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Electric Power Research Institute's Distributed Generation and Energy Storage Program

Ongoing Efforts to Increase Renewables Penetration

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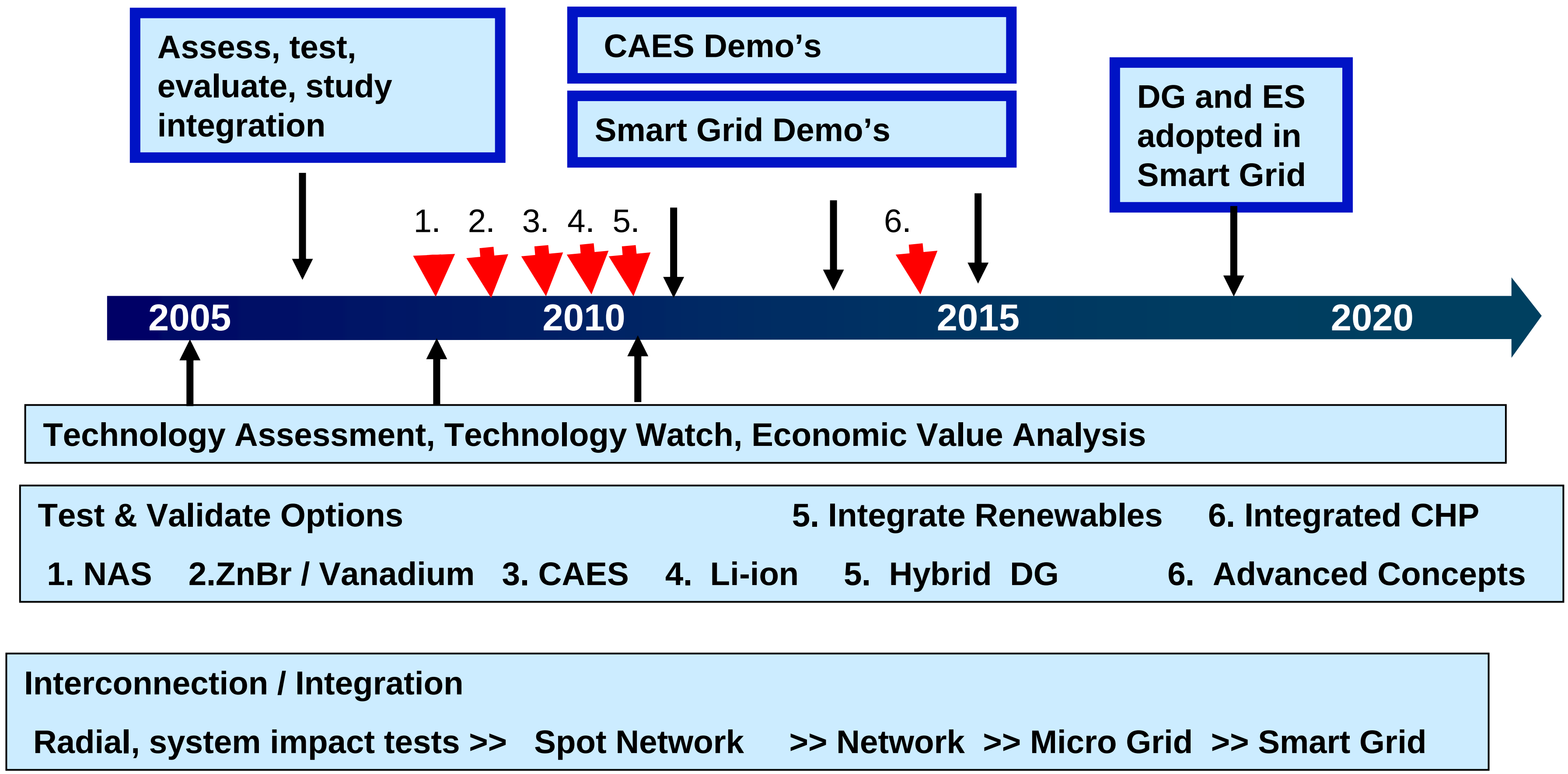
Agenda

