CHANGING WHAT'S POSSIBLE

Advanced Management and Protection of Energy storage Devices (AMPED)

1st Annual Program Meeting

Ilan Gur, Ph.D.

Program Director, ARPA-E

March 4, 2013

Job of an ARPA-E Program Director

Program Creation

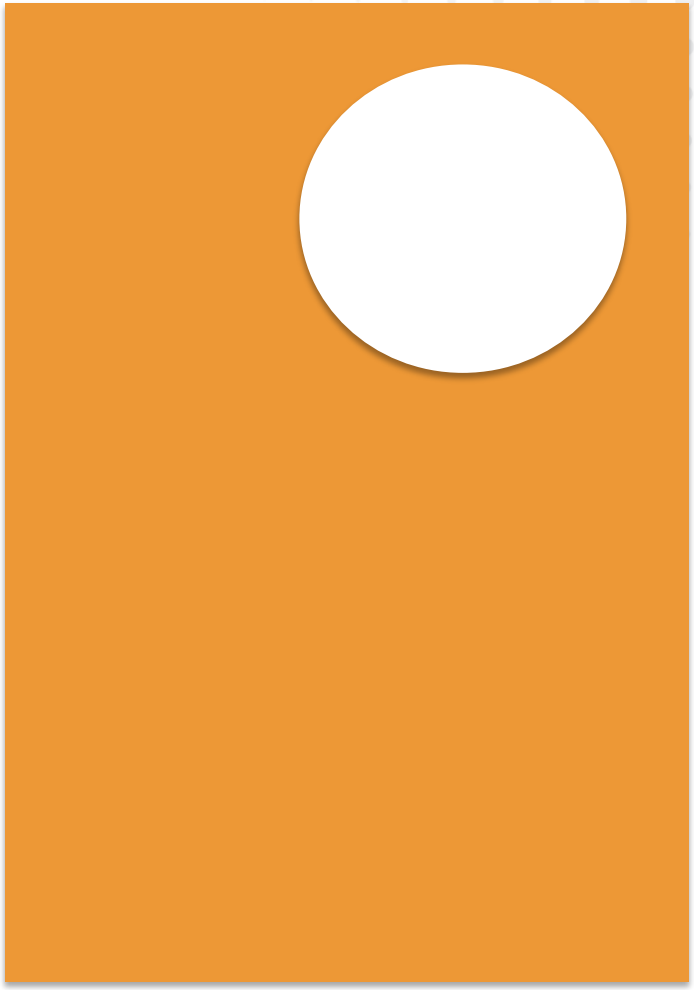
Review and Selection

Project Management

Community Building

Our real job

1. Identify white space – a unique problem set & technology opportunity



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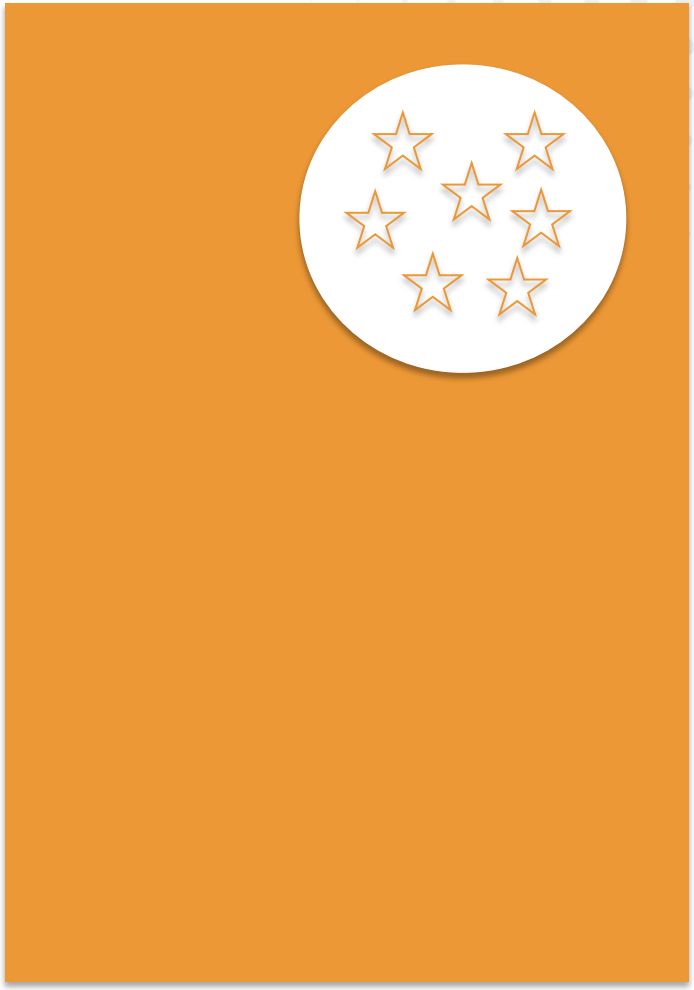

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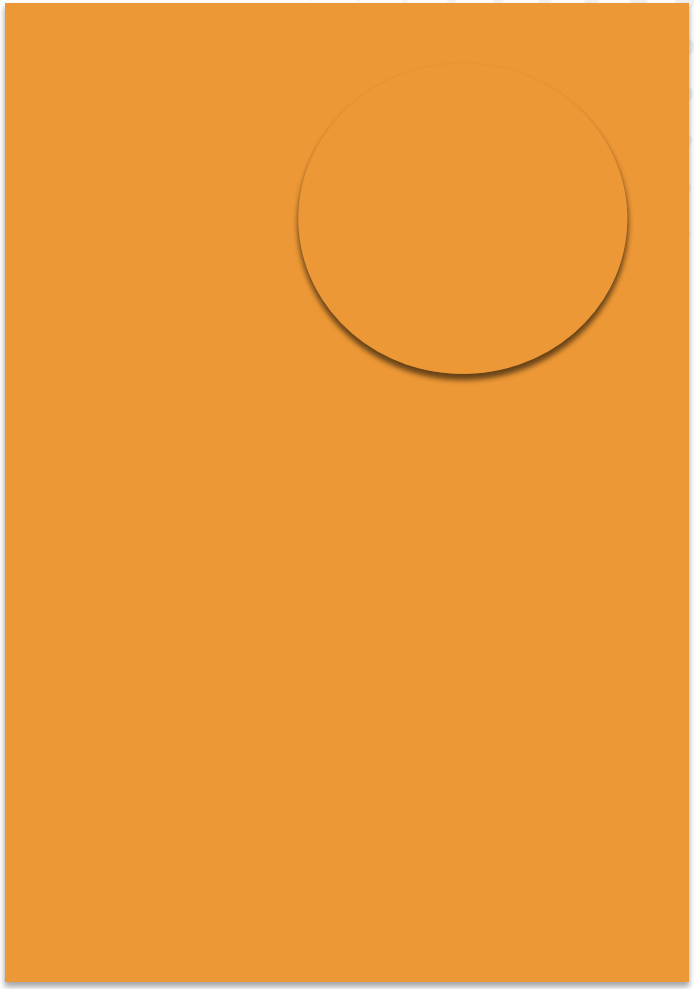

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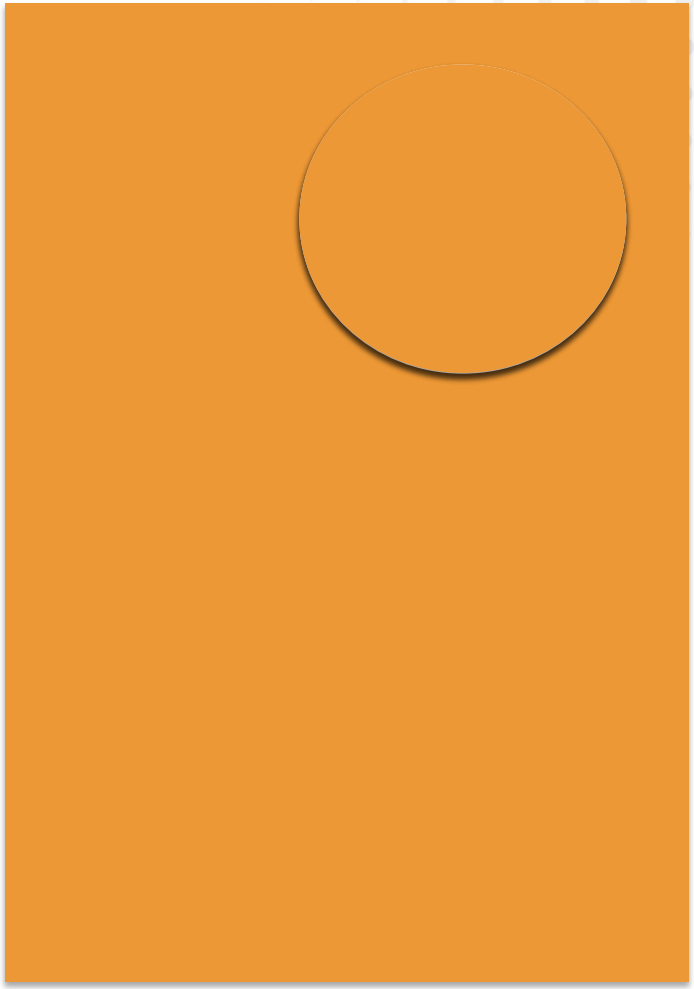
5. Learn from the process to identify new problems and opportunity white spaces



ARPA-E: 14 Focused Programs to Date

Transportation

Electrofuels

BEEST

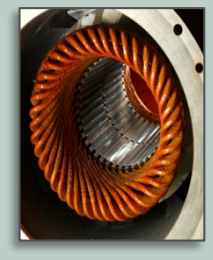
PETRO

MOVE

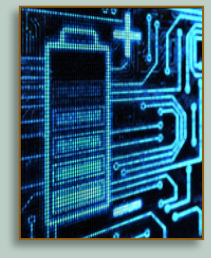
Transportation and Stationary Power / Use

