

# **What Is the Smart Grid?**

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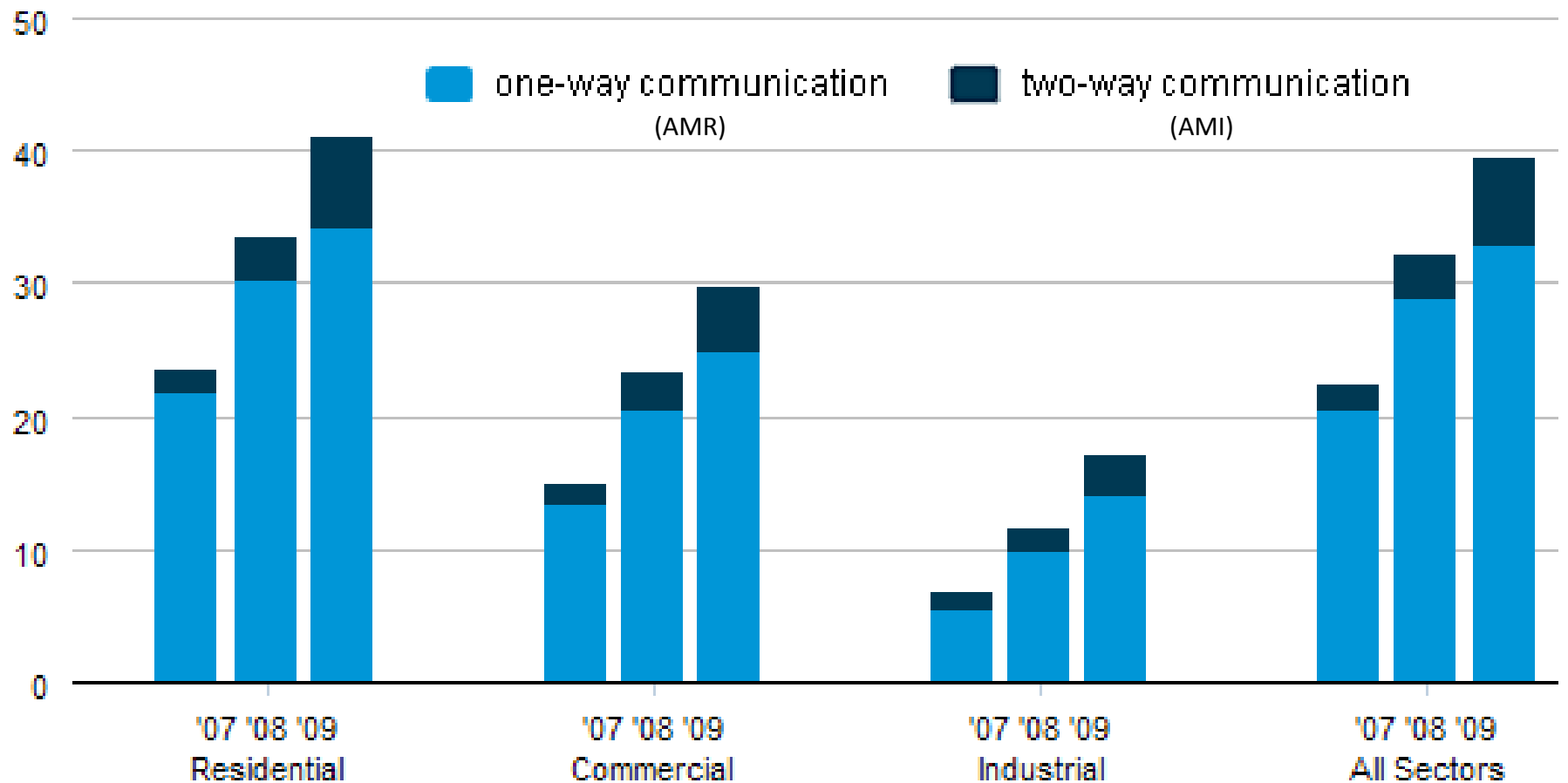
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# “Smart Grid” Surprisingly Difficult to Define

- EIA contractor found 23 different definitions for the Smart Grid.
- Smart meters: market penetration seen as a measure of progress toward the smart grid.
- DOE puts Smart Grid projects into five groups:
  - Customer systems (displays)
  - Advanced metering infrastructure
  - Electric distribution systems
  - Electric transmission systems
  - Equipment manufacturing (smart appliances)

## Advanced meter penetration by end-use sector

percent of customers



Source: U.S. Energy Information Administration - Form EIA-861, Annual Electric Power Industry Report

