ENGIE Brasil Energia

ELECTRIC POWER MARKETS
HOW TO FORECAST AND EXTRACT PERFORMANCE

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PROGRAM CONTENT

- Restructuring of the electric power industry: origin and reasons
- The 4 basic models: advantages and disadvantages
- Dispatch and price formation: where the market begins
- Functioning of an ideal market: price ceiling and investments
- The problem of calibrating supply: backing and energy to what end?

BIBLIOGRAPHY

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- Power System Economics – Designing Markets for Electricity
  - Steven Stoft
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  - Sally Hunt & Graham Shuttleworth
- Formação de Preços em Mercados de Energia Elétrica *(Price Formation in Electric Power Markets)*
  - Edson Luiz da Silva
- Mecanisms de Capacidade em Sistemas de Energia Eléctrica com Predominância de Geração Hidroelétrica (*Capacity Mechanisms in Electric Power Systems with Predominance of Hydroelectric Generation)*
  - Alexandre Zucarato
- Sundry articles


What are your expectations?



Restructuring of the electric power industry

Origins and reasons

THE BEGINNING

- Inefficient competition
  - Between 1887 and 1893, there were 24 power generating companies in Chicago, with overlapping distribution systems
- Establishment of a monopoly
  - Economies of scale and reduction in generation cost
- Vertical integration
  - The complexity involved in operating the electricity sector, more especially the transmission network, and the need to coordinate with generation resulted in the industry's vertical integration
- Regulation
  - Competition is inefficient and the electric power service is a natural monopoly
    - Reduction in the profits of the monopoly x Maintaining profits above the competitive level

WHY RESTRUCTURE?

- Regulation only resolves one problem at a time
  - Service by Cost
    - Maintains prices close to the long-term marginal cost, but does not induce cost reductions, since each innovation which reduces production costs will see its corresponding benefit captured and passed onto the consumer
  - Price Ceiling
    - Establishes limits for passing on cost, allowing production cost reductions to be captured by the producer, although price levels tend to be greater than the marginal cost
  - Trade-off
    - To adjust the price ceiling with some frequency (regulatory lag)

WHY RESTRUCTURE?

- The promise of perfect competition
  - Short-term equilibrium
    - Characterized by the market price and the amount sold
    - Price equal to the Marginal Cost
  - Long-term equilibrium
    - Is characterized when the revenue from a market is enough to recover all costs including the cost of capital
    - Profit is equal to zero
  - Economic Efficiency
    - Maintains prices equal to the marginal costs at the same time that it minimizes the total cost

WHY RESTRUCTURE?

- Barriers to restructuring
  - Presence of a natural monopoly
  - Industry is contingent on scale to be efficient
  - Physical and institutional impossibility of separating the transmission from generation given the degree of verticalization
- Pressures for restructuring
  - Technological developments
  - Reduction in the cost of expansion
  - Consumers raise the possibility of constructing their own generating capacity and choosing the supplier
  - A new paradigm: the electrical product should be sold separately from the transmission service

THE INITIAL DEVELOPMENTS (US)

- Public Utilities Regulatory Policy Act (PURPA 1978)
  - Introduced the idea of competition in the generation segment
  - Established that utilities should buy electricity from independent generators at prices equal to the avoided cost
  - Emergence of the Independent Power Producers (IPP)
    - Could not sell electricity to final consumers but to the local utility only
  - Overestimated avoided costs resulted in excess investment
    - Inclusion of competitive mechanisms in the eighties (PPA)
  - Growth of the IPPs indicative that competition in the generation segment was possible

THE INITIAL DEVELOPMENTS (CHILE)

- The Electricity Act (1982)
  - Based on international experiences
    - Unbundling of generation and distribution, with tariff at cost (UK)
    - Dispatch based on marginal cost (France)
    - Sale between generators for meeting contractual requirements (Belgium)
  - Breakup and subsequent privatization of Endesa
  - Introduction of competition in generation
  - Centralized dispatch by CDEC (*Centro de Despacho Económico de Carga*)
  - Non-discriminatory access to the transmission network
  - Creation of Captive Consumer and Free Consumer concept (>2MW)

