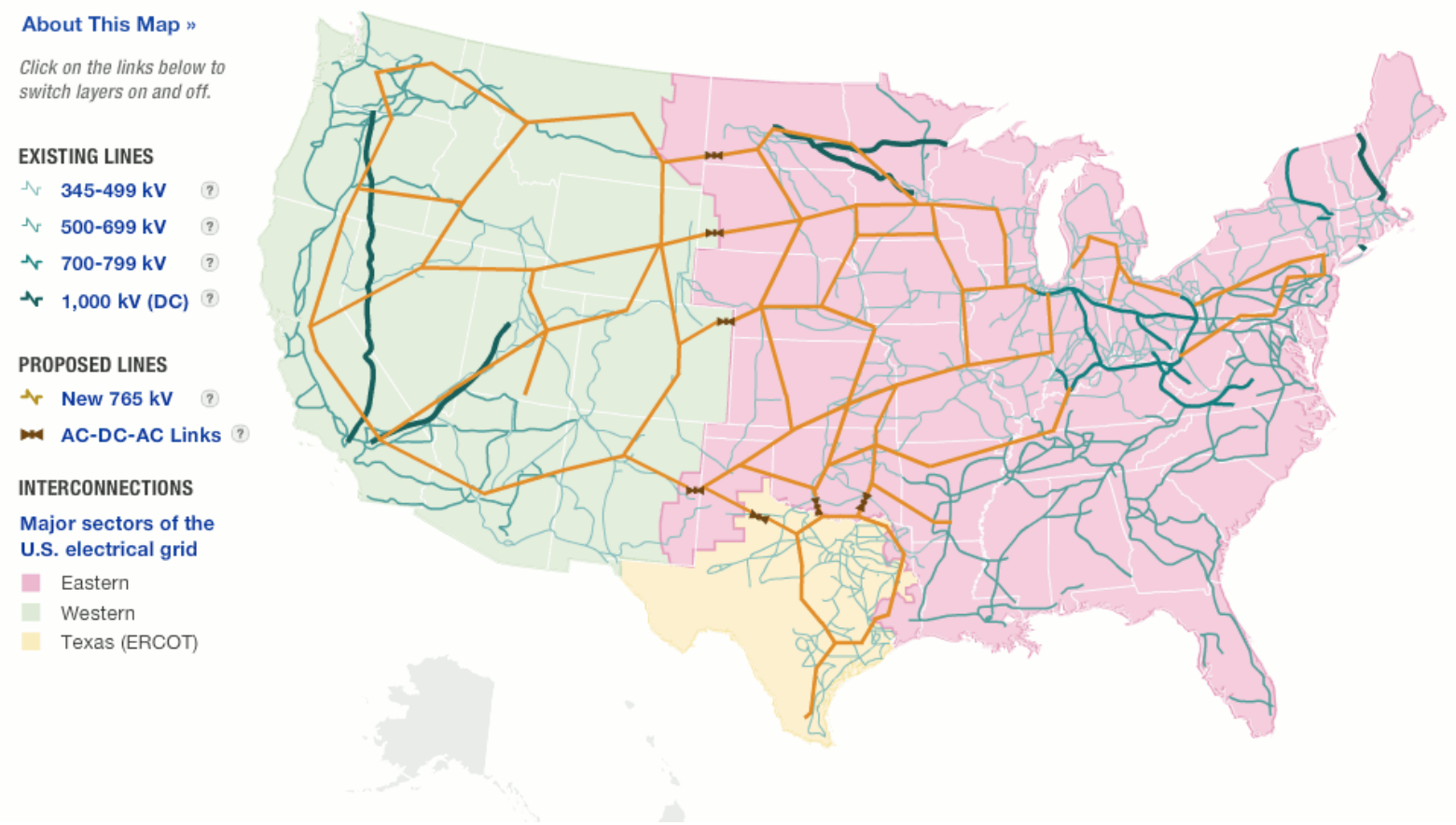
Smart Grid Technology: Microgrids as enablers for Renewable Energy

Electrical Energy Facts

- Electrical energy in U.S. is ~40% of total energy consumption
- Current Electrical Infrastructure is Brittle and Aging
- Most Electrical Energy is currently generated using rapidly depleting energy resources or nuclear
- Current Grid was not built with Renewables in mind
- It will take at least 25-50 years to build a grid that enables the transition from current generation to renewables using our current Bulk generation /Macro Grid model

