EERE Grid Integration Efforts

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U.S. DEPARTMENT OF
ENERGY
Energy Efficiency &
Renewable Energy

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Grid Integration Initiative

DOE Vision of the Future Grid

Grid planners keep several key attributes in balance while recognizing regional and local differences

Cost-Effective and Reliable + Clean and Efficient + Secure and Resilient

Accessible to New Technologies + Empowered Consumers with Options

A seamless, cost-effective electricity system, from generation to end-use, capable of meeting all clean energy demands and capacity requirements, with:

- Significant scale-up of clean energy (renewables, natural gas, nuclear, clean coal)
- Universal access to consumer participation and choice (including distributed generation, demand-side management, electrification of transportation, and energy efficiency)
- Holistically designed solutions (including regional diversity, AC-DC transmission and distribution solutions, microgrids, energy storage, and centralized-decentralized control)
- Two-way flows of energy and information
- Reliability, security (cyber and physical), and resiliency

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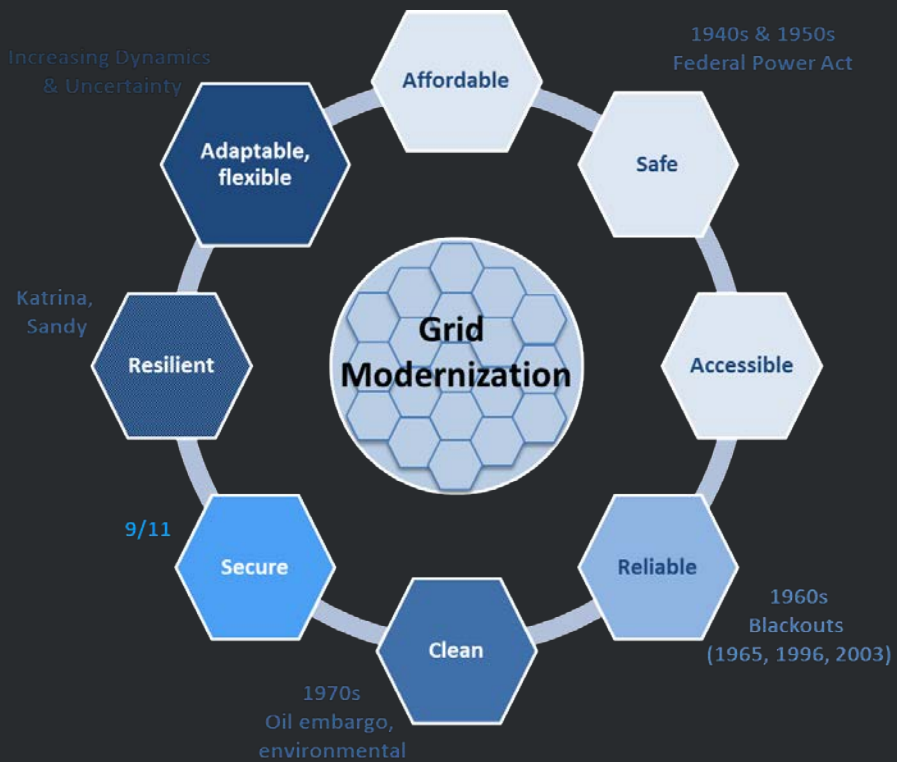
Challenges Facing the Grid

Eight key grid attributes are interactive and must be kept in balance.



New Challenges

Increase in # of Devices	• Rise in distributed energy resources and active loads – thousands to billions of devices requiring system integration
Uncertainty	• Rapid increase in the system operational uncertainty due to changing generation mix, T&D network, and responsive loads
Two-Way Power Flow	• The increase of distributed generation and linked distribution systems are resulting in a massive increase in two-way power flow.
Increase in Grid Instability	• The reduction of conventional generation and the increase of wind and solar is increasing system instability.