THE INITIAL DEVELOPMENTS (UK)

- The Electricity Act (1989)
  - Break-up and privatization of the Central Electricity Generating Board (CEGB)
    - Generation
      - National Power (after being separated from Nuclear Electric)
      - PowerGen
    - Transmission
      - National Grid
  - Introduction of competition in generation
  - Local distributors would be responsible for the transmission service
  - Consumers could choose the supplier
  - Creation of a licensing regime
  - Creation of a regulatory agency
    - Office of Electricity Regulation (OFFER)

RESTRUCTURING AND PRIVATIZATION

- Restructuring
  - Alternative commercial arrangements for electricity supply
    - De-verticalization of the industry
    - Introduction of competition and choice
- Privatization
  - Switch from state to private ownership of assets

DE-VERTICALIZATION OF THE INDUSTRY

- Functional (or Accounting)
  - The costs of the activities are separated into distinct accounts
- Legal
  - The activities are performed by distinct companies even when controlled by the same owner through the medium of a holding company
- Structural
  - The control of the companies which perform the activities is exercised by separate owners



The 4 Basic Models

Advantages and Disadvantages

THE PRINCIPAL ELECTRICAL SERVICES

Group 1

- Generation
- Transmission
- Distribution

Natural Monopoly

- Commercialization
  - Wholesale
  - Retail

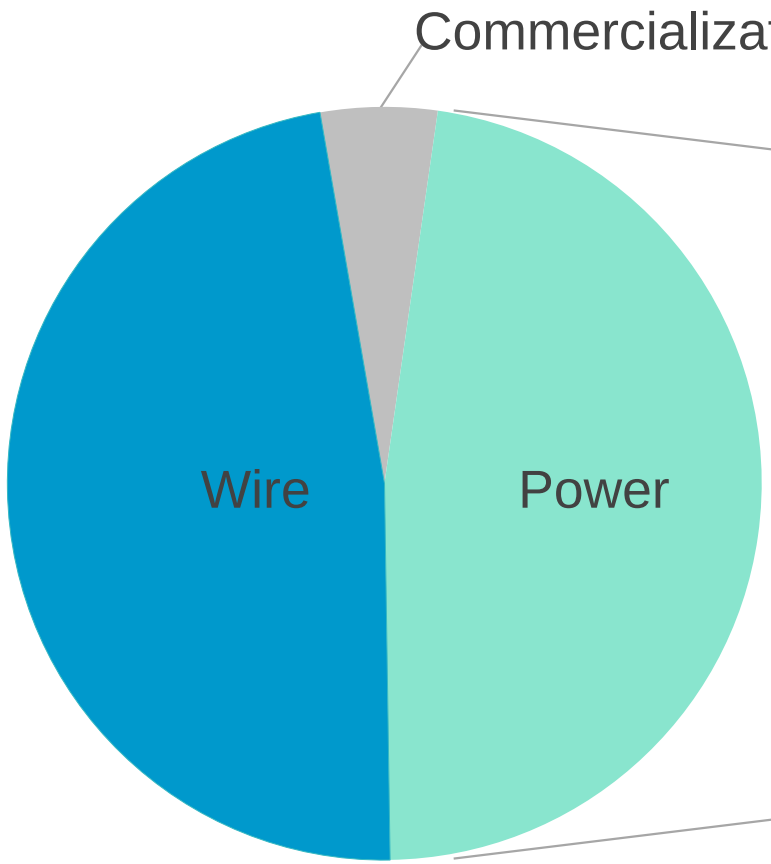
Group 2

- Operation of the System
  - Programming and Dispatch
  - Congestion Management
  - Ancillary Services

WAYS OF RENDERING SERVICES

- Regulated monopoly
  - A single company offers the service based on technical and economic regulation
- Competition by the market
  - The companies compete to offer the service
  - The service is provided based on technical and economic regulation
- Competition in the market
  - There are no barriers to companies rendering the service
  - The service is rendered based on technical regulation, but constitutes an economic activity for account and risk

