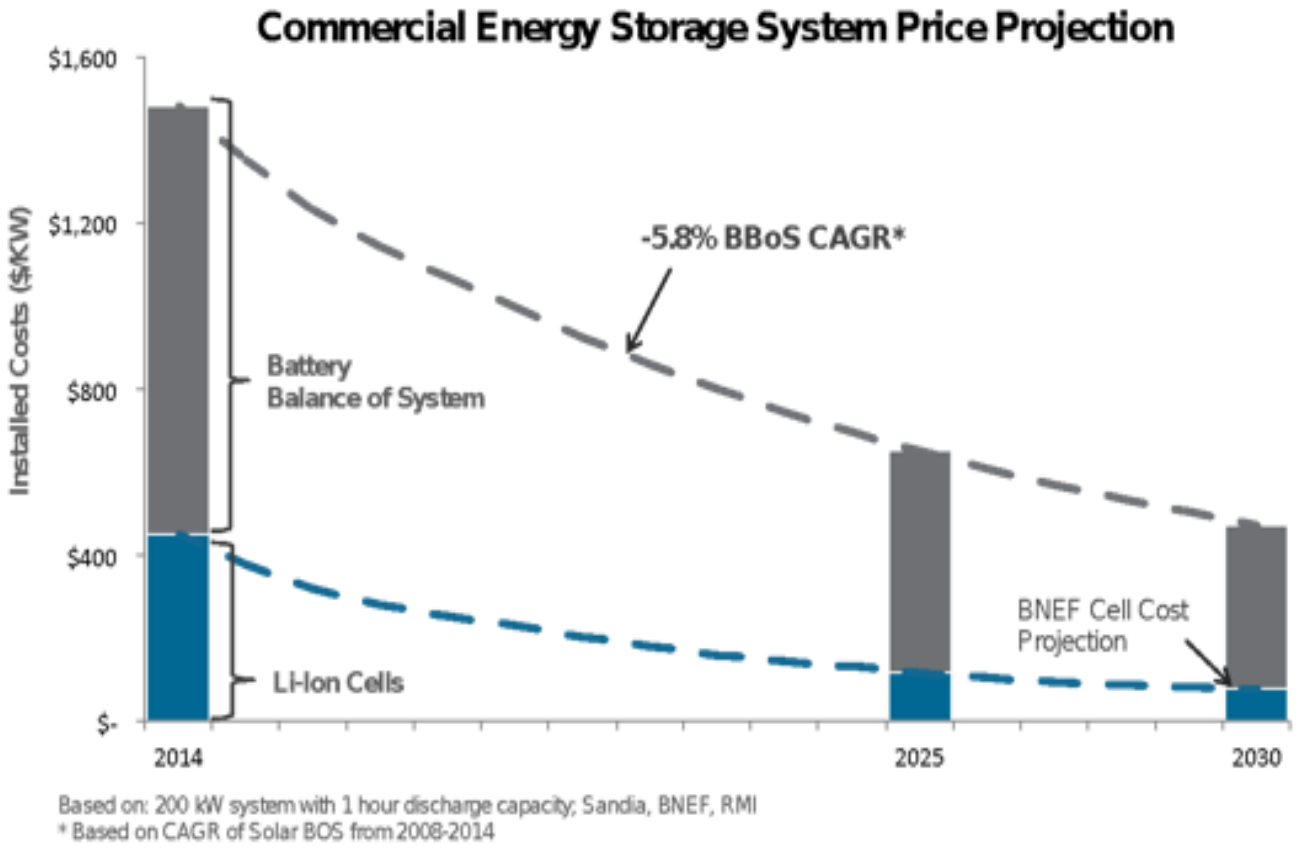
- U.S. energy storage capacity grew 40% from 2013 to 2014 but is expected to triple in 2015 to 220 MW.

- AES Corp alone will add 1,000 MW of storage capacity in Europe and new U.S. markets

- Tesla unveils new residential storage system for ~$350 a kW available summer 2015.

- RMI “Grid Defection” study predicts grid parity for solar plus storage systems in major markets CA, NY, and others by 2025.

Costs expected to continue



Navigant: 4-hr battery install cost as low as $700/kWh by 2020

Oncor: $350/kWh install cost by 2020

Morgan Stanley: battery-only costs as low as $125/kWh to come

Tesla: Li-ion battery-only cost $110/kWh already

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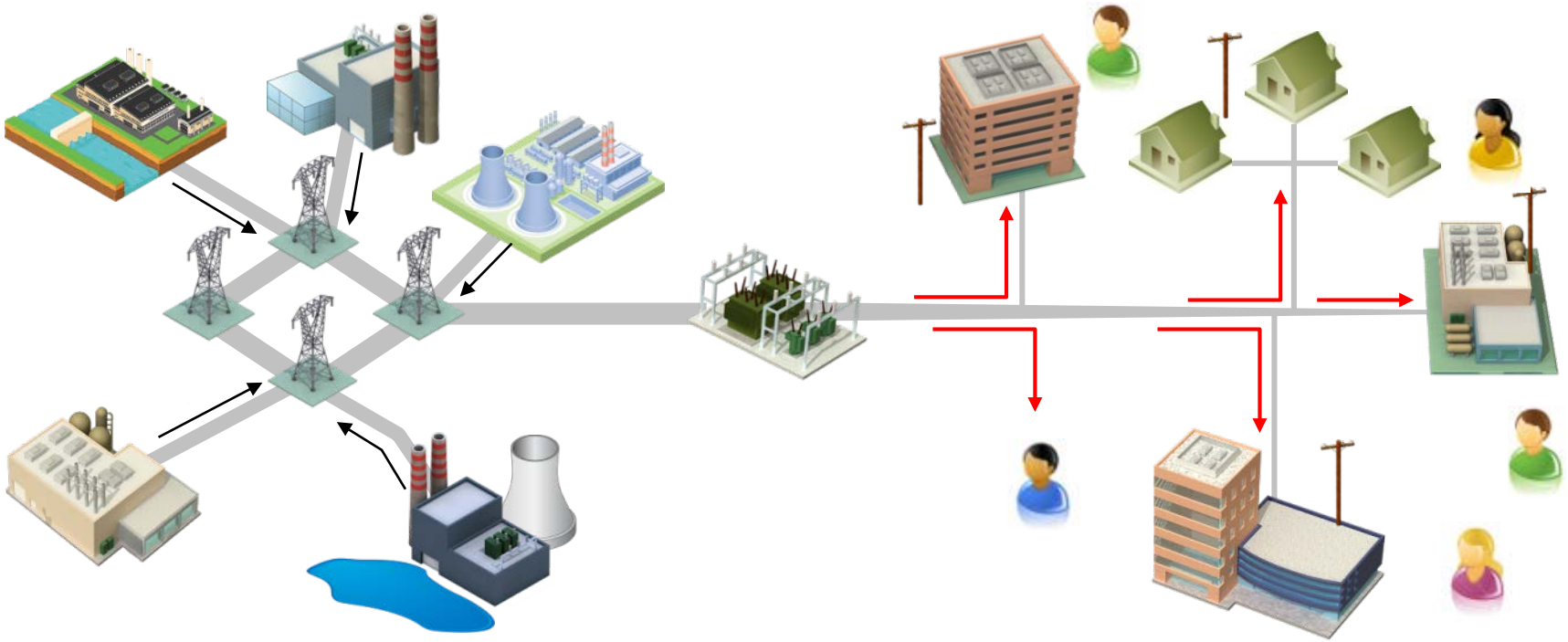
Today's Power System



