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SMART GRID: CHALLENGES AND OPPORTUNITIES

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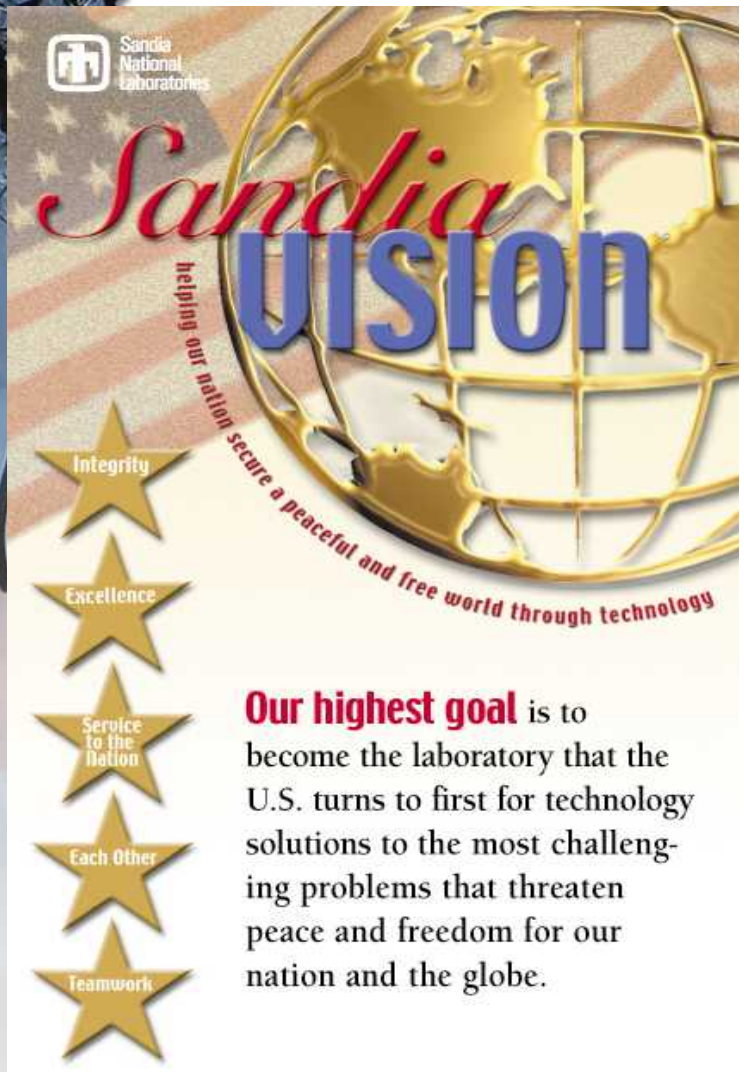

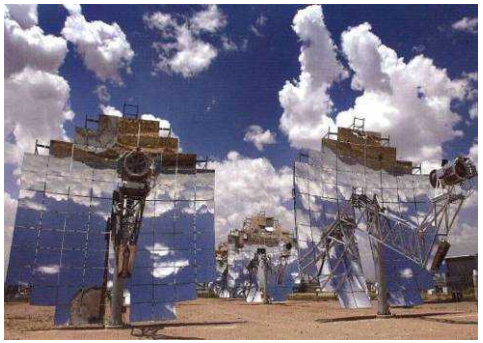

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- **Broad mission in developing science and technology applications to meet our rapidly changing, complex national security challenges**
- **Safety, security and reliability of our nation's nuclear weapons stockpile**

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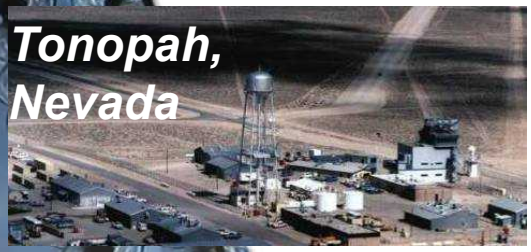

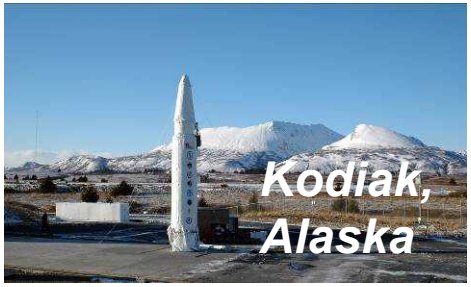

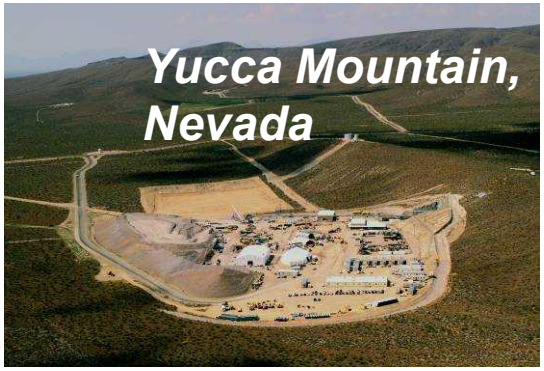

Outline of Presentation

- Power Grid Background
- Smart Grid Description
- National Efforts
- Opportunities
- Challenges

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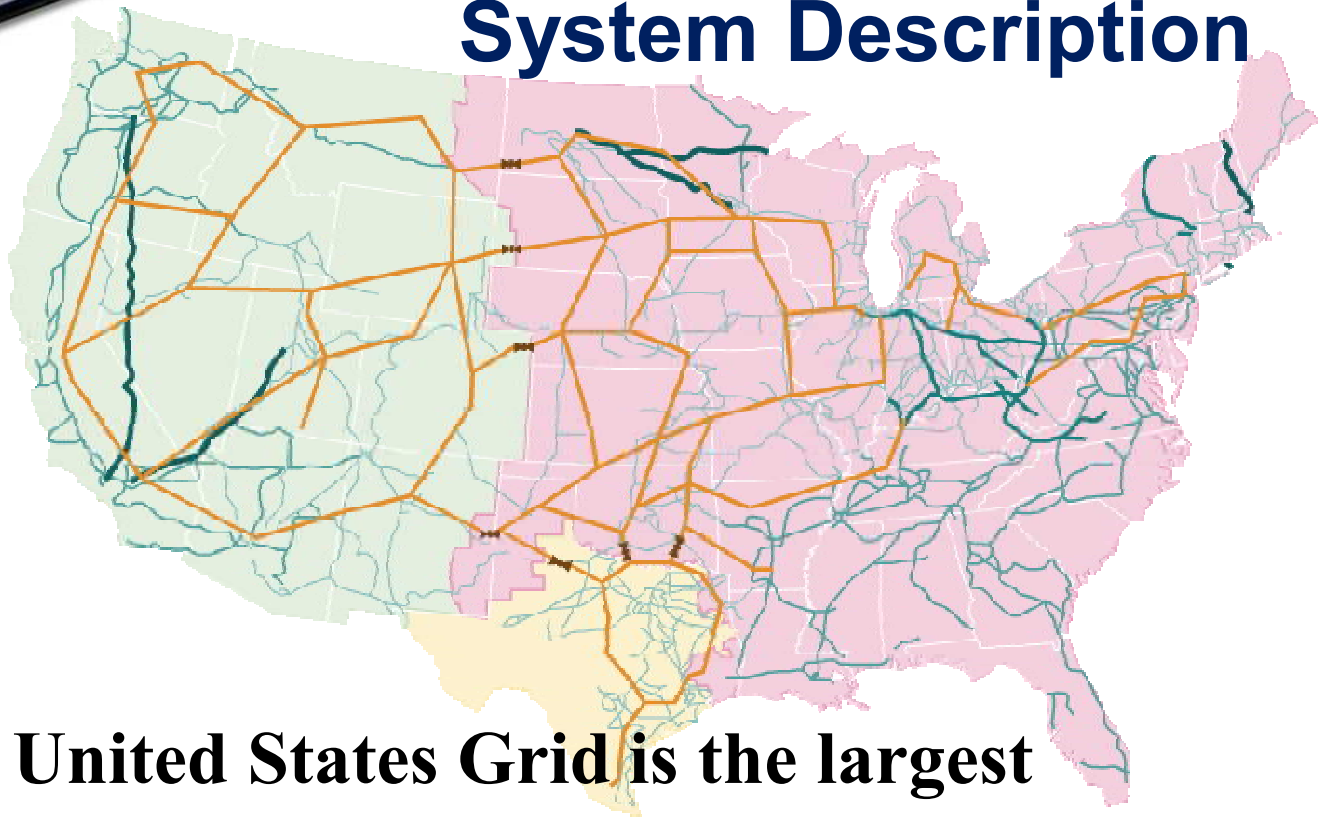
System Description



