



The University of Texas at Austin

Center for Electromechanics

2016 ADVISORY PANEL

21ST CENTURY GRID

Robert E. Hebner, Ph.D.

Center for Electromechanics

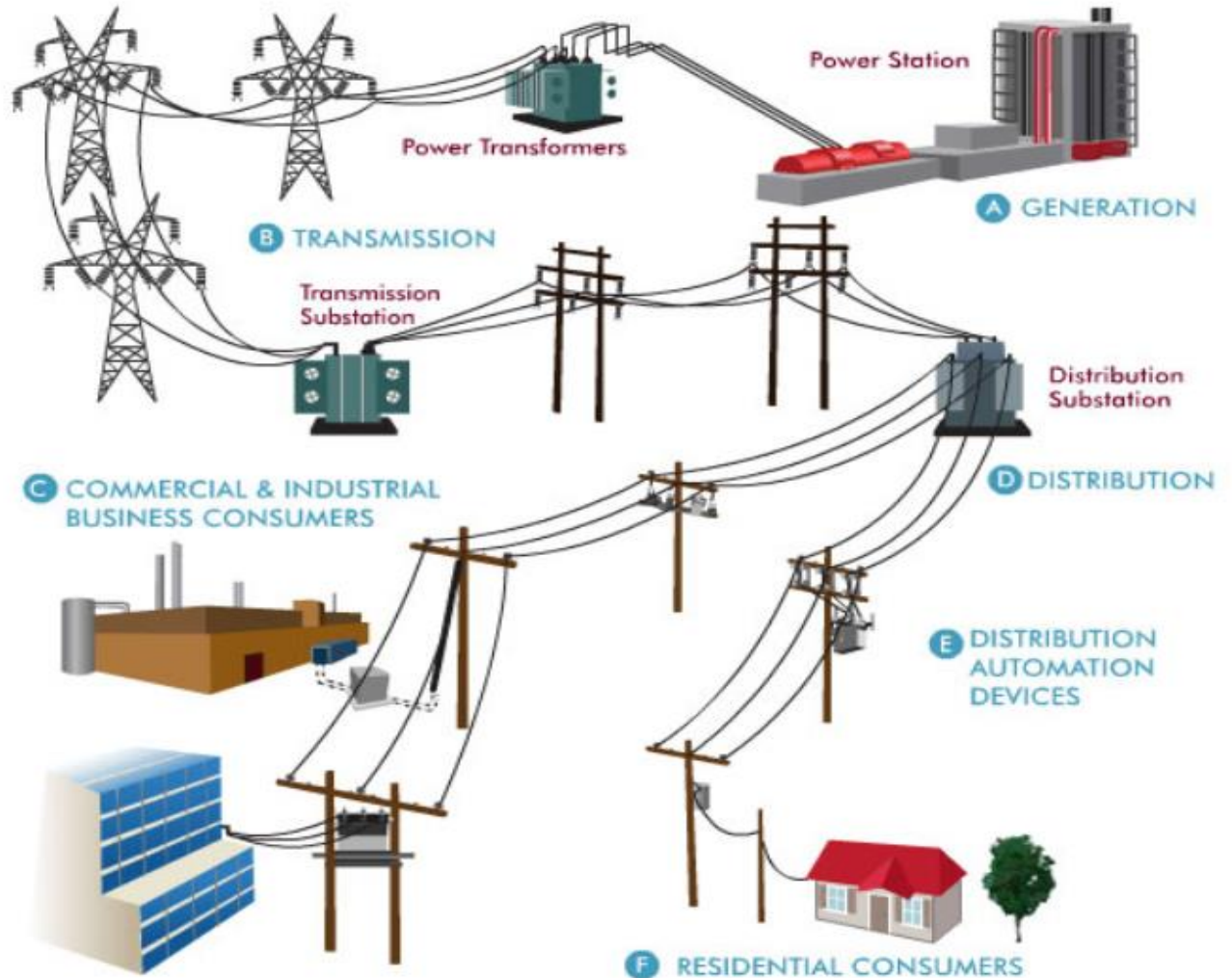
The University of Texas at Austin

5/10/2016

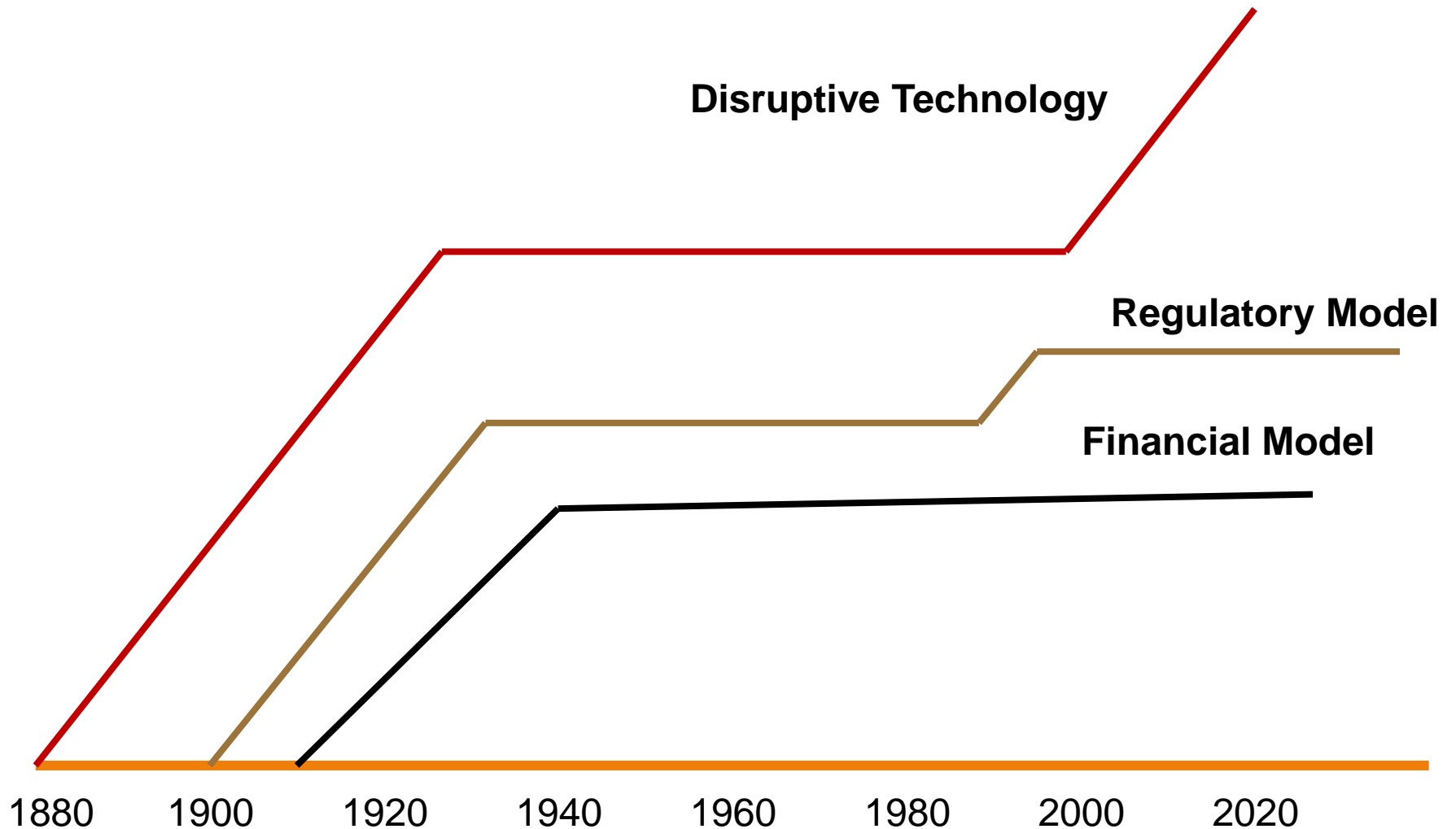
Legacy Grid

Too good to waste

