Industry Restructuring and the Provision of Reliability and Security Services

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Outline

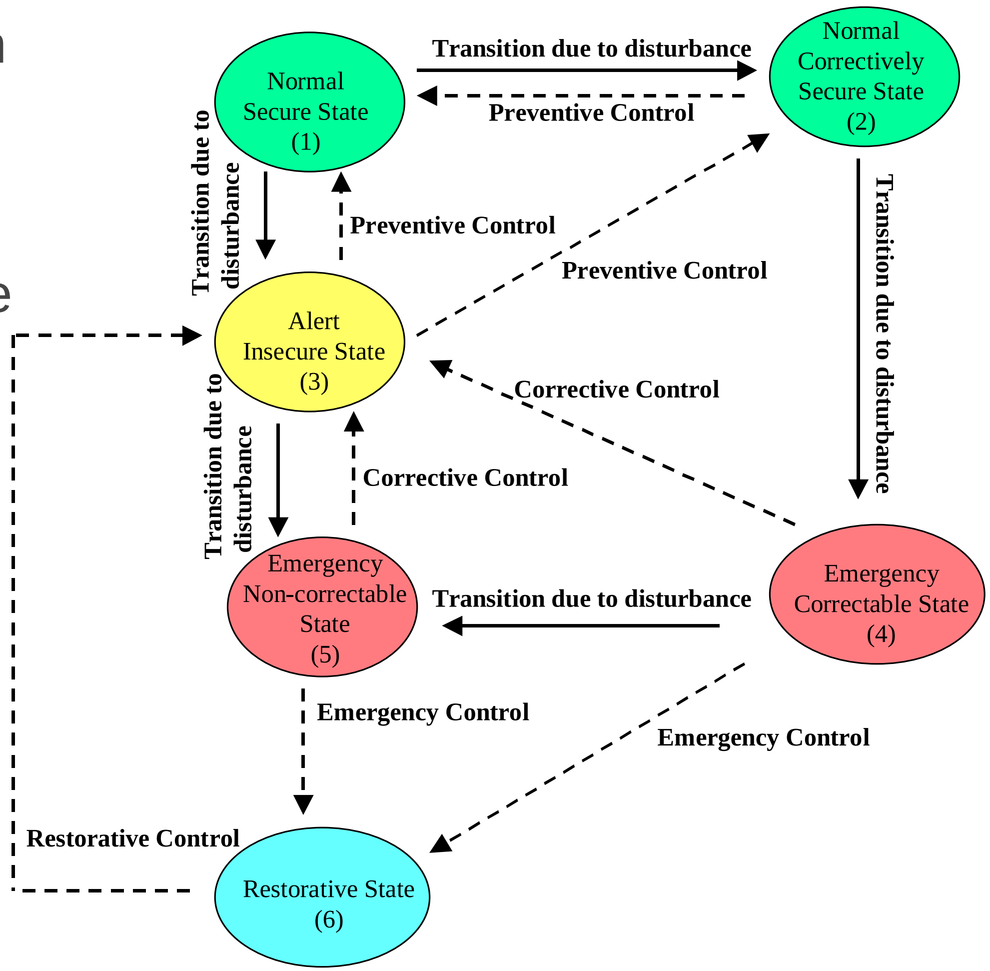
- Introduction
- New challenges to system operations
- Blending engineering and economic perspectives
- Applications of economic approaches to engineering tasks
- Conclusion

Need for Reform

- After the introduction of restructured wholesale markets, TSOs still rely on operating procedures that were designed for the era of vertically integrated utilities
- These procedures were inherited from the utilities and other transmission owners or from pre-existing power pools
- Some amendments and updates have been implemented, but in the main the basic principles of grid management differ little from those established decades ago
- It is crucially important now that these principles be reviewed in light of the central role of markets

Power System Static Operating Security States

- The concept of security emerged in the wake of the 1965 blackout in the Northeast.
- In 1968, DyLiacco provided a framework that is useful to examine security.
- The power system is operated under two sets of constraints: equality and inequality constraints.
  - the equality constraints impose that all loads must be met;
  - the inequality constraints impose operating limits on network variables
- For electricity markets, system security considerations are becoming more critical for efficient market operation

