An Introduction to the Smart Grid – A Game Changer

Presented to:
Metering: Central America and the Caribbean

Presented by:
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1. Introduction

The smart grid has the potential to significantly:

♦ reduce capacity needs and energy costs
♦ improve energy security and energy efficiency
♦ Improve system management
♦ lower CO₂ emissions
♦ make retail competition more effective
♦ assist with theft management, meter reading and billing

It also has the potential to change radically:

♦ the role of the electricity consumer
♦ the role of the system operators
♦ the energy retail and metering business
♦ the business model of energy utilities

This is a source of commercial risk and an opportunity
2. What is the Smart Grid?
General introduction

General definition:

♦ The Smart Grid involves the application of digital electronics along the wires that connect generators with customers.
♦ It allows intelligent integration of behaviour of all users connected to it in order to efficiently ensure sustainable, economic and secure electricity supply.

Like the internet, the SG has two layers:

♦ Infrastructure layer – transmission and distribution lines, smart meters, protocols
♦ Applications layer – with functionality that extracts value for customers and the system
2. What is the Smart Grid?
A graphic representation

Source: Peter Fox-Penner, Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities, Island Press, 2010. Image based on a graphic from The Economist, used by permission.
2. What is the Smart Grid?
Smart metering and smart grids (CEER view)
3. Why the Smart Grid is “hot”
Traditional and new reasons

♦ The availability of new technology is the central driver

♦ Smart grid supports “traditional” demand response
  • Allows real-time dynamic pricing
  • Demand response can play a more important role
  • Facilitates peak shifting, reducing system cost
  • Mitigates wholesale market power

♦ Smart grid also helps to respond to “new” requirements
  • Climate change (renewable energy, energy efficiency)
  • Energy security (PHEV displaces imported oil)
  • Increased customer focus (distributed generation and storage, retail competition)
3. Why the Smart Grid is “hot”
What benefits do smart grids offer?

**Upstream - Transmission**
- Coping with intermittency from renewable generation
- Connecting renewable generation in remote areas
- Improved management of the network

**Upstream – Generation**
- Avoiding or postponing investment
- Reduced CO2 costs through renewables and reduced consumption

**Downstream – Retail and network**
- Improved tariff design and dynamic pricing
- Improved retail competition, new and better services
- Reduced cost of billing, metering and system operations
- Better consumption estimations
- Easier management of customer relationship
- Means of managing theft and disconnection
- Improved and more flexible management of the network
4. Potential benefits of the smart grid – US study
Valuing benefits to the customer

♦ The SG can benefit customers by generating value for customers.

♦ Ahmad Faruqui, a principal of *The Brattle Group*, has developed a model called **iGrid**, which uses the following equation to estimate benefits, measured in terms of avoided costs:

\[
SG = AMI + DR + EE + DER + PHEV
\]

♦ Below, I summarize results using **iGrid** to estimate the potential benefits of SG in the US.
4. Potential benefits of the smart grid - US study
PV of avoided costs to 2050

National Smart Grid Valuation Summary, 2010 - 2050
Present Value of Avoided Costs, Millions of $

<table>
<thead>
<tr>
<th></th>
<th>Meter O&amp;M</th>
<th>Generating Capacity</th>
<th>Energy from Electricity*</th>
<th>Energy from Gasoline</th>
<th>Carbon</th>
<th>Reliability</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>AMI</td>
<td>$51,367</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$51,367</td>
</tr>
<tr>
<td>DR (Dynamic Pricing)</td>
<td>$0</td>
<td>$32,510</td>
<td>$10,367</td>
<td>$0</td>
<td>$2,230</td>
<td>$0</td>
<td>$45,107</td>
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<tr>
<td>DR (Enabling Technology)</td>
<td>$0</td>
<td>$12,195</td>
<td>$3,646</td>
<td>$0</td>
<td>$784</td>
<td>$0</td>
<td>$16,625</td>
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<tr>
<td>EE (IHDs)</td>
<td>$0</td>
<td>$3,125</td>
<td>$16,089</td>
<td>$0</td>
<td>$3,461</td>
<td>$0</td>
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<tr>
<td>EE (Building Commissioning)</td>
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<td>$3,381</td>
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<td>$23,304</td>
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<td>DERs</td>
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<td>$29,237</td>
<td>$0</td>
<td>$3,225</td>
<td>$22,966</td>
<td>$67,860</td>
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<tr>
<td>Total without PHEVs</td>
<td>$51,367</td>
<td>$64,466</td>
<td>$75,058</td>
<td>$0</td>
<td>$13,081</td>
<td>$22,966</td>
<td>$226,938</td>
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<tr>
<td>PHEVs</td>
<td>$0</td>
<td>-$10,811</td>
<td>-$211,151</td>
<td>$560,123</td>
<td>$3,061</td>
<td>$0</td>
<td>$341,222</td>
</tr>
<tr>
<td>Grand Total</td>
<td>$51,367</td>
<td>$53,655</td>
<td>-$136,093</td>
<td>$560,123</td>
<td>$16,142</td>
<td>$22,966</td>
<td>$568,160</td>
</tr>
</tbody>
</table>