Current Grid



Current Grid Architecture

- Predominately Hub and spoke connected to hub and spoke
- Susceptible to ever increasing outages
- Unable to carry projected future load demands without a major upgrade
- Controlled by regional monopolies
- Vulnerable to Security threats

What is a Microgrid

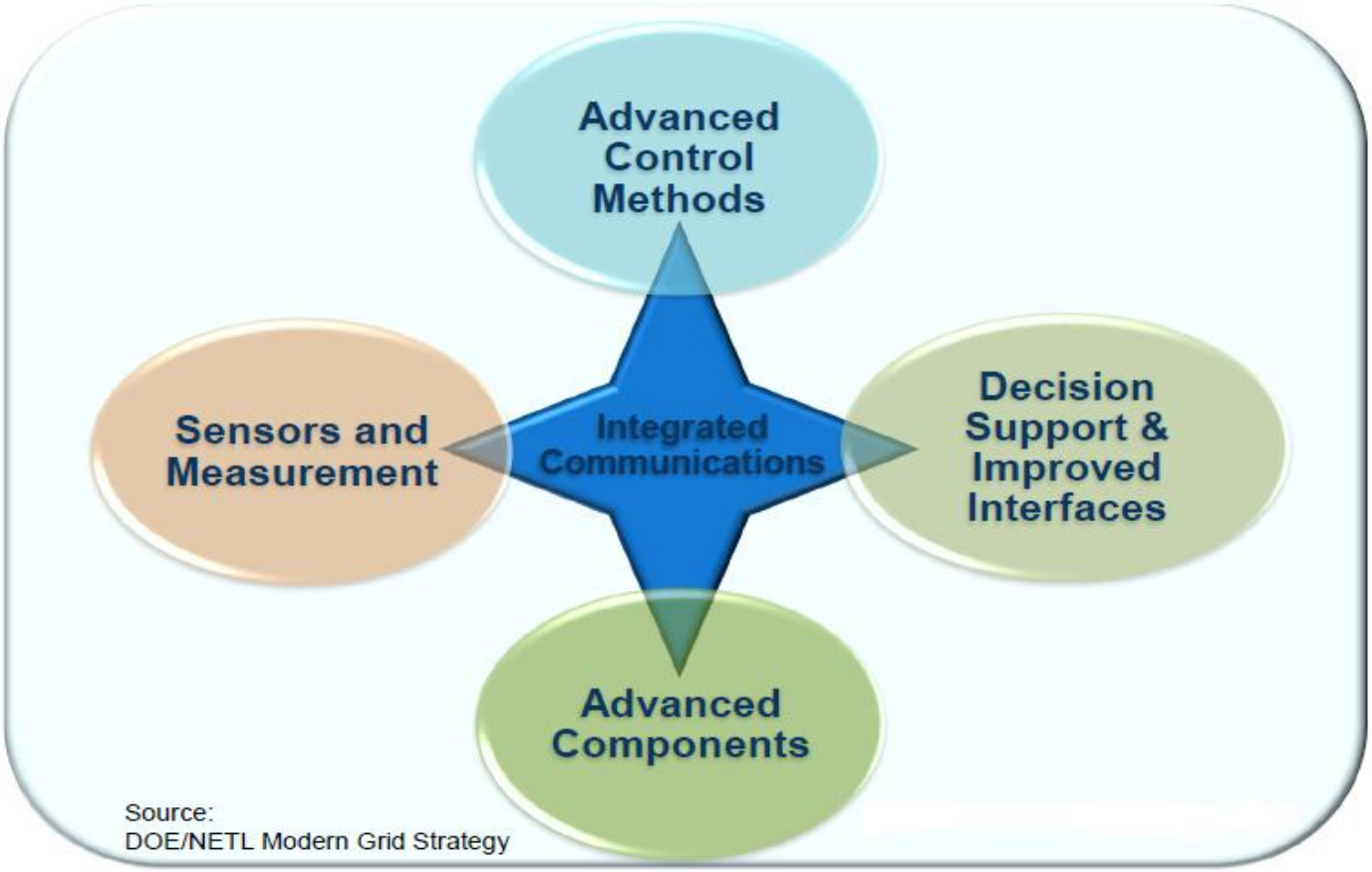
"A **microgrid** is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island mode."

