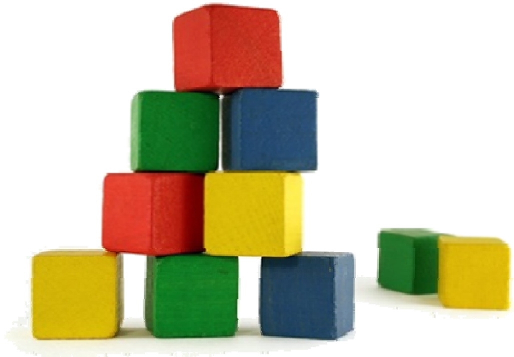


Lessons Learned – Key Characteristics of a Microgrid

Steve Pullins, President

Horizon Energy Group

September 2012

galvincenter for electricity innovation at ILLINOIS INSTITUTE OF TECHNOLOGY

IEEE PES Power & Energy Society®

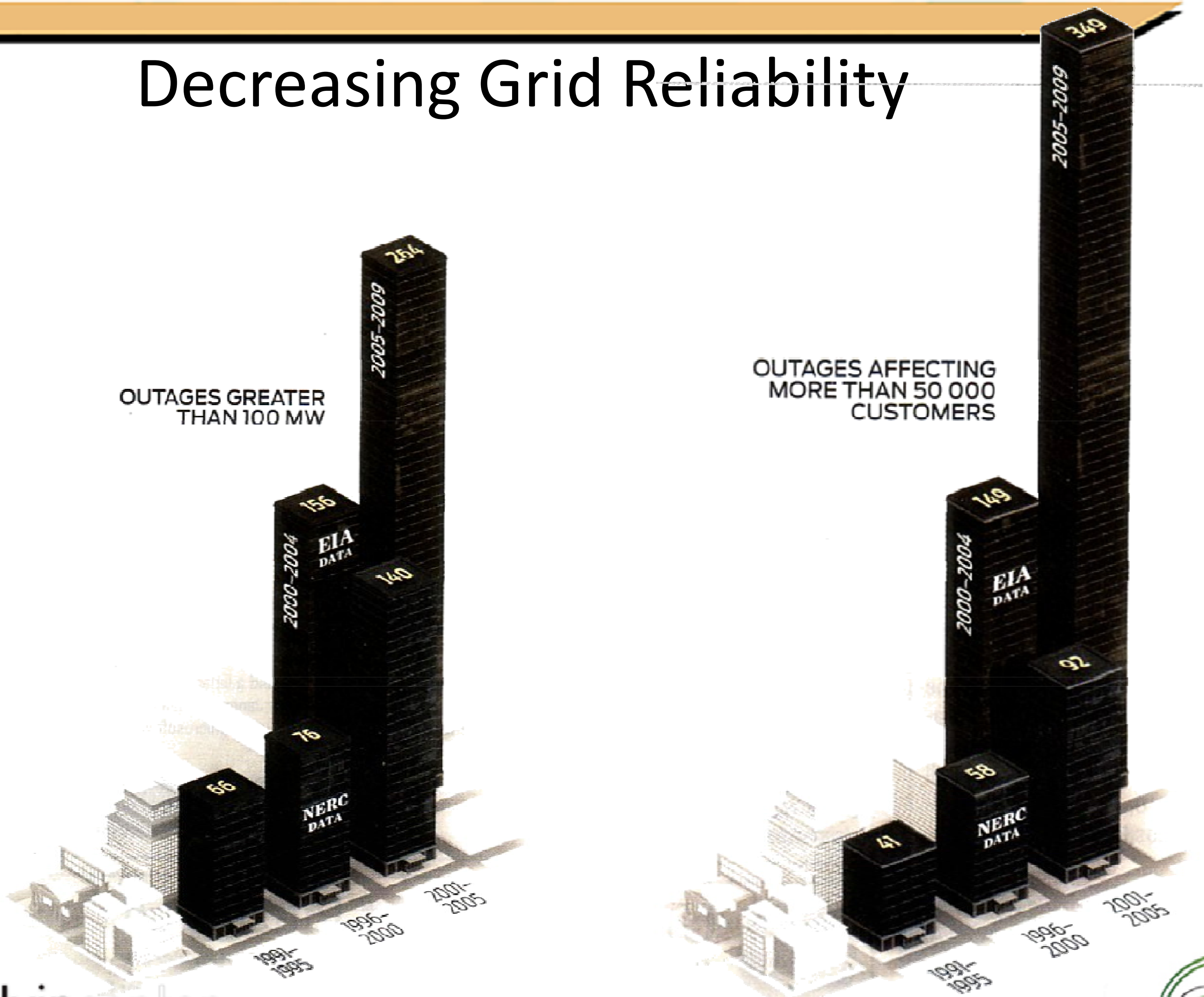
The future requires a shift from passive grid management to active grid management…and the future is here.

