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Ultracapacitors and Frequency Regulation

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Overview

- Ultracapacitors - What are they?
- Ultracapacitors - How do they compare to other ESS device
- Primary vs. Secondary Frequency Regulation
- History of Ultracaps in Application
- Additional Benefits of Ultracaps

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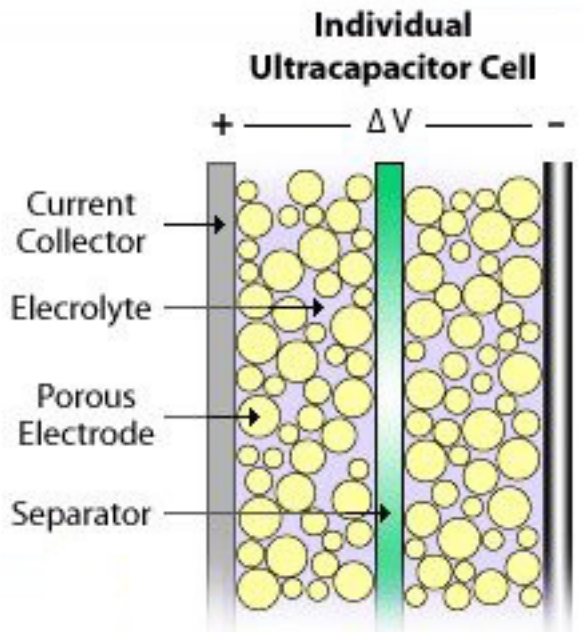
Ultracapacitors - What Are They?



- Approximate a solid state energy storage
- Do not rely on chemical reaction (like batteries)
- Respond electrostatically through ion transport
- Very low ESR (resistance)
  - very high power capacity and throughput
- Limited energy content

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Ultracaps - What's inside Them?

- Activated Carbon
- Aluminum
- Electrolyte
- Separator (paper or film)
- Binding Agents

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How Are Ultracaps Packaged

- Cells and Modules
- Cells <3V
- Modules <200V (typical)
- Systems <2000V

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Ultracaps vs. Batteries; Generally Speaking

Criteria	Ultracaps	Batteries
Life	>10 years	<5 years
Flammable	No	Likely
Explosive Risk	No	Likely
Regular Maintenance	No	Likely
Sensitivity to Low Voltage	No	Yes
Results of Overvoltage	Become Unusable	Can Cause Fire
Cyclabilty	1,000,000	<5,000 Typ.

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Batteries vs. Ultracapacitors Operationally

Criteria	Ultracaps	Batteries
SOC	Voltage	Sensitive Algorithm
SOH	10 Sec current and Voltage	Load Test/10-100hrs
Charge Rate Sensitivity	No	Yes
Discharge Rate Sensitivity	No	Yes
DOD Sensitivity	No	Yes
Shipping Regulations	None	Hazardous
Ramp Rate Limit	~Instantaneous Response	Ramp Rate Limited
Round Trip Efficiency	>95%	<90% Typ.

