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Plug-In Hybrid Electric Vehicle Intro and Battery Requirements

South Coast AQMD
Plug-in Hybrid Electric Vehicle
Forum and Technical Roundtable

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What is a Plug-In Hybrid Electric Vehicle?

- A PHEV uses a grid-rechargeable energy storage system to provide capabilities beyond those of conventional charge-sustaining hybrid systems
- A PHEV is applicable to almost any hybrid powertrain architecture—but potential benefits increase with the level of hybridization and some architectures have inherent advantages
- A PHEV does not imply a PURE ELECTRIC mode, although this is one of the most fundamental attributes
- A PHEV neither requires nor implies the need for dual "FULL" power electric motor and combustion engine systems
- PHEVs are typically most effective in operating scenarios proportional to their onboard storage

Plug-In HEV Technical Challenges

- Energy storage
- Energy management
- Charging and infrastructure
- Quantifying energy and environmental impact
- Certification
- Summary

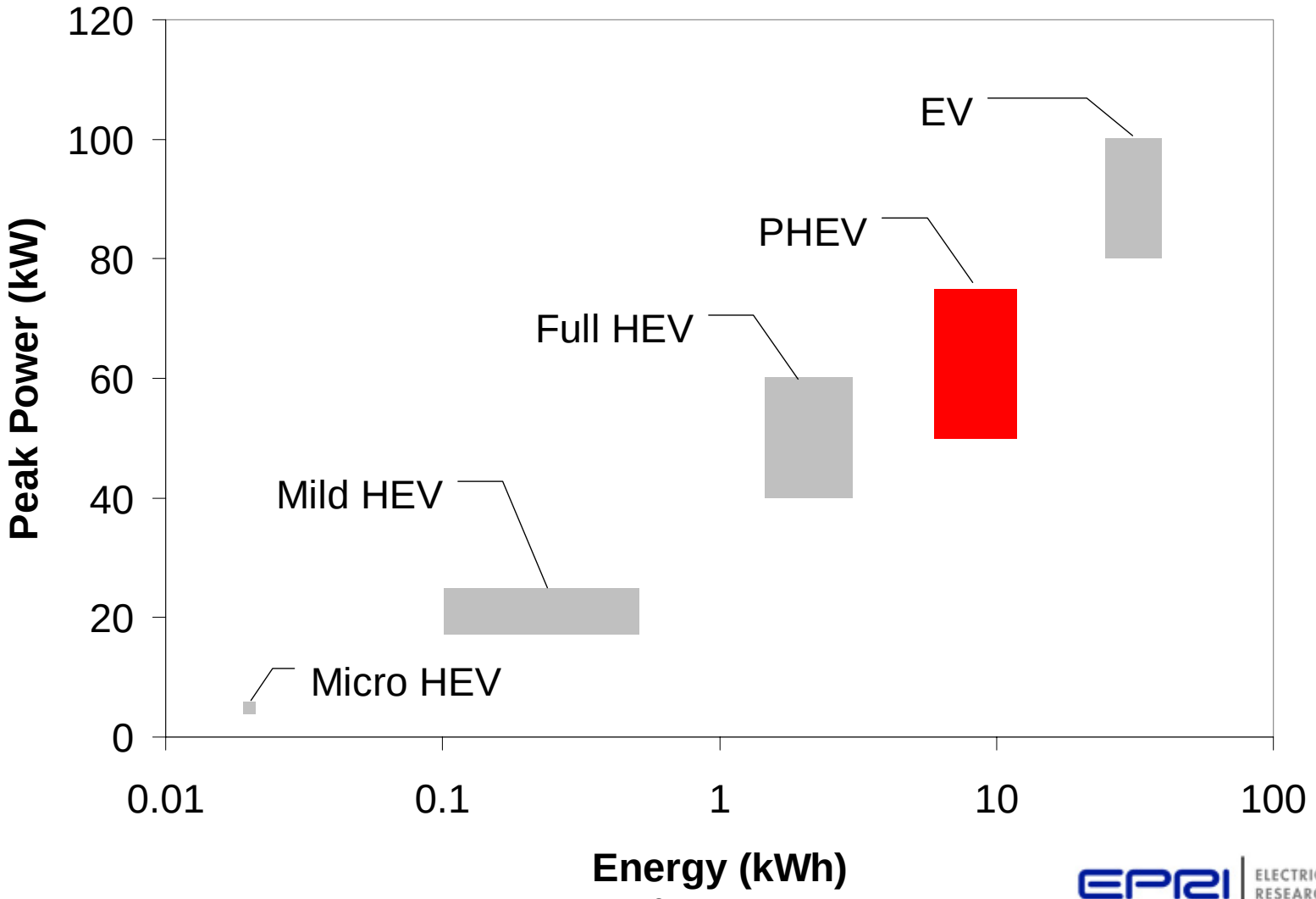
Key Questions for Today's Forum

- What is the status of current battery technologies?
- Are current battery technologies suitable for near-term production plug-in hybrids?
- Existing or planned work on PHEV battery technologies?
- Where are the gaps—what needs to be done?
- What must be done to accelerate development?

