Innovating in a IoT, IoP World (Digital Grid)

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ABB Canada
OPAL RT-17

1. ABB

2. Industry trends

3. Advanced Distribution Management Systems
   1. Storm response
   2. Voltage optimization control
   3. DERMS (Distributed Energy Resource Management System)

4. Storage

5. Microgrids

6. Analytics

7. Digitalization
ABB – A global technology pioneer

Leading market positions in power & automation

~132,000 employees

$33 billion in orders (2016)

Present in ~100 countries

Formed in 1989
merger of Swiss (BBC, 1891) & Swedish (ASEA, 1883) engineering companies
How ABB is organized

Four divisions

**Electrification Products**

Electrification Products delivers products and systems designed to connect, protect and control electrical systems, ensuring reliability, efficiency and safety for your equipment and personnel.

**Robotics and Motion**

Robotics and Motion products, systems and services help improve efficiency and reliability throughout the energy value chain.

**Industrial Automation**

Industrial Automation products, systems and services help optimize operations and processes across the energy value chain.

**Power Grids**

Power Grids helps improve efficiency and reliability throughout the power value chain from generation to transmission and distribution.
ABB in Canada

Region headquarters
Montreal, Quebec

~ 4,000 employees
in Canada

~ $2.1 billion
revenue

55 locations
cost to coast

Over 100 years of
 technological
innovation in Canada

~ 26
sales & service
locations

~ 29
Manufacturing
& assembly
locations

Canadian market
leader in power
transmission and
distribution

Ranked in top 20
Canada’s Best Employers
2016 & 2017

~ 600 Safety
Observation Tours in
2016

~ 55
Manufacturing
& assembly
locations

North American
Center of
Excellence for E-
Mobility

Close to $1 million
given to Canadian
communities in 2016

Top 20 Canada’s best employers ranking by Forbes: https://www.forbes.com/companies/abb/

September 14, 2017
ABB in Canada

State-of-the-art corporate headquarters

Campus Montreal

Reinforcing our commitment to local markets and to maintaining best-in-class facilities in Canada, our high-tech corporate headquarters represents a $90 million investment in Montreal, Quebec.

Inaugurated in 2017, the Montreal Campus is home to 700 employees.

The 300,000 square foot facility houses the corporate headquarters, a research and development, manufacturing and assembly facility and a Customer Innovation Center that brings together the next-generation of cutting edge technologies that will power Canada’s innovation ecosystem.
ABB in Canada
State-of-the-art corporate headquarters

**Campus Montreal**

Was selected as ABB’s North American Centre for Excellence in e-Mobility, where it will develop energy-management solutions for electric buses and trains.
Tackling society’s challenges on path to low-carbon era

Helping customers do more while using less

Rise in electricity demand by 2035 (under current policies)

Source: IEA, World Energy Outlook 2013
In thousand Terawatt-hours (TWh)

ABB power and automation solutions are:

- Meeting rising demand for electricity
- Increasing energy efficiency and reducing CO$_2$ emissions
- Improving productivity to raise competitiveness of businesses and utilities
Renewables are expected to become the dominant source for electrical power generation
So What are Utilities really concerned about?

Managing network complexity going forward

- Increasing complexity in grid operations in the near future
- Enhancements will evolve over time
- Due to cautious nature of the utility, it appears that utilities are somewhat hesitant to invest in emerging technologies
- Top three digital grid investment areas:
  - Outage management
  - Distribution automation
  - Renewable and distributed generation integration

Source – EY Research
The state of grid modernization

US smart grid spending (2008-2016)

1. $58.8 billion invested in US clean energy in 2015
2. On-shore wind in Morocco was recently bid at 3 cents/kWh
3. Utility-scale solar PV in Mexico was recently bid at 2.8 cents/kWh
4. Experience curves (from BNEF):
   - Wind generation drops 19% with every doubling of installed capacity (four doublings in last 15 years)
   - Solar drops over 24% with every doubling of installed capacity (seven doublings in last 15 years)
5. Lithium-ion battery costs will decrease by 75% from 2010 to 2017 (dropping from $1000/kWh to $250/kWh)