CHALLENGING THE PARADIGM

Old Paradigms Challenged

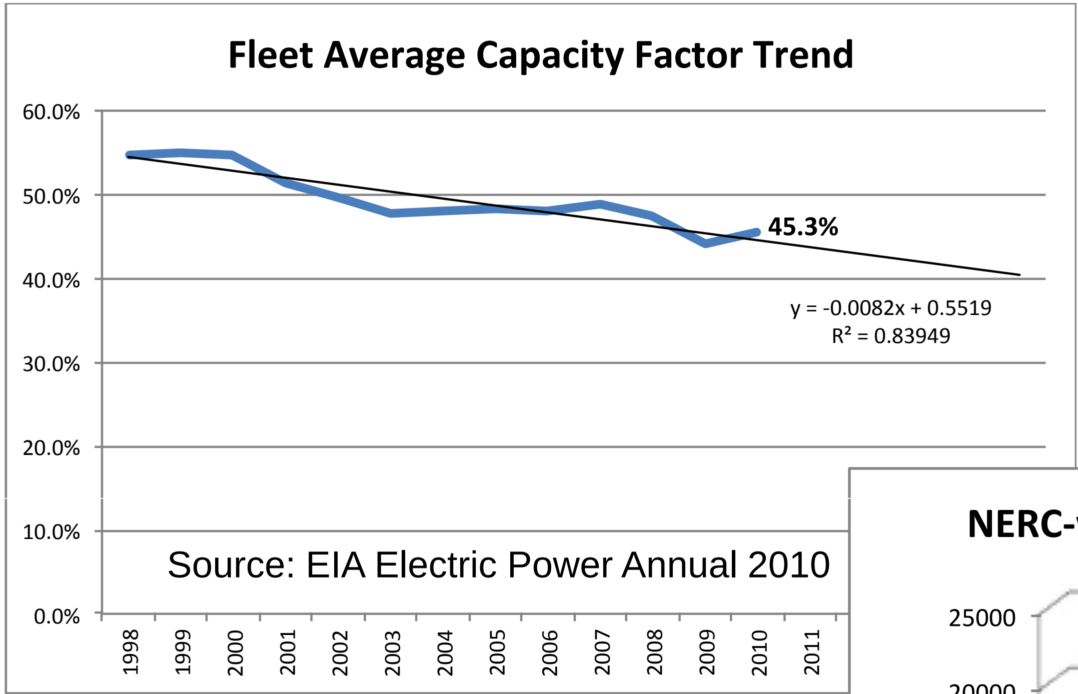
- US average outage duration is 120 minutes and getting worse; rest of industrialized world is < 10 minutes and getting better
- "Build mentality" has yielded $\leq$ 45% capital asset utilization (generation, transmission, distribution) and getting worse…at the same time outage duration and frequency is increasing
- Top down electric power system is not meeting the challenge. Consumers are embracing distributed resources (> 5 GW/year) and participation in peak reduction programs (DR, PTR, CPP, etc)

