Course on Energy Economics

Stylized Facts: Electricity Markets

Natalia Fabra
Universidad Carlos III de Madrid

The Electricity Industry

Where electricity comes from

Interactive description of the electricity industry

Real time demand in the Spanish electricity industry

Seasonal demand in the Spanish electricity industry

Real time supply in the Spanish electricity industry

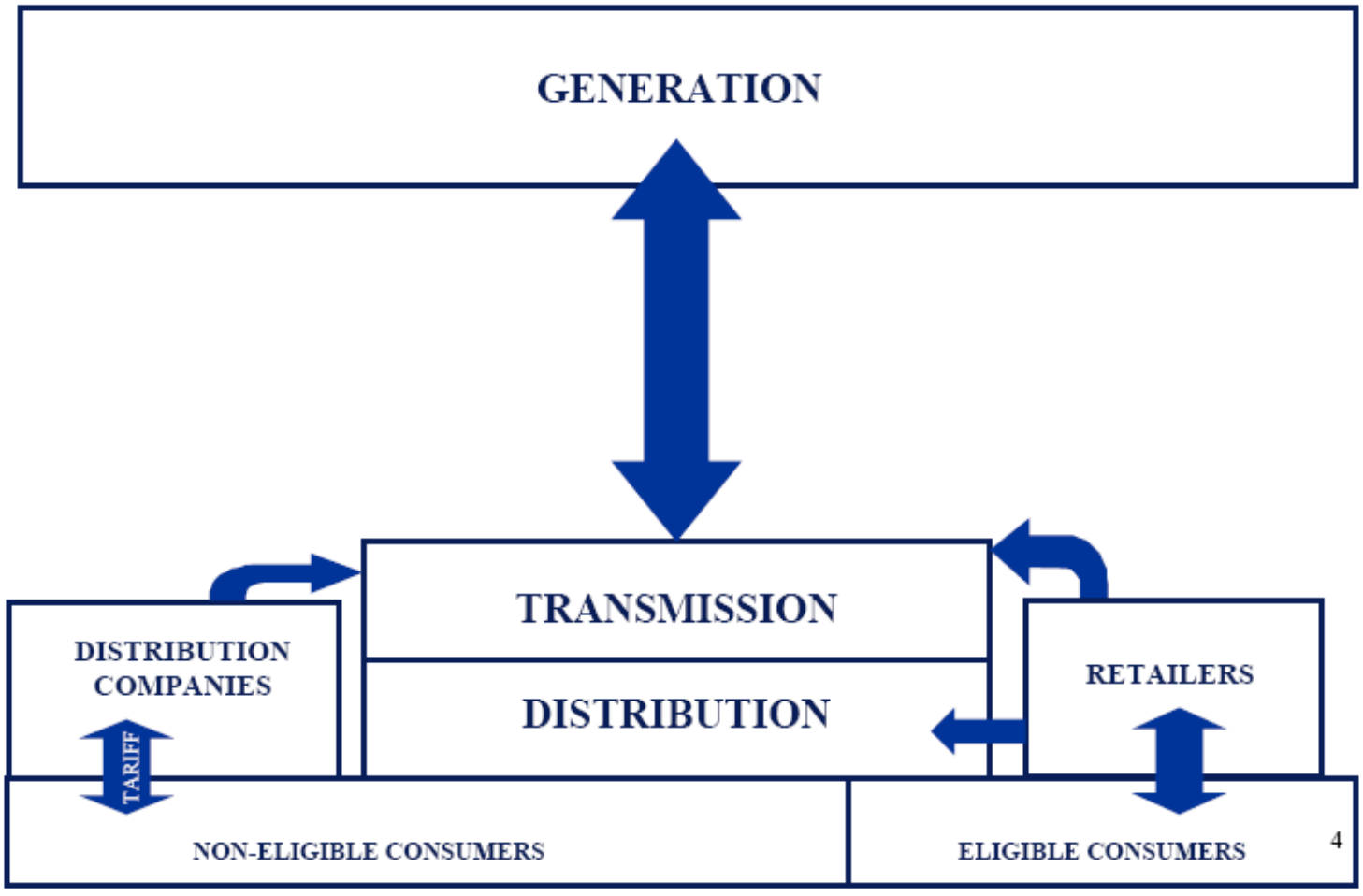
Real time wind production

The Spanish electricity market operator

Introduction

- **Wave of reform** in the electricity industries world-wide:
  - Britain, Norway, Sweden, the United States, Australia, Spain, Canada, New Zealand, Colombia, Argentina, The Netherlands, Chile, Italy...
- Some **common features of the reforms**:
  - Breaking up of the formerly vertically integrated companies
  - Unbundling of generation, transmission, distribution and retailing
  - Arrangements to govern transmission access
  - Reliance on spot markets or/and vertical contracting
- **Ongoing reform to address triple challenge**:
  - sustainability (renewables+energy efficiency), security of supply, affordability