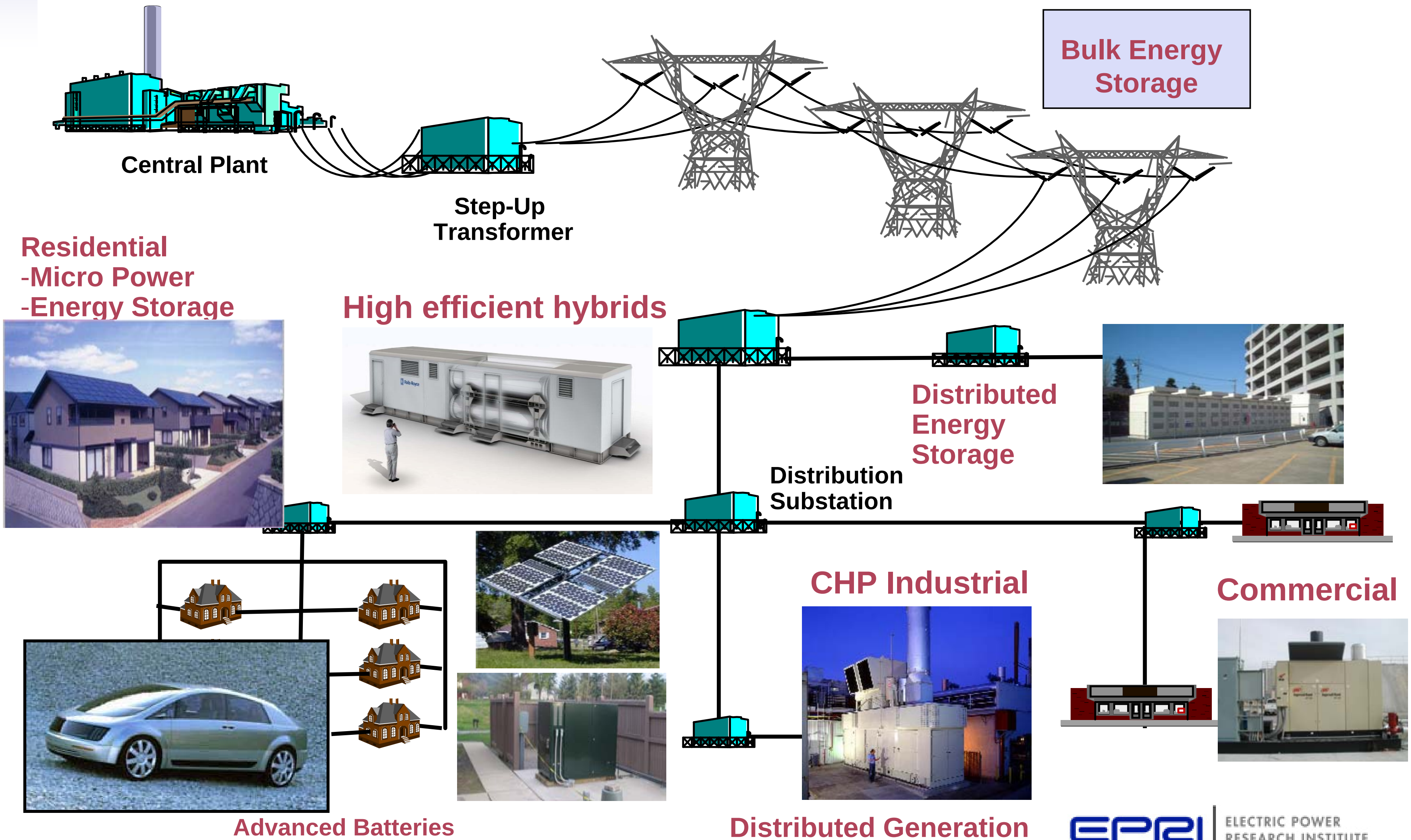
- Energy Storage and Distributed Generation
  - Roadmap
  - Program
- Distributed Energy Storage for Grid Support
- Projects to Assess Opportunities for Distributed PV and Wind Energy within DG and ES Program

Energy Storage and DG Program Roadmap



EPRI's Energy storage (ES) and Distributed Generation (DG) Program

Assets which Enhance the Value of a "Green Smart Grid"



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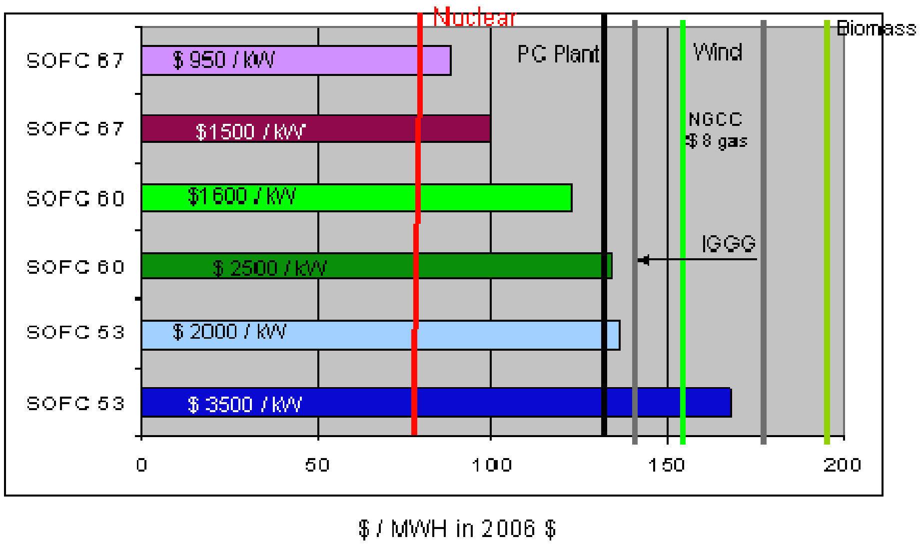
What is New in Distributed Generation?

