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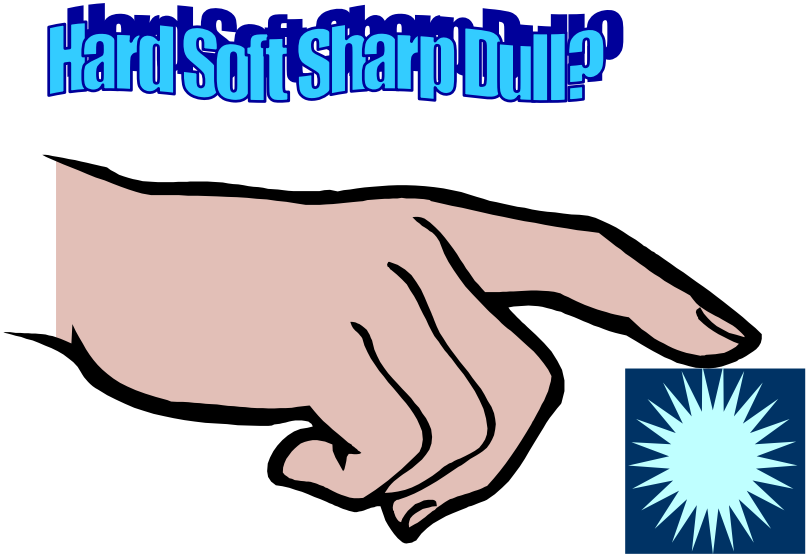
Advanced Metering Infrastructure Discussion

April 14, 2004

Touch ?



- 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.”

