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CEC IEPR Committee Workshop

Energy Storage for Renewable Integration

PANEL 2: Energy Storage Applications and Economics (Costs, Benefits and Revenue)

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Experience you can trust.

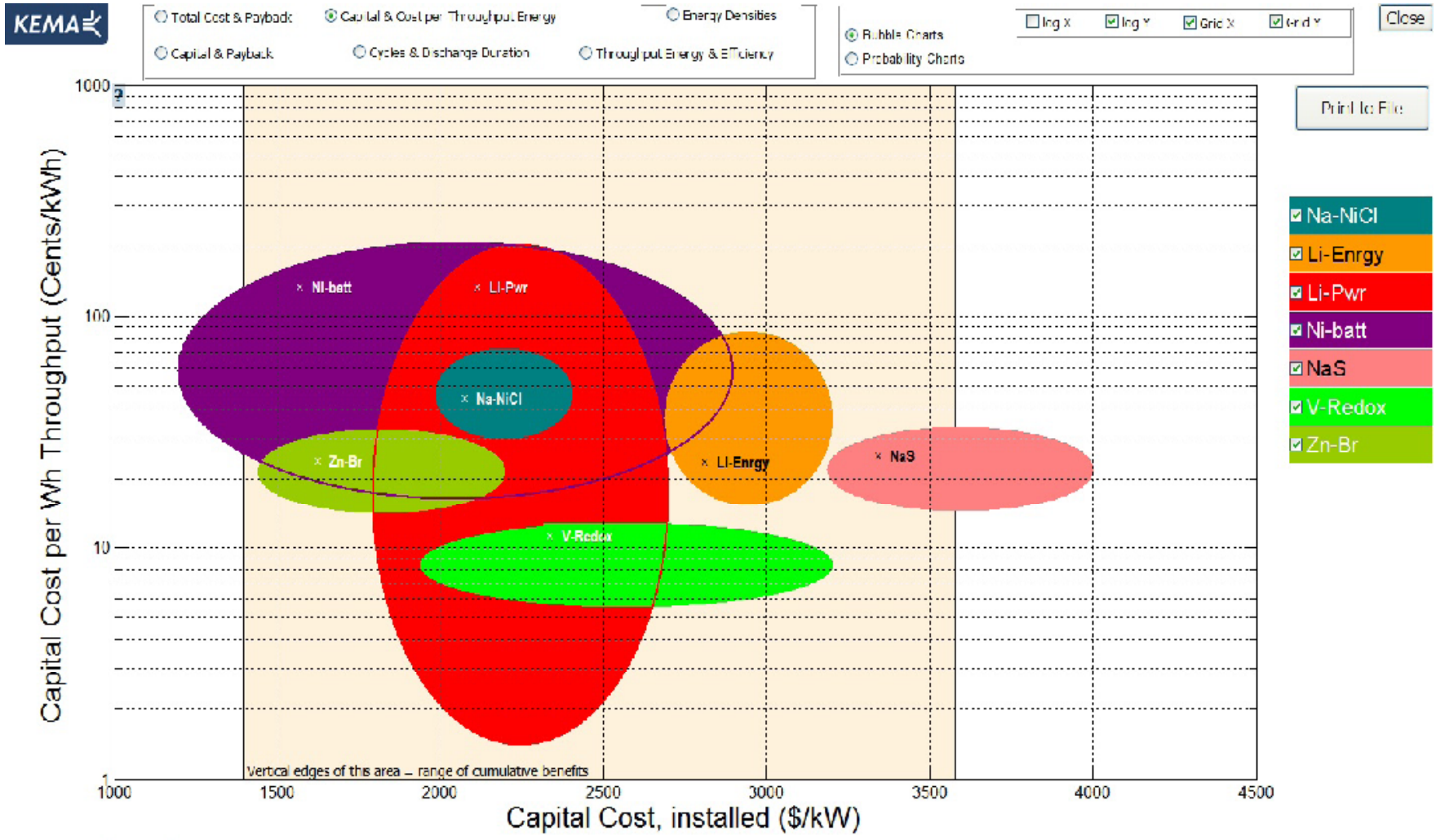
Questions for Panel 2

- What are the costs estimates for the increased use of energy storage?
- How can the benefits of energy storage best be quantified?
- What revenue mechanisms are available to ensure energy storage plays the appropriate role in the California grid of the future?
- What will be the specific economics and cost-benefit data that needs to be developed to support the implementation of the Assembly Bill 2514 Energy Storage development, demonstration, and deployment plan activities?

