Hydrogen Energy Storage for Grid Integration and Transportation Services

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

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Grid Integration Initiative

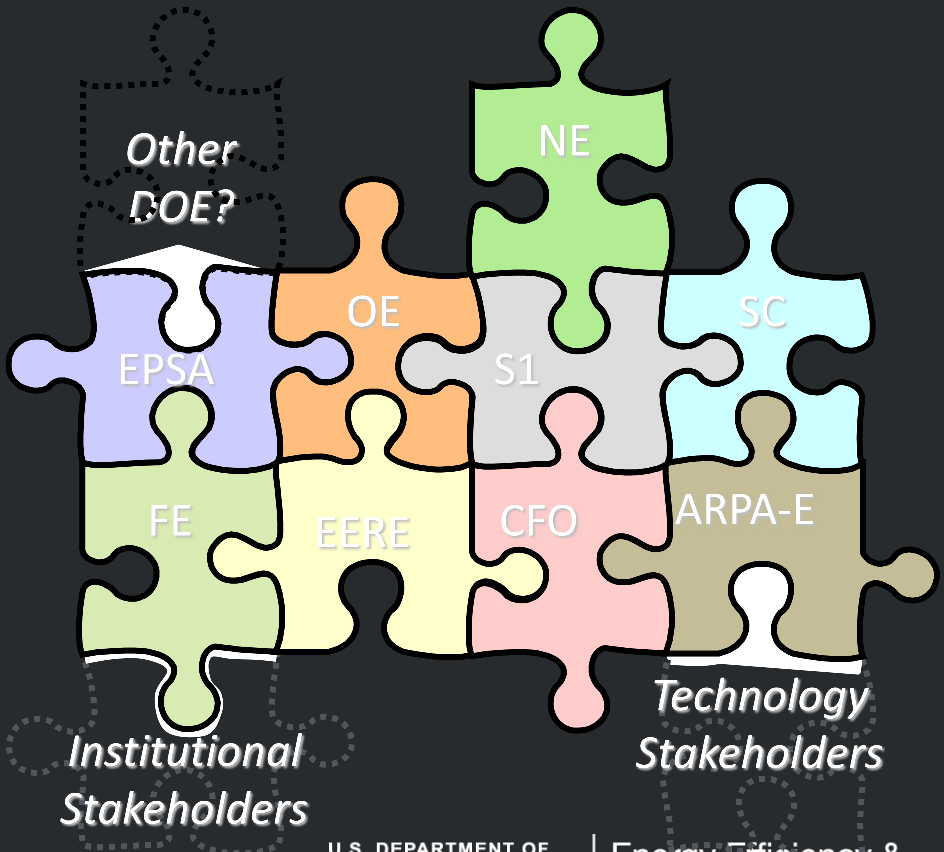
What is the Grid Tech Team?

The GTT is a DOE inter-office work group established in April 2011 by the Undersecretary of Energy to:

- Coordinate and leverage DOE grid resources and activities
- Identify pathways to enable grid modernization
- Develop a long-term strategic vision of the U.S. electricity grid

Value to the DOE

- Holistic systems perspective
- Align internal grid activities
- Minimize duplication of effort
- Optimize the use of funding
- Effective collaboration
  - forum to convene stakeholders
  - coordinated internal/external interactions