Source: American Electric Power, American Wind Energy Association, Center for American Progress, Department of Energy, Edison Electric Institute, Energy Information Administration, Electric Power Research Institute, Federal Energy Regulatory Commission, National Renewable Energy Laboratory, U.S. Environmental Protection Agency, Western Resource Advocates

The United States Grid is the largest interconnected machine on earth

- 9,200 Generating Units
- 1,000,000 MegaWatts of Generating Capacity
- 300,000 Miles of Transmission Lines
- 150,000 Miles of Transmission Lines > 230kV
- 99.97% Reliable

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Historical Viewpoint

The U.S. electric power infrastructure (also known as the grid) has served the nation well and has been prototype to others globally…

BUT it is running up against LIMITATIONS

- Size
- Scale
- Security
- Adaptability

Image courtesy of PowerSouth Energy Cooperative

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Smart Grid's Fundamental Challenge

The U.S. Department of Energy(DOE) is responsible for the wholesale modernization of the national electrical grid WHILE IT IS RUNNING and Fully Functional. This effort is led by the Office of Electricity Delivery and Energy Reliability. This includes energy policy programs

- To Coordinate Standards Development
- To Complete Timely Research & Development

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Smart Grid Technology Landscape

Use of digital technology to improve reliability, security, and efficiency of the electric system with applications for dynamic optimization of system operations, maintenance, and planning

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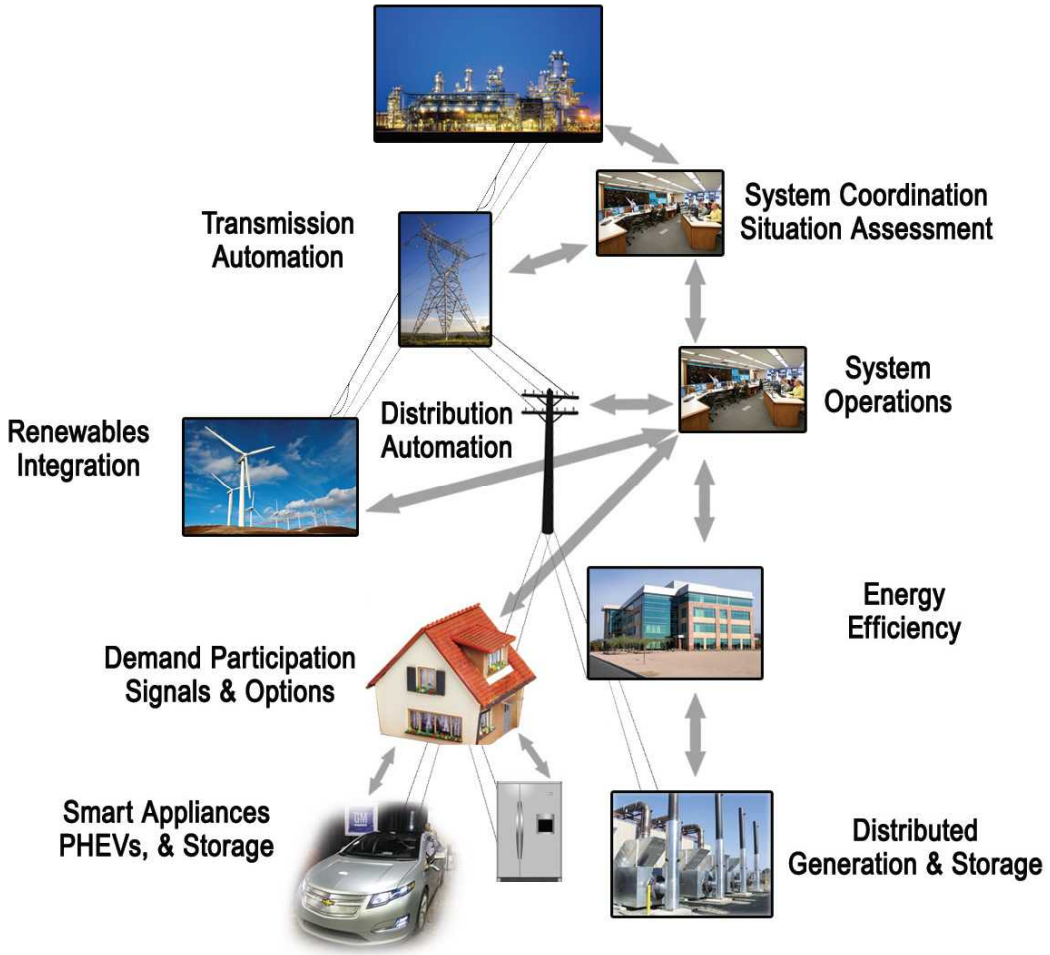

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Smart Grid Characteristics

1. **Enables Informed Participation by Customers**
2. **Accommodates All Generation and Storage Options**
3. **Enables New Products, Services, and Markets**
4. **Provides the Power Quality for the Range of Needs**
5. **Optimizes Asset Utilization & Operating Efficiency**

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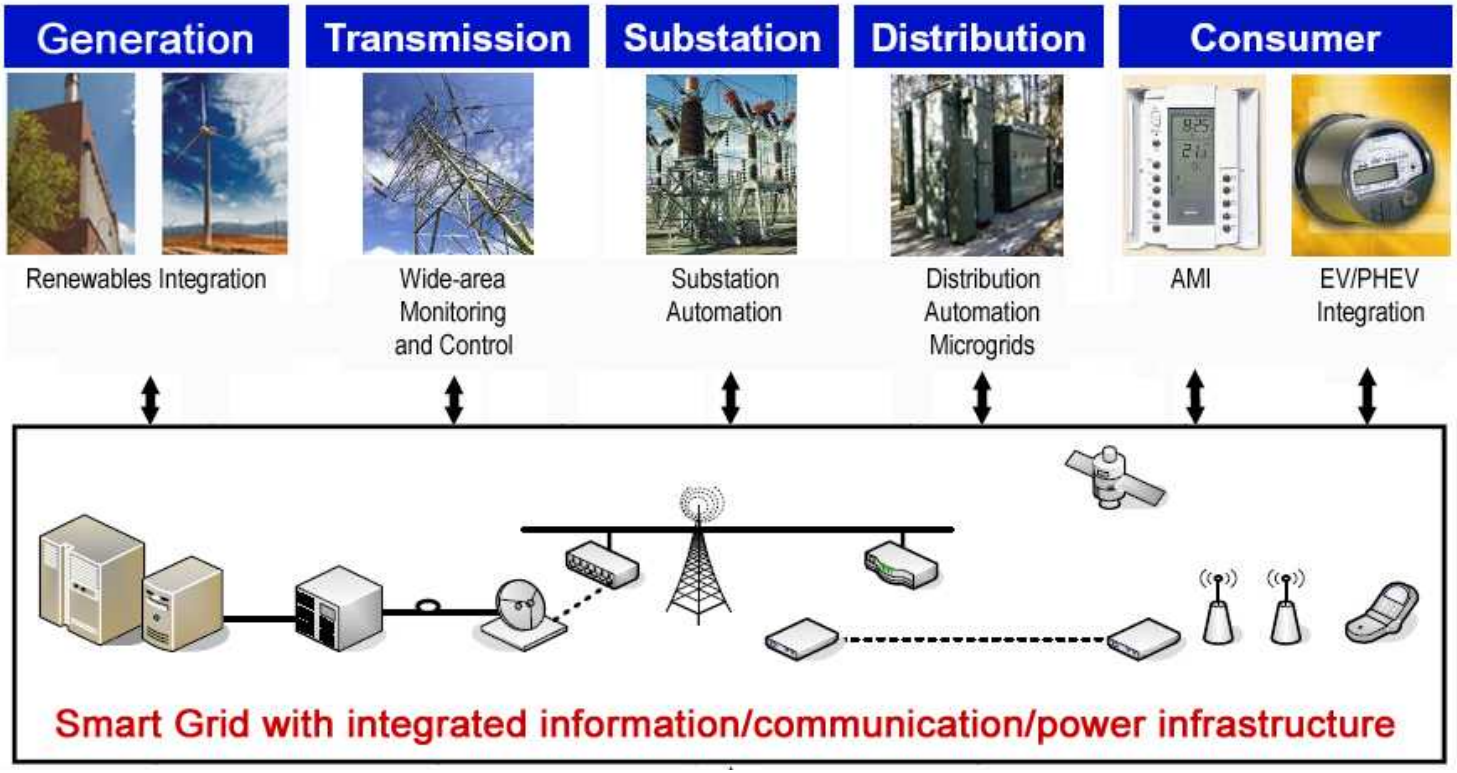
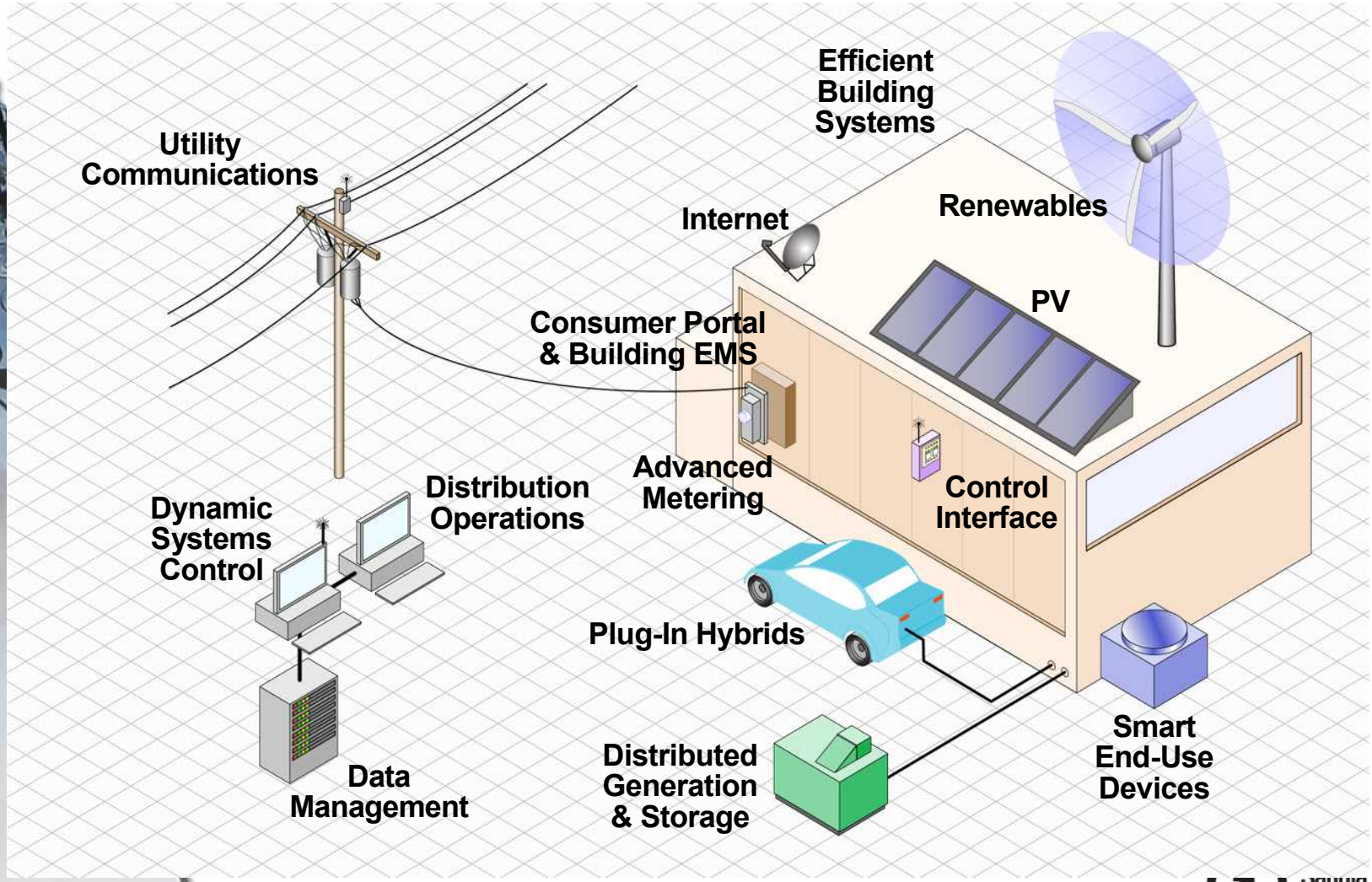
Smart Grid Enables Dynamic Optimization of Grid Resources and Operations