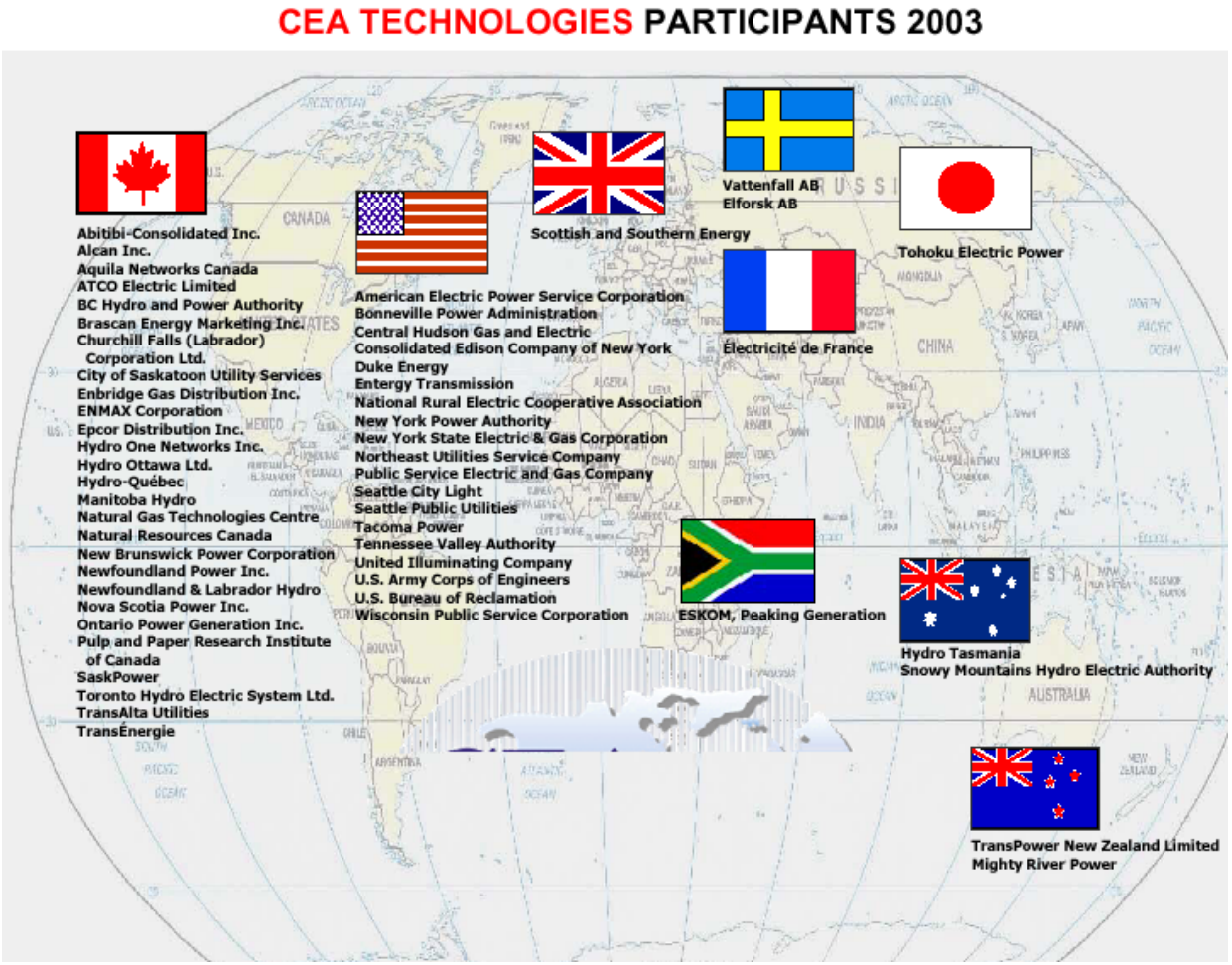
Peter Drucker

“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

Electric Distribution Utility Roadmap

- **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

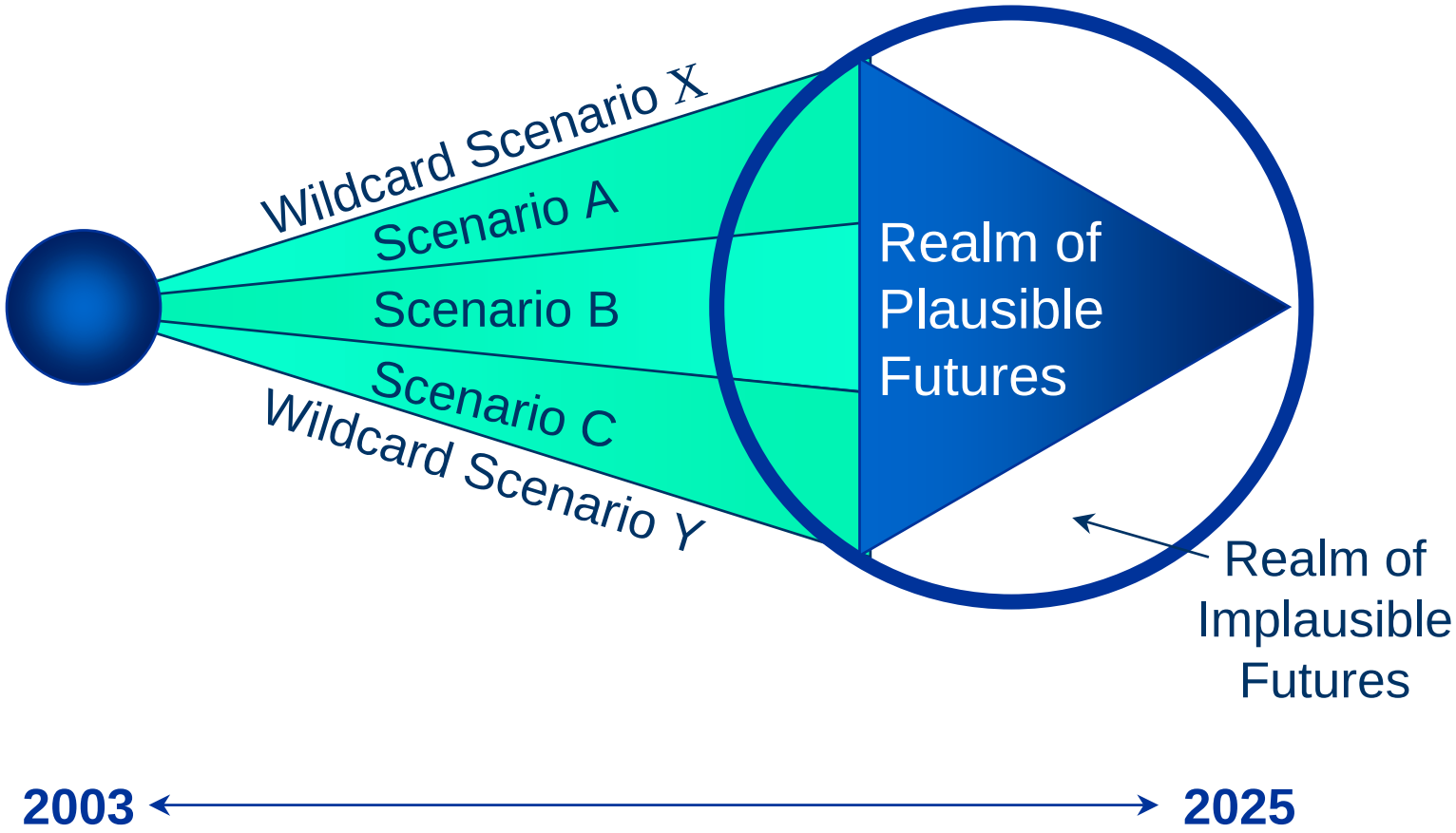
- Over 2,500 hours of work went into the creation of this report.

The process

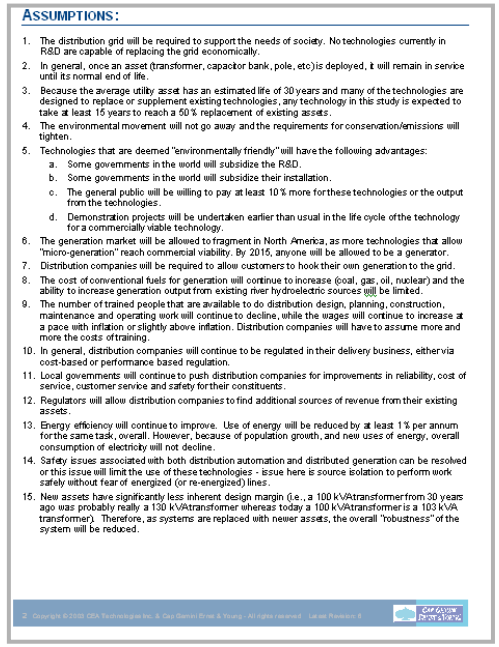
- Did the interviews
  - Developed a technology matrix and distribution value chain
  - Developed a list of common assumptions
  - Determined the drivers that were within and not within the control of the utilities
  - Determined the top drivers that were outside the control of the utilities
- Used the 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

Why Scenarios

Scenarios help to examine a realm of plausible futures.