Decreasing Grid Reliability

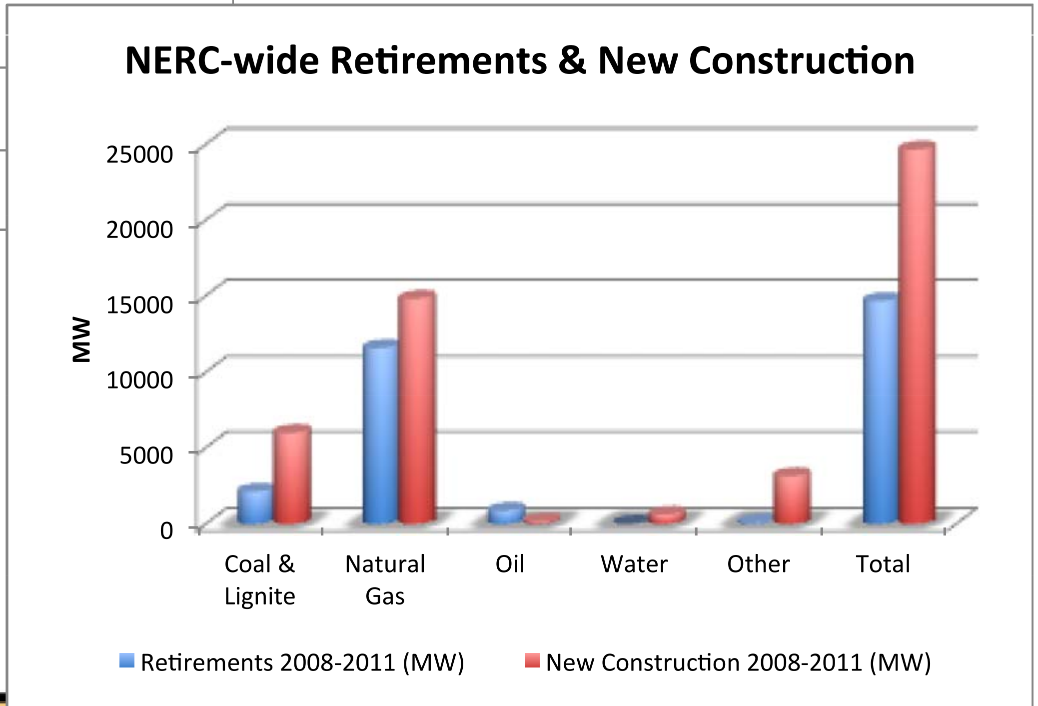


Source: Dr. S. Massoud Amin, IEEE Spectrum, January 2011

Decreasing Capital Asset Utilization

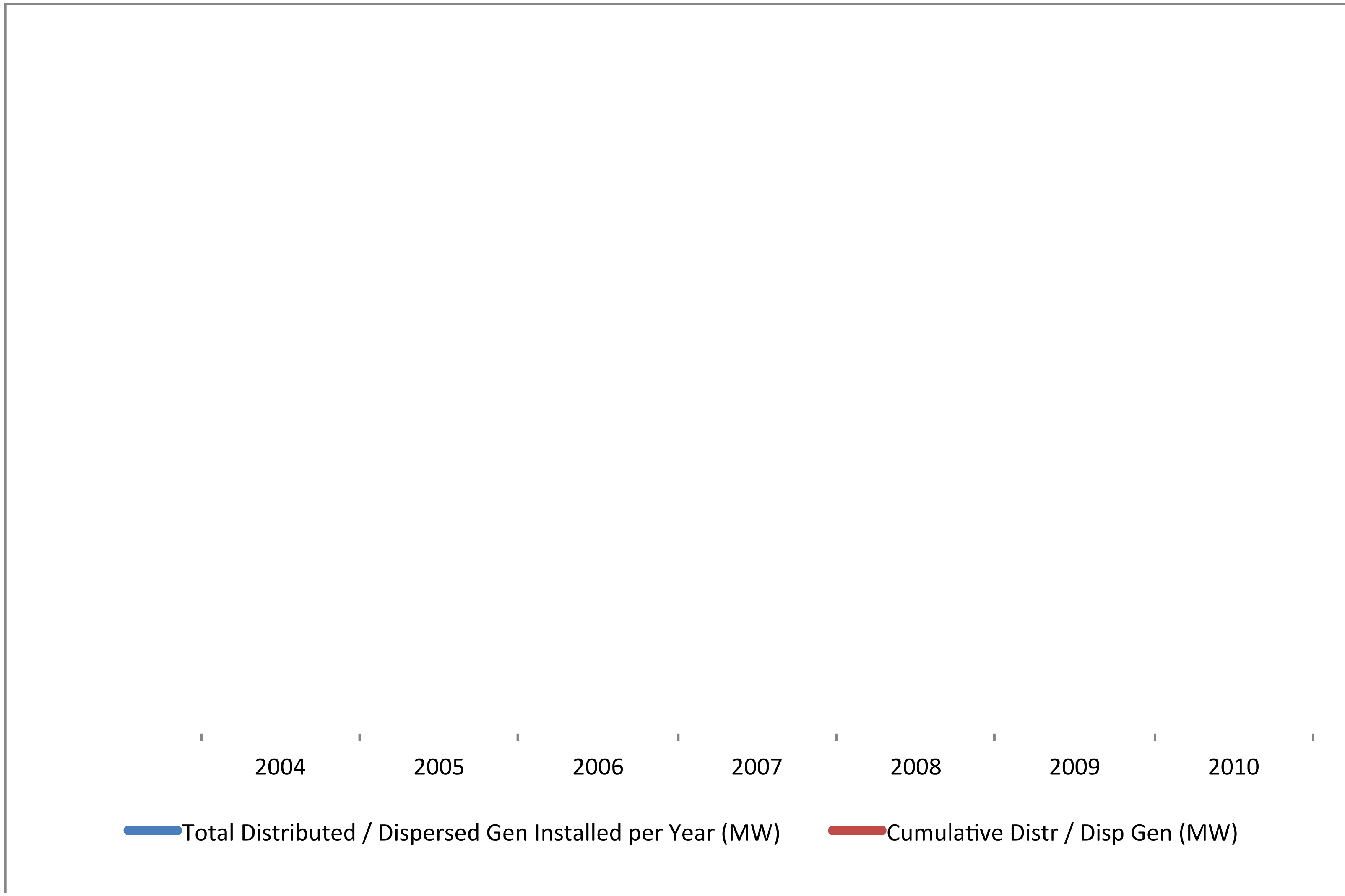


To deliver 1 MW to a customer, we are building