Smart Grid Enables Consumer Participation and Demand Response



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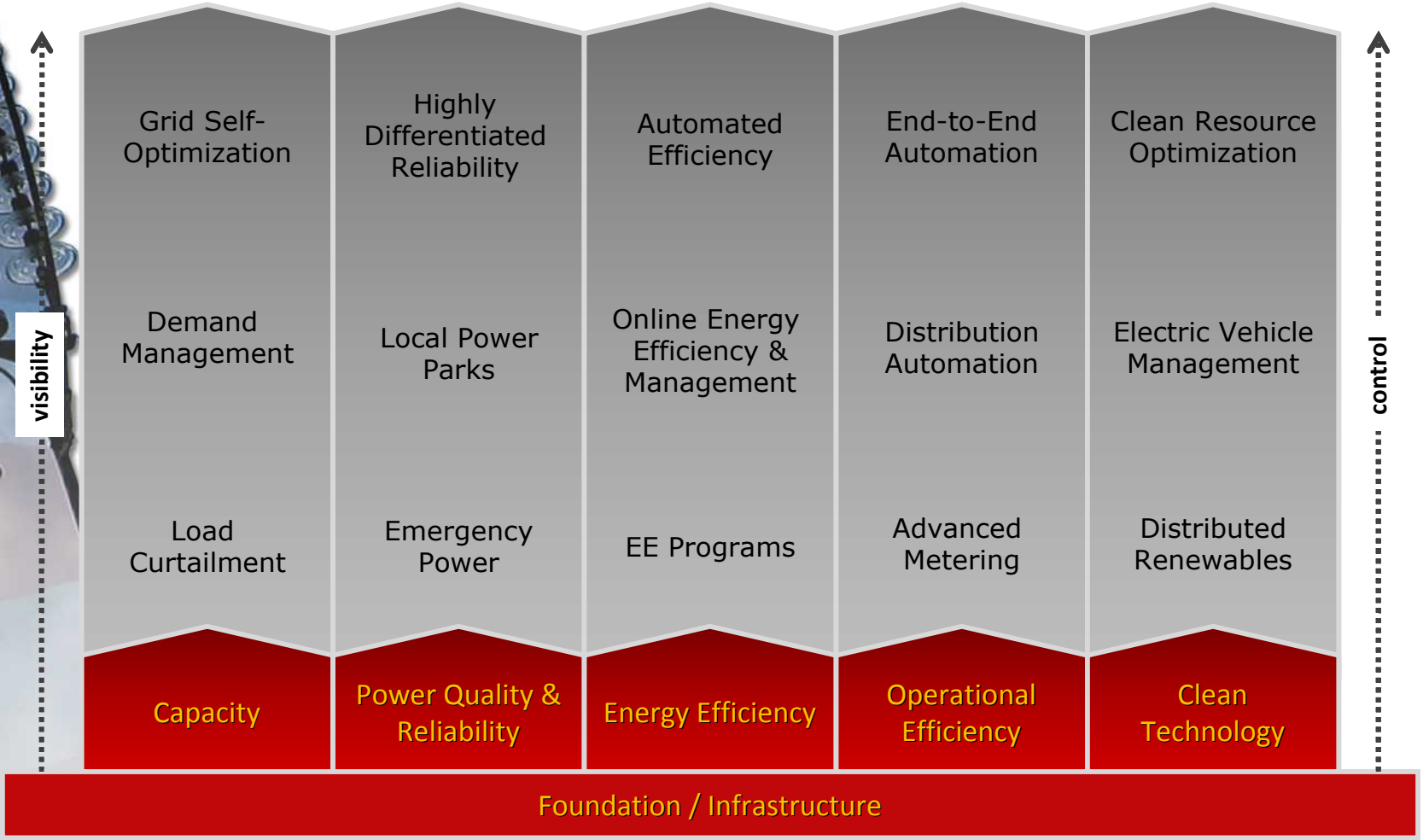
Smart Grid Value Streams

21st Century Smart Grid



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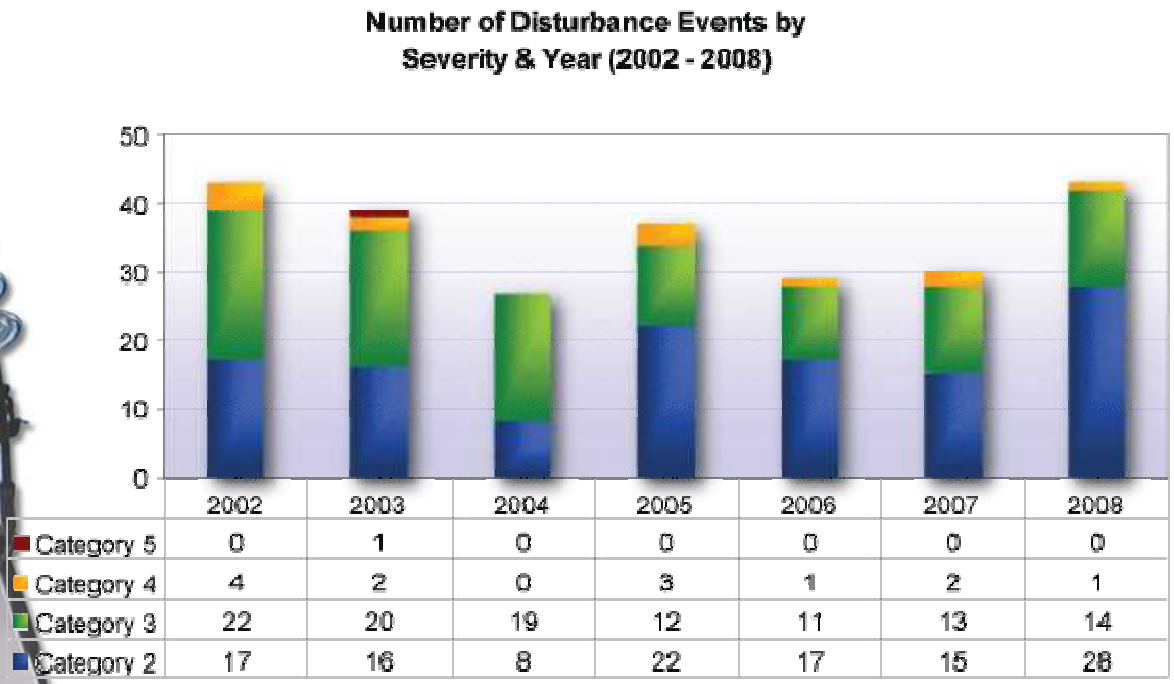
Smart Grid Value in Power Disturbance Savings