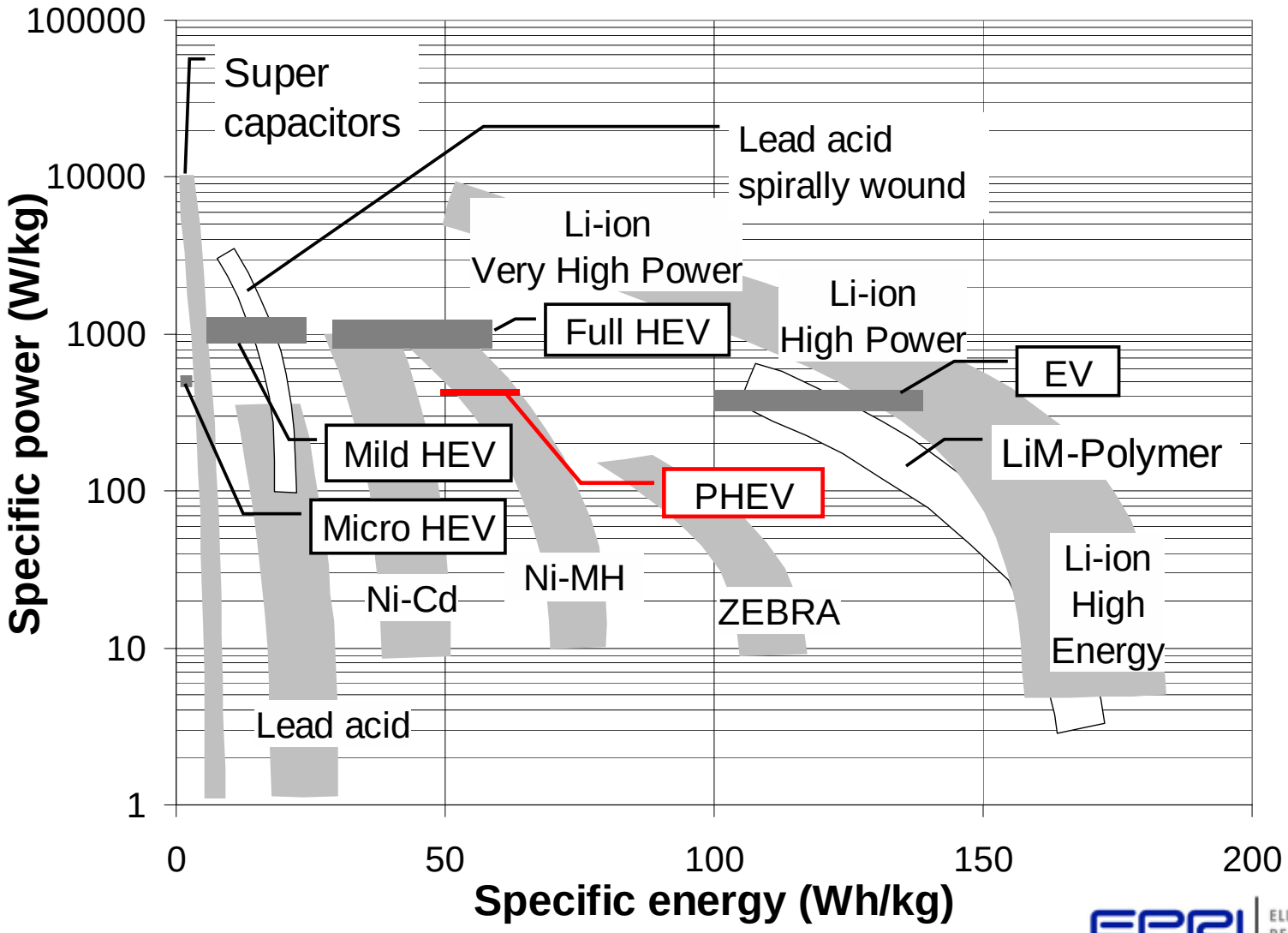
Battery Characteristics of PHEVs

- Battery pack has higher total energy capacity than for HEVs
- Cell design has lower power density, higher energy density
- Battery is deep discharged during driving to a lower minimum state-of-charge (SOC)
- Battery is grid-recharged while vehicle is parked
- Total battery cost is higher than for HEV, and a large portion of projected PHEV cost delta