Energy Storage Technologies

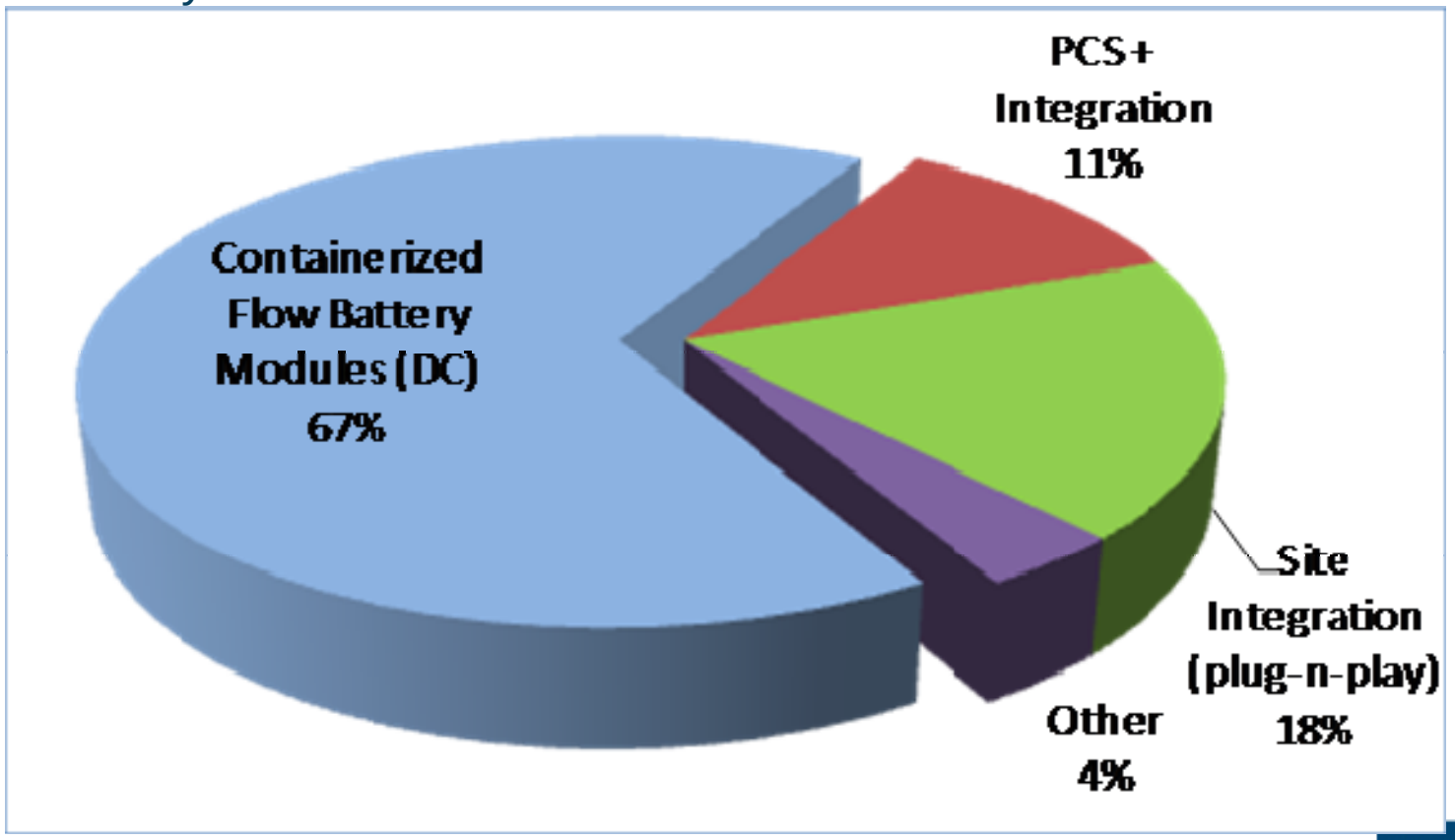
- Expect major advances in many different energy storage technologies in the next 5 years due to R&D funding
- The historical data tends to be focused on batteries and flywheels
- Cost projections are for advanced batteries – hence expect their cost to rapidly decrease in the next 5 years
- Batteries are not the only solution, but there are advantages that show we may want to consider “a portfolio of solutions”
- These modular storage devices can be planned, designed, and installed in months rather than decades
- Can provide both grid services and market based services