HEATS

REACT



AMPED



SBIR/STTR

Stationary Power / Use

BEETIT

IMPACCT

GRIDS

ADEPT

GENI

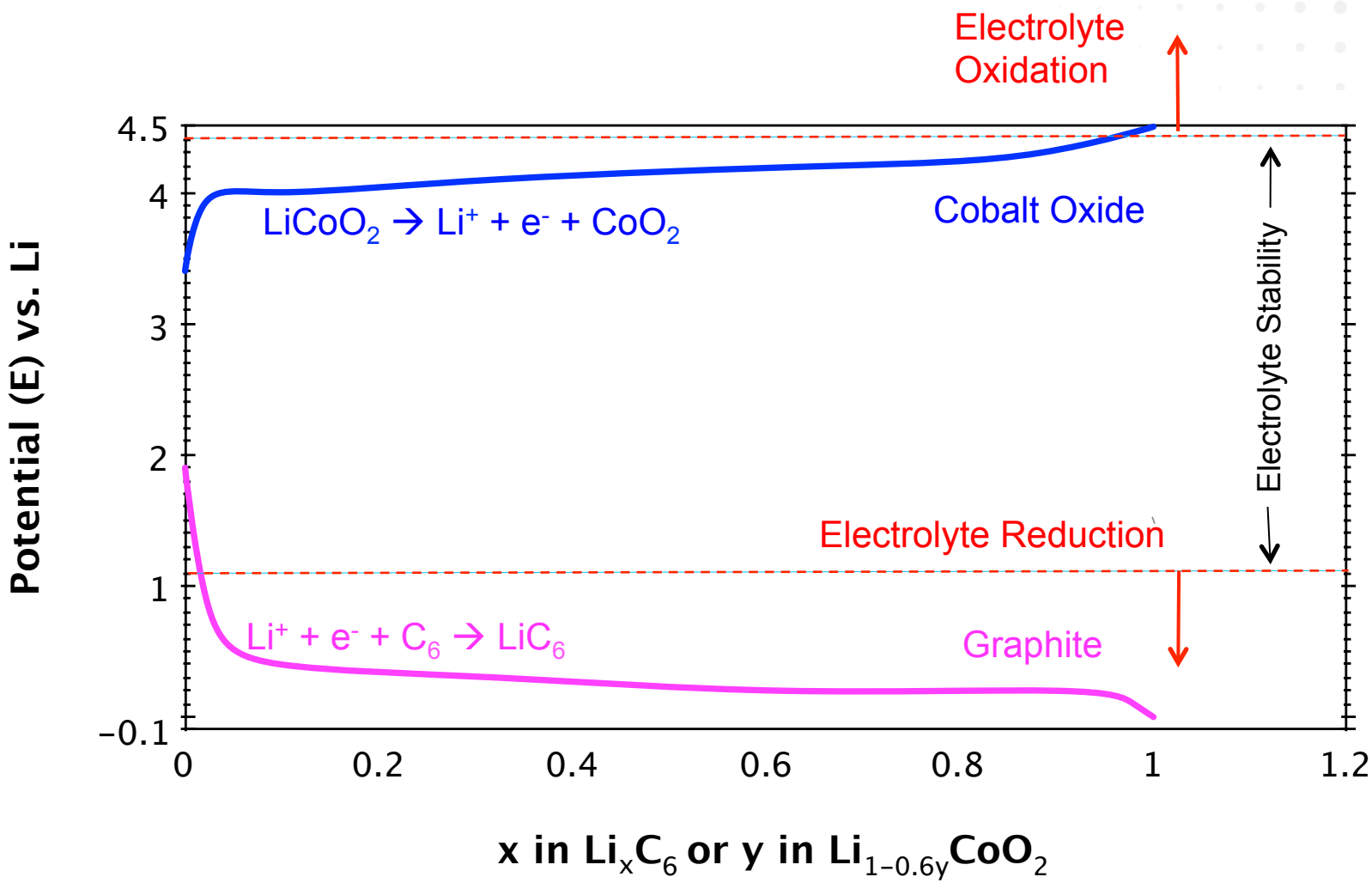
Solar ADEPT

Can’t we do better with today’s chemistries?

Balance of System	Physical protection Thermal management Charge balancing State monitoring Etc.
Overhead Capacity	Additional capacity buffer: safety/lifetime assurance
Propulsion Capacity	Capacity needed to propel vehicle for XX mile range

State-of-the-Art XEV

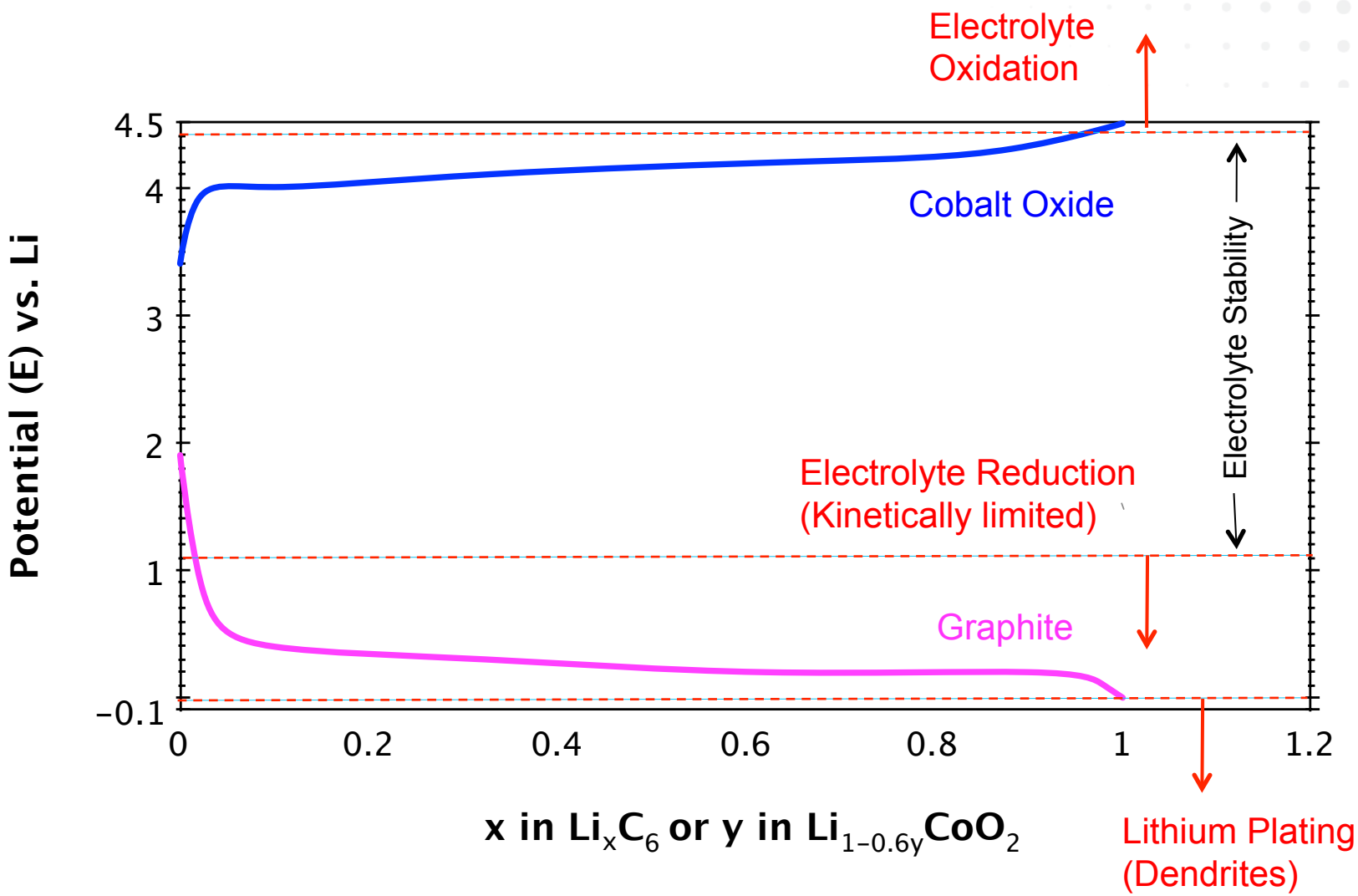
What are we protecting against?



Capacity Lost

Power Loss

What are we protecting against?



Capacity Lost | Power Loss | Short Circuit | Safety Risk

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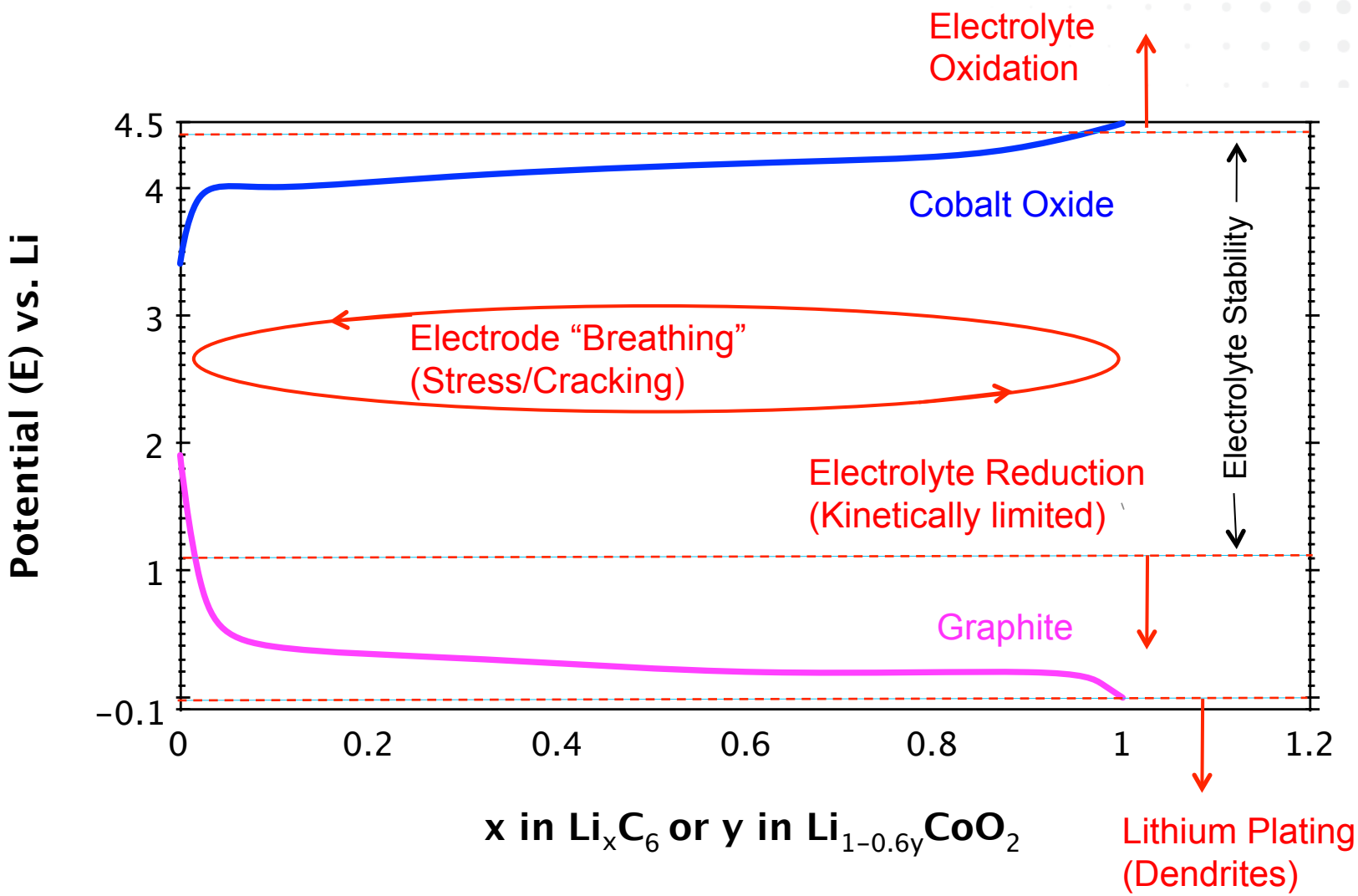
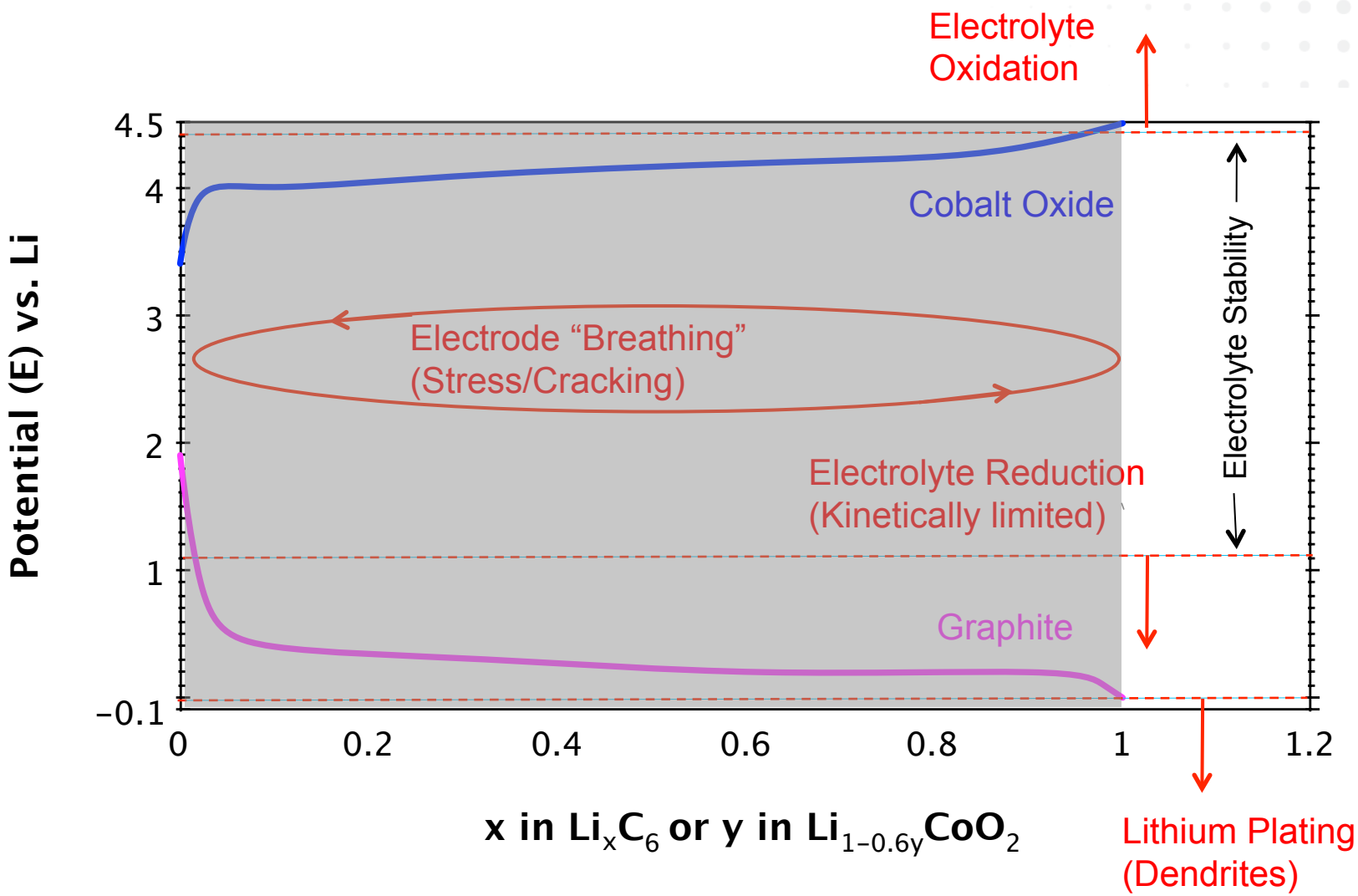


