Plenary session 4:
Uptake of Clean Technologies: Disruption and Coexistence of New and Existing Technologies - the Way Ahead

Background Paper
Disclaimer

The observations presented herein are meant as background for the dialogue at the 16th International Energy Forum. They have been prepared in collaboration with The Boston Consulting Group and should not be interpreted as the opinion of the International Energy Forum or The Boston Consulting Group on any given subject.
Introduction

Market Context

• Energy related technology is evolving at a fast pace impacting operations and business models. To ensure a reliable and sustainable transition, clear and predictable policies are needed.
• There is certain uncertainty related to which new technologies should be promoted, if any, and how to ensure limited impact on existing assets and technologies.
• Policy makers face challenges around how to achieve a well-balanced regulatory framework to foster innovation balancing sustainable, cheap and reliable/secure energy.

Session Objectives

• Discuss the role of energy policy and the regulators in the technological progress in the sector.
• Share experiences on potential initiatives that can be implemented to foster technological progress without endangering market stability and/or energy security.
• Seek common goals that could be pushed in a coordinated manner at international level to foster introduction of new technologies in the energy sector.

Key Question: How can energy policy makers foster new technologies as a way to achieve long term energy strategy: cheap, sustainable, reliable and secure energy?
Fast technological progress allowing to produce and consume clean energy cheaper than ever

Price reduction in different technologies

Source: IEA. Based on BNEF (2017), Utilities, Smart Thermostats and the Connected Home Opportunity; Holdowsky et al. (2015), Inside the Internet of Things; IEA (2017), Renewables; Tracking Clean Energy Progress; World Energy Investment; Navigant Research (2017), Market data: Demand Response. Global Capacity, Sites, Spending and Revenue Forecasts
Fostering a number of disruptions in the energy industry

- Internet of things and sensors
- Robotization
- Renewables and DER
- Smart grids
- Vehicle electrification

- Batteries
- Peer to peer trading
- Shale gas
- Smart energy efficiency
- Electrification of thermal load
At the same time, policy makers trying to reform the market through a set of initiatives

Illustrative example from Europe

- Can we have it all?
- Innovation
- Security of supply
- No nuclear
- No CO2
- Energy independence
- Low prices
- Competition
- New business models
A fundamental shift in power sector stack architecture is underway in the Power sector
Leading to shifts in investment and value pools

Investments in smart electricity infrastructure and software vs investment in global gas generation or the Indian power sector


Source: IEA
Renewables expected to gradually replace conventional technologies in the future power generation mix

Worldwide installed power generation capacity 2016-2040

<table>
<thead>
<tr>
<th>Year</th>
<th>Renewables</th>
<th>Nuclear</th>
<th>Oil</th>
<th>Gas</th>
<th>Coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>6,677</td>
<td>0.8%</td>
<td></td>
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<tr>
<td>2025</td>
<td>8,647</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2030</td>
<td>9,725</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2040</td>
<td>11,960</td>
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</table>

Net capacity additions 2016-2040

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<tbody>
<tr>
<td>8. Gas</td>
<td>1,150</td>
<td>1,199</td>
<td>589</td>
<td>271</td>
</tr>
</tbody>
</table>

1. Includes bioenergy, geothermal, CSP, and marine.
Even in the most 'green' scenario traditional technologies will still play an important role in the mix by 2040

**BCG Green Revolution Scenario**

Technology and regulation drive...
- Technology drives down costs of low-carbona technologies
- Regulatory push based on environmental concerns: clear push to limit CO2
- Government play a strong role

...Electrification, efficiency and renewables
- Solar and wind fully competitive by 2025: Build-out rate ~300 GW/y
- Action on coal for power: active coal closure in OECD; China follows with 10y delay
- Investments in smart grids

Solid push for energy efficiency
- Central coordination of efficiency standards and investment in efficient lighting, cooking and appliances

**BCG Energy Scenario Model**

Total Primary Energy for Power Generation - mtoe (%)

