Creating a Smart Power Grid:
How Technology is Revolutionizing our Relationship to Energy

John Barnick, Industry Solution Executive,
Network Control, Enterprise Software
### Introduction to ABB

A leader in software, mechanical and electrical engineering and materials science

<table>
<thead>
<tr>
<th>What (Offering)</th>
<th>Pioneering technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Products 58%</td>
<td>Systems 24%</td>
</tr>
<tr>
<td></td>
<td>Services &amp; software 18%</td>
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</tbody>
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<table>
<thead>
<tr>
<th>For whom (Customers)</th>
<th>Utilities</th>
<th>Industry</th>
<th>Transport &amp; Infrastructure</th>
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<tbody>
<tr>
<td>~35% of revenue</td>
<td>~40% of revenue</td>
<td>~25% of revenue</td>
<td></td>
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<table>
<thead>
<tr>
<th>Where (Geographies)</th>
<th>Globally</th>
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<tbody>
<tr>
<td>Americas 29%</td>
<td>Europe 33%</td>
</tr>
<tr>
<td></td>
<td>Asia, Middle East, Africa 38%</td>
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| ~$35 bn revenue | ~100 countries | ~133,000 employees |
### Four market-leading entrepreneurial divisions

All businesses in #1 or 2 positions

<table>
<thead>
<tr>
<th>Partner of choice for…</th>
<th>Market size&lt;sup&gt;1&lt;/sup&gt; and growth</th>
<th>Position</th>
<th>Revenues&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Top 3 competitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>...electrification of all consumption points</td>
<td>~$140 bn&lt;br&gt;2 – 4%</td>
<td>#2 in electrification</td>
<td>$9.9 bn</td>
<td>Schneider&lt;br&gt;Legrand&lt;br&gt;Eaton</td>
</tr>
<tr>
<td>...robotics and intelligent motion solutions</td>
<td>~$110 bn&lt;br&gt;3 – 8%&lt;sup&gt;3&lt;/sup&gt;</td>
<td>#1 in motion&lt;br&gt;#2 in robotics</td>
<td>$7.9 bn</td>
<td>Siemens&lt;br&gt;Fanuc&lt;br&gt;Kuka</td>
</tr>
<tr>
<td>...industrial automation</td>
<td>~$130 bn&lt;br&gt;1 – 5%&lt;sup&gt;4&lt;/sup&gt;</td>
<td>#2 in industrial automation&lt;sup&gt;7&lt;/sup&gt;</td>
<td>$6.8 bn</td>
<td>Siemens&lt;br&gt;Emerson&lt;br&gt;Schneider</td>
</tr>
<tr>
<td>...a stronger, smarter and greener grid</td>
<td>~$110 bn&lt;sup&gt;5&lt;/sup&gt;&lt;br&gt;3 – &gt;10%&lt;sup&gt;6&lt;/sup&gt;</td>
<td>#1 in T&amp;D</td>
<td>$10.9 bn</td>
<td>Siemens&lt;br&gt;GE&lt;br&gt;Hyundai</td>
</tr>
</tbody>
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1Unconsolidated 2016; 22016 revenues in new structure as of January 2017; 38% for robotics market; 4Discrete automation segment; 5Consolidated, $140 bn unconsolidated; 6In certain segments; 7After the close of B&R acquisition
Changes in the markets: Energy and Fourth Industrial Revolutions

Digital Transformation: IT/OT convergence as well as integration of historic silos of information

The Energy Revolution

The Fourth Industrial Revolution

Utilities

Industry

Transport & Infrastructure
ABB Ability is a digital platform
Large, global software and digital offering

50 cloud-based services and advanced analytics

>6,000 solutions installed

>70,000 systems installed

>70,000,000 digitally enabled devices connected

>55% of ABB’s sales from software and digitally enabled devices
Importance of the Digital Transformation

Mastering the control room

From physical to digital differentiation
General view of a city
What today’s electric distribution system operator sees

Advanced Distribution Management System (ADMS)
DOE ARRA funding advanced utility distribution systems operations

AMI, Load Flow, Volt/VAr Optimization, Loss/Demand reduction, Fault Location & Isolation
Storm Preparedness
CenterPoint Energy experience