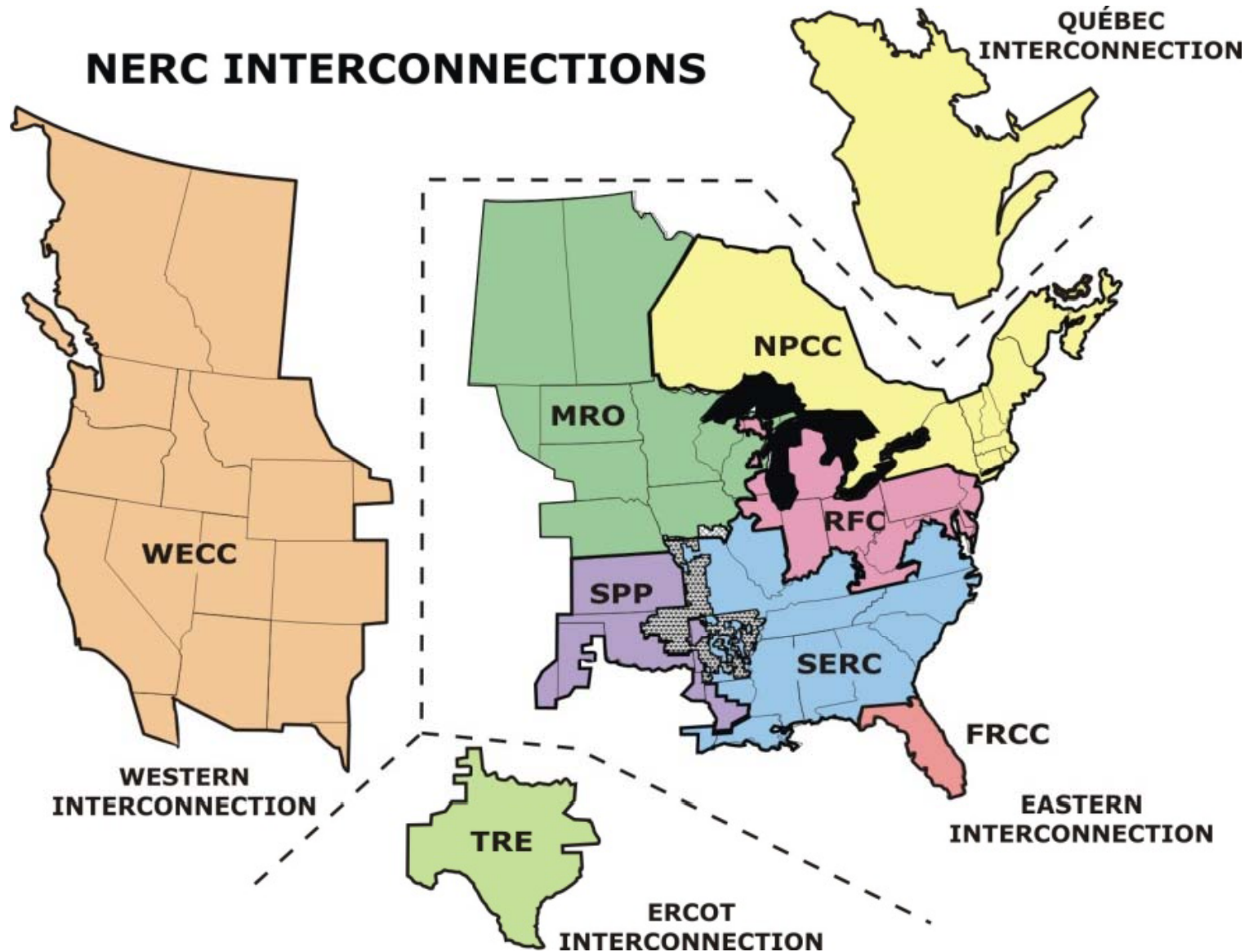
# Intelligent Electric Systems

- Focus on electric systems as a whole instead of just on smart devices.
- Smart grid is the application of microprocessor technology across whole electric systems.
- Microprocessors have:
  - Transformed industries: communications, banking ...
  - Fostered RTO markets and bigger electric systems
  - Not fundamentally transformed the electric business.

