Smart Metering and Smart Grids around the world

- Get Smart with Smart Grids -

PricewaterhouseCoopers
Who am I?

I have over 20 years of experience in the energy and utilities sector. In particular, I have significant experience of advanced/smart metering, smart grid and the implementation of competitive energy markets.

My role in PwC is to provide a focal point for smart metering and smart grids. Specifically I aim to:
• Build a community of experts who can share knowledge and experience allowing us to win work that we otherwise could not
• Update our qualifications and point of view on smart
• Provide business development and project delivery support

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Agenda

1. Introduction to smart metering and smart grids

2. Focus on smart metering

3. Smart metering learning points from around the world

4. Conclusions
Introduction to smart metering and smart grid
The traditional utility value chain is linear and stable...

Build large and centralised power plants
Balance the system with dispatchable generation
Build the system to accommodate maximum demand
Deliver and bill
Use what I want when I want

Generation → Transmission → Distribution → Retail → Customer

Regulation

Allow a rate-of-return in exchange for meeting customer service standards
But is under threat by disruptive forces...

Decarbonisation
Increase in renewable generation
Use of electricity as a low carbon alternative to other fuels (e.g. for electric vehicles)

Changing demand patterns
New uses of electricity (transport, district heating, heat pumps etc.)
Increased demand response
Increased electrification and economic growth in developing countries

Substitution
Independently operated microgrids
Offgrid communities and campuses
Distributed generation

New Entrants
Aggregators
Energy Service Companies
Energy Information Providers
Internet tariff comparison sites

Technology
Lower cost photo-voltaic
Lower cost storage
Lower cost communications and sensors
Digitisation of traditional grid equipment

Customer Expectations
Digital experience
Slick customer service
Increased dependency on reliable and high-quality power
But is under threat by disruptive forces...

Renewable generation is estimated to rise to **25%** of global power generation by 2018


In 2013, industrial demand response capacity amounted to about 27GW globally. By 2019, that number will grow to...

**62GW**

Source: Pike Research “Demand Response for Industrial Markets”

In Germany over **40%** of capacity is from distributed generation.

Source: Bain & Co “Distributed energy: Disrupting the utility business model”

**37%** of consumers in the UK have used a price comparison website to select the best deal for electricity or gas.

Source: Consumer Futures “Price comparison websites: consumer perceptions and experiences”

By 2014 there will be over **2 billion** mobile phones in the world.

Source: Forrester Research “World Smartphone Adoption Forecast, 2012 To 2017 (Global)”

From 2003 to 2012 the levelised cost of photovoltaic power has dropped by nearly **50%**

This will lead to a new networked supply chain...

- Use demand and storage to balance system
- Actively manage the grid
- Offer new products and services
- Engage with customers
- Regulation that fosters innovation and new business relationships
- Become an active participant
- Build renewable and distributed generation
- New Entrants
- Smart Grid
- Retailers
- Transmission
- Distribution
- Generators
- Customers
To support this the existing grid will need to be transformed to a smart grid...

Legacy Grid Model

Smart Grid Model

Distribution Grid

Transmission Grid

Bulk Generation

Passive management

Active management

Controllable Demand
Distributed Generation

Distribution Grid

Transmission Grid

Renewable generation

Bulk Generation

Active management
Smart Grids are being adopted around the world in response to these forces ...

North America
- Managing peak demand
- SAIDI/SAIFI excursions
- Distributed generation

South America
- Theft
- Load growth
- Power quality

Europe
- Network congestion
- Aging infrastructure
- Renewable energy
- Distributed generation

Africa
- Growing demand
- Pre-payment
- Need for reliable power to support inward investment

China
- Long distance transmission
- Rising energy demand
- Economic development

South-East Asia
- Growing demand
- Need for reliable power to support economic growth
- Theft
Successfully managing the transformation requires careful management of three key areas...

<table>
<thead>
<tr>
<th>Technology: Making today’s grid smart</th>
<th>Grids need to change to accommodate renewable energy, distributed generation and new uses of electricity such as electric vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business: New models, processes and relationships</td>
<td>The changes are complex. Issues such as cost recovery and new commercial arrangements with customers and market participants need to be addressed</td>
</tr>
<tr>
<td>Customer: Engaging and changing behavior</td>
<td>New forms of engagement with customers are required to both allow the utility to implement as smart grid and to extract the maximum value from it</td>
</tr>
</tbody>
</table>
Focus on smart metering projects
Characteristics of smart metering projects...

- Highly visible to customers
- Often driven by political imperative
- High cost
- Challenging roll-out
- Challenging technology integration
- High impact across the business
## Smart metering benefits...

