Advanced Metering Infrastructure Discussion

April 14, 2004
Measurement is the only sense that we have for electricity.

Today’s measurement and control is like having a hand with no nerves.

No sense of touch or ability to tell how where the hand is or how hard it is working.

AMI provides the nerves that are required to give that sense of touch and control.
“The question that faces the strategic decision maker is not what an organization should do tomorrow.

It is rather what an organization must do today to be ready for an uncertain tomorrow.”

_Peter Drucker_

“In the past we have made money by Not doing things – In the future, we will need to make money be doing things efficiently”

– Vincent de Rivaz, CEO, EDF Energy UK
November 2002: CEA Technologies (CEATI) invited proposals for technology roadmap research work.

March 2003: the Distribution Asset Life Cycle Management (DALCM) Interest Group awarded a contract to Cap Gemini to develop a technology road map for the consortium utilities.

Capgemini co-funded the project.

January 2004: Roadmap presented at Distributech

Phase II of the project will start in August.
Project Objectives

- A view of the electric distribution utility environment 15-20 years in the future that can be used to determine where utilities need to modify their current design, planning, construction, maintenance, and operating practices.

- A source document to aid in identifying technical and information gaps that need to be closed for electric distribution companies to prepare effectively for change in their technical, business, and regulatory environment.

- Implications of these gaps to assist the DALCM Interest Group in defining its own R&D program.

- An implementation plan (roadmap) that would help utilities to plan and implement the necessary changes required to meet the foreseeable challenges.

- A vision of desirable future service policies and description of required technology development and its implementation.

WE CAN NOT AFFORD NOT TO KNOW! - Hans Brus, Hydro Quebec
The Research

- Review of over 200 current documents from all sources
- Off-the-record interviews with over 300 industry personnel
  - Utility (181)
    - Singapore Power, China Power & Light, Electricity de France, E.On
    - Duke, PG&E, Exelon, etc
    - The CEATI and CEA members
  - Government (84)
    - DOE, DOD, DND, Environment Canada, Industry Canada, etc
  - Industry (92)
    - GE, Ford, Schneider, Cooper, Itron, DCSI, etc.
  - University & Private Research (49)
    - Heidelberg University, University of Montreal, Stanford, Colorado School of Mines, MIT, etc
- Scenario Workshop
- Roadmap Workshop
- European Actors Review Session

- Over 2,500 hours of work went into the creation of this report.
Did the interviews
- Developed a technology matrix and distribution value chain
- Developed a list of common assumptions
- Determined the drivers that were within and not within the control of the utilities
- Determined the top drivers that were outside the control of the utilities

Used the drivers to create scenarios
- 21 Scenarios created from the drivers that were out of the utility’s control
- Tested the scenarios with the core utilities

Ran workshops on the scenarios
Scenarios help to examine a realm of plausible futures.
• distribution grid …support needs of society …
• asset normal end of life …
• existing technologies to replace or supplement …
• environmental movement …
• “environmentally friendly" technologies …
• "micro-generation" …
• cost of conventional fuels for generation …
• number of trained people …
• cost-based or performance based regulation …
• improvements in reliability, cost of service, customer service and safety …
• additional sources of revenue from their existing assets …
• energy efficiency …
• safety issues …
• overall "robustness" of the system …
Business drivers out of the utility’s control

- Internal
- Regulatory
- External
- Consumer
- Commercial & Industrial
- Environmental

Drivers:

Internal Drivers
- Workforce aging
- Cost of assets
- Aging assets
- Directly observe some (Captured: 10%)
- Directly observe wide (all “high priority”) for the impact of events
- Needs identified by measurement of industry and population to green fields
- Separations of Peak & Load (R&D) statement (generation, distribution, transmission, etc.)
- Understanding of Profit & Loss (P&L) statements at the generation level (is this “transmission” probably)
- Cost volatility
- Ability to maintain and train workforce
- Joint, Grid Technologies, AREVA
- Outsourcing for cost reduction / focus on core competency reasons

