IEEE Involvement in Addressing Sustainable Power Grid

To be the leading provider of scientific and engineering information on electric power and energy for the betterment of society, and the preferred professional development source for our members.

~ Approved by the IEEE PES Governing Board, 17 July 2003

Dr. Damir Novosel

IEEE PES President Elect

President, Quanta Technology LLC

March 25, 2015

IEEE JOINT TASK FORCE ON QUADRENNIAL ENERGY REVIEW

DOE has requested IEEE for insights on priority issues

- Effects of renewable intermittency on the grid and the role of storage
- Business case issues related to microgrids and DG, including rooftop PV
- The technical implications for the grid of electric vehicle (EV) integration
- The implications and importance of aging infrastructure and the options for addressing these challenges, including asset management
- Recommendations for metrics for addressing Smart Grid issues, including protocols
- Skilled workforce issues
- Report cards on the condition and performance of the electric grid

Work started in May 2014 and final report submitted on September 5th 2014 - **http://www.ieee-pes.org/qer**

IEEE PES Power & Energy Society®

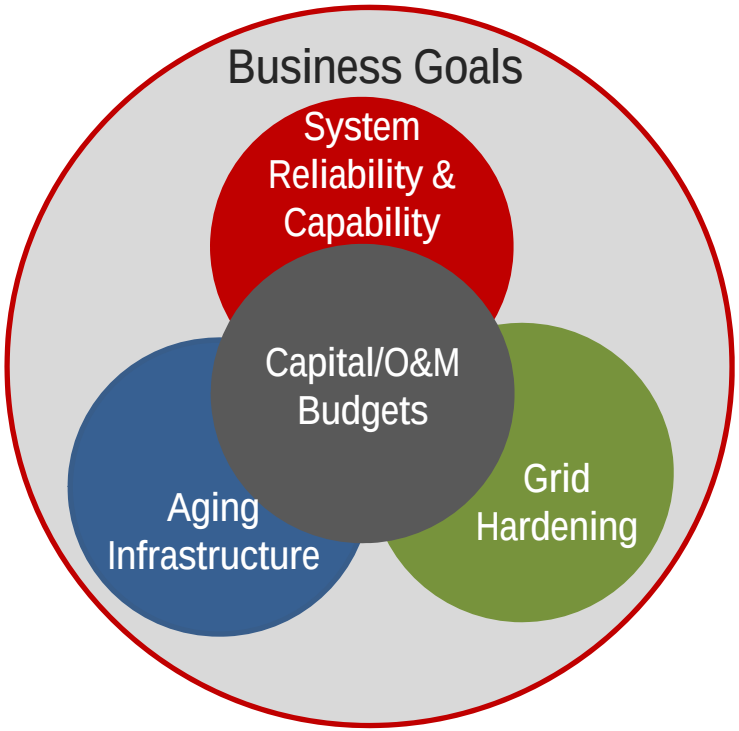
IEEE USA Building Careers & Shaping Public Policy