Goal: Measure, Analyze, Predict, Control

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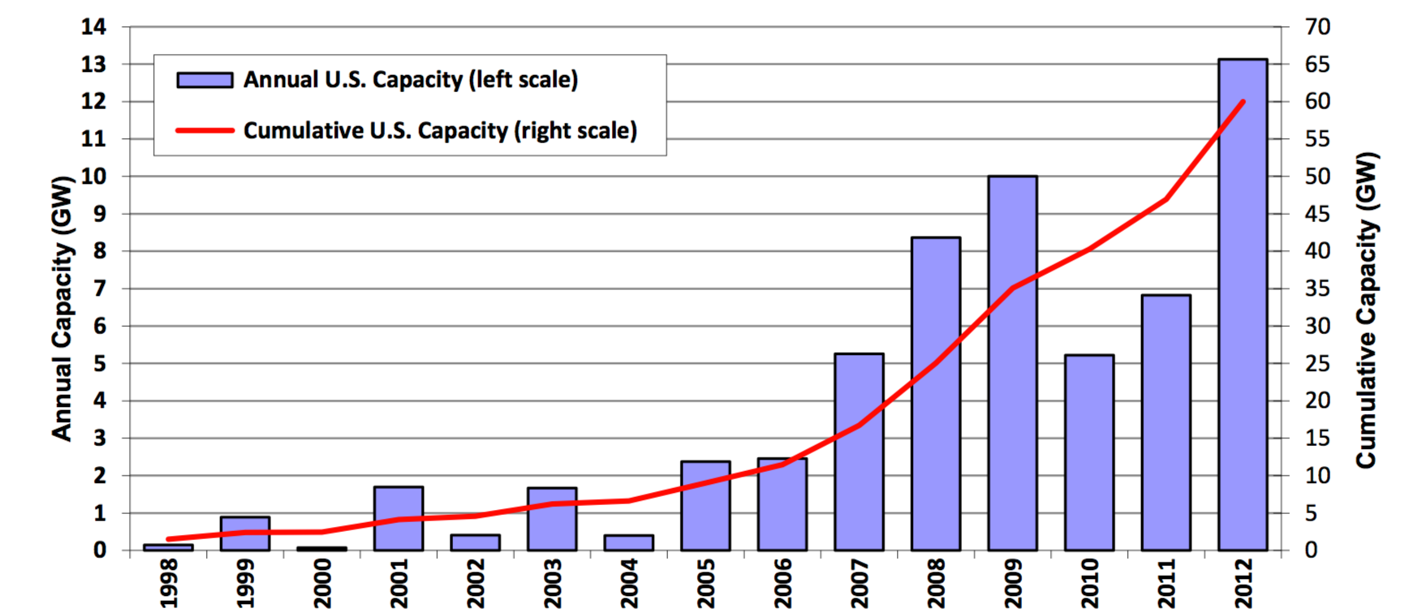
As EERE drives down the cost of emerging technologies, these technologies have started to proliferate into the energy system. The Grid Integration Initiative addresses challenges associated with the physical operation of the power system when these technologies are deployed at scale.



Source: AWEA project database

Figure 1. Annual and Cumulative Growth in U.S. Wind Power Capacity

Seamlessly integrating these technologies into the grid in a safe, reliable, and cost-effective manner is critical to enable deployment at scale.