DOE Microgrid Exchange Group, October 2010

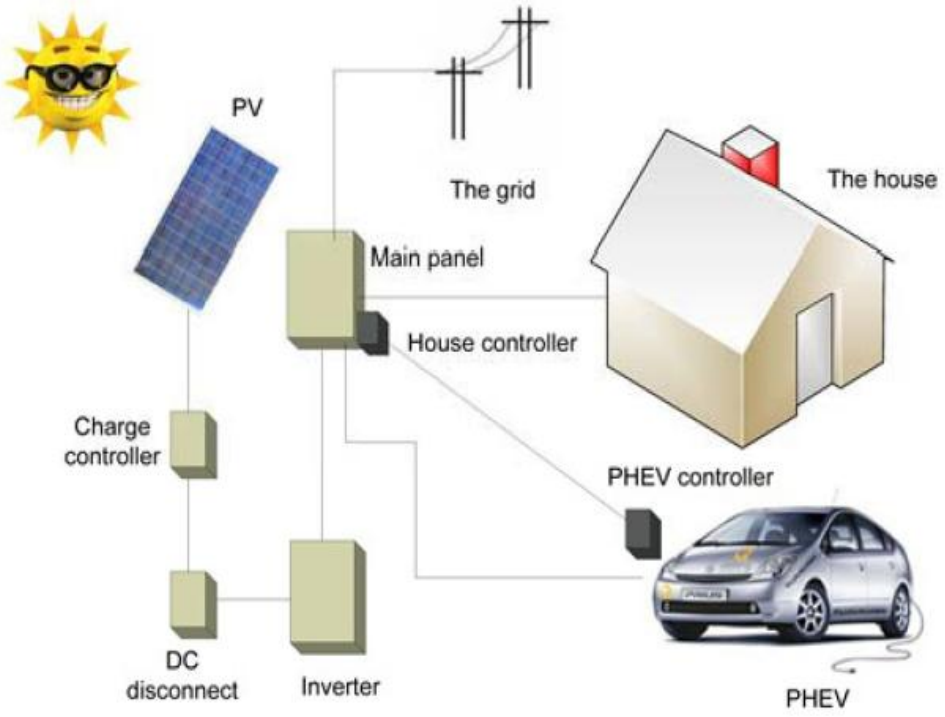
Essential Role of Microgrids

- Develop Smart Grid Technologies on a smaller less expensive scale
- Migration and transition from fuel based energy to renewables
- Address local reliability Challenges
- Address local economic issues
- Enable Energy Arbitrage
- Allow cost effective control of multiple sources of energy

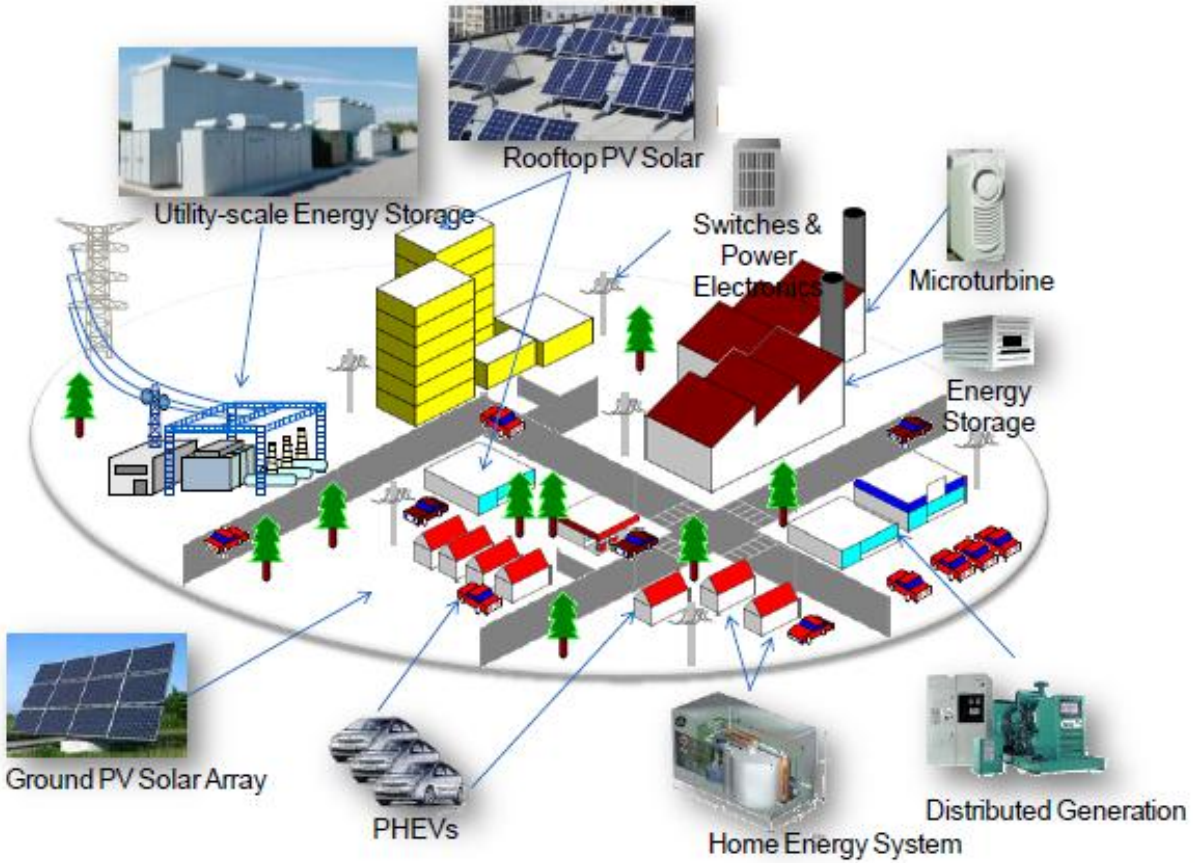
Microgrid
(Conceptual Architecture)



