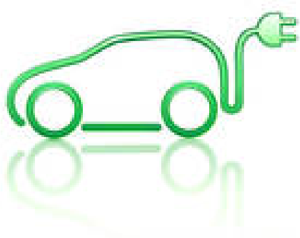
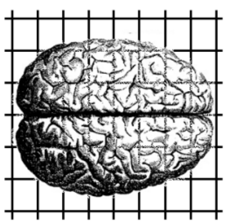
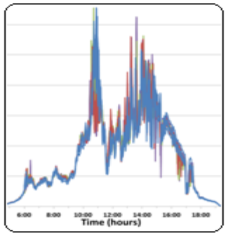
Summary Results of Challenges & Opportunities for Technology Areas of the Grid

From Breakout Group Sessions



Electricity Distribution Workshop

Sheraton Crystal City, Arlington, Virginia

September 25, 2012

DOE Grid Tech Team

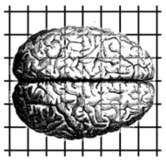
Vision of a 21st Century Distribution System

A *seamless*, cost-effective electricity system, from generation to end-use, capable of meeting all clean energy demands and capacity requirements, while allowing consumer participation and electricity use as desired:

- Significant scale-up of clean energy (renewables, natural gas, nuclear, fossil with CCUS)
- Allows 100% consumer participation and choice (including distributed generation, demand-side management, electrification of transportation, and energy efficiency)
- 100% holistically designed (including regional diversity, AC-DC transmission and distribution solutions, microgrids, and centralized-decentralized control)
- Accommodates two-way flows of energy and information
- Reliable, secure (cyber and physical), and resilient

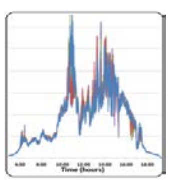
Technology Areas

- Plug-in Electric and Fuel Cell Electric Vehicles
  - *What strategies can prevent adverse impacts to the distribution system as PEVs reach a critical level of market penetration?*

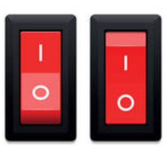


- Smart Grid Technologies & Energy Storage
  - *What is the proper balance of smart grid technologies within new smart grid control architectures?*

- Residential, Commercial, and Industrial Building Loads
  - *What are the speed, scale, quality, and reliability requirements of a building's storage, load management, and generation strategies to achieve effective grid interactions?*

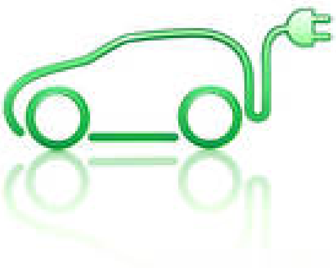


- Distributed Generation: Variable
  - *What are cost-effective, reliable ways to address technical integration issues such as voltage regulation, islanding, protection coordination, and reverse power flow?*



- Distributed Generation: Dispatchable
  - *What system-design, technical, operational, and safety requirements should be met for customer-sited dispatchable DG to provide ancillary services?*

Plug-in Electric and Fuel Cell Vehicles



Top 5 Priorities/Challenges

- **Cost**- how to add features (secondary battery use could reduce cost but no one buying, bi-direction power, DC fast charge, …) and cut costs to consumer acceptable levels to grow market demand for these vehicles. And how to effectively manage these vehicles in the market place and how to prioritize the benefits from incremental implementation
- **Batteries /Fuel cells/ Electrolyzers**– consumer/OEM confidence and experience to meet expectations including grid support at acceptable costs. Performance and reliability, determining appropriate duty cycles.
- **Future Proofing and Flexibility-** Intelligent charging and electrolyzer use to meet customer expectations, maximize life, and not destabilize the grid not only near term, but also in the future. System architecture that can evolve. Role of codes, standards and interoperability
- **Variability and Uncertainty** - Vehicle mix, vehicle fueling/charging infrastructure, duty cycles, and grid operation. Regulatory compliance
- **Unintended Consequences** – understanding how vehicles are going to be used, how they will interact with grid, what customers expectations are, regulations, analytics, lack of education, and quantifying the uncertainties.