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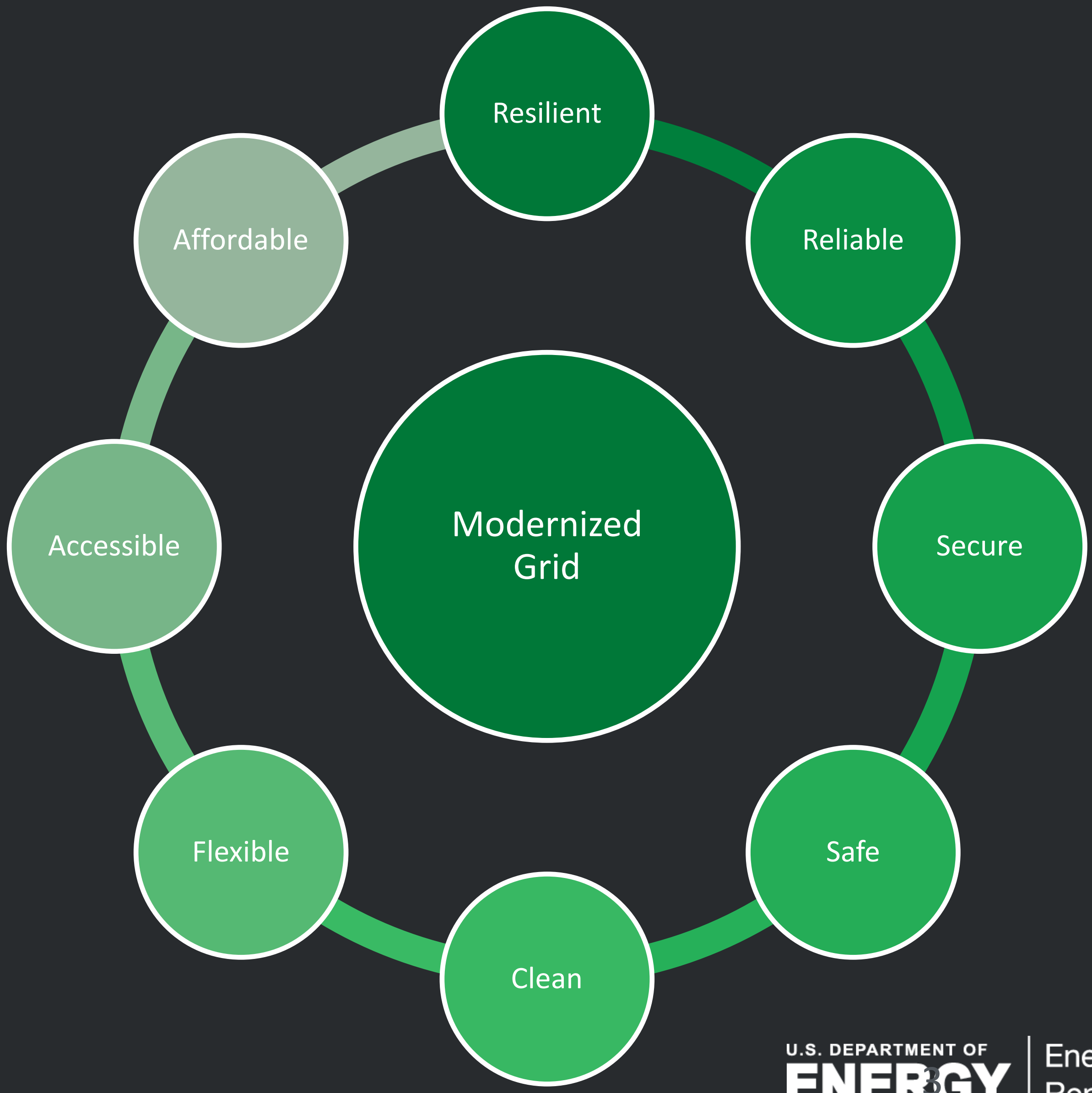
Key Attributes of a Modern Grid