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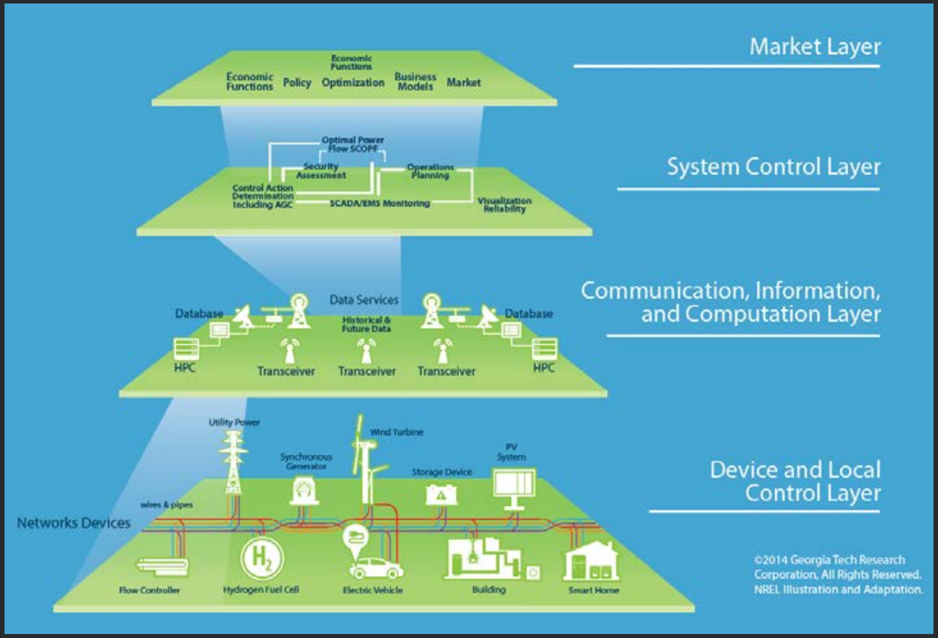
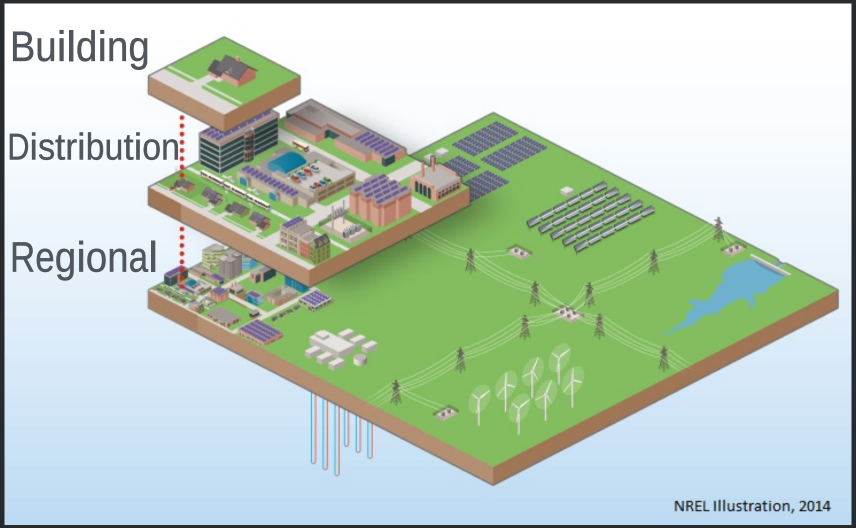
Addressing Challenges by Layer and Scale

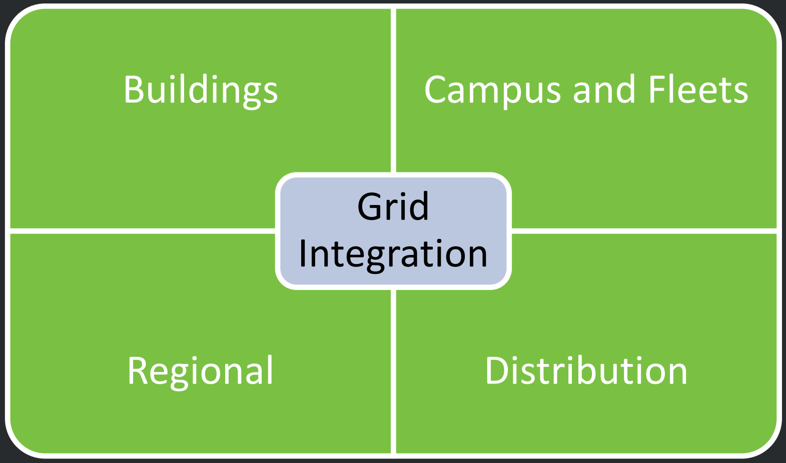




Example Challenges Across Scales and Layers

- Regional: Develop Tools to Better Integrate Clean Technologies into Grid Operations and Planning (System Control Layer)
  - EERE will work with OE in the development of new tools based on natively stochastic methods that more accurately represent the variability of wind and solar technologies.
- Distribution Scale: Smart Devices (Device Layer)
  - EERE will continue to focus on understanding and developing technologies and approaches that provide the ability to communicate with, and control the output of, individual devices. Examples include the development of power electronic inverters for clean energy technologies that allow real and reactive power control.
- Buildings: Develop Technologies that Provide Value to Both the Building and the Grid (Device Layer)
  - EERE will focus on finding new approaches to encourage building owners and operators to more actively participate in the adoption of "smart" clean energy technologies—such as smart hot water heaters, rooftop air conditioning units, and refrigerators—beginning with properly understanding and uniformly describing the grid services these devices can provide.

