DNV KEMA
MicroGrid and Infrastructure Resiliency

Kevin Sullivan
October 2013
DNV KEMA is a leading global energy consultancy addressing the industry’s challenges and opportunities — from policy to customer, and an authority in testing, inspection and certification.
DNV GL Merger = DNV GL

- Founded 1864
- 10,400 employees

**Strong position within:**
- Testing & Certification
- Tankers
- Offshore Classification
- Power & Transmission

- Founded 2013
- Shared ambition for quality and innovation
- 17,100 employees

**A leading company within:**
- Energy
- Classification
- Oil & Gas
- Business Assurance

- Founded 1867
- 6,700 employees

**Strong position within:**
- Renewable Energy
- Container Ships
- Ship Fuel Efficiency
- Marine Warranty
Business activities

**Maritime**
Classification and risk management for the shipping industry

**Oil & Gas**
Risk management for the oil & gas industry

**Energy**
Risk management and sustainability within power generation, distribution and efficiency in use

**Business Assurance**
Certification
Food safety
Hospital accreditation
Corporate responsibility
Stages in North American market evolution – Wholesale and Retail Market convergence “Markets 3.0”

Recent History:
- FERC NOI on VER Integration
- FERC Report on Demand Response
- FERC NOPR on Fast Regulation from Storage
- FERC 745
- FERC 755
- FERC 784

Markets 1.0
- Wholesale Day Ahead Energy on Hourly Schedules
- Ancillary Services
- Balancing and Regulation
- Transmission Rights

Markets 2.0
- Co-optimized Energy and Ancillary Services
- Congestion Pricing
- Nodal Real Time Dispatch
- Capacity Markets for DR

Markets 3.0
- Renewables as Market Resources
- Dynamic Retail Pricing
- Demand Response for Ancillaries
- Capacity Markets for Renewable Firming and DR
- Dynamic Intra Hour Scheduling for Renewables
- DER and Storage now a key resource
- Tighter Linkage of Gas and Electric Supply

1995 - 2003
2001 – 2010
2011-2020
Threat from DER (aka MicroGrid) technologies to utility business model

- DER technologies considered a disruptive technology by many in the industry
- Potential to fundamentally change the electricity market place
- Potential DER threat cycle:
  - DERs lead to lost kWh, revenue and stranded cost recovery unless rates increase
  - Rate increases incentivizes more DERs

Source: EEI, Jan. 13, Disruptive Challenges: Financial Implications and Strategic Responses to a Changing Retail Electric Business
The utility equation

Conventional Utility Model

- kWh Sales + Asset returns
- kWh lost due to DERs
- Asset returns not earned

The DER Challenge

+ DER Asset + Returns
+ DER kWh Sales

Shared Savings

Do Nothing

Unless utilities actively seize DER opportunities/threats, DERs will disrupt the conventional business model.
One needs a sound understanding of Time domains for all Grid Assets to affect flexibility & reliability

Source: DNV KEMA
Central Generation now augmented by Distributed Generation

Benefits of DER across systems and stakeholders

Source: Natural Resources Canada (Quantifying DER T&D Benefits, February 15, 2007)
Microgrids – global markets – Driven by the need for local command and control of DER

- **Exponential Growth Predicted, 2011 - 2017**
  - 330% capacity growth → 1,400 MW to 4.7GW
  - 467% revenue growth → $3B to $17B
  - North America strongest in planned capacity growth
  - Developing world, particularly remote applications, strongest long-term market

- **Growth Drivers**
  - North America, e.g. US, strongest overall market due to:
    - Pockets of poor power quality
    - Heightened Reliability Awareness post Ike, Katrina, Irene, and Sandy
    - Structure of markets for DER → creative aggregation potential behind the meter
    - Offers a quality and diversity of services utilities have not been able to tap → potential for new distribution utility paradigm

- **DOD a major early adopter**

- **Campuses, hospitals, critical infrastructure**
MicroGrid – real-time optimization of energy assets

The MicroGrid concept builds on technical & commercial concepts evolved from advances in automated Demand Response (DR) integrated with Distributed Generation (DG) and Electric Storage (ES). The “MicroGrid” is an integrated energy system of distributed energy resources & multiple controllable electrical loads operating in a single, autonomous grid—allowing ‘islanding” from the utility power grid to provide the following key capabilities:

- **Improved energy security and higher reliability** through direct “command & control” of owned distributed energy resources
- **Enable redundancy and backup** scenarios that ensure operations and mission specific events are risk managed to avoid energy curtailments
- **Optimize energy assets to gain site efficiencies** by managing the load profile and peak demand utilizing own “inside the fence” resources
- **Maximize the return on assets and income** through energy arbitrage and interfacing with energy markets with demand response and ancillary services
How do Microgrids / Managed DER support resiliency and mitigate the risks in energy delivery?

M1: physical hardening

M2: invest in automation, MG, DG

T&D Analyses

Impact Analysis
(Social/Economical impact on different sectors)

NCAR project, NOAA reports

ASCE, NESC
Energy Supply and Demand Management – A Balance!
Variables that enable us to Manage the Grid - Control Area –Macro to Nano

<table>
<thead>
<tr>
<th>Macro: Control Area</th>
<th>Energy Supply Assets</th>
<th>Real-Time Management</th>
<th>Demand &amp; Load Assets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centralized Generation</td>
<td>Control Area</td>
<td>DOD Interface to Grid and Markets</td>
<td>Load Shedding Energy Efficiency</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Micro: MicroGrid</th>
<th>Distributed Generation: RES: – CST, PV, Wind, CHP, W2E, FC, Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>MicroGrid Controller</td>
<td>DOD Local Grid Balancing, Load Visibility</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nano: Self Optimizing Customer</th>
<th>Self Generation (i.e. PV and STOR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart Inverter LC Op Control</td>
<td>Smart Energy Efficient Appliances</td>
</tr>
</tbody>
</table>

- Two-way communication makes customer-owned distributed generation and demand management available to the grid.
- Grid-based generation is coupled and optimized with customer generation and controllable demand to maintain energy balance.
- Customers become suppliers to the market.
Dynamic MicroGrids – Generation which is self driven to find the best fit load to serve at the distribution feeder level!

Microgrids self-island and can also power isolated customers where the distribution is intact.
Enabling Load Control the single most important asset on the Grid
MicroGrid enable this asset – EE, DR and DG and assess the economic benefits based on Real time control
**DER control**
Deterministic real-time control of smart loads is key

- Control is primarily for Dispatchable Demand Response
  - Several DER types may participate in DDR – SOC, general DR/DP, smart EV charging
  - Control technology issue is from aggregator to customer facility / end use
  - Control requires additional security beyond monitoring (authentication / validation)

- Control technologies include the same communications technologies (wireless, Internet, utility SCADA /DA) plus security. Broadcast radio also an option for some resources.
Conclusions

- Horse has Left the Barn; Genie is Out of the Bottle;
- Customers are Increasingly Enabled to Invest in DER for their OWN REASONS
- The Internet has a way of Dis-intermediating Everything
- Utilities are Now Like Every Other Business
  - Understand Customer
  - Create Value Stream
    - Value to customer
    - Value to monetize for utility business
    - Defensible competitive position

Smart local control and real-time coordination of all DER at the distribution feeder level is the game changer this industry needs
Diverse energy assets brought together in a MicroGrid
Real-time management of these assets can ensure energy independence, reliability and resilience
For more information, go to:

www.dnvkema.com

Or email: kevin.sullivan@dnvkema.com
ralph.masiello@dnvkema.com