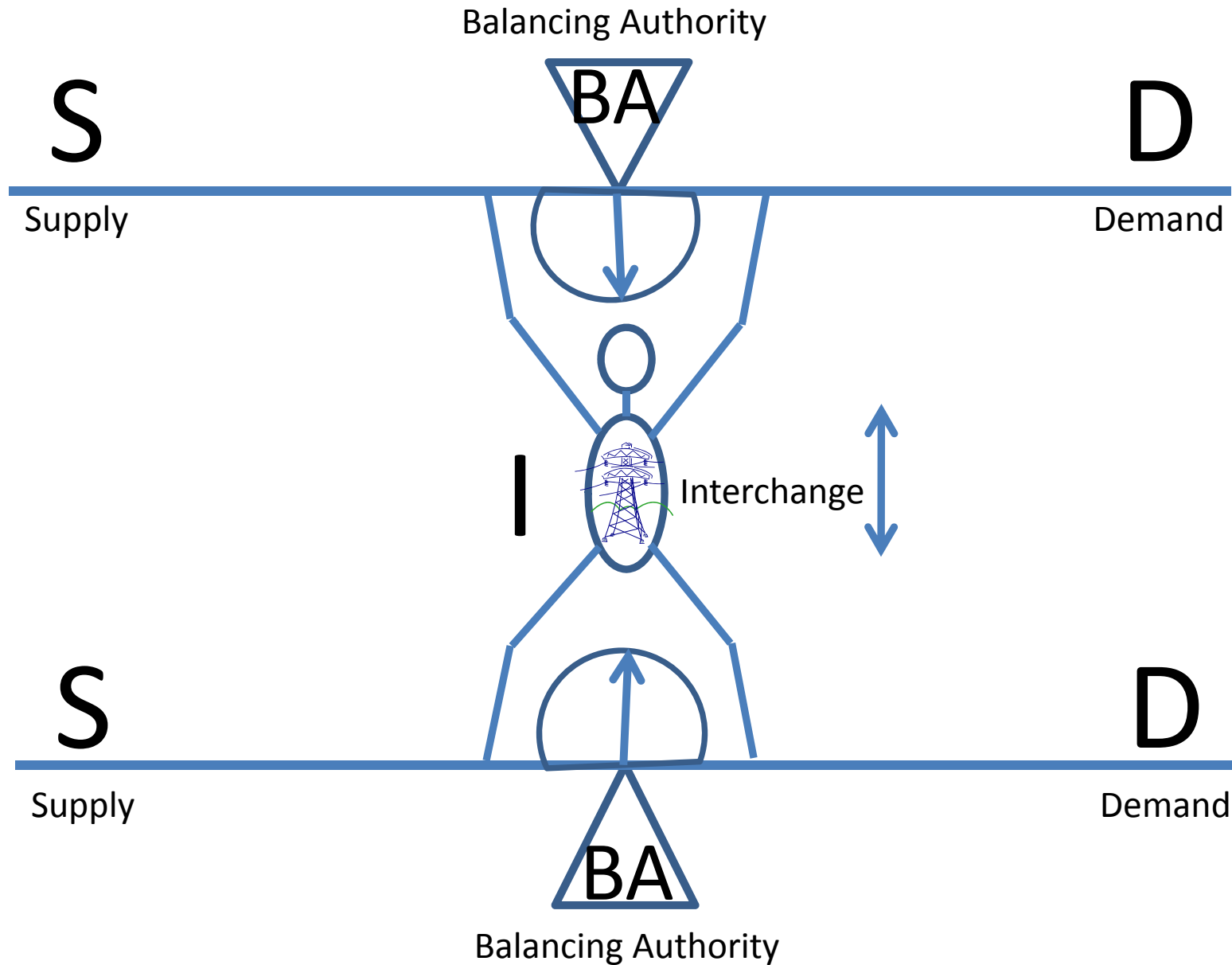
# Operating as Integrated Systems

- Wires connect the equipment that produces electricity with the equipment that consumes it and everything in-between.
- In an Interconnection, electric utilities are tied together to form a single alternating current (AC) grid.
- System devices operate in unison (or synchronized).
- Electricity from the grid is consumed the moment it is produced.