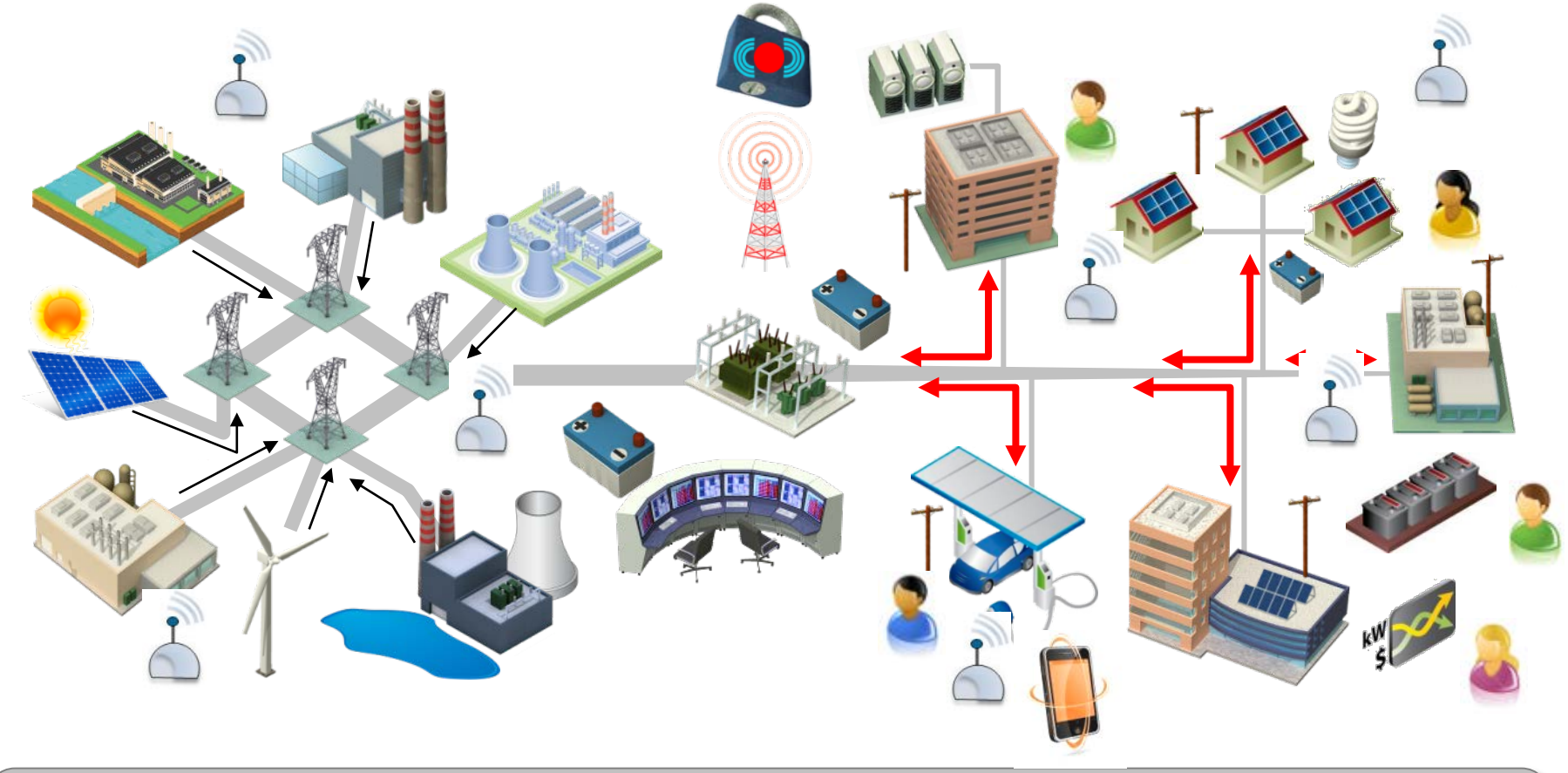
Generation

Delivery

Customer

Graphics from Electric Power Research Institute

Tomorrow's Power System



A Highly Interconnected Power System
that Optimizes Energy Resources

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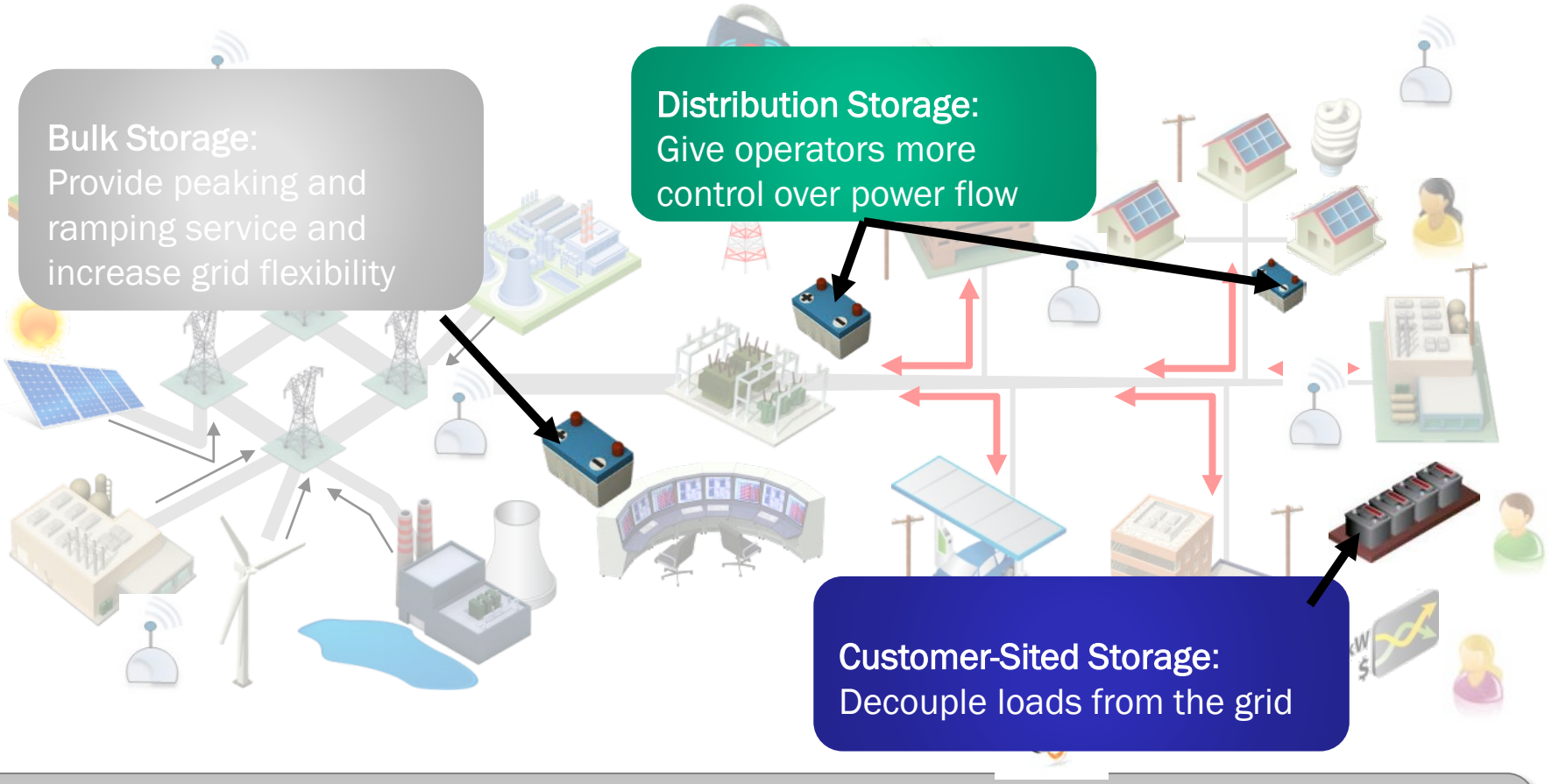
Tomorrow's Power System



A Highly Interconnected Power System that Optimizes Energy Resources

Energy Storage: A Flexible Asset for the Grid

- The grid is a just-in-time supply system, designed to deliver energy as it is produced
- Storage can act as a buffer, making the grid more flexible to accommodate more variable renewable generation
- Storage can provide temporary local power, increasing grid reliability and resiliency
- Storage can improve asset utilization on the grid, reducing the potential for future rate increases