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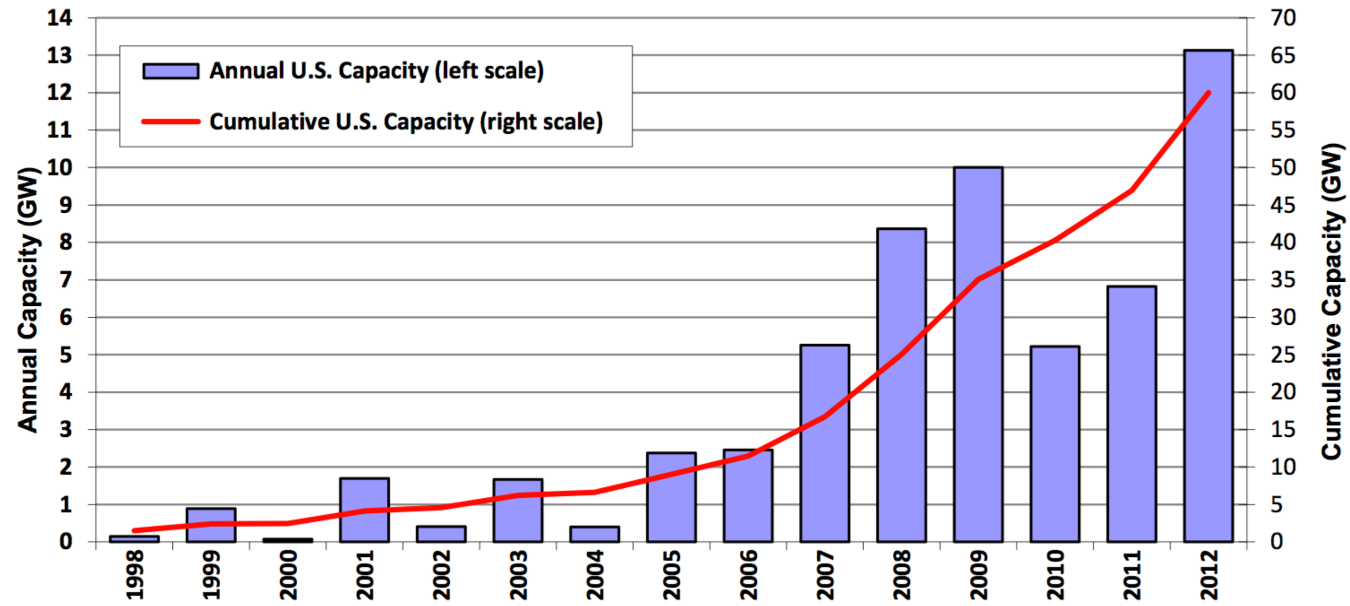
As EERE drives down the cost of emerging technologies, these technologies have started to proliferate into the energy system. The Grid Integration Initiative addresses challenges associated with the physical operation of the power system when these technologies are deployed at scale.