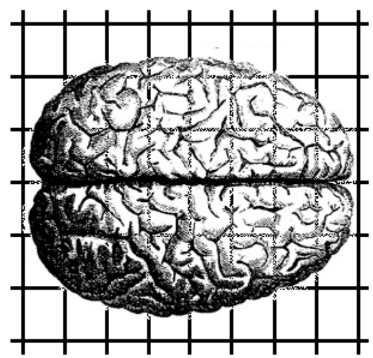
Technical R&D Activities

- **Cost**
  - Use utility vehicle usage/electrolyzer filling station operation/charging data to quantify values to stakeholders.
  - Identify where low or negative pricing exists and map out where to capture dispatchable load where H2 filling and charging stations to build out infrastructure.
- **Batteries /Fuel Cells/Electrolyzers** -
  - Continued battery system development to verify the stress envelop and grid benefit such as bi-directional power flow, fast charging etc.
  - Electrolyzer- need improved controls and power electronics as grid stabilization tool. IEC 61850, IEEE 1547-8

Technical R&D Activities

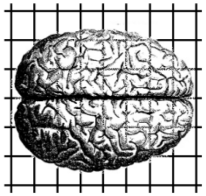
- **Future Proofing and Flexibility**
  - Comprehensive system analysis tools development –Does a fleet of 1M vehicles help the grid (EV chargers, electrolyzers, …)
    - Component- Leverage what has already been done, Develop duty cycle models, better battery/FC/Electrolyzer models.
    - Systems-
      - Distribution – for example GridLAB-D
      - Transmission
  - Large Scale Demonstrations – **QUANTIFY VALUE OF GRID SERVICES**
    - Work place and Buildings, 3rd party EVSE
    - OEM- Utility –“telematics” demonstration. Large multi- OEM multi-utility.
    - Ancillary Services demonstration – E.g.. Frequency regulation, demand response that’s good for the battery, start/stop charging.
    - Complimentary modeling spanning the grid should be included to understand the bi-directional power flow – Goal – quantify the additional benefit and help understand value chain so consumers know if they want to pay for this.

Smart Grid Technologies & Energy Storage



Key Challenges

- Absence of clearly defined hierarchical control systems (also for other DER)
  - Data collection, analytics, storage, state estimation, modeling
  - Interaction on either side of common coupling, e.g., PMU, storage, etc.
  - Connection b/t distr. and transmission
  - Who is the operator? Computer? Person?
- Microgrids – MicroDMS, all of the other issues described above
- System control
  - How to address safety, security and survivability of system?
  - Interoperability b/t components
  - Dynamic and adaptive protection schemes
  - Data management (who owns? Who controls? Secure? Addresses privacy issues? Addresses competitive issues?)and conversion to information for decision making
  - Bridging centralized and distributed approaches in data management, decision making
  - System safety
    - Disconnect, reconnect, backfeed from EVs, PVs, etc.
    - Protection schemes, controls, smarter inverters, education and training, codes and standards

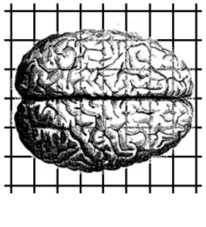


Key Challenges

- Coupling to internet? If? How?
- Define use cases for smart grid (or utilization of what smart grid functionalities for a given scenario) to define barriers to adoption
- Barriers to source or sink power to the grid
- What are the rules of the game?
- How do we generate a level playing field (policy, technical, business) while maintaining core grid functionality?
  - Technical aspects
  - Standards and rules, policy
- Communications (i.e., physical communication)
  - Current infrastructure, systems not adequate
  - Pace of change makes planning tough – AMI example
  - What data is needed? What computational resources? Who owns? Cloud?
  - Identification of requirements to define resources/technology
- How to generate evolvable/adaptable system to reduce the obsolescence challenge?