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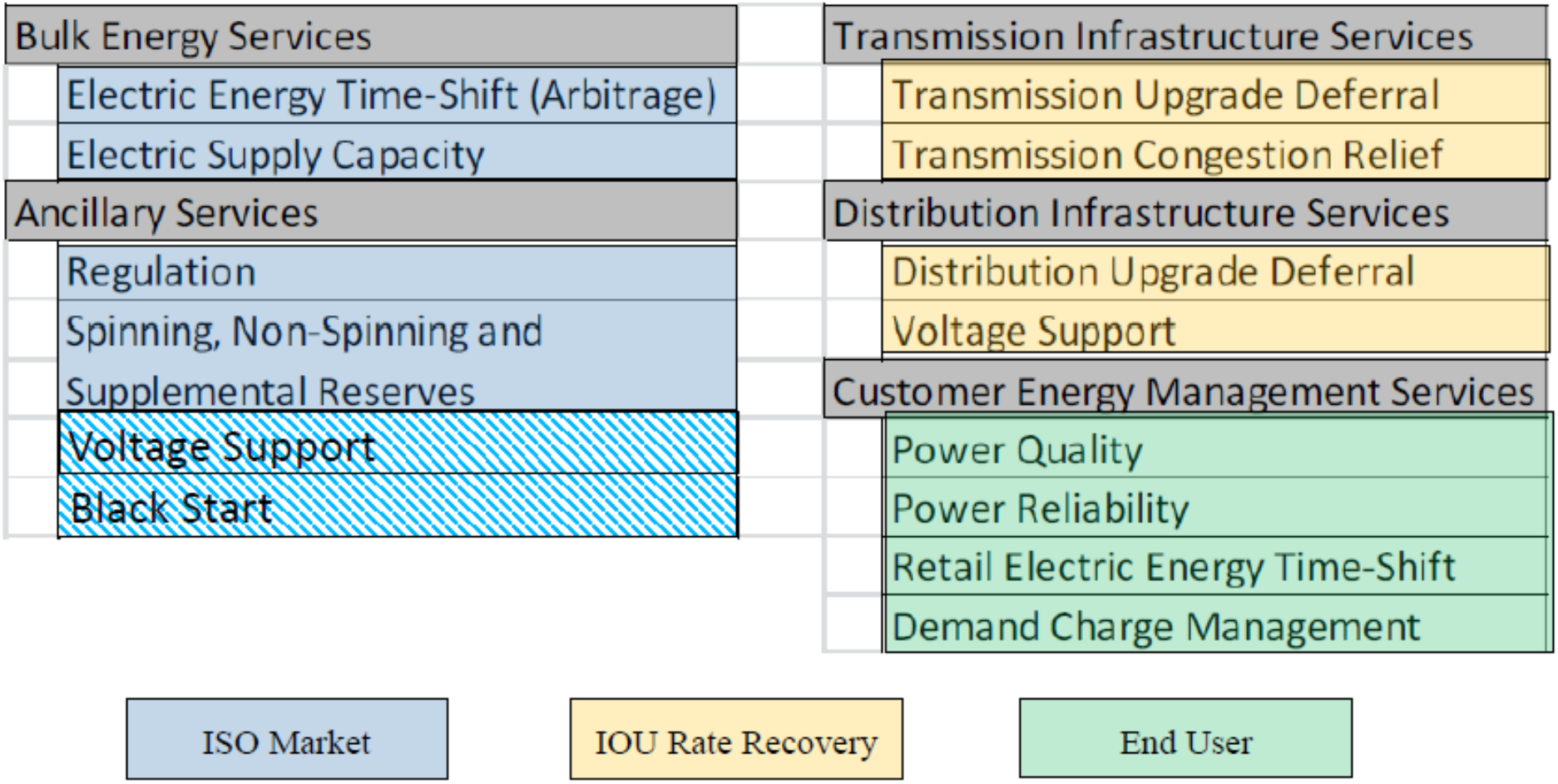
Numerous Applications on the Grid



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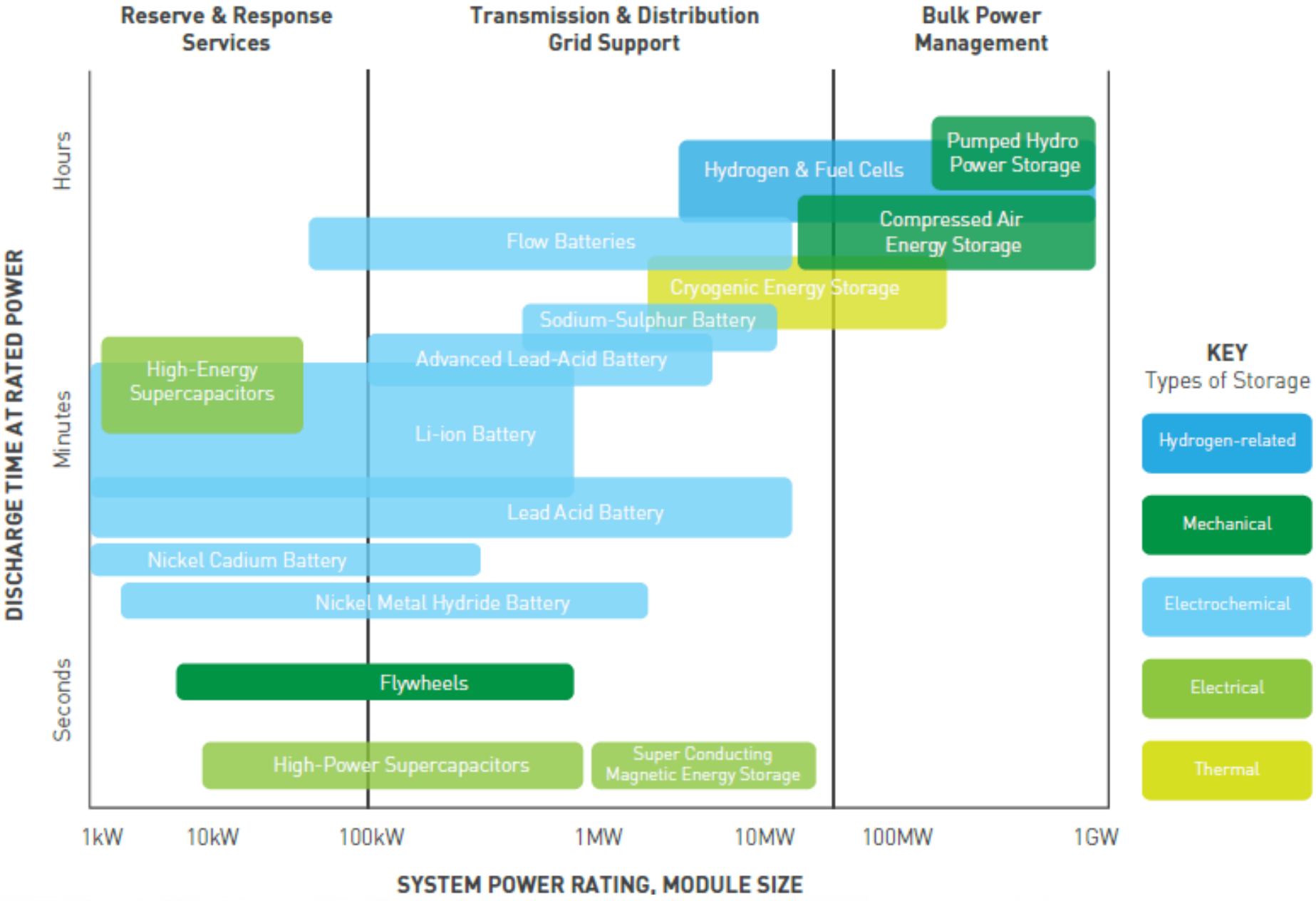
Technologies