COST STRUCTURE TO BE OPTIMIZED



- Investment
- Operation & Maintenance
- Cost of Capital

DEGREE OF COMPETITION AND CHOICE

- Four basic models
  - Monopoly
    - Generation without competition and without the option of choice for the consumers
  - Sole Purchaser
    - Allows competition in generation but consumer does not have the option of choosing a supplier
  - Competition in the Wholesale Market
    - Wholesale purchasers can choose their supplier, non-discriminatory access to transmission being required
  - Competition in the Retail Market
    - Retail purchasers can choose their supplier, non-discriminatory access to distribution being required

MODEL 1: MONOPOLY

- Characteristic
  - Verticalized monopoly at all levels without the ability to chose on the part of participants and reduced transition cost
- Advantages
  - Centralized planning may enable the expansion of minimum cost
  - Reduced cost of capital since consumers take the risks
  - Institutional simplicity
  - Major capacity to accommodate public policies
- Disadvantages
  - There are no mechanisms for challenging centralized planning
  - Decision maker does not suffer the consequences of decisions adopted
  - Consumers take industry risks

MODEL 2: SOLE PURCHASER

- Characteristic
  - New-entry generator compete for a long-term power purchasing agreement (PPA), subject to technical regulation. The sole purchaser may discriminate generators and/or create locational prices
- Advantages
  - Centralized planning may enable the expansion of minimum cost
  - Allows competition in order to reduce amount of investment
  - Reduced cost of capital since consumers take the risks
  - Large capacity to accommodate public policies
- Disadvantages
  - Decision maker does not suffer the consequences of decisions adopted
  - Consumers take industry risks (less construction risk)

MODEL 3: COMPETITION IN THE WHOLESALE MARKET

- Characteristics
  - New entry and existing generators compete to service the market. Wholesale consumers can choose their supplier
  - Presence of an independent system operator for buyers and sellers, responsible for maintaining frequency and voltage and a wholesale market permitting the purchase and sale of electricity
  - Creation of spot and future contracts, rendering of ancillary services and use of the transmission installations
  - Investment level, energy matrix, location, maintenance and disinvestment are market choices and require appropriate economic indicators
- Advantages
  - Allows competition between existing and new entry generators, with pressure to reduce the value of the investment and operational cost
  - Market and technological risk reverts to the generators
  - Contracts become more financial than physical
- Disadvantages
  - Greater cost of capital (since there is a greater risk)
  - Greater institutional complexity and an increase in transactional cost
  - Limited capacity to take on board public policies

MODEL 4: COMPETITION IN THE RETAIL MARKET

- Characteristics
  - Similar to Model 3, with all consumers able to choose their own supplier
  - Creation of the contracts of use of distribution and the retailer
- Advantages
  - In addition to the advantages of Model 3, allows competition between existing and new-entry traders, with pressure to reduce purchasing costs and to improve service levels
  - Empowerment of the consumer
  - Ease of incorporating distributed energy resources
- Disadvantages
  - Besides the disadvantages of Model 3, the institutional complexity and transactional costs grow exponentially
  - Pressure for efficiency is dependent on the credible threat that the consumer can effectively switch supplier

Dispatch and Price Formation

Where the market begins



MARKET ARCHITECTURE

- This is a map of the various “sub-markets” which constitute the electricity market
- Each “sub-market” may be classified by type
- The different “sub-markets” are linked from the economic point of view, whether explicitly or implicitly (arbitrage)



THE SYSTEM'S OPERATIONAL SERVICES

- Need to organize 3 basic functions of the industry
  - Programming and Dispatch
    - Short-term selling of electric power
  - Congestion Management
    - Allocation of the use of the transmission network
  - Ancillary Services
    - Instantaneous equilibrium between supply and demand