Common assumptions about the business



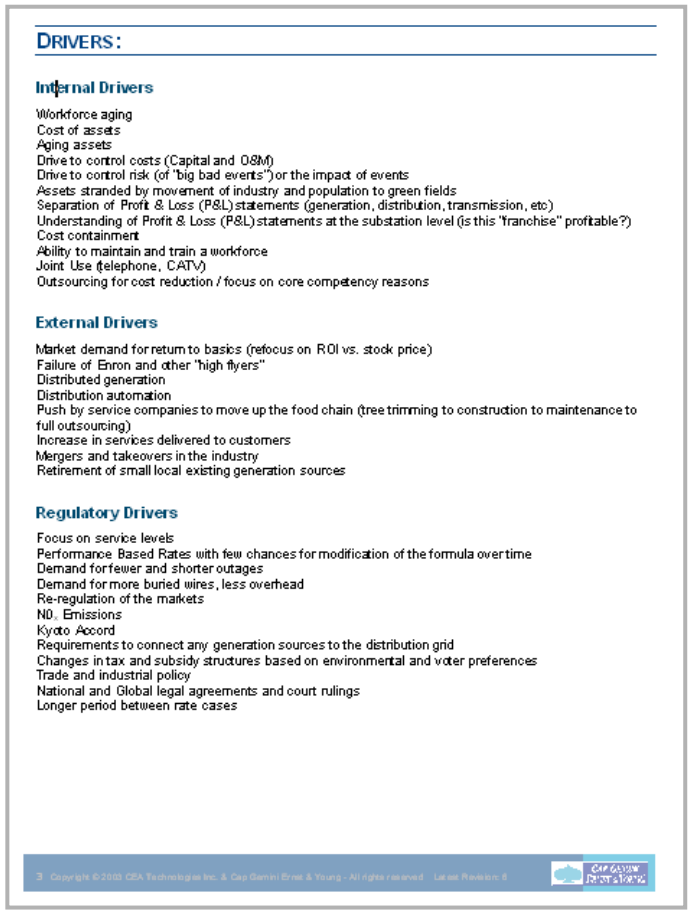
ASSUMPTIONS:

1. The distribution grid will be required to support the needs of society. No technologies currently in R&D are capable of replacing the grid economically.
2. In general, once an asset (transformer, capacitor bank, pole, etc) is deployed, it will remain in service until its normal end of life.
3. Because the average utility asset has an estimated life of 30 years and many of the technologies are designed to replace or supplement existing technologies, any technology in this study is expected to take at least 15 years to reach a 50% replacement of existing assets.
4. The environmental movement will not go away and the requirements for conservation/emissions will tighten.
5. Technologies that are deemed "environmentally friendly" will have the following advantages:
   a. Some governments in the world will subsidize the R&D.
   b. Some governments in the world will subsidize their installation.
   c. The general public will be willing to pay at least 10% more for these technologies or the output from the technologies.
   d. Demonstration projects will be undertaken earlier than usual in the life cycle of the technology for a commercially viable technology.
6. The generation market will be allowed to fragment in North America, as more technologies that allow "micro-generation" reach commercial viability. By 2015, anyone will be allowed to be a generator.
7. Distribution companies will be required to allow customers to hook their own generation to the grid.
8. The cost of conventional fuels for generation will continue to increase (coal, gas, oil, nuclear) and the ability to increase generation output from existing river hydroelectric sources will be limited.
9. The number of trained people that are available to do distribution design, planning, construction, maintenance and operating work will continue to decline, while the wages will continue to increase at a pace with inflation or slightly above inflation. Distribution companies will have to assume more and more the costs of training.
10. In general, distribution companies will continue to be regulated in their delivery business, either via cost-based or performance based regulation.
11. Local governments will continue to push distribution companies for improvements in reliability, cost of service, customer service and safety for their constituents.
12. Regulators will allow distribution companies to find additional sources of revenue from their existing assets.
13. Energy efficiency will continue to improve. Use of energy will be reduced by at least 1% per annum for the same task, overall. However, because of population growth, and new uses of energy, overall consumption of electricity will not decline.
14. Safety issues associated with both distribution automation and distributed generation can be resolved or this issue will limit the use of these technologies - issue here is source isolation to perform work safely without fear of energized (or re-energized) lines.
15. New assets have significantly less inherent design margin (i.e., a 100 kVA transformer from 30 years ago was probably really a 130 kVA transformer whereas today a 100 kVA transformer is a 103 kVA transformer). Therefore, as systems are replaced with newer assets, the overall "robustness" of the system will be reduced.

- 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
Drive to control costs (Capital and O&M)
Drive to control risk (of "big bad events") or the impact of events
Assets stranded by movement of industry and population to green fields
Separation of Profit & Loss (P&L) statements (generation, distribution, transmission, etc)
Understanding of Profit & Loss (P&L) statements at the substation level (is this "franchise" profitable?)
Cost containment
Ability to maintain and train a workforce
Joint Use (telephone, CATV)
Outsourcing for cost reduction / focus on core competency reasons