Spoiler alert:
Microgrids can make it better



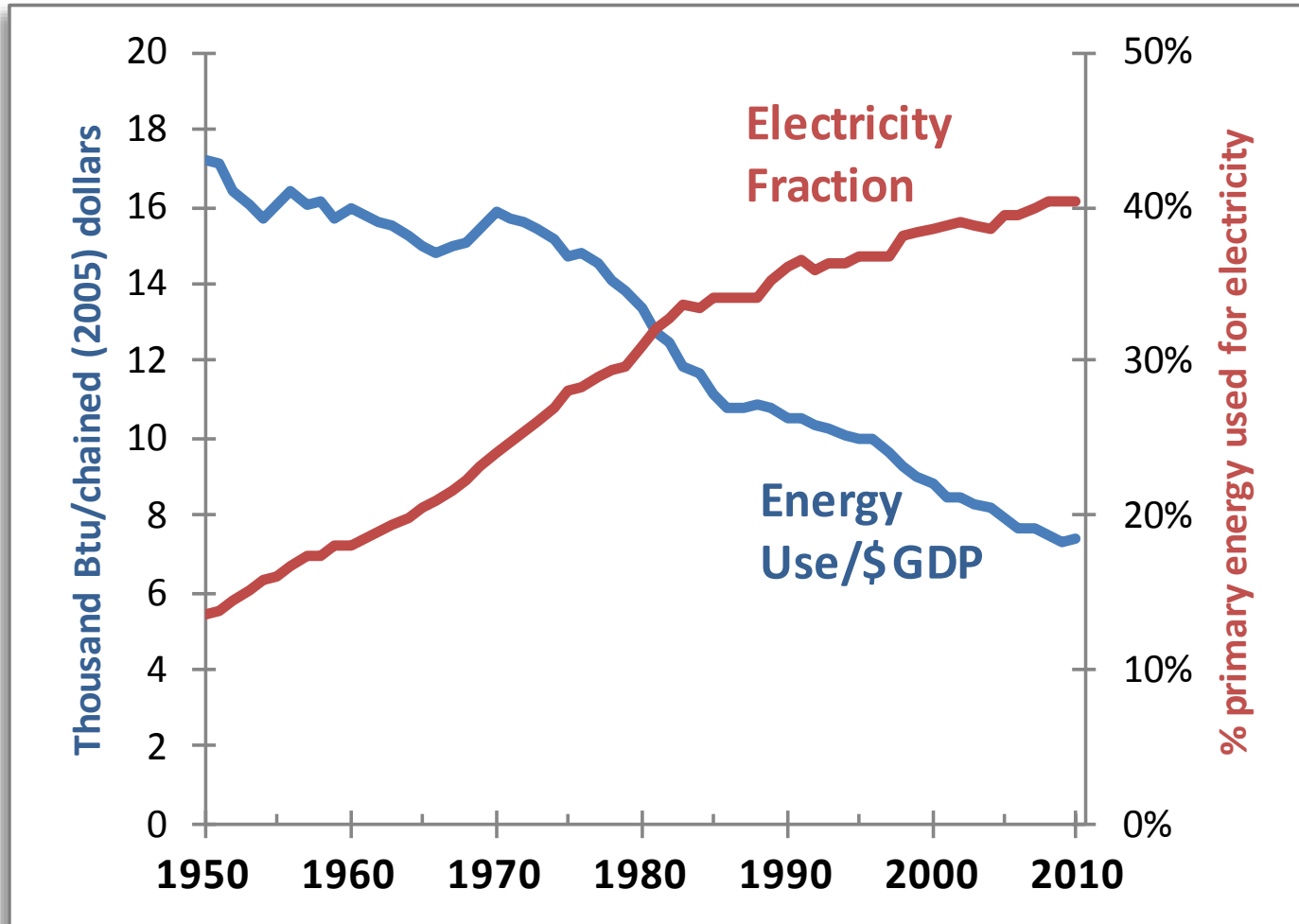
Technology Is a Key Reason Why 21st Century Grid Will Be Different