The Electricity Industry



Roadmap

An overview of electricity markets in practice

1. Why is electricity special?
2. What are the implications?
3. Electricity market design
4. What are the key questions today?

Why is Electricity Special?

- **Electricity is non-storable**
  - Demand must be **instantaneously balanced** with supply at every point in time, at very location over the network.

Implications

- Since demand and supply imbalances cannot be easily accommodated and could cause disruptions in the entire system (blackouts), a **central coordinator** is needed to maintain electrical equilibrium and...
- The market needs to provide **adequate reserve capacity** and ensure that extra generating capacity is always available
  - Because blackouts can impose large externalities, the provision of reserve capacity has important **public good** characteristics
  - If there is no separate market or payment for new installed capacity, **private generators are not likely to build plants** that will be rarely utilized

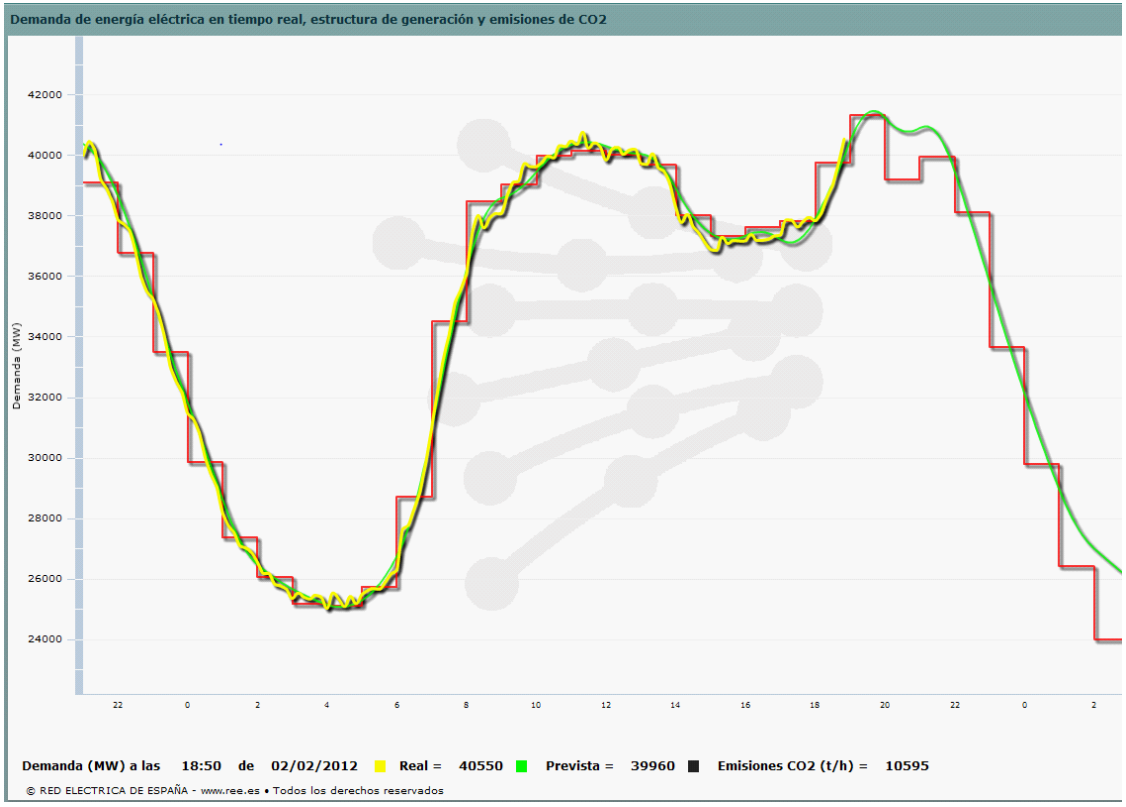
Why is Electricity Special?

