Great Lakes Symposium
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“Return on Investment for Resilient Renewable Energy Grids”

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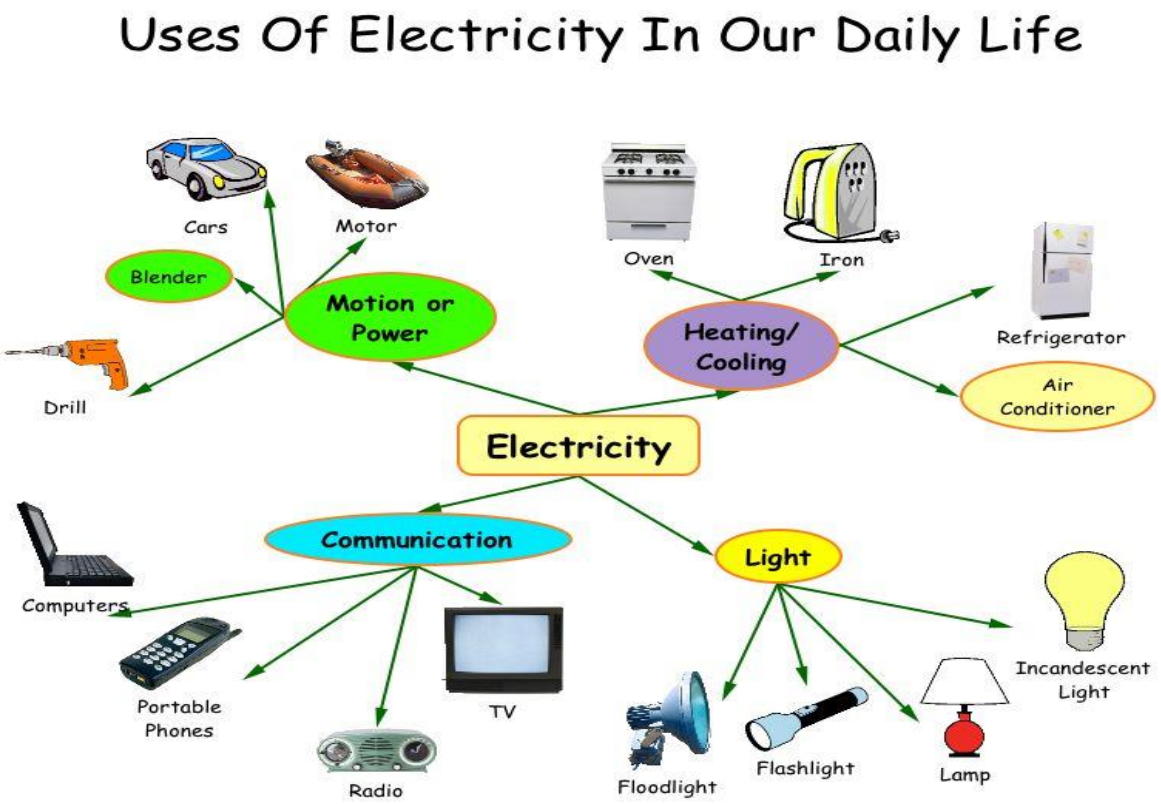
IEEE PES Power & Energy Society®