Self-healing technology
Automatically identify the fault location
Isolate faulted section of the grid
Re-route power from other source

Benefits
Restoring nearly 1.2 million without a phone call
Avoiding over 102 customer outage minutes
Improving reliability over 28% (SAIDI/SAIFI)

Outage analytics
Near real-time notification to stakeholders
Data from ADMS is replicated within 3-5 minutes
Utilize past storm data to improve grid resiliency

Industry recognition
Winner of the 2016 ISGAN (International Smart Grid Action Network) Award of Excellence
POWERGRID International – Project of the Year for Grid Optimization, 2016
A Test of the Storm Preparedness
CenterPoint Energy experience

Field devices  ➔  Communications  ➔  Advanced Distribution Management System  ➔  Outage analytics

2016 Spring Storms
• Up to 16 inches of rain in 6 hours
• Flooding in every part of Houston
• Once in a 200 year event
• Winds, lightning wide spread flooding
• State of emergency declared
• 600 line fuses, 650 transformers taken out of action.
• 240K customers without power
• Extensive outages and road closures hampered crews from restoration sites

ADMS, mobile, dashboards performance
• Reduced crew journeys
• Provided a targeted response
• 90% of 240K people restored within 27 hours

Overall ADMS performance since go live
• Reduced outages by >194 million minutes
• Enabled >1.5 million outage cases without a customer call
• Saved consumers >$20M/year in service costs
• Saved fuel equivalent of up to 40K tons CO2 emissions

3 minute video summary of ADMS performance: https://www.youtube.com/watch?v=ufRRlC8VlgQ
Big shift in the electrical value chain
Distributed Energy Resources and Microgrids are changing energy delivery

Traditional grid

New grid
Challenges with today’s legacy inverters and higher penetration PV

Legacy grid interconnection standards did not consider impact of significant DER penetration

- Significant load / generation imbalance per phase
- Back feed generation to the grid on light load days
- Network/equipment not designed for two way flows
- Utility distribution planning network model limitations
- Faults drop out inverters covering “ghost load”
- Increased short circuit interrupting capability required
- Voltage and power variations from clouds and sunset
Example of power variations
Duke Energy Substation in Eastern NC 115kV/12kV

One-minute real & reactive power flow measured at distribution bus, 48 hour period: Aug 4-5, 2013

One-minute real & reactive power flow measured at distribution bus, 48 hour period: Oct 4-5, 2014

Source: CA ISO “Duck Curve”
“The innovation taking place occurs faster than we can regulate.”
Michael Picker, President, California Public Utilities Commission, January 30, 2017

- GridWise Architecture Council (GWAC) goal to enable all elements of electric system to interact
  - 13 industry representatives supported by the U.S. D.O.E.
  - Transactive Energy: “a set of economic and control mechanisms that allows the dynamic balance of supply and demand across the entire electric infrastructure using value as a key operational parameter

- Who owns and/or operates the DER can provide value

- Value of DER? It depends..........  
  - Renewable generator or energy storage device  
  - Watts vs VAr performance, availability, location on the feeder and time of day  
  - Autonomous vs remotely controllable can have difference values

- Regulatory policy is the biggest hurdle to transactive energy, not technology
Transactive Energy Possibilities

Regulatory policy required for rules & responsibilities for reliability & markets

Distribution System Operator (DSO)

Distribution utility: Metering, control, reliability, etc.

Independent Distribution System Operator (IDSO)

Distribution System Operator(s)

Transactive Markets

The distribution infrastructure can be considered the platform
Advanced Distribution Management System
Distributed Energy Resource Management System

Architecture and applications are evolving in pilot projects awaiting regulatory policy.
Key Takeaways

Technology is available for real time monitoring and control of the distribution grid.

As utility rates rise to compensate for deployed Distributed Energy Resources and solar PV costs continue to decline, more consumers are finding solar PV becoming more economical.

Higher penetration of DER is resulting in new challenges for utility distribution grid operations, aggregators and consumers.

Integrating advanced distribution management systems (ADMS) applications with distribution energy resource management systems (DERMS) can improve efficiency and reliability.

Regulatory policies and education are needed to continue the evolution towards distribution transactive energy markets.