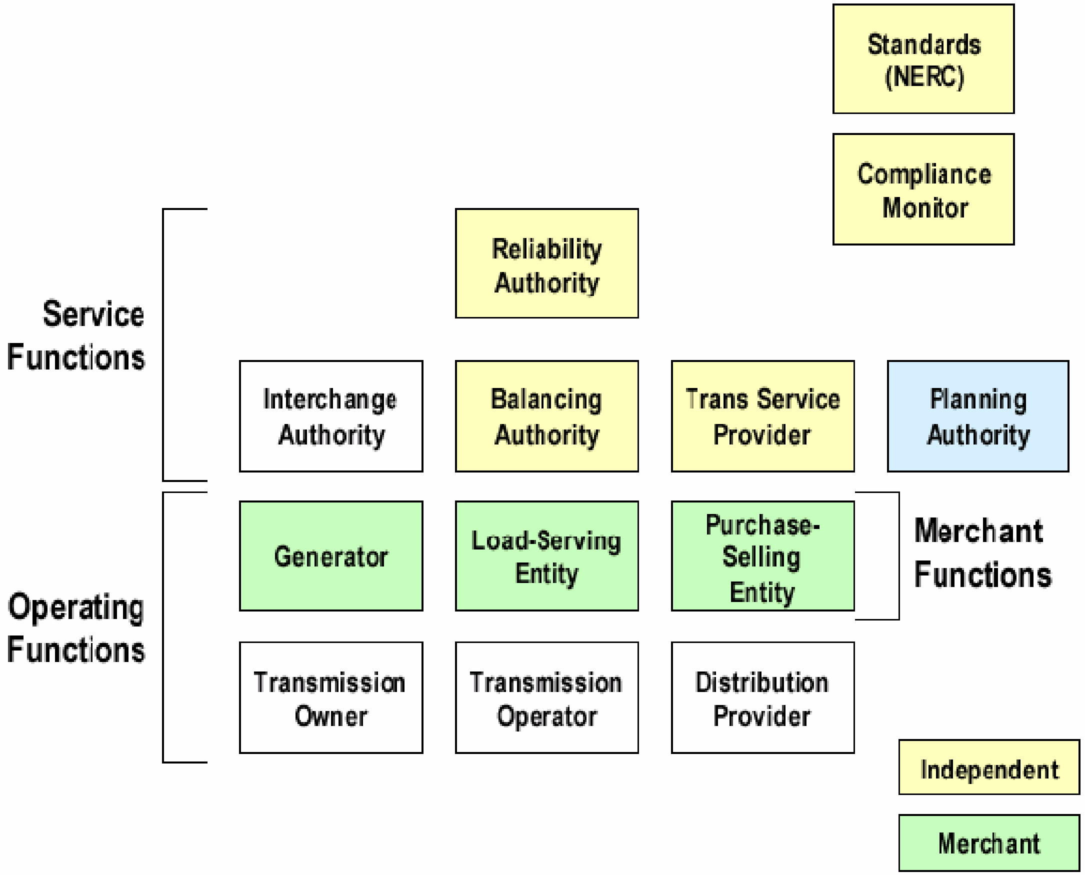


Traditional Power System Planning and Operation for a Vertically Integrated Utility

- Control Areas were established by utilities to operate individual power systems in a secure and reliable manner
- The traditional Control Area operator balanced load with generation and implemented interchange schedules with other Control Areas
- Due to restructuring of the electric industry, the functions performed by Control Areas began to change to reflect the new emerging needs
- These changes have made the NERC Operating Policies to become more difficult to apply and enforce
- Recognition of this problem led to the creation of a Task Force sponsored by NERC that started a project to identify all functions required for maintaining electric system reliability.

The NERC Functional Model

- This Functional Model is now being used as the basis for developing new operating standards for both power systems and markets.
- NERC and the North American Energy Standards Board (NAESB) have agreed to coordinate the development of reliability standards (by NERC) with wholesale electric business practice standards and communications protocols (by NAESB)

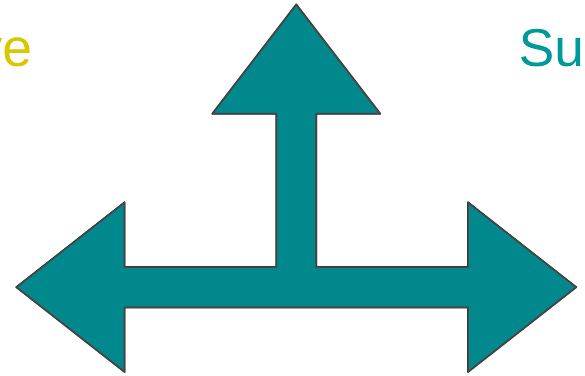


Reliability Depends on Successful Markets

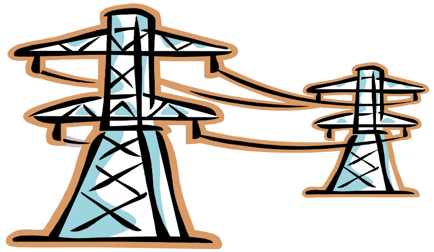
- Attributes of successful wholesale electricity markets include