Capacity Lost | Power Loss | Short Circuit | Safety Risk

Utilization Constraints



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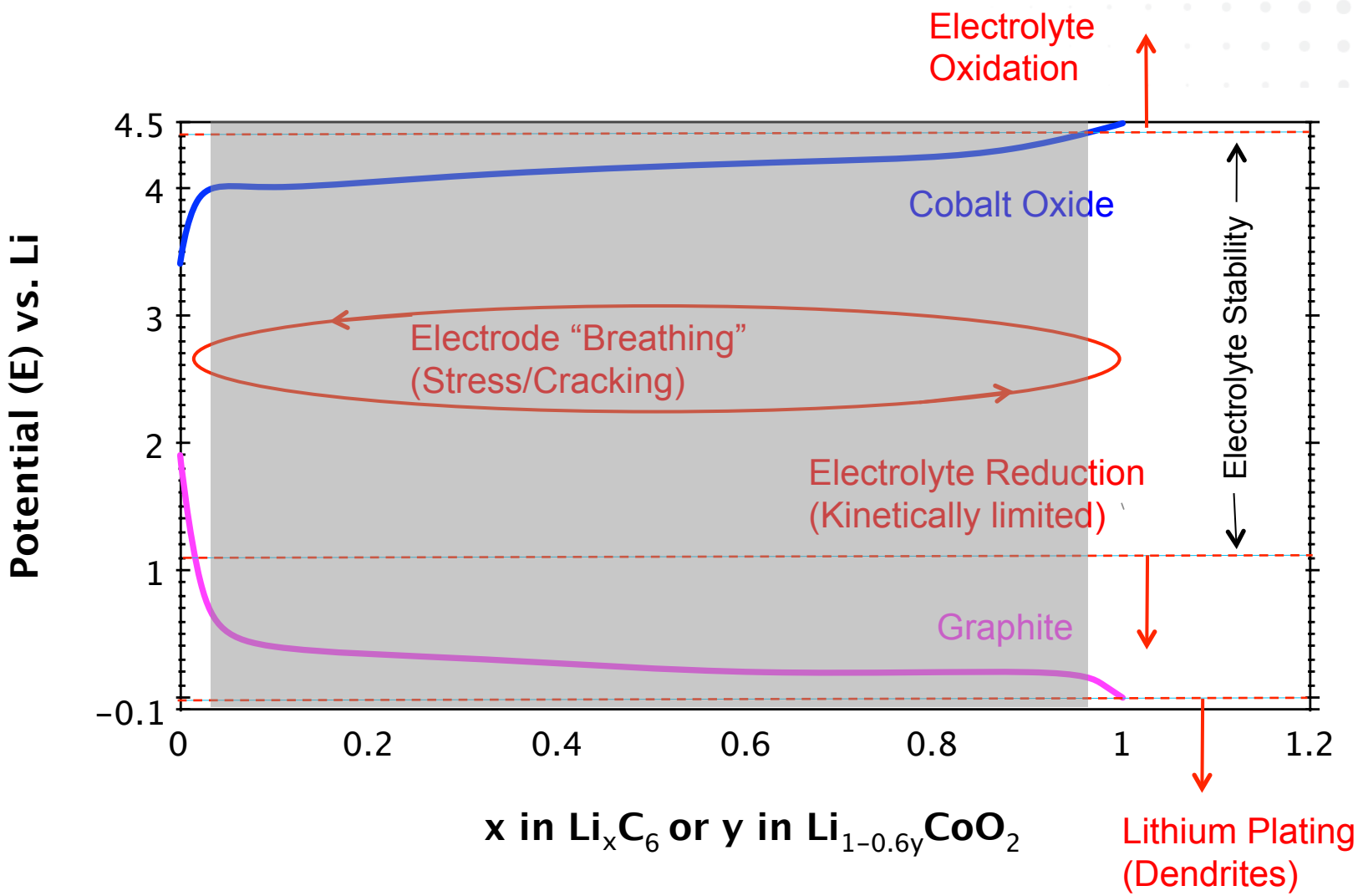

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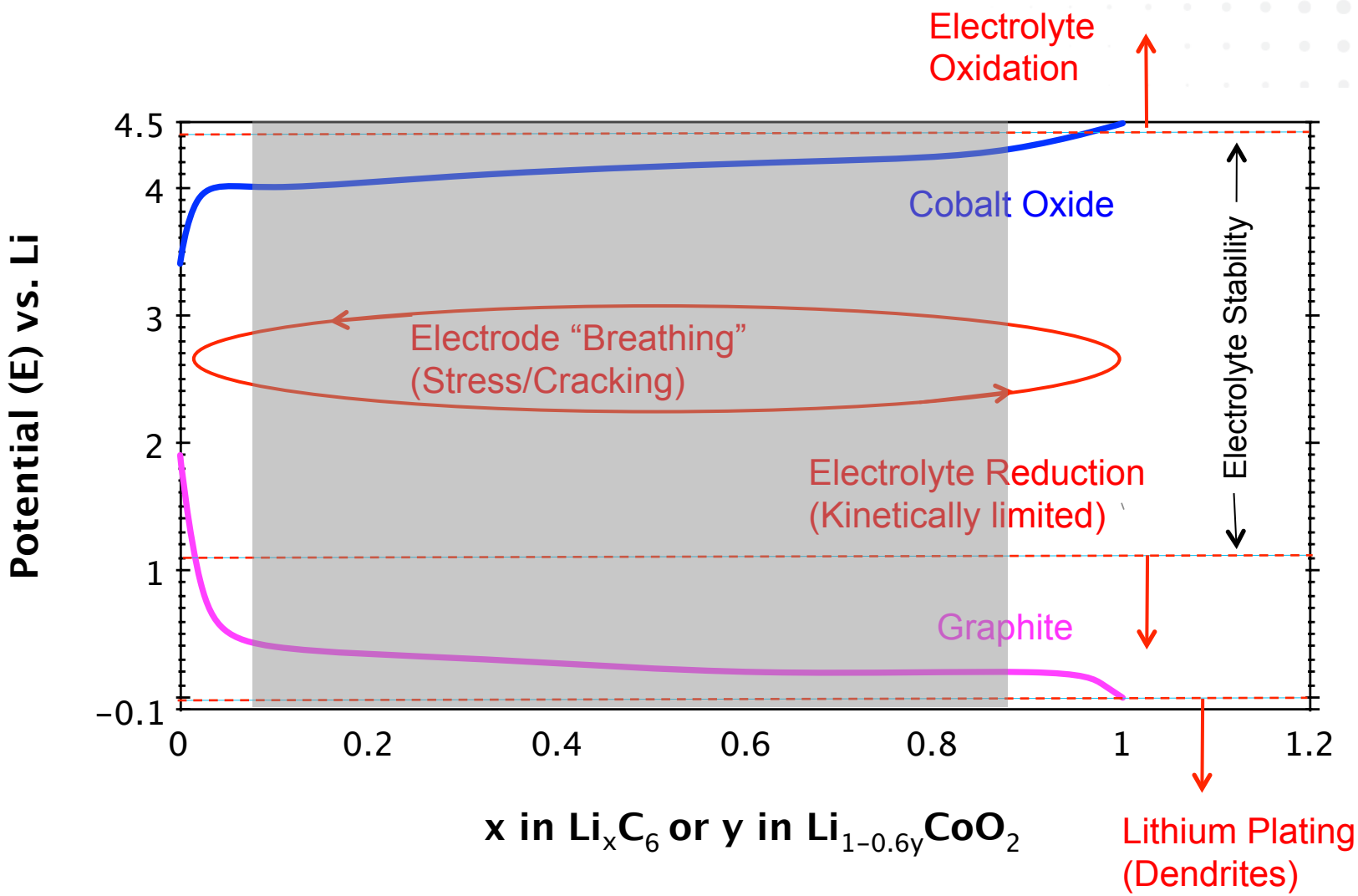