DISPATCH MODELS

- Centralized Dispatch or Pool
  - System operator
    - Normally independent with no assets (ISO)
  - Generation programming
    - Established by the operator with a view to minimizing the operational cost of the system, dispatching plants according to order of merit
      - Cost based (tight pool)
      - Price based (loose-pool)
  - Price
    - The short-term price reflects the physical dispatch of the system
  - Contracts
    - The contracts are financial instruments for reducing the agents' exposure to spot price volatility

CENTRALIZED DISPATCH VARIABLES

- Tight Pool – Cost based
  - Thermoelectric generators state their costs and availability
    - Hydroelectric generators have their cost (value of the use of water resources) calculated by the operator
  - The plants are “stacked” in increasing order of cost (order of merit) until demand is fully satisfied
  - The marginal resource is the equilibrium price (spot price)
- Loose Pool – Price based
  - Generators offer the amounts and respective prices at which they are prepared to generate electricity
  - The plants are “stacked” in increasing order of price (order of merit) until demand is fully satisfied
  - The marginal resource is the equilibrium price (spot price)



Functioning of an Ideal Market

Price ceiling and Investments

STRUCTURAL ASPECTS

- Technology
  - Cost structure of the market is determined by the energy matrix
- Concentration of production
  - The more concentrated a market, the greater the possibilities of exercising market power
- Elasticity of demand
  - First demand fault
  - Requires the installation of meters in real time and real time pricing
- Level of reliability
  - The second demand fault results in supply and demand curves not intersecting during moments of scarcity
  - Load cut and a price ceiling must be established
  - The spot market is a critical factor in establishing investment levels in generation

“BASIC MARKETS”

- Is the electric power market where the short-term price is the principal factor driving decision making both in the short- as well as long-term
  - The contracts’ market exists and is also a factor in driving decision-making, albeit the contracts are always derivatives of the short-term price

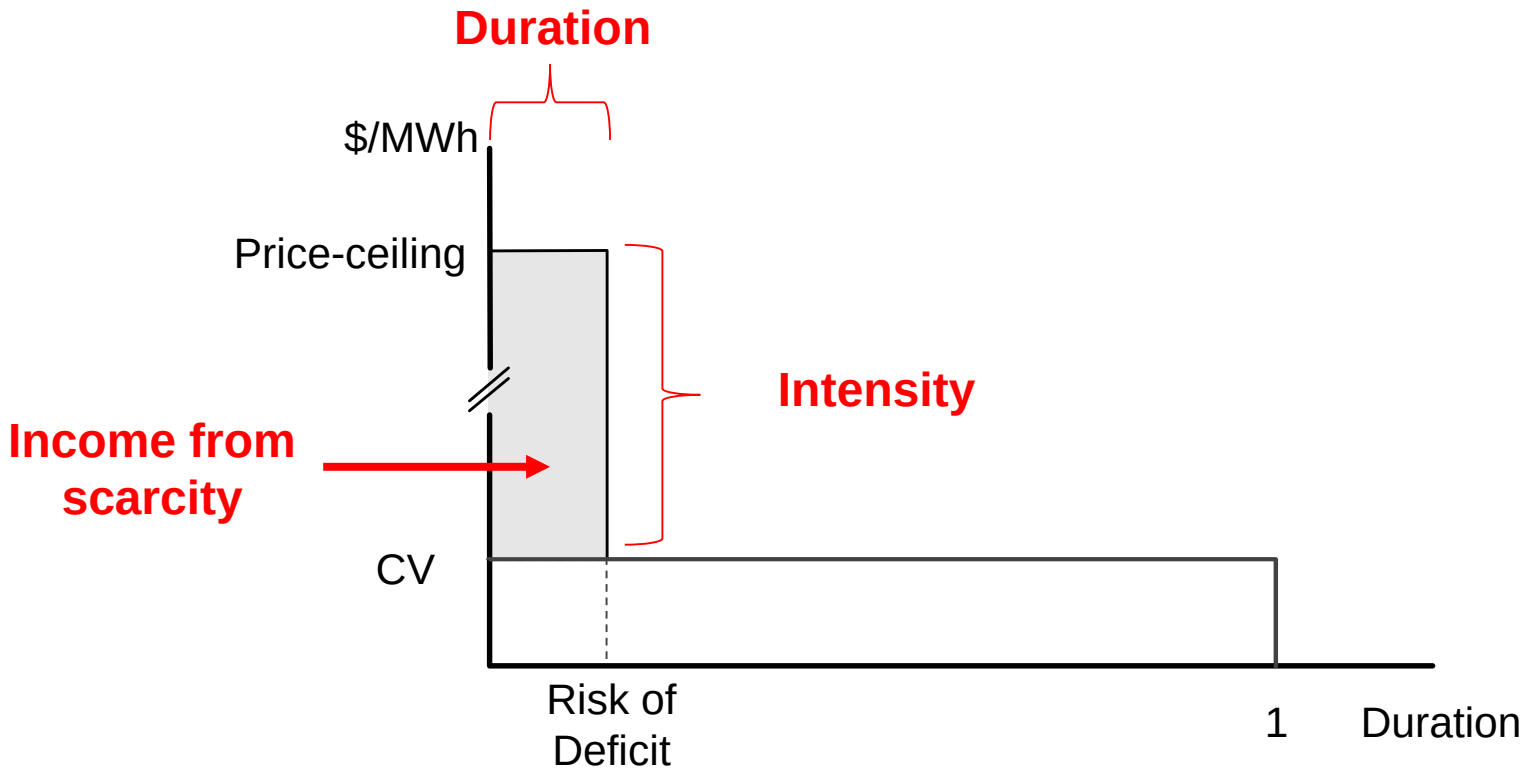
HOW SHOULD THE MARKET OPERATE?