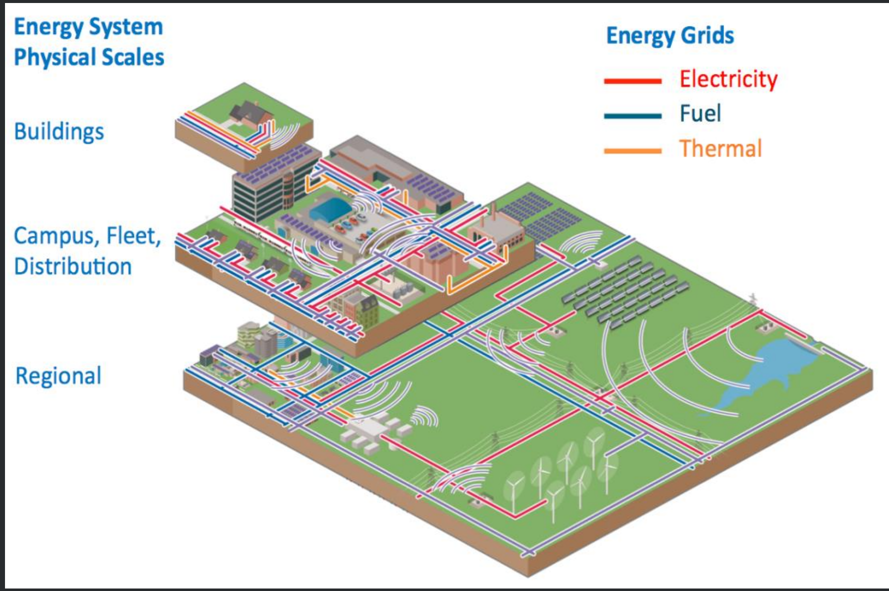


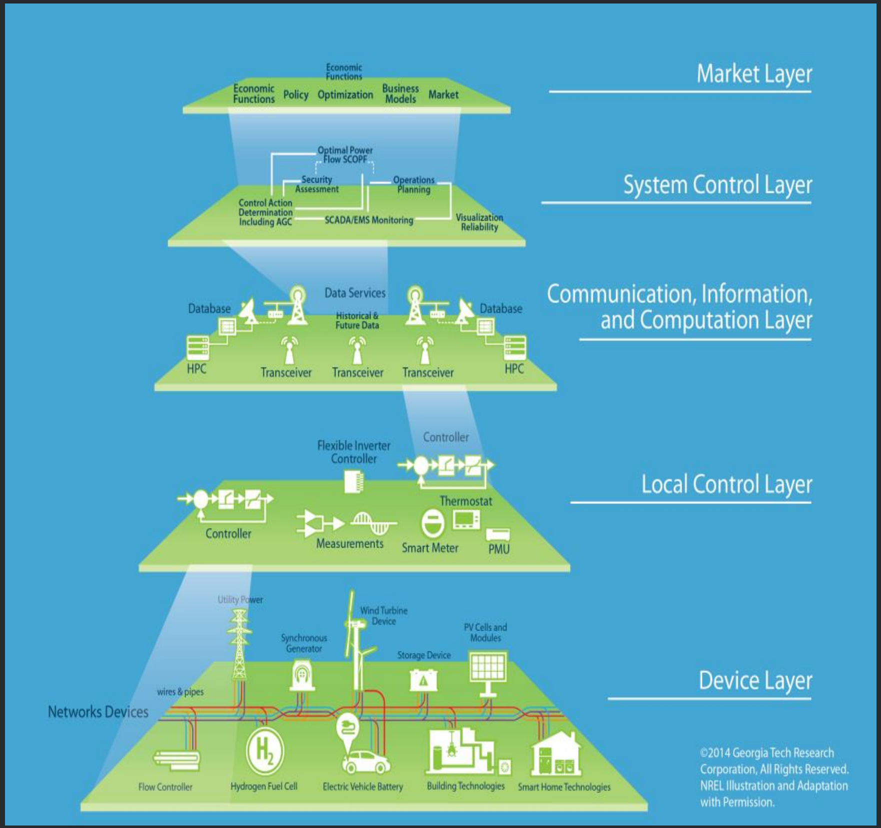
Source: AWEA project database

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.

Addressing Challenges and Opportunities by Scale and Layer





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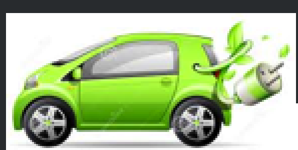
Emerging Technologies

Renewable Energy

Sustainable Transportation



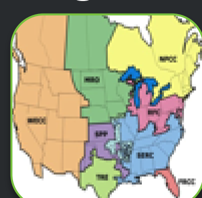
Energy Efficiency

Scales and Challenges

Consumer

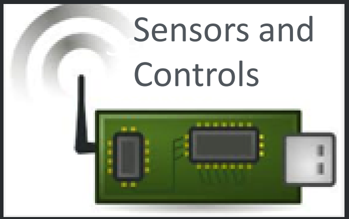
City

Regional



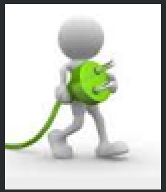
- More Variable Supply and Demand
- Limited Grid Flexibility
- Aging Infrastructure
- Vulnerability to Extreme Events
- Challenges to Reliability
- Increasing Costs