* Also includes value of ancillary services for DERs
4. Potential benefits of the smart grid – US Study
The distribution of benefits by value stream (w/o PHEVs)

Distribution of Benefits by Value Stream ($ Billions)

- DER, $68
- AMI, $51
- DR (Price), $45
- EE (IHDs), $23
- EE (CBC), $23
- DR (Tech), $17

Distribution of Benefits by Value Stream ($ Billions)
4. Potential benefits of the smart grid – US Study
The distribution of benefits by metric (w/o PHEVs)

Distribution of Benefits by Performance Metric ($ Billions)

- Capacity, $64
- Energy, $75
- Metering Costs, $51
- Reliability, $23
- Carbon, $13
- Energy, $75
4. Potential benefits of the smart grid - US Study
Advanced Metering Infrastructure (AMI)

♦ The direct value of AMI derives from avoided meter reading costs:
  • Over the forecast horizon, this amounts to $51.4 billion in avoided costs (present value)
♦ However, this technology is a gateway to other SG applications.
4. Potential Benefits of Smart Grid – US Study
Residential AMI penetration 6.2% as of May 2009

May 2009 Residential AMI Penetration

AMI Meters 6.2%
Non-AMI Meters 93.8%

6.2% of residential meters represents 8.3 million smart meters in homes
4. Potential Benefits of the Smart Grid – US Study
FERC predicts AMI Penetration of 36% in 5-7 years

This leaves 33 million traditional electromechanical meters, which are expected to be eventually replaced by AMI rather than AMR meters

<table>
<thead>
<tr>
<th>Meter Type</th>
<th>Quantity</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing AMR meters</td>
<td>53,000,000</td>
<td>36%</td>
</tr>
<tr>
<td>Existing AMI meters</td>
<td>7,000,000</td>
<td>5%</td>
</tr>
<tr>
<td>Traditional electromechanical</td>
<td>33,000,000</td>
<td>23%</td>
</tr>
<tr>
<td>meters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New AMI Meters (Projected)</td>
<td>52,000,000</td>
<td>36%</td>
</tr>
</tbody>
</table>
4. Potential Benefits of the Smart Grid – US Study

AMR meters may discourage further upgrades to AMI

AMR technology
- No 2-way communication & not as technically advanced as AMI
- Read by drive-by or walk-by remote readers, providing operational cost savings
- Do not enable innovative forms of pricing and demand response

Utilities that have already upgraded to an AMR system may be less likely to further upgrade to AMI
- AMI upgrade would need to be justified solely on the basis of avoided resource costs, because the operational benefits are already being realized through the existing AMR system

This limits the size of the untapped AMI market
4. Potential benefits of smart grid – US Study
Demand response (DR) benefits

- System peak reduction reaches 4% by 2050
- Annual sales reduction is 0.2% by 2050
- Annual CO$_2$ reduction reaches 11 million metric tons by 2050

Avoided Costs from DR (2010 - 2050)
PV of Benefit = $61.7 billion

- Generating Capacity 72%
- Energy 23%
- Carbon 5%
4. Potential benefits of the smart grid – US Study
Energy efficiency (EE) benefit

♦ System peak reduction is 1.5% by 2050
♦ Annual sales reduction is 1.4% by 2050
♦ Annual CO₂ reduction is 64 million metric tons by 2050

Avoided Costs from EE (2010 - 2050)
PV of Benefit = $46 billion

- Energy 69%
- Carbon 15%
- Generating Capacity 16%
4. Potential benefits of smart grid – US Study
Distributed Energy Resource (DER) benefits