External Drivers
- Market demand for return to basics (focus on R&B or look price)
- Future of Building and other “high priority”
- Distribution automation
- Cultural changes communicate to move up the food chain (streamlining to construction to maintenance to full outsourcing)
- Increase in services delivered to customers
- Navigating and weathering the industry
- Performance of small scale existing generation business

Regulatory Drivers
- Focus on cost levels
- Performance based tariffs with no chance for modification of the formula overtime
- Demand for longer and shorter cycles
- Demand for lower fixed costs, lower overhead
- Regulation of the market
- NL Electricity
- KVA to Mega

Requirements to connect any generation source to the distribution grid
- Changes rules and subsidy structure based on environmental and voter preferences
- Trade and intellectual policy
- National and Global legal agreements and cost negotiations
- Longer period between rate cases
Government (How it views the importance of infrastructure)

- **Scenario A**: Engineer's Dream
- **Scenario D**: CYA when the lights go out

Regulator (Focus of attention – Deep and specific technical focus or a focus on results only.)

- **Scenario B**: Bang for the Buck
- **Scenario C**: Building a House of Cards
- **Scenario E**: Business as Usual

**Scenario Matrix**

- Investment to be sustained
- “Hard” technical
- “Soft” market
- Cash grab

Advanced Metering Infrastructure Discussion
All Scenarios pull in the same direction

- serving more demanding customers …
- focusing on affordability, reliability and power quality …
- offering much more sophisticated tariff structures …
- regulated for the delivery of energy …
- delivering service quality at the same level that customers receive from non-utility industries …
- operating a self-diagnosing and self-healing electric distribution grid …
- connected to a large number of consumer-owned energy sources …
- working predominantly in a live-line environment …
- managing multidirectional power flows with customers
- making both regulated and non-regulated income from asset utilization offerings …
- self-learning knowledge workers gainfully deployed in an asset-intensive business …
- a blurring between trade & professional jurisdictions…
- changes in employee demographics are huge …
- **Optimize Assets**
  - Improve asset utilization and performance.
  - Extend life cycles to maximize usefulness.
  - Achieve cost efficiencies and revenue enhancements from existing assets.
- **Improve Processes**
  - Benchmark leading practices and change current work processes to catch up or leapfrog.
  - Increase effectiveness along the value chain.
  - Proactively test and implement new technologies.
- **Capture New Revenue**
  - Develop new products and service offerings in response to customer needs.
  - Seek “non-wires” business opportunities and establish revenue streams.

### Identified and listed over 150 technologies

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<tr>
<th>Technology</th>
<th>Value Chain</th>
<th>Asset Management Strategy</th>
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Advanced Metering Infrastructure Discussion

March 14, 2004
Of the top 50, when considered across the distribution value chain:

- Most (32) impact the Operations segment.
- 21 impact Maintenance.
- 18 are End User (customer) related technologies.
- Few (6) impact Construction.
- Few (8) impact Design.
- 3 cross all value chain segments;
  - Workforce Management
  - Distributed Resources Interconnect
  - Knowledge Management
"Top 10" Critical Distribution Technologies

1. Asset Management IT Systems
2. Asset effectiveness monitoring
3. Fault detection and reporting, automated
4. Broadband Over Power Line
5. Device self-reporting
6. Maintenance, Reliability Centered
7. Rates, market-based
8. Modeling, real-time dynamic load
9. Photovoltaic (solar cells)
10. SCADA network penetration

- 7 of 10 enabled by AMI!
- 9 of the 10 are IT related and/or dependent.
- Only Photovoltaic is not directly IT related.

We are headed to a two-way, information intensive system!
Outcomes

1. The future of the distribution industry is secure, at least through 2025; there is no technology on the horizon that will replace the grid.