	2002	2003	2004	2005	2006	2007	2008
Category 5	0	1	0	0	0	0	0
Category 4	4	2	0	3	1	2	1
Category 3	22	20	19	12	11	13	14
Category 2	17	16	8	22	17	15	28

43 significant disturbances and outages occurred in 2008, as compared with 30 such events in 2007. A rise in misoperations of protection systems and controls and other factors (equipment failure, vegetation contacts, and human error) drove the increase in 2008.

Smart Grid technologies would reduce power disturbance costs to the U.S. economy by $49 billion per year, according to the EAC report titled "Smart Grid, Enabler of the New Energy Economy," December 2008.

North American Electric Reliability Corporation, Reliability Performance Gap Index

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Smart Grid Value in Energy Efficiency

Mechanism	Electricity Sector Energy and Carbon Reductions*	
	Direct	Indirect
Conservation Effect of Demand Response Consumer Information	3%	-
Marketing/Outreach Synergy Between Demand Response and Efficiency Programs	-	0%
Measurement and Verification for Efficiency Programs	1%	< 0.2%
Smart Grid-Enabled Diagnostics in Residential and Small/Medium Commercial Buildings	3%	-
Conservation Voltage Reduction and Advanced Volt/VAr Control	2%	-
Load Shifting from Demand Response	< 0.1%	-
Support Additional Electric Vehicles (EVs) / Plug-In Hybrid Electric Vehicles (PHEVs)	3%	-
Reduced Need for Regulation and Reserves to Achieve 25% RPS: Solar Photovoltaic Integration and/or Wind Energy Integration:	< 0.1%	5%
Total Savings	**12%**	**5%**

Assuming 100% penetration of smart grid in 2030:

- **12% direct reductions**
  - **3% reductions from smart charging of PEVs at very high penetrations (> 60%)**
- **5% indirect reductions from reinvestment of $ from avoiding the addition of extra capacity for regulation and reserves to support a 25% renewable portfolio standard**
- **~ ±50% uncertainty under each mechanism investigated**

Pratt, R. G., et al., "The Smart grid: An Estimation of the Energy and CO2 Benefit," Pacific Northwest National Laboratory, Dec 2009.

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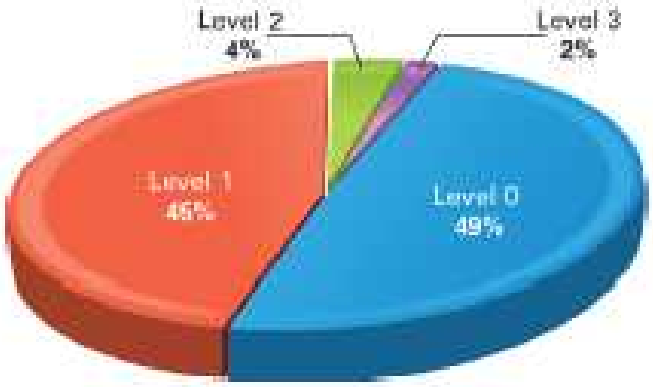
Smart Grid Maturity Model (SGMM)

- SGMM assets conveyed from IBM and the Intelligent Utility Network coalition to SEI for stewardship, Mar 09
- Updated model documents available on SEI web site, Aug 09
- First annual report released at GridWeek, Sep 09
  - Reports data from first 53 surveys
  - Available at www.sei.cmu.edu/smartgrid



SGMM scores indicate that most utilities are just beginning their smart grid journeys—overall maturity scores are almost evenly split between levels 0 and 1 (out of 0-5)

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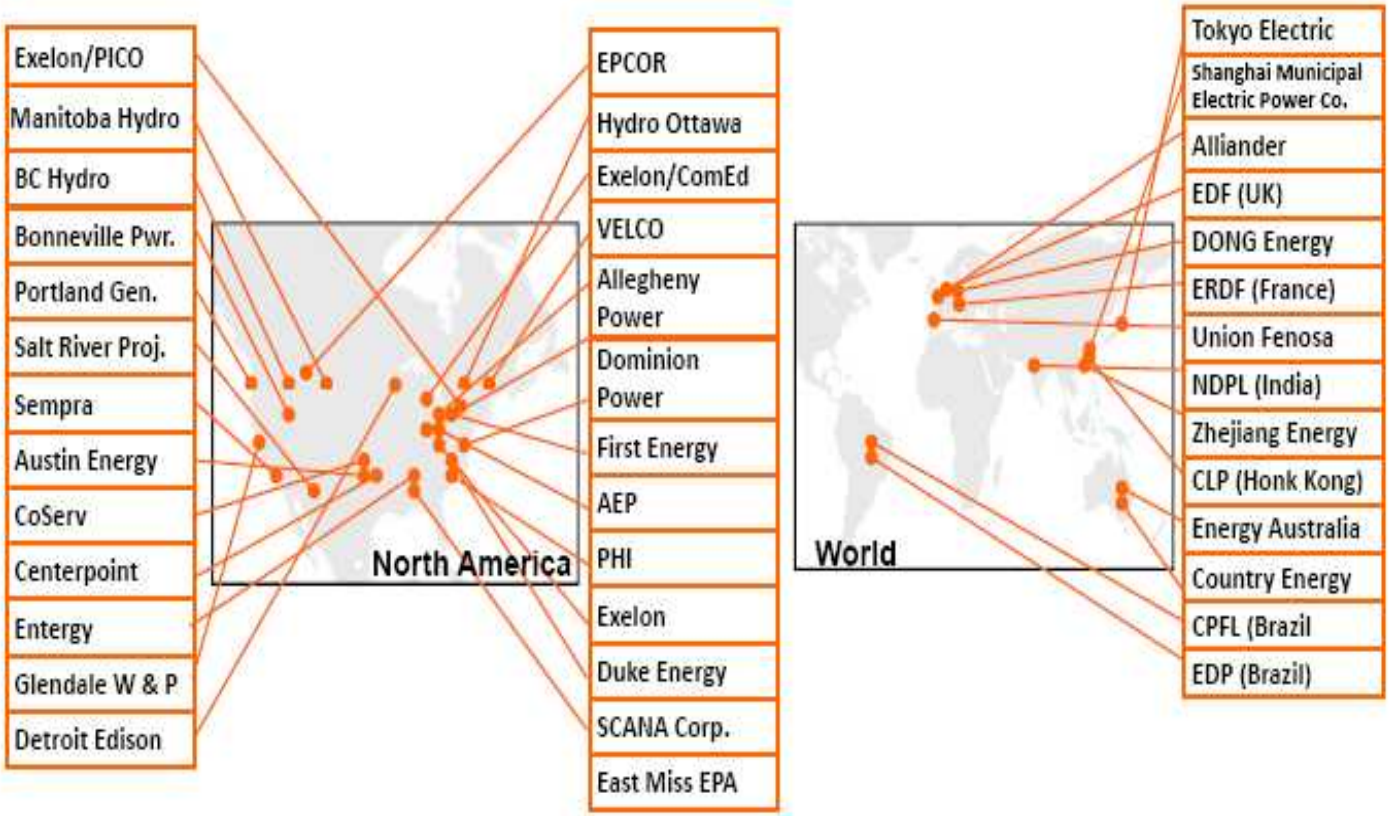
60+ SGMM Completed Surveys

A management tool to help utilities benchmark smart grid development and share best practices; 60+ utilities have completed SGMM surveys



