Introduction

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The Traditional Supply Industry

Monopoly  Optimization

Electricity Supply and Delivery Under Regulation

Generation  Transmission  Distribution

“Vertically Integrated Utility” (e.g. Allegheny Power)

https://www.e-education.psu.edu/ebf483/node/641
How is it operated? Three-way balance
What about money?

• Minimizing costs
  – Operating costs
    • Fuel, personnel, maintenance
  – Investment costs
    • Generators, lines, transformers, switching devices, ...
What about Reliability?

• Operational reliability (Security, Short-term reliability)
  – Withstand faults, failures, forecasting errors and other regular operational problems
  – Operate with a security margin

• Resilience (Adequacy, Long-term reliability)
  – Withstand natural disasters
  – Build a more robust system
Cost of Reliability

• Providing a security margin costs money
  • Run additional generating units to have some operating reserve
  • Limit production of some generating units to avoid problems in case of a sudden outage
• Build additional generators and transmission lines to improve resilience.
Value of Reliability

- Loss of revenue
- Loss of comfort
- Measured using surveys
  - Estimate the cost of latest outage or
  - Willingness to pay extra to avoid outages
- Value of lost load (VoLL)
- Average value of MWh not delivered
- Estimates range from $2,400 to $20,000
  ~100 times larger than the cost of energy
Balancing the Greed and the Fear
How to model this balance?

- Mathematical optimization problem
- Cost minimization or profit maximization
- Reliability introduced through constraints
  - Explicit costing of reliability is still controversial
Upholding the Delicate Balance

Supply

Demand
Upholding the Delicate Balance

Supply

Demand
Three-way balancing

- More complex optimization problems.
- Some environmental effects can be monetized
  - Operating cost of renewable generation is essentially zero
  - Carbon tax or carbon trading to reflect the effect of $CO_2$ emissions.
- Other can not be monetized
  - Effect of hydro generation on salmons.
  - Modeled using additional operating constraints.
What is wrong with the traditional approach?

• Removed the incentive to operate efficiently.
• Encouraged unnecessary investments.
• The cost of the mistakes that utilities made are passed on to the consumers.
• Linked to governments: Politics could then interfere with good economics.
  • Public utilities were treated as cash cows.
  • Public utilities were prevented from setting rates at a level that reflected costs or were deprived of the capital that they needed for essential investments.
What is the alternative?

• Deregulation
• Free market
• Competition
• Treat electricity as a commodity
Competition and privatization:

- Privatization is the process by which publicly owned utilities are sold by the government to private investors.
- Privatization is not a prerequisite for the introduction of competition.
- Public utilities can coexist with private companies in a competitive environment.
- In many cases, competition is accompanied with privatization.
Why Competition?

• Prices would be lower
• The overall economy will be more efficient.
  • Competing companies would choose different technologies.
  • Less likely to make unwise investment.
Can we treat electricity as a normal commodity?