Cost of (Battery) Energy Storage Technology



Power Conversion System(PCS) Costs

- For PCS Cost, KEMA examined 3 recent applications that broke down individual cost of technologies
  - To Estimate PCS cost of the system, KEMA averaged the typical percentage that was dedicated PCS system and used that in our analysis



Quick Primer on Storage Technologies

Is there a "Best" Technology Today?

- Many technologies offering variety of characteristics

- **Compressed Air Energy Storage** – will be utilized for "centralized" applications
- **Above Ground CAES** → Gen II, projected as 5MW, above ground (SustainX)
- **Sodium Sulfur (NaS) battery** → Long duration, Transmission back-up, but expensive

- **Vanadium Redox Battery** – Long duration, flow battery, used for back-up applications
- **Advanced Lead Acid Batteries** – 1 to 4 hours, used for renewable integration
- **Sodium Nickel Chloride Battery –** Targeting vehicles and small backup (Telecom)
- **Li-ion – High Energy** – Used for CES, renewable integration, maybe regulation

- **Li-ion – High Power** – used for frequency regulation, renewable integration
- **Flywheels** – 15 minute, many cycles, used for frequency regulation

- Each application is finding its niche, but for one device that can serve all applications – not there yet?
  - Need fast response, 2-4 hour duration, efficiency > 90%, cost competitive
  - Generation II technologies are trying to fill 2-5 hours gap

T&D value of storage (reliability and economics)

- Peak shaving
  - extend life of transformers, etc.
- Voltage support
  - Reduce flicker and meet voltage standards
- Frequency response
  - Automatic Injection of energy when freq. < 59.92 Hz
- Grid stability
  - Sub-second burst of energy, trigger by PMU, to stop grid oscillations and improve grid damping.
- Simulated inertia
  - Simulated governor control action by smart inverters as a replacement for loss of inertia on the system