- Battery energy is directly related to per mile electrical energy consumption and desired range or equivalent range
- Battery mass is greater, but typically not to the extent that vehicle perfomance is significantly affected.

Battery Power/Energy Requirements



Current Technology



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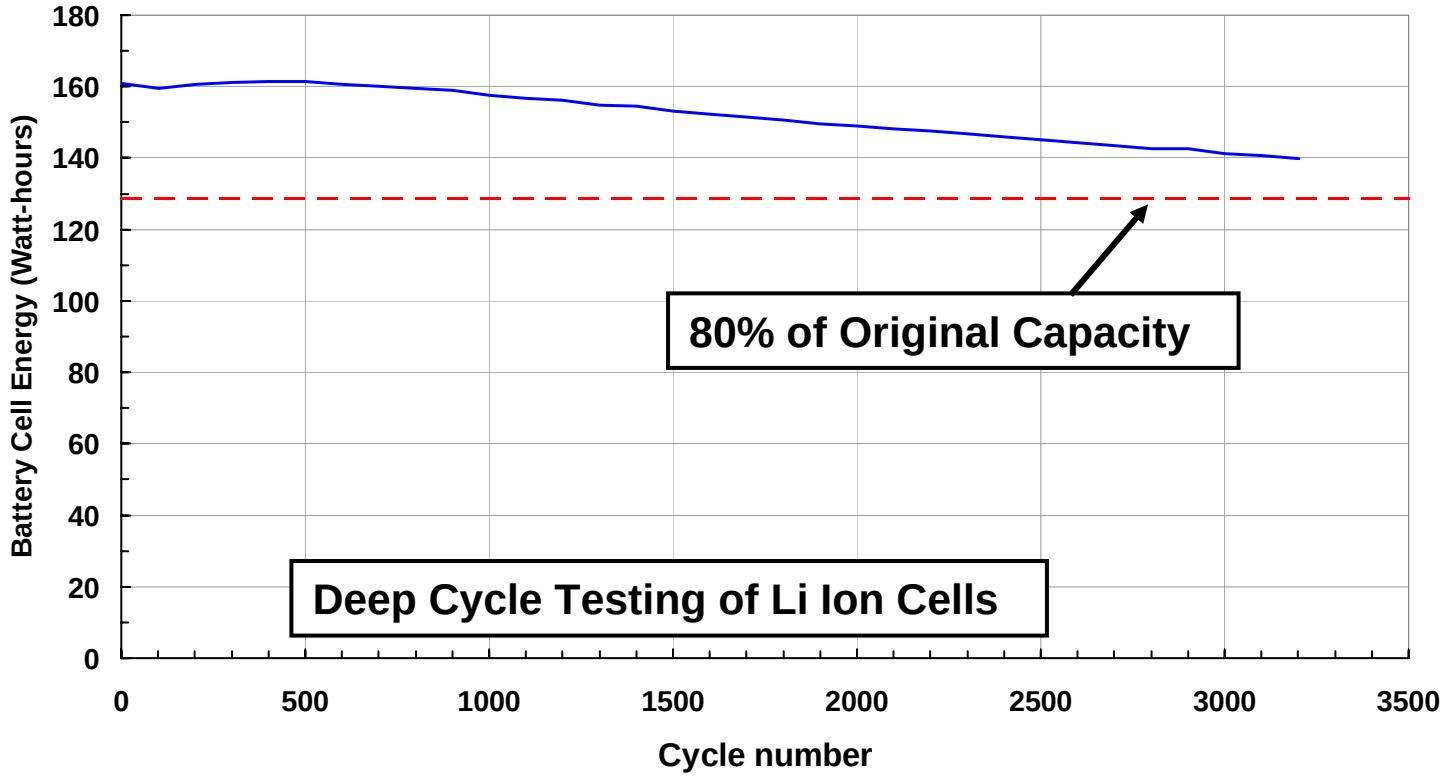
Battery Performance