Life's Essentials

- Clean Air
- Clean Water
- Safe Food
- Shelter



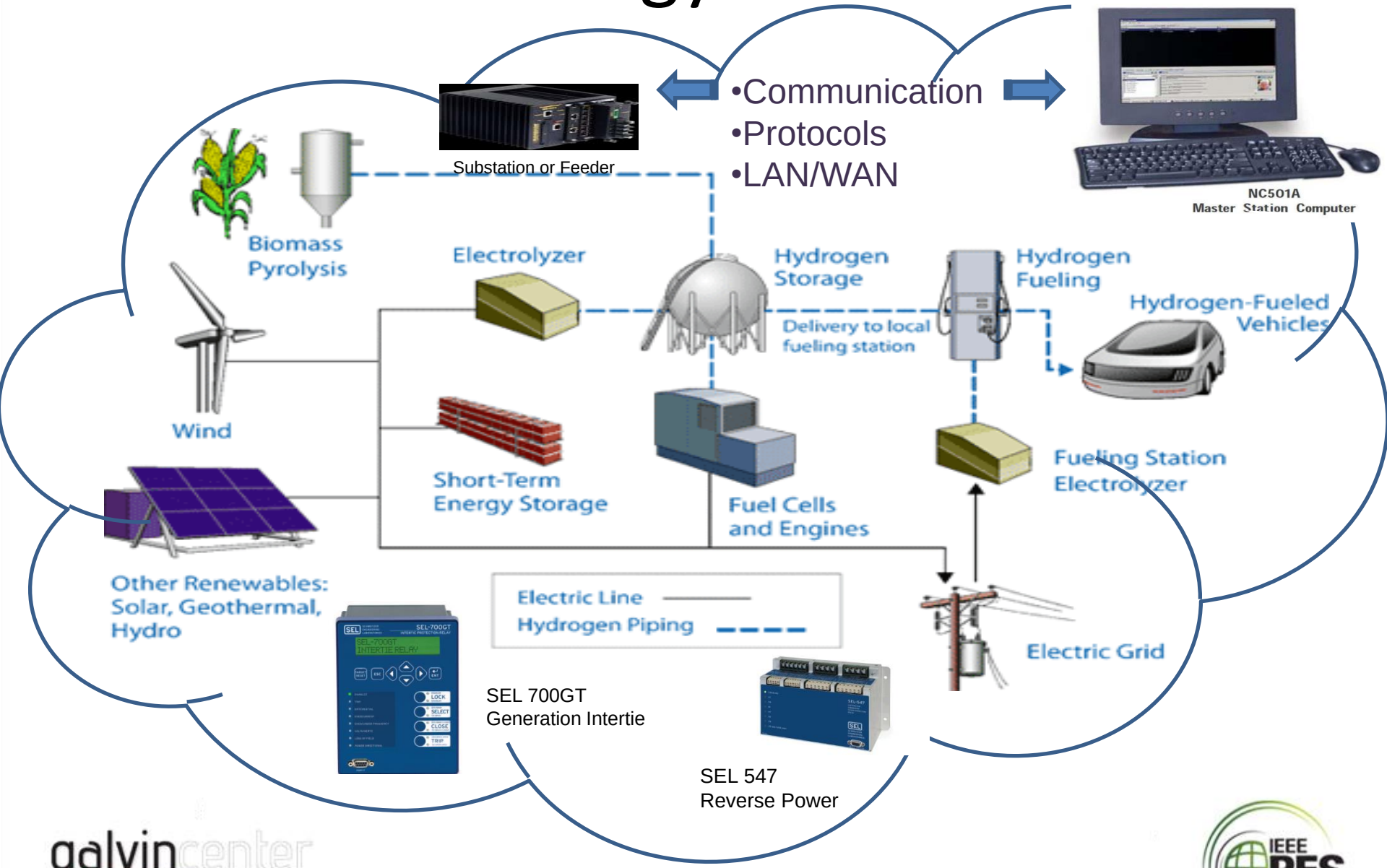
- **Electricity** – Resilient 24/7 supply achieved by automation

Company Profile

- 107 Years of industry experience
- Scalable automation
  - Reclosers
  - Switchgear
    - pad mount
    - vault
- Current Limiting Protectors (CLIP)
- Cable Accessories

- 50 Years of Industry Experience
- SCADA and DMS software
- DMS software
- Advanced solution modules
  - FDIR
  - CVR
  - Load flow

