Lighting the Way to a Smarter Grid

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Overview

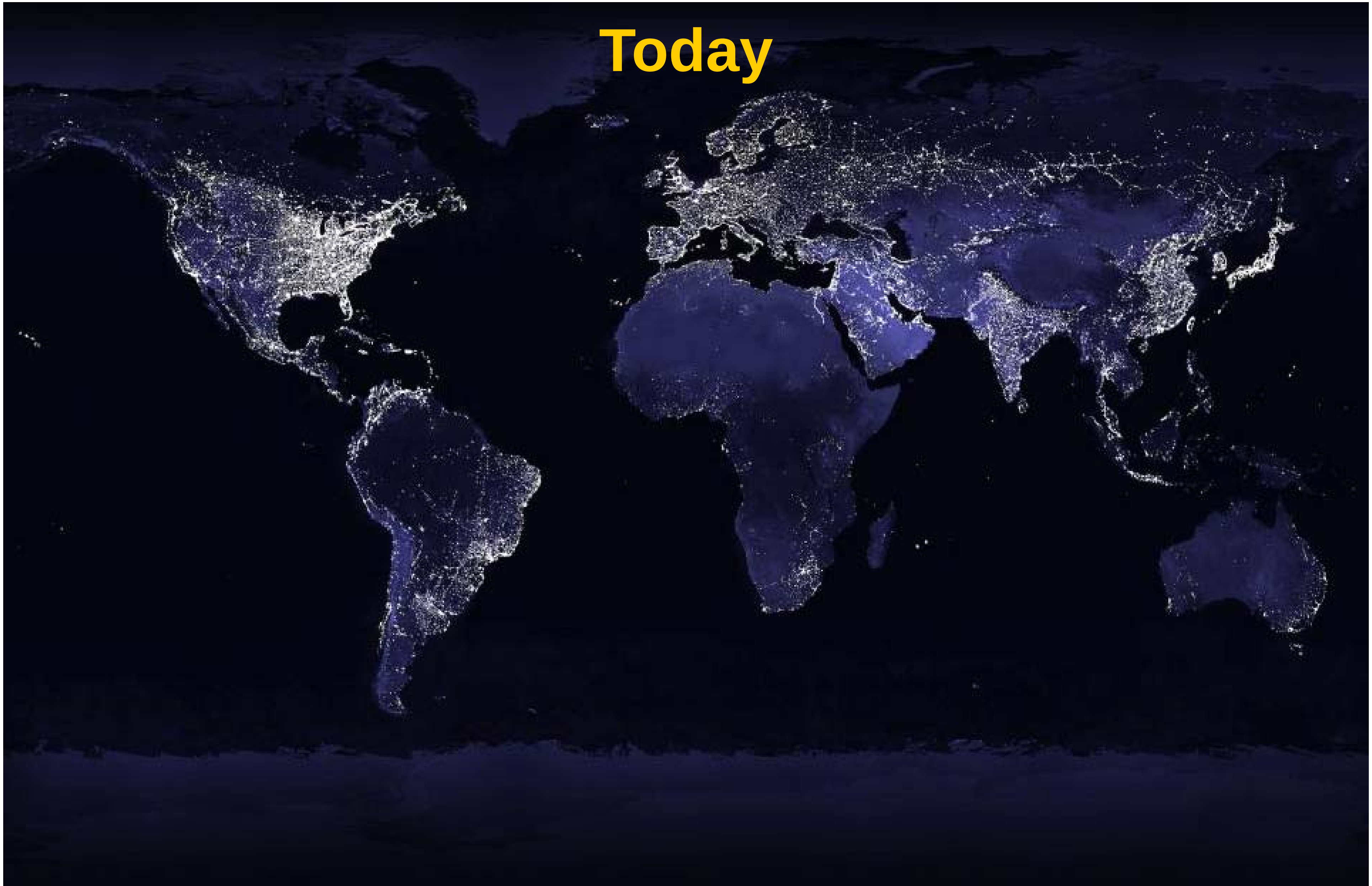
- S&C Electric Company
- A Changing Power and Energy World
- Investment Anticipated
- Smart Grid Realities
- Challenges and Advancements
- Managing the Journey