2. Choosing to retain today’s design standards and equipment, opting for small incremental changes in the way that business is done today, will result in an un-profitable future for a distribution utility.

Key Findings:

1. The grid has to get more intelligent.

2. The coming technologies will have an impact on all aspects of the distribution value chain and they need to be “planned-in” in the standards and designs for the system.

3. Rates, tariffs, and operating rules will have the largest impact on the ability of distribution companies to operate.

4. The organization itself has to become much more capable to deal with the complexity of the future distribution system.

5. The mix of people and skills will change radically over the next 20 years.
Impacts: Customers

- The customer will be the driver
- Their needs and expectations are becoming more refined:
  - Home networking
  - Security systems
  - Domestic applications
  - Smart buildings and roads
- They will demand a product that will meet their needs at a price they can choose (bronze, silver, gold)
- That's a long way from the present situation, where the customer has to call the utility to advise them of a power outage
The Top 10 has a hidden #11 - AMR

- For each 1 million meters
  - 110 million records per day
    - 96 million for usage
    - 10 million for voltage
    - 4 million estimating the missing readings from the system
- Approximately 2% of customer will have distributed generation
  - This will add 4 million additional records per day
- With Load Management there will be an additional 50 million records per day
- Annually this will be 59 Terabytes of data
AMR Lessons Learned & Pain Points

- Fear of picking the wrong technology
- Impact on the rest of the infrastructure
- Trusting a single vendor to provide the whole solution – “one throat to choke”
- Not effectively integrating the AMI solution into the rest of the infrastructure
- Underestimating the process changes that AMI creates in the business
- Not thinking through how to get good data into the systems
- Using it only as a meter reading system – not as a data collection system to provide the data to everyone
- Handling return material management
- Determining the right order for the deployment
- Data management – synchronization, alignment and quality
- Data is retained in silos and not available to everyone who needs it
- Systems are partially deployed for years and “sampled” so that the system is constantly treated as “unreliable”
- Routes and manual reads are never replaced
- Regulations are not updated to allow full use and value of the system
- Cannot be implemented in traditional silos
AMI Benefits

- Settlement (2-4%)
- System Control (4-11%)
- Billing & Customer Care (2-7%)
- Asset Management (4-19%)
- Tariff & Regulatory (1-4%)
- Outage & Restoration (3-8%)
- Vegetation Management (3-7%)
- Demand Management (2-22%)
- Metering (2-4%)
- Collections (15-25%)
- Field Work Management (3-7%)
- Safety (2-5%)
- Load Forecasting (9-14%)

Percentages based on Real Savings at AMI Deployments
AMR Benefit Priorities

1. Outage and Restoration
2. Safety
3. Demand Response/ Load Management
4. Forecasting
5. Power Management
6. Customer Services and Billing
7. System Planning
8. Engineering
9. Collection and Revenue Protection
## Demand Management

<table>
<thead>
<tr>
<th>Program</th>
<th>Benefits</th>
<th>Concerns</th>
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</thead>
<tbody>
<tr>
<td>Rolling Blackouts</td>
<td>95% of expected reduction</td>
<td>Public outcry – regulatory nightmare</td>
</tr>
<tr>
<td>Active Control</td>
<td>90% of expected reduction</td>
<td>Program design - incentives</td>
</tr>
<tr>
<td>Active Control – override</td>
<td>70% of expected reduction</td>
<td>Reduction is least in most needed areas - Murphy</td>
</tr>
<tr>
<td>Incentives</td>
<td>40% of expected reduction</td>
<td>Least reduction on critical peak days</td>
</tr>
<tr>
<td>Price Signals</td>
<td>30% of expected reduction</td>
<td>Consumers making 10cent decisions</td>
</tr>
<tr>
<td>Voluntary</td>
<td>15% of expected reduction</td>
<td>Scattered use of the program, high cost to maintain</td>
</tr>
<tr>
<td>Education</td>
<td>No expected reduction – get what you get</td>
<td>Has little lasting impact unless started in 1st Grade</td>
</tr>
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Global Trends