- Why will the competitive price recoup fixed costs?
  - If the price fails to recoup fixed costs
    - Investors will not build new generators
    - Increased demand will raise prices
  - If the price generates more income than is necessary
    - New investors will build generators to harness this income
    - With greater offer the price will fall
- Price spikes will allow the recouping of fixed costs
  - Portion of accumulated distribution of the spot price which exceeds the marginal cost of the most expensive plant

PRICE SPIKE

- Important characteristics
  - Duration
    - Fraction of time when there is scarcity
  - Intensity
    - The value of the price in periods of scarcity
  - Income from scarcity
    - Revenue associated with periods of scarcity
- Condition of long-term equilibrium
  - Zero profit
- Recouping fixed cost
  - Installed capacity is increased until there is no more income to be extracted from the market
  - The market is also able to establish the amount of investment required for each type of generation source

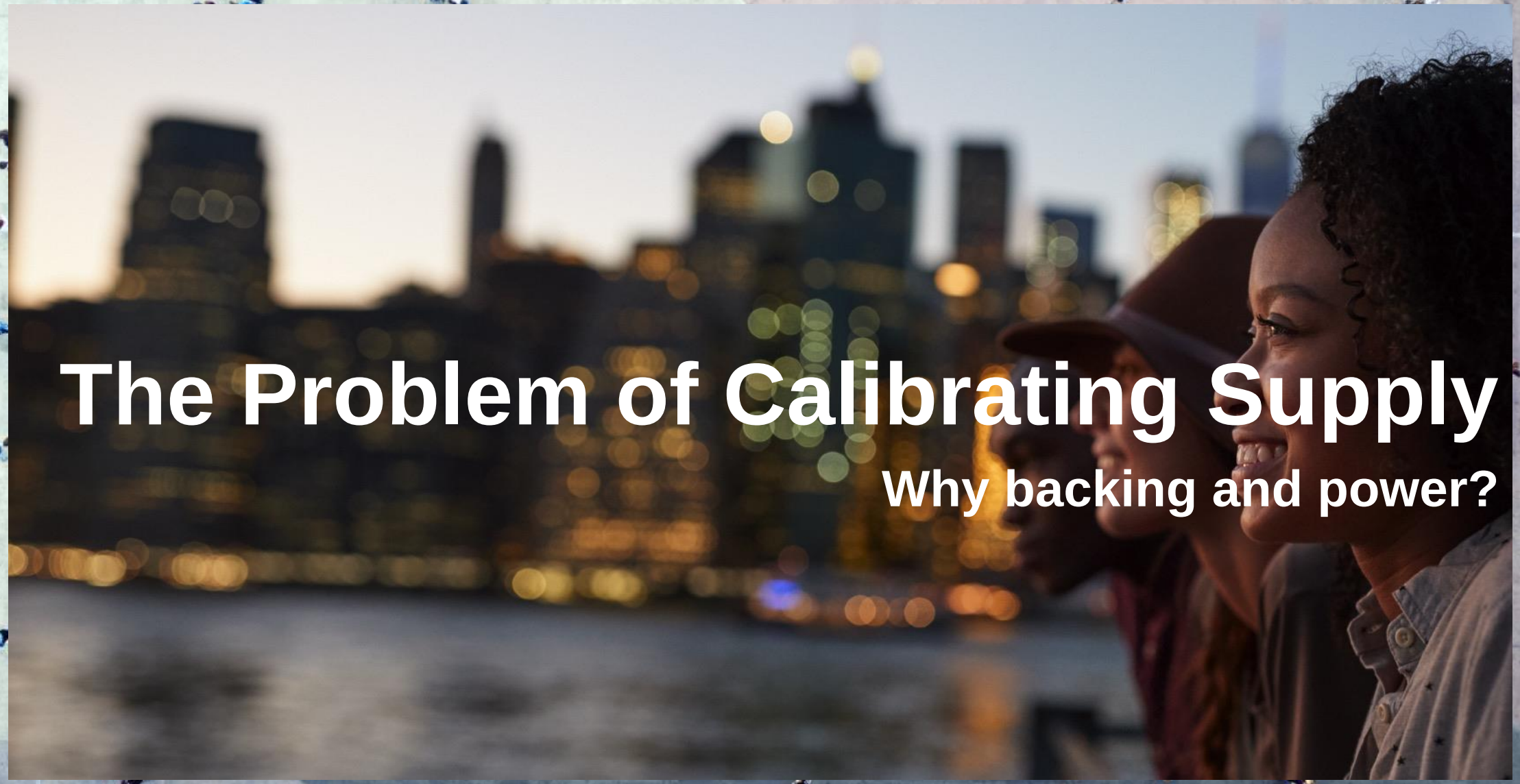
PRICE SPIKE



Reliability < 100% !!!

“BASIC MARKETS”

- Deficiencies
  - Imperfect competition
    - Possibility of exercising market power
  - Incomplete information
    - Absence of historical data for estimating price distribution
  - Regulatory risks
    - Credibility in the maintenance of the rules
- Even under ideal conditions...
  - Antagonistic objectives: reliability x volatility
    - Inverse relationship between Risk of Deficit and Price Ceiling
  - Investment cycles
    - Investment does not take place on a sustained basis
  - Reliability is a public asset
    - Absence of economic indicators for supply reliability based on private decisions



The Problem of Calibrating Supply

Why backing and power?

SECURITY X ADJUSTMENT

Security of supply

Capacity of an electric power system to support sudden faults such as short circuits and/or equipment downtime

Operational Horizon

Adjustment of supply

Capacity of an electric power system to meet demand assuming a given supply criterion