S&C Electric Company

- Headquartered in Chicago
- Operations in:
  - Milwaukee, WI
  - Alameda, CA
  - Orlando, FL
  - Canada
  - Mexico
  - Brazil
  - China
  - United Kingdom
- 2600 employees
- Founded 1911
- Employee-owned as of 2007

S&C Electric Company
John R. Conrad Industrial Campus
Chicago, Illinois

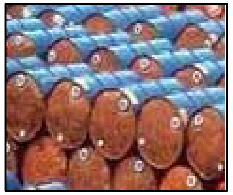
Today




2030

Changing Power and Energy World

Growing Population, More Electronics



Rising Cost of Energy

Increasing Environmental Requirements

Escalating Security Concerns

Heightened Investor Demands

Driving Technology:

- Carbon Management
- Electric Transportation
- Sustainability
- Distributed Sources
- Efficiency
- Modernization
- Reliability

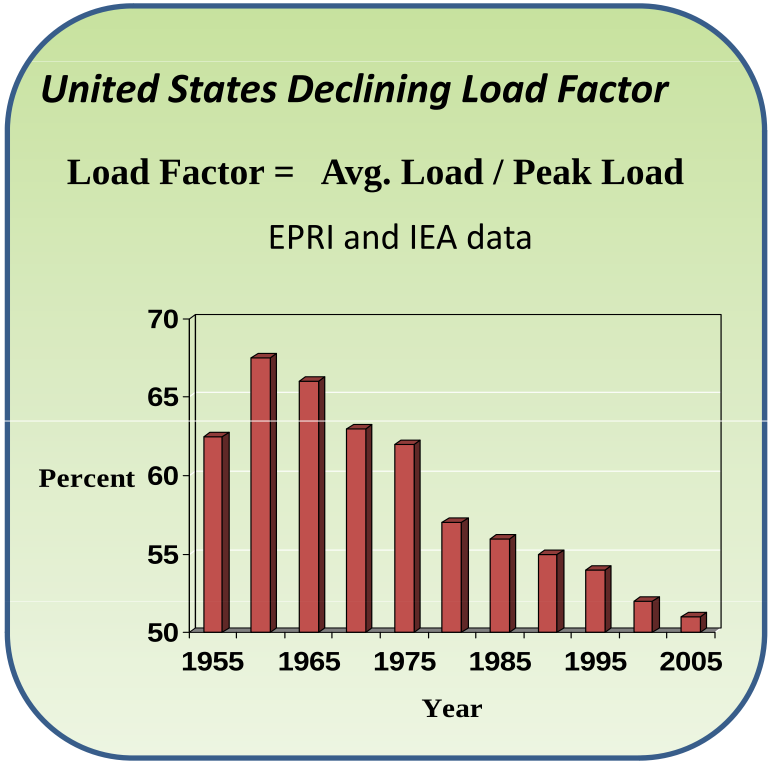
Recognizing the Need for Power

- Consumer electronics represent the largest single use for domestic electricity
- Computers and gadgets will account for 45% of electricity used in the home by 2020
- Increases demand for near-perfect power quality and uninterrupted power availability

Sources: "The Ampere Strikes Back: How Consumer Electronics Are Taking Over The World," Energy Saving Trust, June 2007; "The Rise of The Machines: A Review of Energy Using Products In The Home From The 1970s to Today" Energy Saving Trust, June 2006; "Electric Power – The Next Generation: The Intelligent Grid," Center Point Energy, April 2007

And, the Response …

- Reliability is not changing or differentiated
- Assets - generally aging, under-utilized and not very efficient
  - Electrical losses
  - Generation capacity factor
  - Spinning reserve drops efficiency
  - Declining US load factor
- Vulnerable during peak conditions occurring ≤ 1% of the time
- Uncertainty and complexity: intermittent sources, distributed options