- Sweden – National mandate for AMR – rollouts have started
- Germany – National mandate for any customer who chooses to use an alternate supplier, discussion of 100% AMR underway
- China – moving from no meters to pre-paid meters with AMR capability for the whole country – China Power and Light is first others to follow
- Ontario – Moving to a ruling on smart meters, expectation is 100% rollout over the next 4 to 5 years
- France – AMR to be expanded to all C&I customers by the end of 2005, expectation is that all 30 million meters will be AMR by the end of 2020.
- AMR business cases have been written by 7 out of the 10 largest utilities in the world
Residential Meter Cost Trends

- 2000 – Residential Meter $50 to $70 each
- 2000 – AMR transponder $60 to $120 each
- 2000 – Load Control Device (5 relays) - $200 to $300 each
- Average installed cost $600
- 2004 – Residential Meter $20 to 35 each
- 2004 – AMR transponder $25 to 50 each
- 2004 – Load Control Device (5 relays) $100 to 150 each
- Average installed cost $300
- Expected volumes in 2005 to 2007 should reduce the hardware costs by 30 to 40%
## FPL - Customer Base

<table>
<thead>
<tr>
<th>Sector</th>
<th>Number of accounts</th>
<th>Average monthly consumption (Kwh)</th>
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<tbody>
<tr>
<td>Residential</td>
<td>3,566,000</td>
<td>1,189</td>
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<tr>
<td>Commercial</td>
<td>435,000</td>
<td>7,663</td>
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<tr>
<td>Industrial</td>
<td>15,000</td>
<td>21,764</td>
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Summer Peak - 19,668  
Winter Peak - 20,190
Load Control Programs at FPL

- Residential and Business On Call
  - Direct Control - Bidirectional
  - Powerline Communications System
  - First units installed in 1987
  - 710,000 Customers
  - 815,000 Transponders
  - 1,000 MW in normal operation
  - 2,000 MW in an emergency - SCRAM
  - 460 Substations equipped for On Call
Does On Call Work ???

On Call SCRAM

Over 975 Megawatts Shed in 60 Seconds

August 1995

Today Have 2000 MW Available for SCRAM

Predicted Demand Profile

System SCRAM

Generation Lost

Normal Load Control

Restoration Suspended

More Generation Lost

System re-SCRAM

80 Minute Time-out

Restoration Started

Restoration Started

TIME OF DAY

System Load (MW)

Over 975 Megawatts Shed in 60 Seconds

Today Have 2000 MW Available for SCRAM

Predicted Demand Profile

System SCRAM

Generation Lost

Normal Load Control

Restoration Suspended

More Generation Lost

System re-SCRAM

80 Minute Time-out

Restoration Started

Restoration Started

TIME OF DAY

System Load (MW)
Back up
The other 16 Scenarios

Government (How it views the importance of infrastructure):

- Peace, Quiet, and Connected
- Cool & Calm
- High Density
- Isolated

Consumer (Where people will choose to live and prosper):

- Cool & Calm
- High Density
- Isolated

Regulator (Focus of attention – Deep and specific technical focus or a focus on results only.)

- Peace, Quiet, and Connected
- High Density
- Isolated

Proactive
Passive
DIY or DIE
It's my turn to use the strata flashlight

Government (How active in shifting to the renewable 'green' economy):

- Green 'R' US
- Investment to be sustained
- Backed up & Blackout

Consumer (Where people will choose to live and prosper):

- Green 'R' US
- Cash grab

Regulator (Focus of attention – Deep and specific technical focus or a focus on results only.)

