

Game Aspects of Power Systems

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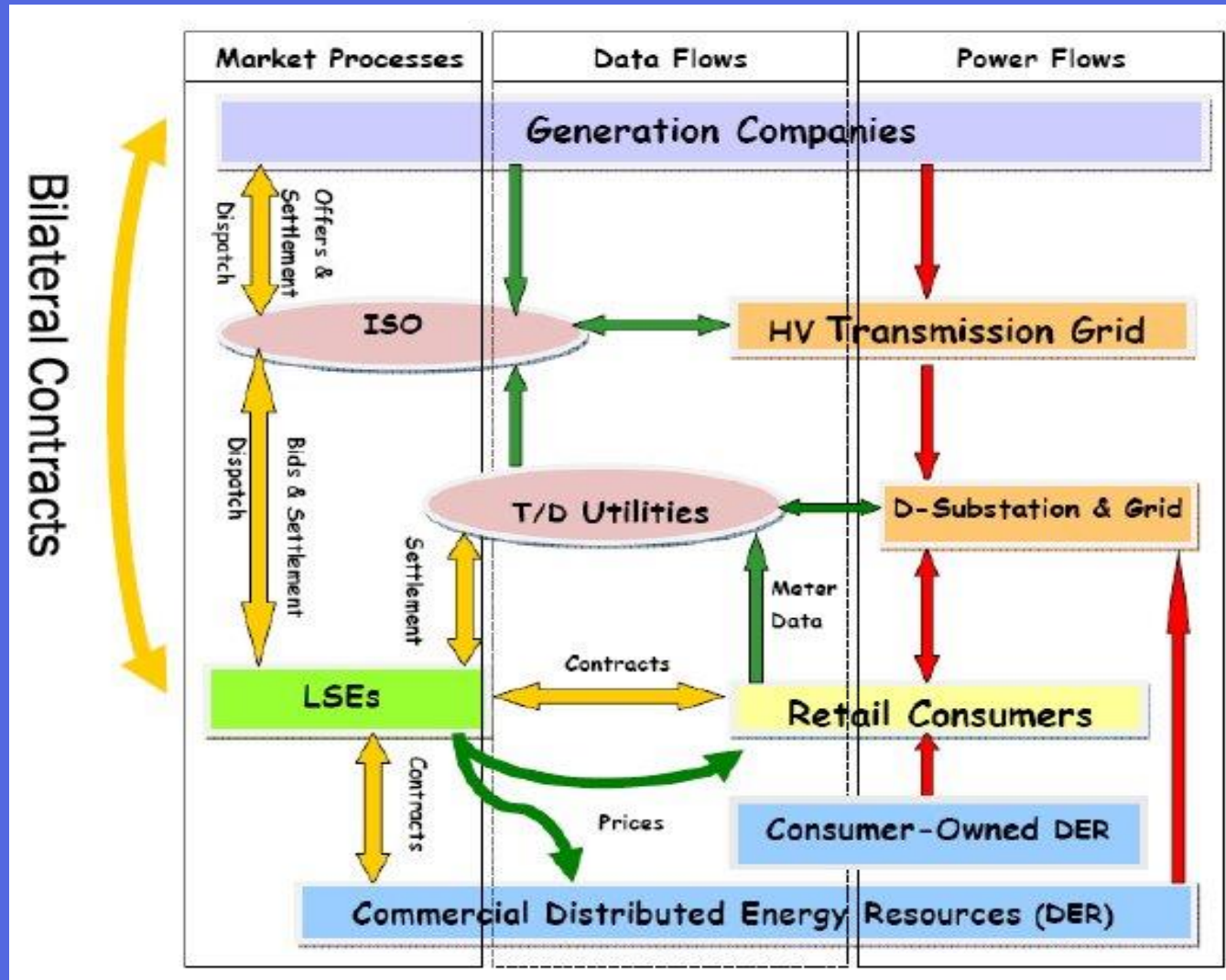
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Challenges Posed by Restructuring

- Traditional Organization (Vertically-Integrated Utilities)
 - Each VIU has operational control over gen, trans, & distribution in its franchised area, subject to regulatory oversight
 - Regulatory focus on reliability of system operations, not efficiency
- Restructured (Unbundled) Competitive Electricity System
 - Many types of participants, each controlling distinct aspects
 - Different perspectives, different objectives
- How to make the system work so that all participants are satisfied (i.e. objectives achieved to satisfactory degree)?

