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

Professor Marija Ilic
ECE and EPP Departments
Carnegie Mellon University
milic@ece.cmu.edu

May 26,05 Delft University Netherlands

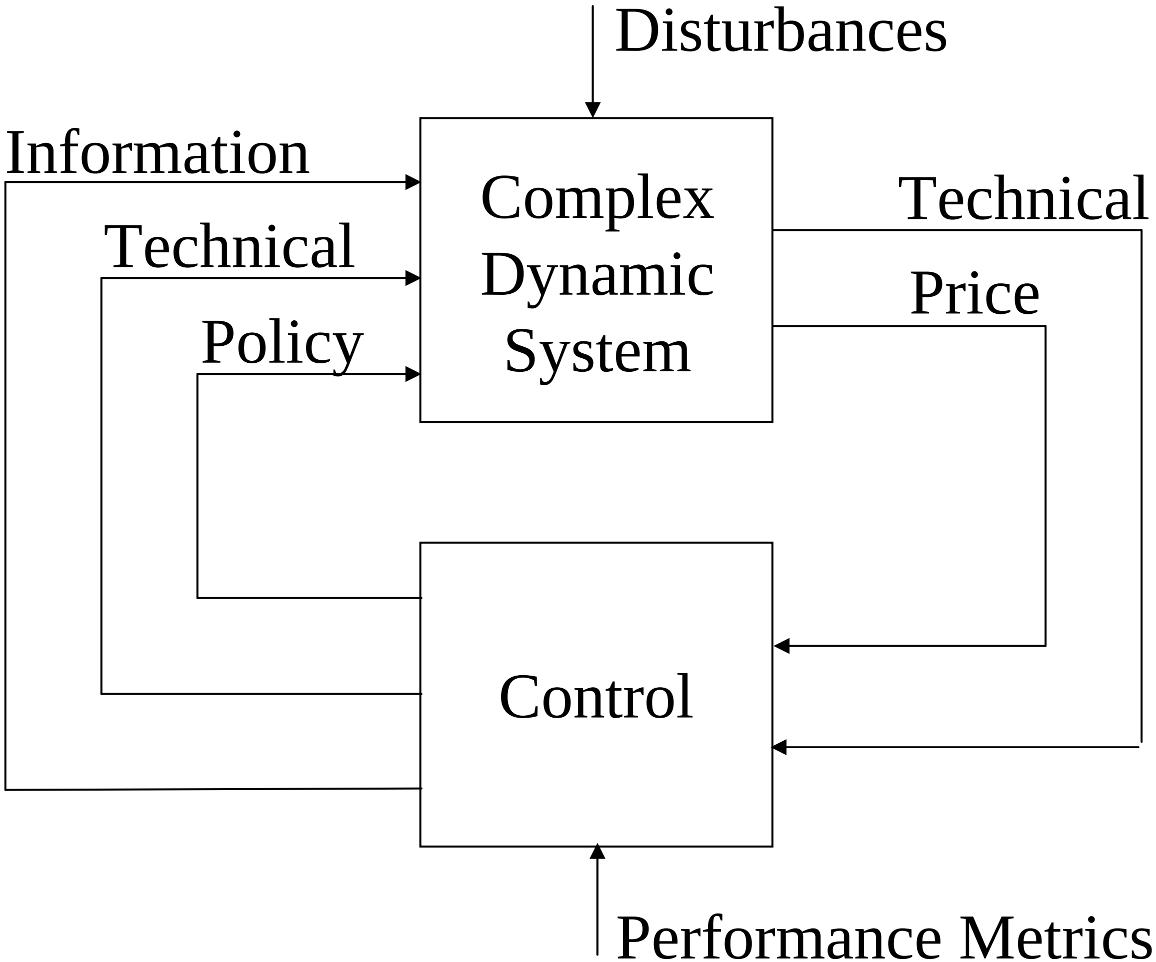
Talk outline

- 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 Hierarchal 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" ARCHIETECTURE.