Renewable Energy Automation



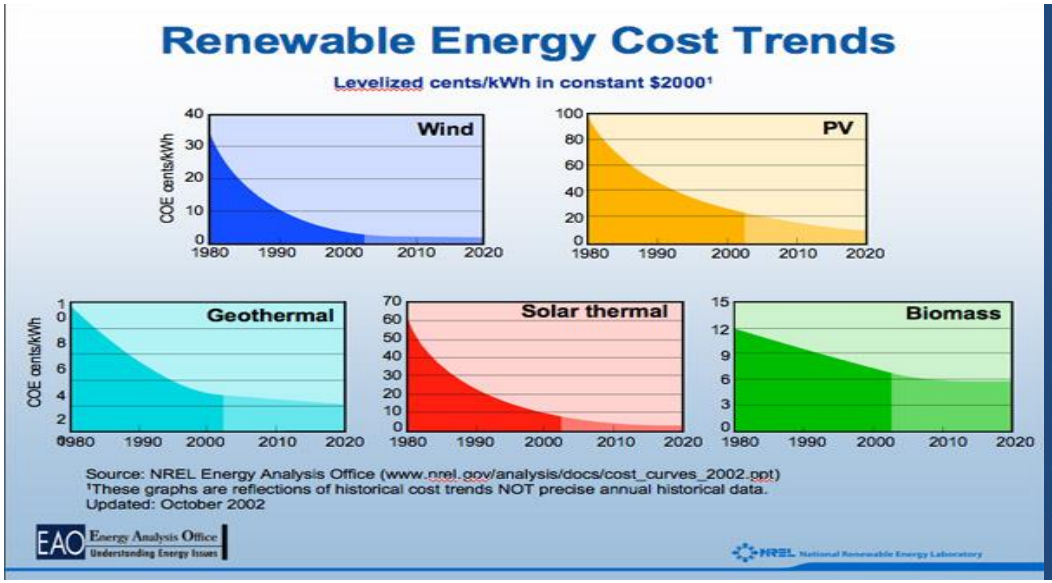
Renewable Energy Solutions

Tower Switchgear

Collector System Switchgear

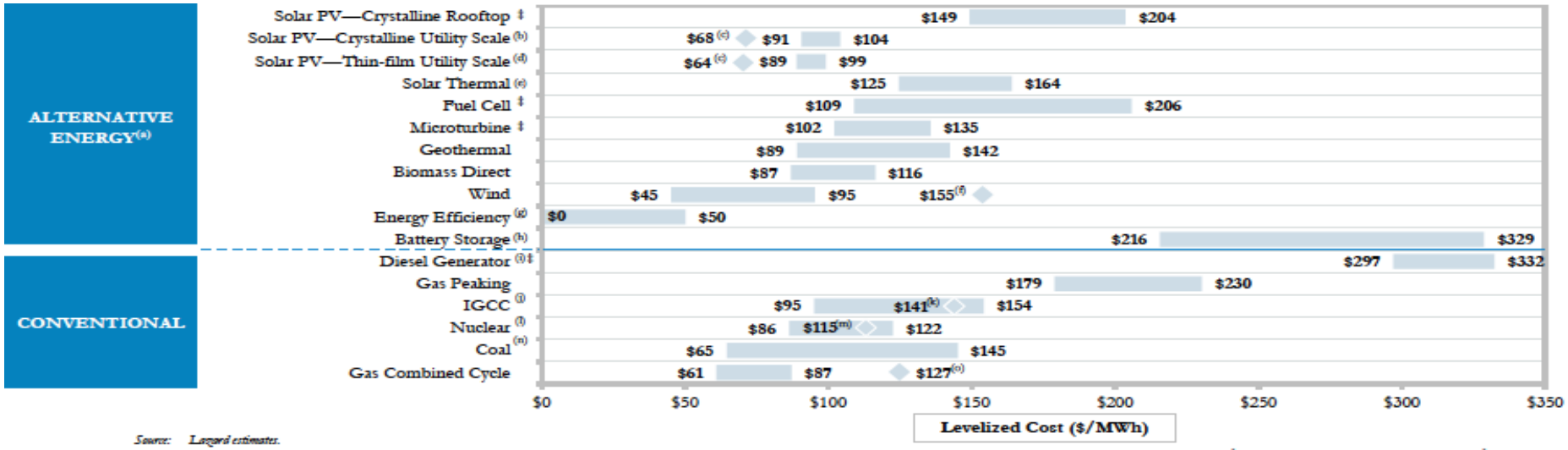
Current Limiting Protectors (CLiP)