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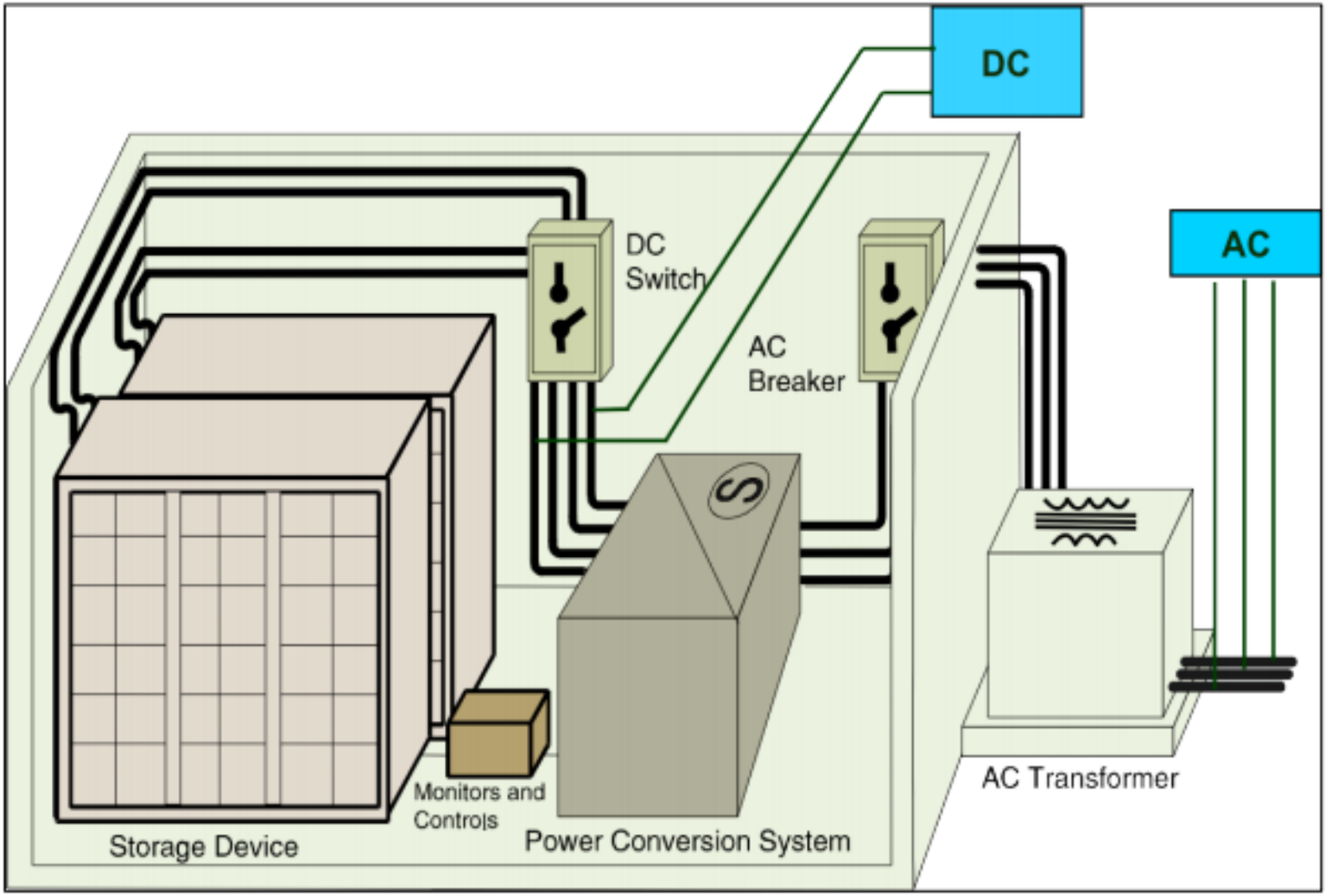


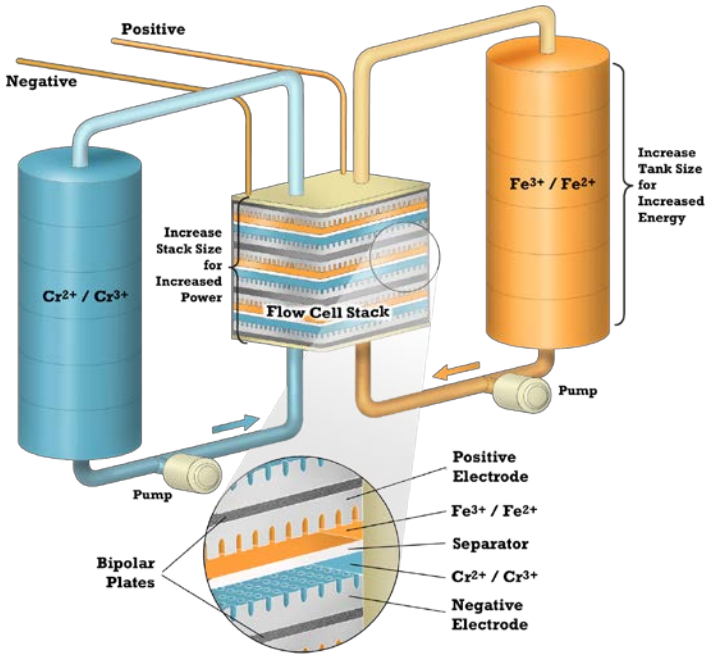
Figure 1. Schematic of a Battery Energy Storage System

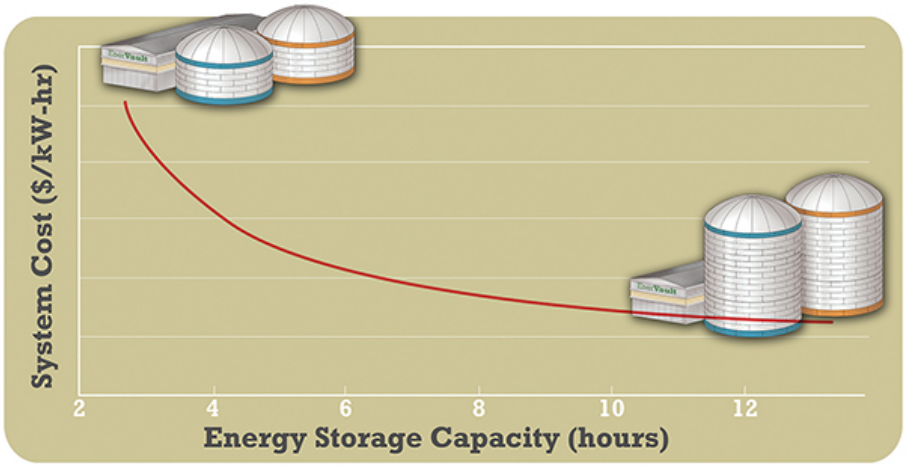
(Source: Sandia National Laboratories)

Redox Flow Batteries

Energy stored is decoupled from power delivery

- system energy storage capacity independent from system power capacity
- normalized system cost curve matches the storage value curve





- limited electrical & thermal hazard
- high life cycle sustainability
- configuration optimized to project
- system scaling is less complex
- commercially-available components
- regional supply chain & factory assembly

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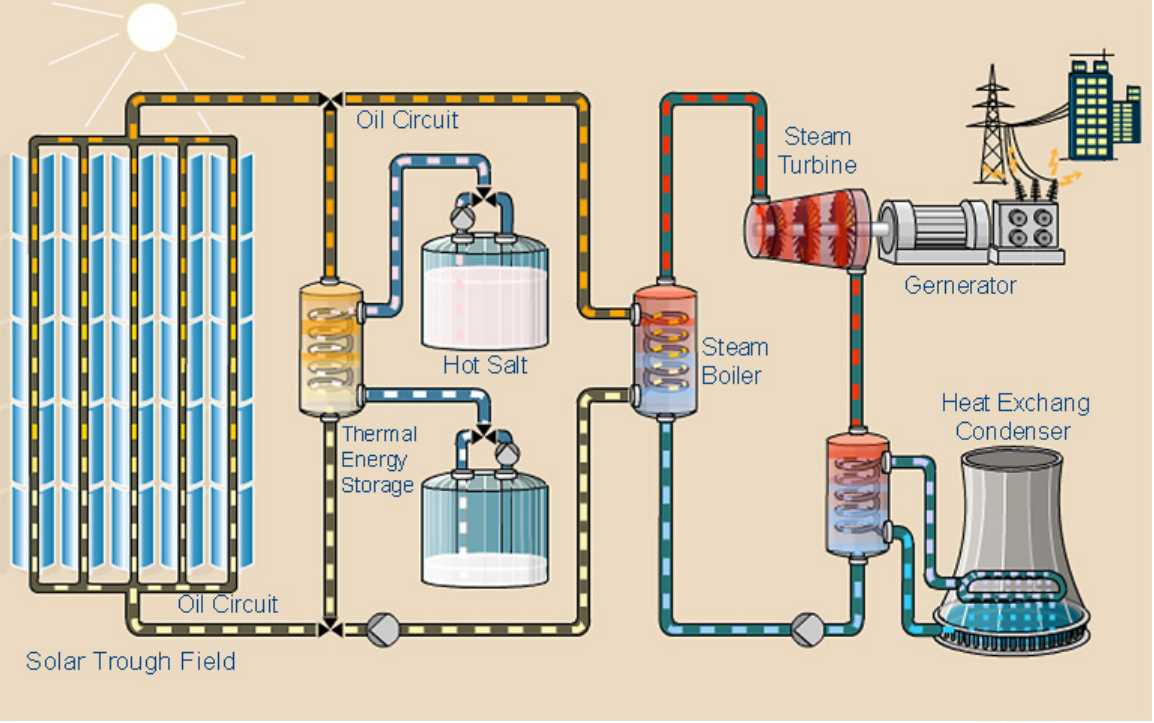