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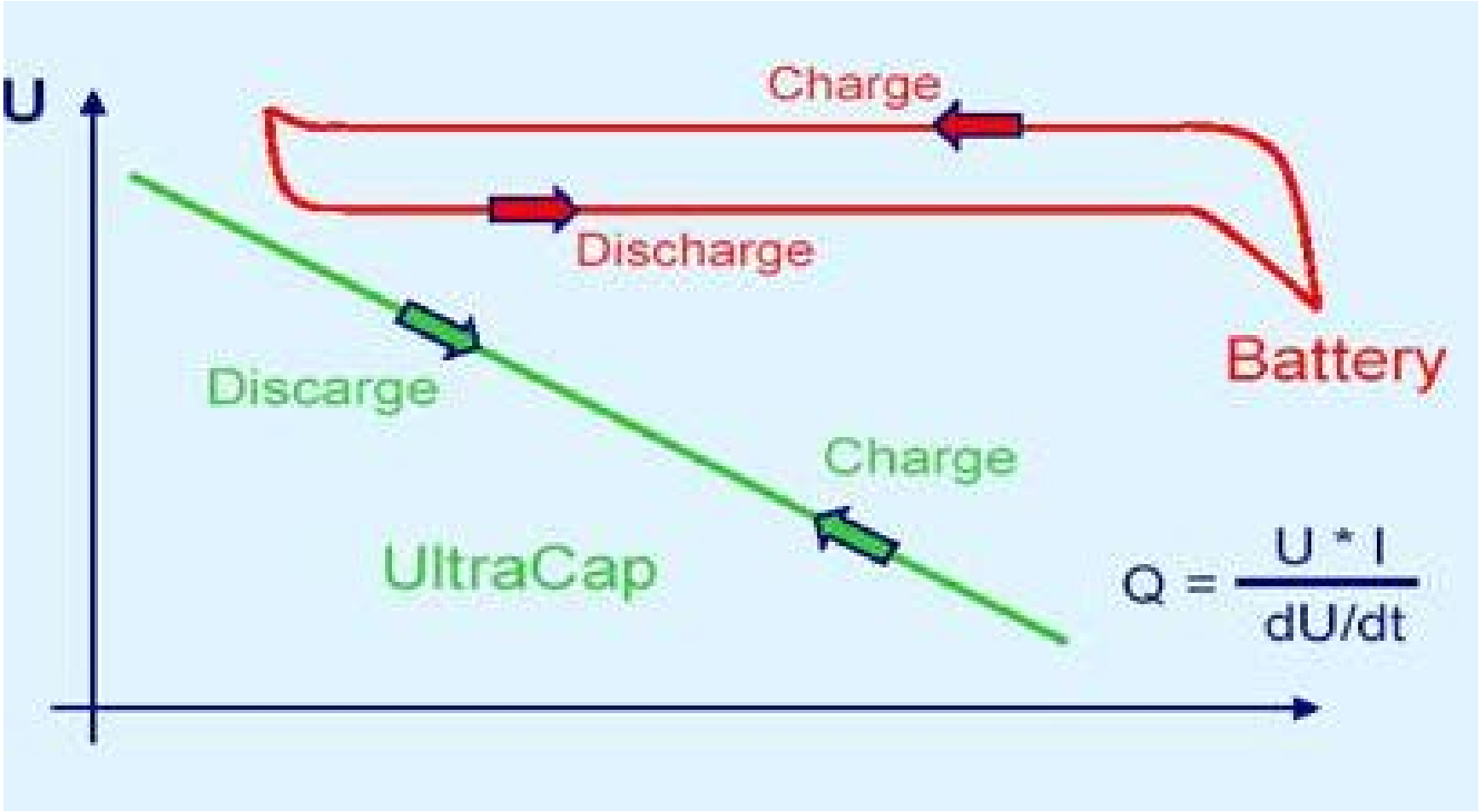
Operational Range of Energy Storage Systems