Key Challenges

- What is the business model for participants incl. utilities in the future grid state?
  - Accommodate all costs for each involved party, price all values and allocate appropriately
  - Market provides appropriate incentives
- Modeling at many levels
  - System, market, planning, controls, current and future state estimation
  - Speed, accuracy
- Component/provider interfacing with utilities
- Acceptance of new technologies onto grid
- What is the market? What does the consumer want/need? Who is the consumer of these services? At what level is the consumer participation?
  - Recognize difference by the ‘consumer’ side and ‘utility’ side of market
- What is the larger market structure (regulated vs. de-regulated)?
- Interaction of new functionality with legacy infrastructure
- Holistic understanding of physical, information and other dimensions of the system



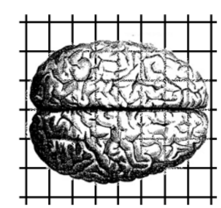
Opportunities: Summary

Systems approach for SG is critical

1. Define use cases (requirements, market, business case)
2. System architecture
   - System management hierarchy
   - Simulation, models
   - Control system (bridging dist. and centralized)
   - Evolvability
3. Communications
   - Interoperability incl. cyber security
   - Data collection, storage, conversion to information
   - Infrastructure
4. Interface between distribution and transmission
5. Protection
   - Dynamic and adaptive for 2-way flow
   - System operation under loss of, e.g., communications

Opportunities

1. Defining use cases (requirements, market, business case)
   - Generate/document baseline engineering use cases, e.g., from DOE SG Demos, EPRI, international, etc., to identify impacts on system control and architecture issues
     - Generate reference architecture from requirements pulled from SG Demos
     - Ex: Distributions Systems Operator Interface with Aggregator of Demand Response at Community Level
     - Ex: Extract appropriate sensor architecture from SG Demo information, i.e., ‘Optimal placement of AMI meters for system management’
   - ‘Lessons Learned’ to include what works, what does not work
   - Program to coordinate with SGIP use case process



Opportunities

2. System Architecture

- Help define standardized hierarchical system/management architectures for various scales and system types
- Help define data exchange/collection at various levels
- Tools and advancements for modeling and simulation including computational methods
  - Improved coverage of appropriate timescales from ms to hours
  - Technical models for component and system scale
  - Tool to simultaneously model dynamic system/component response and communications
  - Modeling methods that better captures and deals with various uncertainties
  - Model validation and calibration
  - Distribution scale simulators
  - Facilitate interchange of information between vendors and users
  - Improved visualization tools that can solve real challenges for users
- Interface between transmission and distribution

Opportunities

3. Communications

- Help establish communications requirements for various components under various configurations

- Develop conformance testing and certification for interoperability incl. cyber security

- Define requirements for data collection, storage, conversion to information based on use case, desired outcome, etc.

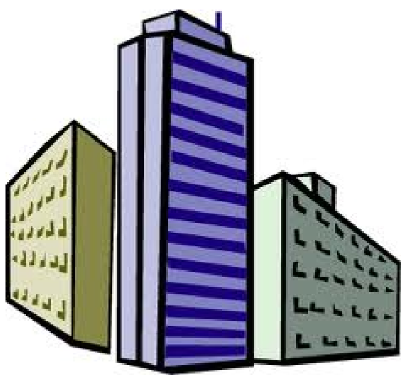
- Infrastructure

Opportunities

4. Protection

- Dynamic and adaptive for 2-way flow
- System operation under loss of, e.g., communications

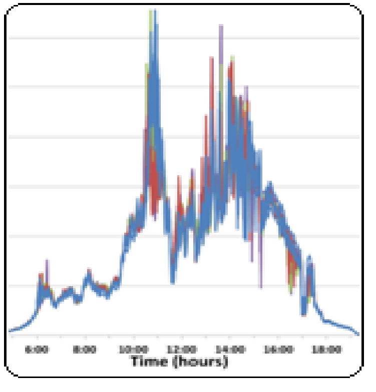
Residential, Commercial and Industrial Buildings