Cycle Life

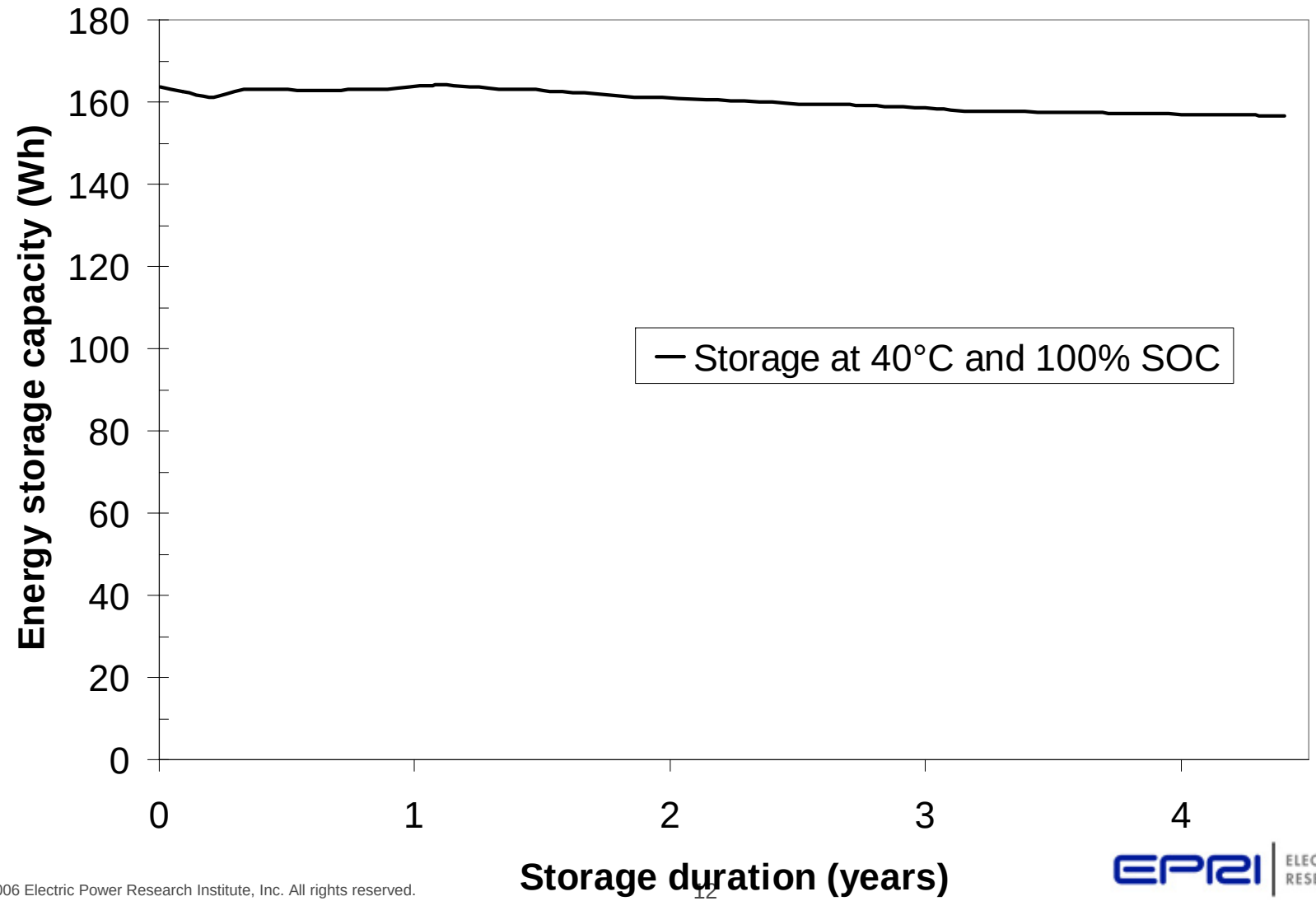
Lithium Ion Technology is Promising for Plug-in Hybrids

- High energy, power density
- Likely to meet target cycle life
- Cost-volume relationship equal or superior to NiMH
- Potentially promising innovations in new designs