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Business is Changing

Our Past	Our Future
Regulated business models	Emerging “customer choice”
Large generation stations	Distributed & green resources
Centralized dispatch	Distributed intelligence
Minimal constraints	Pressures for “green power”
Outages “tolerated“	Less tolerance of outages
Grid “over designed”	Infrastructure exhausted
Radial distribution	Looped or meshed distribution
Homogeneous technology	Mixing old with new
Slow distribution operations	Near real-time micro-grids
Uni-directional power flow	Multi-directional power flow

Major Investment Anticipated

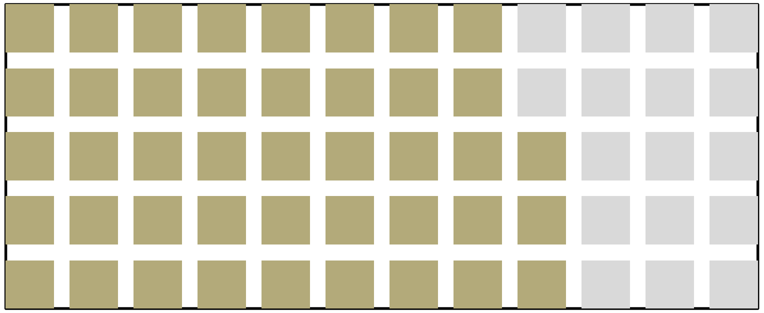
SGIG Spending

$7.9 billion with cost share to be spent through 2015

Adoption Factors:

- Economy
- Policy
- Technology
- Consumer Acceptance
- Reliability Needs

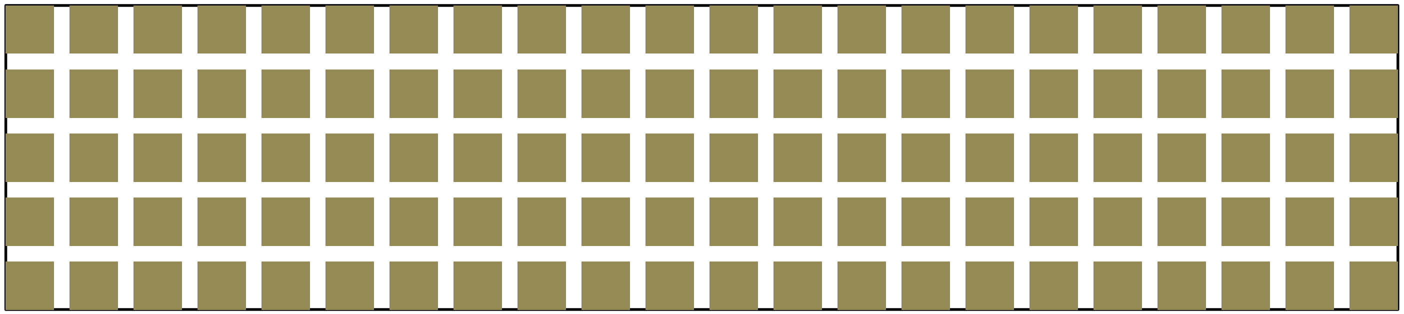
EPRI Estimate



$338 - $476 billion needed through 2030

EPRI. Estimating the costs and benefits of the smart grid: A preliminary estimate of the investment requirements and the resultant benefits of a fully functioning smart grid. EPRI, Palo Alto, CA; 2011.

Brattle Group Estimate



$880 billion needed through 2030

Chupka, M.W. Earle, R., Fox-Penner, P., Hledik, R. Transforming America's power industry: The investment challenge 2010 – 2030. Edison Electric Institute, Washington D.C.,: 2008.

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Graphics adapted from a US DOE Office of Electricity Presentation on ARRA Smart Grid Projects