Source: BNEF 2017

Grid modernization game changers – distribution automation, DER integration, and analytics
Utility industry drivers

<table>
<thead>
<tr>
<th>Utility drivers</th>
<th>Core T&amp;D Operations Products and Systems</th>
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<tbody>
<tr>
<td>- Safety</td>
<td>- Solar PV inverters</td>
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<tr>
<td>- Reliability and resiliency</td>
<td>- Energy storage</td>
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<td>- Efficiency</td>
<td>- Microgrids</td>
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<tr>
<td>- Capacity</td>
<td>- EV charging infrastructure</td>
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<tr>
<td>- Sustainability</td>
<td>- Phasor measurements</td>
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<td>- Customer engagement</td>
<td>- Asset management</td>
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<td>- Operational efficiency</td>
<td>- Utility analytics</td>
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<td>- Mobile work force management</td>
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Driving grid reliability, efficiency, performance, asset health, DER integration & management, and resource plans
### Strategic focus

#### Grid Management
- Substation automation
- Advanced distribution management
- GIS management
- Sensors

#### Grid Reliability
- Event detection and management
- Demand response
- Peak load management
- Fast response energy storage
- Asset health management

#### Smart Energy Applications
- Utility scale renewables
- Consumer energy efficiency
- Distributed energy resources
- Smart appliances

#### Future Application Value
- Higher reliability
- Operate closer to grid limits
- Early event detection and condition-based response
- Grid congestion management
- T&D planning and IRP optimization
- Renewable integration
- Power Quality
Energy and Fourth Industrial Revolution

The Energy Revolution

Utilities

The Fourth Industrial Revolution -- IIOT

Transport & Infrastructure

Industry
Solar surprise: Capacity prices fall below wind

A turning point for renewables in lower-income countries

Source - BNEF
Renewable energy

Global installed capacity more than doubles by 2040

Wind and solar amount to 50% of total renewables in 2040

Source: International Renewable Energy Agency (IRENA) Statistics
Technical challenges of renewable energy integration

Variable renewable generation as % of total demand

Technical challenges

- Variability, dispatchability, and operational characteristics of renewable generation
- Coordination with existing centralized generation
- Grid capacity and reserve
- System inertia and grid voltage
- Short circuit power
- Potential for significant variable RES curtailment

Grid investments and technologies required to address the challenges
Industrial markets primed to adopt digital technologies

Computing + connectivity + cloud + analytics set to unlock value

Digital S-Curve

Level of digitalization

Time

Note: relative size of industry for advanced economies

September 14, 2017
What does it take to win in digital?

Mastering the control room

From physical to digital differentiation
### Power systems of the future

Digitalization trend – Internet of Things, Services & People

<table>
<thead>
<tr>
<th>Industrial IoTs</th>
<th>Utility applications</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Things</td>
<td><strong>Design and build</strong></td>
<td>- Optimized design through simulation</td>
</tr>
<tr>
<td>Services</td>
<td><strong>Control and operate</strong></td>
<td>- Faster configuration process</td>
</tr>
<tr>
<td>People</td>
<td><strong>Analyze and maintain</strong></td>
<td>- Lower lead times and higher quality manufacturing &amp; assembly process</td>
</tr>
</tbody>
</table>

**Utility applications**
- Distribution automation – FDIR and VOC
- Power generation scheduling and dispatch
- Electricity market management
- Ownership of assets and business models
- **(Big) Data analysis – continuous learning**
- Remote access – communications
- Sensors, monitoring, management, and service aligned with expert knowledge
- Workforce management
Grid modernization

Modernization Technologies

Changing Landscape

Renewables will take the major share in electrical power generation:
- Disruptive elements
  - Renewable generation
  - Storage
  - Digitalization – the digital grid
- Distributed generation with changing consumer and producer patterns
- Distribution grid role changing
- Transmission backbone essential
- New business & operational models
Advanced Distribution Management Systems (ADMS)

Modular distribution operations platform

Distributed Energy Resource Management System (DERMS)
Network Manager ADMS

ADMS Analytics

Common Graphical User Interface

Distribution Applications
- Load Flow
- FLISR
- Overload Reduction Switching
- Restoration Switching Analysis
- Volt/Var Control
- Short Circuit Analysis