- System peak reduction is 3% by 2050
- Increase in wind generation is 4% by 2050
- 200 minutes of outage per customer are eliminated
- Annual CO₂ reduction is 34 million metric tons by 2050

Avoided Costs from DERs (2010 - 2050)
PV of Benefit = $67.9 billion

- Energy and A/S: 43%
- Generating Capacity: 18%
- Reliability: 34%
- Carbon: 5%
4. Potential benefits of the smart grid – US Study
Plug in electric vehicle (PHEV) benefit

♦ System peak increases by 1.7% by 2050 because some vehicles are charged during the peak hours
♦ Annual electricity sales increase by 7% by 2050
♦ Annual personal vehicle gasoline consumption decreases by 33%
♦ Annual CO₂ reduction is 23 million metric tons by 2050

Avoided Costs from PHEVs (2010 - 2050)

- Present Value of Avoided Cost (Billions of $)

- Energy from Electricity ($211 B)
- Energy from Gasoline ($560 B)
- Generating Capacity ($11 B)
- Carbon ($3 B)
- Net Benefit ($341 B)
5. **Opportunities and challenges**  
*Opportunities for customers and utility*

The SG will change the relationship of the utility with its customers

- Customers will be more active participants
- They will have greater choice
- New services will be available
- All this will challenge conventional utility models, creating opportunities as well as challenges
5. Opportunities and challenges
Opportunities for entrants

The SG will attract new entrants into retail market:

♦ Retail Energy Providers
♦ Energy service companies (ESCOs)
♦ Curtailment service providers
♦ Equipment manufacturers
♦ Battery/energy storage manufacturers
♦ Manufacturers of small-scale renewable generation
♦ Auto manufacturers
♦ Telecom firms
♦ IT firms
♦ Metering equipment and service providers
5. Opportunities and challenges
Strategies for existing utilities

Major new investment and a challenge to business model

Several corporate strategies can be envisioned:
- Neutral bystander
- Infrastructure manager
- Market catalyst
- Market enabler
- Active market participant

As an active participant, two (of many) models
- Home Area Network Business Model
- Energy Services Business Model
5. Opportunities and Challenges
The Home Area Network – helping consumers get smart

• Real-time display units

• Text alerts when energy prices are high

• Ultimately real-time control of appliances – bundling as a reserve service
5. Opportunities and Challenges
The Energy Services Company – Sell outputs, not inputs

- Km travelled
- Litres of hot water
- Heating degrees
- Lumens of light
- Computing hours

Smart grid
Home storage
Smart meter
Home generation
5. Opportunities and Challenges
Clients hire us to answer a range of questions

Smart grid policy, strategy and regulation – policy makers
♦ Do the benefits outweigh the costs from a public policy perspective?
♦ How should smart grid programs be designed?
♦ Who will undertake the investment and how will they be remunerated?
♦ What is the appropriate regulatory framework?

Designing and evaluating smart grid pilots – policy makers or utilities
♦ How will customers respond to dynamic pricing and smart grid technologies?

Assessing smart grid potential on the power system – policy makers or utilities
♦ What is the total potential impact that the smart grid could have on the system?

Supporting the business case – utilities, retail, metering and other companies
♦ What is the dollar value of smart meter or smart grid deployment and does it outweigh the costs – how does it affect cash flows?
♦ What threats/opportunities are there for my business and how do I value them?
5. Opportunities and Challenges
Example - PV costs-benefits of smart meters in the EU

![Bar chart showing costs and savings gap related to high and low adoption rates of smart meters.](chart.png)
6. Conclusion – the way forward
Political and corporate decisions

1. The SG can transform the power industry in a beneficial way and will change the roles of the players.

2. The subject is now on the table in developed and developing countries, where the costs/benefits differ.

3. It will require a significant investment in AMI and enabling technologies and challenge existing utility business models.

4. Regulators and political leaders will need to weigh these costs against the benefits in deciding how best to deploy the SG.

5. Companies should prepare for change, recognize the risks and opportunities and be active in the policy debate.
Dr. David Robinson consults on competition, regulation, and corporate strategy in energy and other regulated sectors. As a recognized architect of liberalization in Europe, he advises governments and corporations on public policy and corporate strategy in infrastructure sectors. He has most recently been advising major energy companies on how to shape and benefit from climate change regulations in Europe. He is currently working on a book about U.S. energy and climate change policy.

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