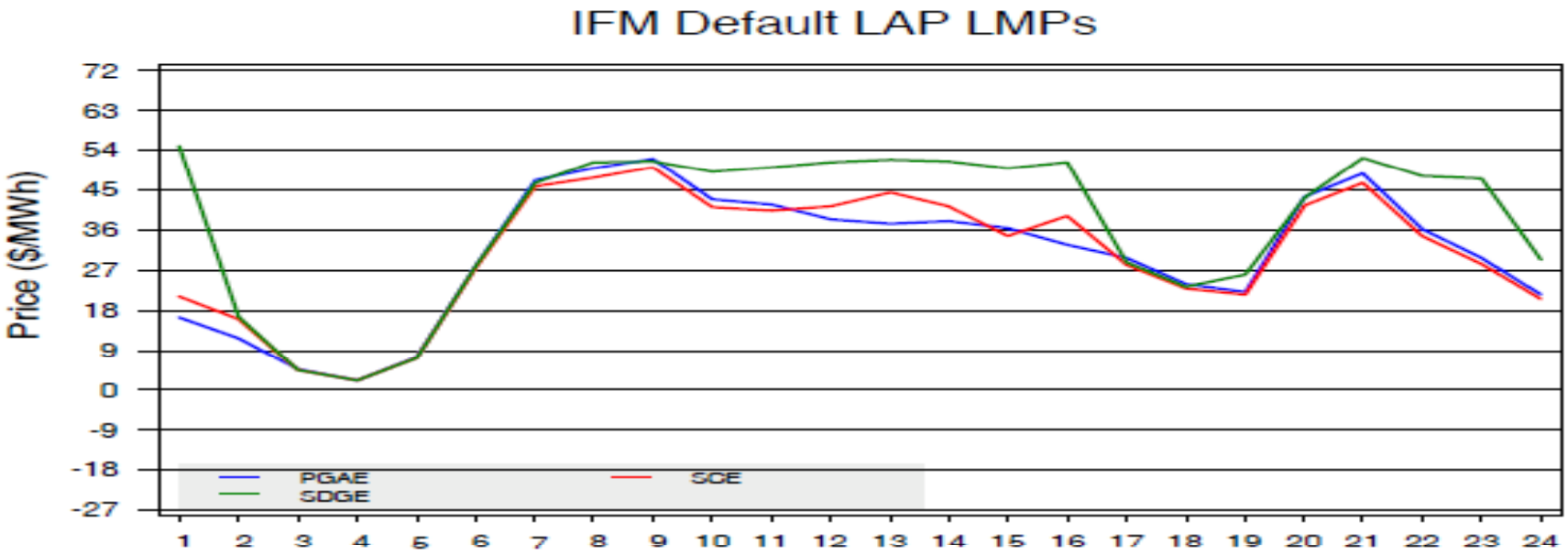
Market based value of storage

Value is determined by market prices for the services provided

- Energy shifting in Day-Ahead Market
  - Buy excess energy off-peak and deliver on-peak
- Energy price arbitrage in 5 min. real-time market
  - Buy energy when prices are low and sell when prices are high
- Ancillary Services – Regulation
  - Provide capacity to the normal regulation market or to the new ISO **R**egulation **E**nergy **M**anagement (REM) service