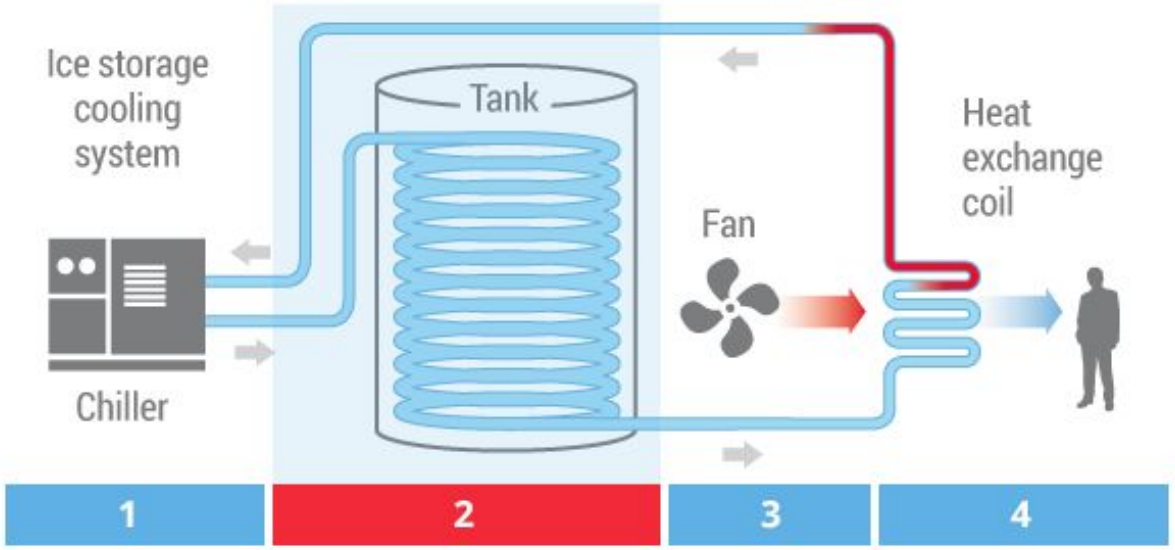

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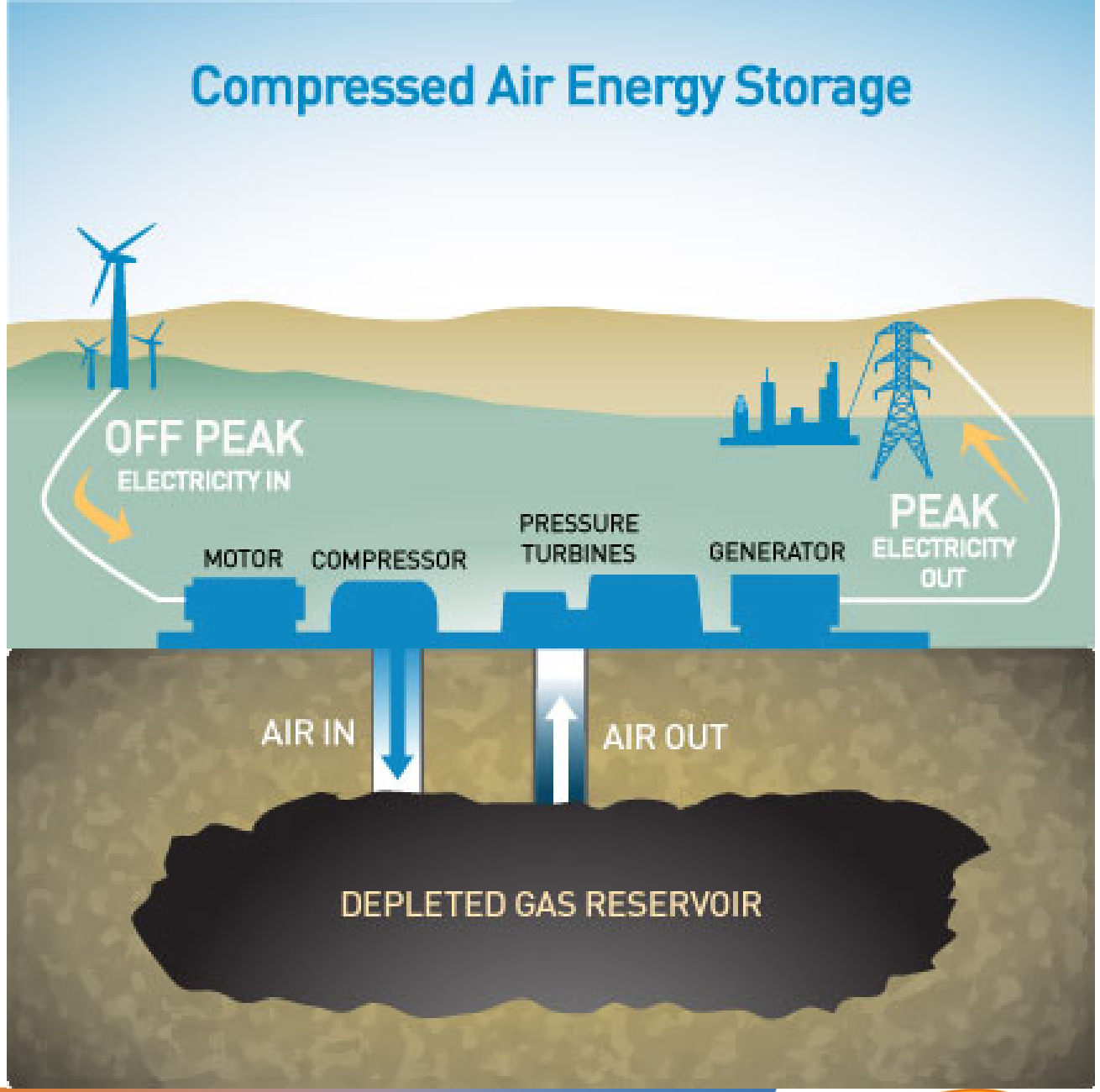
Compressed Air Energy Storage
OFF PEAK
ELECTRICITY IN
MOTOR
COMPRESSOR
PRESSURE
TURBINES
GENERATOR
PEAK
ELECTRICITY
OUT
AIR IN
AIR OUT
DEPLETED GAS RESERVOIR