Residential, Commercial and Industrial Buildings

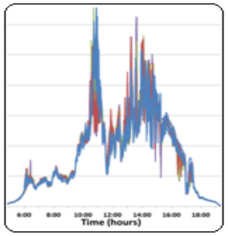
Gap	R&D
Building resiliency: Lack of understanding of relationship between building performance and grid operations.	Develop models to understand characteristics of how buildings can/do interact with the grid. Analysis on measured characteristics. Catalog systems and solutions map to characterizations.
Lack of technical infrastructure (controls/sensors) in buildings.	Identify the ideal characteristics of building control solutions, for all building types. Develop and deploy low cost, plug & play, packaged solutions of cognitive, secure, standardized, and scalable infrastructure for building operations and grid interaction. Develop/deploy low cost, application specific sensors
Lack of adequate information and communications systems to communicate energy and other valuable information between all interfaces of buildings and grid.	Survey of existing communications systems and infrastructures. Appropriately develop, deploy, and/or integrate the existing communications interfaces between building and grid. Standardize measures for communicating/signaling. Common lexicon for communicating info. Security implied
Lack of business case to achieve solution on both sides.	Develop model business plans to identify and monetize potential and existing value streams across the ISO, utilities, end users, and other market actors. Develop analytic tools, demos, and pilots to achieve goals. Implied adherence to rules/regulations.
Lack of uniform, national specifications for integration and interconnection applicable to	Work with the market to develop a national standard for integration and interconnection taking into account safety,

Distributed Generation: Variable



Key Challenges

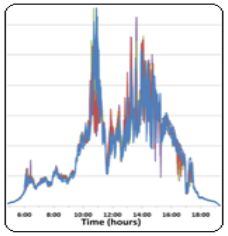
1. Burdensome and varying interconnection processes
2. Lack of planning tools necessary to evaluate impacts of variable DG on the grid
3. Lack of operations tools and systems – Need real time, predictive analysis for grid operation
4. Determining and communicating true cost and value of DG to stakeholders to guide planning and operation – business model, customer education
5. Lack of robust, low cost, resilient, secure communication system for visibility and control of DG
6. Evolvement of codes and standards; Interoperability of software and hardware



Most Important Technology Development Opportunities / Activities

1. ***Burdensome and varying interconnection processes***
   - Need uniform, consistent, and transparent analyses and processes (IEEE standards activities) that are based on a rigorous and sound engineering principles
   - Support the development of a timely, streamlined process
   - Develop technical forums to develop better case studies and best practices
   - Identify better defined triggers for interconnection studies that are based on a rigorous and sound engineering principles
   - Identify data and models (at the appropriate level of detail) needed for interconnection studies
   - Include information on certified equipment that are easy to access
   - Better resource information to characterize DG

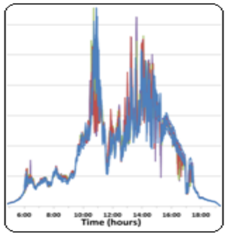
2. ***Lack of planning tools necessary to evaluate impacts of variable DG on the grid***
   - Need to develop dynamic models, algorithms (separation of planning and operation)
   - Better resource information to characterize DG
   - Collection the right data, understand the data, publish results; better dissemination of findings
   - Develop process to educate engineers to use existing tools
   - Develop better integration of tools and interoperability, data sharing (.e.g. GIS, CIM)
   - Develop generic, transparent processes; increase DOE facilitation role and help adoption of tools; workshop
   - Needs maturity and convergence of tools
   - Need tools to bridge between distribution and transmission



Most Important Technology Development Opportunities / Activities

3. ***Lack of operations tools and systems – Need real time, predictive analysis for grid operation***
   - Traditionally engineering tools are stove piped - hard to exchange data between software systems; need modern enterprise tools (vs. islanded tools) to deal with movable things like DG
   - Interaction and coordination of grid control functionalities – e.g. VAR control conflicts anti-islanding scheme;
   - Easy button for operators and planners
   - Develop real time (e.g. 15-minute) forecasting capability