Confidential & Proprietary | Copyright © 2015

IEEE

Holistic Asset Management

Asset Management: Predictability of Cost & Reliability



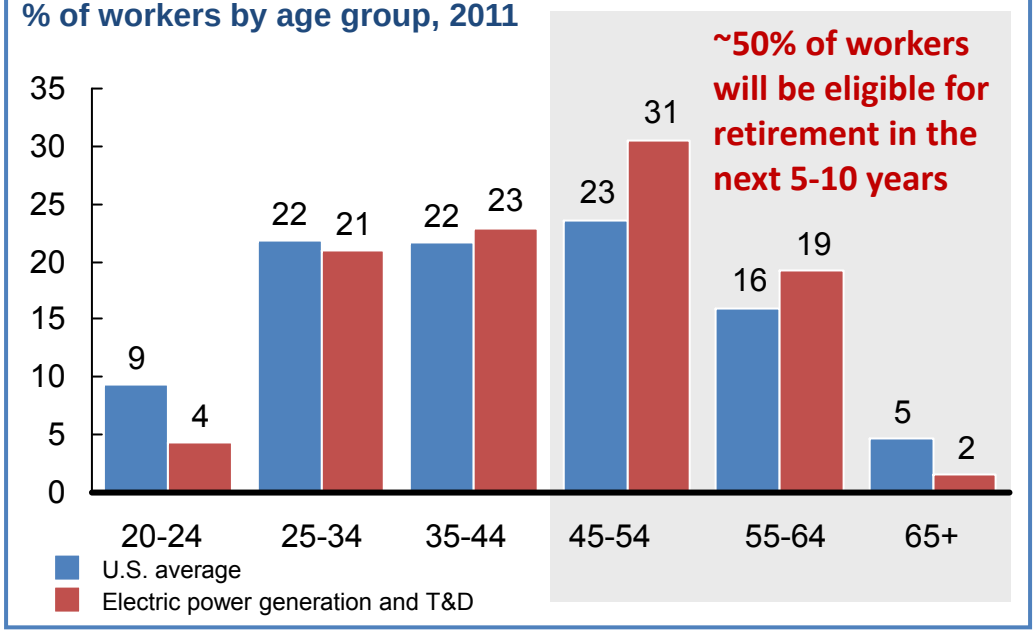
The Grid is 40 to 60 years old on average, with 25% of the Grid a performance concern.

- As system ages, operating cost increases and reliability decrease - limited resources for wholesale replacements
- How to manage Smart Grid assets?
- Sound strategy for controlling the symptoms of aging within the utility's overall business plan - maintain *accepted levels of performance*

Aging Workforce

- Perfect Storm: Aging Workforce + Aging Assets = Reliability Decline
- Requirement: Programs to attract, train and develop engineers, linemen, station electricians, P&C resources, and other technical resources

The U.S. utility workforce is getting old …



…limiting the labor pool for utilities

- Utility workforce not adequately replenished
- Recession has hurt development effort
- Long training lead times
- Limited utility labor supply