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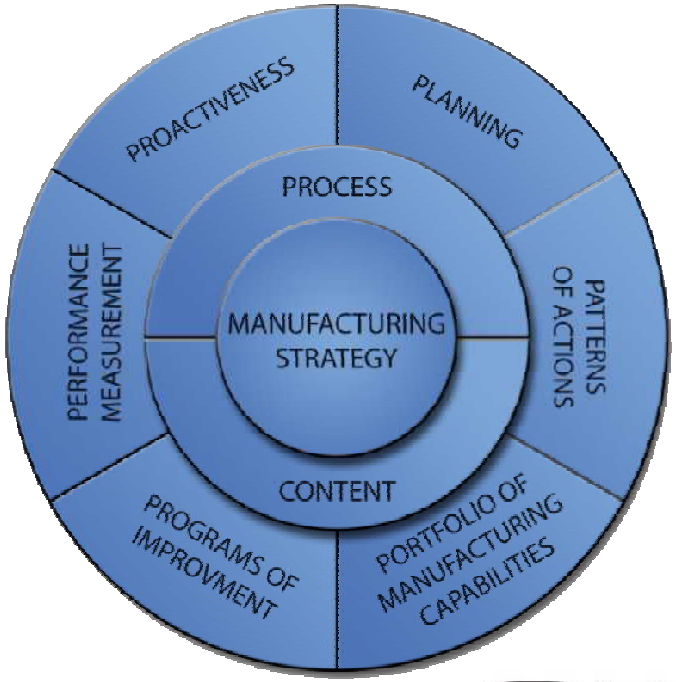
Energy Policy Elements Description

- **The Multifaceted Approach of Energy policy occurs on several levels; Local, Regional, and National, and involves:**
  - National Actions
  - Regulatory Issues
  - Financing Instruments
  - Research & Development
  - Energy Tech Road Map
  - International Cooperation to satisfy the Supply & Demand Balance



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SG (Local) Opportunities

The basic Research and Development and Fundamental Technologies that will move the Smart Grid forward

1. **Integrated Communications**
   - To connect components to open architecture for drive real-time information and control allowing every part of the grid to both "talk" and "listen" at the same time
2. **Sensing and Measurement Technologies**
   - To support faster and more accurate responses such as remote monitoring, time-of-use pricing, and demand-side management
3. **Advanced Components**
   - To apply the latest research in superconductivity, storage, power electronics, and diagnostics
4. **Advanced Control Methods**
   - To monitor essential components that enable rapid diagnostics and precise solutions appropriate for any event

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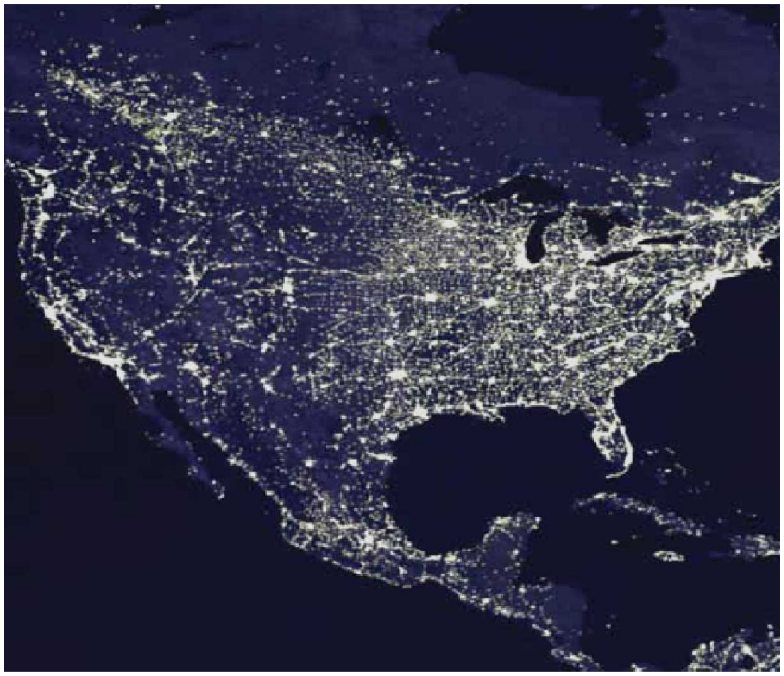
SG (Regional & National) Opportunities

Before looking at the particular technologies for moving forward, the government and utilities have shared input about basic functions they require of the smarter grid

- **Be self-healing**
- **Resist attack**
- **Provide higher quality power that will save money lost on outages**
- **Motivate consumers to actively participate in grid operations**
- **Accommodate all generation and energy storage options**



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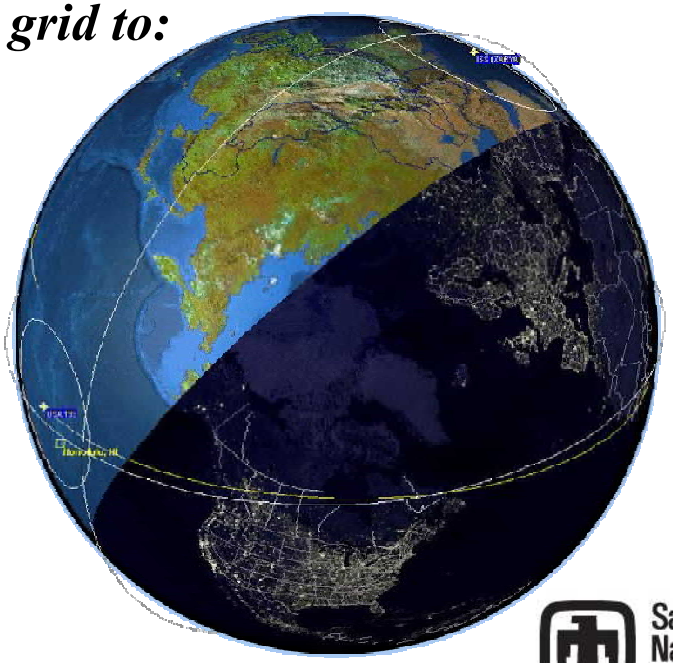
SG Analysis Objectives for Global Opportunities

The smart grid is a simple upgrade of the 20th century power grids which generally 'broadcast' power from a few central power generators to a large number of users to be capable of routing power in more optimal ways to a very wide range of conditions to charge a premium to those who use energy at peak hours or inefficiently. The global energy challenges that are policy and technical will require efficient analysis for the smart(er) grid to:

- Run the grid more efficiently
- Enable electricity markets to flourish
- Enable higher penetration of intermittent power generations sources



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Socio-Technology Concern: Privacy

- Security implications of linking power grid to public Internet
- Increase in the level of personal detail available
- SG designed to provide customers (businesses and homes) real-time feedback on power consumption patterns
- Demonstrate how utilities plan to prevent others from gleaning important granular, minute-by-minute data that can be used to take advantage of information that reveals home occupancy and type of user?

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Top 10 Possible SG Privacy Concerns

1. **Identity Theft**
2. **Determining personal behavior patterns**
3. **Determining specific appliances used**
4. **Performing real-time surveillance**
5. **Revealing activities through residual data**
6. **Targeted home invasions**
7. **Providing accidental invasions**
8. **Activity censorship**
9. **Decisions and actions based upon inaccurate data**
10. **Revealing activities when used with data from other utilities**

Dr. Christopher Velstos, proponent of Privacy Impact Assessment/NIST (IT Compliance)

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Technology & Market Overlap

- **The predominant SG architecture is based on the current infrastructure of utility implemented control systems that monitor and manage the generation and the distribution of power.**
- **The Smart Grid of the future has new stakeholders, new technologies and features need to be implemented**

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Smart Grid Technical Challenges

- Interoperability
- Network Communications
- Demand Response
- Energy Storage
- Distribution Grid Management