Relevant Technology Megatrends

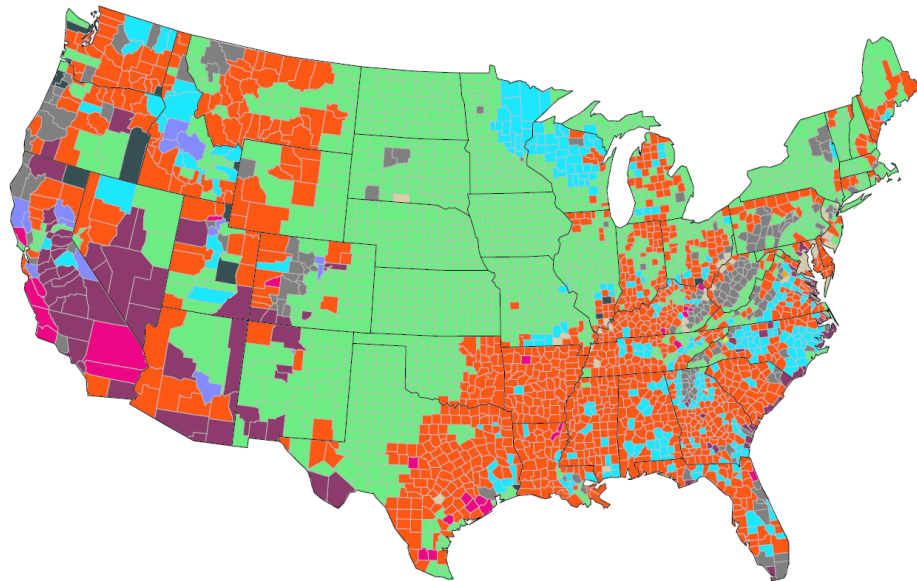
- **The Internet of Things**
- **Big Data analytics**
- **Power sources that violate economy of scale**
- **Wide band gap semiconductor technology**
- **Nanotechnology**

Technology Advances Linked to Significance of Electricity

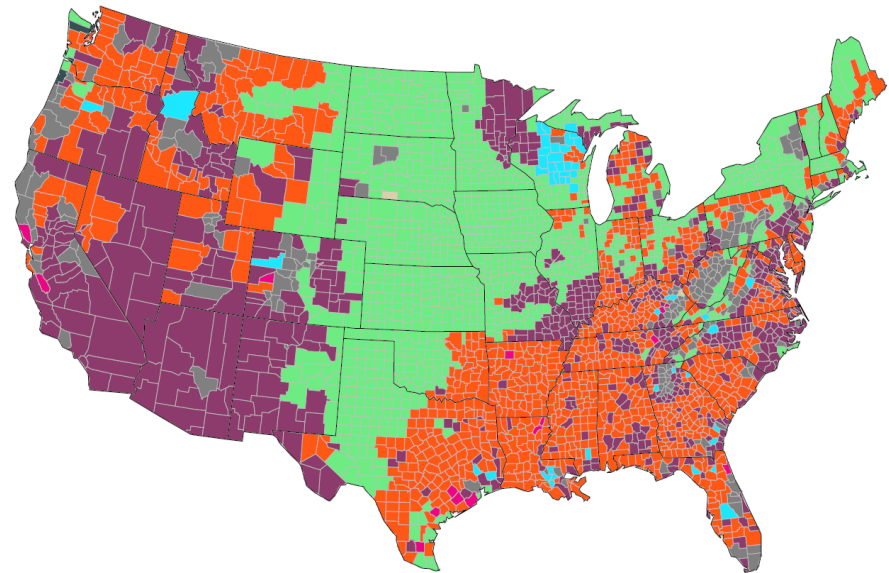


Impact of Technology – An Example

From paper under review – do not redistribute



- | | | | |
|---------------------------|---------------------------|---------------------|------------------------------|
| ■ Coal (BIT) (n = 1) | ■ Coal (SUB) CCS (n = 38) | ■ NGCC CCS (n = 0) | ■ Solar PV, resid. (n = 202) |
| ■ Coal (BIT) CCS (n = 17) | ■ CSP (n = 16) | ■ NGCT (n = 27) | ■ Solar PV, utility (n = 97) |
| ■ Coal (SUB) (n = 2) | ■ NGCC (n = 1132) | ■ Nuclear (n = 294) | ■ Wind (n = 1284) |