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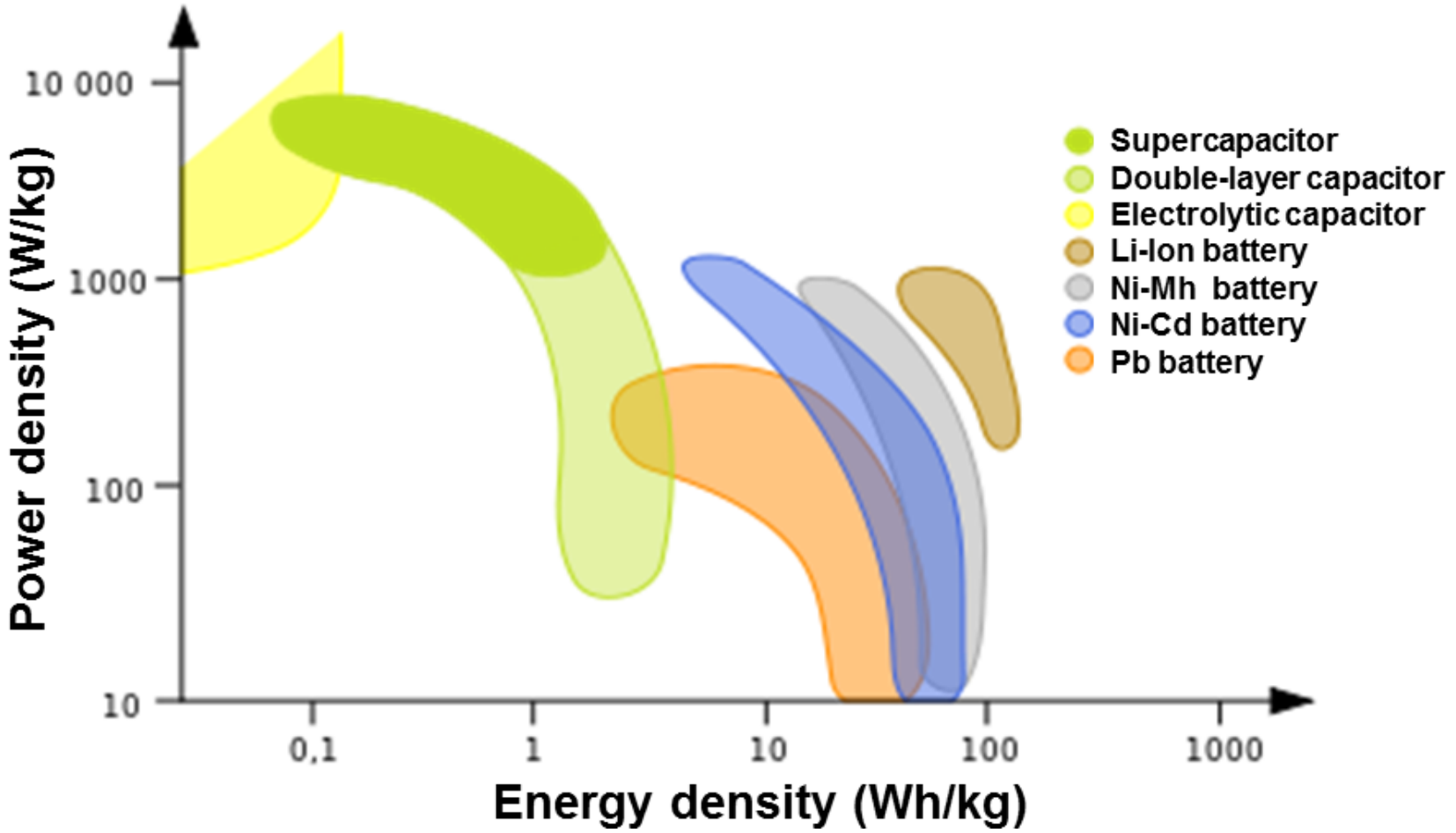
Energy vs. Power of Common Single Chemistry ESS