Solutions



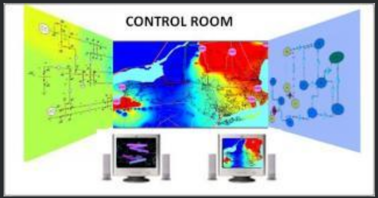
Energy Storage

Interconnection



Interoperability

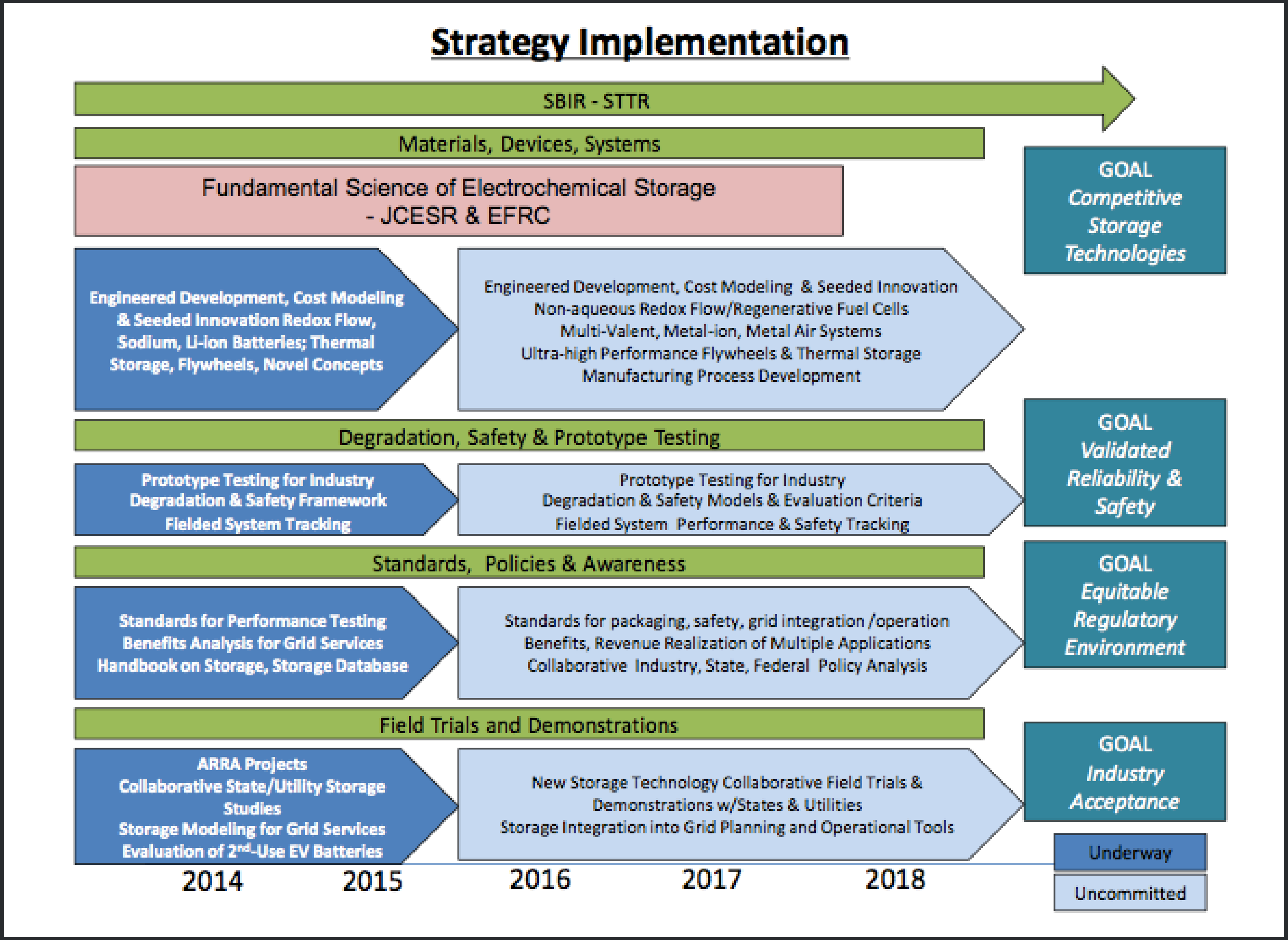
Analysis, Modeling and Simulation



Markets and Business Models

Policy and Regulation

DOE Grid Energy Storage Report



http://energy.gov/sites/prod/files/2013/12/f5/Grid%20Energy%20Storage%20December%202013.pdf