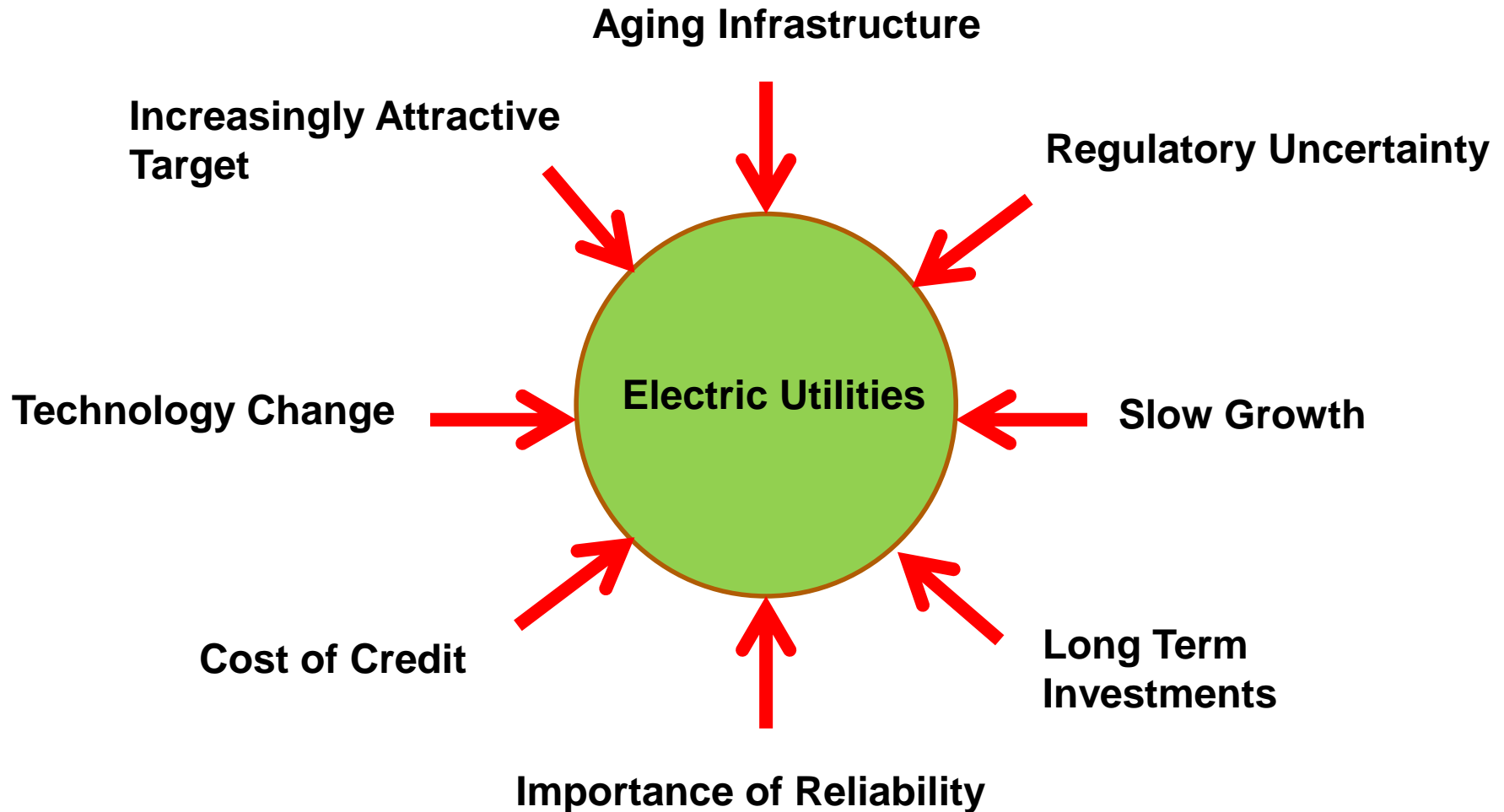


- | | | | |
|--------------------------|--------------------------|--------------------|-------------------------------|
| ■ Coal (BIT) (n = 0) | ■ Coal (SUB) CCS (n = 2) | ■ NGCC CCS (n = 0) | ■ Solar PV, resid. (n = 222) |
| ■ Coal (BIT) CCS (n = 5) | ■ CSP (n = 0) | ■ NGCT (n = 15) | ■ Solar PV, utility (n = 668) |
| ■ Coal (SUB) (n = 0) | ■ NGCC (n = 1091) | ■ Nuclear (n = 49) | ■ Wind (n = 1058) |