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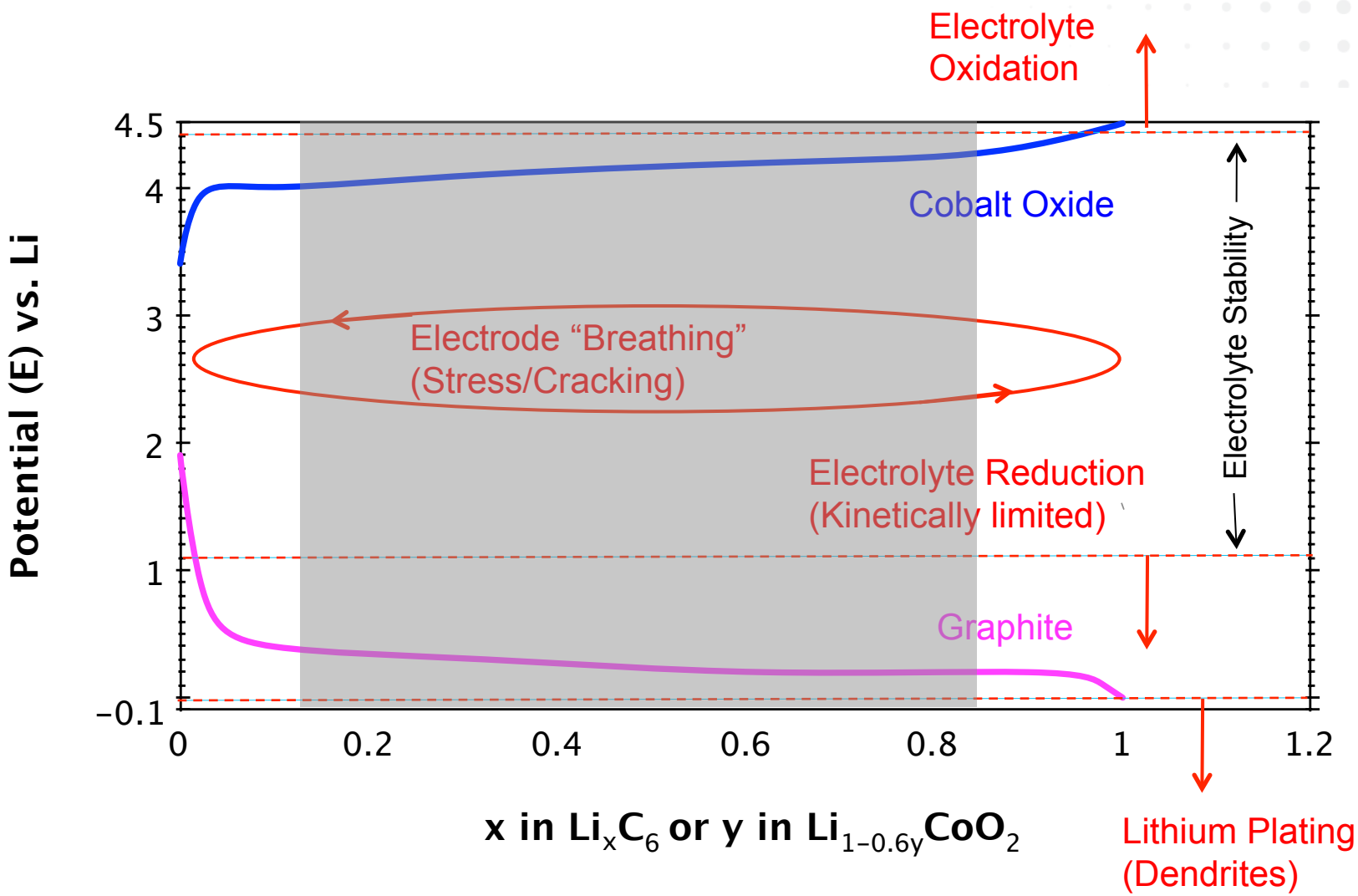

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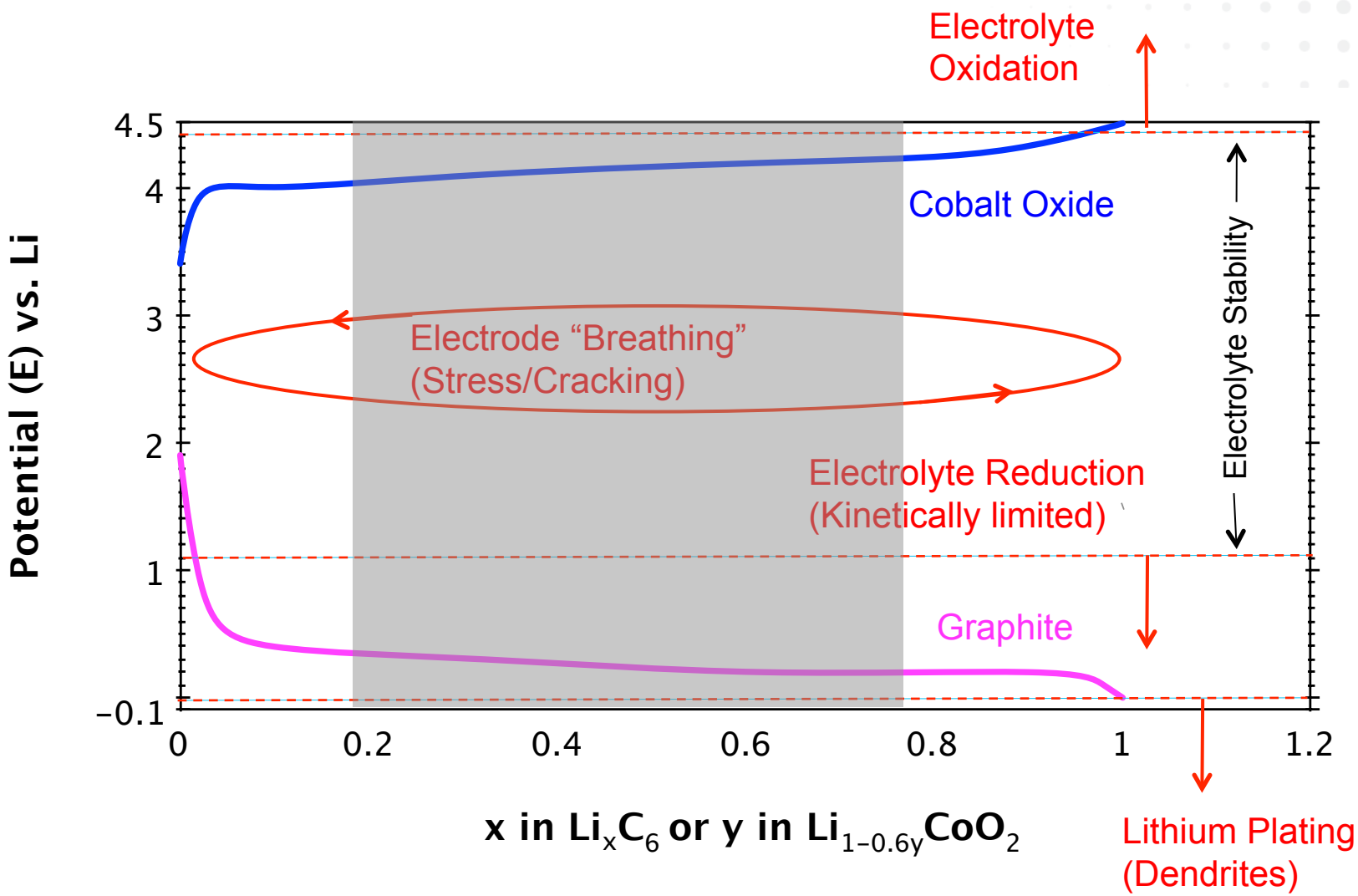


Capacity Lost | Power Loss | Short Circuit | Safety Risk

Removing the Blinders

Inside every cell

What we are protecting against

Electrolyte Oxidation

Electrode “Breathing” (Stress/Cracking)

Electrolyte Reduction (Kinetically limited)

Lithium Plating (Dendrites)