Home Microgrid



Neighborhood-Community Microgrid



City-Town Microgrid

Microgrid- Key Technologies

- Distributed Energy resource (DER) and Volt Ampere Reactivity (VAr) management
- Feeder Automation Systems technologies (FAST)
- Advanced Energy Storage (AES)
- Outage and Distribution Management Systems (OMS/DMS)
- Price-Driven Load Management (PDLM)
- Hi Tech Inverters
- Series Compensation

Research Underway

Three main approaches:

1) Environmentally Driven
   - DOE Renewable & Distributed Systems Integration (RDSI)
2) Reliability Driven
   - DOD/DOE Energy Surety Microgrids
3) Security Driven
   - Smart Power Infrastructure Demonstration for Energy, Reliability and Security (SPIDERS)

RDSI Projects

- **Chevron Energy Solutions**—CERTS Microgrid Demo at the Santa Rita Jail - large-scale energy storage, PV, fuel cell
- **SDG&E**—Beach Cities Microgrid - demand response, storage, outage management system, automated distribution control, AMI
- **U of HI**—Transmission Congestion Relief, Maui - intermittency management system, demand response, wind turbines, dynamic simulations modeling
- **UNLV**—"Hybrid" Homes - Dramatic Residential Demand Reduction in the Desert Southwest - PV, advanced meters, in-home dashboard, automated demand response, storage
- **ATK Space System**—Powering a Defense Company with Renewables - Hydro-turbines, compressed air storage, solar thermal, wind turbines, waste heat recovery system
- **City of Fort Collins**—Mixed Distributed Resources - PV, bio-fuel CHP, thermal storage, fuel cell, microturbines, PHEV, demand response

- **Illinois Institute of Technology**—The Perfect Power Prototype - advanced meters, intelligent system controller, gas fired generators, demand response controller, uninterruptable power supply, energy storage
- **Allegheny Power**—WV Super Circuit Demonstrating the Reliability Benefits of Dynamic Feeder Reconfiguration - biodiesel combustion engine, microturbine, PV, energy storage, advanced wireless communications, dynamic feeder reconfiguration
- **Con Ed**—Interoperability of Demand Response Resources - demand response, PHEVs, fuel cell, combustion engines, intelligent islanding, dynamic reconfiguration, and fault isolation

Energy Surety Microgrids

Objective

- Use military bases to develop approaches for implementing high reliability microgrids because of immediate needs, interest, and funding to implement
- Use cost/performance data and lessons learned from military efforts to accelerate commercial implementation

13 Bases evaluated – 30 microgrid designs

Technical Scope

Use risk-based energy assessment to develop microgrids that:

- Can use distributed and renewable energy resources
- Will improve site energy infrastructure safety, security, and reliability
- Enhance critical mission assurance at military bases

SPIDERS: Smart Power Infrastructure Demonstration for Energy, Reliability, and Security

Objective

- Improve reliability for mission-critical loads by connecting generators on a microgrid using existing distribution networks.
- Reduce reliance on fuel for diesel power by using renewable energy sources during outages.
- Increase efficiency of backup generators through coordinated operation on the microgrid.
- Reduce operational risk for energy systems through a strong cyber security for the microgrid.
- Enable flexible electrical energy by building microgrid architectures that can selectively energize loads during extended outages.