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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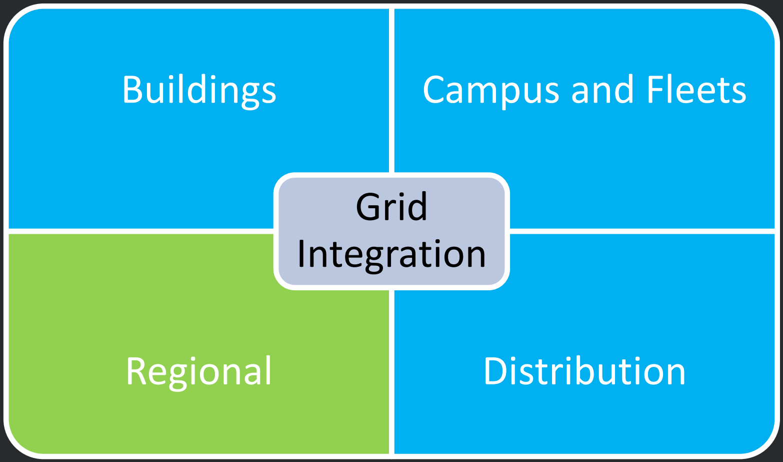
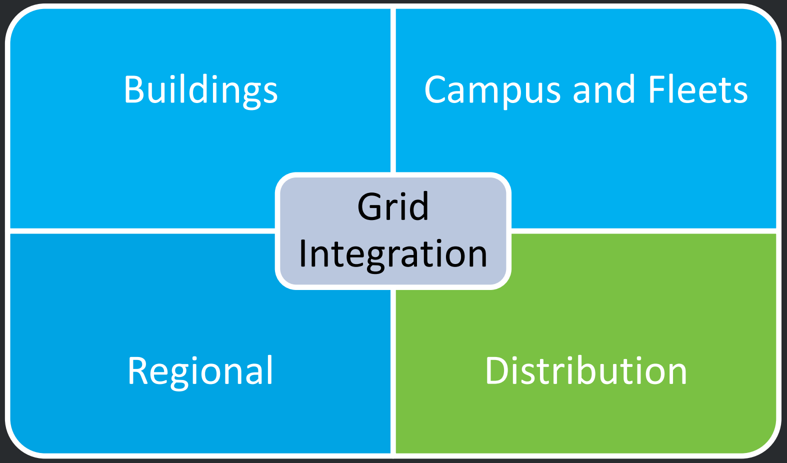
Regional Scale: Challenges

Regional Scale Integration

1. Enhancing operations to manage variability and uncertainty of high penetration of renewables.
2. Inadequate tools for regional entities to plan for increased variable generation (VG) on the grid.
3. Impacts of renewables on markets and improved understanding of integration costs.
4. Impact of distributed assets on bulk power system reliability.