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Smart Grid Interoperability

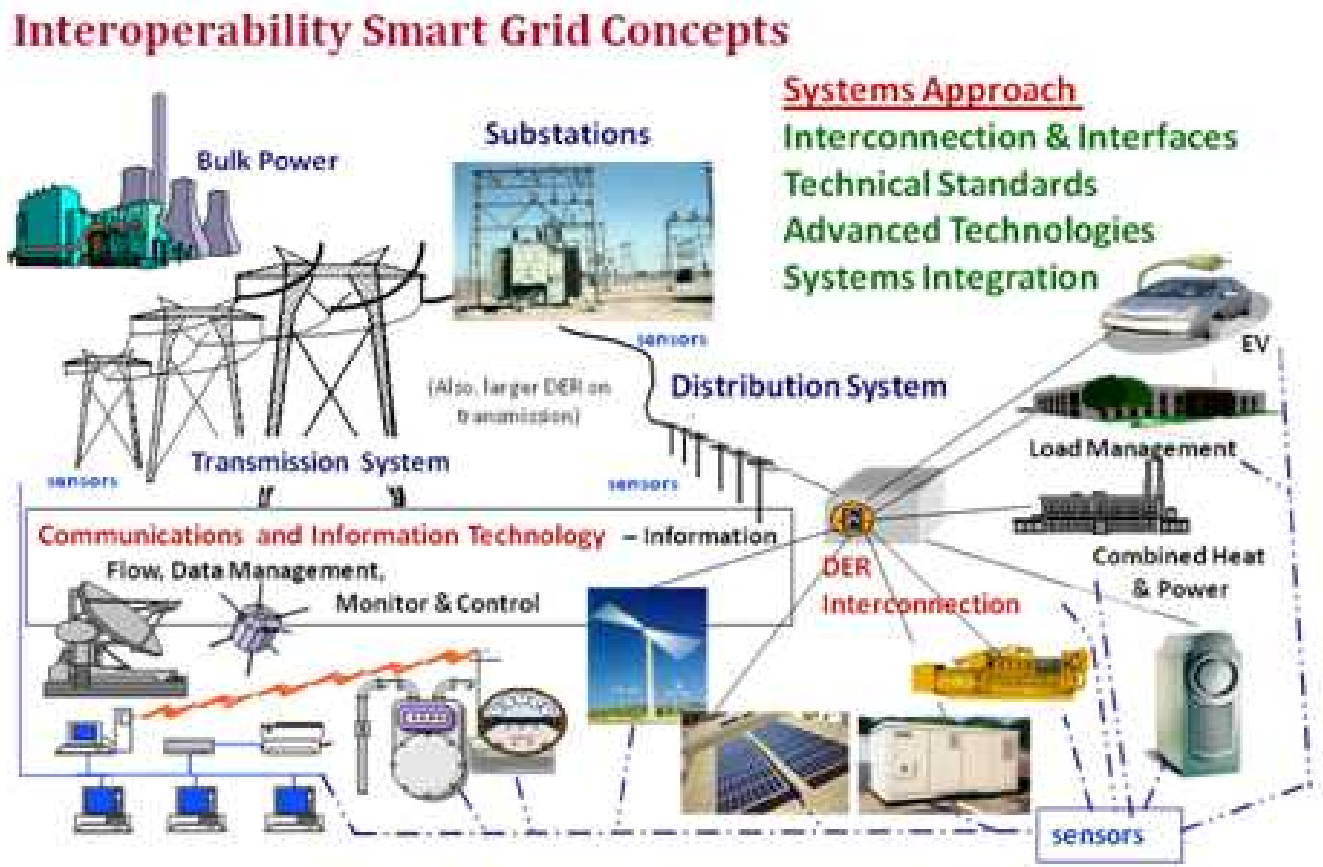

Image from IEEE – http://grouper.ieee.org/groups/scc21/2030/docs/sgg%20491_321.bmp

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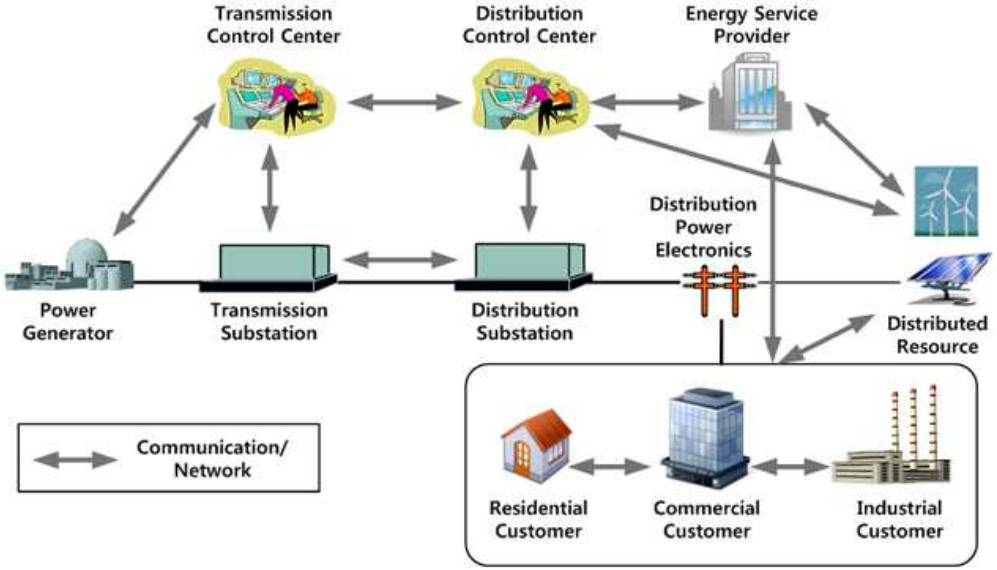
Smart Grid Network Communications

The Smart Grid domains and sub-domains will use a variety of public and private communication networks, both wired and wireless. This variety of networking environments is critical to

- –Identify performance metrics
- –Validate core operational requirements of different applications, users, and domains
- –Maintain appropriate security and access controls



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Smart Grid Demand Response

Demand Response (DR) mechanisms and incentives characterize basic Smart Grid objectives for utilities, business, industrial, and residential customers to

- Cut energy use during times of peak demand
- Be efficient when power reliability is at risk.
- Optimize the balance of power supply and demand regardless of system size

http://www.echelon.com/company/press/2009/images/smarthome_lg.jpg

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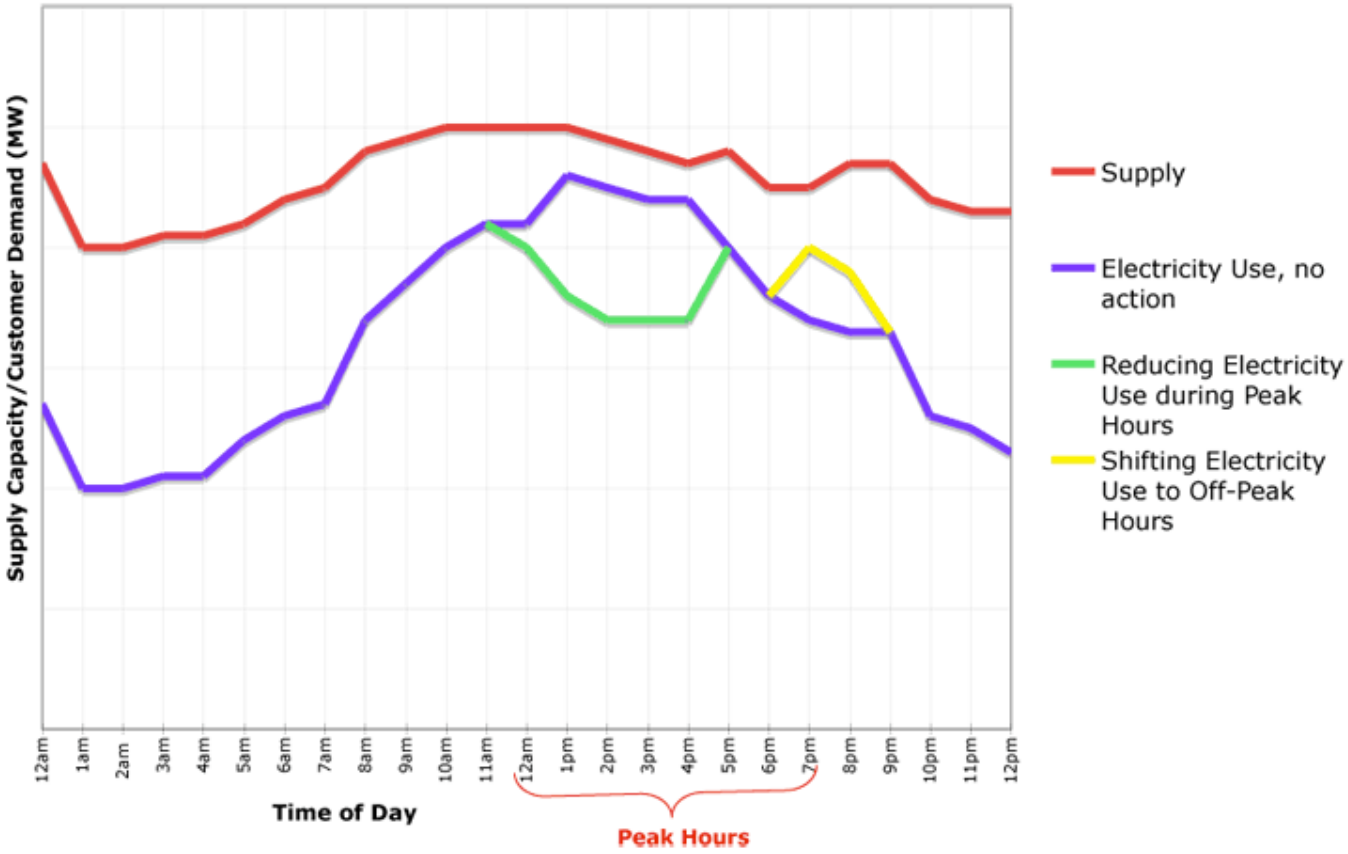
Demand Response