Power System as a Complex Dynamic Multi-Agent Game



Key Decision-Makers within the Machinery

- Private trading companies (GenCos, LSEs, Marketers,...)
- Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs)
- Private transmission companies (TransCos)
- Distribution Companies (DisCos)
- Retail consumers (households, commercial & industrial businesses)
- Regulators (e.g., FERC, NERC)

Generating Company (GenCo):

- Produces and sells electrical energy in wholesale market
- Owns and operates generating plants
 - Single plant
 - Or a portfolio of plants with possibly different technologies
- Often called an Independent Power Producer (IPP) when coexisting with a vertically integrated utility
- **Objective:**
 - Maximize **own** net earnings from sale of energy & other services

Note:

$$\text{Net Earnings} = [\text{Revenues} - \text{Avoidable Costs}]$$

Load-Serving Entity (LSE)

- Buys electrical energy on wholesale market
- Resells this energy “downstream” to retail consumers
- The consumers contracting with any one LSE can be spread over multiple buses & multiple distribution networks
- Typically does not own large physical assets
- Occasionally a subsidiary of a GenCo or a DisCo
- **Objective:**
 - Maximize **own** net earnings by “buying low and selling high”

Independent System Operator (ISO):

- Maintains the security of the system
- Should be independent from other participants to ensure the fairness of the market
- Usually runs the market of last resort (“real-time market”)
 - Ensures generation and load balanced in real time (adequacy)
- In U.S., an ISO typically also acts as a market operator, managing the operation and settlement of a day-ahead market (DAM)
- Owns only computing and communication assets
- **Objective:**
 - Ensure system reliability (security and adequacy)
 - Ensure efficient market operation (no wastage of resources)

Transmission Company (TransCo):

- Owns transmission assets such as lines, cables, transformers, and reactive power compensation devices
- Operates these assets according to instructions of an ISO
- TransCos are sometimes subsidiaries of companies that also own generating plants.
- An **Independent Transmission Company (ITC)** is a TransCo that does not own generating plants and that operates its own transmission assets (acts as its own ISO)
- **Objective:**
 - Maximize **own** net earnings

Distribution Company (DisCo):

- Owns and operates distribution network
- Traditional environment:
 - Monopoly for the retail sale of electrical energy to consumers in a given geographical area
- Competitive environment:
 - Operation and development of distribution network separated from the retail sale of electrical energy to consumers
 - Operation of distribution network remains a regulated monopoly
- **Objective:**
 - Maximize **own** net earnings

Small Retail Consumer (Typically Residential):

- Buys electrical energy from a retailer
- Leases wire connection from the local DisCo
- Market participation is usually limited to choice of retailer
- **Objective:**
 - Maximize **own** net benefits (i.e., benefits minus costs) from use of electrical energy

Large Retail Consumer (Commercial, Industrial):

- Often participates actively in electrical energy markets
- Buys electrical energy directly from wholesale market
- Sometimes connected directly to the transmission grid
- May act as a “demand response” resource for the ISO to help control the system (e.g., agree to have its demand curtailed under certain stated conditions)
- **Objectives:**
 - Maximize **own** net earnings

Regulators:

- Government bodies
- Determine or approve market rules
- Investigate suspected “market power” abuses (manipulation of prices for one’s own gain)
- Set or constrain the prices for products and services provided by monopolies
- **Objectives:**
 - Make sure that the overall electrical energy sector operates in a ***fair and economically efficient*** manner
 - Make sure the overall electrical energy sector operates in a ***reliable*** manner (security and adequacy)
 - Ensure quality of supply