- Demand is **highly variable** over the day and has strong **seasonal** components
- Demand is **highly inelastic** in the short-run
  - Demand elasticity is **constrained by the installed equipment**
  - Furthermore, electricity tariffs to final consumers typically **do not change in real-time** as wholesale electricity prices vary
  - Even when they do, hourly price differences do not typically induce consumers to pay attention to hourly prices to respond accordingly

Implications

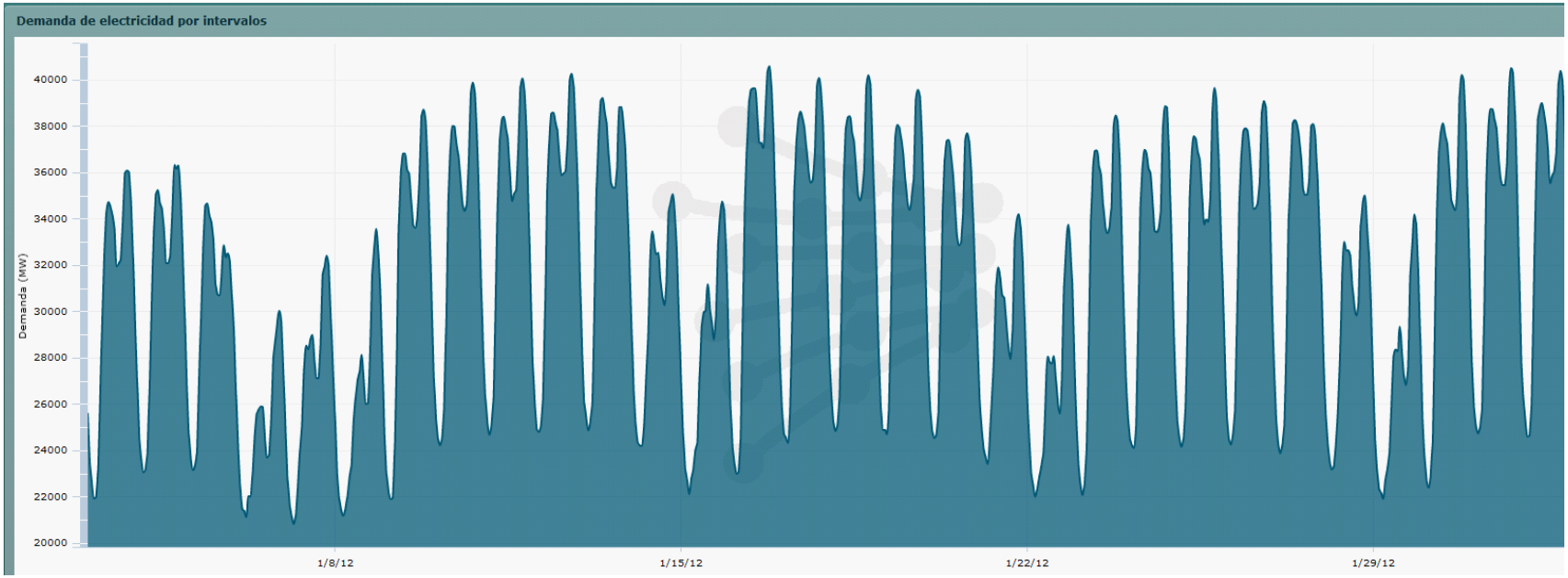
- **Market power concerns**
  - At periods of low demand, there is excess capacity and typically strong competition among producers
  - ...while at periods of peak demand, firms face no competition from rivals, the lack of demand elasticity does not contribute to stop firms from raising prices
- Need to maintain excess capacity
- **Demand rationing** occurs when there is insufficient capacity