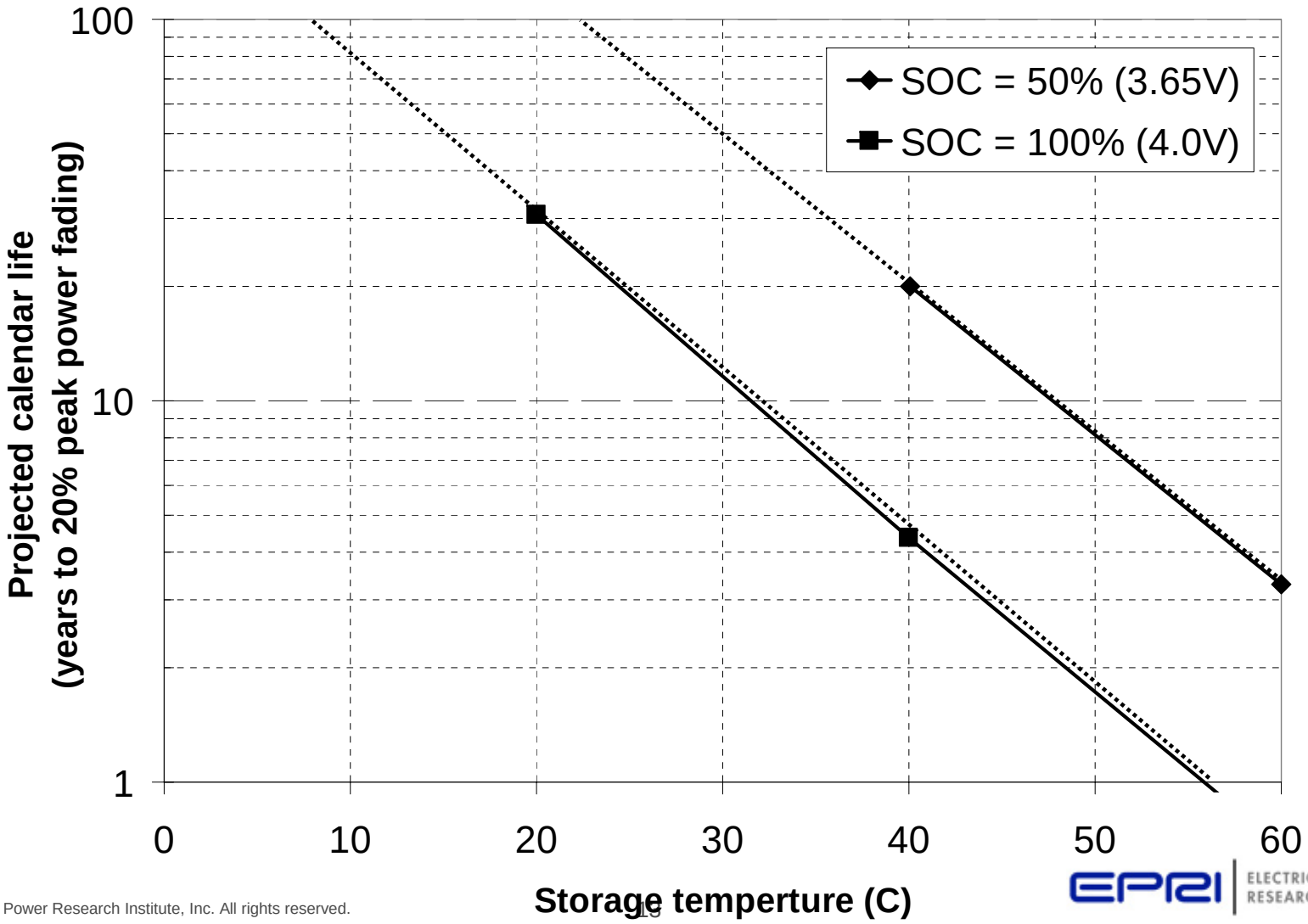


Calendar Life

Li Ion Calendar Life Test