and paying for 2.2 MW generation and transmission.



A long-term increasing generation capacity with a long-term decreasing capacity factor is an unsustainable business model.

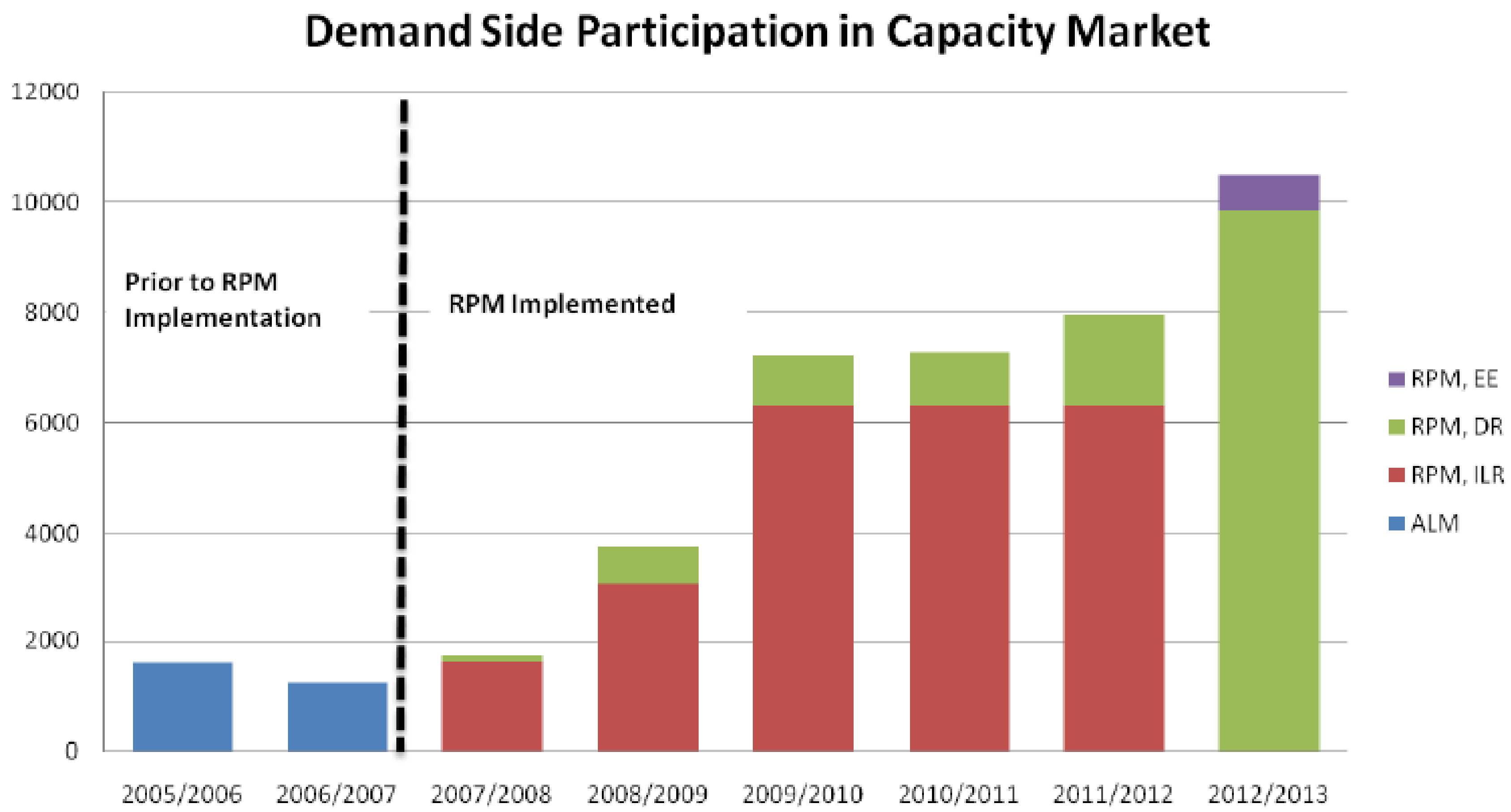
C&I DG Installations since 2004 (MW)