Ultra-high efficient systems may be emerging within a few years

- Rolls Royce Developing 1 MW (60% eff.) Solid Oxide Fuel Cell Hybrid
- 1st Field Demonstration Unit planned at AEP in 2009.

Relative Cost of Delivered Electricity of Rolls Royce SOFC System vs. Bulk Power Options
Natural gas $ 10/MMBtu, Capital Carrying Chare 15%; 8 cents for delivery



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Examples of Fossil Fueled Distributed Generation that can be integrated with Energy Storage Systems

Applications in Industrial, Commercial, Residential

1 MW Backup Generator

Natural Gas Generators in CHP Application

Stirling Engine in Renewable Fuel Application

240 kW Micro-turbines / 100 T chiller

4 MW CT at Hospital site

1 kW micro-CHP system for homes

Distributed Energy Storage Systems Gaining Market Adoption for Grid Support Applications

– Adoption with Renewables being assessed

6MW / 48MWh at TEPCO's Ohito Substation

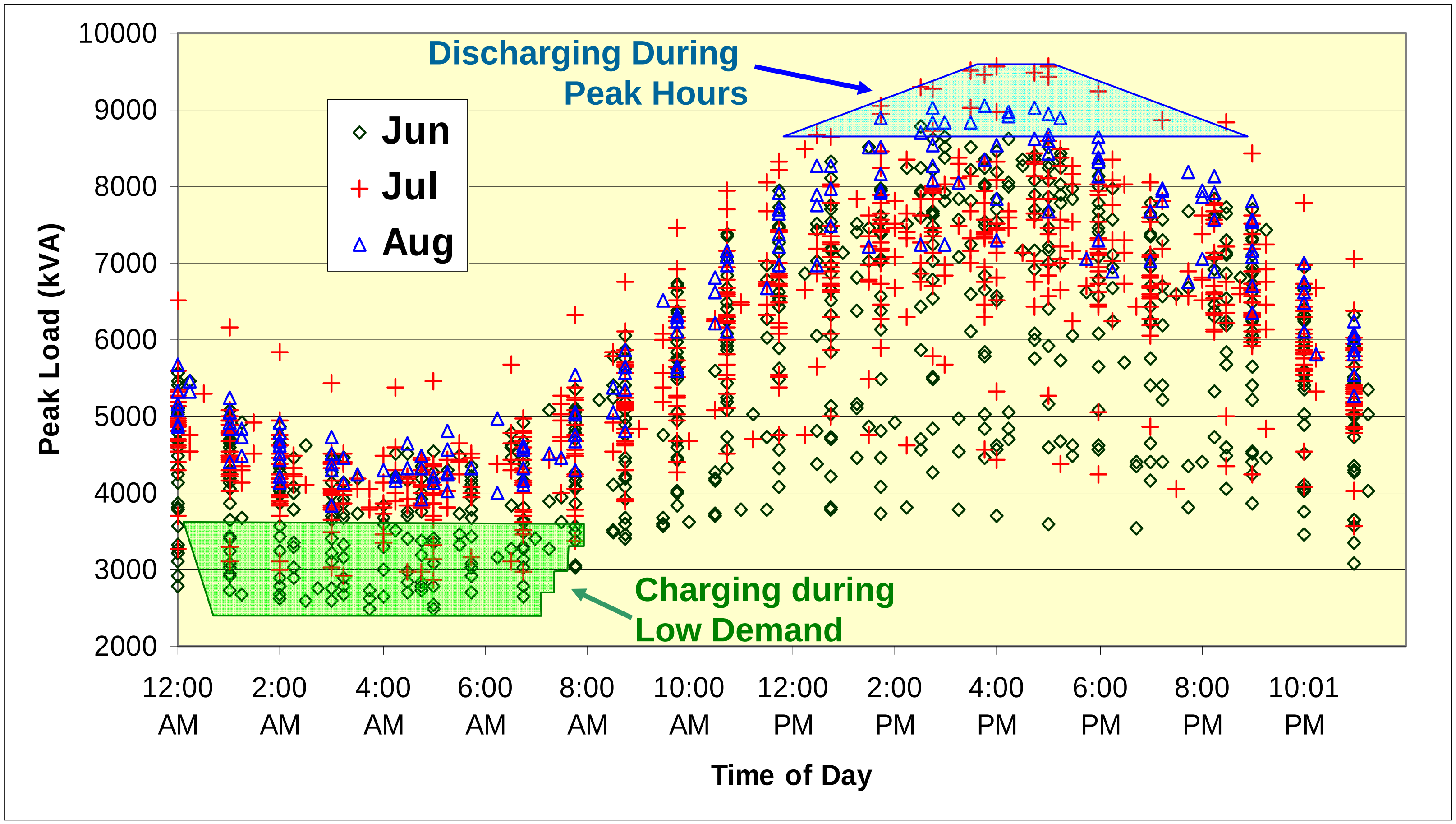
1 MW / 7.2 MWh   NYPA – End-User Peak Shaving