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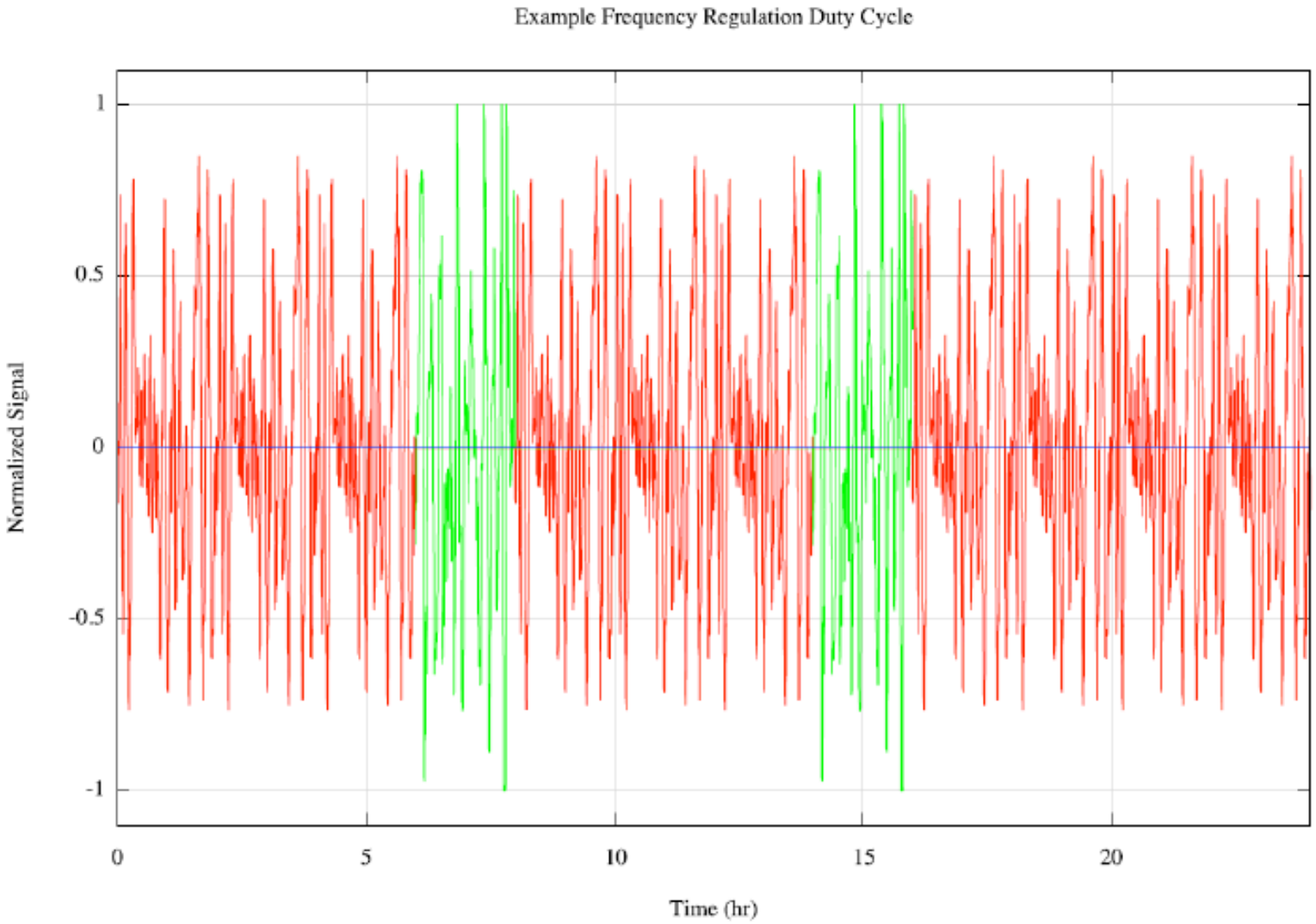
Load Variation Compensation



ESS must be able to charge and discharge at same rate!!!

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Load Variation Correction

- Must be round trip efficient
- Must be able to charge at same rate as discharge
  - This requirement drives battery sizing up
- Response time effects power quality
  - Batteries have a ramp rate and often a sensitivity to reversibility,
  - Ultracaps do not