a

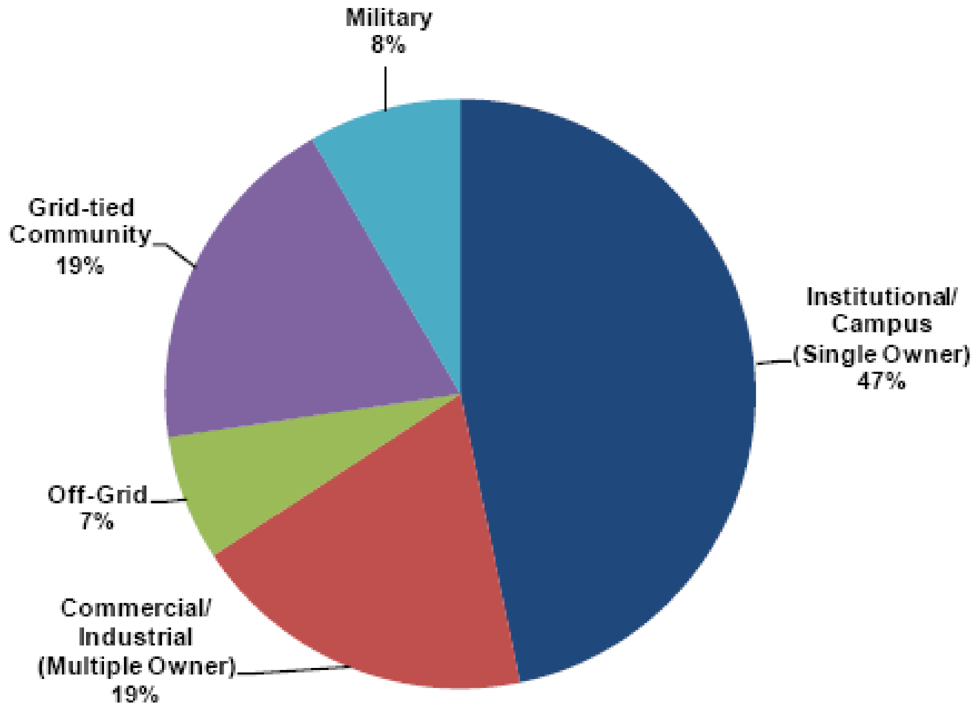
DOE BUGS report (2010) shows total DG capacity is greater, ~230 GW