- Green 'R' US
- Backed up & Blackout

Once Brown, always Brown

We know what's best for you - Green

You can have anything, along as it's Green

We offer Brown, Silver, or Green

Brown is the Colour, Reliability is the Game

Once Brown, always Brown

We know what's best for you - Green

You can have anything, along as it's Green

We offer Brown, Silver, or Green

Brown is the Colour, Reliability is the Game

Once Brown, always Brown

We know what's best for you - Green

You can have anything, along as it's Green

We offer Brown, Silver, or Green

Brown is the Colour, Reliability is the Game
Example - Scenario Story: “Green R Us”

In the 20th century, large, central generation stations dominated the electric power supply in North America. Renewable energy technologies such as wind turbines were in operation in some utilities. But overall, small-scale generation and renewables were not able to economically compete with this form of low-cost production.

The landscape began to change with increasingly stringent environmental concerns. The Kyoto Protocol in 1997 was proclaimed as the solution that would actually do something to abate global warming. Critics initially downplayed its influence and viewed governments that signed as basically providing “lip service” to appease green voters. It wasn’t until 2008 that the climate-change theories were shown to be accurate, or what really mattered, politically acceptable. The data came from analyzing consecutive years of massive forest fires and critical low-water levels. For a couple of utilities, these events also severely impacted their ability to generate and transmit centralized electric power. New life was breathed into the Protocol and international commitments made to significantly reduce greenhouse gas emissions by 2020.

Governments responded to the accelerating world demand for environmentally friendly power by creating great interest in distributed generation utilizing alternate energy sources. As one example, the Ontario Provincial government in 2003 passed legislation to facilitate connection of generation facilities to local electric distribution systems.

The private sector also called for a change in philosophy. These were the energy suppliers who produced equipment that enabled small localized power grids to use solar or fuel cell generators. “Such a system is more reliable than the current system that relies on massive, far-flung plants connected by vulnerable grids”, said one company President. "This old, massive, centralized power distribution system does not fit in the modern world."
Advanced Metering Infrastructure Discussion

Residential Load Control - On Call

- Appliances placed “On Call”
  - Central Air Conditioning
    - Cycle - 15 minutes off, every 30 minutes, for 3 hours
    - Extended - 3 consecutive hours off in 24 hours
    - 7 months: April through October
  - Central Strip Heat
    - Cycle - 15 minutes off, every 30 minutes, for 3 hours
    - Extended - 4 consecutive hours off in 24 hours
    - 5 months: November through March
- Appliances placed “On Call” - continued
  - Electric Water Heaters
    - Extended - 4 consecutive hours off in 24 hours
    - 12 months: year round
  - Swimming Pool Pumps
    - Extended - 4 consecutive hours off in 24 hours
    - 12 months: year round
- Incentive Payments - Annual total per customer: Typical $80 old / $45 new
Customer Promotion Today

- Business On Call - Targeted marketing
- Residential On Call - No marketing
  - Number of MW is capped
  - Word of mouth
  - Friends, neighbors, relatives
  - 300 calls a week
  - Web site - 60 inquiries a month
  - Closure rate: 80% to 85%
  - Still extremely popular
Customer Inconvenience

• The key to successful Direct Load Control is a proper understanding of customers and their feelings

  … Surprise … Surprise !!!

• Extensive, up front, research must be done to find out the points where
  • Customers notice you are controlling them
  • Customers get upset enough to exit the program

• FPL does an excellent job - The proof is in the pudding ... very few customers ever drop out
Direct Load Control - On Call

• Customers get to:
  • Choose to participate or not
  • Choose the devices controlled
    ▫ Central Air Conditioning
    ▫ Central Strip Heat
    ▫ Water Heater
    ▫ Swimming Pool Pump
  • Set the degree of “inconvenience” experienced
    ▫ Cycling strategy
    ▫ Extended strategy
• FPL actively works with customers to help them reduce their use of electricity and control their bills.

• These programs remain among the most effective in the nation

• In total, have reduced enough electricity demand to date (3,300 MW) so that FPL has been able to avoid building the equivalent of 10 (400 MW) power plants.