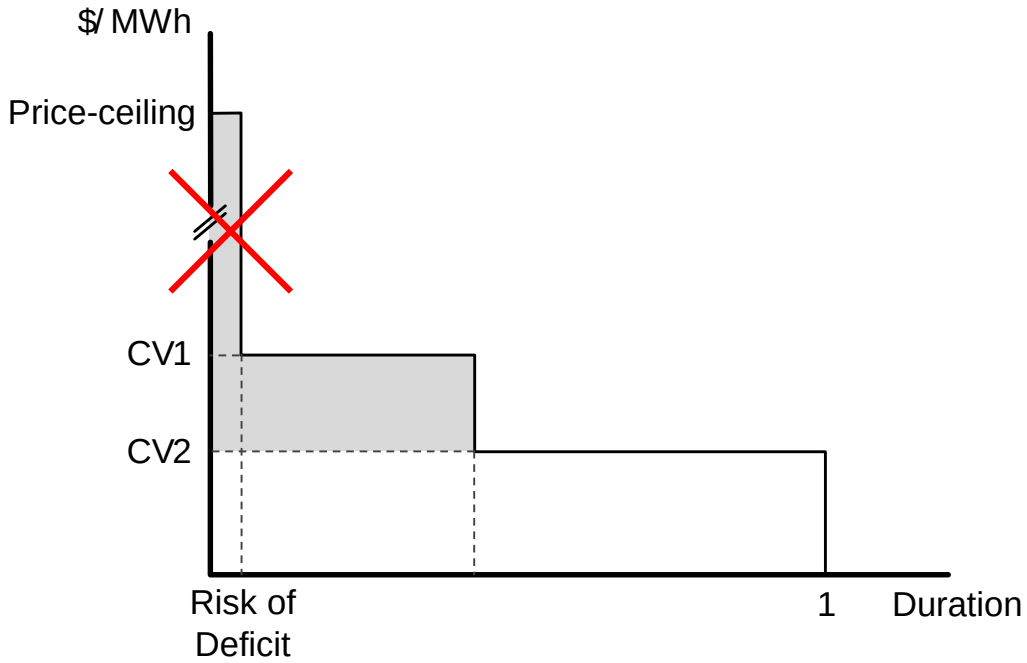
Expansion Horizon

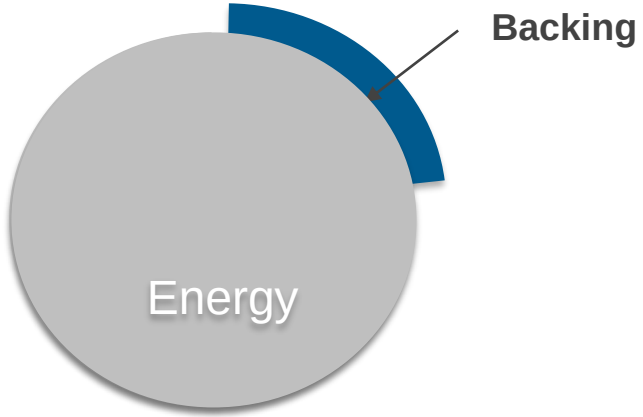
SUPPLY ADJUSTMENT MECHANISMS

- Objectives
  - To supply more stable revenue flows to generation agents
  - Recouping of fixed cost is independent of price spikes
  - Reliability requirement decoupled from the energy market price ceiling
- Advantages
  - Reduction in revenue volatility
  - Reduction of the space for exercising market power
- Complementation of the short-term price indicator should induce the exact amount of investments
  - Neither more nor less
- Parameters should be correctly calibrated
  - The additional revenue should be exactly equal to the portion of the fixed cost not recouped in the short-term market

SUPPLY ADJUSTMENT MECHANISMS

- Introduction of complementary economic indicators to the short-term price
- Principle of functioning
  - Substitution of part of the short-term market revenue which is uncertain and associated with scarcity, for a controllable and predictable cash flow





SUPPLY CRITERION



Thermoelectric systems

- Aversion to capacity deficit risk
- Investment in plants to the point where available capacity is sufficient to meet peak demand plus a margin
- $P_{Avail} = 1.05 \times D_{Max}$