Attracting sufficient investment in the infrastructure

Producing competitive market prices



Supporting secure and reliable system operations



- Coordinated markets
- Externality markets
- Imperfect markets
- Incomplete markets

- Distributed control
- Indirect control
- Imperfect control
- Noisy control

Interface between Engineering and Market Operations

- Engineering requirements have important implications for the design and performance of markets
  - Multiple settlements are needed: day-ahead transactions, and real-time deviations
  - Transmission system operator’s (TSO’s) interventions can have large distributional effects on market participants
- Conversely, the new role of wholesale markets may also affect engineering principles in important ways
  - Engineering operations now depend on procuring needed resources from markets
  - The TSO’s management of the grid, and its management of those markets that the TSO conducts, are now required to support and enhance the efficiency of trading among participants

Blending Engineering and Economic Perspectives

- The emergence of competitive electricity markets has challenged both the power system engineering paradigms and the traditional market economics precepts
- Many of the practices and underlying premises that evolved over many years with the aim of assuring reliable supply of electricity are not amenable to market-based implementations
- One promising approach is to borrow the concept of system security states and apply it to wholesale power markets
- Economic principles of risk management have proliferated in many engineering areas that have adopted probabilistic risk assessment and cost-benefit studies as the basis for dealing with decision making under uncertainty
- The inherent incompleteness of electricity markets implies that many operational decisions will still need to be made without the benefit of market mechanisms.
- It is unrealistic to expect that competitive markets will always provide the resources needed for secure system operations: OOM and RMR

The economic principle of incentives is essential to market design

- Market design specifies the rules of the tariff and operating procedures that influence possible actions
- On a short time frame these actions might include some subset of: bids in prescribed formats, unit commitment, scheduling day-ahead for energy and reserve capacity, deviations in real time.
- Bids might be for unit commitment, energy day-ahead and in the balancing market, various categories of reserves, and/or adjustments to alleviate congestion.
- The actions also include obligations, such as advance scheduling of maintenance, bidding all available capacity, providing AGC and reactive power, responding to dispatch instructions, and recalling exports in emergency conditions.
- The holy grail of market design is to create rules such that when each market agent acts selfishly within the rules the system as a whole performs as if it were run by a central planner with perfect information and full control of all resources

Application of Economic Approach to Operating Procedures - Transmission Planning

- Operating procedures need to be modified to mitigate some of problems engendered by restructured wholesale markets
- An adverse effect of restructuring was the demise of integrated resource planning by vertically integrated utilities
- Consequences include a collapsing planning horizon, uncoordinated generation and transmission capacity investments, and futures/forward markets that are too short-term to send useful price signals for planning and construction
- New transmission planning principles need to be established that can ensure reliability, accommodate load growth, provide loads with access to competitive markets, maintain existing firm transmission rights, and facilitate major regional and inter-regional power transfers

Application of Economic Approach to Operating Procedures - Congestion Management

- Whenever there is transmission congestion, some local high-cost generation capacity must substitute for remote low-cost generation capacity.
- With heavy use of the grid and significant inter-regional trading, some transmission inter-ties and segments will at times be fully loaded.
- When this is expected, to meet loads and to ensure reliability the control center must manage transmission congestion.
- This requires changes in scheduling and dispatch of generators, and may result in altered load patterns.
- Outstanding issues include “seams” between control areas, loop flows from adjacent regions, scheduling of distributed generation units, and emergency procedures