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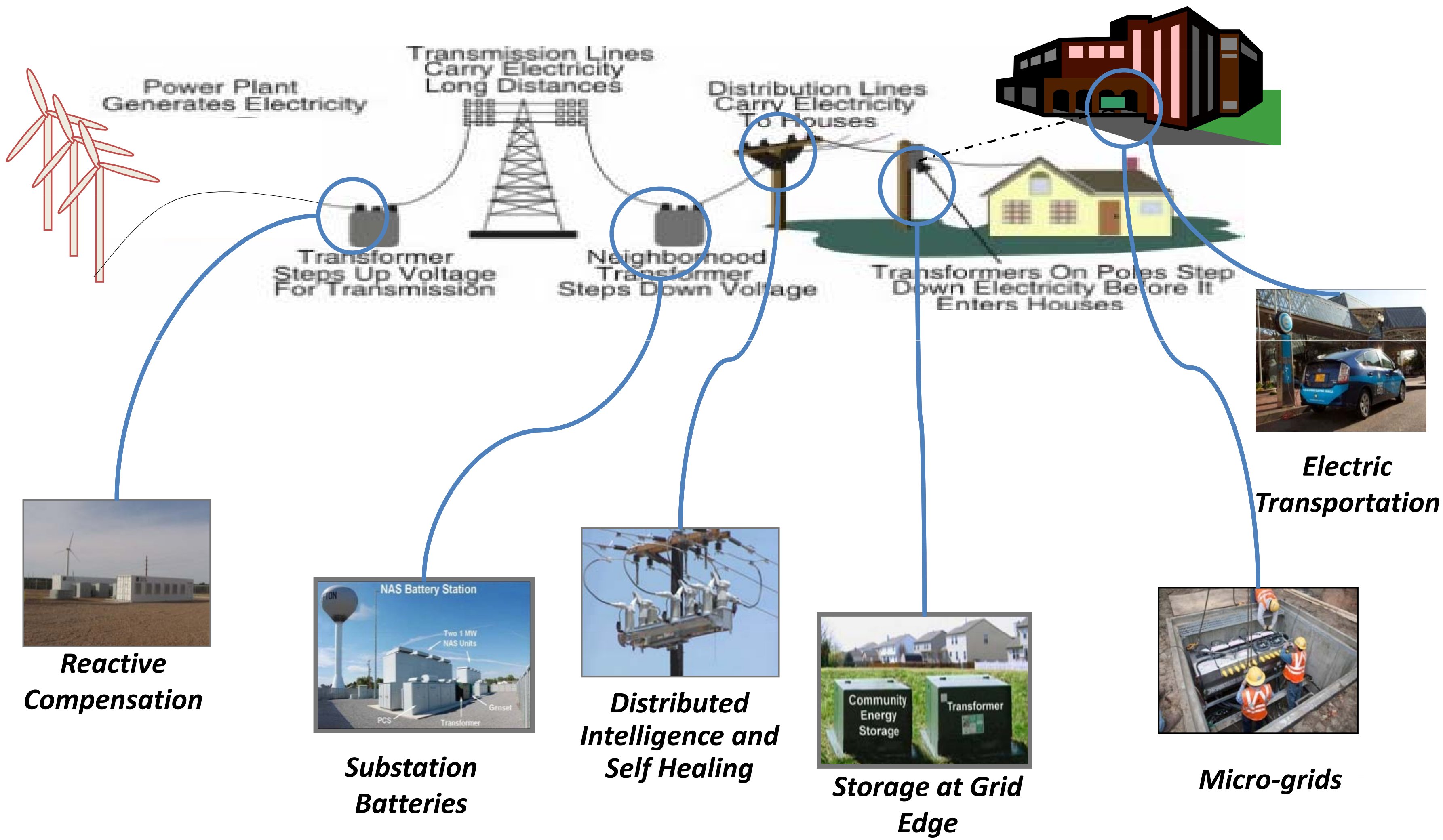
Smart Grid Realities