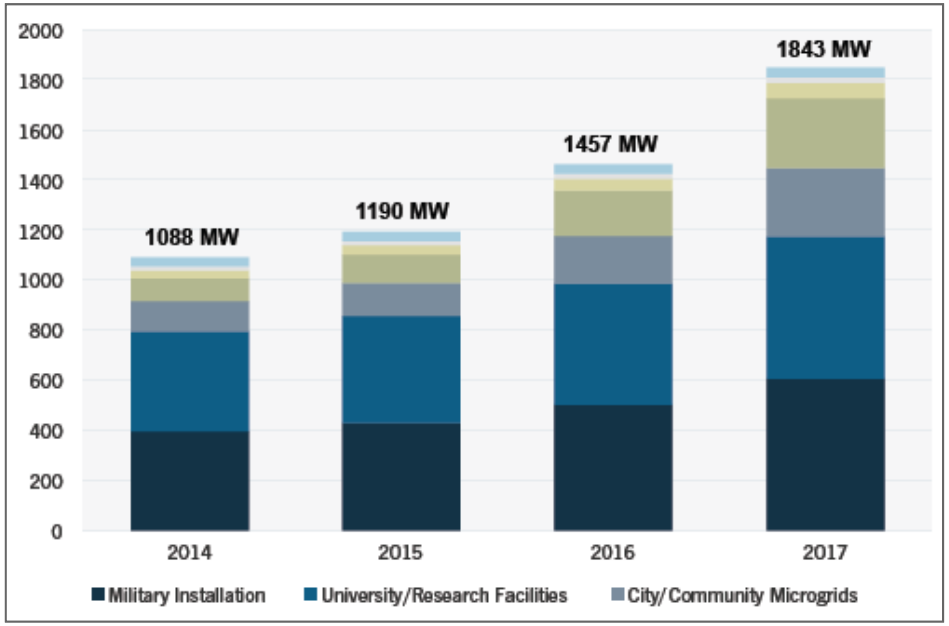
IEEE PES Power & Energy Society®

Confidential & Proprietary | Copyright © 2015

IEEE

Optimized Hybrid Microgrids

- Utility grid and micgrogrids must work synergistically to fulfill all the needs, e.g. serving all the load all the time
- Policy should support value creation, with results-based rewards, and not unduly favor either incumbent utilities or non-utility MG sponsors
  - Assessing costs should include efficiency, reliability, safety, optimizing life-cycle costs, and resilience for the grid
  - Costs and benefits must be apportioned to each relevant party in a multi- stakeholder microgrid business case
  - Regulatory policy to reward costs incurred in planning, operational changes, and the optimal integration of assets



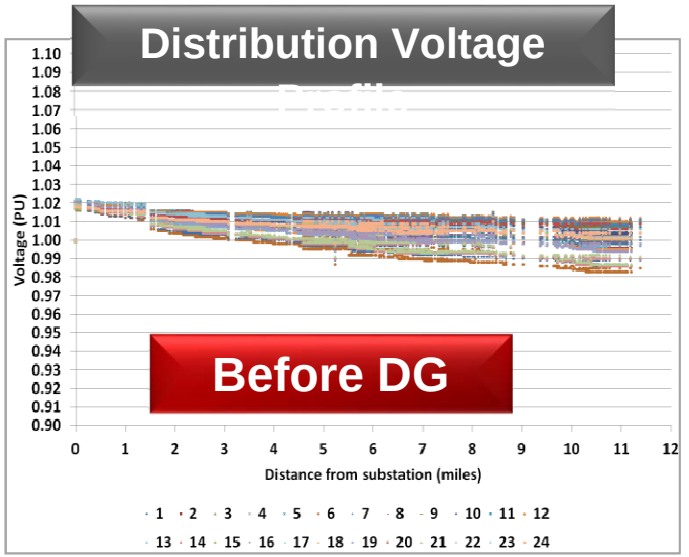
IEEE-USA
Building Careers & Shaping Public Policy