- 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

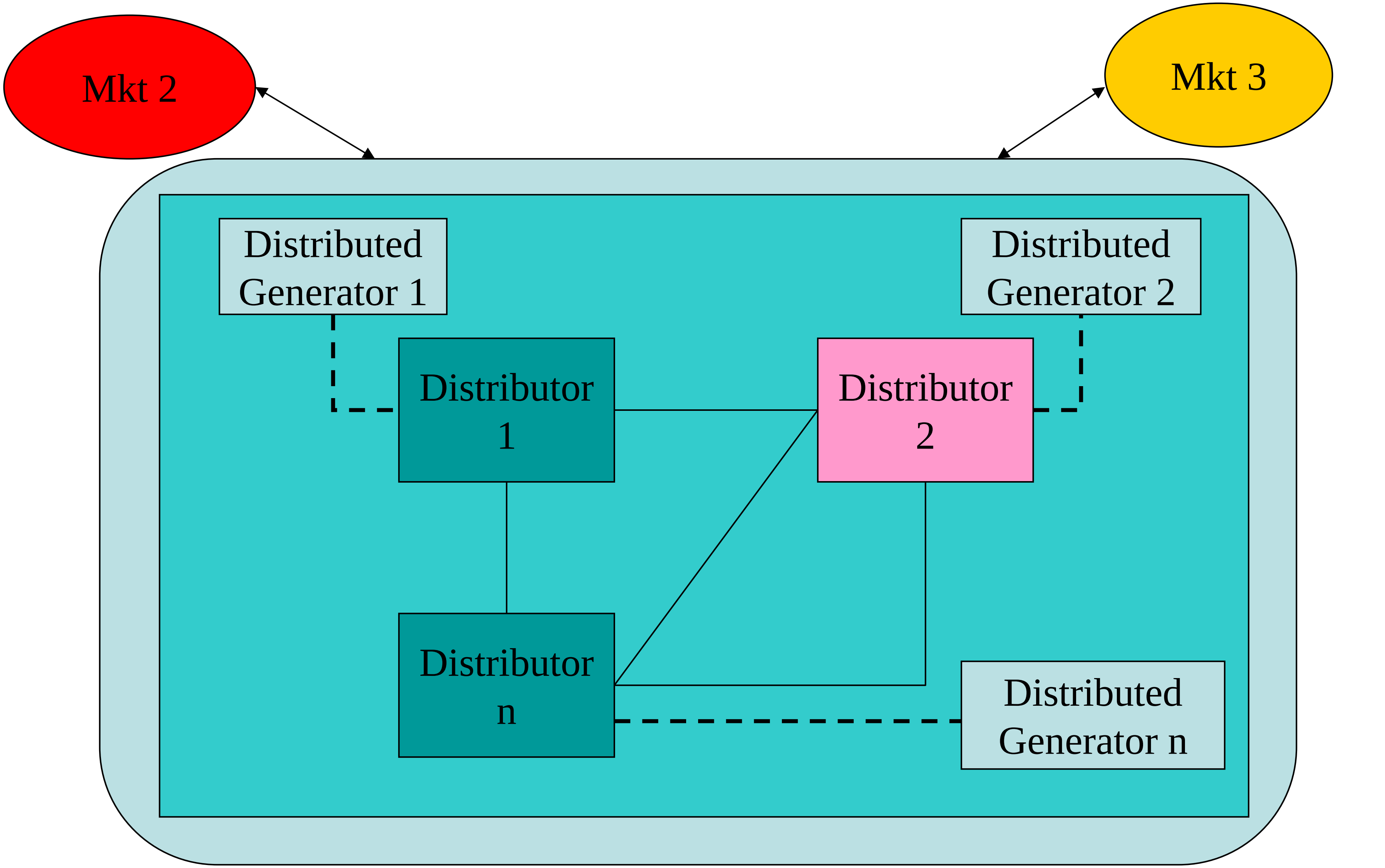
Interaction at several industry layers and over various times