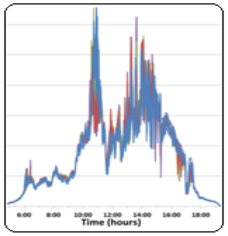
4. ***Determining and communicating true cost and value of DG to stakeholders to guide planning and operation – business model, customer education***
   - Understanding of rate structure; more interaction with PUCs
   - Develop tools to analyze rate cases and rate structures to help inform regulators
   - Quantify the various cost components of DG integration (e.g. interconnection cost)
   - Additional analysis on do-nothing option as a baseline
   - How to utilize new technologies in cost-effective ways to mitigate DG integration impacts



Most Important Technology Development Opportunities / Activities

5. ***Lack of robust, low cost, resilient, secure communication system for visibility and control of DG***
   - Develop tools to evaluate cost-effective communication options
   - Standard protocols for interoperability
   - Interagency work (e.g. FCC) – frequency allocation
   - Need to address control issues (latency and BW requirements)

6. ***Evolvement of codes and standards; Interoperability of software and hardware***
   - More support for code and standard development to accelerate the processes
   - Validation of standards in the laboratory and in the field
   - Evaluation of DOE involvement in additional standard activities (NEC, IBC)
   - Better inform / educate state regulators
   - Collaboration with international standard bodies and harmonize standards



Distributed Generation: Dispatchable

Dispatchable DG

- What is dispatchable?
  - Anything with an “on-off” switch, including battery storage, conventional generators, renewables (fuel cell, hydro, biomass). Both energy export and reactive power support / ancillary services.
  - From the customer side–cover own demand or export to the grid
  - Size range: 5kw to ~10-20MW
  - Ownership – both customer and utility

Key Challenges: Summary

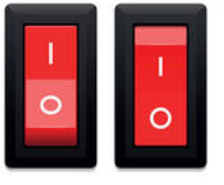
1. Economic Issues / Market

   *Out of scope for today's discussion

2. Communication, Data, Information -
   at all levels

3. Equipment Protection / Reliability / Safety

4. Equipment-Specific Research Needs



Key Challenges

2. Communication, Data, and Information at All levels
   - Managing two-way (power and communication) flows in a diverse regulatory environment
     - Faster-responding signals from meters
     - Development of interface standards and protocols
     - New power flow algorithms for EMS and DMS
     - New equipment to mitigate voltage fluctuations
     - Integrating communications into power electronics device (inverters)

Key Challenges

3. Equipment Protection, Reliability, & Safety

   – How does the system operator evaluate the reliability of distributed resources (how to deal with unpredictable reliability of resources)

     • Improved analytics to identify health of the system

     • Testing, evaluation, and validation of candidate systems

     • Development of standard metrics to evaluate reliability, availability, and system performance

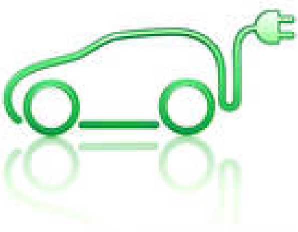
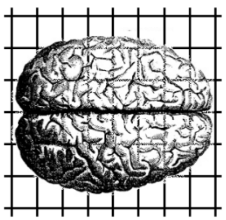
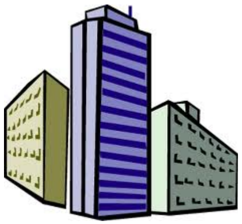
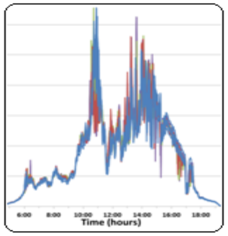
     • Remote diagnostics for DG systems

Key Challenges

4. Equipment-Specific Research Needs

   - Categorized response times (including cycling) of DG resources - improving dispatchability of DG (fuel cells, geothermal, etc.)
     - Charge-discharge cycle time improvement
     - Development of hybrid systems for high efficiency, faster response, and low cost
     - Materials research to support systems capable of cycling
     - R&D to characterize performance of systems in a cycling environment and developing tools to optimize cycling/dispatch

End

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