Internal Cell Defects

What we currently monitor

Temperature

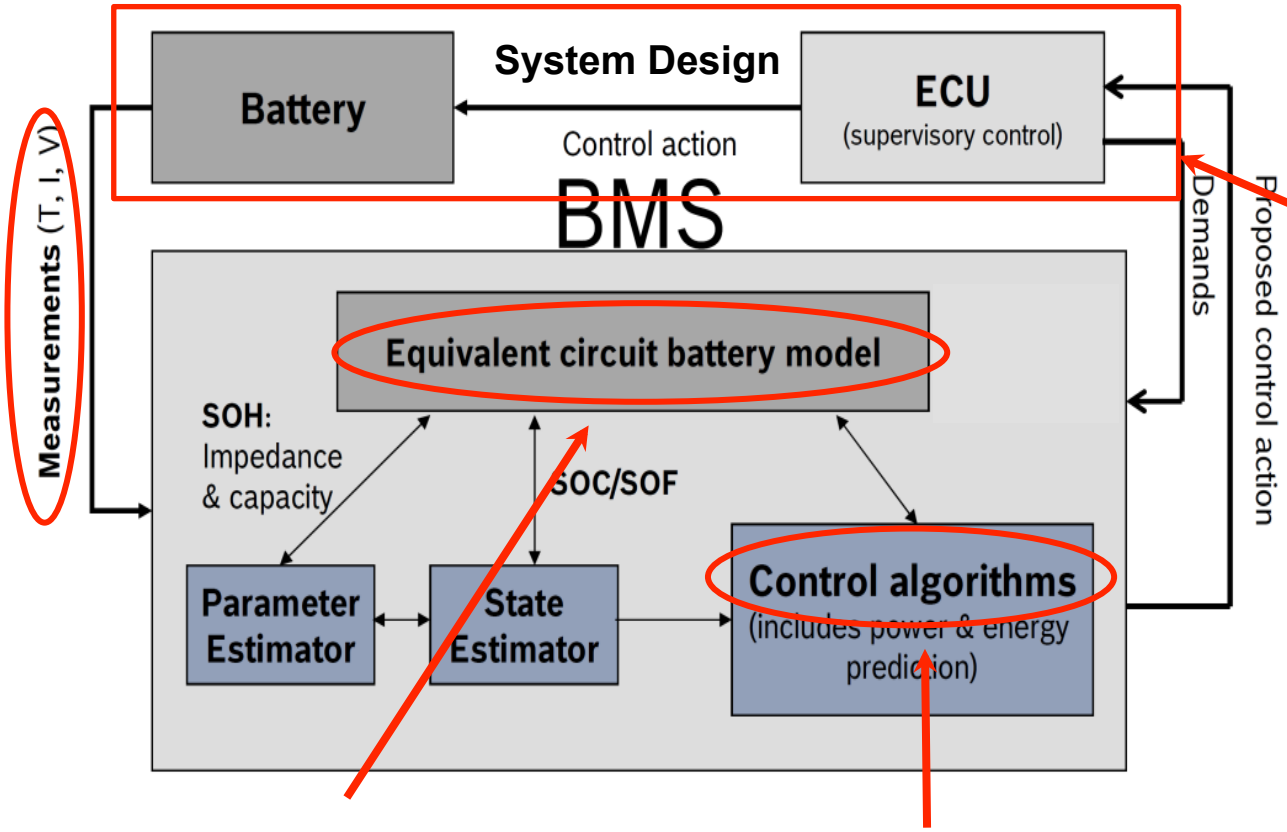
Voltage

Current

Groups of cells

Many opportunities for disruptive BMS innovation

1. Sensing provides only indirect state information with low spatial resolution



4. Little system flexibility : direct wiring, passive balancing, modular monitoring and control

2. Simple equiv. circuit models, heuristically validated, limited accuracy

3. Simple rule-based control imposes “static” and conservative constraints

Full Situational Awareness and Response

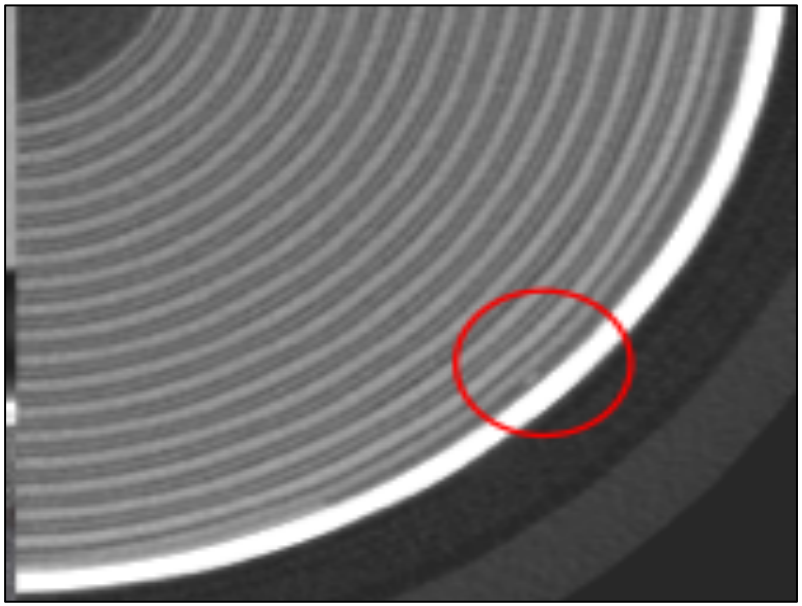
State of the cells
- Thermal
- Chemical
- Physical

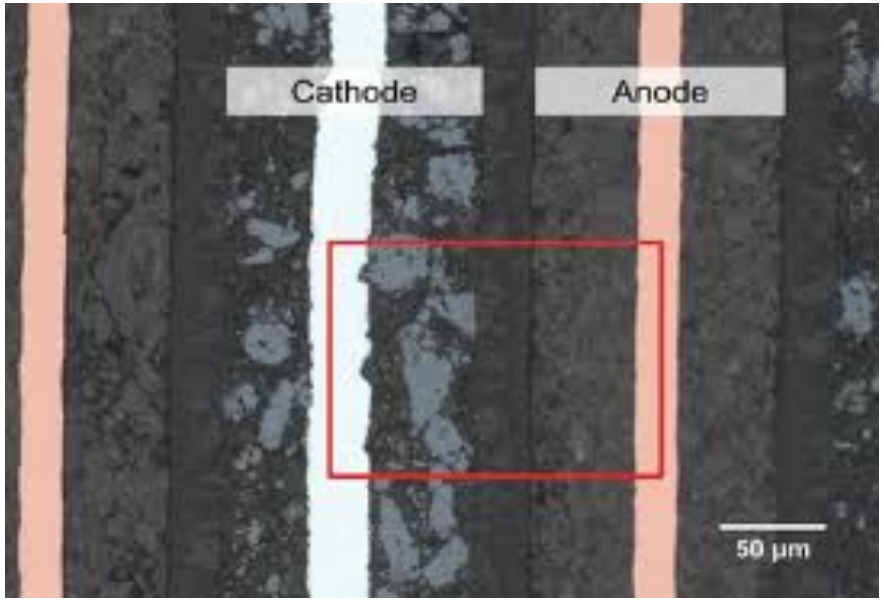
Operational state
- Weather
- Terrain
- Drive profile

Degradation
- Extent
- Modes
- Impact

Operational flex
- Level of control
- Hybridization
- Behavior / economics

Awareness and Response - Dendrites





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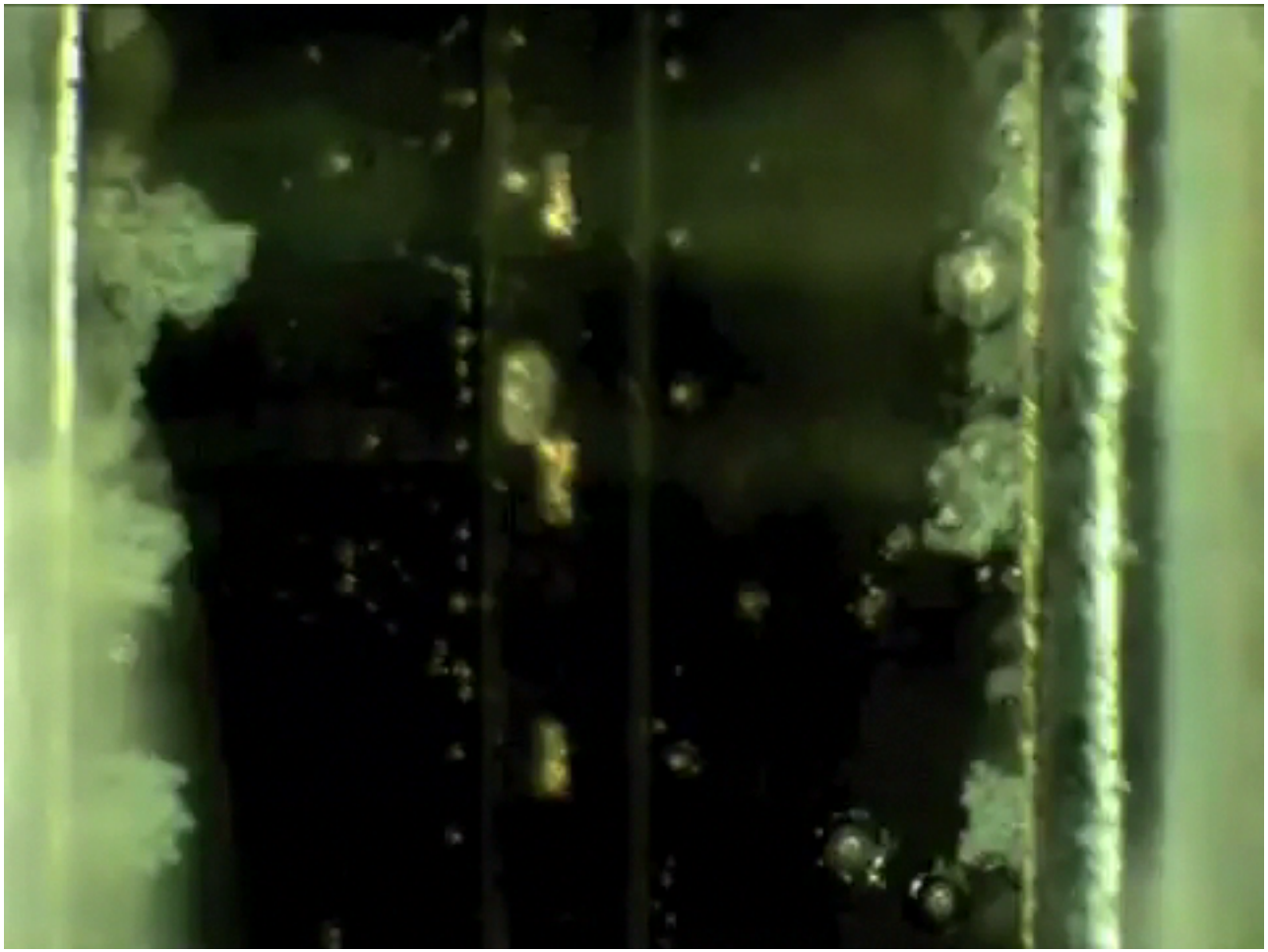