Li Ion Calendar Life vs. Temperature



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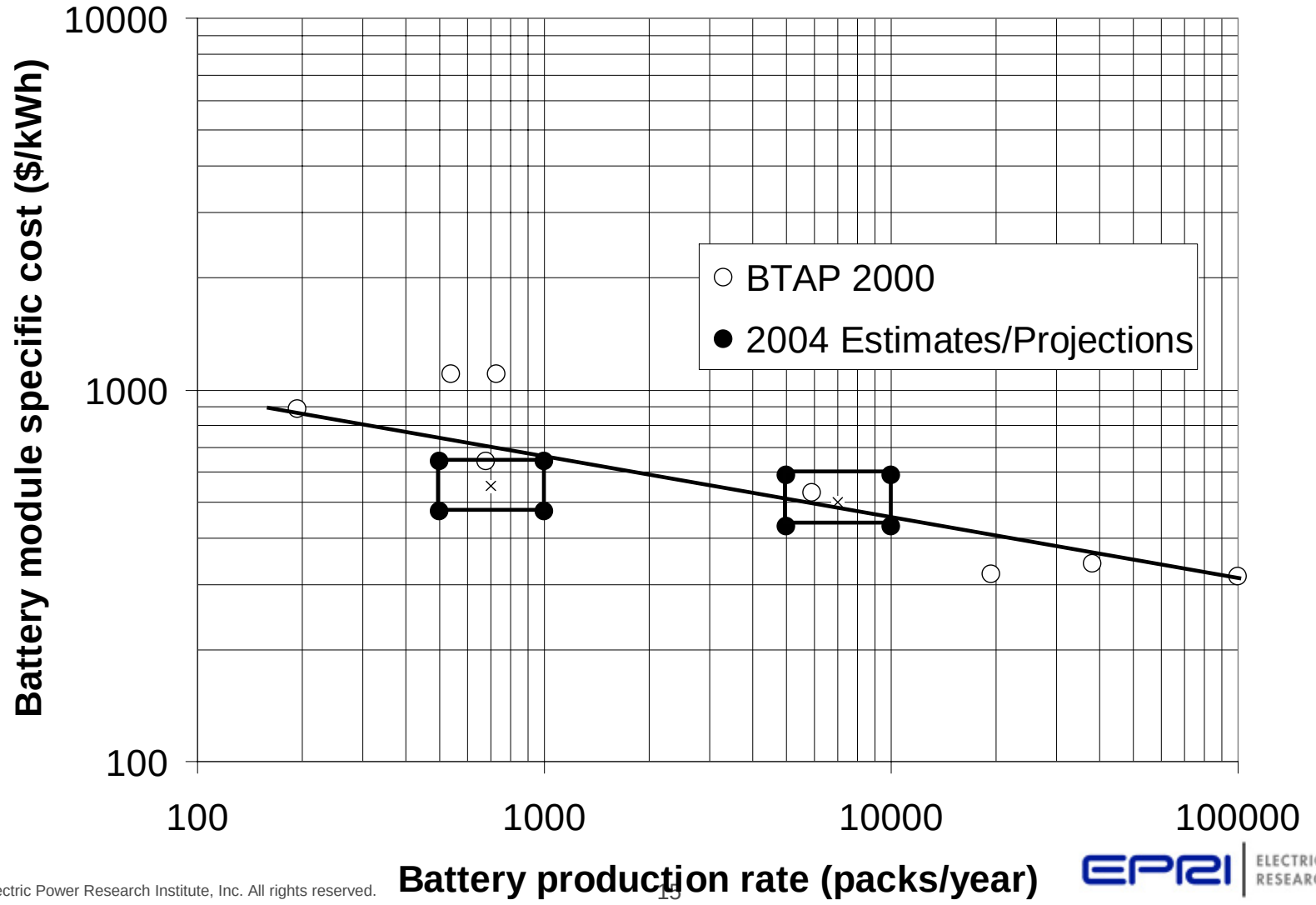
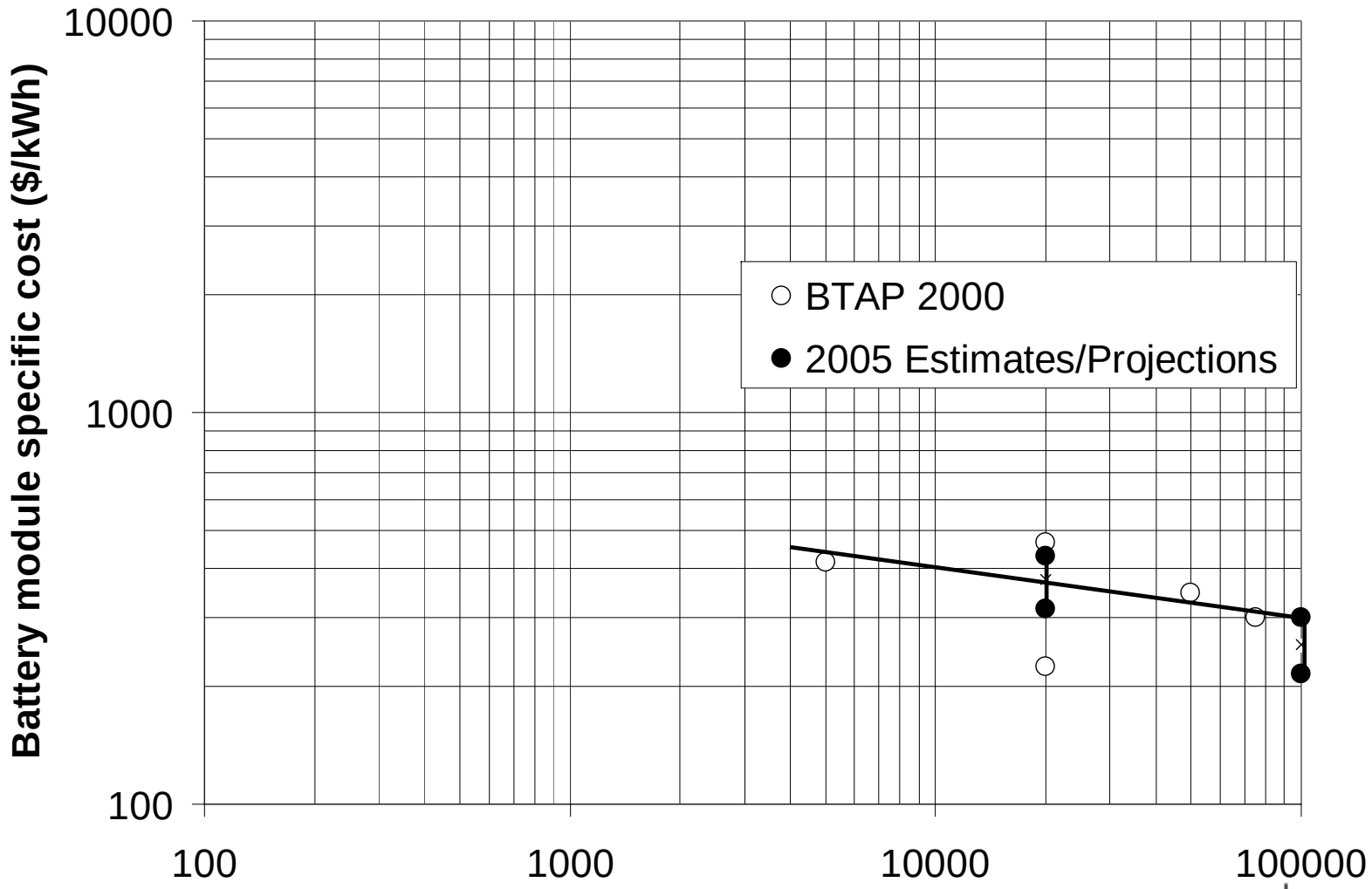
Cost Estimates