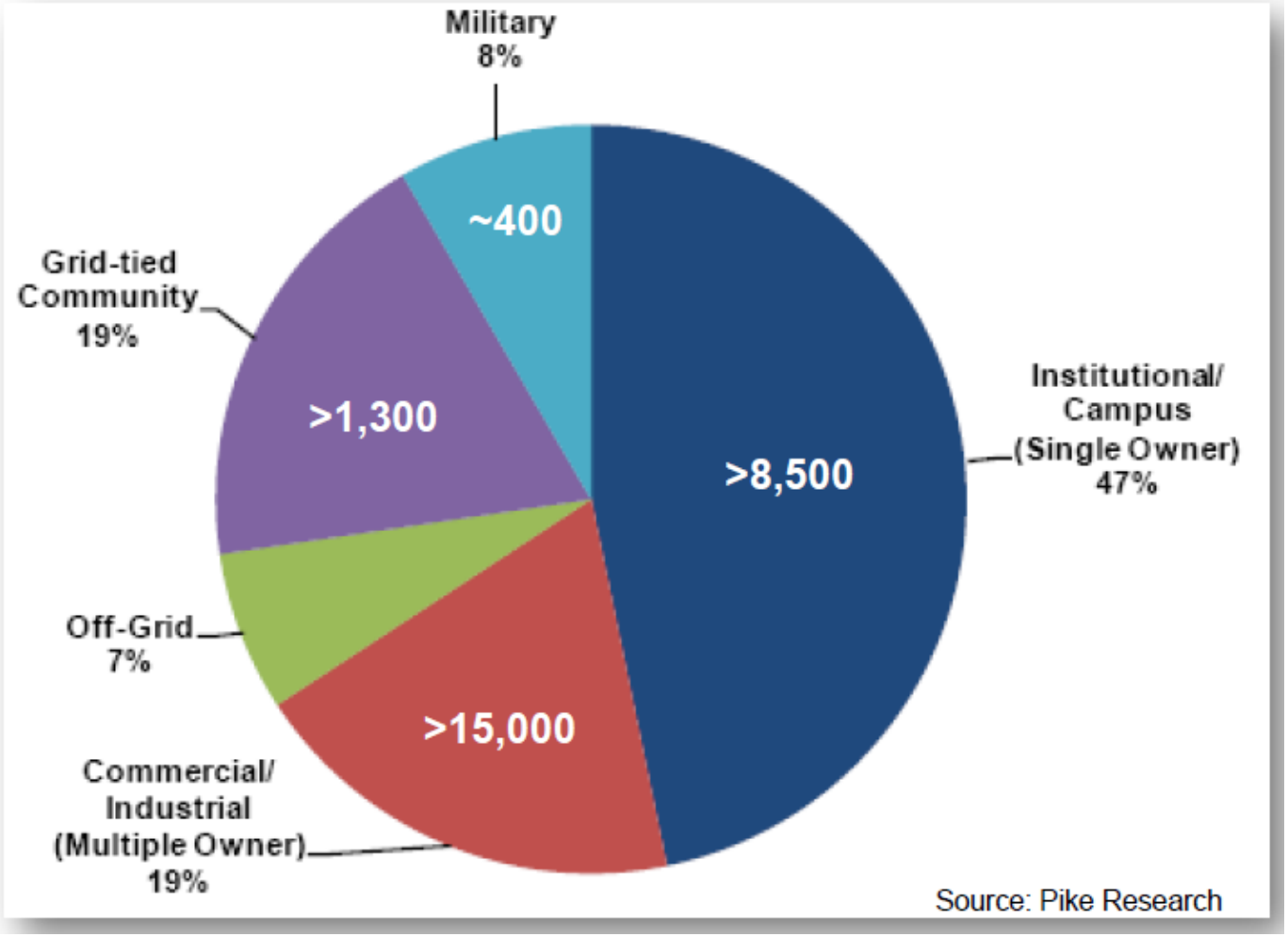
Technical Scope

DoD, DOE, and DHS collaborate to design and implement three separate microgrids supporting critical loads at DoD bases. Each one is slightly larger and more complex in scope than the previous. The sites include:

- Joint Base Pearl Harbor Hickam
- Fort Carson
- Camp Smith

A key part of the project is the standardization of the design approach, contracting, installation, security, and operation of these microgrids to support future applications.