# Electricity Interconnections



# Electricity System Balancing

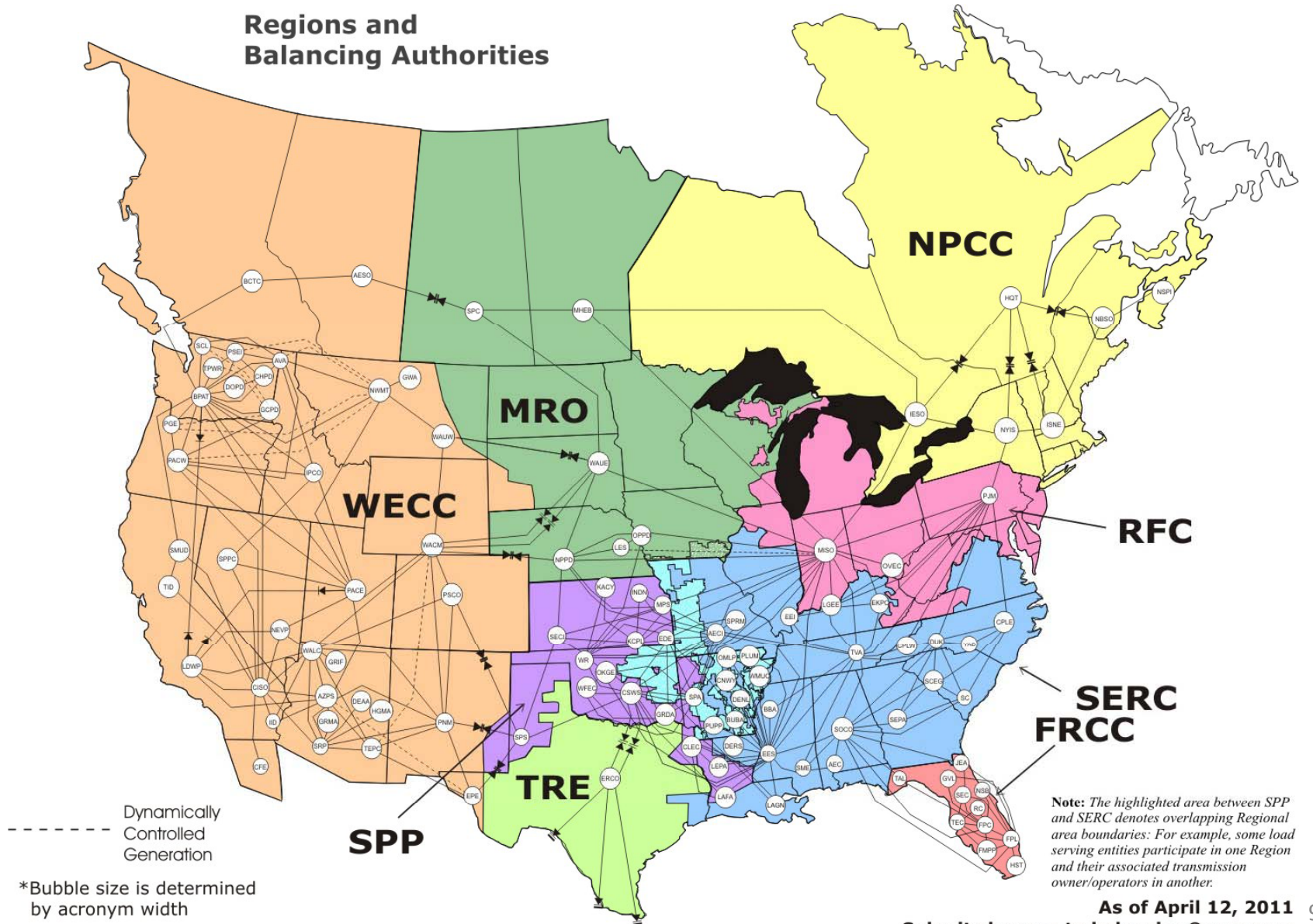


# Flexibility of Balancing Authorities

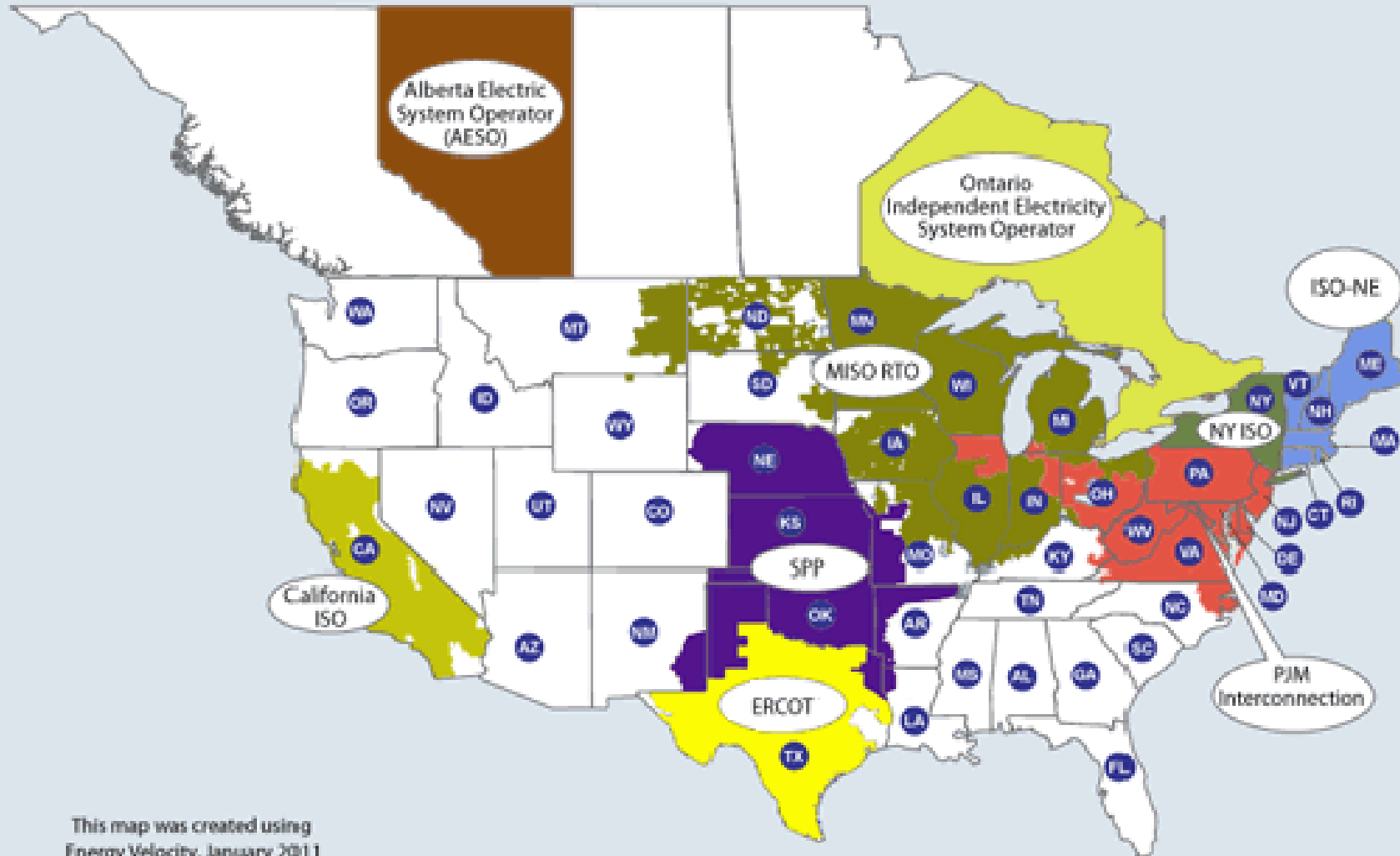
- About 100 interconnected BAs in U.S. & Canada
- BAs vary greatly in size.
- Some regions have few BAs others have many.
- Most RTOs are BAs, but it is not necessary.
- There has been a trend toward BA consolidation.
- Generation and distribution only BAs
- Dynamically controlled generation
- Arrangements have more to do with commercial than operational considerations.