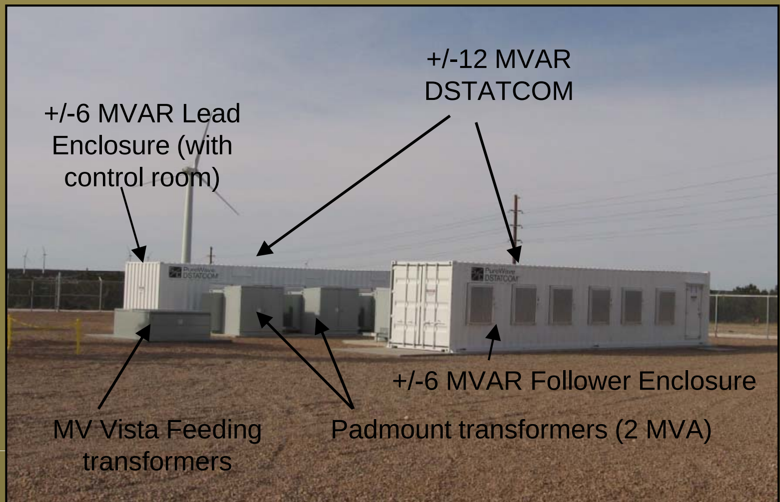


Reactive Power Compensation

- Inverter-based dynamic compensation using 1.25 MVAR modules
  - 264% continuous rating for 2 – 4 seconds
  - Use in conjunction with mechanically switched devices

Dynamic Compensation Installations to Meet Grid Codes

Typically includes power factor and Low Voltage Ride Through (LVRT)



+/- 12 MVAR for 90 MW Wind Park in New Mexico, USA. Includes 91 MVAR of switched capacitors.

±6.25/16.5 MVAR for 48 MW Wind Park in the UK with 8 MVAR of switched capacitors and 7 MVAR switched reactor

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Energy Storage

- Operational Challenges
  - Wind generation: mismatched with load
  - Transmission constraints
  - Large penetration of rooftop solar
  - Constraints for electric vehicles
  - Declining load factor

- Growing interest for energy storage to be a "balancing energy" source

- Varying benefit streams
  - Asset deferral, reliability, renewables, frequency regulation, peak reduction

- Approval challenges

Luverne, Minnesota
NaS Battery Installation

1.0 MW for 6 hours
Used for wind farm smoothing to facilitate dispatched wind and peak shaving

Micro-Grid Solution

- High Speed Fault Clearing System is a non-interruptible micro-grid technology for underground distribution systems
- Main loop faults are cleared using:
  - High-speed communications
  - Fault interrupter switchgear tripping
- Maximum 6 cycle fault clearing time
- A fault on a backbone segment is automatically isolated; power flow to loads continues uninterrupted
- SCADA is not required for protection

Specially configured Remote Supervisory Vista Underground Distribution Switchgear

Distributed Intelligence

- Harnesses capability of microprocessors
- "Simpler" reconfiguration logic
  - Dynamic
  - Processes multiple contingencies
  - Remote upgrades
- Robust, redundant, resilient, secure
- Scalable to build incrementally
- Minimizes latency concerns / issues
- Graceful performance under duress