Hydroelectric systems

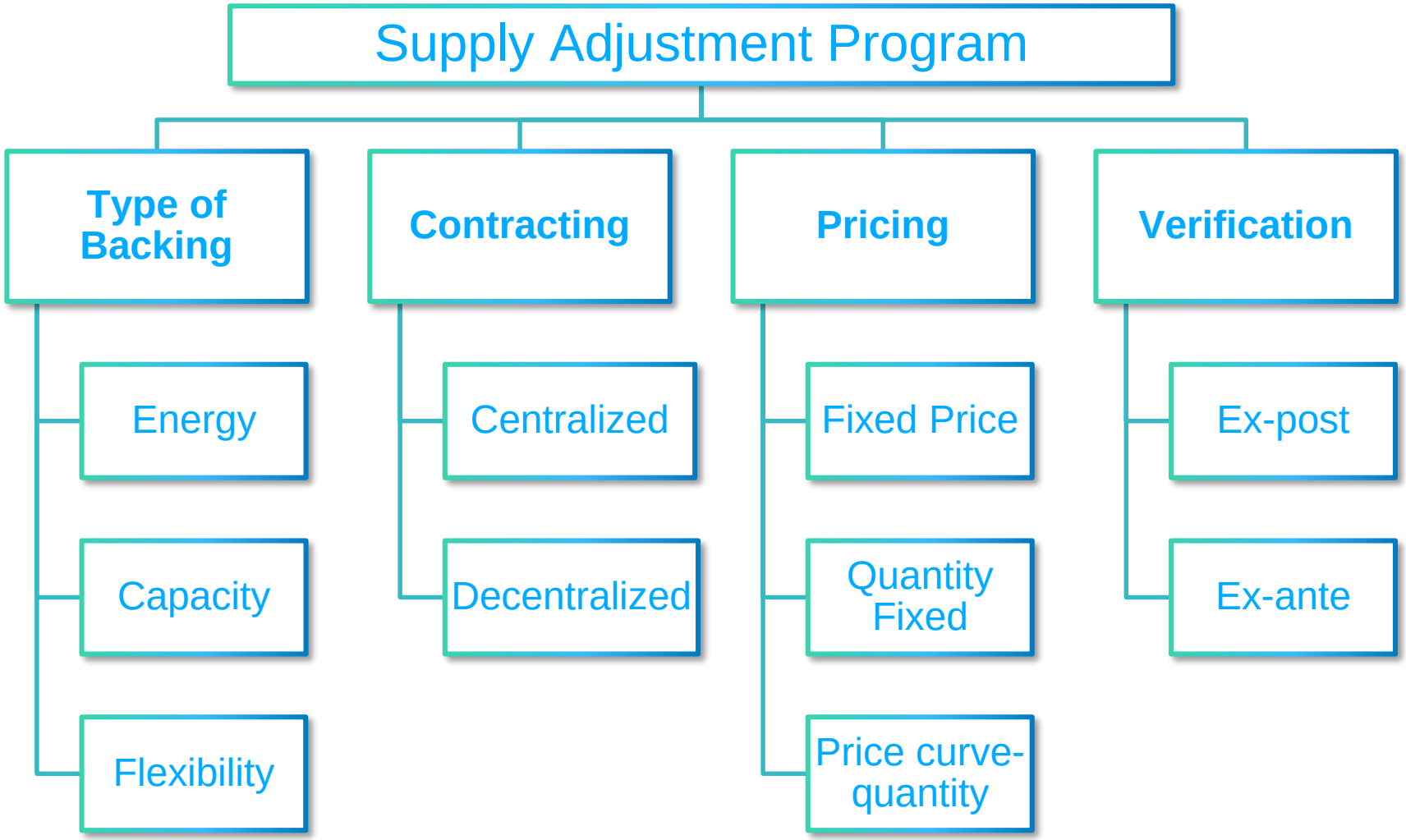
- Aversion to power deficit risk
- Investment in plants until the provision of energy load at a certain level of risk is guaranteed
- E_{Ass} = Load



ERNC systems

- Aversion to flexibility deficit risk
- Investment up to which the continuity of supply is guaranteed in the light of a given scenario of disequilibrium
- $Flex_{Operative} > Flex_{Critical}$

THE VARIABLES OF MARKET DESIGN



Thank you!