Steingardt, et. al

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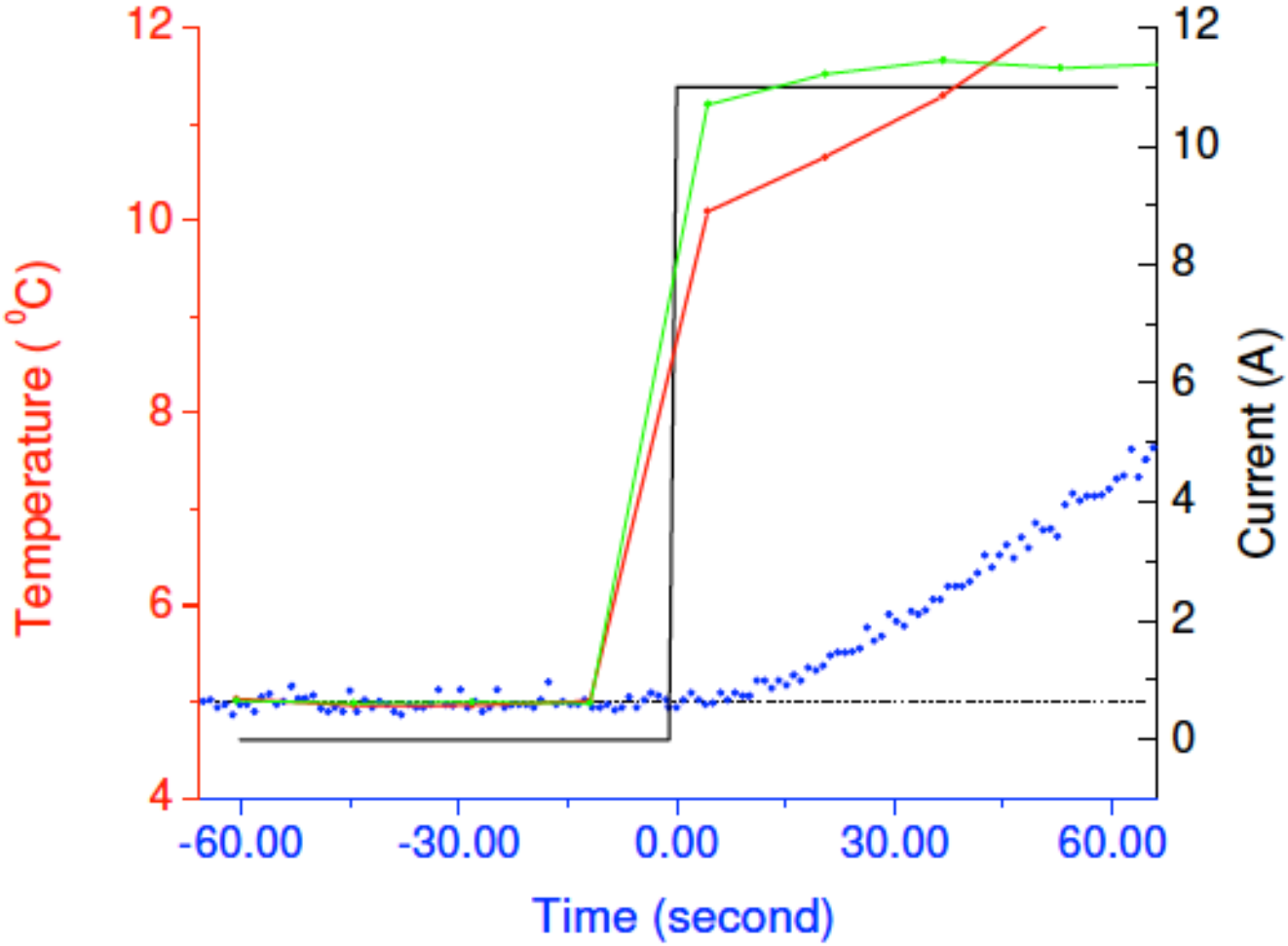
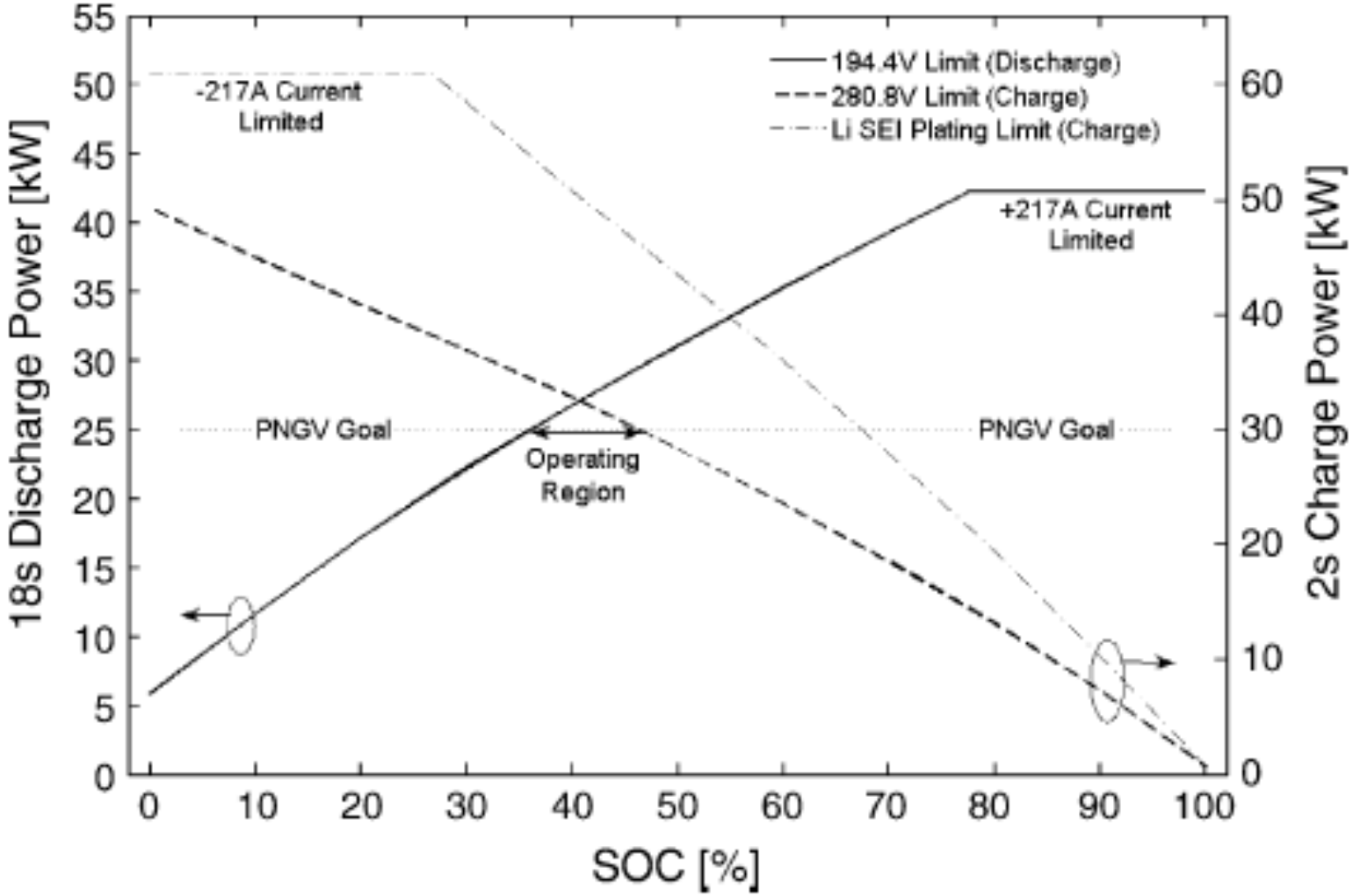
Awareness and Response - Temperature



Awareness and Response - Potential



K. Smith, C.-Y. Wang / Journal of Power Sources 160 (2006) 662–673

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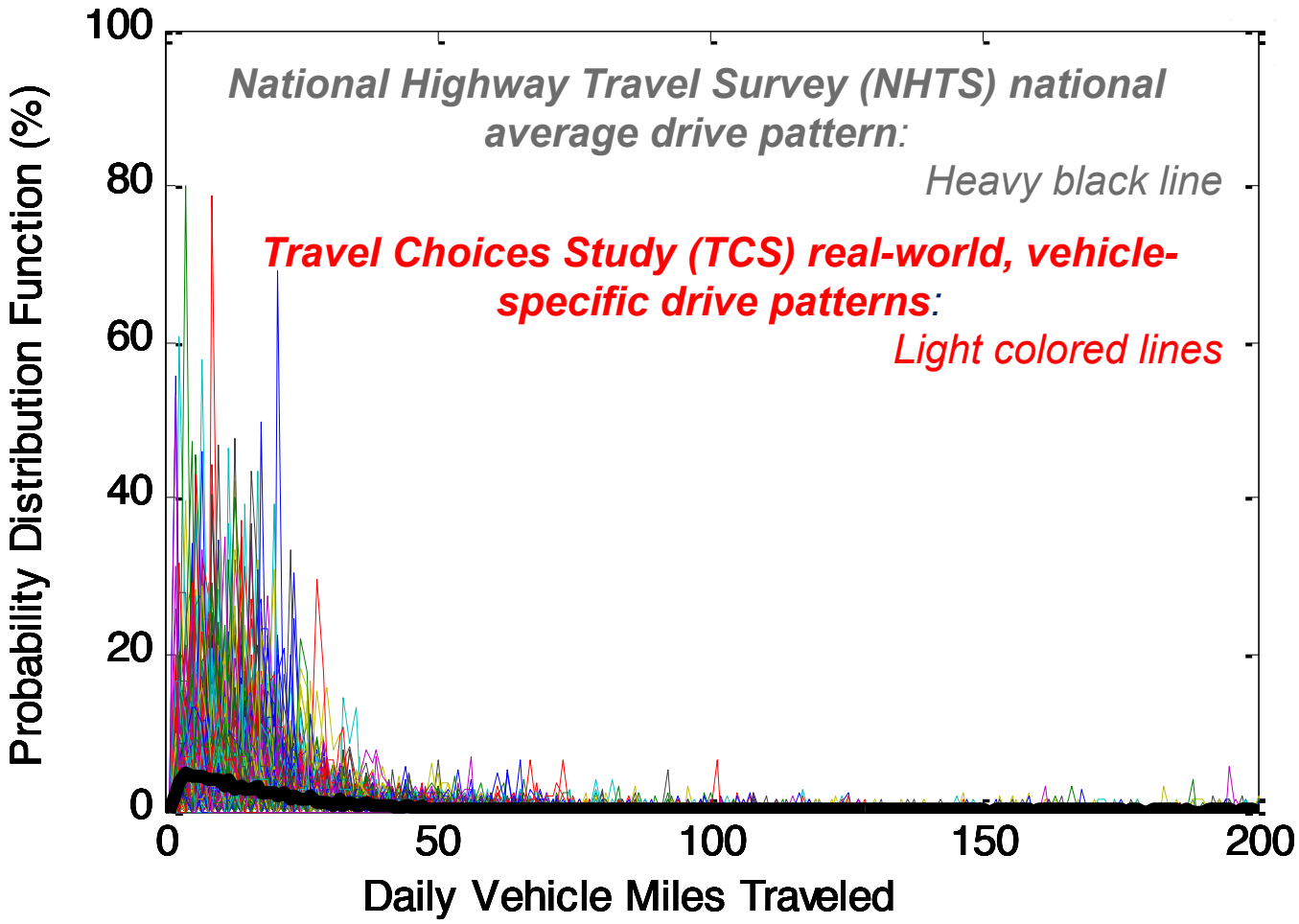
Awareness and Response - Load