<table>
<thead>
<tr>
<th>Benefit areas</th>
<th>Benefits:</th>
</tr>
</thead>
</table>
| **Societal**                         | - Deferral of new or replacement generation, carbon reductions and energy cost savings due to:  
  - Enablement of demand response  
  - Peak lopping due to Time-of-Use rates  
  - Conservation due to increased energy awareness; and  
  - Enablement of distributed generation through net metering  |
| **Energy Markets and settlements**   | - Increase in dispatchable load  
  - Potential new entrants providing demand response aggregation services to the market  
  - Potential for half-hourly settlement at residential level  |
| **Distribution Operations**          | - Distribution system optimisation through using meter as an active sensor  
  - Improved outage management through using meters to detect when an outage occurs and when restoration is achieved  
  - Data input to an autonomic (self-healing) grid  |
| **Distribution System Planning**     | - Improved accuracy through use actual historic information for planning purposes  |
| **Billing Operations**               | - Removal of estimated bills  
  - Improved billing accuracy – less disputes  
  - Elimination of truck rolls for connect/disconnect and of-cycle reads  
  - Lower debt by load limiting poor payers and/or billing poor payers more regularly  
  - Opportunity to increase/introduce pre-payment  |
| **Meter Reading**                    | - Elimination of meter readers  |
Use of smart metering data within utilities...

There are four types of data that come from a smart meter...

- Interval Reads: Read from meter cyclically (e.g. daily, 2x daily etc.)
- Register Reads
- Events
- Alarms: Sent ‘real time’ from the meter
Use of smart metering data within utilities...

**Smart Meter** → **Interval Reads**

**Interval Data**
- Anything where there is a measurement taken each interval (e.g.)
  - kWh (import/export)
  - kVArh (import/export)
  - Voltage
  - Max. demand in interval

**Typical Uses**
- Billing and settlement
- Web presentment
- Network analysis and planning
- Forecasting
- Customer analytics
Use of smart metering data within utilities...

Examples of customer data analytics...

- Likelihood of default – changes to consumption patterns that may indicate a change in employment status
- Theft – unusual consumption patterns or unusual changes to consumption
- Theft – consumption at disconnected properties
- Candidates for energy efficiency or demand management programs
Use of smart metering data within utilities...

Register Data

Anything where there is a daily cumulative measurement taken (e.g.)

- kWh (import/export)
- kVArh (import/export)
- Max. demand over day

Typical Uses

- Billing and settlement
- Web presentation
- Forecasting
Use of smart metering data within utilities...

**Event Data**

Any monitored condition for which the utility does not want immediate notification of e.g.
- Momentory outage (flicker)
- Over/under voltage
- Etc.

**Typical Uses**

- Billing (for customer compensation)
- Network management – offline trouble shooting and analysis
Use of smart metering data within utilities...

Alarm Data

Any monitored for condition for which the utility wants immediate notification of e.g.
- Power outage
- Tamper
- Etc.

Typical Uses

- Outage management
- Theft management (tamper)
- Public safety (tamper)
Smart metering global summary

North America
Stimulus funding created an initial surge in activity which has now abated

Europe
With the exception of Sweden, Italy and Finland who were early adopters the rest of Europe is pursuing an 80% by 2020 goal

China
Large volumes of “smart” meters” being deployed but these are largely for AMR

South-East Asia
A number of pilots but no government or regulatory mandates mean progress is slow

South America
Pilots being considered mainly in response to high levels of theft

Africa
Increasing activity with pilots but no national deployments. Pre-payment is the main driver

Australasia
New Zealand and some states in Australia are undertaking full rollouts
Components of a smart meter roll-out

Customer Journey

Process Change

IT Integration

IT Systems

Field Installation

Communications

Infrastructure
Components of a smart meter roll-out

- Customer Journey
- Process Change
- IT Integration
- IT Systems
- Field Installation
- Communications
- Meters
- In-home Displays
- Home Area
- Last Mile
- Field Area
- Backhaul
- In-home displays
- Meters
- Data Collection Units
Multi-utility communications architecture...
Communications technology options...

- **Home Area Network**
  - e.g. Zigbee or WiFi

- **Last Mile Network**
  - e.g. PLC or RF Mesh

- **Backhaul Network**
  - e.g. Cellular or Fibre

- **Field Area Network**
  - e.g. RF Mesh or WiMax
**Communications technology options...**

Choice of communications depends on a number of factors...