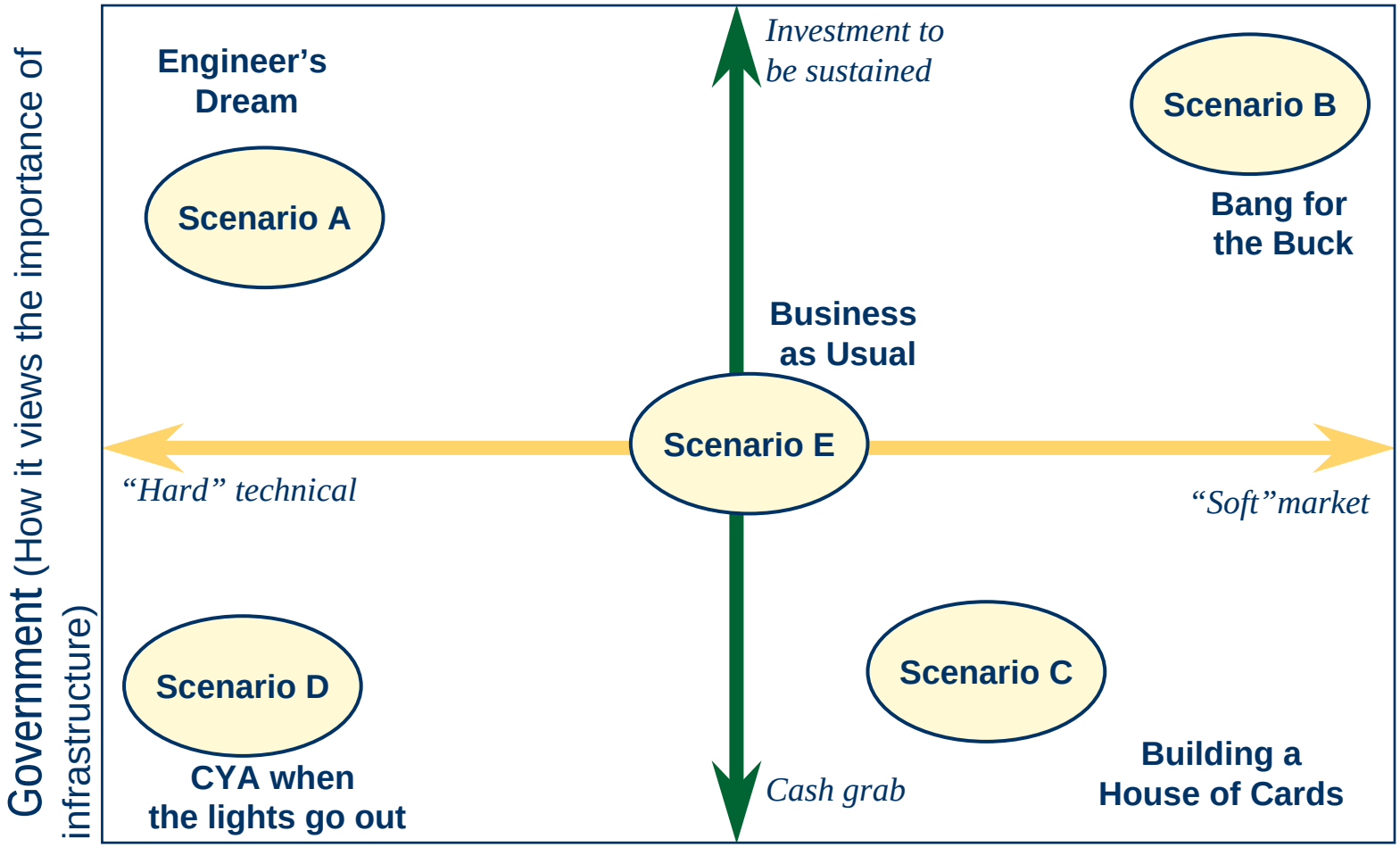
External Drivers

Market demand for return to basics (refocus on ROI vs. stock price)
Failure of Enron and other "high flyers"
Distributed generation
Distribution automation
Push by service companies to move up the food chain (tree trimming to construction to maintenance to full outsourcing)
Increase in services delivered to customers
Mergers and takeovers in the industry
Retirement of small local existing generation sources

Regulatory Drivers

Focus on service levels
Performance Based Rates with few chances for modification of the formula over time
Demand for fewer and shorter outages
Demand for more buried wires, less overhead
Re-regulation of the markets
NO_x Emissions
Kyoto Accord
Requirements to connect any generation sources to the distribution grid
Changes in tax and subsidy structures based on environmental and voter preferences
Trade and industrial policy
National and Global legal agreements and court rulings
Longer period between rate cases

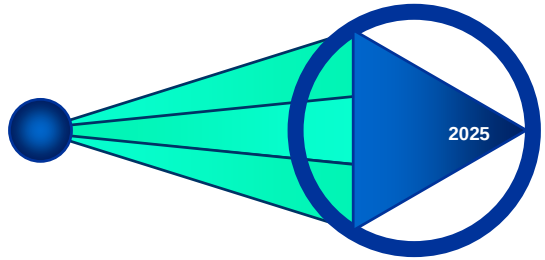
Scenario Matrix: Government/Regulator



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

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 …



Vision

ELECTRIC DISTRIBUTION UTILITY BUSINESS VISION

An organization typically creates a vision statement to define a sense of direction. It is a "realistic, credible, attractive future for the organization."[1]

A vision provides focus and meaning for everyone in the organization. This notion can also be extended to give meaning to a group of organizations that form an industry. The power of a vision is its ability to inspire, energize, and aid individuals to undergo a shift in mindset, to unleash talent and potential.

The following table highlights differences in some characteristics of organizations with and without a shared vision.