North American Microgrid Market 2015

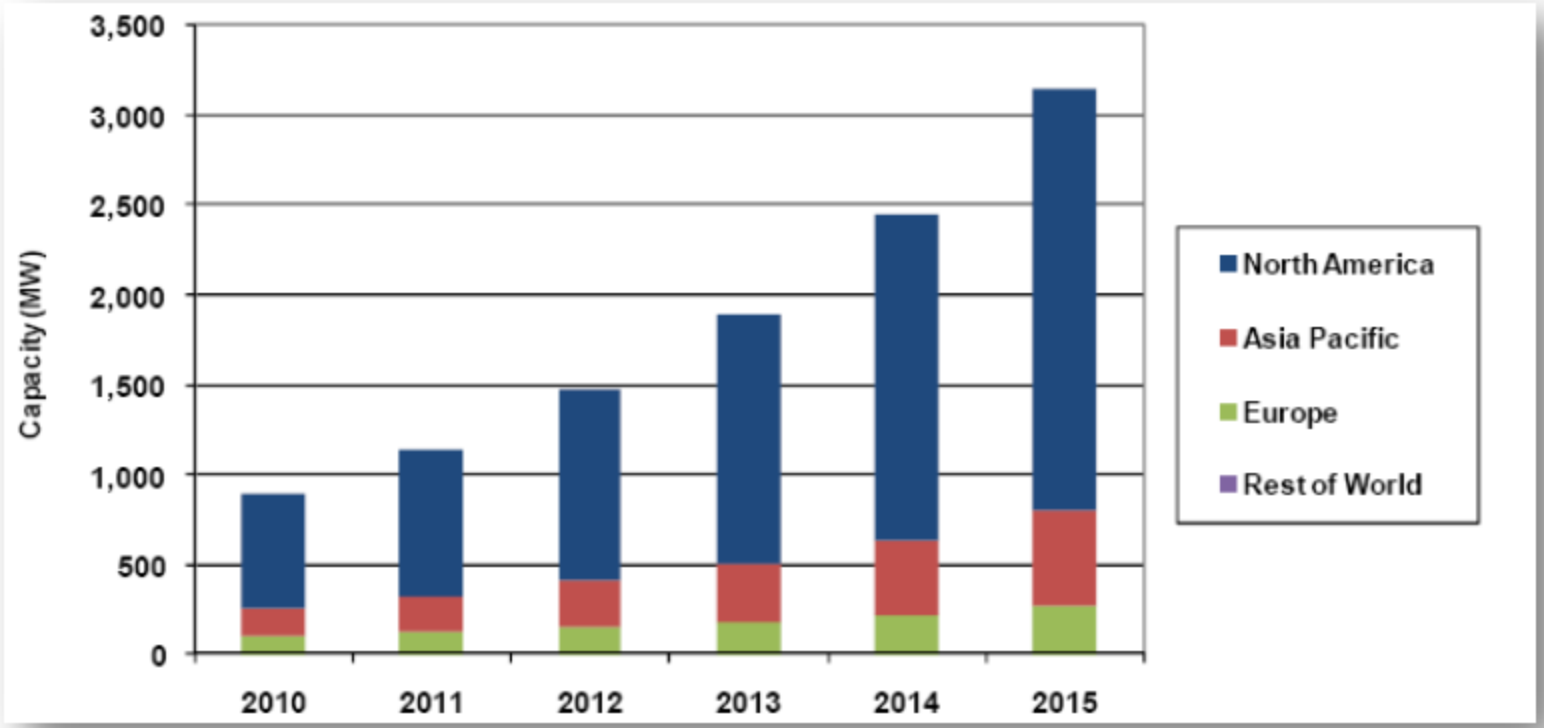


Market Size

2,000 US microgrids by 2015

- Pike Research, Dec 2009

Microgrid Capacity, World Markets: 2010-2015



Source: Pike Research

~$2B annual US market by 2015

- Pike Research, Dec 2009

Microgrid vs. BAU

Characteristic	Microgrid	BAU Central Station Supply
Enable active participation by consumers	X	
Accommodate all generation and storage options	X	
Enable new products, services, and markets	X	
Provide power quality for the digital economy	X	X
Optimize asset utilization and operate efficiently	X	
Anticipate & respond to system disturbances (self-heal)	X	
Operate resiliently against attack and natural disaster	X	

Steve Pullins, Horizon Energy Group (2011)

Thanks

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