<table>
<thead>
<tr>
<th>Factor</th>
<th>Factor Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network topology</td>
<td>1. Ratio of the number of customers to transformers, feeder lengths, distance between meters</td>
</tr>
<tr>
<td>Availability of spectrum</td>
<td>2. Effectiveness of RF solutions is dependent on spectrum availability</td>
</tr>
<tr>
<td>Building construction</td>
<td>3. Building construction effects RF communications</td>
</tr>
<tr>
<td>Meter location</td>
<td>4. Proximity of meter to dwelling, location of meters and nature of installation</td>
</tr>
<tr>
<td>Applications</td>
<td>5. Types of applications that will be run over the network</td>
</tr>
</tbody>
</table>
Components of a smart meter roll-out

Customer Journey

Process Change

IT Integration

IT Systems
- Head-End
- MDM
- Analytics
- Customer Portal

Field Installation
- Communications
- Meters
- In-home Displays

Communications
- Home Area
- Last Mile
- Field Area
- Backhaul

Infrastructure
- In-home displays
- Meters
- Data Collection Units
Components of a smart meter roll-out

Customer Journey

Process Change
- Customer Operations
- Distribution Operations
- Metering Operations
- AMI Operations
- Market Operations

IT Integration
- Asset Management
- Field Force Automation
- Pre-Payment
- Billing
- Outage Management
- N/W Planning
- N/W Operations
- Industry Datahub

IT Systems
- Head-End
- MDM
- Analytics
- Customer Portal

Field Installation
- Communications
- Meters
- In-home Displays

Communications
- Home Area
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- Backhaul

Infrastructure
- In-home displays
- Meters
- Data Collection Units
Datahubs

In competitive environments there is a need to share data between market participants...

Point-to-point approach

Datahub approach

DNO – Distribution Network Operator

MP - Market Participant
Datahubs can take on different functions...

<table>
<thead>
<tr>
<th>Function</th>
<th>Ontario MDM</th>
<th>UK DCC</th>
<th>Danish Datahub</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data collection</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Processing of raw data</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Automation of market processes</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Data exchange</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Provision of data to customers</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Retail settlement</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
</tbody>
</table>
Components of a smart meter roll-out

Customer Journey:
- Planning
- Pilot
- Rollout
- New Tariffs
- Demand Response
- Distributed Generation
- Electric vehicles

Process Change:
- Customer Operations
- Distribution Operations
- Metering Operations
- AMI Operations
- Market Operations
- Industry Datahub

IT Integration:
- Asset Management
- Field Force Automation
- Pre-Payment
- Billing
- Outage Management
- N/W Planning
- N/W Operations
- Head-End
- MDM
- Analytics
- Customer Portal

Field Installation:
- Communications
- Meters
- In-home Displays

Communications:
- Home Area
- Last Mile
- Field Area
- Backhaul

Infrastructure:
- In-home displays
- Meters
- Data Collection Units
Smart Metering - Learning points from around the world
Six key learning points from projects around the world...

1. Choose the right technology

2. Create a cross-functional team

3. Ensure rollout processes and systems are thoroughly tested

4. Customer engagement is key

5. Implement functionality in phases

6. Consider security and privacy from the start
1. Choose the right technology...

**Communications**

- Unlikely that a single solution will work throughout
- Test solutions at large enough scale to prove communications will work in your territory
- Consider smart grid applications not just metering

**Example:**

- PG&E started their smart meter roll-out using a low bandwidth PLC solution
- Part-way through the roll-out this technology was abandoned in favour of wireless mesh which provided a more smartgrid ready infrastructure
- The extra cost was US$572m
1. Choose the right technology...

**IT Systems**

- Ensure systems are scaleable
- Ensure systems can manage exceptions with automated processes and error handling
- Ensure systems have adequate audit trails and controls

**Example:**

- IESO in Ontario implemented a centralised MDM from a leading vendor
- Extensive testing by the IESO revealed problems with the solutions validation and error correction routines
- Fixing these problems caused an unexpected delay to the project
1. Choose the right technology...

**Meter**

- The key question is “thin” vs. “thick”
- A thin architecture limits functionality on the meter
- A thick architecture builds functionality like time-of-use accumulation and pre-payment credit management on the meter

**Recommendation:**

- Where possible limit functionality on the meter
  - It’s easier to make changes
  - It’s makes securing the meter easier
  - It’s the approach undertaken in most of the world
Six key learning points from projects around the world...

1. Choose the right technology
2. Create a cross-functional team
3. Ensure rollout processes and systems are thoroughly tested
4. Customer engagement is key
5. Implement functionality in phases
6. Consider security and privacy from the start
2. Create a cross functional team...

**Issue:**

Metering was traditionally an isolated part of the utility business.

Smart metering impacts many different parts of the business.

**Key Learning points:**

- Strong collaboration between metering, IT and other business areas is required to ensure success
- No one part of the business has all the expertise required
Six key learning points from projects around the world...

1. Choose the right technology
2. Create a cross-functional team
3. Ensure rollout processes and systems are thoroughly tested
4. Customer engagement is key
5. Implement functionality in phases
6. Consider security and privacy from the start
3. Ensure rollout processes and systems are thoroughly tested...

The deployment process is one that you want to get right before starting mass deployment...