Visioned Organizational Differences

	Organization Without Vision	*Organization With Shared Vision*
Primary thrust	Problem-driven	Opportunity-driven
Worldview	Stable Predictable	Change Permanent volatility
Information systems based on	Historical performance	Progress goals
Decision making	Tactical	Strategic
Performance measures	Short-term results	Long-term results
Control mechanism	Habit, fear	Peer group pressure
Planning style	Reactive	Proactive
Risk	Avoid	Measured
Legal	Compliance	Lead, Stewardship
Competition	Play to don't lose	Play to "raise the bar"

It is within this spirit that the following vision of the electric distribution business was prepared - to characterize the future world that utility executives, managers, professionals, and tradespeople will be facing. Instead of a single statement or paragraph format, the vision consists of several points launched from the preceding set of assumptions and business drivers.

(Note: The following is not meant to provide utilities with a readily adoptable strategic direction. This is an exercise that each utility must undertake on its own. Rather, it is intended to provide necessary input for distribution asset strategy development and the selection of technologies to enable that strategy.)

[1] B. Nanus, *Visionary Leadership*, (San Francisco: Jossey-Bass, 1992) p8

Identified and listed over 150 technologies

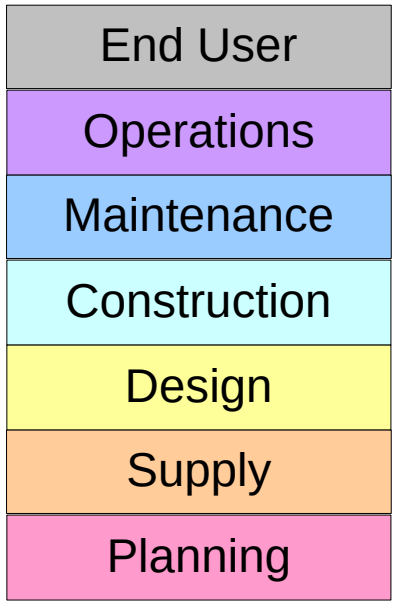
- Optimize Assets
  - Improve asset utilization and performance.
  - Extend life cycles to maximize usefulness.
  - Achieve cost efficiencies and revenue enhancements from existing assets.
- Improve Processes
  - Benchmark leading practices and change current work processes to catch up or leapfrog.
  - 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.

		Value Chain							Asset Management Strategy		
				Deliver							
	Technology	Planning	Supply	Design	Construction	Maintenance	Operation	End User	Asset Optimization	Process Improvement	New Revenue Capture
1	Agent based modeling					x	x		x	x	
2	Air conditioning; super high efficiency							x	x		
3	Automated Meter Reading (AMR), fixed read						x			x	
4	AMR; mobile read						x			x	
5	AMR; using Broadband over Power Line (BPL) or Power Line Carrier (PLC)						x			x	
6	Appliance reporting					x		x	x	x	x
7	Artificial Intelligence - Fuzzy logic					x	x			x	
8	Artificial Intelligence - True artificial intelligence						x			x	
9	Artificial Intelligence - Expert systems						x			x	
10	Artificial Intelligence - Neural nets						x			x	
11	Artificial Intelligence - Machine intelligence					x	x				
12	Asset effectiveness monitoring					x	x		x	x	
13	Asset Management IT Systems						x		x	x	
14	Asset modeling	x				x			x	x	
15	Automated workflow and sign-offs			x	x	x	x			x	
16	Batteries, Liquid		x								
17	Bio fuels		x								
18	Boring machines				x					x	
19	Broadband Over Power Line (BPL)					x	x	x		x	x
20	Buying agent, intelligent							x			x
21	Cameras, wearable				x	x	x			x	
22	Camouflage, asset	x		x	x						
23	Capacitors, electrochemical		x				x		x		
24	Capacitor, protection of						x		x		
25	Circuit breakers for feeders					x	x		x		
26	Computing, pervasive					x	x			x	
27	Conductor materials (Al vs. Cu)	x		x	x	x	x		x		
28	Corrosion prevention materials				x	x			x		
29	DC transmission to AC distribution		x	x			x		x		
30	DC distribution		x	x			x	x	x		x
31	DC in the consumer location						x	x			x
32	Demand management agent						x	x		x	
33	Demand side management on the consumer site						x	x		x	x
34	Device control via remote						x	x		x	x
35	Devices; remote control of to manage load shapes							x	x		
36	Device self-reporting					x	x		x	x	
37	Distributed workforce				x	x				x	
38	Fault anticipators						x			x	
39	Fault detection and reporting, automated						x		x	x	
40	Fiber Optic Field Support						x	x		x	
41	Fuel Cells		x								
42	Flywheel		x								

Critical Technologies

- 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

Distribution Value Chain



"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.