Slide from Jeremy Neubauer, NREL

Awareness and Response - Load

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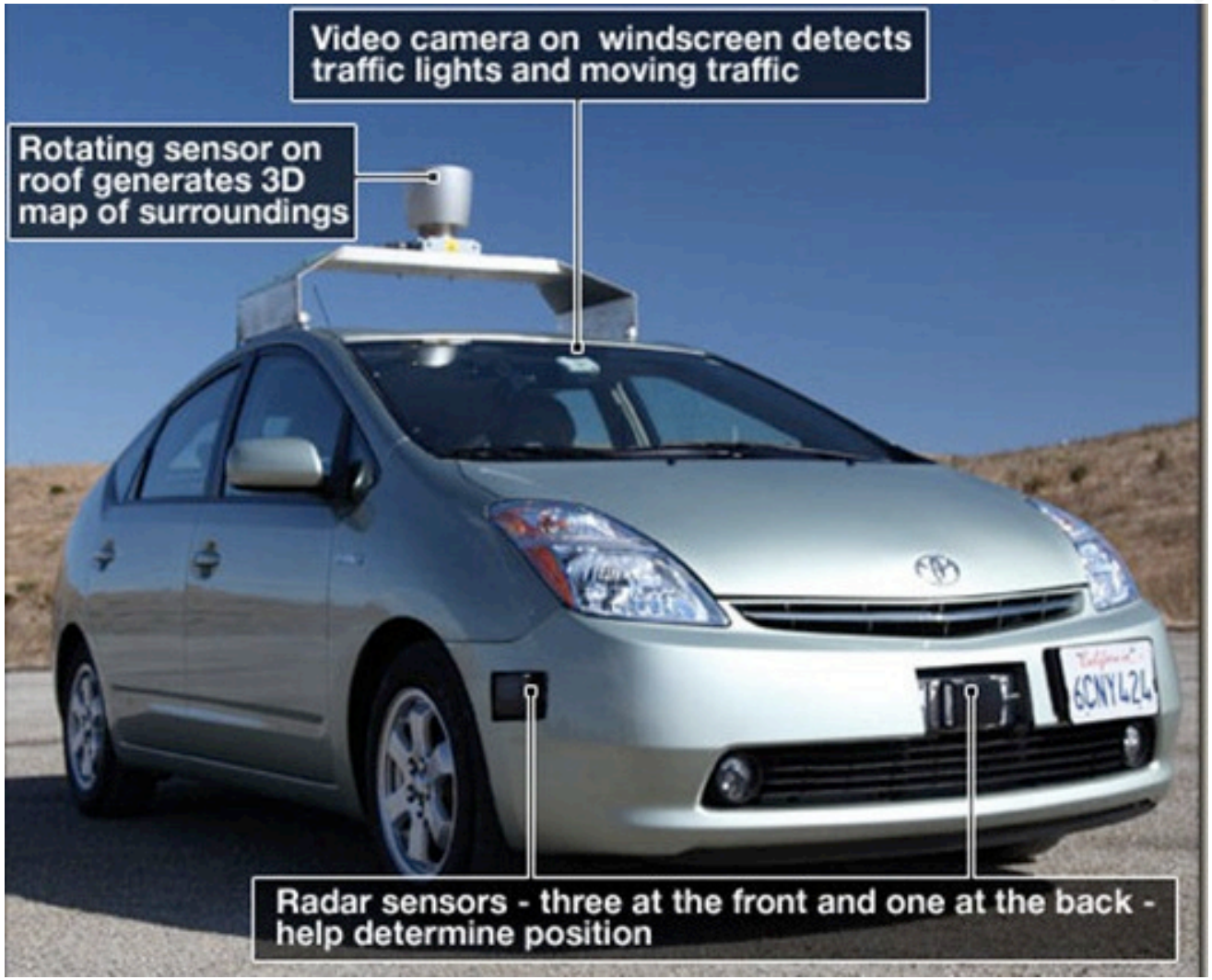
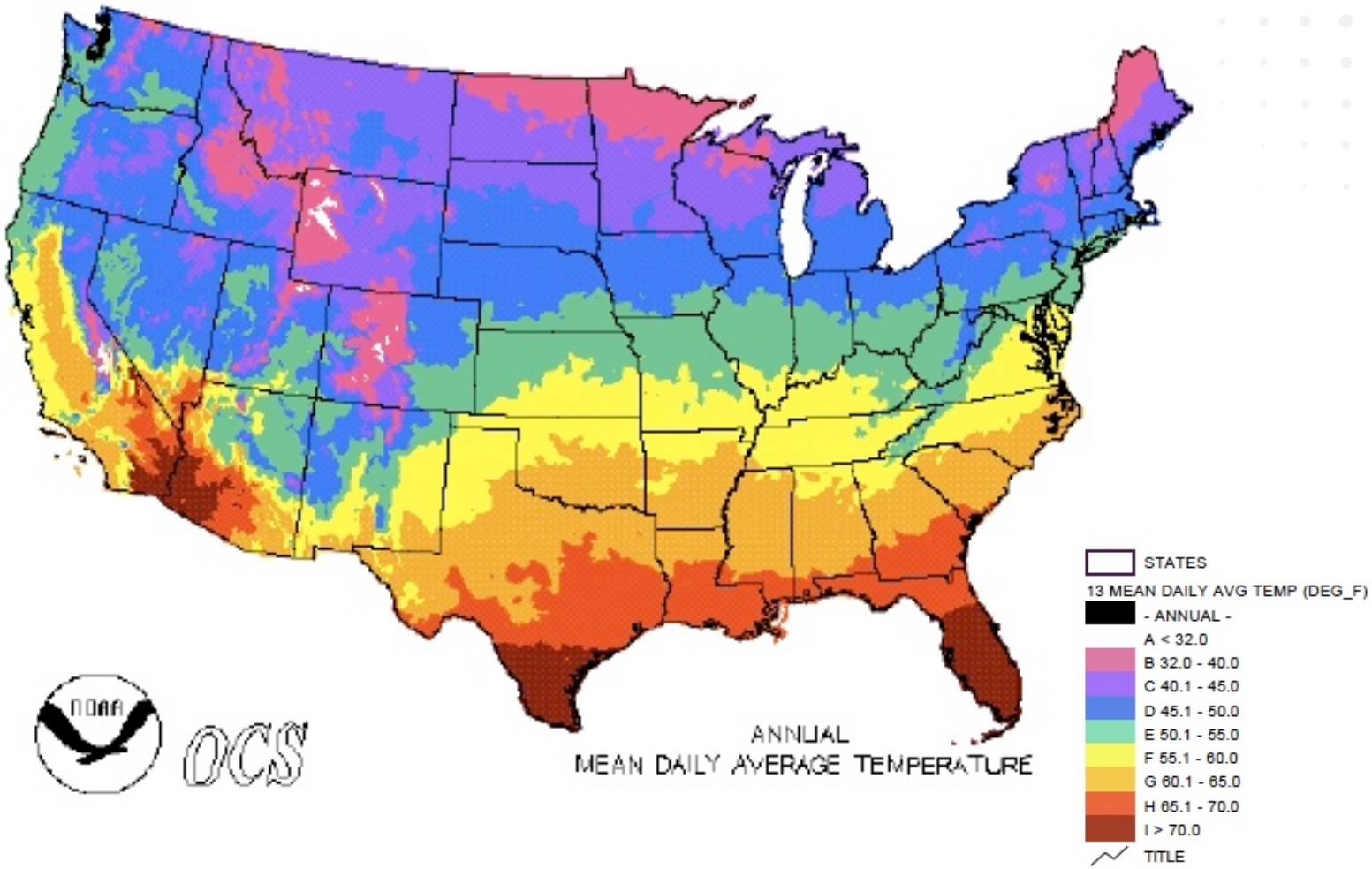


Awareness and Response - Environment



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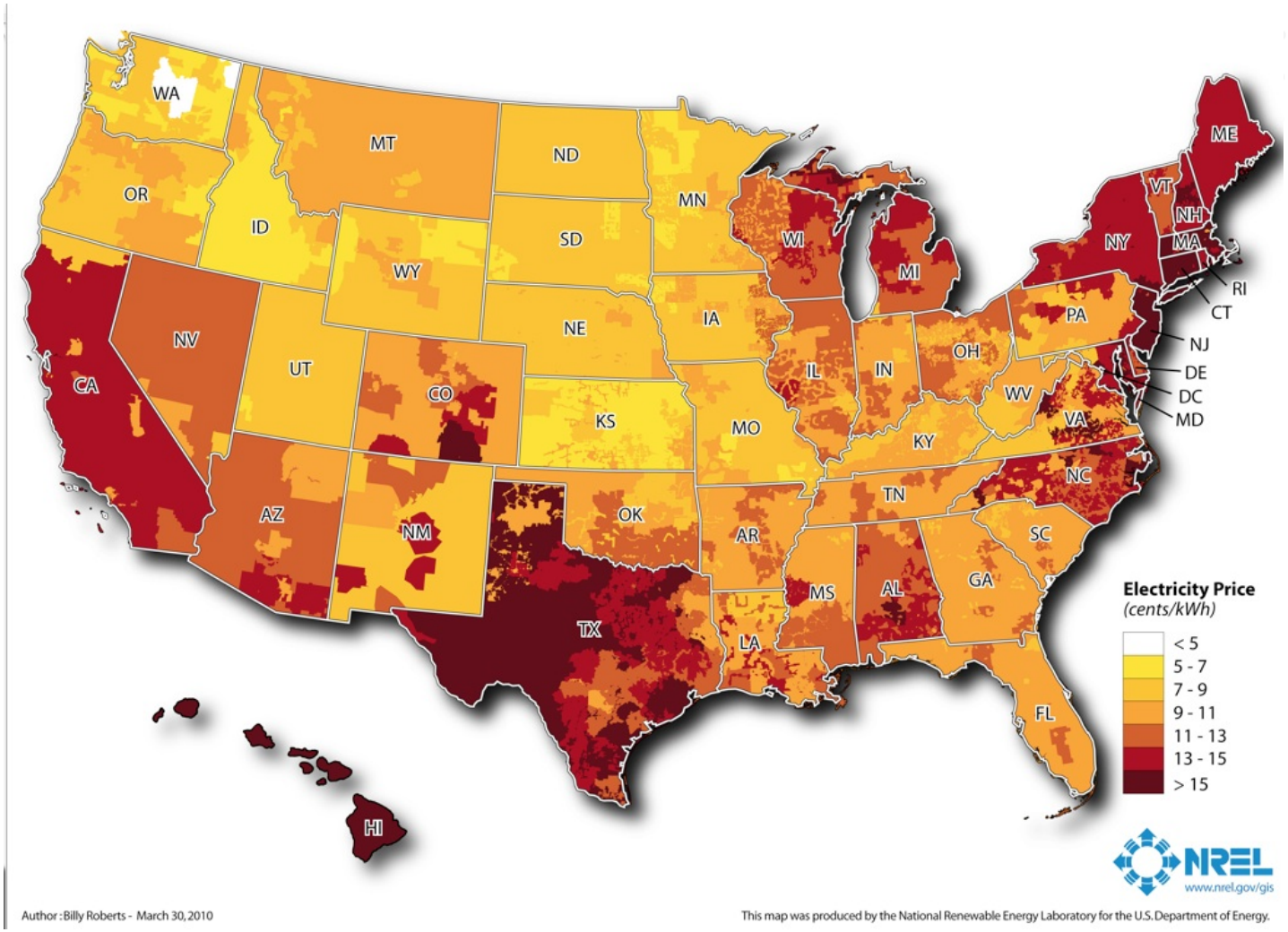

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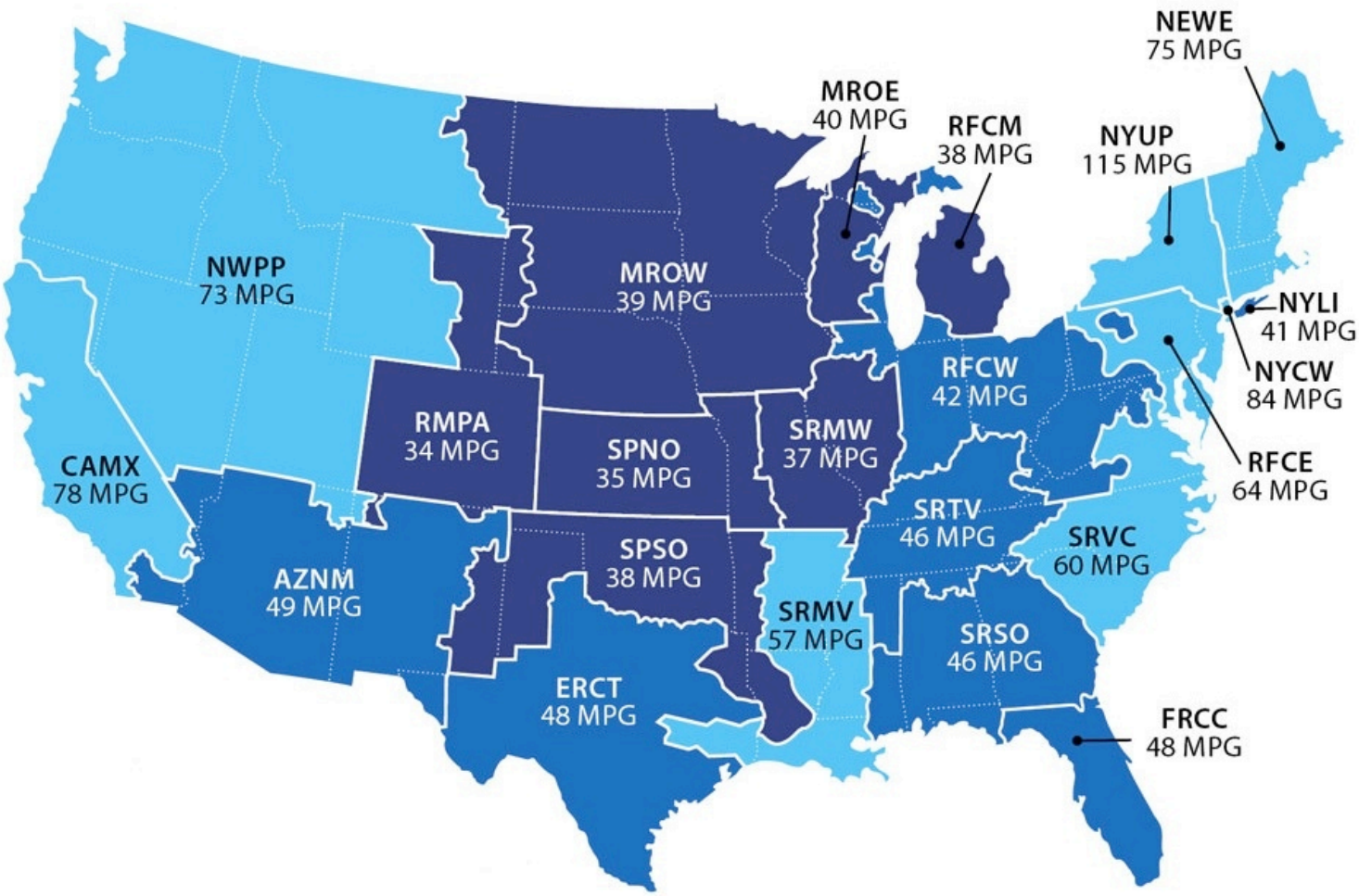

Awareness and Response – State of Health

Awareness and Response – State of Health

Awareness and Response – State of Health

AMPED Portfolio

1. Sensing

- Monitor **internal cell temperature** in real time?
- Monitor **intercalation strain** for SOC/SOH estimation?
- Monitor physical/chemical states with **optical sensing**?
- Track **gas signatures** of various degradation modes?