IntelliRupter
Self Powered, Self Contained, Fault-Interrupting Switch

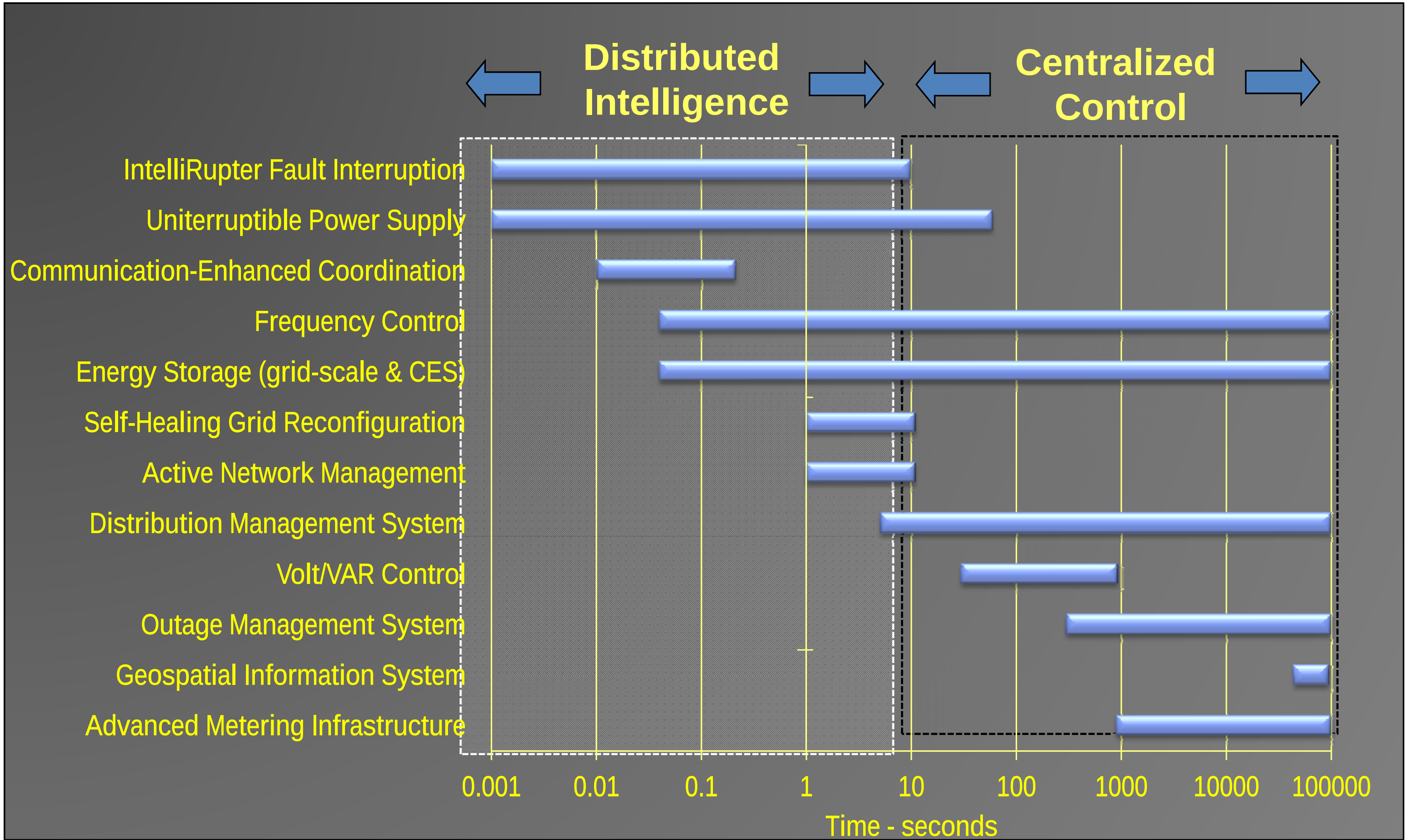
Community Energy Storage

Distributed energy storage connected to the secondary of transformers serving a few houses or small commercial loads:

- Local voltage regulation
- Peak shaving
- Buffer plug-in vehicles
- Aggregate control

Smooth effects of distributed sources, improves reliability, mitigates voltage sag, reduce losses, provides emergency transformer relief, improves grid utilization

Need for Speed Varies by Application



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Benefits ARE Possible: Balance is Needed

- Many benefits -- efficiency, savings, reduced emissions, energy security, economic growth, reliability….
- Solutions require balance well beyond technology