Outage Management
- Trouble call, AMI, outage notifications
- Outage prediction
- Auto-creation and management of ETRs
- Crew management
- Planned work
- Switch Order Management

SCADA
- Data acquisition
- Alarming
- Trending
- Real-time calculations
- Integrated data engineering
- Historian

DERMS
- DER Program Management
- Optimal Power Flow
- Volt/Var Control
- DER Forecasting
- DER Optimization
- Distribution Markets

Common Data Model, Simulation and Training

Communications

SCADA Communications

External Adaptors & Data Exchange
Why are we worried about power reliability?

Disaster events include insect infestation, drought, wildfire, earthquake, avalanche, landslide, rock fall, subsidence, volcanic activity, flood, extreme temperature, storm, famine.
Storm preparedness & recovery

Using advanced distribution management system
Improved detection and restoration times

Detection & restoration times with and without automation

Without visibility

- Fault Occurs
- Travel Time: 5-10 minutes
- Customer Reports Outage
- 15-30 minutes
- Time to Perform Manual Switching: 10-15 minutes
- Fault Locate: 15-20 minutes
- Field Crews On-Scene: 45-75 minutes
- Power Restored to customers on healthy sections of feeder: 1-4 hours
- Fault Locate: 15-30 minutes
- Travel Time: 5-10 minutes
- Customer Reports Outage: 1-5 minutes
- Patrol Time: 1-10 minutes
- Field Crews On-Scene: 1-10 minutes
- Power Restored to customers on healthy sections of feeder: 1-4 hours
- Feeder Back to Normal

With visibility and remote control

- Fault Occurs
- Travel Time: 5-10 minutes
- Customer Reports Outage: 1-5 minutes
- Field Crews On-Scene: 1-10 minutes
- Power Restored to customers on healthy sections of feeder: 1-4 hours
- Feeder Back to Normal
New York State reforming the energy vision

- 50% of generation will be renewable.
- One goal is reduction of peaking generation to achieve 1.2 to 1.7 billion dollars in potential annual savings.
- Utilities filed Distributed Systems Implementation Plans in 2016
- Requests for proposals for Non Wires Alternatives have been released and awarded.
- Regulatory reform continues to move forward – service model for Distributed Systems Platform providers

The state is pushing forward to establish new utility business models
Storage – Creating value from the many use cases

- Microgrids
- Solar power
- Wind power
- Residential loads
- Industrial loads

- Peak Shaving
- Load Levelling
- Frequency Regulation
- UPS / Islanding
- Capacity firming
- Voltage support
48 Projects totaling 130 MW in North America

IKIC Anahola Project 6MW / 4MWh

Two 3MW PCS units and integrated controls

20MW Project for the PJM Market

Five 4MW PCS units and integrated controls

Skid-mounted BESS 500kW / 224 kWh

AES Angamos BESS 20 MW / 5 MWh

Five 4MW PCS units and integrated controls

Tehachapi Energy Storage Project 8MW / 32 MWh

Two 4 MW PCS units and integrated controls for 8 different applications

Southern Company Project 1MW / 2MWh

Turnkey BESS and integrated controls
## Microgrid segments and drivers

### Segments and Typical Customers

<table>
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<tr>
<th>Segments</th>
<th>Typical customers</th>
<th>Main drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Island utilities</td>
<td>(Local) utility, IPP*</td>
<td>Social: Access to electricity</td>
</tr>
<tr>
<td>Remote communities</td>
<td>(Local) utility, IPP, Governmental development institution, development bank</td>
<td>Economic: Fuel &amp; cost savings, Environmental: Reduce CO2 footprint and pollution, Operational: Fuel independence, Uninterrupted supply</td>
</tr>
<tr>
<td>Industrial and commercial</td>
<td>Mining company, IPP, Oil &amp; Gas company, Datacenter, Hotels &amp; resorts, Food &amp; Beverage</td>
<td></td>
</tr>
<tr>
<td>Defense</td>
<td>Governmental defense institution</td>
<td></td>
</tr>
<tr>
<td>Urban communities</td>
<td>(Local) utility, IPP</td>
<td></td>
</tr>
<tr>
<td>Institutions and campuses</td>
<td>Private education institution, IPP, Government education institution</td>
<td></td>
</tr>
<tr>
<td>Grid-connected utilities</td>
<td>(Local) utility</td>
<td></td>
</tr>
</tbody>
</table>

### Drivers

- **Main driver**
- **Secondary driver**

IPP: Independent Power Producer
Utility Analytics – The Current State of Smart Grid Analytics

What is driving your analytics projects?