Lowest cost plant to build today

Lowest cost plant to build with \$1/watt solar

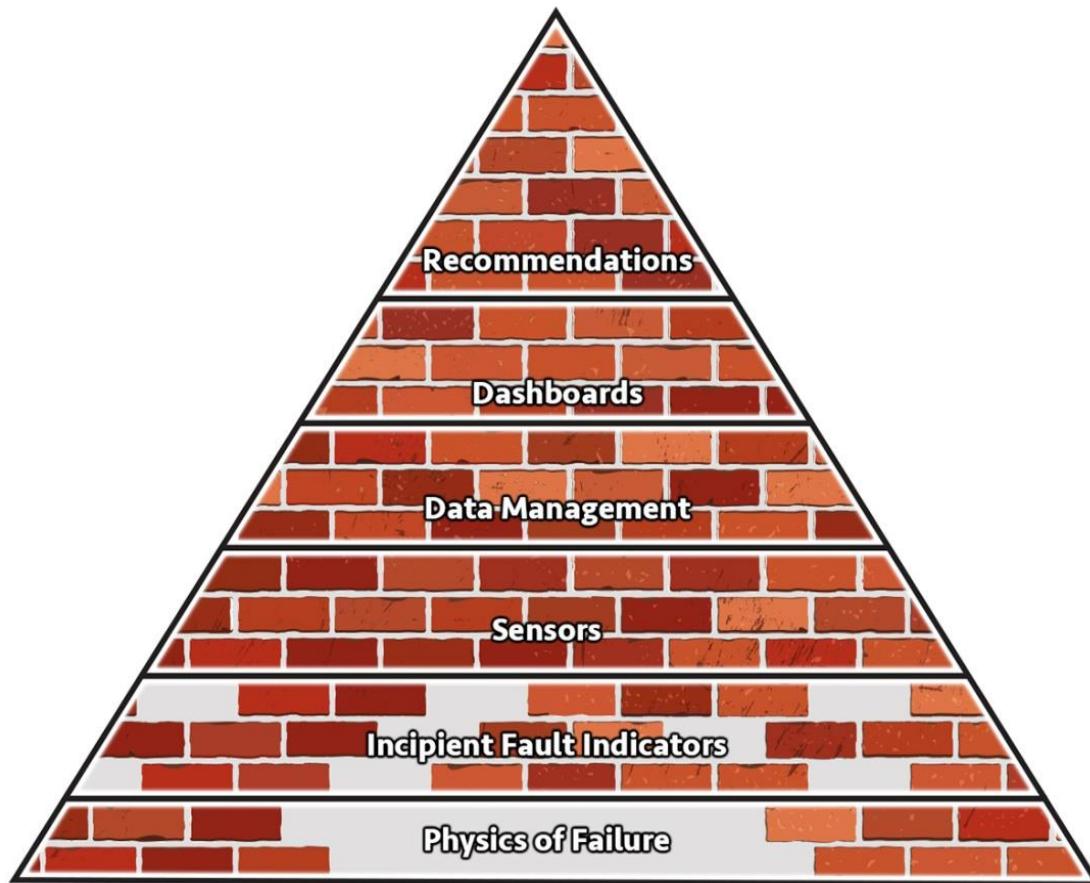
Technology Changes Stimulating Business Changes in a Highly Constrained Business Space