http://www.fypower.org/images/flexalert/now_shifting_graph.gif

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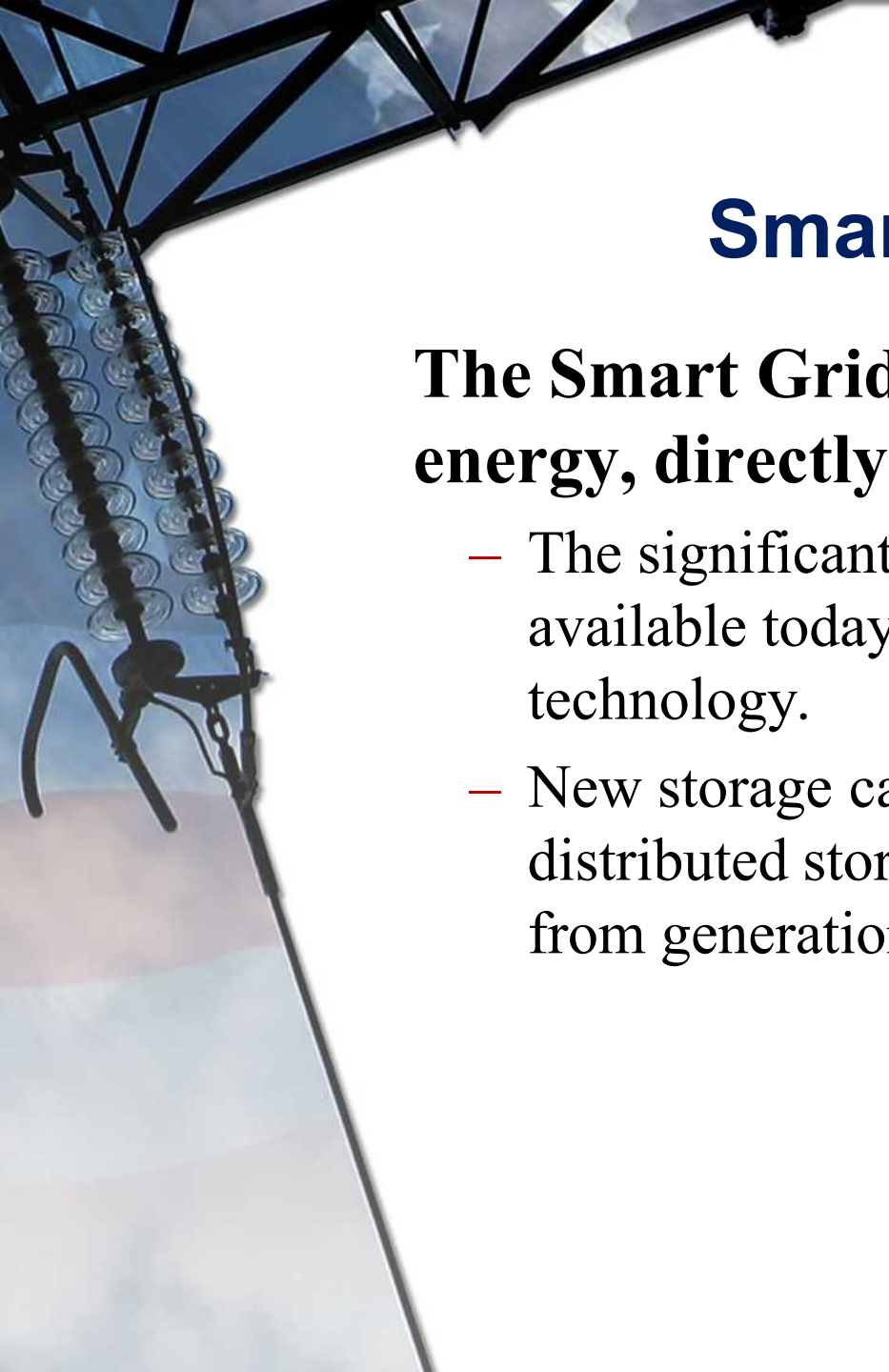

Smart Grid Energy Storage

The Smart Grid requires a means of storing energy, directly or indirectly.

- The significant bulk energy storage technology available today is pumped hydroelectric storage technology.
- New storage capabilities—especially for distributed storage—would benefit the entire grid, from generation to end use.

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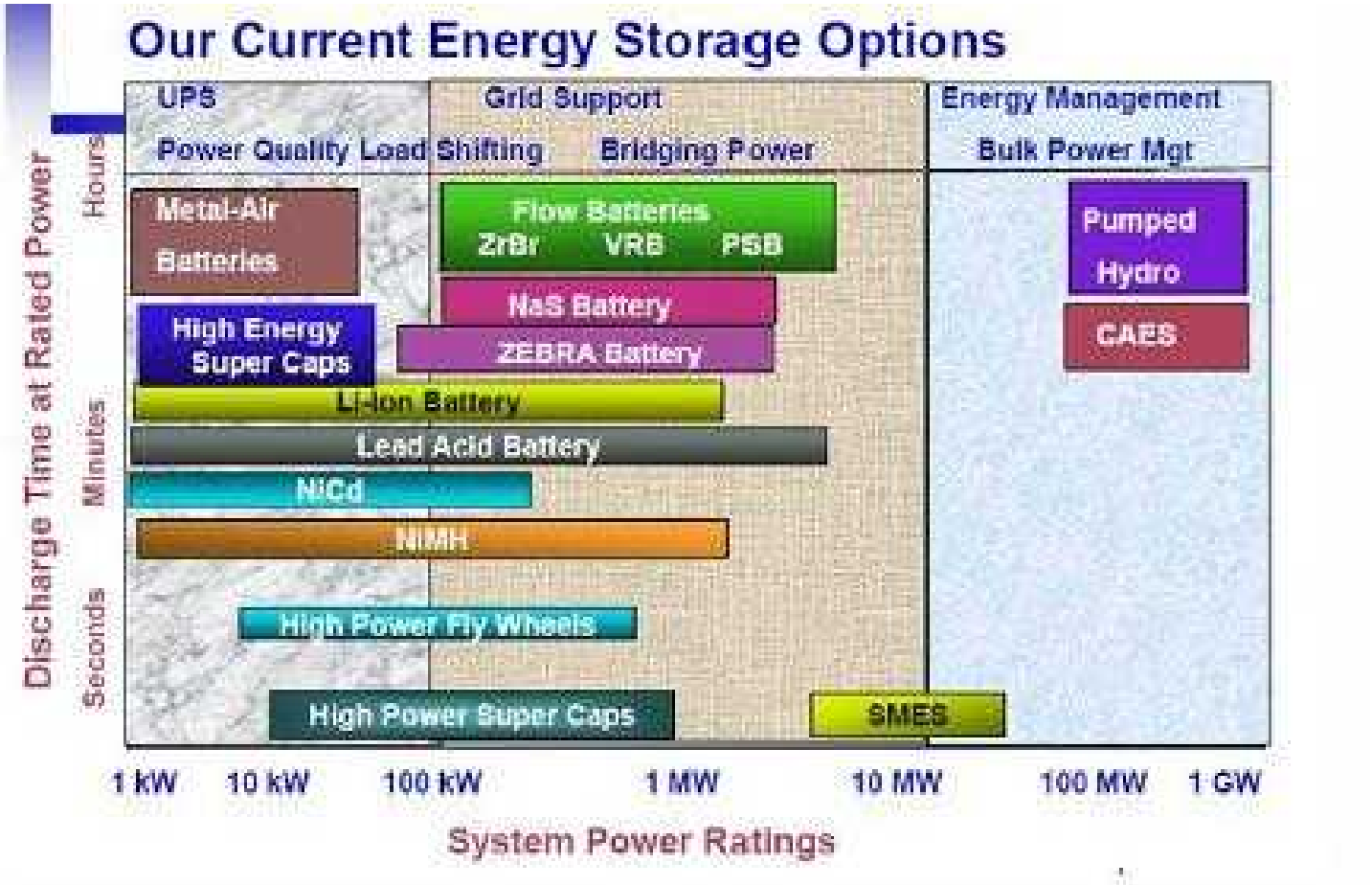
Energy Storage



http://www.matternetwork.com/images/Matter/stationary-storage2.JPG

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SG Distribution Grid Management

- Maximizing performance of feeders, transformers, and other components of networked distribution systems
- Integrating transmission systems and customer operations