1 MW / 7.2 MWh NAS

AEP Substation

AEP Peak Shaving – W. Washington Feeder

source AEP



One Profile may Fit All Summer Peak Days

Demonstration of 1 MW / 7.2 MWh NAS Battery Case Study

Objectives:

- Demonstrate ability of the NAS Battery to achieve commercial success:
  - Cost savings & benefits to customer
  - Document Case Study and Lessons Learned
- Monitor and Assess Testing in 2008

Approach

- Participate with NYPA in demonstration
- Monitor and report on results

Questions Research Results will answer

- Performance and reliability of NAS system in a customer peak shaving application

Test and Evaluation of Advanced Battery Systems

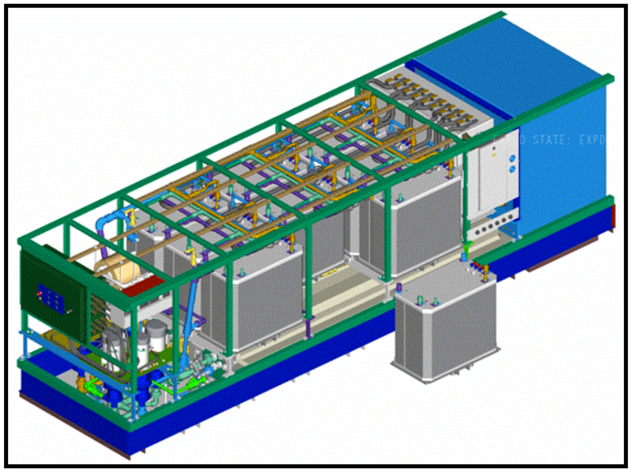
Approach:

- Conduct Case Study of Altair Nano 1 MW Li-ion System planned for test with AES
- Conduct Case Study Tests of Premium Power ZnBr System
- Assess performance for renewables integration and regulation (for which the market is expanding with increased renewables on the grid)

Research Results will answer:

- Performance and viability of new energy storage systems
- How to optimize for regulation and integration with wind energy systems