- 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

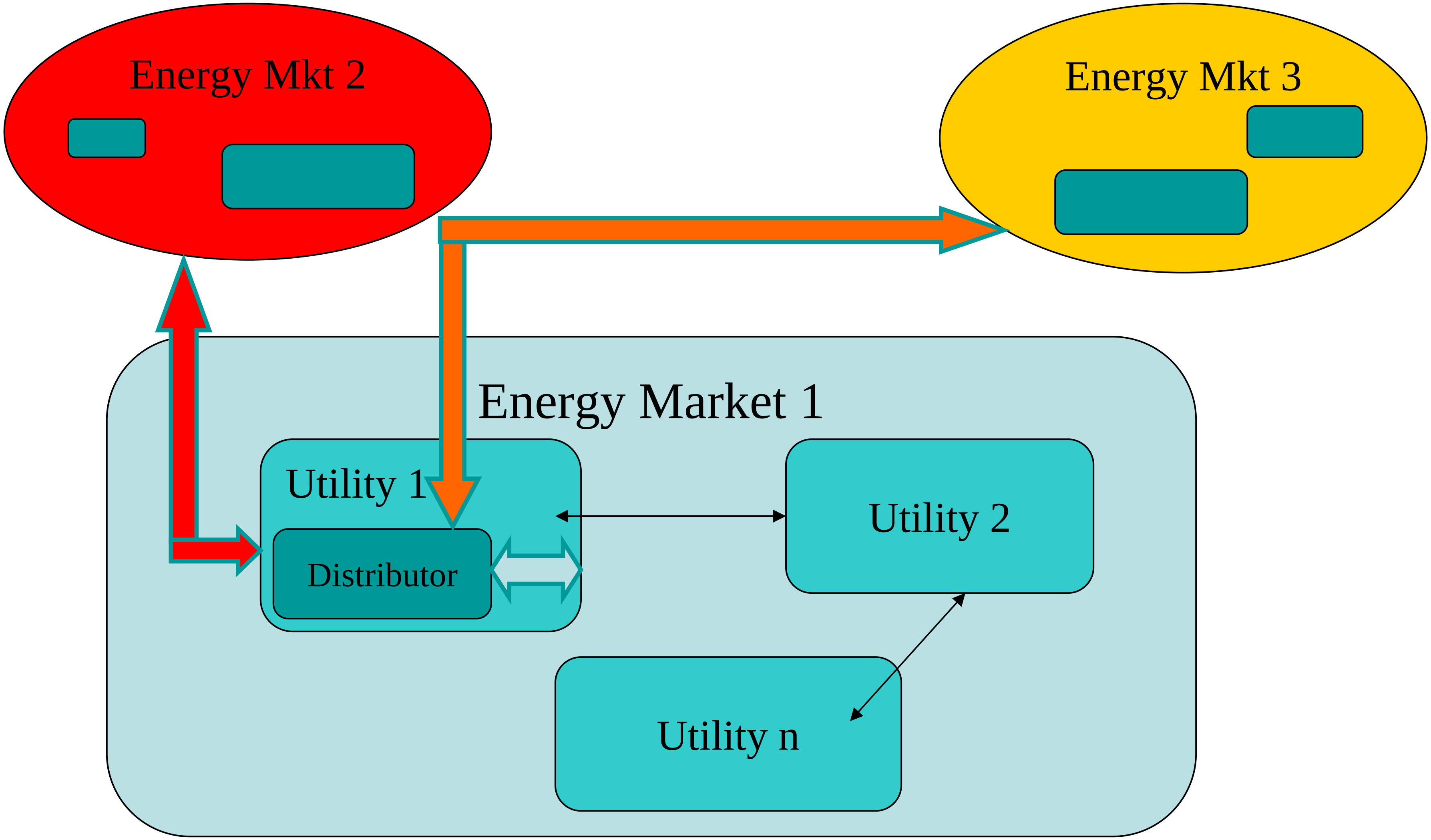
Role of industry protocols

- 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