Consumers

Awareness, perception
Early engagement
Behavioral shifts
Education
Privacy

Markets

Business models
Cost allocation
Power markets
Utilities and suppliers

Policies

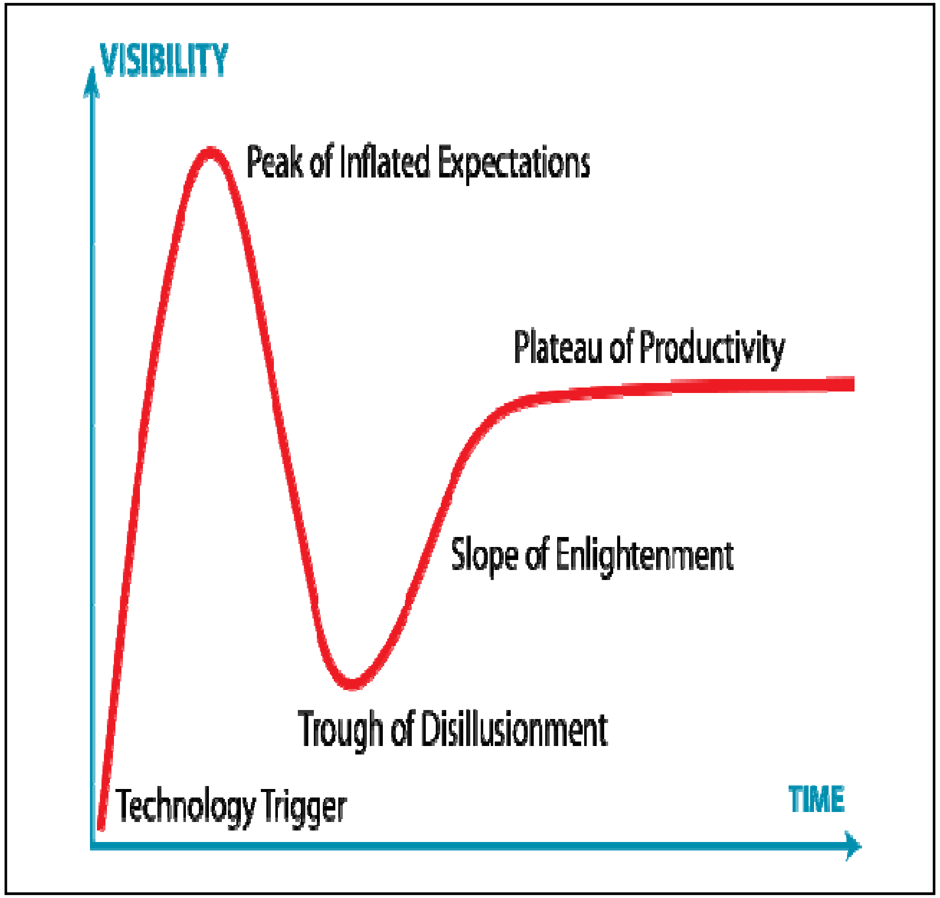
Certainty and predictability
Jurisdictional clarity
Stability: regulation / incentives
Reliability for digital economy
Clear standards

Technologies

Electric vehicles
Renewables
Automation
Storage

Managing the Innovation Journey

- Establish a long-range plan addressing priorities, challenges
- Provide real solutions
  - Building on existing technology know-how, accepted practices
  - Demonstrate successfully
  - Involve customers early
  - Delivery quality
  - Understand motivators
- Aligns expectations and benefits
- Achieves faster market acceptance



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Utility Communications
Efficient Building Systems
Internet
Renewables
PV
Consumer Portal & Building EMS
Advanced Metering
Distribution Operations
Control Interface
Dynamic Systems Control
Plug-In Hybrids
Smart End-Use Devices
Data Management
Distributed Generation & Storage

Advancements are Needed

- Increase electronic durability to align with delivery norms
- Place intelligence / control where needed with capable communications
- Apply into standard practice: modeling, training, testing, simulation
- Effectively manage data relevancy; ensure security
- Create visualization, pre/post disturbance analysis, self-diagnostics, fool-proof operational schemes, warning mechanisms
- Develop adaptive protection schemes
- Standardize to easily interoperate and scale
- Integrate controls to meet wide-reaching utility needs that includes priority setting for adaptability
- Innovate and incorporate grid friendly end-use loads

IEEE Smart Grid

IEEE is leveraging its foundation to develop standards, share best practices, publish developments and provide educational offerings to advance technology and facilitate successful Smart Grid deployments worldwide.

- IEEE Smart Grid portal
- Monthly e-newsletter
- Peer-reviewed publications
- Conferences
- Standards
- Technical tutorials
- Linked-In
- Twitter *@ieeesmartgrid*
- YouTube channel

IEEE SMARTGRID

http://smartgrid.ieee.org

Conclusion

- A smarter grid can accommodate more renewables, reduce demand and improve utilization, reliability and efficiency.

- Necessity for grid modernization
  - —Involve the consumer and community
  - —Seek state regulatory support and certainty
  - —Strike a balance: markets, consumer, regulatory, technology
  - —Recognize that it is a journey: have a plan, progress logically, set reasonable expectations, address challenges, share lessons

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