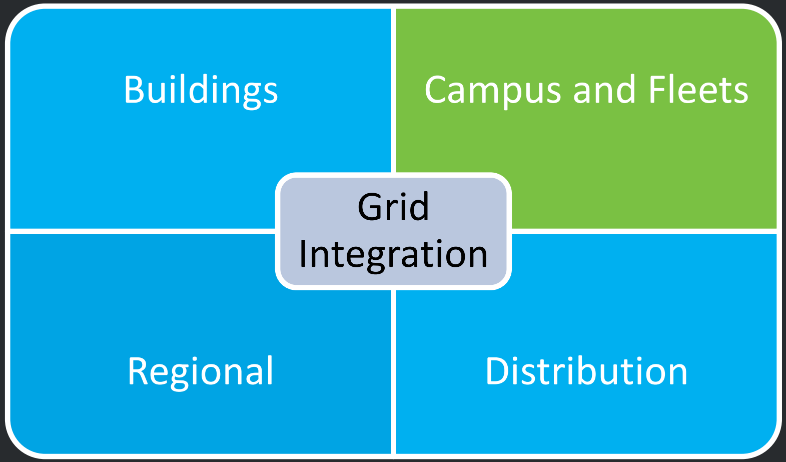
Distribution Scale: Challenges



Distribution Scale Integration

1. Incorporate high-penetration distributed renewable generation and storage into legacy voltage-control systems.
2. Coordinate protection schemes to accommodate distributed generation and storage at high penetrations.
3. Populations of distributed generation and storage do not exacerbate transmission disturbances nor compromise utility worker safety.
4. Distribution operators have the tools needed to manage systems with large numbers of variable distributed assets.
5. Business models and regulatory policies do not limit penetration of advanced energy efficiency and renewable technologies into distribution systems.

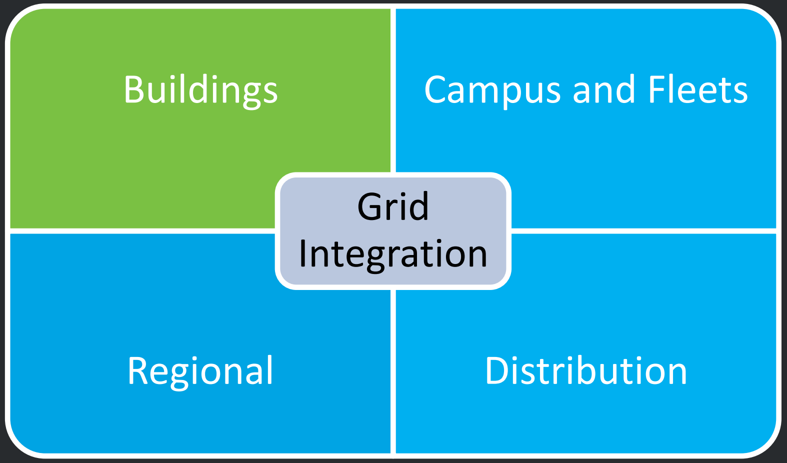
Campus and Fleets Scale: Challenges



Campus and Fleets

1. Multi-source energy integration and optimization; how to combine and optimize the performance of multi-domain energy systems.
2. Aggregation of geographically dispersed assets; communications and control over geographically distributed areas and large numbers of devices.
3. Microgrids for energy reliability; integrating high penetrations of RE and EE technologies into microgrids.

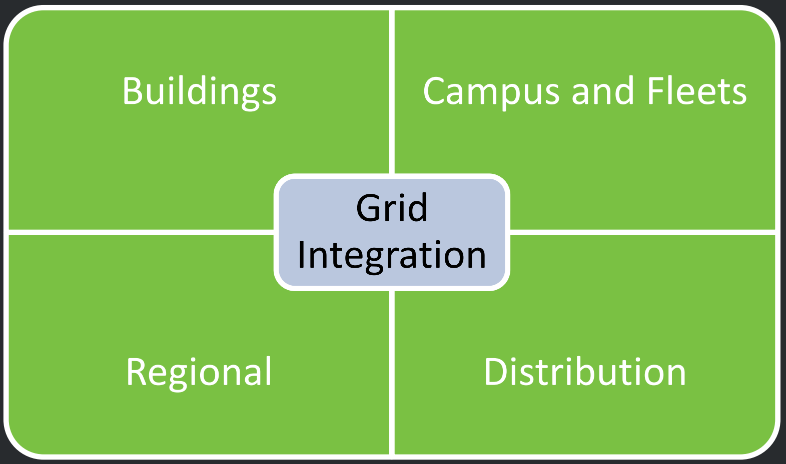
Buildings Scale: Challenges



Buildings Scale Optimization

1. Cost effective components and grid interconnection includes the research needed for ***physical components*** of buildings to grid concepts, such as sensors and controls, and reducing the cost of key components to accelerate the adoption of energy efficiency and renewable energy technologies.
2. ***Data management, analysis, and controls*** include research needed to capture and analyze data, and interoperability of the energy systems.
3. ***Business models*** limiting the adoption of EE and RE technologies include research needed for transactive energy as well as market requirements and value proposition.
4. ***Characterization*** addresses research and implementation challenges and considers the need for improved characterization of buildings/components along with the need for consumer/utility "protection" similar to the ENERGY STAR and appliance standards efforts within DOE.
5. ***Continuous management*** addresses research and implementation challenges of managing multiple energy systems and optimizing systems for disparate stakeholders.