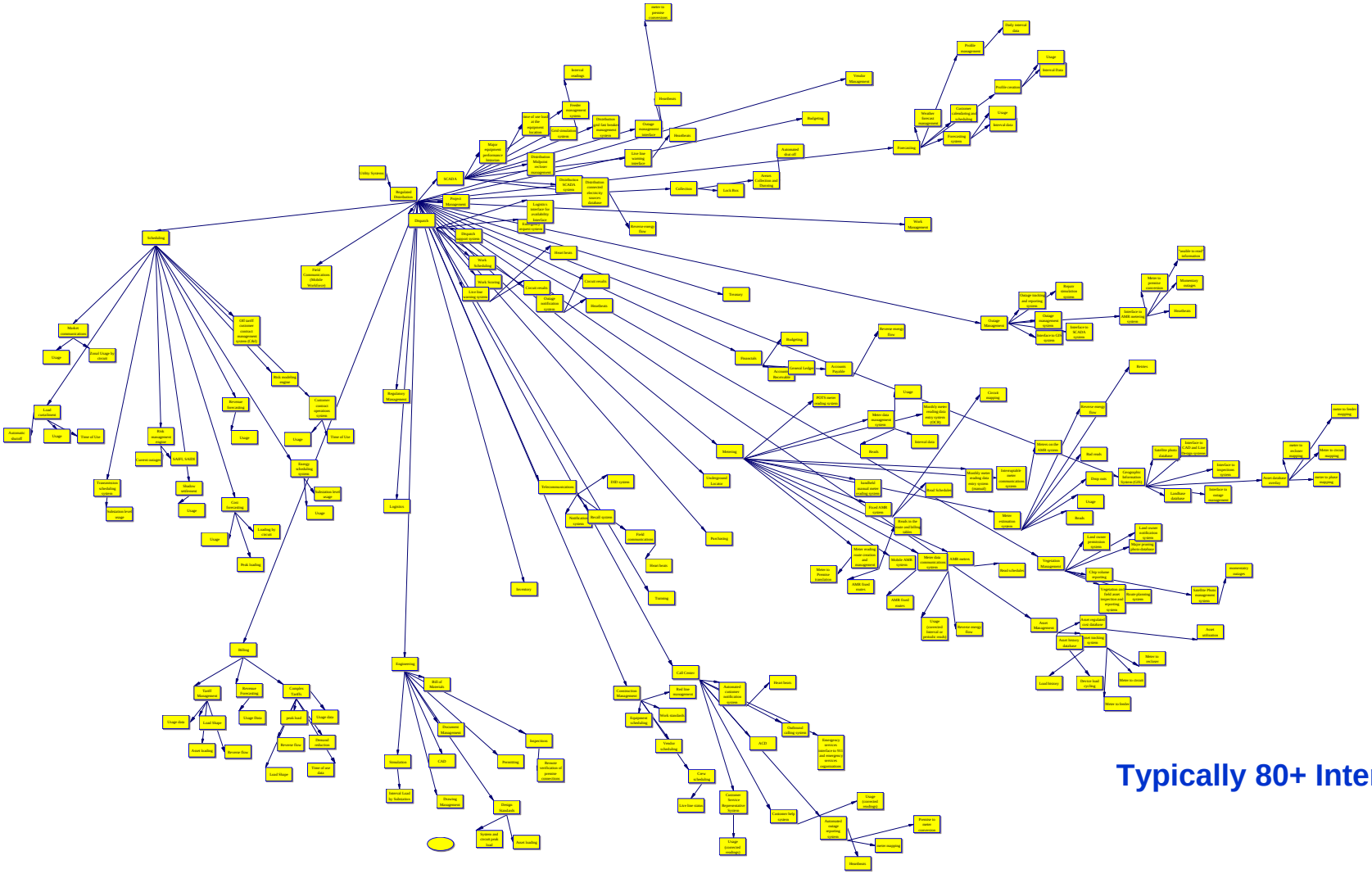
Impacts: Customers

- 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 Data Implications

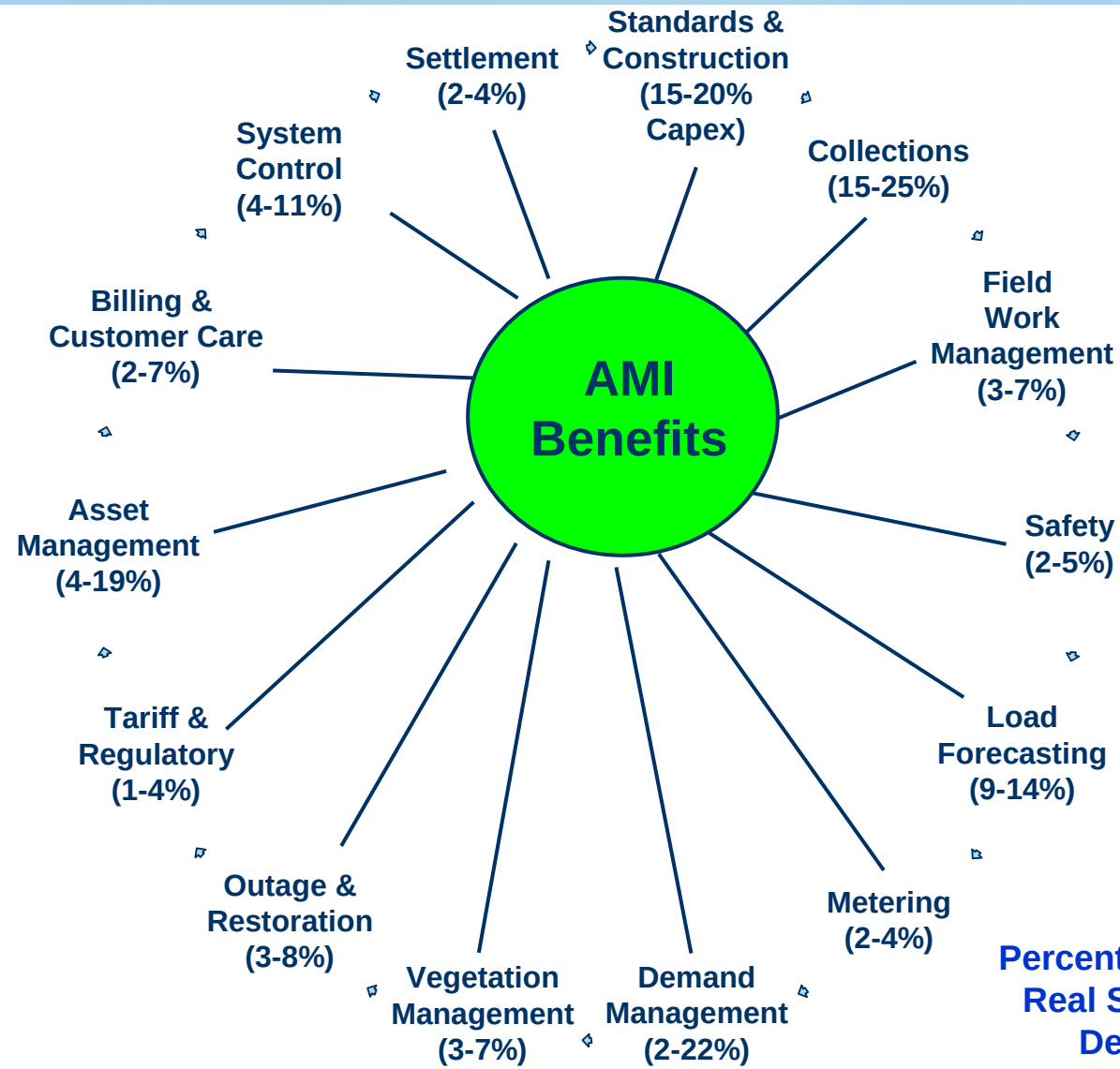


Typically 80+ Interfaces

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 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

AMR Benefits



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

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

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%

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Case Study - FPL

FPL - Customer Base

Sector	Number of accounts	Average monthly consumption (Kwh)
Residential	3,566,000	1,189
Commercial	435,000	7,663
Industrial	15,000	21,764