Important Technology Opportunities for CEM

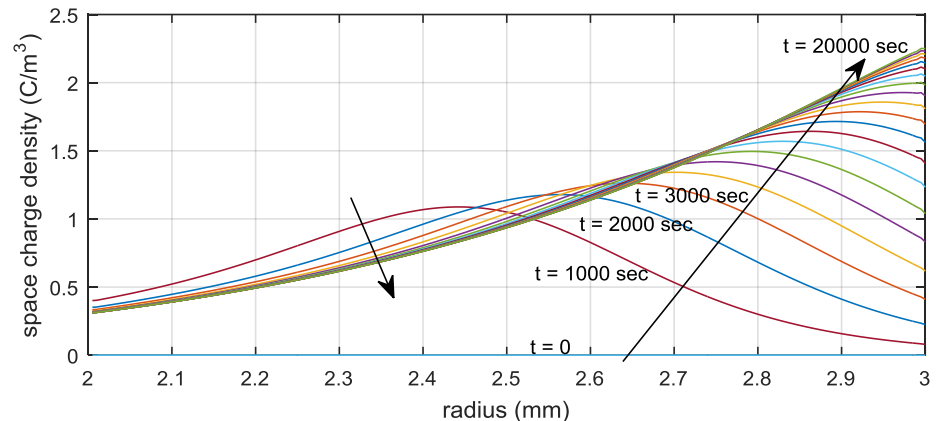
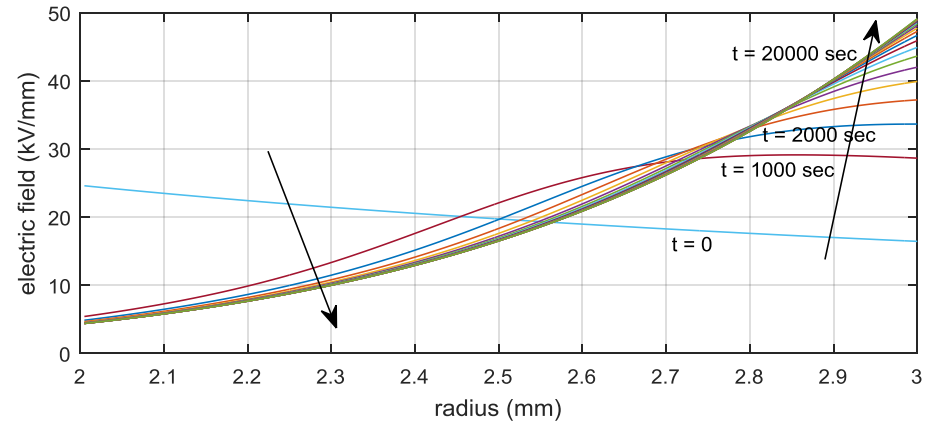
- **Model based control (observer-based control)**
 - **Asset management**
 - **Cybersecurity**
- **Power electronics**
- **Smaller power system components**
- **AC/DC hybrid microgrids**
- **Asset management**