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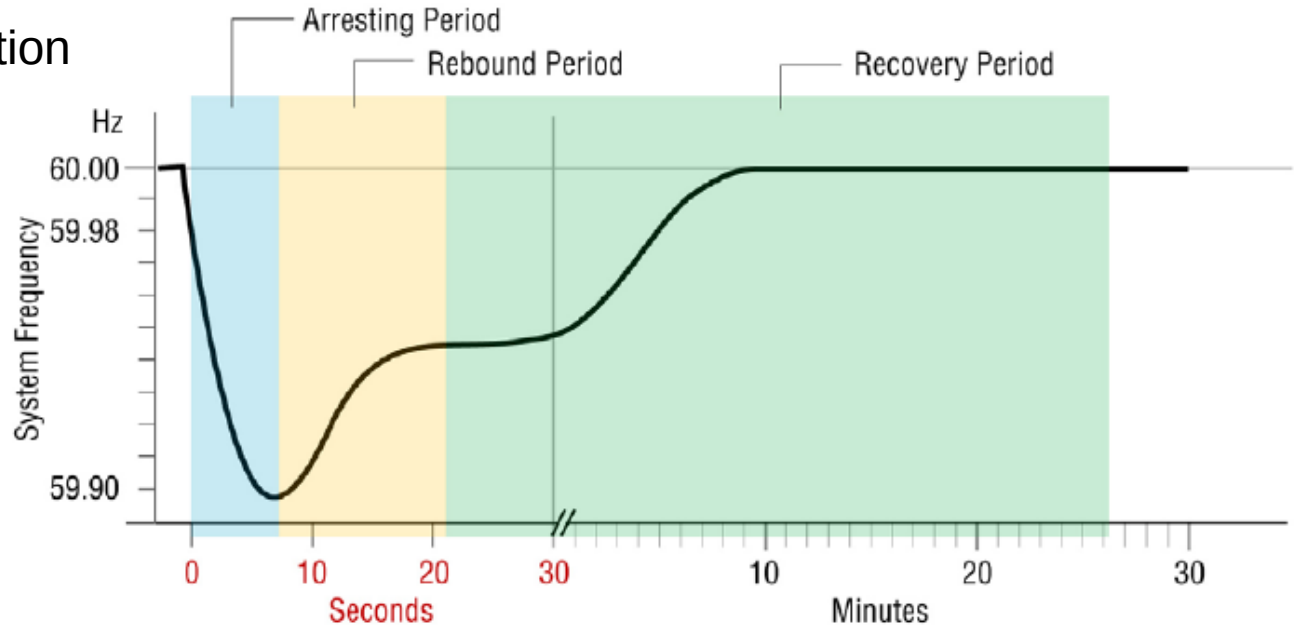
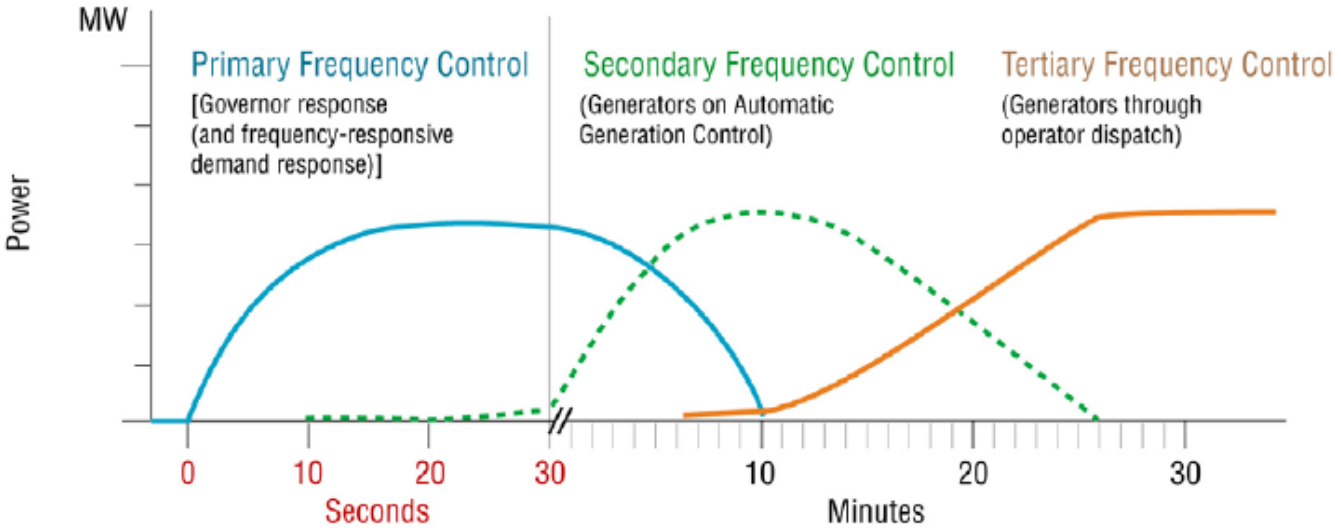
Discrete Event Applications