NiMH Cost Estimate



Li Ion Cost Estimate



Charging and Infrastructure

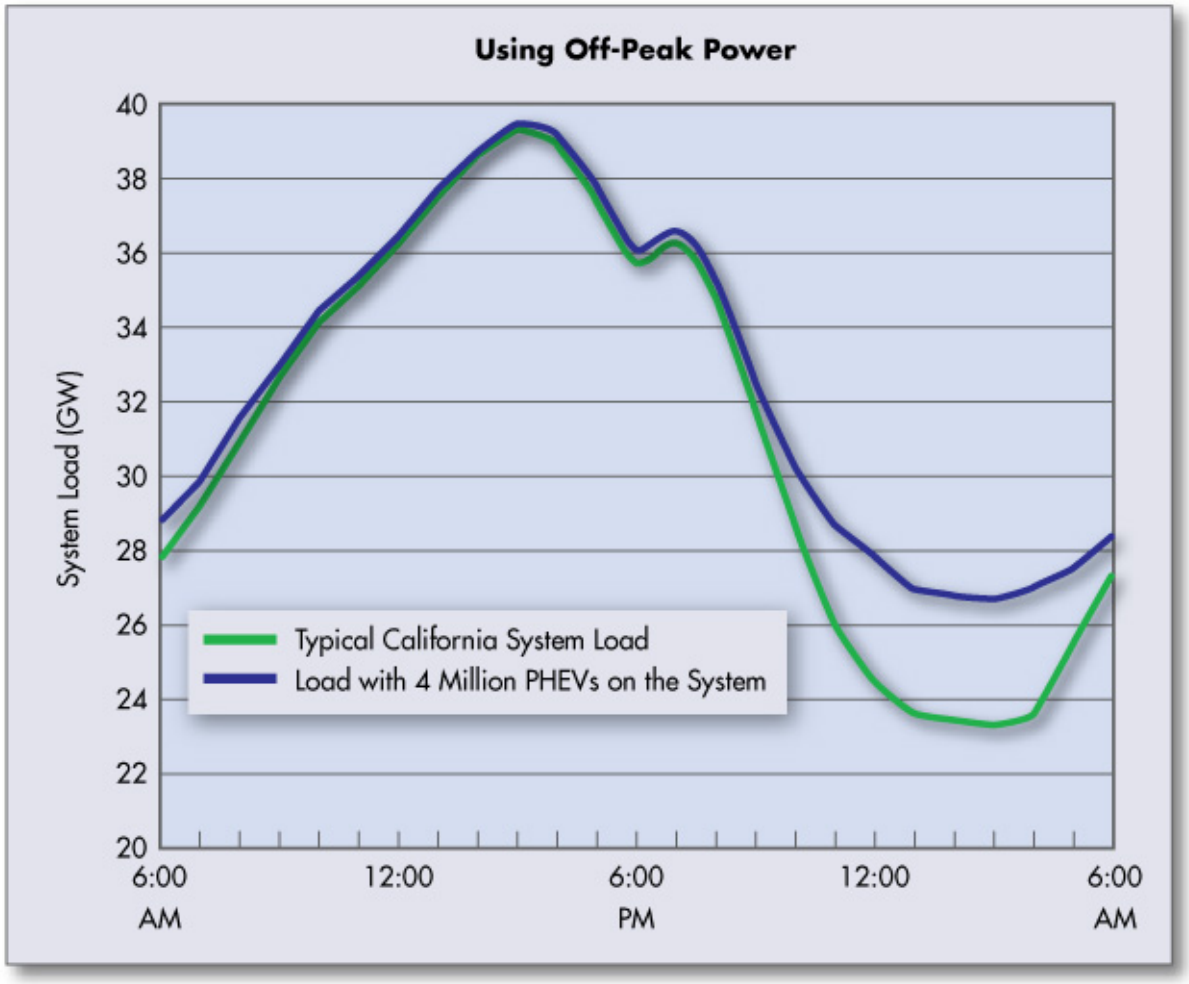
Charging Infrastructure

- Plug-in hybrids require relatively low power charging
- Wide availability of infrastructure
  - Initial focus on private chargers
- Array of options
  - 120 VAC, 15 amp (~1.4 kW)
  - 120 VAC, 20 amp (~2.0 kW)
  - 208/240 VAC, 30 amp (~6 kW)
- 120 VAC strongly preferred due to cost, availability

PHEV 20 Vehicle	Pack Size	Charger Circuit	Charging Time 20% SOC
Compact Sedan	5.1 kWh	120 VAC / 15 A	3.9 – 5.4 hrs
Mid-size Sedan	5.9 kWh	120 VAC / 15 A	4.4 – 5.9 hrs
Mid-size SUV	7.7 kWh	120 VAC / 15 A	5.4 – 7.1 hrs
Full-size SUV	9.3 kWh	120 VAC / 15 A	6.3 – 8.2 hrs

1.2 – 1.4 kW power, 1 or 2 hours conditioning

High Level of Available Off-Peak Capacity
Simulated Cal ISO System Load



Source: Cal ISO and EPRI Data, September 1-2, 2005

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Summary

- Both NiMH and Li Ion batteries meet the performance requirements for Full HEV operation
- Modest changes should allow NiMH to meet PHEV operation up to about 40 miles
- Li Ion batteries should meet the performance requirements for PHEV operation for longer ranges
- Both NiMH and Li Ion batteries appear capable of exceeding 3000 deep discharge cycles
- Both chemistries show excellent prospects for meeting 10 – 15 year calendar life requirements
- Current projections indicate the future mass production costs of Li Ion batteries will be lower than for NiMH batteries