# Interconnected Balancing Authorities



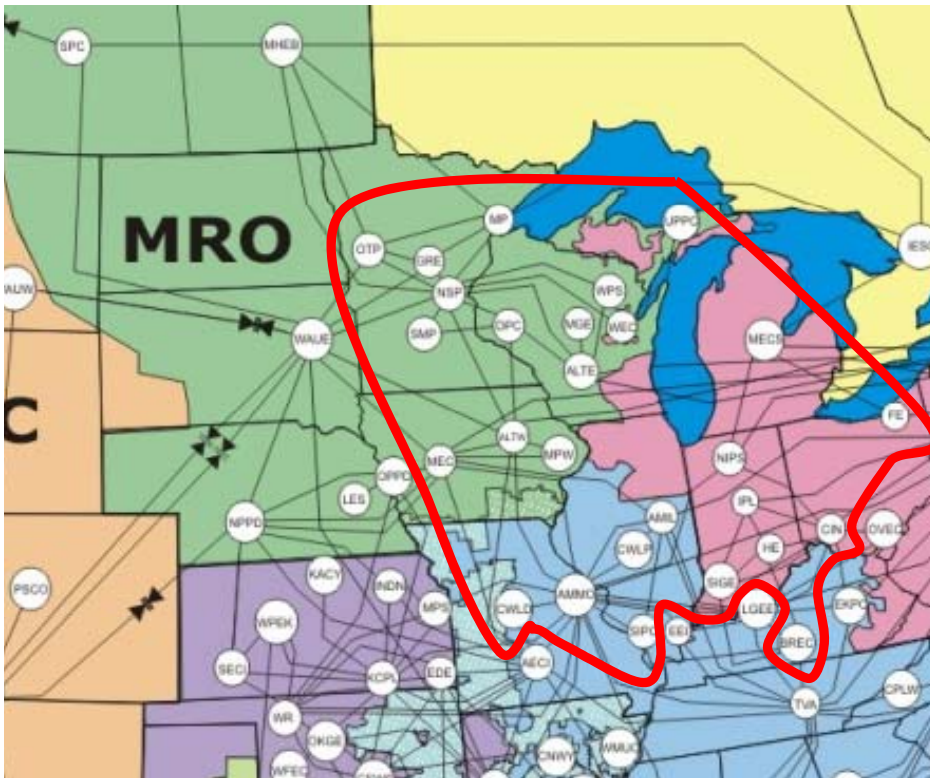
# REGIONAL TRANSMISSION ORGANIZATIONS



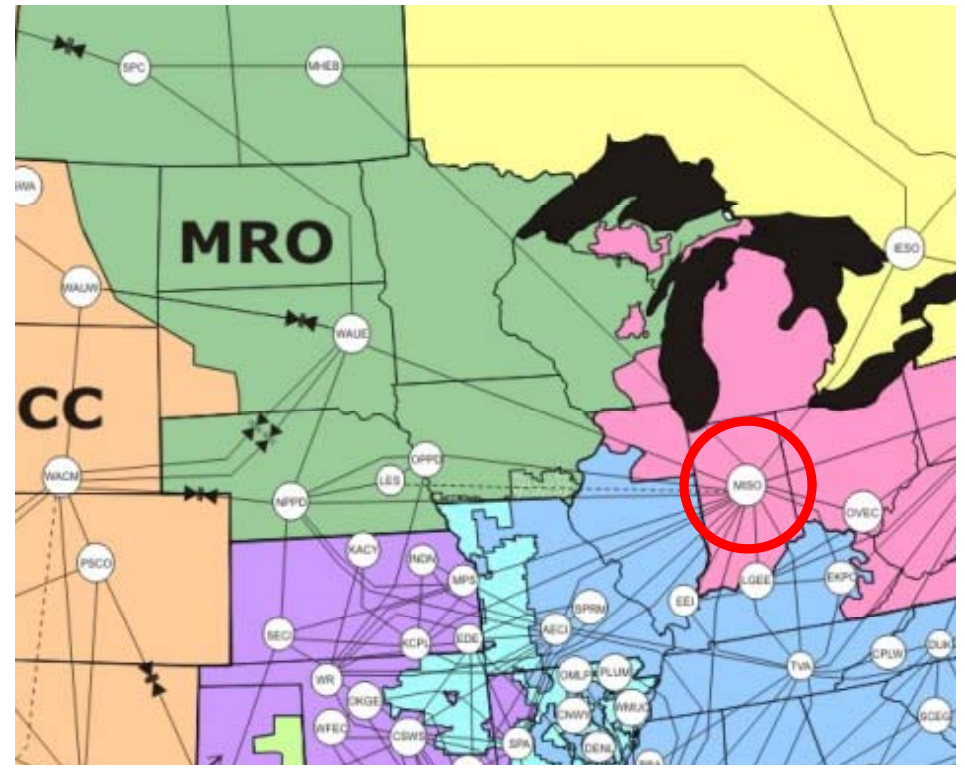
This map was created using Energy Velocity, January 2011