Crosscutting Solutions Across the Scales



- ***Sensors*** include the physical technologies to make measurements and the data and information that the sensors can produce to control energy production, delivery, storage, and consumption.
- ***Energy storage*** will become increasingly important with increases in variable generation especially at high penetrations.
- ***Interoperability*** includes the logical data and information that needs to be passed between devices to allow them to function in a compatible fashion.
- ***Forecasting*** is the ability to predict energy production and consumption. For variable renewable energy systems such as wind and solar it is important to be able to forecast the expected generation output.
- ***Tools, models, and approaches*** to support the adoption of EE and RE technologies in planning, operations, and management of distributed assets.
- Evaluations of ***policies, markets, and business models*** are needed to fully understand the impact on consumers and the energy environment of wide-scale adoption and use of EE and RE technologies.

Strategy Regional Scale

- Flexibility Analysis
  - Evaluate how the order of implementing: BA consolidation, use of forecasting, deployment of DR, etc. impact their usefulness/cost impacts, reliability impacts…
- Stochastic Unit Commitment
  - Using equivalent inputs set up a side-by-side evaluation of a tool such as PLEXOS against a Stochastic UC tool to better understand the benefits of Stochastic tool deployment
- Forecasting Cost Savings
  - Study impacts of improved VG forecasts on production costs
- Using H2 Production for Curtailed Wind and Solar
  - Evaluate the economic potential to deploy electrolyzers coupled with curtailed wind farms to set up Green H_2 fuel production.
- ERGIS/WWSIS III
  - Finalizing studies on the impacts of contingencies in systems with high penetrations of solar and wind

Strategy for Distribution/Building Scale

INTEGRATE Project 1.0 (FY14-15)

- Characterization of EERE Technologies for Grid Services (Task 1)
- Communications/Interoperability Platform development and evaluations (Task 2)
- Management and Coordination of Distributed Assets (Task 3)
- INTEGRATE RFP Awards – work with awardees to demonstrate integrated system solutions that increase hosting capacity. Demonstrate how RFP awards can be used to improve technology models and analysis of impacts at high penetrations

INTEGRATE Project 2.0 (FY15-16)

- Focus on integration of higher level system controls and market signals

Strategy for Distribution/Building Scale (SETO, BTO, VTO, FCTO)

Reference Document Development – document current state-of-the-art and multi-year plan for each area

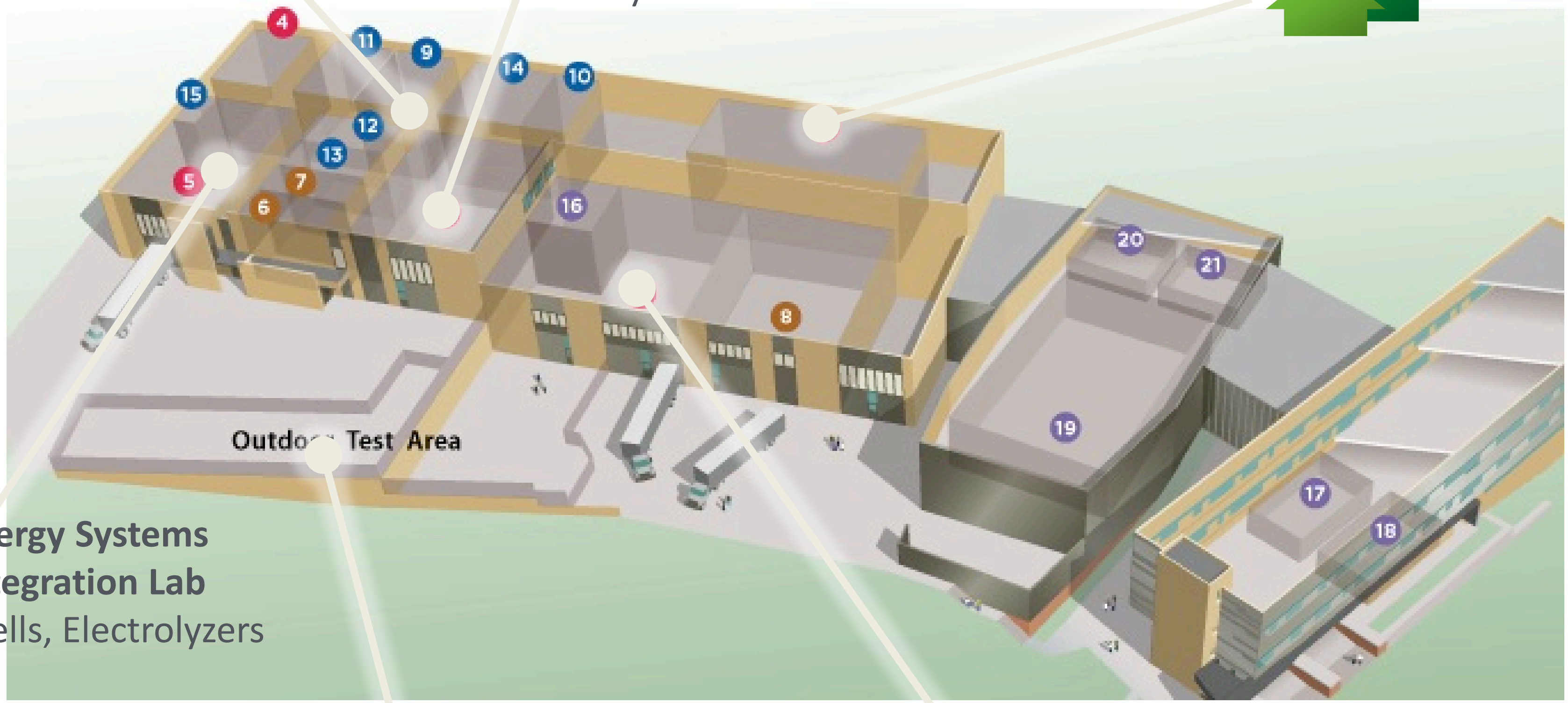
- Sensors and Controls – discuss sensor and control technologies from buildings (energy controls) to distribution system (voltage controls and protection)
- Distribution Modeling – discuss current practice with modeling impacts of DER and DSM at distribution level.
- Distributed Energy Storage – discuss wide range of options to provide energy storage (battery, thermal, H2) and virtual energy storage through load shifting