Things that can go wrong:

- Meters (or in-home displays) are associated with the wrong customers
- Meters fail to communicate and re-visits are required to sort the problem out
3. **Ensure rollout processes and systems are thoroughly tested...**

### Key things to get right...

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Assign the meter or in-home display to the customer in the field.</td>
</tr>
<tr>
<td>2</td>
<td>Install and test communications before the smart meters.</td>
</tr>
<tr>
<td>3</td>
<td>Ensure the meter has connected to the communications network before leaving.</td>
</tr>
<tr>
<td>4</td>
<td>Automate as much as possible with hand-held devices and barcodes etc.</td>
</tr>
<tr>
<td>5</td>
<td>Test the processes thoroughly. Any errors will be expensive and high-profile</td>
</tr>
</tbody>
</table>
Six key learning points from projects around the world...

1. Choose the right technology
2. Create a cross-functional team
3. Ensure rollout processes and systems are thoroughly tested
4. Customer engagement is key
5. Implement functionality in phases
6. Consider security and privacy from the start
4. Customer engagement is key...

The initial customer experience of smart meters risks being negative...

Coupled with customer concerns over:
- Accuracy
- Safety (RF)
- Privacy
- Security
4. Customer engagement is key

With social media things can develop quickly....

Google search for “BC Hydro Smart Meters”

17th November, 2013
4. Customer engagement is key

Two contrasting examples of customer engagement...

Oklahoma Gas and Electric:

• OG&E provided a “best bill” guarantee which ensured customers will not pay more.

• OG&E instituted a closed group Facebook page during its pilot. Customers shared success stories and provided feedback. The information gathered was used to tailor the full roll-out

BC Hydro:

• BC Hydro has recently revealed how much money it will charge customers who are refusing smart meters

• The Crown corporation sent out letters to customers saying that if they refuse a smart meter they will be charged a $35 monthly fee.
Customer engagement is key

How do your customers want to engage...

- Apps
- Social media
- Gamification

- On bill information
- Bill inserts
- Consumption web portals
- In-home displays
4. **Customer engagement is key**

- Engage early
- Monitor social media
- Think through customer experience
- Get consumer groups onside
- Coordinate communication with others (Government, consumer groups etc.)
- Think about how your customers want to engage with you
Six key learning points from projects around the world...

1. Choose the right technology
2. Create a cross-functional team
3. Ensure rollout processes and systems are thoroughly tested
4. Customer engagement is key
5. Implement functionality in phases
6. Consider security and privacy from the start
5. Implement functionality in phases

Applications for smart metering cut across the utility business...

**Customer Centric**
- Billing accuracy and timeliness
- Digital customer experience
- New time-of-use tariffs
- Theft Detection

**Distribution Centric**
- Outage management
- Power Quality Management
- Distributed Energy Resource management
- Asset Management
- Network management
- Demand Response

Applications for smart metering cut across the utility business...
5. Implement functionality in phases

Typically utilities implement in phases from left to right.
5. Implement functionality in phases

An incremental phased approach...

- Reduces risk
- Reduces timeline for implementation
- Allows high-benefit areas to be realised early
- Allows options to be held open to later in the implementation
- Allows new technologies to be implemented in stages
- Allows the utility to gain experience
Six key learning points from projects around the world...

1. Choose the right technology
2. Create a cross-functional team
3. Ensure rollout processes and systems are thoroughly tested
4. Customer engagement is key
5. Implement functionality in phases
6. Consider security and privacy from the start
6. Consider security and privacy from the start

**Security**

- The smart meter network will be the biggest computer network that the utility runs
- The network is out in the field and visible to hackers
- Threats could range from tampering with individual meter settings through to simultaneously disconnecting millions of meters

**Reccommendations**

- Build in security from the initial design with security experts embedded in the project
- Use security experience from outside utilities – outsource if you don’t have capability
- How secure is your supply chain. Do you know who is writing the firmware on the meters?
6. **Consider security and privacy from the start**

- In the Netherlands, smart meter roll out was halted because of fears over meters becoming a ‘spy in the home’

- The rollout was only restarted after legislation was re-drafted to assuage consumer group concerns
### 6. Consider security and privacy from the start

#### Privacy

- Smart meter data can reveal information about customer behaviour that customers don’t feel utilities have a right or need to know.
- However, customers readily accept greater privacy invasion from smart phones and apps.
- The difference seems to be “choice“. Customers perceive smart meters are forced on them whereas they have a choice with smart phones.

#### Recommendations

- Engage early with consumers, consumer groups and data protection/privacy regulators.
- Build in as much ability for customer opt-out as possible.
Conclusions
Conclusions

Phased Implementation starting with deployment of a technology platform that is fit for longer term goals

Consider customer engagement issues from the start. Look hard at the customer experience

Build in security and privacy form the start. Leverage expertise from outside the industry