Dispatching Demand Side on the Rise



Demand Side Participation in the PJM Capacity Market

Source: PJM Interconnection

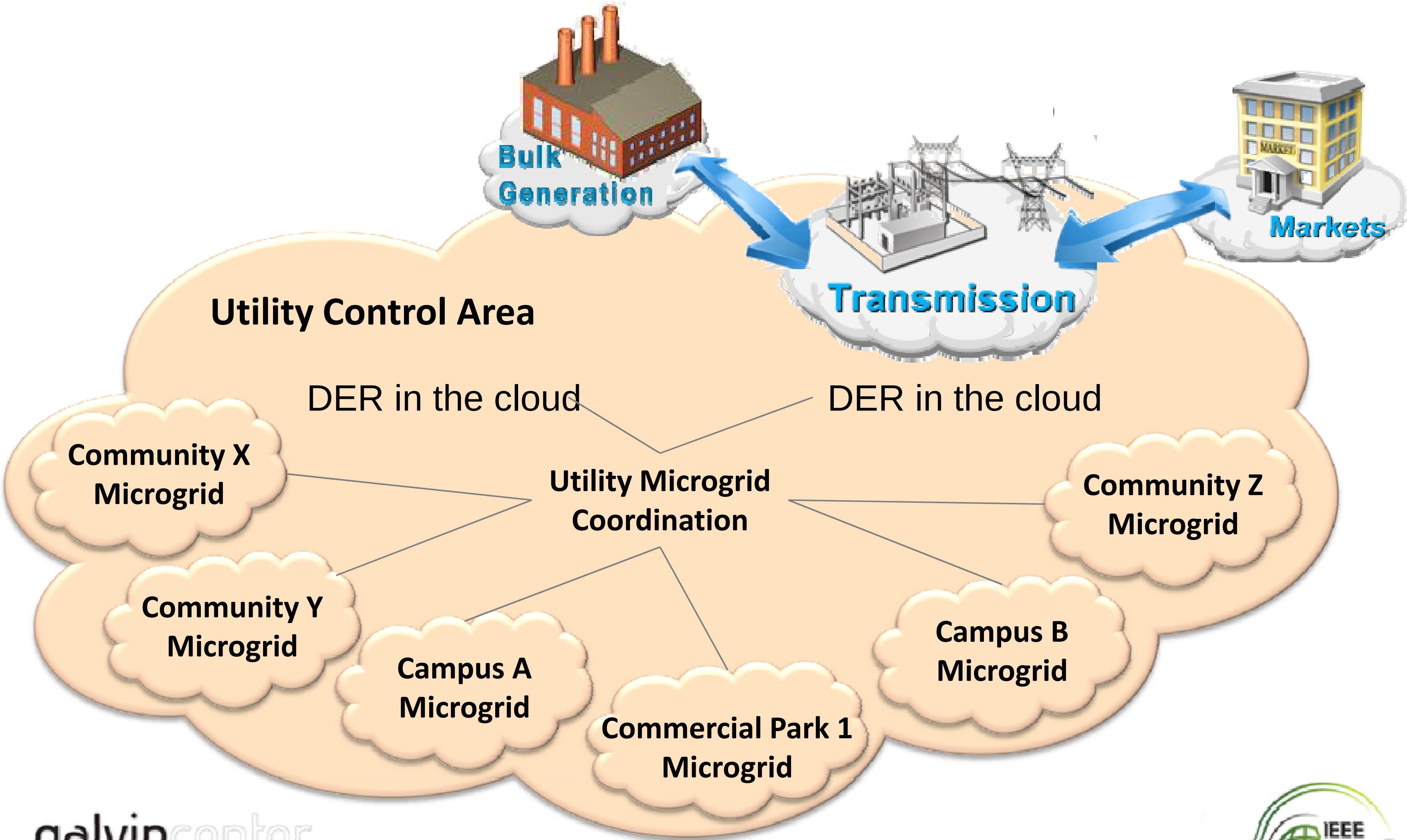


LESSONS…SO FAR

Utility Distribution Microgrid Uses

- Somewhat remote communities
  - Highly concentrated PV communities
  - Address variability of high renewables targets
- Custom power offerings tailored to customers with specific economic, reliability, and emissions objectives
- Active management to drive improved reliability
- Local resource mix hedge to a single grid supply
  - Municipals and Cooperatives

Future Distribution Architecture



galvincenter for electricity innovation at ILLINOIS INSTITUTE OF TECHNOLOGY

IEEE PES Power & Energy Society®

Lessons - Microgrid Characteristics

- Most interest is behind the meter
- Economically viable
  - Commercial & Industrial consumers – 4 to 40 MW
  - University campuses – 2 to 40 MW
- Significantly improves on-site reliability; a MUST
- All solutions (to date) reduce emissions footprint, but not the major objective
- All solutions (to date) include energy storage and 3 to 6 other resource types
- All solutions (to date) include integration to building controls and price-driven load management
- Most selected Scenario: MaxSavings
  - 80% to 86% self-generation, rest from grid
  - Always grid connected
  - Sales to grid: zero to minimal

Lessons on Typical Project

- Design and Integrate Multiple Resources
  - DG, PV, Wind, CHP, FC
  - Utility-scale and distributed storage
- Automate Distribution
- Grid Interconnection and Islanding
- Price-Driven Load Management
  - Intelligent load management
  - Demand response
- Multiple Revenue Streams
  - Primary energy and demand
  - Utility peak load programs
  - Utility ancillary services

Lessons on Optimization Design

- Industry-leading converged energy and financial model
- Commercial and industrial businesses, and university campuses are focused and looking for solutions
- Four main scenarios
  - MaxSavings
  - MaxRenewables
  - MaxDiversity
  - Grid Independence
- Incorporate federal, state, and utility tax credits and incentives

Microgrid vs Traditional Supplier Roles

Criteria	MEA/Shell	IIT/Exelon	Calpine[8]	NextEra[9]	US Avg.
Source Energy Intensity (mmBTU/MWh)	3.8	6.6	7.3	8.0	9.1
CO_2 Intensity (lbs/MWh)	610	0	870	650	1330
SO_2 Intensity (lbs/MWh)	0.3	0	0.0044	0.44	3.0
NOx Intensity (lbs/MWh)	0.3	0	0.12	0.33	1.4
Water Consumption (gallons/MWh)	>400*	240*	100	230	>400*
Solid Waste Recycled (waste recycled/total waste)	16%*	60%	0%*	28%*	65%
Renewable Energy Credits (bonus points)	6	0	0	0	N/A
PPI Rating Score (max 100)	**91**	**79**	**68**	**64**	**41**
Percent Renewable	**60%**	**40%**	**6%**	**13%**	**9%**

**Numbers estimated from available data*

Notes: Results adjusted for average system losses. MEA is the Marin Energy Authority contracting with Shell Energy. IIT is the Illinois Institute of Technology contracting with Exelon.