Electricity demand over the day



Source: www.ree.es

Electricity demand over the week



Source: www.ree.es

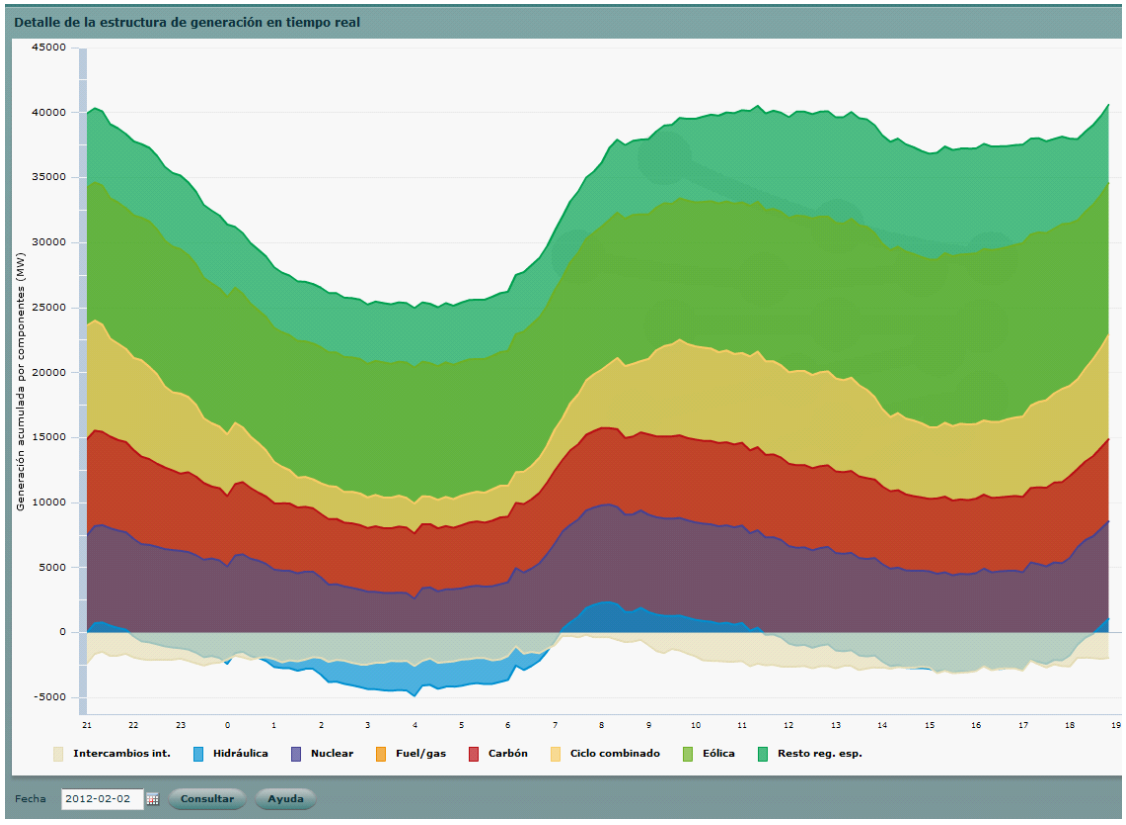
Why is Electricity Special?