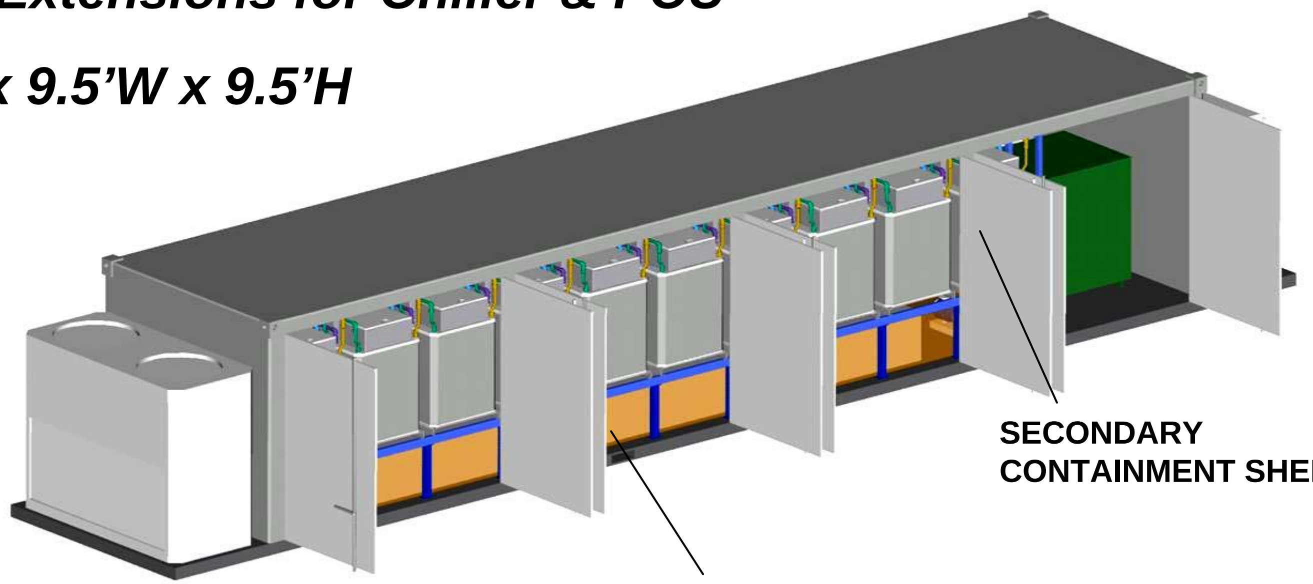
Altairnano 50Ah Pack



Premium Power PowerBlock 150

Transportable ZnBr System for Grid Support - Candidate Technology for Wind Integration

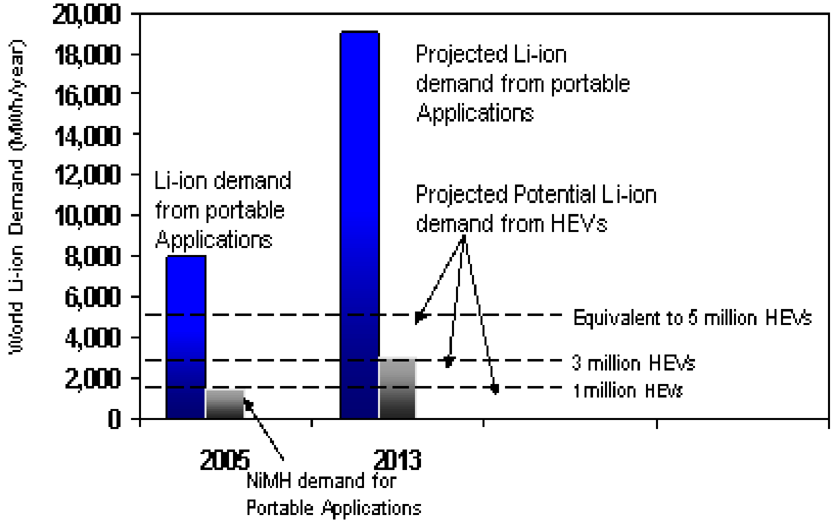
- ***1/2 MW Power / 2 MWh Energy***
- ***Portable & Off-loadable Freight Container***
- ***Integrated Extensions for Chiller & PCU***
- ***Size: 40'L x 9.5'W x 9.5'H***

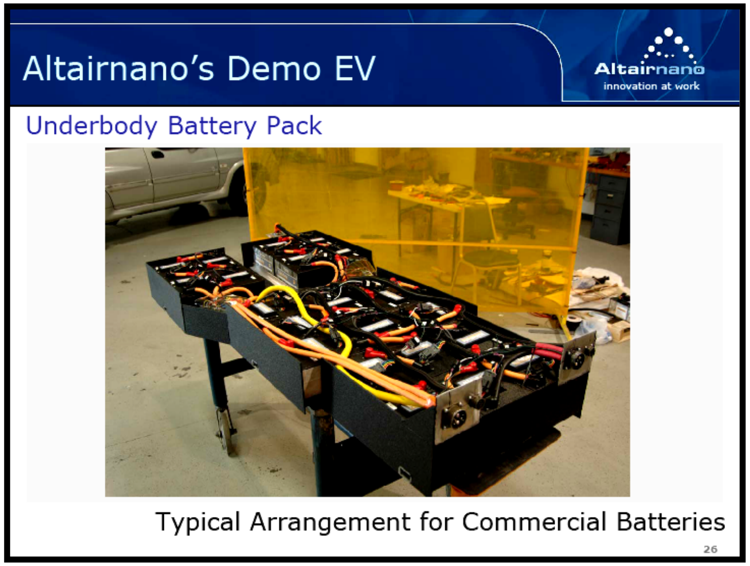


EPRI Developing Field Demonstration Initiative

Emerging Li-Ion Batteries May Play a Significant Role in Distributed Energy Storage

Li-Ion technology -- the technology of choice for the transportation sector -- can reduce the cost for stationary applications