Lost Generation





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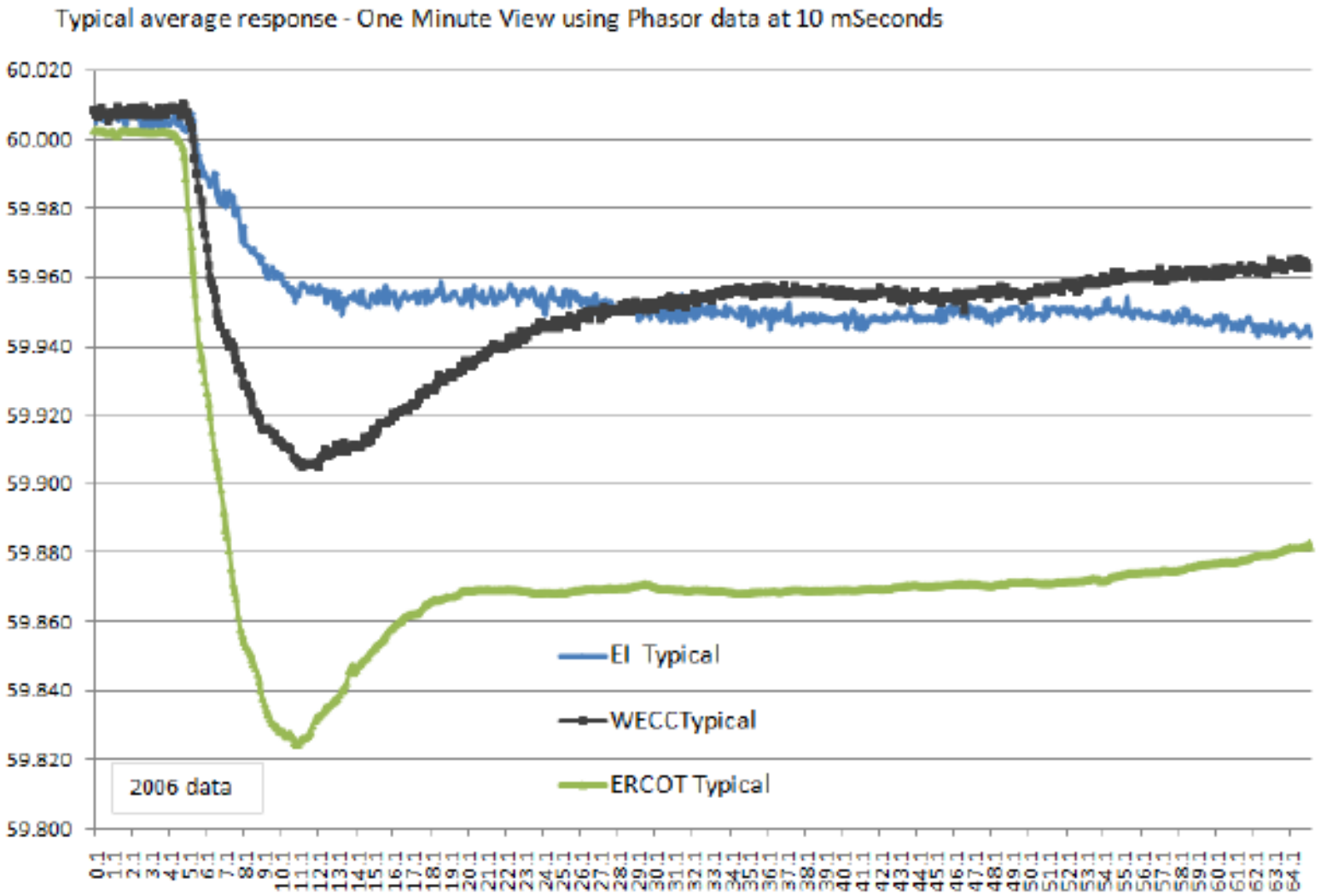
Real Power Loss Data at Main Interconnects



Source: NERC (2009a)