- Coexistence of **several production technologies** that produce a completely homogenous good, and they are all subject to capacity constraints
  - Inverse relationship between fixed and marginal costs: renewables, nuclear, coal, combined cycle turbines, gas, fuel, (and hydro)
  - Very different characteristics: intermittency of renewables, carbon emissions of thermal plants, storability of hydro

Implications

- Competition typically takes place among the **marginal units**, so that concentration within technology families is relevant to assess market power
- In the absence of free entry, the marginal cost of the marginal technolgy need not reflect the average costs of all technologies in the market

Multiple Technologies



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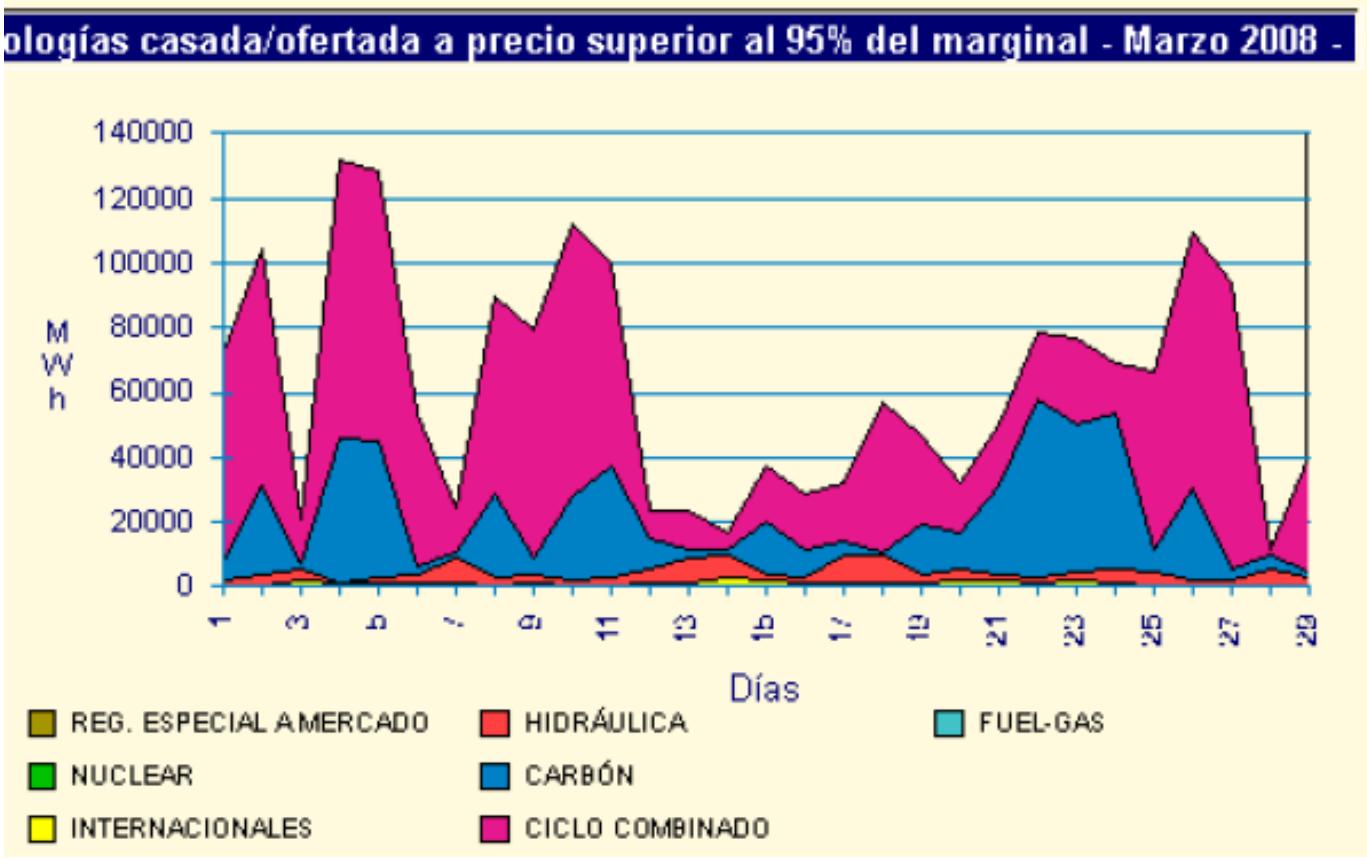
Marginal Technologies