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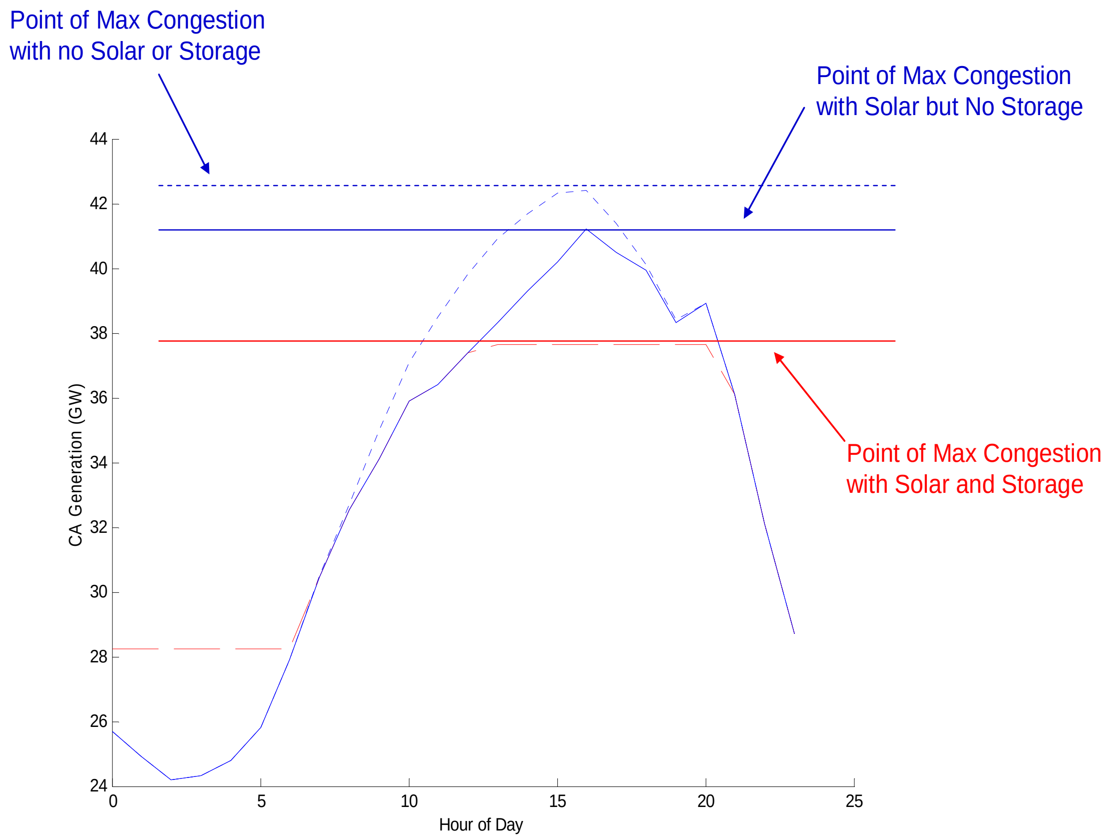
Solar PV and Storage Benefits to Infrastructure from Utility Perspective



- **The benefits of solar alone is limited because the peak of solar generation does not coincide with the peak demand.**
- **If storage is added, the benefit is enhanced significantly**
- **Energy storage can be <u>dispatchable</u> such that the utility can rely on it.**

Estimates of Value of Distributed Energy Storage to California in Combination with Solar Photovoltaics

The combination of distributed energy storage with solar creates two benefits:

- Complementary peak-shaving (solar shaves the first half of the peak and the storage the second half).
- Reduction of installation and balance of system costs, *primarily through a combined inverter*.