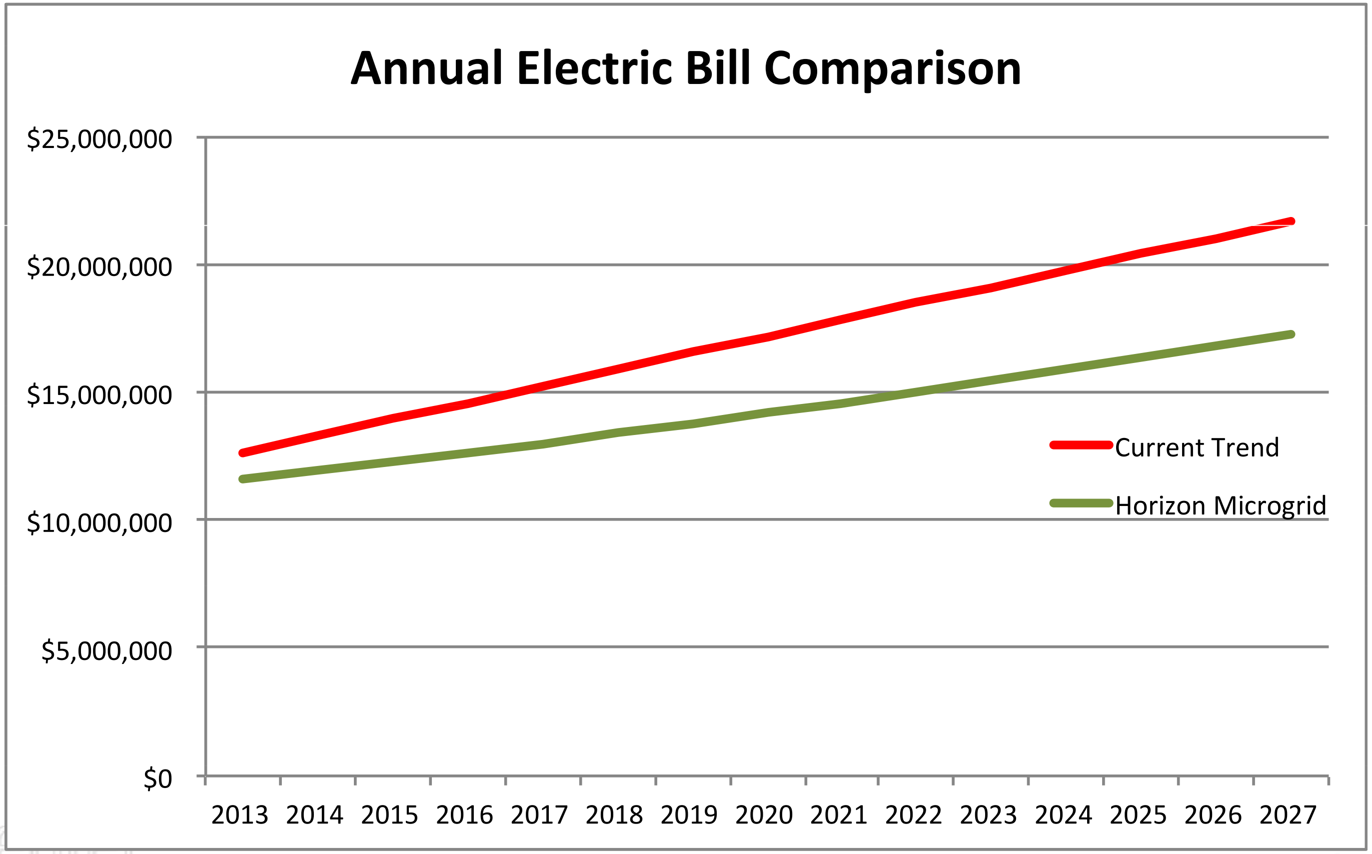
Table 3, Assessing Power Supply: Environment and Energy Efficiency, Perfect Power Institute, July 2012

[8] Calpine (2010). *Annual Report: A Generation Ahead, Today.* www.calpine.com/docs/CPN_Annual_Report.pdf