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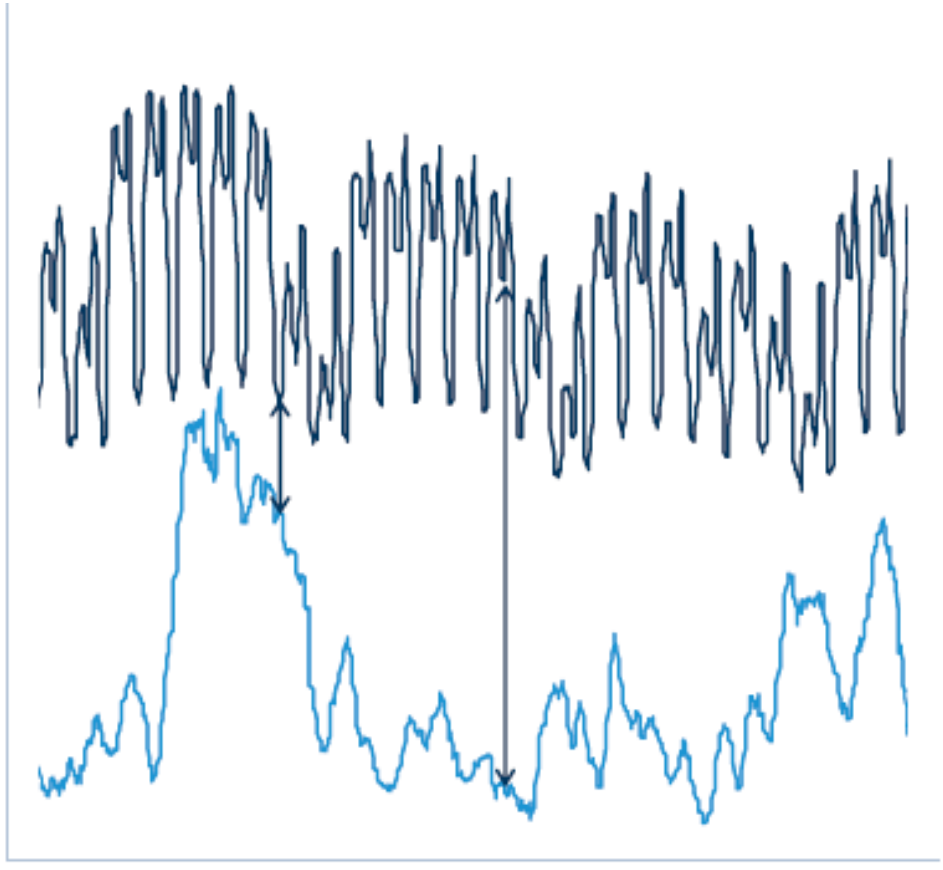
Renewables are intermittent



Electricity demand and renewables production

Why is Electricity Special?

- All electricity must be delivered through the **transmission network**
  - ...and there is usually no way to distinguish the KWhs produced by each firm (no surprise they are called *electricity pools*!)