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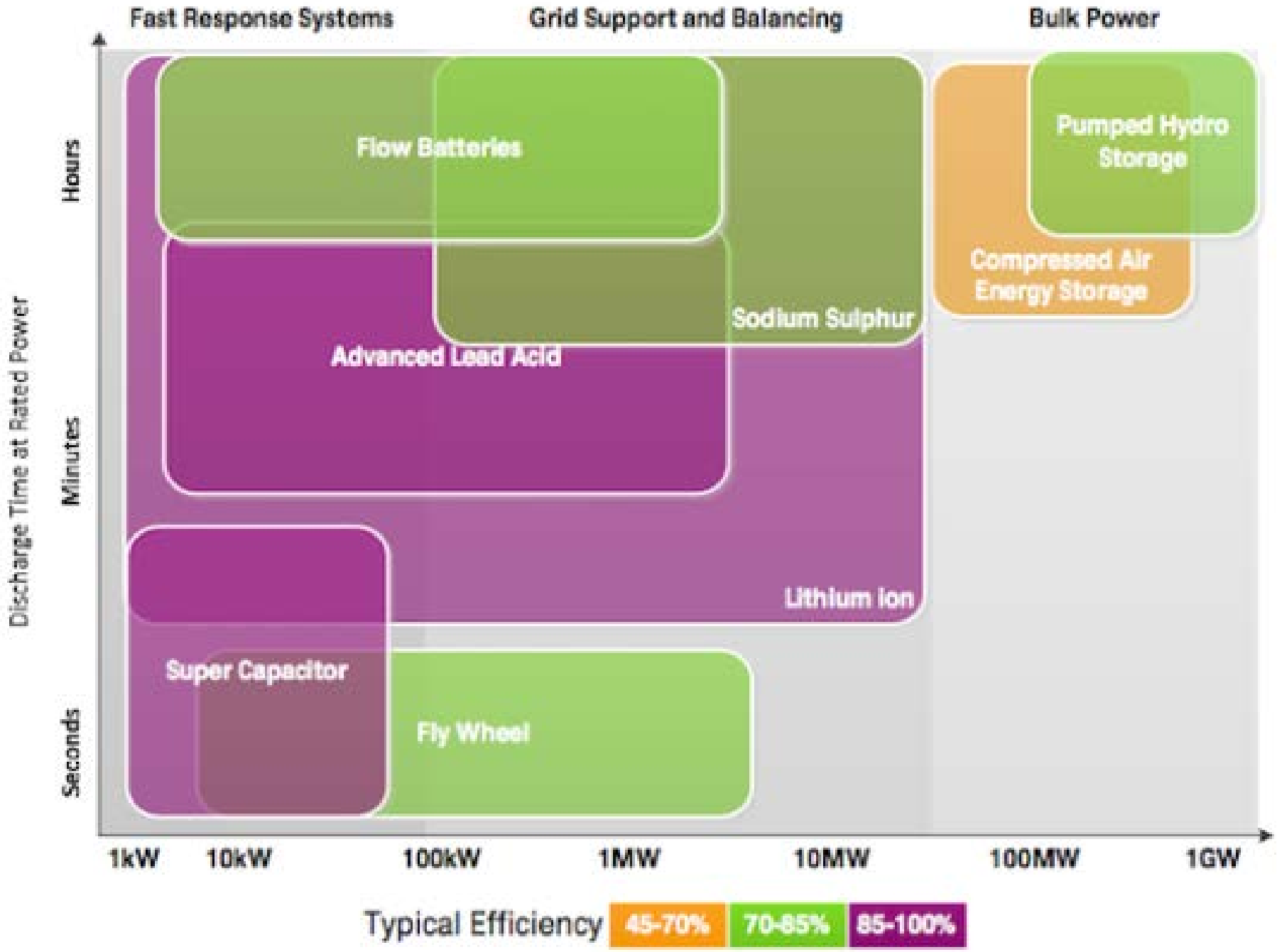
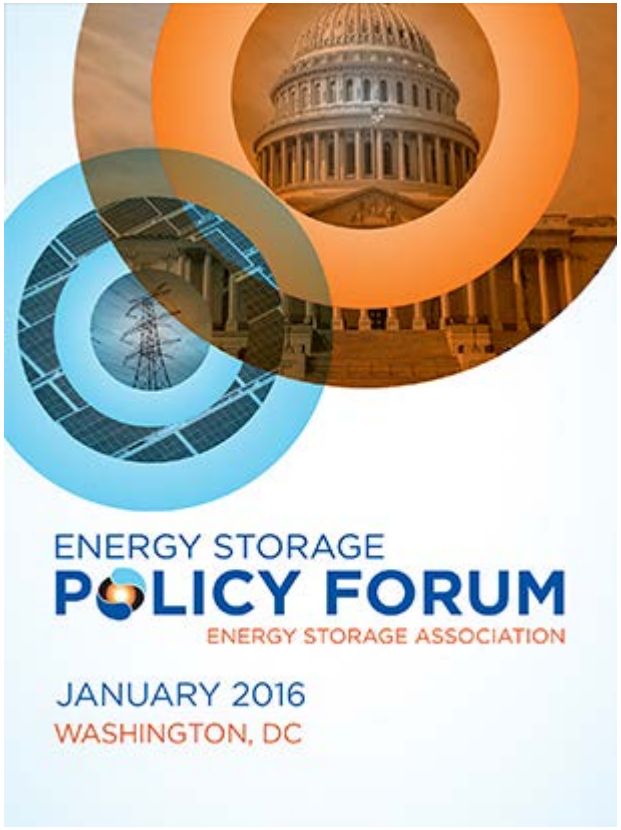
Figure 8 Electricity storage technologies comparison – discharge time vs. power capacity (MW). [5]





EnergyStorage-Events.org

The Hub for All Storage Industry Events and Resources

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Carlos Augusto Leite Brandão,
Executive Director at ABAQUE and
Owner of CAE- Energy Consulting
Company.

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Associação Brasileira de Armazenamento
e Qualidade de Energia

Energy Storage in the Americas: Challenges in the US and Brazilian Markets (August 27,2015)

ABAQUE
Associação Brasileira de Armazenamento e Qualidade de Energia

by

ABAQUE

ESA Energy Storage Association

Memorandum of Understanding (MOU)
Between
Brazilian Energy Storage and Power Quality Association
and
the Energy Storage Association

Summary

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OBJECTIVE

- To start-up a proactive process of Energy Storage in Brazilian Market, considering:
  - The impacts in Transmission and Distribution.
  - The impacts in transports.
  - Front of the meter and behind the meter technologies and uses.

INDEX

- Basic Motivations for Storage in Brazil.
- Uses and Applications in Brazil.
- Challenges for deployment of technologies and commercial acceptance.
- Proposals for R&D projects.

Highlights

- Brazil has the first pumped hydro in the World: Pedreiras, dated 1939, operated by EMAE.

- Universities in Brazil with PhD programs related to storage.

- DOE:
  - 1 278 projects in the world
  - 185.278 MW

Basic Motivations for Storage in Brazil

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Needs of System

- Brazilian Grid needs peak shaving solutions, spinning reserve, frequency control, among others.
- Supply remote villages using solar and storage. Deferral of new investments in Distribution and Transmission lines.
- Introduction in large scale of intermittent generation (about 20% to 25%) by year 2023.
- Electric transportation will introduce a concept of mobile load in large scale.
- Distributed generation, renewables boom and Storage technologies will be the next drivers for Electricity in Brazil

Brazilian Strenghts

- Large market for any kind of storage. Generation about 133 GW.
- Very good technical background for Pumped Hydro and a very detailed inventory. About 90's a study of CESP/ELETROBRAS indicated a pumped hydro potential about 250GW.
- PV generation projects deploying very fast.
- Brazil has all conditions to deploy a large market and to export technology. South America has more than 60% of Li reserves of the world. Brazil could develop a Supply chain related to Storage Systems.
- A very strong Regulatory expertise by ANEEL to introduce a Regulatory Framework for Storage.
  - RN 482
  - RN 517
  - Decree 8.461 (June 2, 2015)

Uses and Applications in Brazil by Technology Type

Based on DOE Report Dec.2013 ✓(Yes) X (No) ⊙(not conclusive)