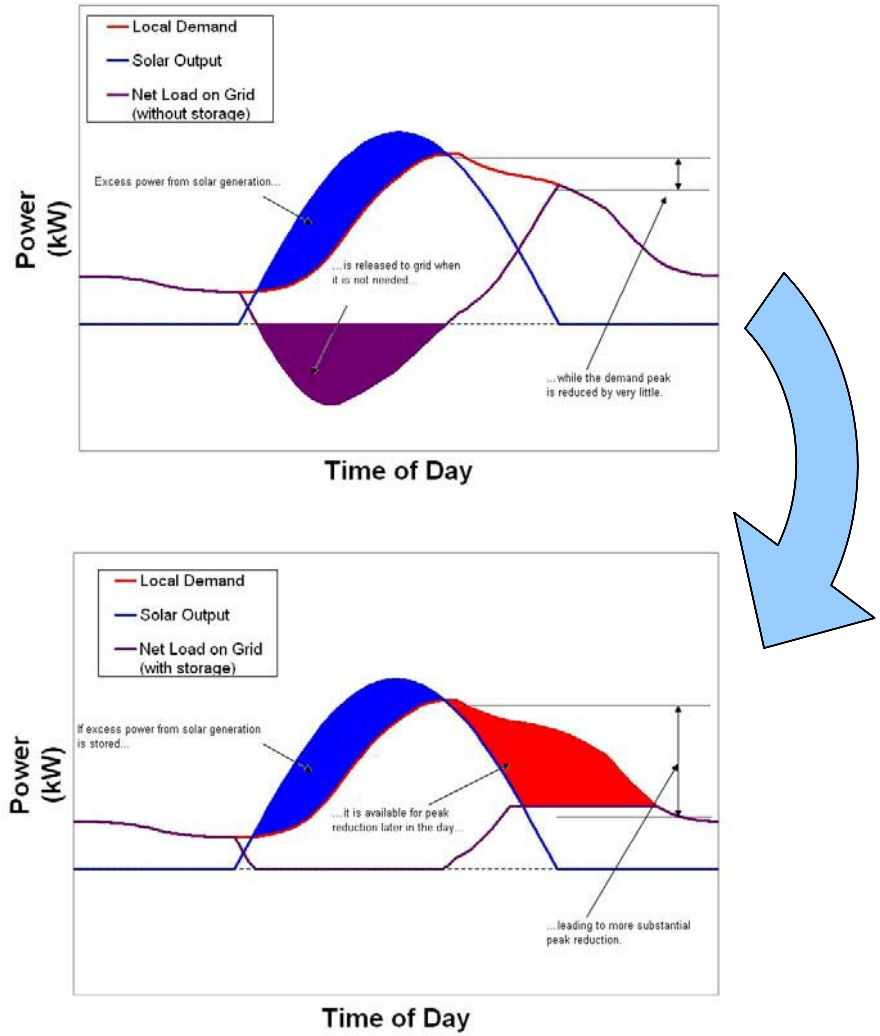
Preliminary analysis estimates the benefit of energy storage around $170 / kWh for residential applications and $230 / kWh for commercial applications. Based on estimated performance for the California solar market, the total societal benefit of combining 5 kWh of energy storage with each kW solar is roughly $2.8 billion dollars as shown in the table below:

Sector	Solar Market Funding	Estimated PV Market	Estimated Societal Value of Storage	Estimated Societal Benefit of 5 kWh Storage per kW Solar
Total	$ 2.9 billion	3,000 MW	-	$ 2.85 billion
Retrofit Residential	$ 1.75 billion	1,810 MW	$ 172 / kWh	$ 1.55 billion
Commercial	$ 750 million	776 MW	$ 234 / kWh	$ 940 million
New Residential	$ 400 million	414 MW	$ 172 / kWh	$ 355 million

Energy Storage Solutions to Enable PV and Support Customer Peak Load Shifting

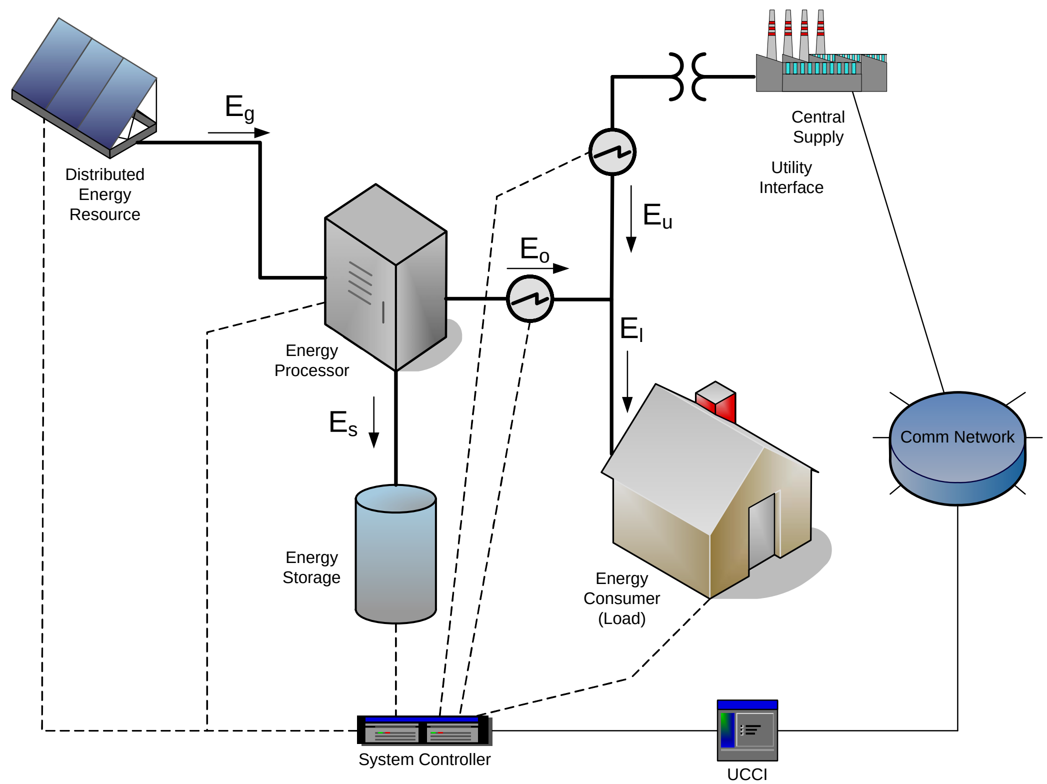
EPRI Developed Functional Spec.