- Ancillary Services – Operating Reserves
  - Provide capacity to the Spinning reserve market

Day Ahead Energy Shifting

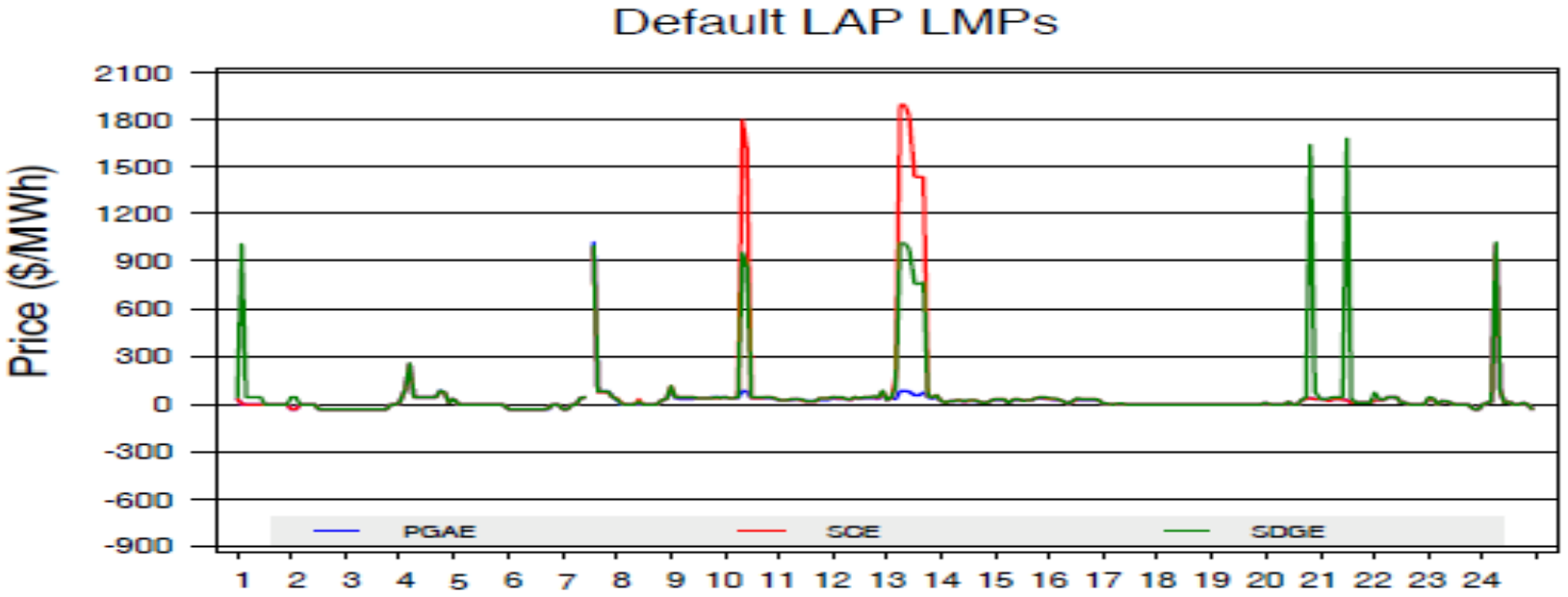
An energy storage resource could buy 4 MW-Hrs of energy from Hour- Ending 2 (HE2) to HE6 for an average price of $9 ($36 total) and sell 3.2 MW-Hrs at $40 ($128) from HE12 to HE 16 (assumes 80% round trip efficiency) for a profit of $92 or $23/MW-Hr.