<table>
<thead>
<tr>
<th>Year</th>
<th>Nuclear</th>
<th>Bioenergy</th>
<th>Other Renewables</th>
<th>Gas</th>
<th>Oil</th>
<th>Coal</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>5,178</td>
<td>5,319</td>
<td>5,455</td>
<td>5,535</td>
<td>5,961</td>
<td>6,143</td>
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<tr>
<td>2020</td>
<td></td>
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<td>2040</td>
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</tbody>
</table>

Source: BCG analysis (BCG Energy Scenario Model—Dec 2016); IEA (World Energy Outlook 2015, New Policies Scenario)
Specially in developing economies: i.e., China and India

BCG Green Revolution Scenario: total Primary Energy for power generation 2015-2040

K mtoe

Non-OECD E.Europe/Eurasia
Non-OECD Middle East
Non-OECD Africa
Non-OECD LATAM
India
Rest of non-OECD Asia
China
OECD Oceania
OECD Europe
OECD Americas

Coal
Gas
Bioenergy
Oil
Nuclear
Other Renewables

Baseline

Specially in developing economies: i.e., China and India

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Coal and Gas could still be predominant in a scenario of abundant and cheap unconventional gas

BCG Blue Gas Economy Scenario

Abundant unconventional gas drives...
- The US leads the way
- Shale gas boom in China and Argentina

... A drop in gas prices...
- Gas prices below 5$ / mmbtu in exporting countries
- Gas prices below 10$ / mmbtu in importing countries

... And a switch to gas
- Power, industry and buildings: switch in China and Argentina
- Decreased efficiency improvements in buildings: Slower deployment of building standards compared to Baseline
Replacement of fuel sources is not new and takes time.

Major Sources in the US Energy Mix (1825-2008)

Consumption (in %)

- Wood & Biomass
- Coal
- Petroleum & NGLs
- Gas
- Hydroelectric
- Nuclear
- Other Renewables

Illustrative
The different policy choices do have an impact on prices

**Electricity prices in different countries**

<table>
<thead>
<tr>
<th>Country</th>
<th>Industrial</th>
<th>Household</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>15.2</td>
<td>30.5</td>
</tr>
<tr>
<td>Spain</td>
<td>10.6</td>
<td>23.0</td>
</tr>
<tr>
<td>EU-28</td>
<td>11.4</td>
<td>20.4</td>
</tr>
<tr>
<td>UK</td>
<td>12.7</td>
<td>17.7</td>
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<tr>
<td>France</td>
<td>9.9</td>
<td>16.9</td>
</tr>
</tbody>
</table>

- Transition towards RES resulting on electricity prices +40% more expensive than less RES reliant countries
- Cheapest of major Western EU economies—Heavily reliant on nuclear

-45%
A 'wait and see' strategy can allow to benefit from a cheaper and more mature technology: e.g., Mexico

Mexico started later than other countries in Renewable development and is now achieving some of the cheapest prices around the world.
A new landscape of players is emerging

"Utilities are crazy if they don't start offering customers innovative financing packages for solar and distributed generation ... because others will." – Honda Executive
New environment impacting market capitalization of energy companies, limiting capacity to invest in large scale assets

Digital companies are now leaders by market capitalization

Note: circle sizes relative to market capitalization in 2Q 2017. Source: IEA
However, the energy industry still requires a significant amount of long term investment in the coming years.

Average yearly investments in power sector, 2016 ($B)

Source: IEA World Energy Outlook 2017, BCG analysis
Key Questions

1. Should policy regulate/constrain technological progress?

2. Can technology in Energy be a source of competitive advantage for countries?

3. Is it possible to develop a leveled and sustainable regulatory framework to achieve the various goals and functionalities required (clean, cheap, access for all)?

4. Is there a mature technology that should be promoted?

5. How to foster innovation and competition without compromising long term investment required?

6. What to do with previous investments and potential stranded assets?
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