- Ongoing Tests, Evaluations
- Assessments
- Test Beta unit
- Advance field demonstrations



Technical Specification for a Lithium Ion Energy Storage System for PV Support

- Initial specification:
  - 2 kW, 10 kWh battery
  - 3kW PV array
  - Integrated controller and inverter for both PV and battery
  - Communication with the utility through AMI or other communication systems



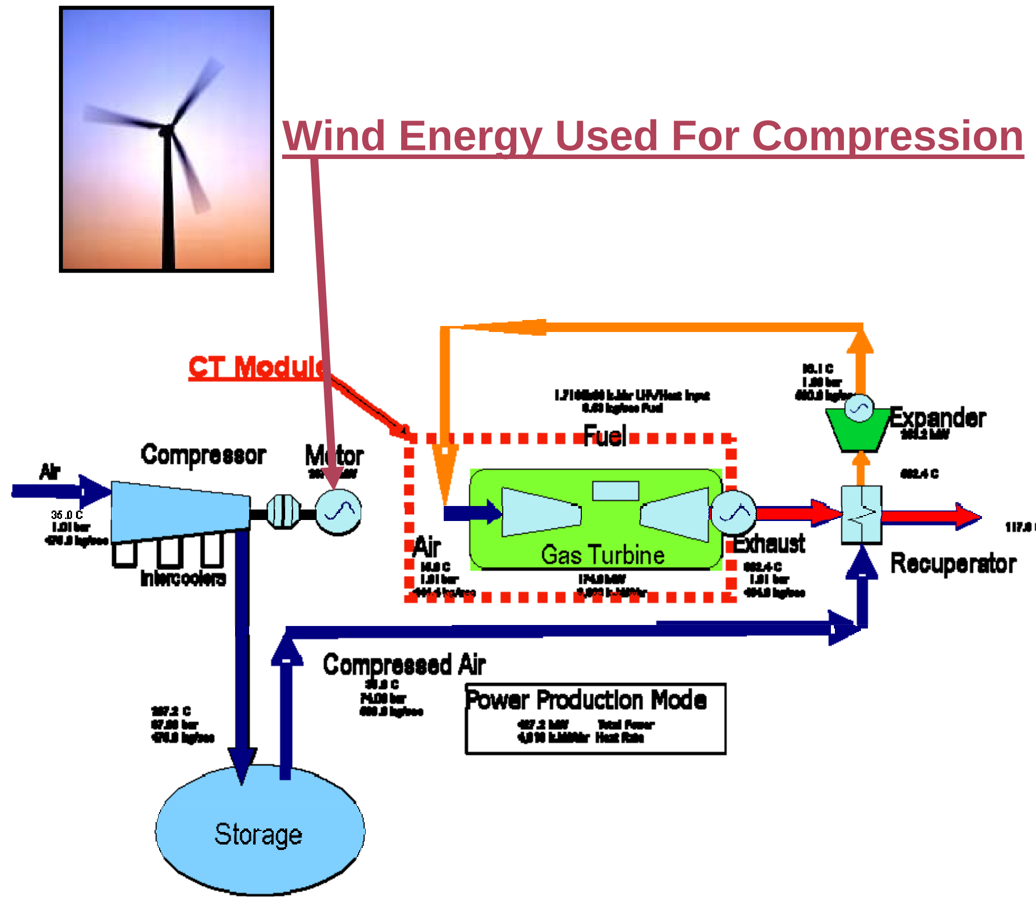
CAES System Requirements and Cycles to Support Large Wind

Objectives

- Identify CAES system design(s) to support wind resource penetration
- Opportunities for CAES to support Wind

Questions Research Results will answer

- How CAES can support / enable Wind?
- What types of CAES plants are needed to address moving off-peak wind energy to on-peak demand time periods and to mitigate wind generator fluctuating power issues
- What is the Value proposition for CAES plants to support wind resource penetration



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