DA Energy Prices April 14, 2011

Energy price arbitrage in 5 min. real-time market

Buy energy to charge storage every time energy prices are below $10 and sell energy when prices are above $50. 4-12-2011 had 7 price spikes of $1000 or above which fast responding energy storage could profit by selling energy.

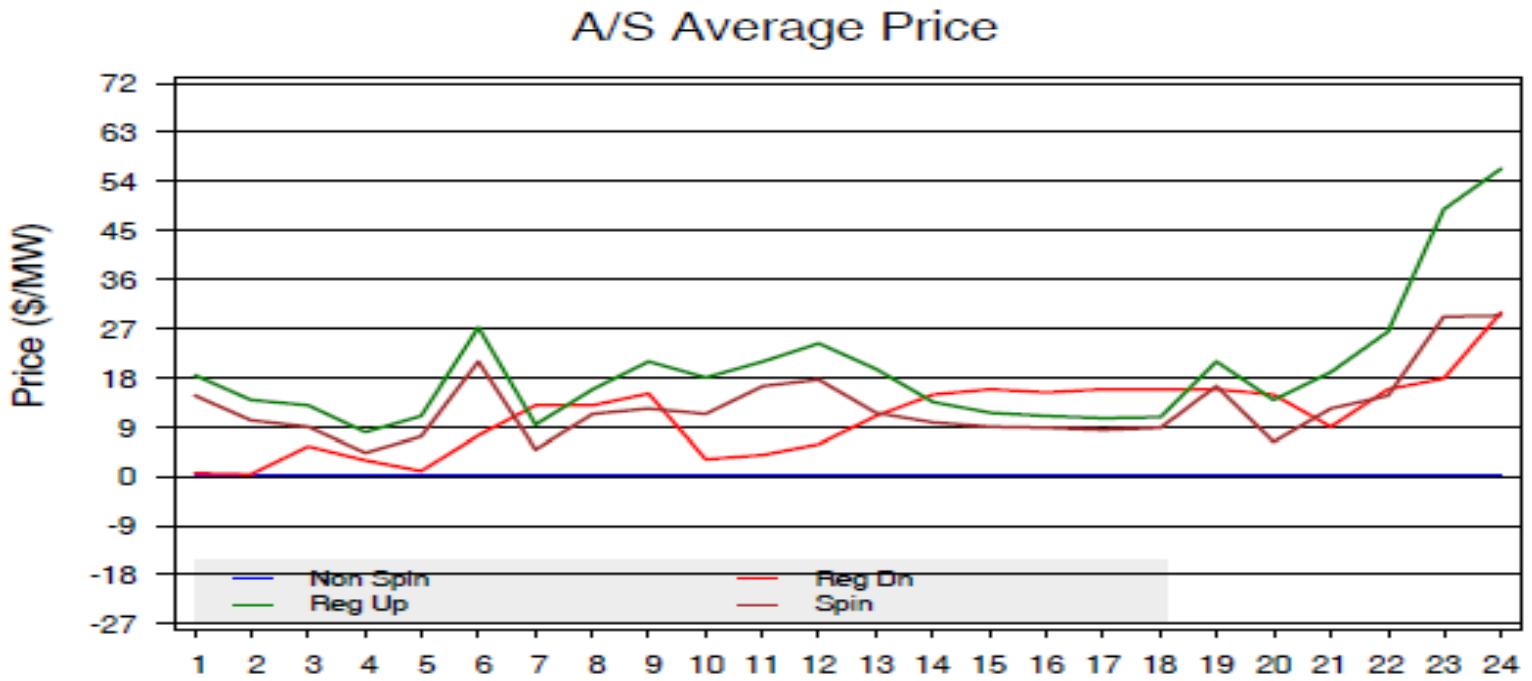


Ancillary Services Prices 4-14-2011

The CAISO procures 100% of their AS Requirements in the DA Market.

Regulation UP on 4/14/2011 was approx. $15/MW and Reg. Down was approx. $9/MW, except for the last 3 hours of the day.

1 MW of Energy storage in the Regulation Market = $24*24 Hrs = $576



Economics and cost-benefit data needed for implementation of AB 2514

- For T&D – Grid Reliability & Economics
  - Potential savings produced by deferring replacement of T&D facilities due to storage
  - Performance based contracts for non-utility owned storage
- Market based energy storage needs price volatility for financial success.
  - Need better models that show value of storage with price projections, price sensitivity and risk.
  - Value of Inertia and improved reliability
  - Testing and validation of ISO REM product.

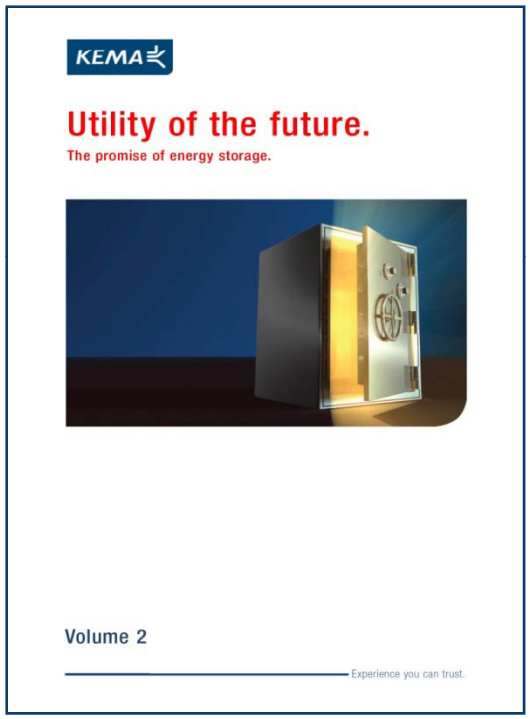
Conclusions from Trends in Energy Storage System(ESS) Design

- ESS currently faces a cost challenge on most applications
  - Drivers for technologies are still cost and for some applications, duration
    - Batteries need to target $250-400 /kW
      - Balance of plant costs puts additional barriers to cost reductions
    - Duration needs to be in the 2-4 hour range to span all applications

- Cost challenges are expected to carry through to PCS

- When KEMA sees PCS components being “spliced out” of large-scale applications, tendencies are that the component will become a commoditized component
  - Less opportunity for designing “value-adds” such as controls into the component

Thank You



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