# MISO Merges BAs

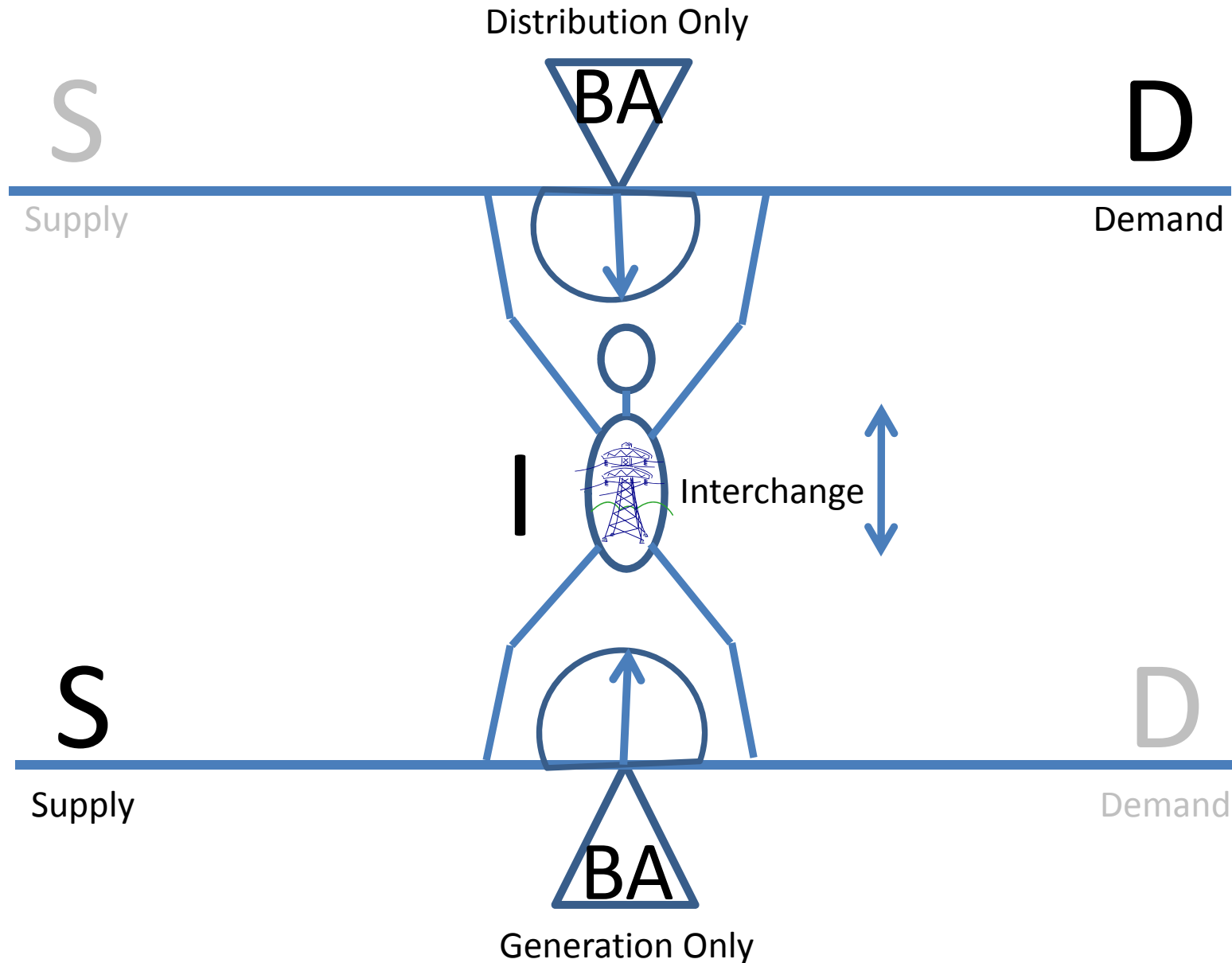
Before January 6, 2009



After January 6, 2009



# Types of Balancing Authorities



# The Smart Grid Can Enhance Balancing

- Better metering of system element status (from a modeled to a measured approach)
- Measuring demand
- Enhanced communications and speed
- Allow participation of new system elements
  - Storage
  - Distributed generation
