Investment, Finance and Safeguarding Public Interests in the Liberalized Electric Sector

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Talk outline

• Evolving public needs in the electric sector
• A systems engineering point of view (new technologies and institutional arrangements)
• Evolution from current to more reliable and flexible organizational structures
• Change from hierarchical to multi-layered industry
• The challenge of managing change
Evolving public needs in the electric sector

• Large backbone infrastructure already in place
• Needs for maintaining the existing and gradually replacing/enhancing it by many distributed small-scale technologies
• Hard to make the case for new very-large scale new capacity (economies of scale vs. economies of scope)
• Instead, huge need for extracting efficiencies reliably in highly flexible just-in-time ways
A systems engineering point of view

- Temporal and spatial complexity
- Evolving structures
- Reliability and flexibility metrics
Change from Hierarchical to Multi-Layered Organizations

• 1. Existing paradigm: Centralized, large scale

• 2. Transitional paradigm: Aggregation across non-traditional boundaries

• Likely end state paradigm: Very decentralized, large number of small scale actors
Evolution from current to more reliable and flexible organizational structures

- Technological advances (from complex coordinating switching to many decentralized switches)
- Regulatory progress (from RoR through PBR to no regulation type signals)
- Economic (pricing) processes (signals for dynamic investments into distributed technologies)
- Political forces (obstacle/catalyst-switches)
- Their interplay: Hybrid system
Fundamentally New Opportunities in the Electric Power Industry Sector

• POSSIBLE TO DEPLOY TECHNOLOGICAL TOOLS FOR FLEXIBLE AND ROBUST PERFORMANCE OF A COMPLEX SYSTEM, SUCH AS THE ELECTRIC POWER INDUSTRY.

• CONCEPTUAL CHALLENGES TO ENGINEERING SYSTEMS VARY VASTLY DEPENDING ON WHICH STRUCTURE IS IN PLACE. NO SINGLE “OPTIMAL” ARCHITECTURE.

• TREMENDOUS NEED FOR INSTITUTIONAL SUPPORT OF THE RIGHT EVOLUTION.
Critical changes in the existing infrastructures

- Cost-effective DG technologies
- Cost-effective customer choice technologies
- Cost-effective low voltage wire control
- Distributed IT infrastructure

- Industry restructuring—institutional
The $M$ Question: Is it possible to be secure and efficient service at the same time??

- Secure performance requires the worst case design, much reserve (inefficiency, aggregate level thinking). TRADITIONAL OVER-DESIGN
- Efficient performance requires dynamic response/adaptation to changing conditions so that the overall resources are used most efficiently (distributed decision making, much flexibility at ALL level of the grid).
- THE ONLY WAY TO MAKE THE SAME SYSTEM ROBUST AND EFFICIENT IS TO HAVE HIGHLY RESPONSIVE (``SMART”) GRID AND RESPONSIVE END USERS. THIS IS A QUALITATIVELY DIFFERENT MODE FROM THE CURRENT OPERATING PRACTICES.
- DISTRIBUTION OF SMALL SCALE ACTORS REPLACING VERY LARGE FEW ACTORS HELPS.
The challenge of managing change

• Understand the value of various technologies under specific paradigms

• Develop operating, maintenance and planning decision tools (systems engineering) for all three paradigms and their transitions

• Value IT and computing for all three paradigms
Critical concepts

• Flexible reliability-related risk management
• Closely related to the questions of back-up power at times of price spikes/interruptions
• From extensive interconnections for reliability to distributed reliability provision; and, flexible (smart) delivery system.
Hard engineering issues

• Current engineering practices are not well suited for flexible (efficient) use of capacity
  - the worst case design, hard to relate to efficiency
  - reliability challenge concerns very low probability, high impact events; hard to manage; fat tail distributions
  - general spatial and temporal complexity
Hard institutional questions

- This industry does not lend itself to well established cost-plus wholesale only frameworks
- Insufficient to apply macro-economics for wholesale markets without carefully aggregating effects of micro-actions (DG, conservation, smart use of wires)
- Need for new generation performance-based regulation in support of near-complete markets
The resulting challenge

• No good engineering nor economic/financial tools to manage complexity presented to us
• An incremental approach without much understanding of the outcomes
• THE MAIN CHALLENGE: NO INCENTIVES TO SUPPORT RELIABILITY/SECURITY NOR FLEXIBILITY; NO INVESTMENTS IN RIGHT TECHNOLOGY FOR SECURITY AND EFFICIENCY.
• N.B: Maybe not real need for traditional backbone capacity
Possible way forward

- Revisit current engineering practices for reliable operation and planning
- Move toward industry structures which support complete products provision and valuation (beyond energy; reliability; transmission) –REAL OPPORTUNITY
- The demand for these must come from the customers; PROTOCOLS FOR CHOICE
Interaction at several industry layers and over various times

- Basic interactions (protocols) across industry (replacement for vertically structured industry)
- Basic Interactions Between a Distributor and the Others
- Basic Interactions at the Energy Market Level
- Basic Interactions Among Energy Markets
Role of industry protocols

- Communicate DYNAMICALLY demand and willingness to pay by the end users, to the distributors;
- Communicate services and conditions under which the distributor provides services to the group of customers;
- Provide ways for distributors to seek in the whole-sale the best services for its customers (delivery and generation);
- Provide a basis for sustainable value-based businesses for value-based reliability
Dynamic Protocol --- Utility Level

Mkt 2

Distributor 1

Distributed Generator 1

Distributor 2

Distributed Generator 2

Distributor n

Distributed Generator n

Mkt 3
Dynamic Protocol --- Energy Market Level

Energy Mkt 2

Energy Mkt 3

Utility 1

Utility 2

Utility n

Distributor

Energy Market 1
Dynamic Protocol --- Customer Level

Customer Properties

Quality of Service Specifications

Appliance Type

Oil vs. Gas vs. Electrical

• AMR
• Control of devices

Qel(t)  Qgas(t)  Qinfo(t)

Negotiated with Distributor

Negotiated with Distributor

Negotiated with Distributor

Bundled Service

Bundled Charge

• Projected
• Spot Price

Cel(t)  Cgas(t)  Cinfo(t)
Critical open problems

• Design of **complete architectures** (including markets) for managing service at value (including physical reliability-related risks) over a wide range of time horizons and their inter-temporal dependencies;
• **The effect of decentralization** (coordination needed for system-wide efficiency; could be through price incentives, and/or engineering rules)
• Tools for **re-bundling over time and space** to facilitate transparent complete architectures
• **Education challenges**: Defining infrastructures as heterogeneous large-scale dynamic systems; re-visiting state of art large-scale systems (CMU course 18-777); aggressive development of useful computer tools and IT
Conclusions

• Systematic development of the envisioned protocols is an important interplay of economic, technical, policy and IT signals, all evolving at the well understood rates

• Only products/services specified in protocols are provided/sold; critical to have a complete set to provide service as desired by customers; regulated industry particular case

• Software supported, flexible implementations

• Without this, it may be impossible to perform both in an efficient and secure way.