[9] NextEra Energy (2011). *Sustainability Report 2011.* http://www.nexteraenergy.com/pdf/sustain-report.pdf

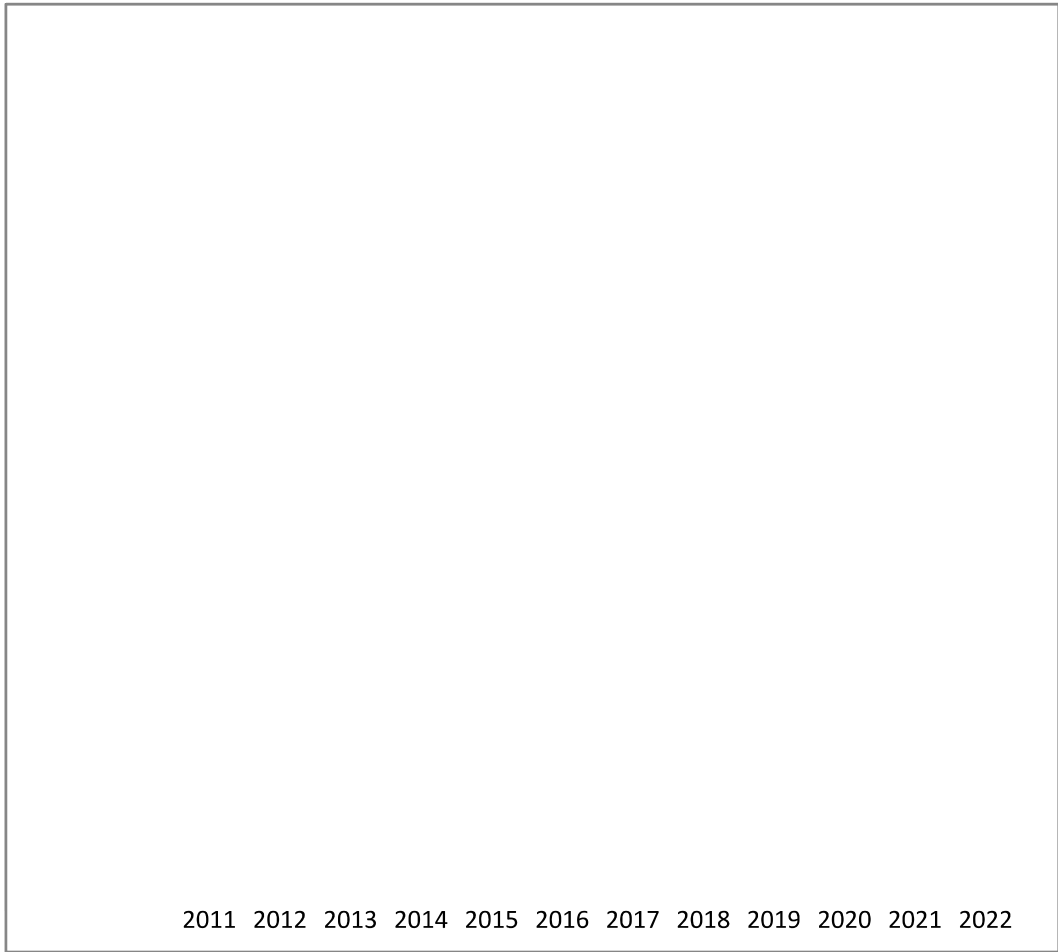
Case Study: 11 MW Shipyard

Shipyard will save ~$23 million in the first 10 years of the microgrid operations.



Case Study: 3.5 MW Engineering Center

The campus will save almost $10M in the first 10 years of the microgrid operations



Case Study: What if ConEd?

Compare 500 MW over 20 years	ConEd BAU	ConEd Microgrid
Amount of microgrids	--	500 MW
Reliability (avg customer outage minutes/year)	120	12
Power Plant Capacity Factor	45.3%	83.2%
Emissions (NO_X, SO_X, CO_2)	--	532,727 Tons less
Consumer Savings	--	$2,091 M higher
Distr. Marginal Cost	$600/kW-year	<$250/kW-year

Case Study based data from an 11 MW industrial microgrid design.

Conclusions

- Must move distribution network from passive to active management
- Most microgrid action is behind the meter
- Business and university consumers are motivated
- For the consumer, well developed microgrids are more capital efficient, energy efficient, and reliable than traditional service

Thank you!

Questions?

Contact info:
Steve Pullins
spullins@horizonenrgygroup.com
865.300.7395
www.horizonenergygroup.com