  - Energy management
  - Electric vehicles



# Smart Electricity Storage Devices

## Hot Water Heater

105-gallon electric water heater demonstrates minimization of cost while responding to the PJM wholesale price signal and the PJM frequency regulation signal.



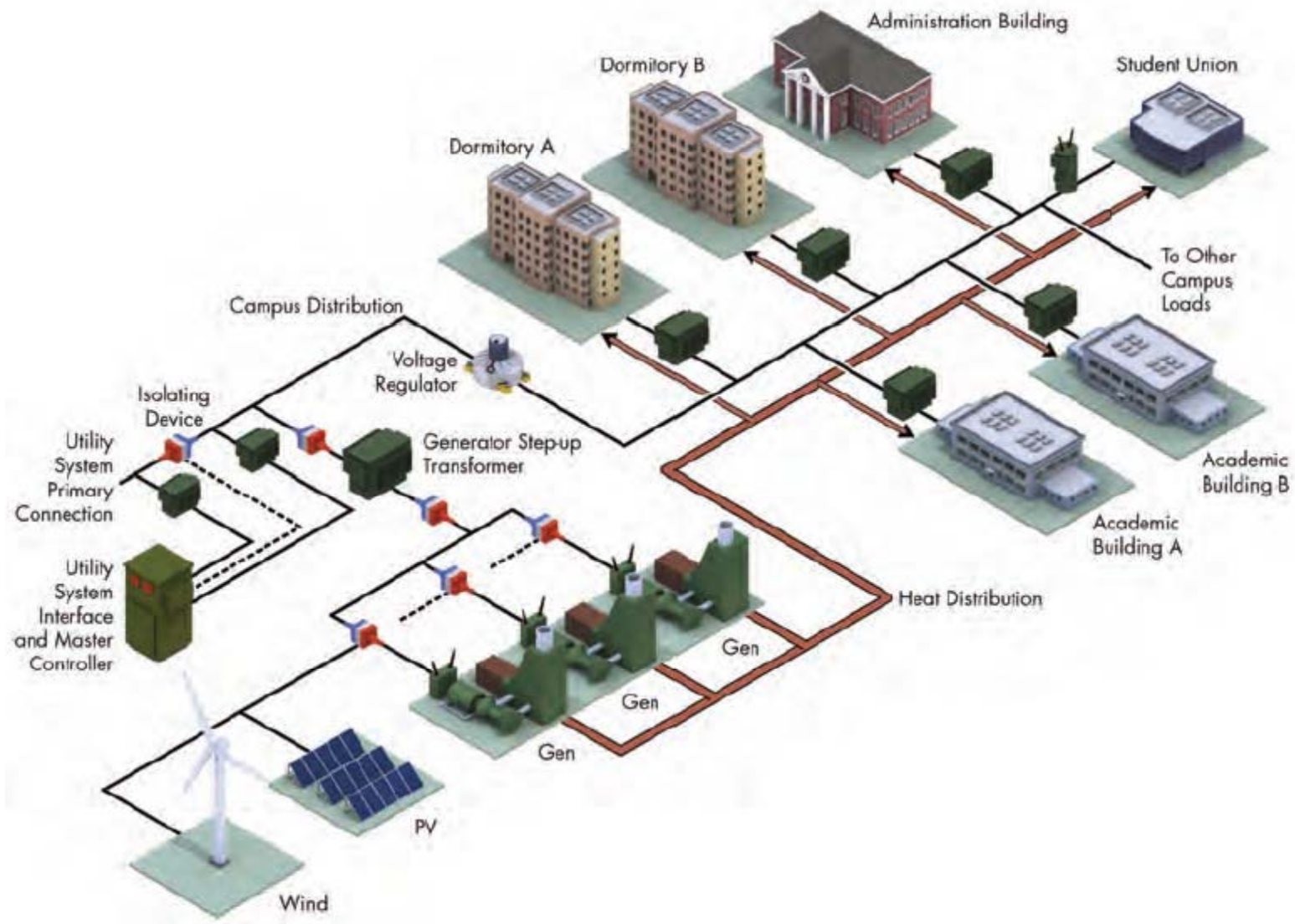
Source: Andy Ott, Senior Vice President – Markets  
PJM Interconnection, Inc.