Declining Cost of Renewable Energy



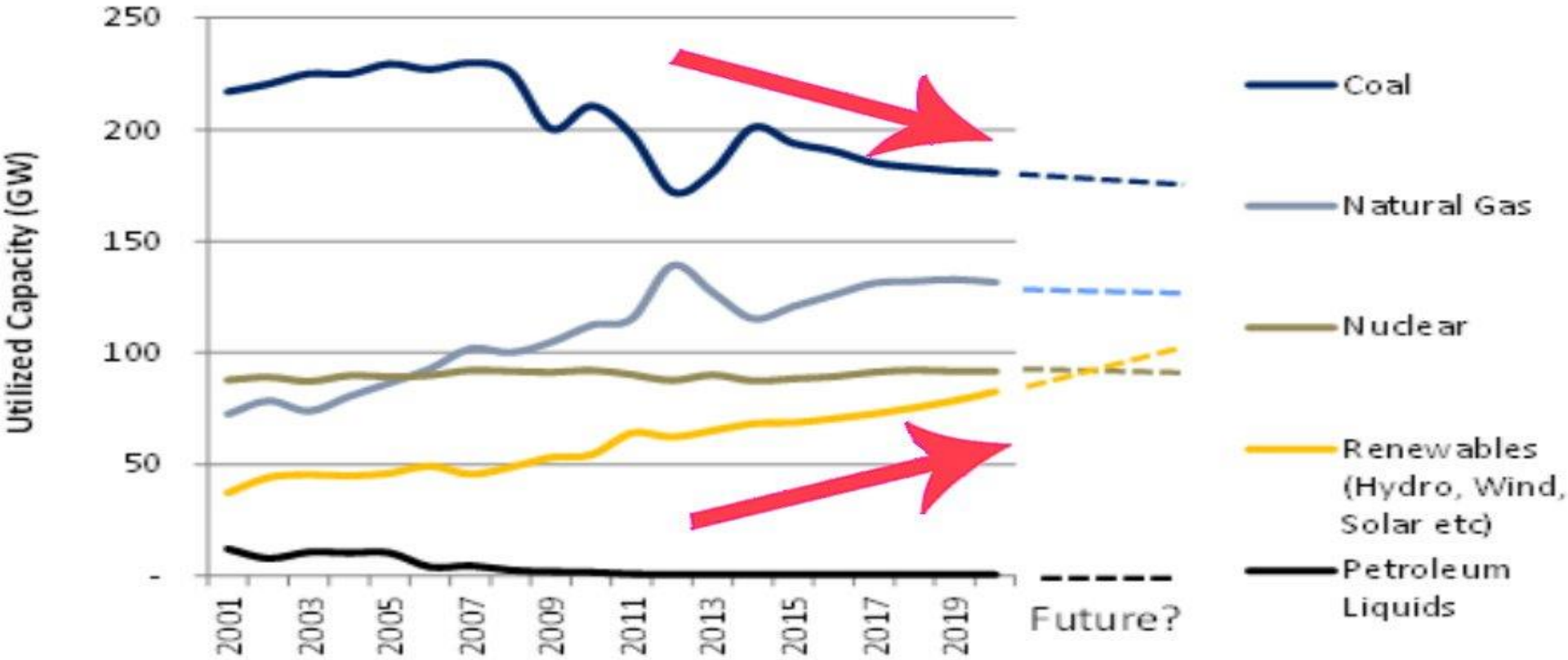
Comparison of New Sources

Source	¢ kWh	Renewable Energy
Natural Gas	6.3	No
Hydroelectric	**8.6**	**Yes**
Conventional Coal	9.5	No
Wind	9.7	Yes
Geothermal	10.2	Yes
Biomass	11	Yes
Nuclear	11.4	No
Solar PV	21	Yes