Thoughts on Asset Management



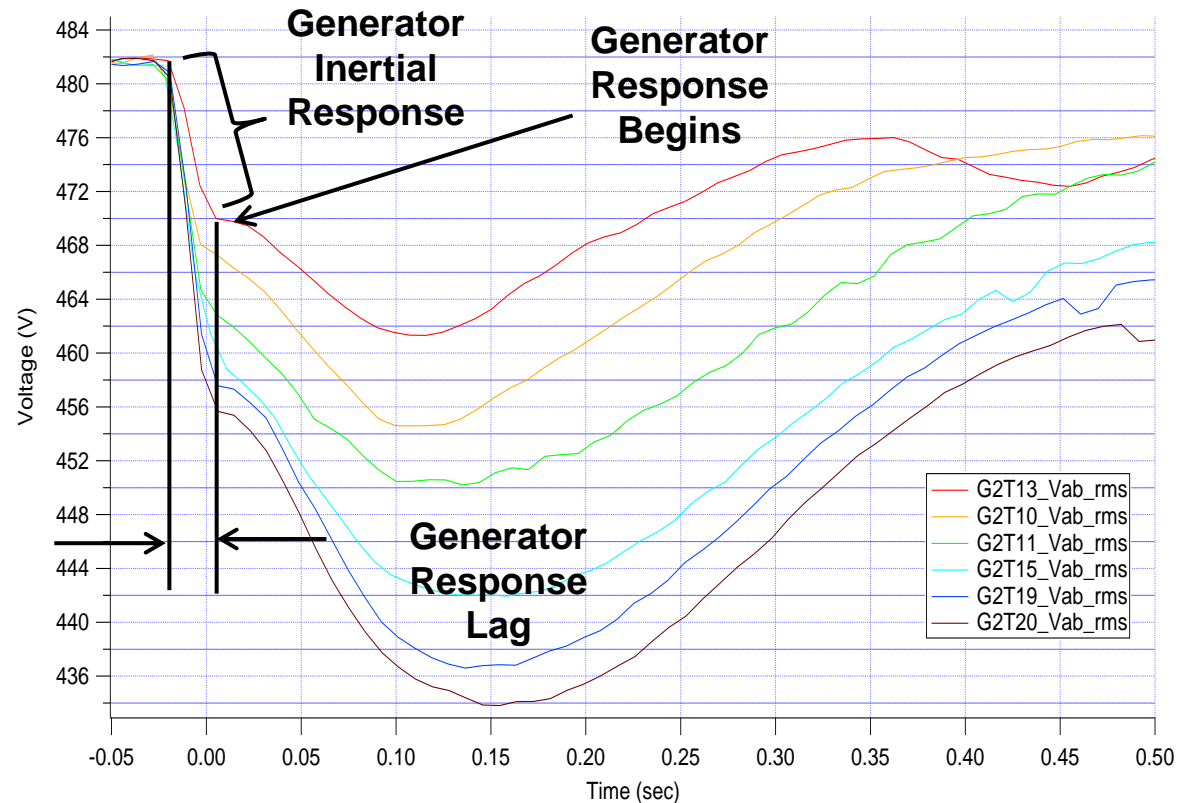
Current Projects – Cable Testing

- **Partial discharge centric**
 - **Nondestructive**
 - **Long history**
 - AC has computer-aided interpretations
 - DC is more complex
- **Nanotechnology producing interesting new materials**
 - **Improved thermal conductivity**
 - **High glass transition temperature**
 - **High breakdown strength**



Current Projects – Microgrid Transients

- Assessing transient response of microgrids
 - Theoretically
 - Real-time hardware-in-the-loop simulations
 - Experimentally
 - MW scale microgrid
- Response depends on system inertia, ramp rates and control speed



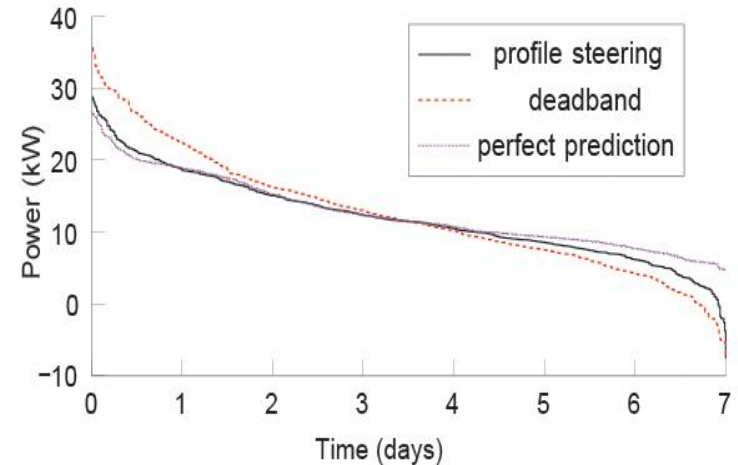
Current Projects – Wind Turbine

- **Trying to drive down the cost of wind power**
- **International effort**
- **Eliminate gear box**
- **Superconducting generator**



Current Projects – Load Management

- **Utilities and consumers play well together with technology as the aggregator**
 - Accelerated by IoT
 - Local frequency limits need for hierarchical information transfer
- **Negotiation among utility and consumer loads**
 - Constraints set by consumers and utilities
- **Interesting inference from Pecan Street data**
 - Diurnal usage in a single house is a poor predictor of usage in that house in subsequent days
 - Diurnal usage in 10 houses is a good predictor of usage in those houses in subsequent days



Current Projects – DC Data Center

- **Collaboration with**
 - NEDO
 - NTT
 - TACC
 - CEM
 - With participation from HP
- **Determining the advantages of dc recognizing**
 - Native load is dc
 - Emerging sources are dc
 - Back-up batteries are dc
 - Legacy grid is ac



Desired Growth Areas

- **Based on technical need, not available funding**
 - **Physics of failure**
 - Asset management
 - New product assessment
 - **Control approaches**
 - Model-based control
 - Control-storage-load management trades
 - Including hardware-in-the-loop controls testing of small power systems
 - **Technology to reduce generation cost at smaller size**
 - Solar
 - Wind
 - NG generators
 - SMRs
 - **Power nodes**
 - Distribution aggregation/disaggregation

Takeaway

- **CEM is contributing to the definition of the 21st century grid technically**
 - **Appropriately far term for academia**
- **Legacy grid is important and we need to keep it technically up to date**
 - **CEM would like to contribute more**
- **Opportunities for improvement far exceed national funding**