Summer Peak - 19,668
Winter Peak - 20,190

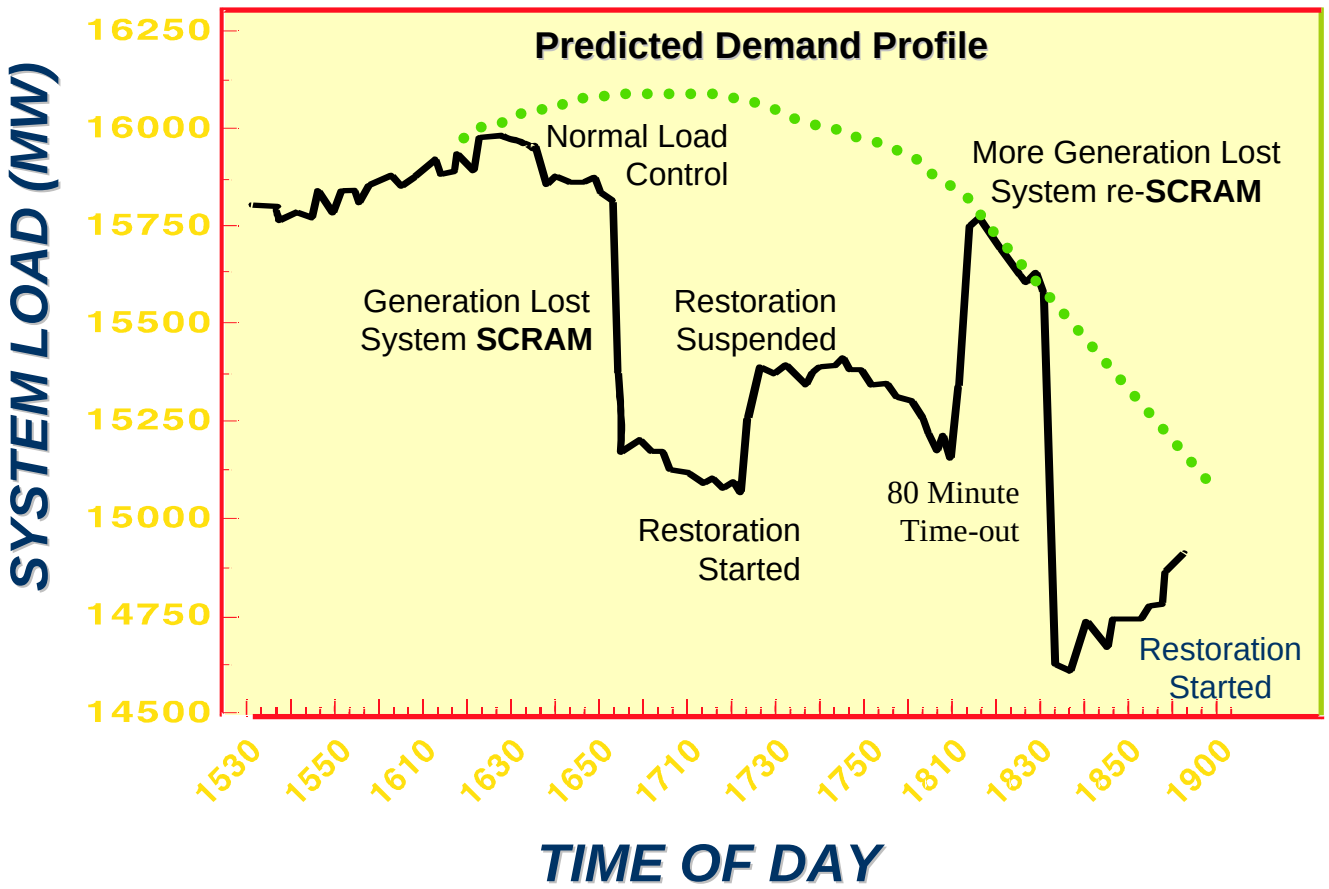
FPL April 2003

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

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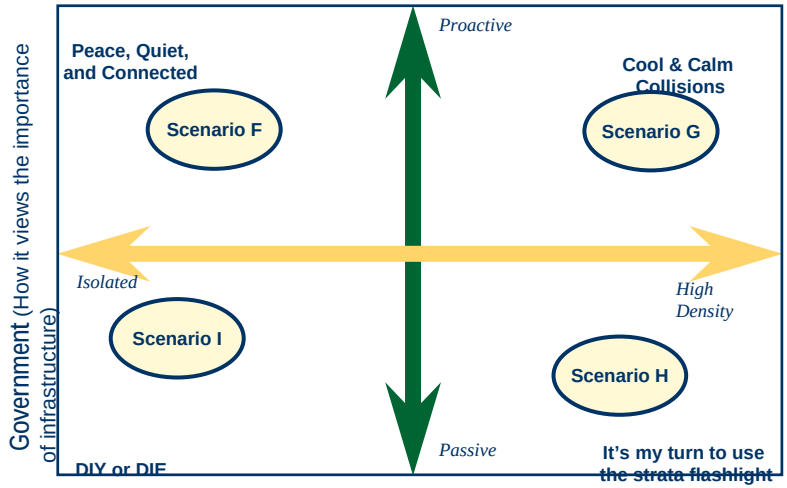
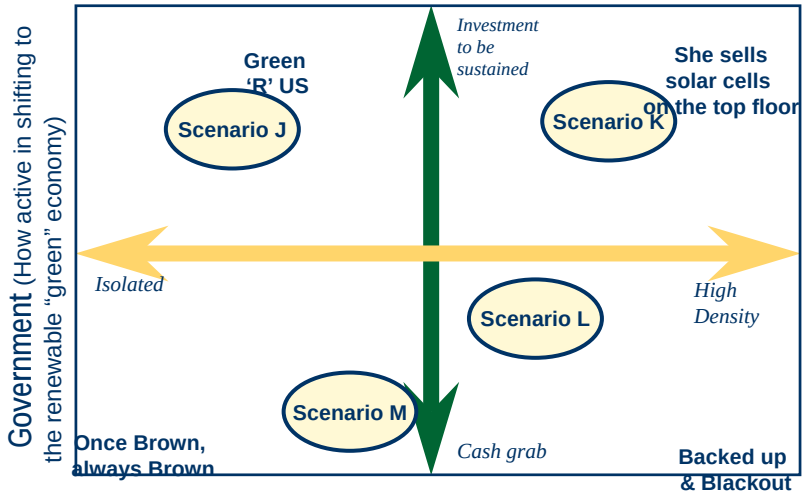
Back up

The other 16 Scenarios



Consumer (Where people will choose to live and prosper)



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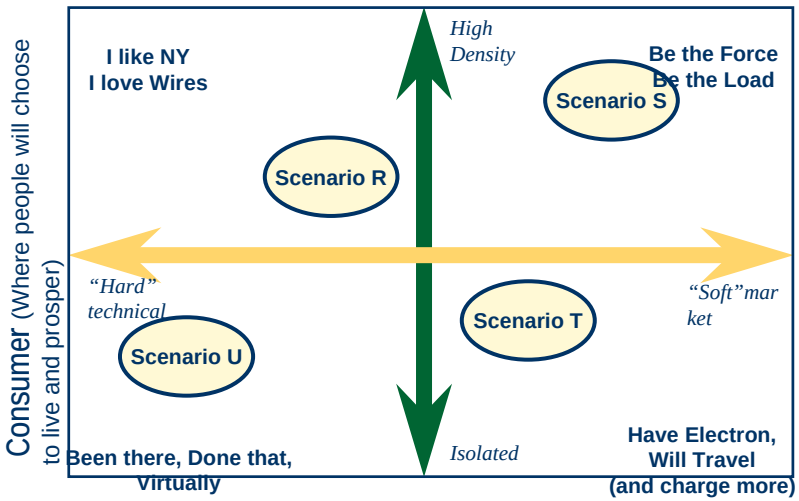