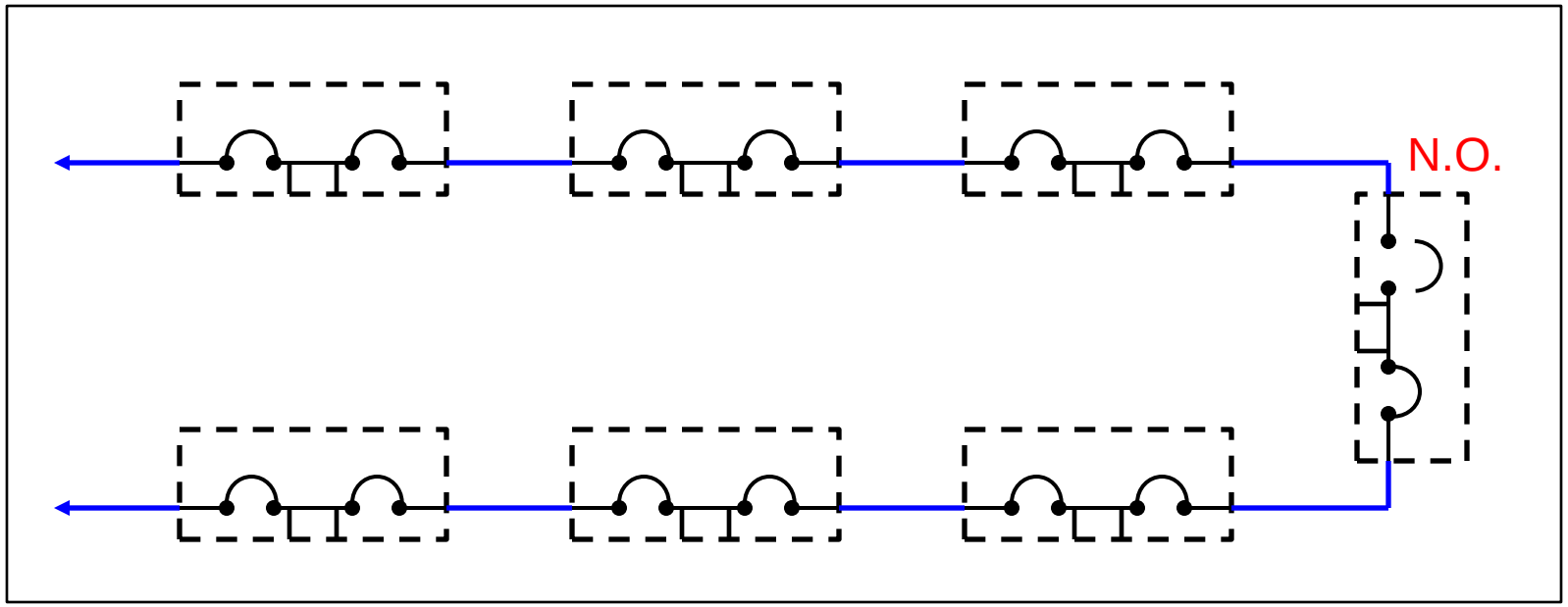
Source: Lazard estimates.

Increasing Use of Renewables



Citi Research

Open Loop Scheme ROI Example



- Two sources connected in parallel
- Switchgear units are fault interrupting with one normally open point
- Closest fault interrupter opens to clear fault
  - Next fault interrupter in loop opens to isolate and N.O point closes to restore power
- Peer to peer communication assisted protection for high speed tripping
  - Directional and instantaneous elements – primary
  - Timed overcurrent - secondary

Customer Outage Cost

Average Cost

	Large C&I (> 1MW)	Small C&I (<1 MW)	Residential
Voltage sag	$15,601	$203	$
1-2 seconds	$23,097	$1,230	$5.84
1 minute	$12,944	$543	$
15 minutes	$18,245	$831	$
30 minutes	$70,238	$2,367	$5.81
4 hour	$119,715	$4,220	$7.14
8 hours	$88,224	$7,361	$5.15
Average	$70,634	$2,735	$6.59

Information from **A Framework and Review of Customer Outage Costs: Integration and Analysis of Electric Utility Outage Cost Surveys (November 2003) –** written by Leora Lawton, Michael Sullivan, Kent Van Liere, and Aaron Katz (Population Research Systems, LLC) for US Department of Energy

Automated Open Loop Scheme ROI

Metrics and Reliability/Resilience

- Interruption time can be measured in seconds
- Reduces initial outage time to less than 1 minute (would actually be closer to 5-10 seconds)

Financial

Example – 5 large industrial customers on loop

- Assume a premium of $45k per switch or $450k total
- Assume worst case reduction of outage to 10 seconds at cost of $10,786 for 5 customers

Outage	Average	1 Minute	30 Minutes	4 Hours
Savings / Event	$342,384	$53,934	$340,404	$587,789

Annual Return on Investment
1 event x (30 min) – 76%

Payback Period
1 event x (30 min) – 1.3 years

Resilient Microgrid Example

Questions?

What city scored the highest of 34 cities for energy efficiency according to the American Council for an energy efficient economy?

BOSTON!