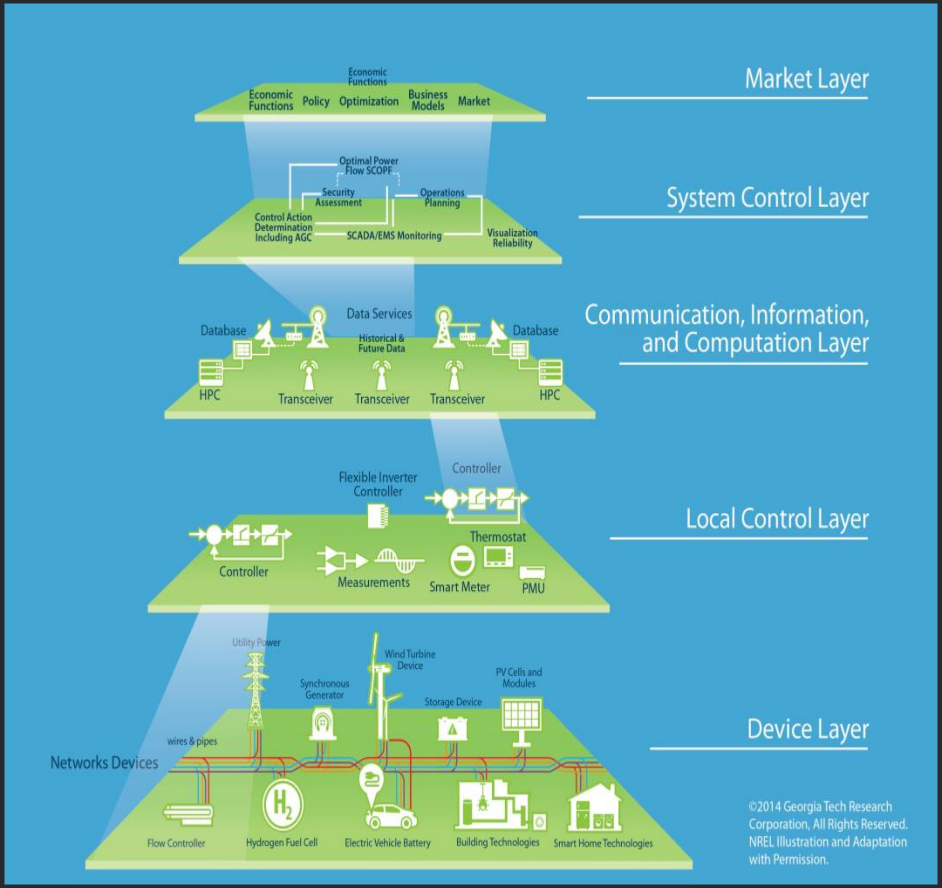
Crosscutting Issues Across the Scales



- ***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.

System Architecture

- ***Device Layer***, consisting of the physical energy devices and networks that produce, consumes, stores or transports energy. Examples of elements in this layer are high voltage wires, a turbine machine, a battery, a pipe, or the power elements of a transformer.
- ***Local Control Layer***, consisting of the electromechanical, electronic or software based modules necessary to control a single device (in the Device Layer) in a stand-alone manner. This layer includes necessary device sensors, power electronics controller stages, embedded software for device control, actuators, and local protection.
- ***CIC Layer***, including communications, information, and computation platforms necessary to support control applications at the system level.
- ***System Control Layer***, including system monitoring, system state estimation, energy network security assessment, etc. and is responsible for the system level concerns of security and reliability of a collection of connected devices.
- ***Market Layer***, addressing economic, regulatory, financial, and policy aspects of the system.



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