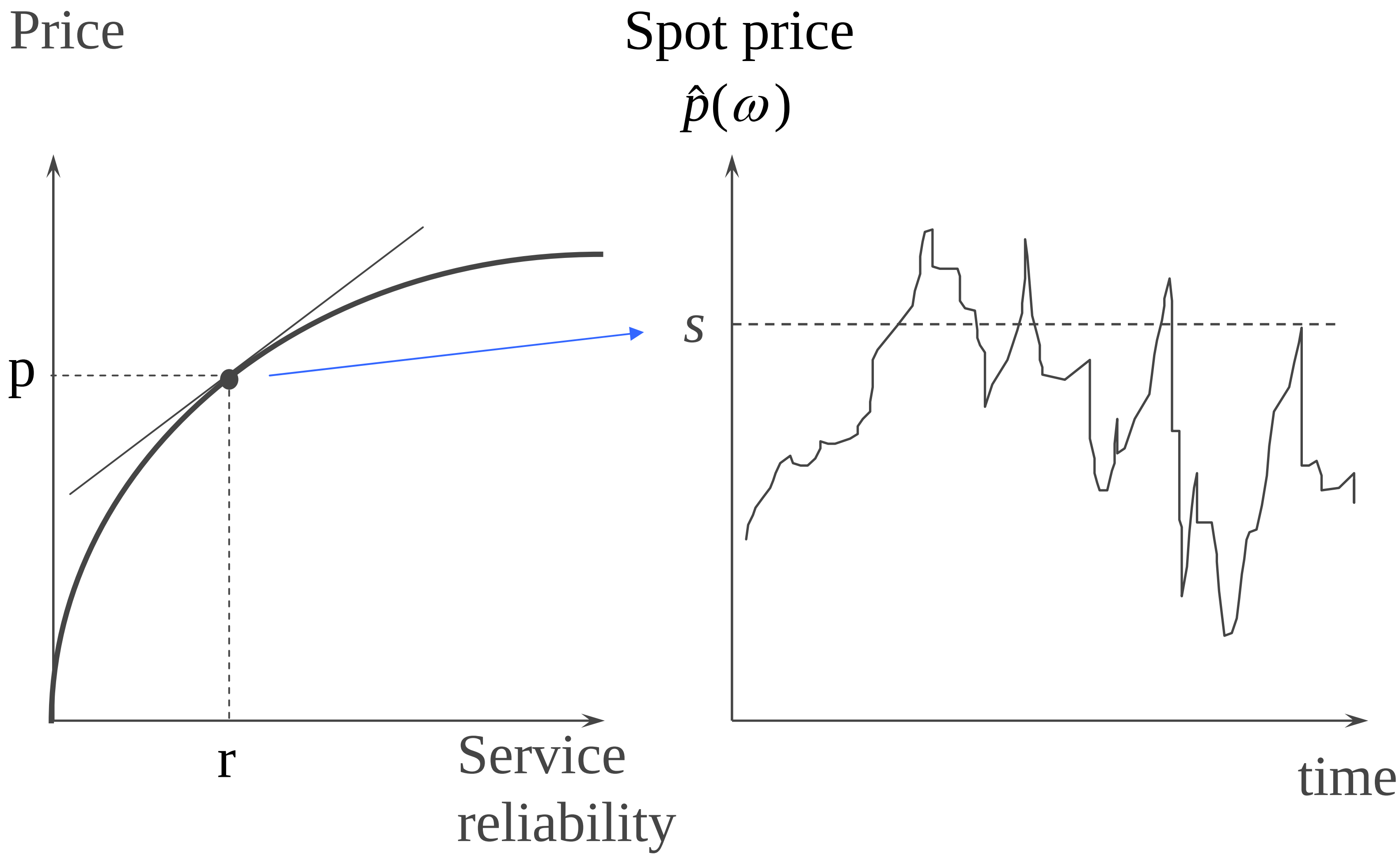
Application of Economic Approach to Operating Procedures - Ancillary Services

- Ancillary services are “necessary to support the transmission of electric power from seller to purchaser given the obligations of control areas and transmitting utilities within those control areas to maintain reliable operations of the interconnected transmission system.” (FERC)
- Such services need to be explicitly priced in the regulated markets.
- The following costs should be captured in the ancillary service tariffs: direct cost of unit providing service, opportunity cost of unit providing service, and opportunity cost of other re-dispatched units
- Real-time energy balancing involves dispatch of resources in economic merit order, but there are various circumstances that result in the need for dispatches in other than merit order.
- A critical tool that can help the system operator achieve an efficient real-time imbalance energy dispatch while adhering to both reliability and economic criteria is Security-Constrained Economic Dispatch (SCED).