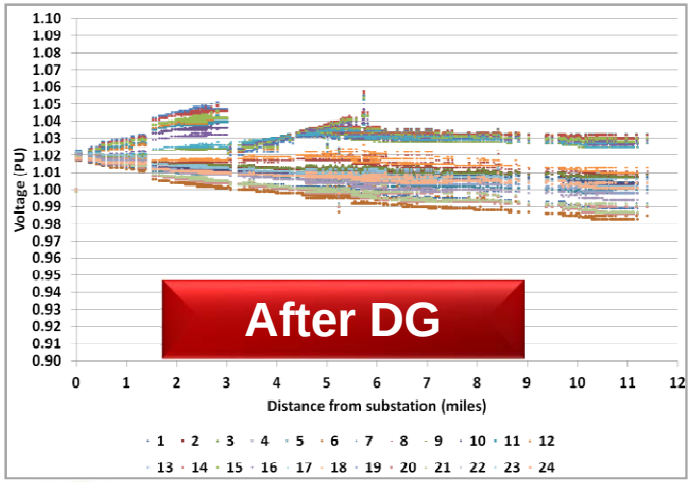
IEEE PES
Power & Energy Society®

Confidential & Proprietary | Copyright © 2015

IEEE

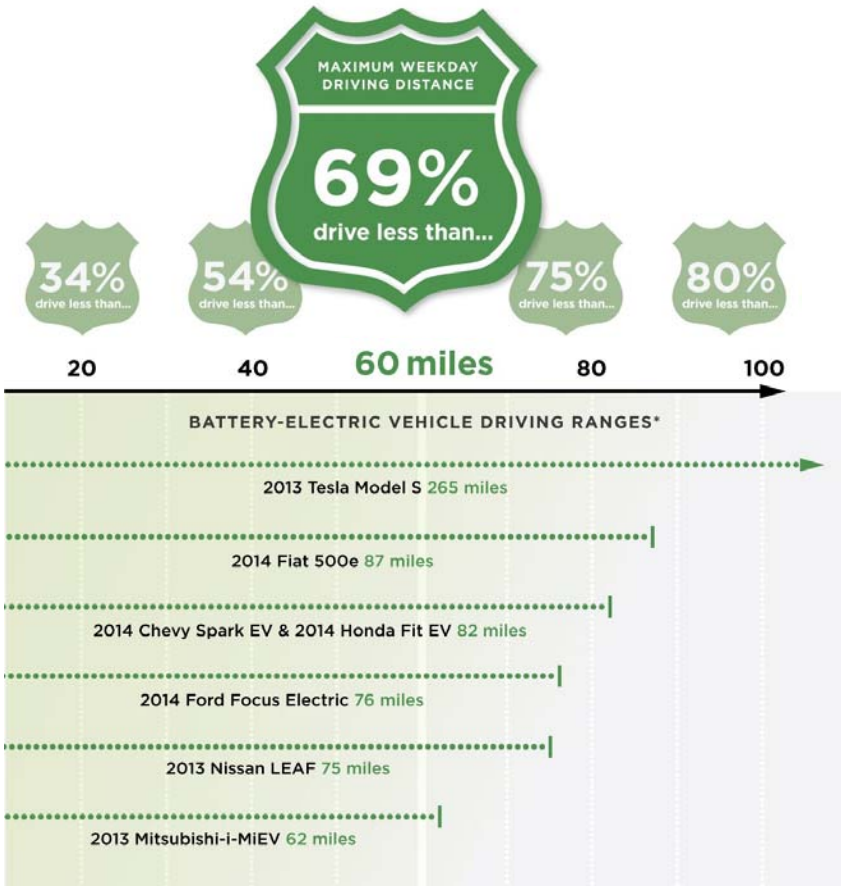
Renewable Intermittency & Storage





- Grid Level: Uncertainty of renewables can be tolerated at penetration levels around 30%
  - Traditional power system planning and operations need to be updated
  - Energy storage, while a useful and flexible system tool, is not essential as other, often more cost-effective options are available such as fast responding generation and demand response
- Distribution: High penetration levels of renewable DG creates challenges, requiring
  - Battery storage systems
  - Advanced power electronics technologies
  - Real-time monitoring, control and automation

Integrating PEV



Source: "Survey Says: Over 40% of American Drivers Could Use an Electric Vehicle," Union of Concerned Scientists

About 250,000 PEVs & 20 models on the road

- Generation and transmission systems can handle millions of plug-in electric vehicles
- Good understanding of technical issues on the distribution system
  - Potential overloads of distribution transformers and circuits
  - Changes in equipment cooling patterns
  - Inability to accommodate high-power charging in older neighborhoods with legacy distribution infrastructure

Future Grid Roadmap

G, T & D Investment Will Increase

- ✓ Grid connection required for reliability and market reach - Microgrids, DER, and EVs require a robust, hybrid T&D grid
- ✓ Infrastructure *Investment* – U.S. Electric utility industry will require up to $2 trillion by 2030, including generation (EEI)

Fuel Transformation Will Continue

- ✓ Dash to gas, renewable surge, plant retirements

Demand For Electricity Will Increase

- ✓ Population growth, electric vehicles, use of renewable energy, etc.

Grid Will Be Made Smarter, Reliable, Resilient, Secure

- ✓ Advancements in technology and skilled workforce

Customers Will See Value Beyond Commodity

- ✓ Increased choices, digital age reliability, comfort value

Societal and Economic Goals Met

- ✓ Sustainability and support of growing economy

QUANTA TECHNOLOGY
Smart Solutions, Practical Results

IEEE PES Power & Energy Society®

IEEE

Technical Council Goals & Initiatives

- ✓ Committee Structure & Coordination
- International Involvement & Presence
- Technical Committee Awareness & Participation
- Publications & Access