MICROGRIDS & VPPS

ASSOCIATION OF MUNICIPALITIES OF ONTARIO

NOVEMBER 3, 2016
ENERGY CLOUD IS MADE UP OF A DIVERSE SUITE OF DISTRIBUTED ENERGY RESOURCES (DER) TECHNOLOGIES

- Emerging infrastructure is far more integrated, dynamic, and complex

DISTRIBUTED GENERATION (DG)
Includes the generation of electricity from many small energy sources, including renewables; typically mass-produced, small, and site-specific

MICROGRIDS AND VIRTUAL POWER PLANTS
Applications or groupings of distributed energy resources (DER) that operate either connected or independent from a traditional centralized grid

ENERGY STORAGE
Devices or physical media that store energy to perform useful operation at a later time; balance the supply and demand of energy; improve power quality

DIGITALIZATION OF THE GRID:
- Smart inverters
- Smart meters
- Advanced sensors, controls, and operation systems
- Behind-the-meter (BTM) technologies and solutions
- Demand response (DR)

BUILDING ENERGY MANAGEMENT SYSTEMS
Digital control systems installed in buildings; enables energy efficiency, DR, and automated DR

(Source: Navigant Consulting)
Enernet Links Up Nanogrids to Microgrids to VPPs

(Sources: EMERGE Alliance, Navigant Research)
Mapping Utility Microgrid Strategies

Supportive

Obstructive

Active

Passive

- Impede Interconnect Requests
- Engage Interconnect Requests
- Develop Plot
- Wait and See
- Impact Policy
- Product/Service Offering
- Competing Product/Service

(Source: Navigant Consulting)
MICROGRIDS IN NORTH AMERICA
MICROGRIDS CAPACITY FORECAST: NORTH AMERICA

Microgrid Capacity by Segment, North America: 2015-2024

(Source: Navigant Research)
REMOTE MICROGRIDS IN THE LEAD IN CANADA*

Annual Microgrid Capacity by Segment, Canada: 2015-2020

(Source: Navigant Research)

*Proposed 100 MW in SSM, Ontario could radically alter this assumption.
Annual UDM Capacity & Implementation Revenue, United States: 2015-2020

(Source: Navigant Research)
GLOBAL MICROGRIDS GROWTH TRENDS
CANADA RANKS IN TOP 10 COUNTRIES FOR MICROGRIDS


United States: 41%
China: 30%
Russia: 6%
Canada: 6%
Australia: 5%
Indonesia: 4%
India: 2%
Denmark: 2%
France: 2%
Haiti: 2%

(Source: Navigant Research)
Total Microgrid Power Capacity Market Share by Region, World Markets: 2Q 2016

North America: 42%
Europe: 12%
Asia Pacific: 39%
Latin America: 4%
Middle East & Africa: 3%
Antarctica: 0%
North Africa: 3%

(Source: Navigant Research)

- Remote: 53%
- Utility Distribution: 15%
- Institutional/Campus: 10%
- Military: 5%
- Community: 11%
- Commercial and Industrial: 6%
- Direct Current: 0%

(Source: Navigant Research)
### THREE CLASSES OF VIRTUAL POWER PLANTS

Mixed-asset VPPs enhanced by battery energy storage assets are poised to become clear VPP market leader

<table>
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<tr>
<th>Classes</th>
<th>Description</th>
<th>Strength</th>
<th>Weakness</th>
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| DR VPP            | • Traditional DR markets  
                     • Software aggregation                                                     | • Low cost, flexible                           | • Uneven markets  
                     • Policy uncertainty                                                          |
| Supply-side VPP   | • Renewable generation  
                     • Smart grid enabled  
                     • Software aggregation                                                      | • Large, stable vendors                       | • Niche markets (EU)  
                     • Few projects                                                                |
| Mixed-asset VPP   | • Unites DG + DR  
                     • Resource flexibility  
                     • Enhanced by storage                                                       | • Large pool of solar  
                     PV+ES nanogrid assets  
                     • IT innovation  
                     • New business models                                                        | • Controls standards  
                     • Immature AS markets                                                         |

(Source: Navigant Research)
VPP Customer Acquisition Strategy

- **System Benefits**: Customers on feeders with congestion, voltage, resiliency needs

- **Customer Demographics**: Income, age, EV drivers, current CDM program participants

- **Energy Profiling**: Identify load profiles that match well with system

- **Physical Limitations**: Requirements for solar, roof space, and configuration

(Source: Powerstream)
MARKET FORECAST:
TELEMETRY, DEVICE CONTROLS & SOFTWARE

Total Annual VPP Capacity & Implementation Spending by Region, World Markets: 2016-2025

(Source: Navigant Research, Virtual Power Plant Enabling Technologies Report, 3Q 2016)