Role of 5G in Energy and Industrial Revolutions?
Energy and Industrial Revolutions

World as we know it is being disrupted – at unprecedented rate of change

Utilities
- Renewable electrification
- Smart distribution

Industry
- Industry 4.0
- Collaborative, Flexible Manufacturing
- Real-time energy optimization

Transport & Infrastructure
- Smart Cities
- E-Mobility
- Mobility-as-a-Service
- Data centers
Renewables and storage driving unprecedented change
Consider these developments

<table>
<thead>
<tr>
<th>Renewables growth</th>
<th>Energy storage price reductions</th>
<th>New regulations &amp; incentives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>+27%</strong></td>
<td><strong>$36/ Month</strong></td>
<td><strong>8-10%</strong></td>
</tr>
<tr>
<td>Already over 27% of all energy generation in Europe comes from renewables, while in the US 15%</td>
<td>Average American consumes 903 kWh/month → 30 kWh/day By 2020 it will cost $36.8/month ($1.2/day) for a full day of electricity storage</td>
<td>Global renewables capacity has increased by 8-10% y-o-y since 2010 and the trend is to continue, with over 150GW added annually (2/3 of all capacity addition)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Renewables penetration</th>
<th>Disruption through new business models</th>
<th>The Green agenda</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>85%</strong></td>
<td><strong>$0</strong></td>
<td><strong>$350 billion</strong></td>
</tr>
<tr>
<td>At certain times of year in Germany the max hourly variable renewable generation rate already above 85% of hourly demand. Result: NEGATIVE ENERGY PRICES</td>
<td>SV Startup Volta offering FREE EV charging in exchange for media rights at prime high-value properties. If this business model succeeds, the EV MARGINAL COST of energy will be ZERO</td>
<td>China recently said it would shut 85 coal plants and instead invest $350 billion in renewable sources of energy</td>
</tr>
</tbody>
</table>
Current challenges and changes facing utilities

Aging infrastructure
Nearly 70% of the transformers in the US are more than 25 years old.¹

Reliability
There is increasing pressure to continually improve reliability and customer satisfaction.

Need for improved customer engagement
Customers expectations of “engagement” are changing. 25 billion devices (not counting smartphones, tablets or computers) will be connected to the IoT by 2020.³

Business model disruption
By 2020 non-utility players will seize 20% of the energy retail market. 2.5 GW of electricity will be generated by 20% of Fortune 500 companies, who will wholesale their distributed energy resource excess power through utility-independent subsidiaries.⁴

Transitioning workforce
40% of the workforce at America’s electric and natural gas utilities will be eligible for retirement in the next five years.⁶

Renewables penetration
Global renewables capacity has increased by 8-10% y-o-y since 2010, and the trend will continue with over 150GW added annually (2/3 of all capacity addition).

Spending justification
Continued revenue challenges and regulatory inspection will drive Totex focus and cost constraints.

Cyber security
Attacks on critical infrastructure are increasing in terms of regularity and sophistication. Through 2018, 50% of IoT device manufacturers will not be able to address threats from weak authentication practices.⁷

Resulting in increasing complexity in Energy System

New challenges for traditional paradigms for control and commerce

- Distributed energy resources at customer sites
- System in which EV sell demand response services to the grid
- Control in-home appliances to switch off high-load components (load disaggregation)
- Collect, store and report residential energy use information
- Underlying communication to support Smart technology
- Health Monitor network parameters & control devices remotely
- Managing voltage levels & reactive power (VAR) with assets owned by the utility and otherwise
- Generation & Storage
- Behind-the-meter
- Active Distribution Networks
- Aggregation
- Markets
- Intelligence
- Distribution connected renewables generation and storage
- Aggregation of DERs for wide-area grid support and market trading
- Load management at customer sites through e.g. dynamic pricing
- Regulatory requirements for more granular pricing schemes and markets
- Prosumers locally sell excess energy from their distributed energy
- Decentralized market platform for charging EVs
- Frequency Regulation

©ABB
October 2, 2017 | Slide 5
EV: Electric Vehicle
DER: Distributed Energy Resource
Smart Manufacturing offers tremendous business potential
Tapping into benefits requires much greater agility that typical today

“Smart factories have the potential to add $500 - $1,500 billion annually to the global economy in the next five years.”
Source: Capgemini 2017

“Smart factories are revolutionizing manufacturing by enabling a 7x increase in overall productivity by 2022.”
Source: Capgemini 2017

Industrie 4.0 - DEU
Launched in 2011 at the “Hannover Messe” by the German government. Industrie 4.0 combines production methods with state-of-the-art information and communication technology.

National Network for Manufacturing Innovation - USA
Launched in 2011 by the US government. Network of research institutes focusing on developing and commercializing manufacturing technologies.

Innovation in Manufacturing 3.0 - KOR
Launched in 2015, it aims to invest KRW200 billion ($172 million) annually from 2015 to 2020 to facilitate the building of 1,500 smart factories by 2020.

Made in China 2025 - CHN
Launched in 2015 by the Chinese government, the initiative aims to comprehensively upgrade Chinese industry.
Now – what about evolution of Industrial Automation?

Sweden beginning of 20th century – human closing the loop
The evolution of industrial automation

USA in 1940’s – programmable controllers
The evolution of industrial automation

1970-80s Distributed Control Systems
The evolution of industrial automation
Currently – we have digital, layered control systems
Dynamic operating environment shifts Automation Hierarchy...

- ERP (Level 4)
- MES / CPM (Level 3)
- Supervisory control (Level 2)
- Regulatory control (Level 1)
- Process (Level 0)
...towards a dynamically networked systems architecture
Today's Hurdles in Machine-to-Machine Communication addressed with

<table>
<thead>
<tr>
<th>Automation and Machine Supplier</th>
<th>Machine User</th>
</tr>
</thead>
<tbody>
<tr>
<td>✳ Multiple communication protocols</td>
<td></td>
</tr>
<tr>
<td>✳ Limited innovation speed</td>
<td>• Locked into proprietary eco systems</td>
</tr>
<tr>
<td>• High integration effort</td>
<td></td>
</tr>
</tbody>
</table>

| Solution: | Unified Communication based on OPC UA over TSN |
Recently announced OPC UA over TSN alliance

Example of forming interoperability ecosystems
Summary: ABB Ability & Digitalization
Customers will increasingly have to deal with very **dynamic environments**

The need for **faster decisions** and **real-time action** requires **visibility** of the entire business

**Digitalization** is the answer for the necessary agility and decision-making velocity
ABB Ability™ Solutions & Platform

Partnership with Microsoft to build up a common digital platform across the value networks

Utilities | Industry | Transportation & infrastructure

- ABB digital solution
- Customer digital solution
- ABB+ Customer solution
- ABB digital solution

**What**
Delivers customer benefit (uptime, speed, yield...)

**How**
ABB provides efficiency and scale

Platform
(common technologies for device, edge, and cloud)
Ecosystems start blending together - Intercloud

Secure digital solutions on-premise, in the cloud, and in an ecosystem
Winning with Digital takes ability. ABB Ability™.