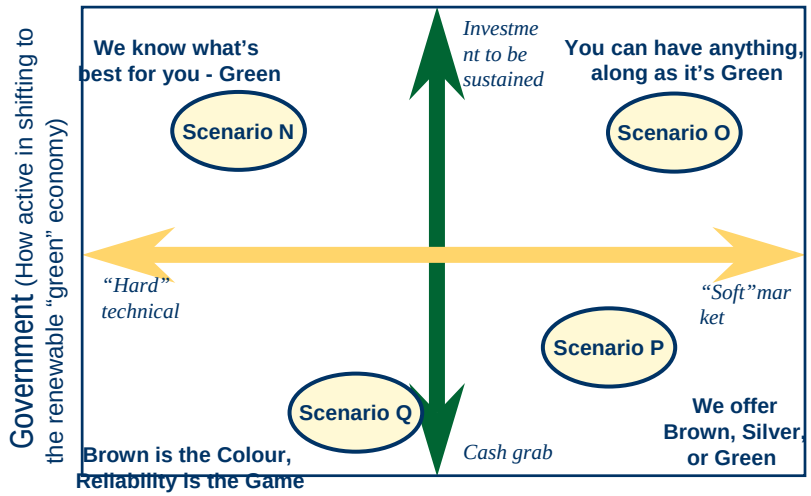


Regulator (Focus of attention – Deep and specific technical focus or a focus on results only.)



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

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."

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 your 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 - All Load Management Programs

- 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.