- Improving business efficiency: 49%
- Cost savings: 44%
- Meeting regulatory requirements: 36%
- Increasing reliability (SAIDI, CAIDI, or...): 33%
- Address aging infrastructure: 29%
- Improve customer service: 29%
- Achieve smart grid return on investments: 23%
- Improve safety: 16%
- Other: 9%

Source: The Utility Analytics Institute 2017 Energy Central

*Multiple responses allowed*
Advanced Analytics is key to the digital grid

Drivers for grid analytics

- The deployment of potentially millions of new intelligent grid devices into a distribution network all generating valuable information across all parts of the business.
- New distribution assets with embedded sensor technology are combined with communications and analytic technologies
- Intermittent generation sources can require "millisecond" response times
- Understanding the risk and impact of events in real time is an absolute requirement to ensure safety and reliability of the grid.

Global Utility Analytics Spending 2012-2029

Cumulative analytics investment is forecasted to grow more 500% from 2012 to 2029

Sensor performance models

Transmission based algorithms

**Breaker Simulated Travel (Patent)**
Simulated travel utilize auxiliary switch timing in place of transducers to calculate contact speed, reaction time and mechanism time.

**Transformer Temperature Balance**
Compare actual transformer temperatures with a model to indicate changes in the cooling conditions or heat generation, that might restrict loading or limit overloading.
Reduce failure rates and increase productivity

Building a business case for asset health management

- **VALUE DRIVERS**
  - **REVENUE LOSS AVOIDANCE**
    - Reduce forced downtime / outages
    - Reduce catastrophic events (collateral damage)
    - Reduce (expensive) unplanned emergency work
    - Reduce cost of planned work with improved data
    - Reduce time-based repetitive tasks
    - Reduce material storage and handling costs
  - **O&M COST**
  - **CAPEX**
    - Extend asset life
    - Lower CAPEX procurement costs
    - Reduce working capital (inventory)
  - **REDUCTION OF RISK EXPOSURE**
    - Environmental Risk
    - Regulatory Risk
    - Safety Risk

- **REDUCTION OF RISK EXPOSURE**
  - Reduce environmental risk
  - Reduce regulatory risk
  - Reduce safety risk

- **REDUCTION OF COST EXPOSURE**
  - Reduce operational and maintenance costs
  - Reduce capital expenditure costs

- **REDUCTION OF WORKING CAPITAL EXPOSURE**
  - Reduce inventory levels
  - Reduce working capital requirements
Digital Grid

Drivers for the digital grid

- A digital grid enables bi-directional flows of energy and information and makes use of digital technology and advanced analytics to monitor, control and automate the network, while improving reliability, availability and efficiency of the grid.

- A digital grid makes use of software technology and industry expertise to fuel better decision-making.

- Investment in digital grid over the next five to seven years is expected to be in the region US$500b. (EY Research 2016)

Main drivers for adoption of the digital grid

- Growth of renewables (72%)
- Improvement in infrastructure operations and performance (72%)
- Cybersecurity risks (60%)

Source: EY Research

Market adoption of the digital grid continues to grow
Digitalization of utilities – the digital grid

Reduced installation time (<40%), maintenance costs (<50%) and outage time (<50%)

- Advanced distribution management
- Distributed energy resource management
- Asset performance management
- Maintenance workflow management
- Energy market trading system
- Automated digital substation
- Standard IP communications
- Microgrids and Storage
Innovating in a IoT, IoP World

Conclusion

• New value chain augmented and interconnected by digital technologies

• Enhanced analytics are essential to fully achieve the potential value of the digital grid

• Both power and information flow in multiple directions

• Much more engaged consumer
THANK YOU

Let’s write the future...Together