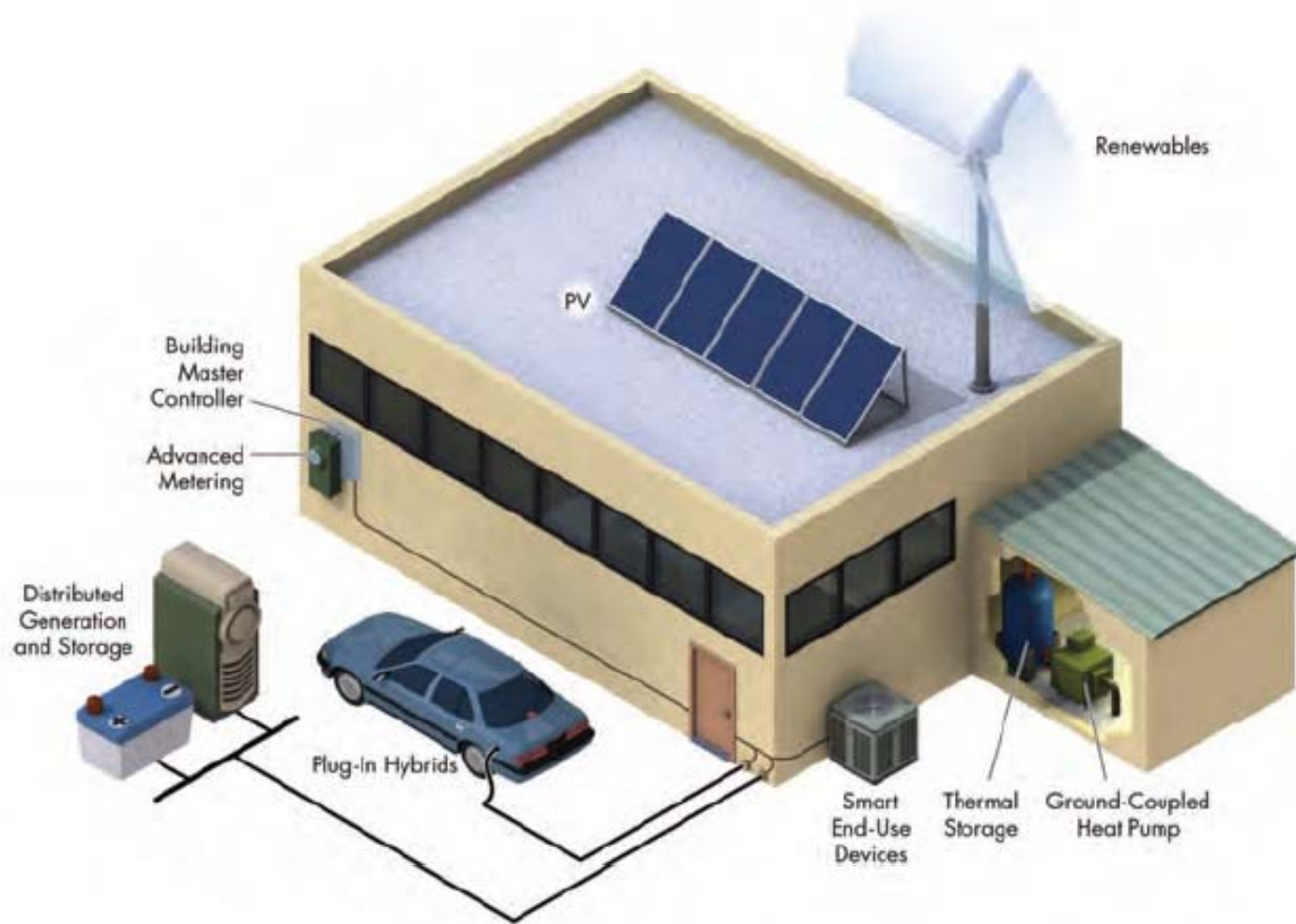
## Beacon Power's 20 MW Flywheel Plant in Stephentown, New York

Source: Beacon Power's website

# Campus-Level Local Energy Network



# Building-Level Local Energy Network





# Nested Smart Systems

- New system elements appear as either supply, demand or both (like interchange).
- They can be flexibly incorporated into the balancing function.
- Owners of devices or systems can choose manage them or join a group.
- This configuration flexibility and choice may be the greatest value of the smart grid.

# Smart Grid Benefits (EPRI)

- Allows direct participation by customers
- Accommodates all generation and storage options
- Enables new products, services and markets
- Provides power quality for digital economy
- Optimizes asset utilization and operational efficiency
- Anticipates and responds to system disturbances (self-healing)
- Operates resiliently against attack and natural disaster.

“Pervasively collaborative distributed intelligence”