2. Modeling & controls

- Utilize **real-time physical state and degradation models** to optimize utilization and balancing control?

3. Systems

- Implement **cost effective cell-level power management?**
- Utilize **flexible power architectures** for diff'l diagnostics?
- Move to **Wireless communications** and control?
- Design **intra-cell thermal management** systems?

4. Diagnostics & prognostics

- Identify degradation/failure modes quickly with non-destructive **acoustic inspection?**
- Measure **high-precision columbic efficiency** on production cells and practical drive cycles?

Program Meeting Objectives

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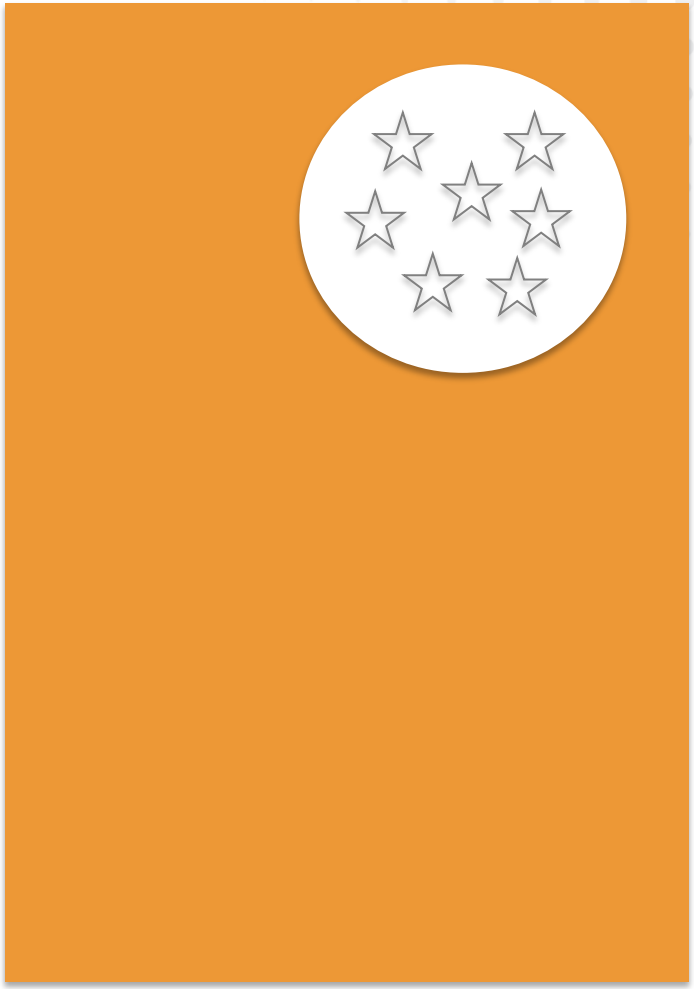


Kickoff Meeting Attendees

- 14 Teams
- Leads and partners
- Industry, edu, labs
- Multidisciplinary

- DOE Vehicle Tech
- DOE Storage Hub
- DOE Office Elec
- DOD (various)

- OEMs / suppliers
- Primarily automotive
- R&d, engin., market
- Other experts

- AMPED Prog Team
- Other Storage PMs and Tech-to-Market

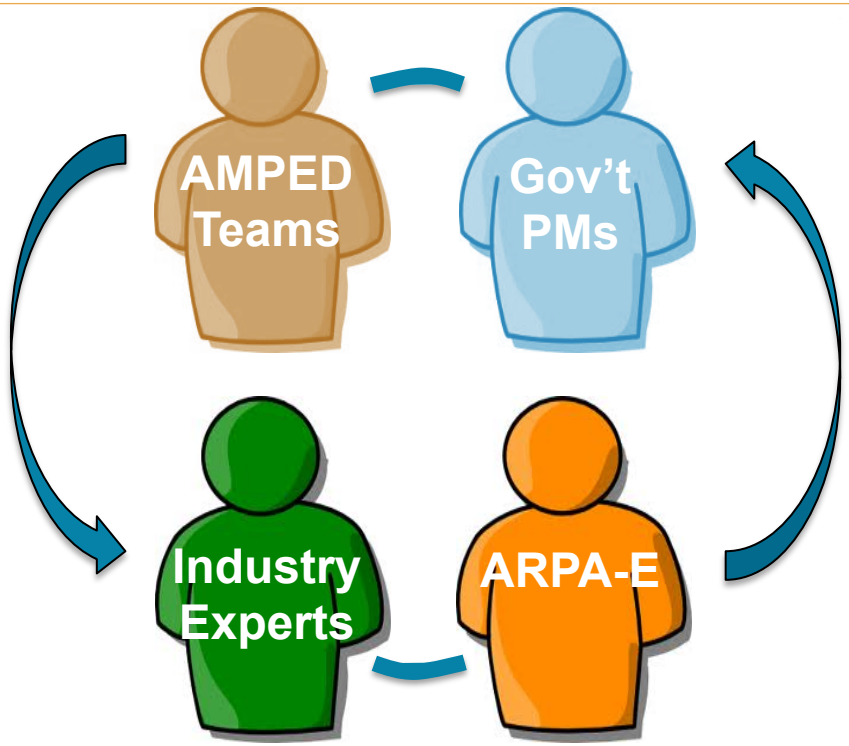
Kickoff Meeting Objectives

Knowledge

Cross-disciplinary learning about issues and opportunities

Skills and industry insights for researchers & gov't

Introduction to AMPED R&D for industry and gov't



Community

Relationships

Potential collaborations between research teams

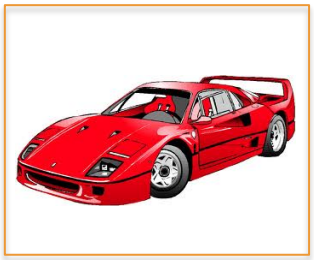
Industry engagement to improve and gain access to research

Future development opportunities within industry and gov't

Agenda

Tuesday

Cross discipline tutorials



XEV design tutorial

AMPED project overviews

Industry reactions

Networking reception

Wednesday

Cost-benefit discussion

BMS design safety tutorial

AMPED for Defense

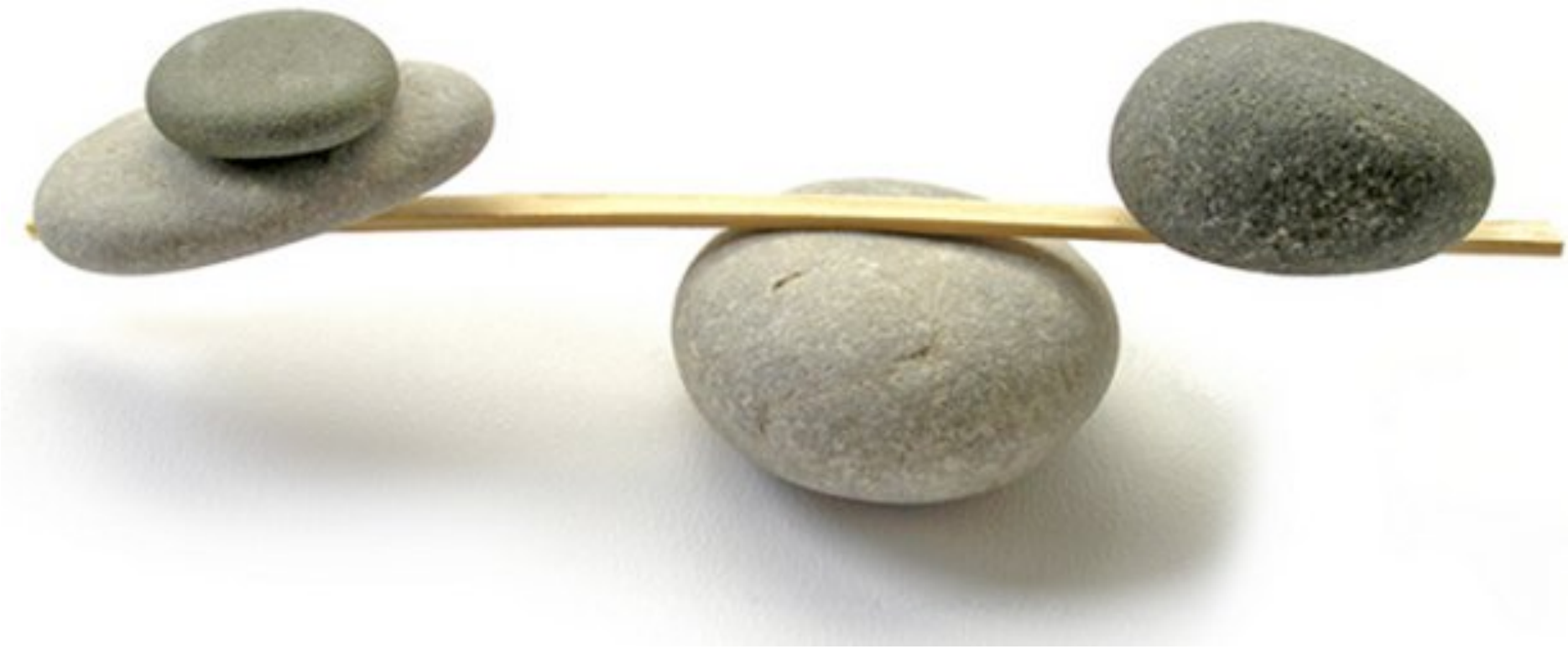
DOE context for AMPED

Expanding the community

In Your Packets

- Agenda
- Facebook of attendees
- AMPED project quad charts
- Project feedback forms
- Your top AMPED related literature list
- Your top AMPED related conference list
- Evaluation form for this event

Striking the right balance…



Final guidelines…