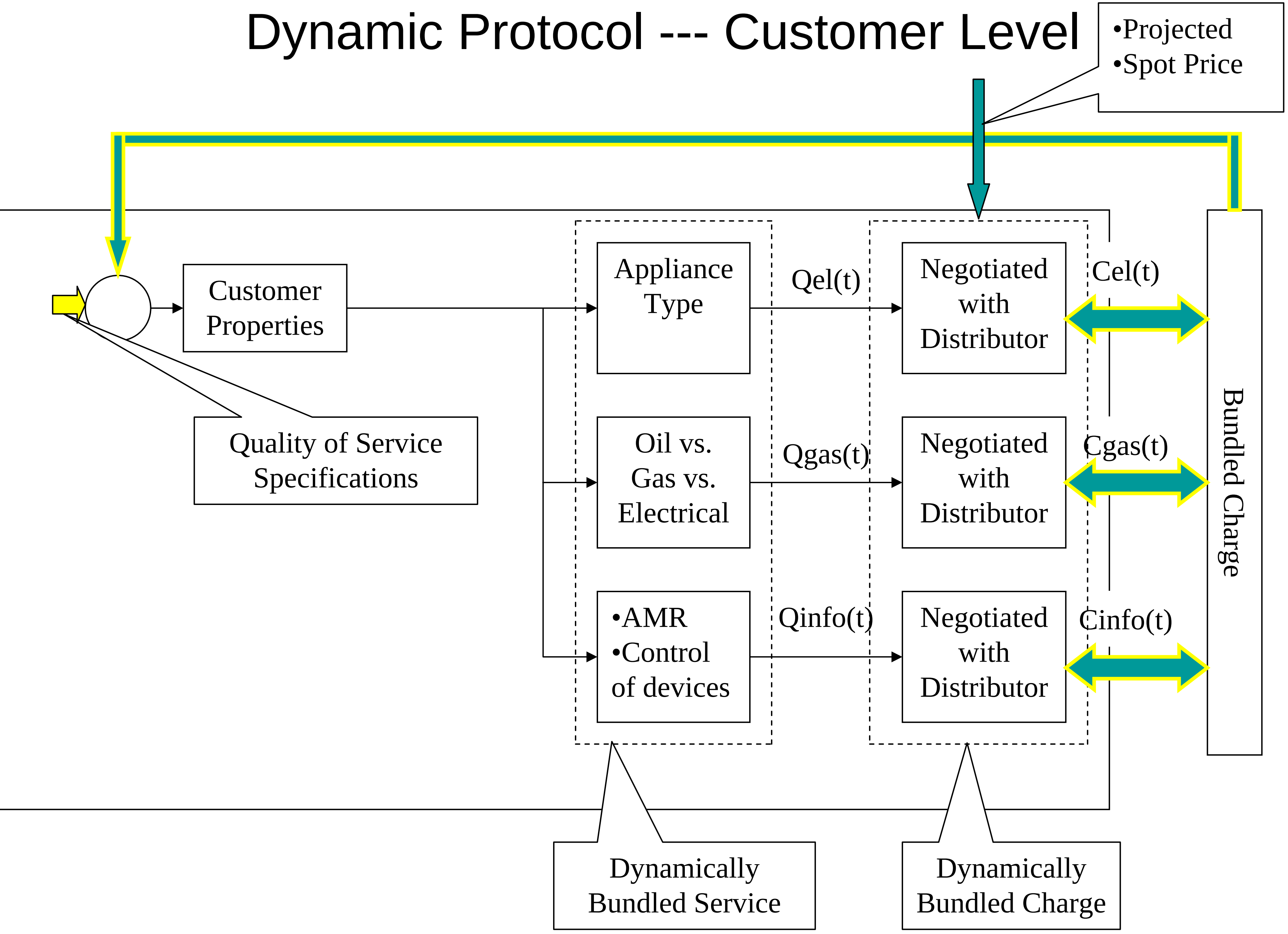
Dynamic Protocol --- Utility Level



Dynamic Protocol --- Energy Market Level



Dynamic Protocol --- Customer Level



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.