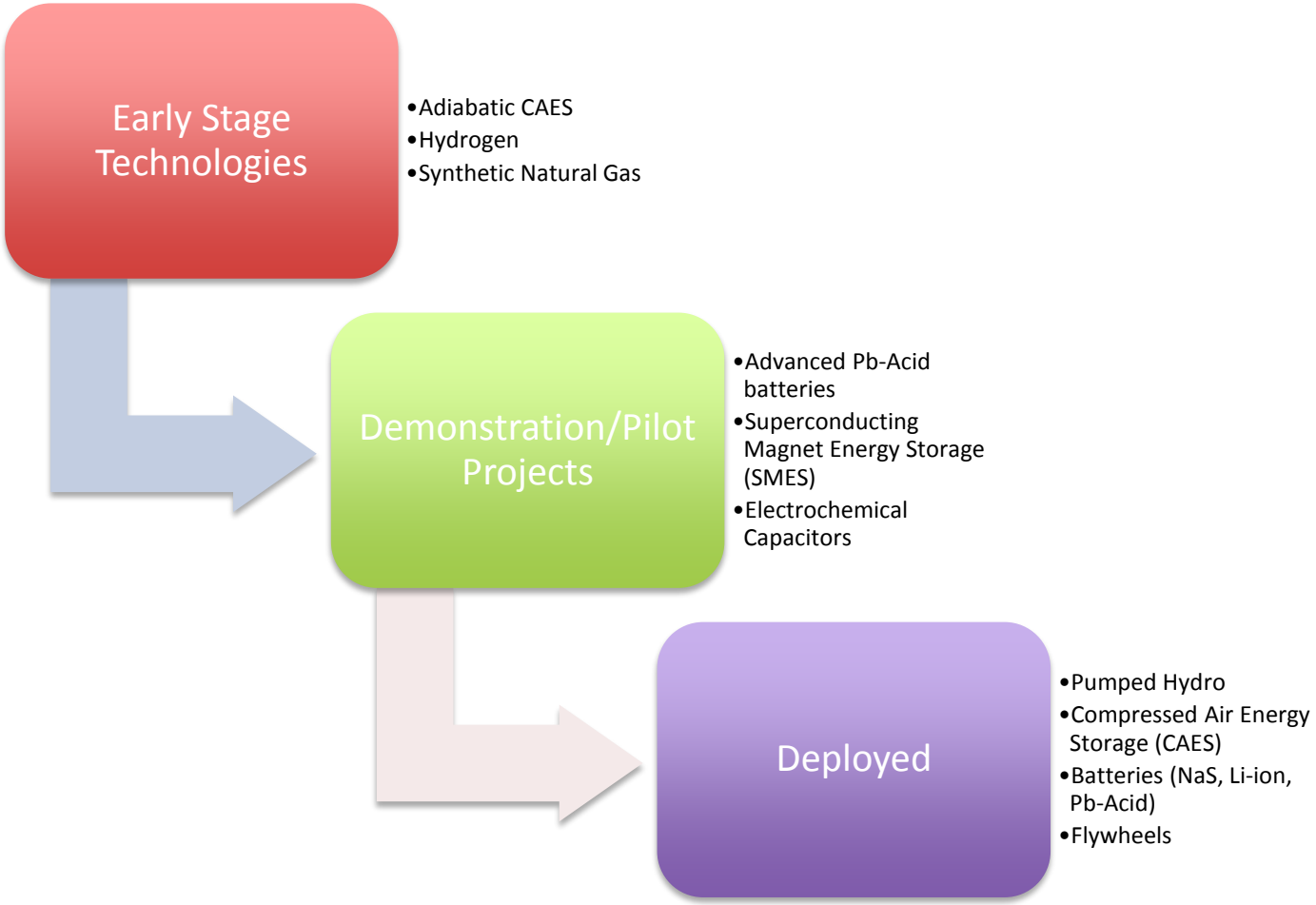
Application	Description	CAES	Pumped	Flywheels	Lead-Acid	NaS	Li-ion	Flow Bat.
Off-to-on peak intermittent Shifting and firming	Charge at the site of off peak renewable and/or intermittent energy generation. Discharge energy into the grid during on peak periods.	⊙	⊙	X	✓	✓	✓	✓
On-peak intermittent energy smoothing/shaping	Charge/Discharge sec. to min. to smooth intermittent generation and/or to charge	X	⊙	⊙	✓	✓	✓	✓
Ancillary service provision	Provide ancillary service capacity in day ahead markets and respond to ISO signaling in real time	⊙	⊙	⊙	⊙	⊙	⊙	⊙
Black start provision	Unit sits fully charged, discharging when black start capability is required	⊙	⊙	X	✓	✓	✓	✓
Transmission/ Distribution Investment	Use an energy storage device to defer upgrades in transmission and Distribution as well to Voltage Support Services.	X	X	X	✓	✓	✓	✓
Transportable distribution-level outage mitigation	Use a transportable storage unit to provide supplemental power to end users during outages due to short term distribution overload situations	X	X	X	⊙	✓	✓	✓
Peak load shifting downstream of distribution system	Charge device during off peak downstream of the distribution system (below secondary transformer); discharge during 2-4 hour daily peek	X	X	X	✓	✓	✓	✓
Intermittent distributed generation integration	Charge/Discharge device to balance local energy use with generation. Sited between the distributed and generation and distribution grid to defer otherwise necessary distribution infrastructure upgrades	X	X	X	✓	⊙	⊙	⊙
End-user time- of-use rate optimization	Charge device when retail prices are low and discharge when prices are high (Arbitrage)	⊙	⊙	X	⊙	⊙	⊙	⊙
Uninterruptible power supply	End user deploys energy storage to improve power quality and /or provide back up power during outages	X	X	⊙	✓	✓	✓	✓
Micro grid formation	Energy storage is deployed in conjunction with other technologies to create an islanded micro-grid	X	X	X	✓	✓	✓	✓
Supply Remote Villages (Amazon Region) instead of oil thermal generators	Using PV + Storage.	X	X	X	✓	✓	✓	✓

Challenges for Storage in Brazil

Cost Competitive	**Development of Integration Technology to T&D Systems in Regulatory Procedures.** **Promote all the "storage technology Industrial Chain" in order to have a nationalization process in long-term.** **Debt financing of commercial energy projects.**
Cost Benefit Analyses for each technology	Validation of performance, reliability, performance, efficiency, etc. Track, document and measurement of benefits of installed systems.
Regulatory Framework	Collaborative public-private sector characterization and evaluation of grid benefit storage and hot to monetize grid services provided by storage. Development of procedures and standards of industry and regulatory agency ANEEL for siting, grid integration, procurement and performance evaluation.
Reliability and Safety	Development of procedures for all applications and technologies, specially those to supply energy to remote villages.

Technology performance and benefits track records for market acceptance	Development of Data Base with information and dissemination of costs, guarantees and applications. R&D Strategic Programs to demonstrate storage applications and technologies.
Technical Standards Deployment	Strategic program related to all institutions related to standards and procedures, as ONS, ABNT and others.
Innovation and R&D programs in Brazil	Identification and development of support mechanisms for Fundamental and Applied research existing in Universities. To promote R&D demonstrations on site technologies. Evaluation on how variable speed pumped storage can provide ancillary services and add to system flexibility.
Brazilian Industry Supply Chain	Incentives to the whole chain in engineering, construction and services.

Proposal for R&D Strategic Projects in Brazil



Proposal for R&D Projects in Brazil

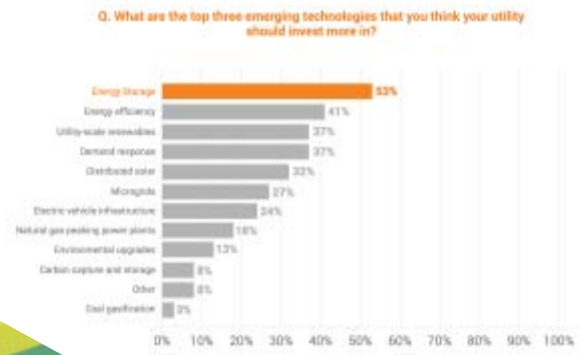
- Replacement of Oil Generators in medium voltage electric energy time-shift (arbitrage); investment deferral for T&D, voltage support, etc. From 1 to 20 MW from 13.8KV to 138 KV.
- 150 KW to 300 KW, stand alone units to provide reliability and to improve customers own utilization of electricity (customer side of meter storage).
- Storage facilities from 1 MW to 40 MW (13.8 KV- 138 KV) in conjunction with local facilities to crate an islanded micro-grid.
- The same kind of storage facilities with PV facilities to supply villages and small cities in remote areas instead of oil thermal generators.
- Storage facilities from 10 MW and up for load following/ramp support for renewables.
- Pumped hydro projects using existing facilities in many large hydro power plants.
- Pumped hydro projects based on the inventory of Small Hydro Power Plants under analyses of Aneel.
- Other projects that can use more than one technology at the same time, together.