Energy Systems Integration Facility (ESIF)

Rooftop PV & Wind

Energy Storage Lab
Residential, Community & Grid Battery Storage, Flywheels & Thermal

Smart Power Lab
Buildings & Controllable Loads



Energy Systems Integration Lab
Fuel Cells, Electrolyzers

Outdoor Test Area
EVs, MV equipment

Power Systems Integration Lab
PV and Grid Simulators

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Thank you!

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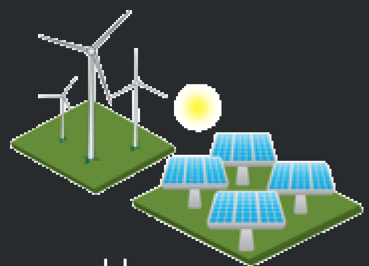
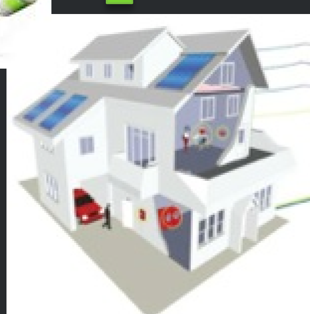
Emerging Technologies



Renewable Energy

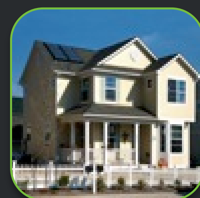
Sustainable Transportation



Energy Efficiency

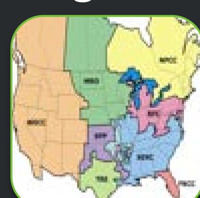
Scales and Challenges

Consumer



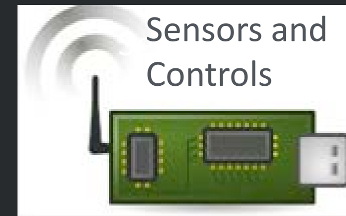
City

Regional

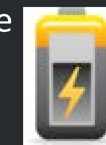


- More Variable Supply and Demand
- Limited Grid Flexibility
- Aging Infrastructure
- Vulnerability to Extreme Events
- Challenges to Reliability
- Increasing Costs

Solutions

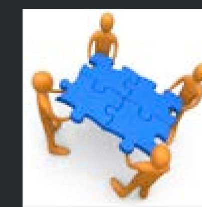


Energy Storage



Interconnection

Interoperability



Analysis, Modeling and Simulation

Markets and Business Models

Policy and Regulation