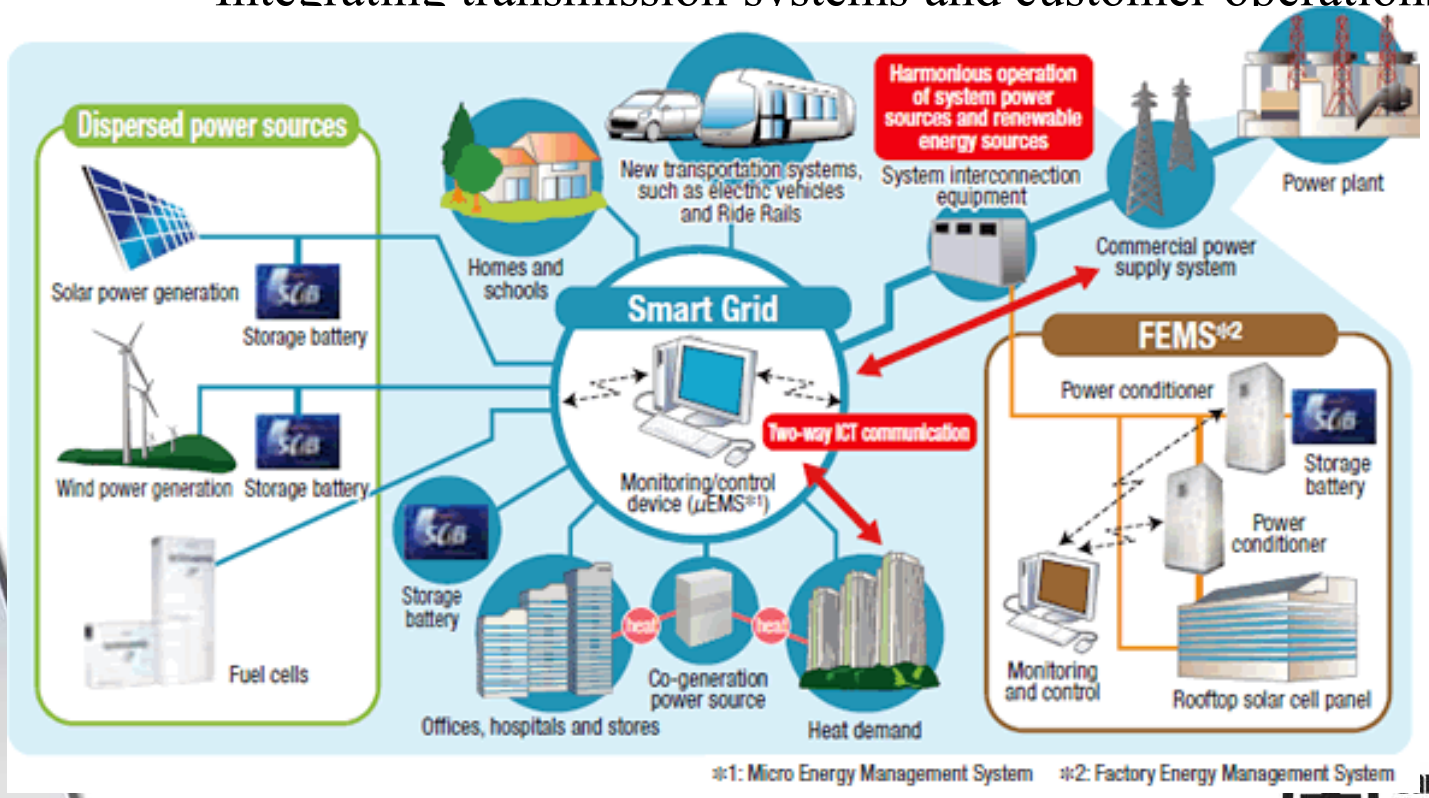
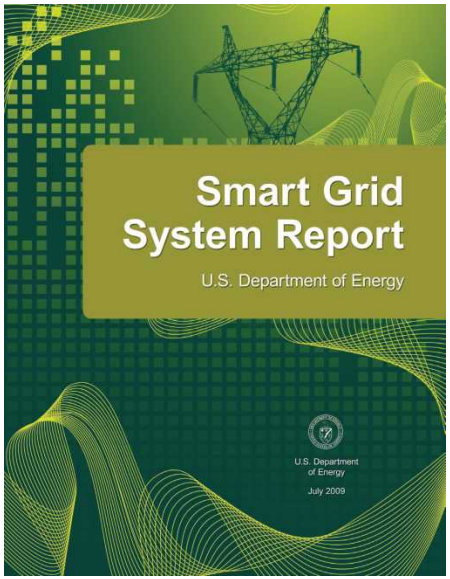


Image from Toshiba

Smart Grid Challenges

Smart Grid System Report (July 2009)* identifies challenges to smart grid deployments in 4 broad categories

- Costs and their recovery
- Interoperability standards
- Technical barriers
- Changing technologies and policies



* Report available at http://www.oe.energy.gov/DocumentsandMedia/SGSRMain_090707_lowres.pdf

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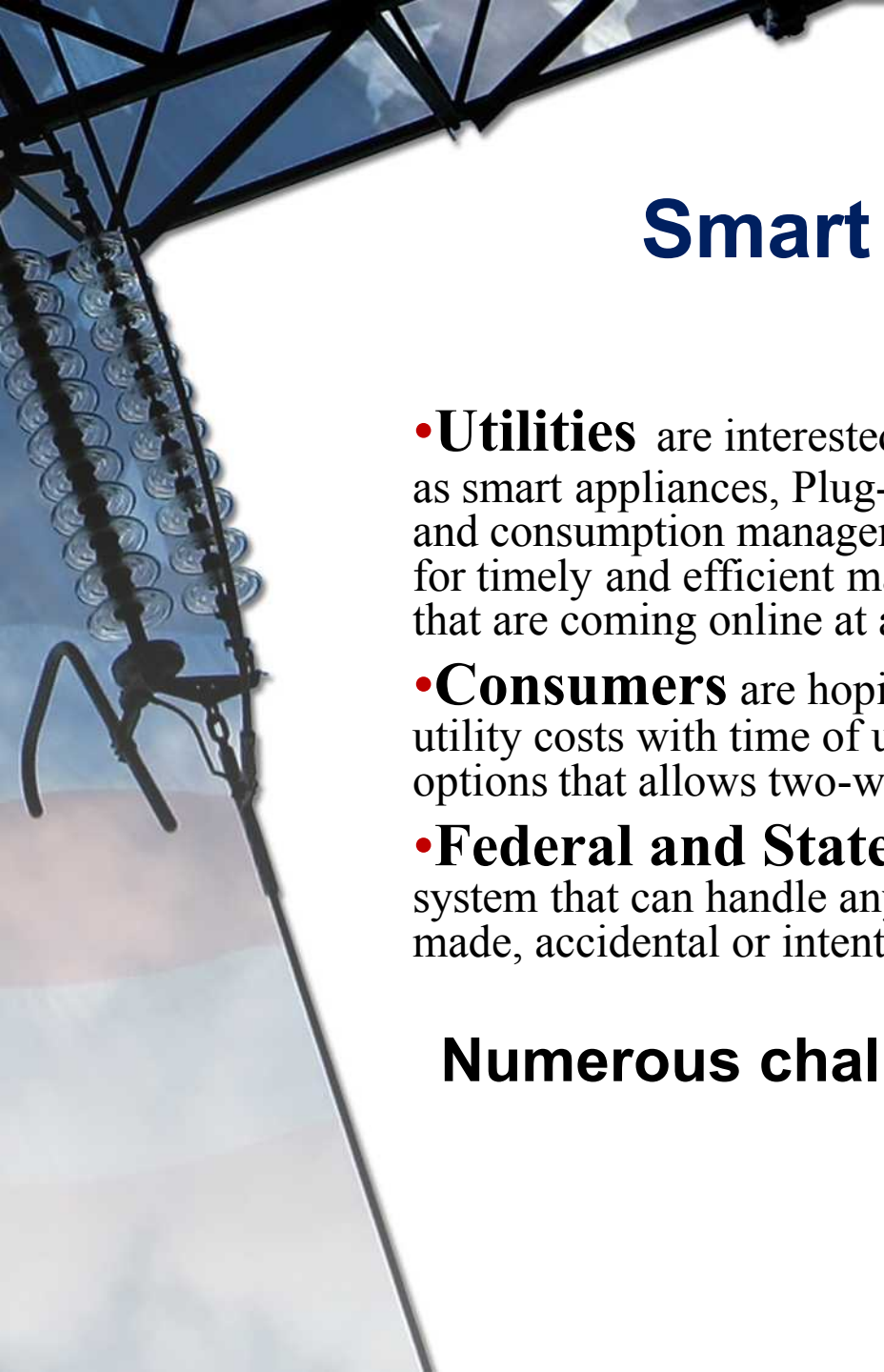

Smart Grid Overall Summary

- **Utilities** are interested in more aggressive load shedding tools, such as smart appliances, Plug-in Hybrid Electric Vehicle (PHEV) storage, and consumption management. They are also looking at the Smart Grid for timely and efficient management of large-scale wind and solar assets that are coming online at accelerated rates.
- **Consumers** are hoping that the SG will help curtail ever increasing utility costs with time of use (TOU) electric rates, and net-metering options that allows two-way power transmission and accounting.
- **Federal and State governments** want to assure a secure system that can handle any conceivable threat, whether natural, man-made, accidental or intentional.

Numerous challenges, but great opportunity

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Thank you!

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