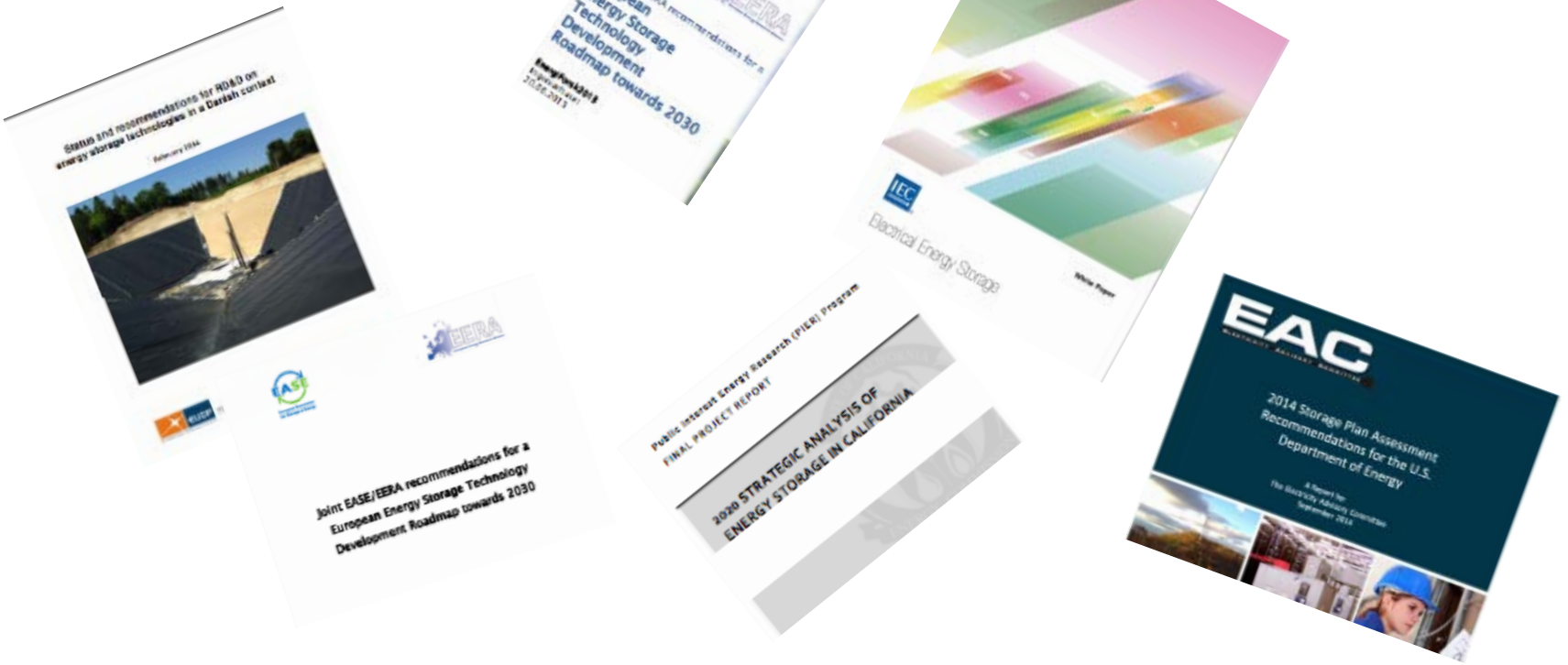
Results from R&D projects

- To consolidate Storage Technologies in Brazil and to support actual developments, mainly in Universities.
- To develop a regulatory framework for storage applications with a clear understanding of benefits and cost-benefit analysis methodology.
- To ensure track records for Brazilian Industry.
- To deploy standardization process for all products and services involved with storage.
- To revitalize hydro technologies using pumped hydro projects.
- To propose a very pro-active movement towards modernization of T&D Infrastructure.

Final Remarks

- Storage is considered the 1st one to invest.
  - Utility Dive 2015 State of Electric Utilities Survey Results
- R&D programs under way in all the world.
  - Deployment of different technologies.
- It applies:
  - Captive Market
  - -Free Market





Thank you

- *Chair of the Board:*
  - *Jim Hart*
- *Executive Director:*
  - *Carlos Augusto Leite Brandão*
- *Technical Director:*
  - *José Augusto Pimentel.*
- *Institutional Director:*
  - *Angela Jabur*

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Energy Storage Systems In the Americas: Challenges in the US and Brasilian Markets

National System Operator
27th, August

Speaker: Francisco Arteiro

- International evidence highlights that power system transformation is already occuring and is accelerating

- Power system transformation can assist in achieving the public policy goal of a clean, affordable, reliable and resilient power system

- Power systems are fueled by various distinct forces, each powerful in its own right, including:
    - Technology cost reduction
    - Responses to climate change and local pollution
    - Convergence with information tecnologies
    - Changing customer preferences, and
    - Energy security/resilient strategies

Measuring the power system transformation 2014-2019

(1) Biomass power generation

Type	2014		2019		Trends 2014-2019	
	MW	%	MW	%	MW	%
Hydro	94.375	73,7	113.086	68,0	18.711	19,8
Nuclear	1.990	1,6	3.395	2,0	1.405	70,6
Gas / LNG	11.625	9,1	15.477	9,3	3.852	33,1
Carbon	3.210	2,5	3.550	2,1	340	10,6
Biomass	6.428	5,0	7.969	4,8	1.541	24,0
Others (1)	1.021	0,8	1.649	1,0	628	61,5
Oil / Diesel	4.628	3,6	4.731	2,8	103	2,2
Eolic	4.759	3,7	15.567	9,4	10.808	227,1
Solar	8	0,0	898	0,5	890	-
Total	**128.044**	**100,0**	**166.322**	**100,0**	**38.853**	**30,0**

- Following the international trend, The Brazilian System in undergoing a transformation and transient process. Hydropower will continue as the main energy resource until 2019, despite the fact of a fall in its prominence, from 74%, to roughly 68% in 2019.
- The majority of new hydropower will be “run of the river plants”
- The system will gradually lose its regulation capacity and therefore become more dependent on complementary sources, especially during the dry period.

Transmission System Vision

In the past:

- **Transmission network planning took into account:**
  Customer load growth, generation growth, and overall reliability consideration

- **Planning** has been traditionally restricted to within established single-utility balancing áreas.

In Transforming The Power System:

- **Transmission Technology:** Voltage Source Converter – VSC, Modular Multi-level Converter (MMC)

- **Energy storage solutions:**
  - Provides sufficient grid flexibility to accomodate higher penetration levels of intermittent sources of electricity

- **In planning sphere:**

  - Transmission-connected bulk energy storage
  - Distribution connected energy storage located at a utility substation

- **In operation sphere:** providing ancillary services, expansion of the balancing areas,

Barriers

Economic issue: Technology Costs

Regulatory issue: The value for providing energy, regulation, spinning reserve, and other services that change from hour to hour, creating challenges to economic benefits.

- In transforming power system:

- Energy storage solutions providing sufficient grid flexibility to accomodate higher penetration levels of intermittent sources of electricity

- In planning sphere:

- Transmission-connected bulk energy storage
- Distribution connected energy storage located at a utility substation

-In operation sphere: Providing ancillary services, technology permits the customer to become an active agent

Final Messages

Framework for the expected medium/long term:

- Evidence from around the world highlights that power system transformation is already happening

- Power system transformation can help to achieve the public policy goal of clean, affordable, reliable and resilient power systems

- Power system transformation is fueled by various distinct forces, each powerful in its own right, including: technology cost reductions, response to climate change, convergence with information Technologies, changing customers preferences, and national fiscal and energy security and resilient strategies.

Thank you!

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Questions?

Energy Storage Association

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