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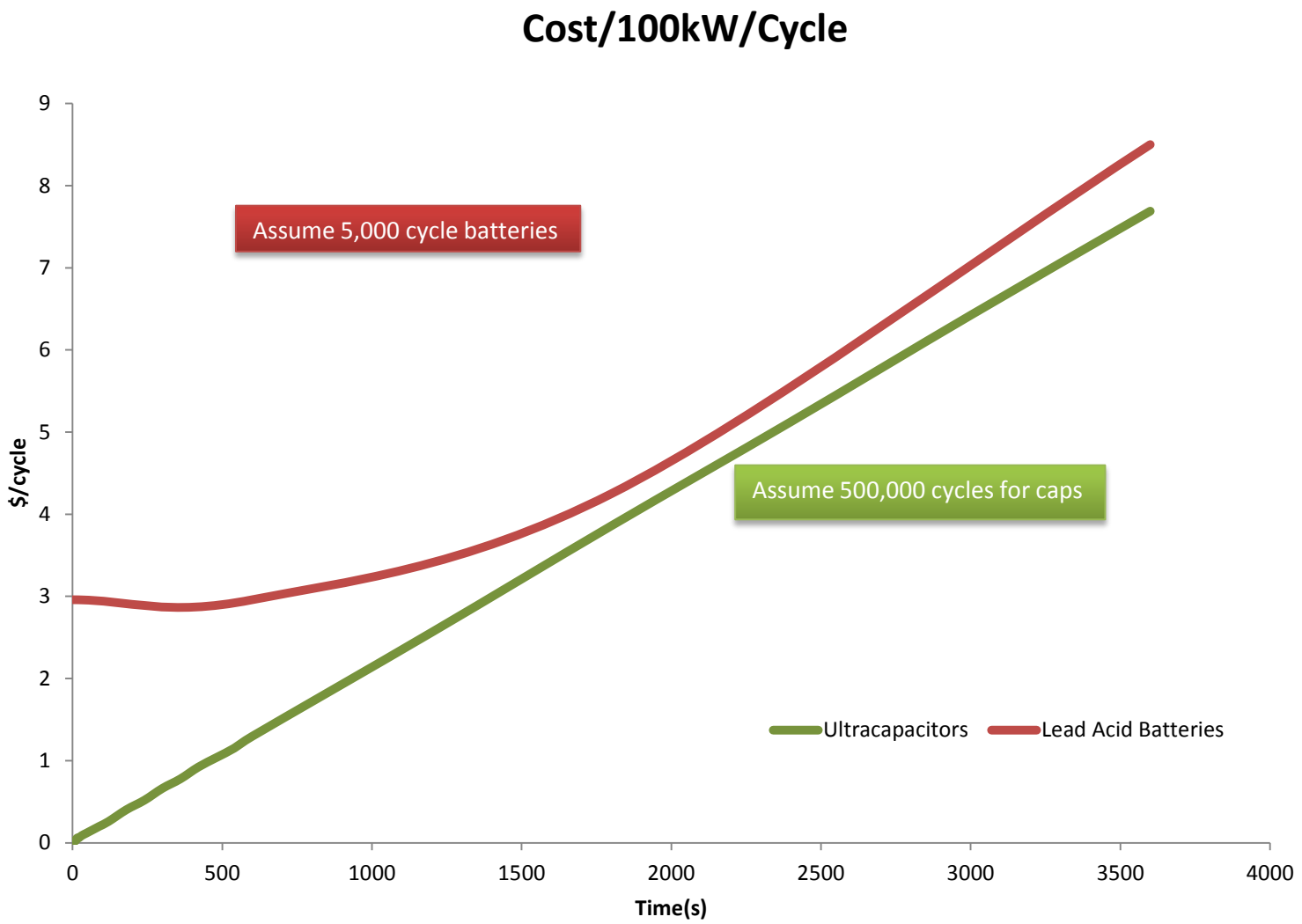
System Costs



Assumes system optimized for the ESS choice

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Ultracapacitor Solutions in this space

- Voltage Sag Compensation (VSC) and Dynamic Voltage Regulation dominated by ultracapacitors and capacitors
  - TMEIC has for a decade, used Ultracap based VSC
  - Rockwell Collins (Softswitching Technologies) offers "Batteryless" VSC
- >10GW of global capacity
- Typical systems 1-4MW, Common up to 200MW

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Thank you…

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- Kathy Bray et al, *Protocol for Uniformly Expressing the Performance of Energy Storage Systems,* Pacific Northwest National Laboratory, October 2012

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