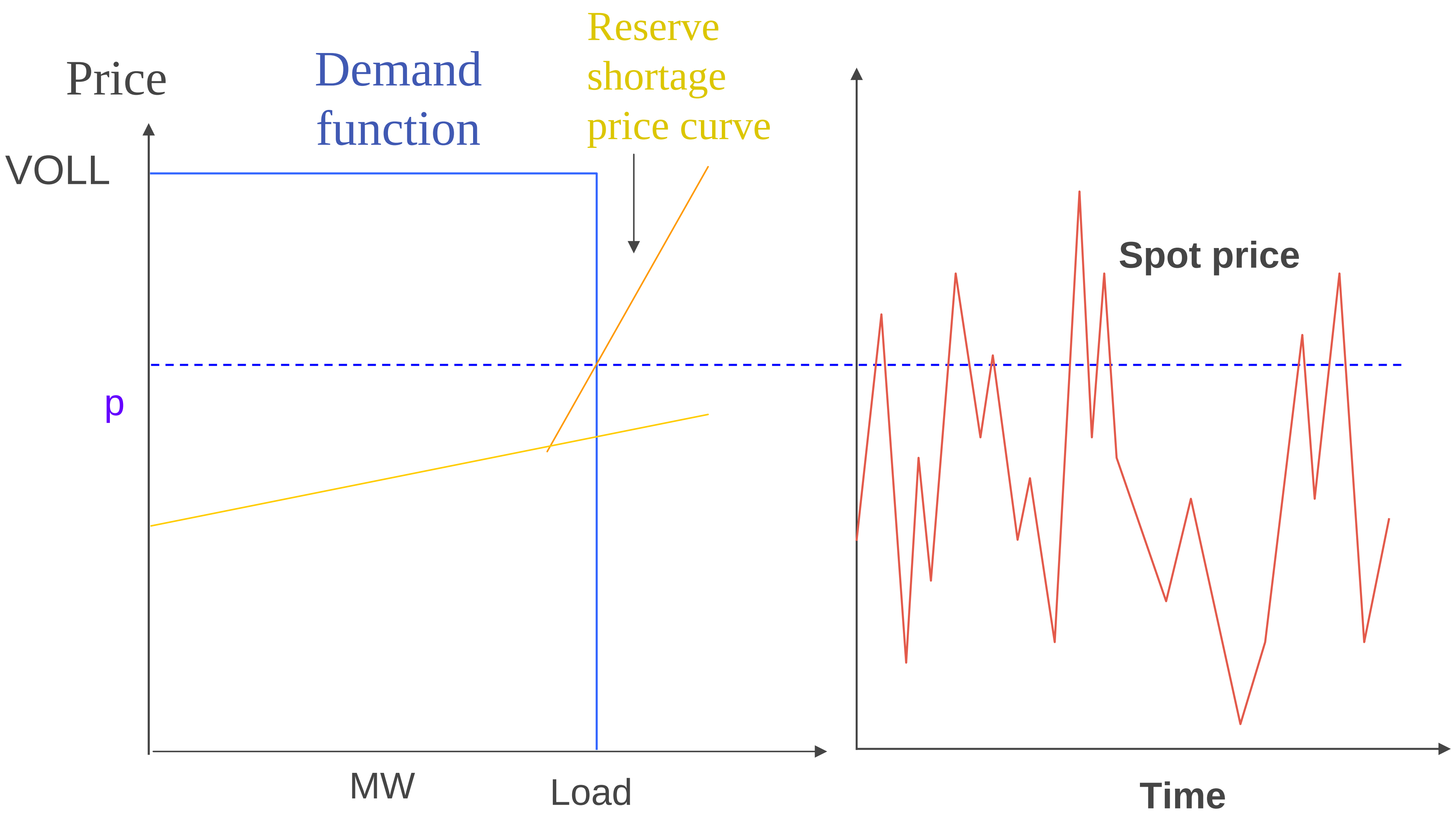
Differentiate Private and Public Good Aspects of Reliability

- Conceptually, system reliability includes system security and system adequacy
- System security is a public good
  - It represents system's capability to sustain short-term disturbances
  - Provision of security requires central coordination
- System adequacy is somewhat ambiguous
  - It represents the capability to meet predicted demands
  - Load is shed only when there is a physical shortfall
  - "Obligation to serve" is incompatible with the notion of a competitive market and must give way to "Obligation to serve with limited risk"
  - To the extent consumers can choose different levels of service, reliability is a private good
  - Consumer choice is predicated on metering and control technologies that are feasible today

Differentiated Reliability Services



The reserve shortage price should reflect the risk of system security



Conclusion

- The current operating procedures inherited from the era of vertically integrated utilities
- The basic principles of grid management need to be updated to integrate economic and engineering perspectives
- The private and public good aspects of reliability need to be considered