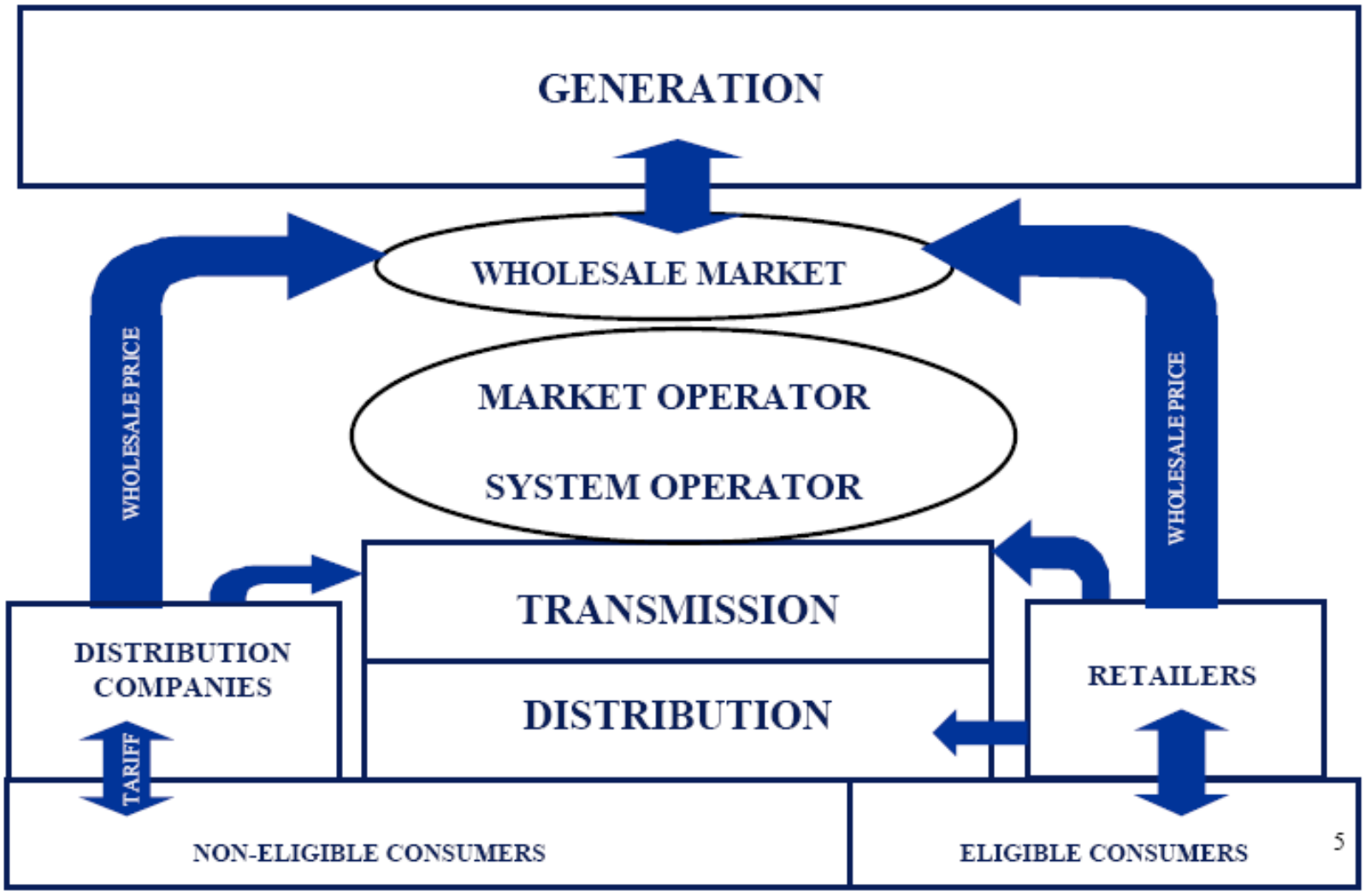
Implications

- The **definition of the relevant market** changes over time: local pockets of market power where firms that are small on the aggregate could become monopolists facing inelastic demand
- Competition cannot come from abroad unless interconnection capacity is increased to a large extent (**national markets**)
- Great importance of **pricing rules under congestion**, as well of arrangements for access and pricing of network facilities
- Extra value of transmission expansion: mitigation of market power

Market Design

- **The wholesale market design**: The central coordinator functions as a market maker and serves as a central exchange for most transactions.
  - Examples: initial UK design, California, Spain, etc.
- **The bilateral market design**: The central coordinator takes a more passive role, simply accepting schedules of parties that negotiate bilaterally. It also ensures that the system remains in balance.
  - Examples: current UK design, Texas, etc.
- Regardless of whether the central coordinator takes a more active or more passive role, electricity markets are organized through **auctions.**

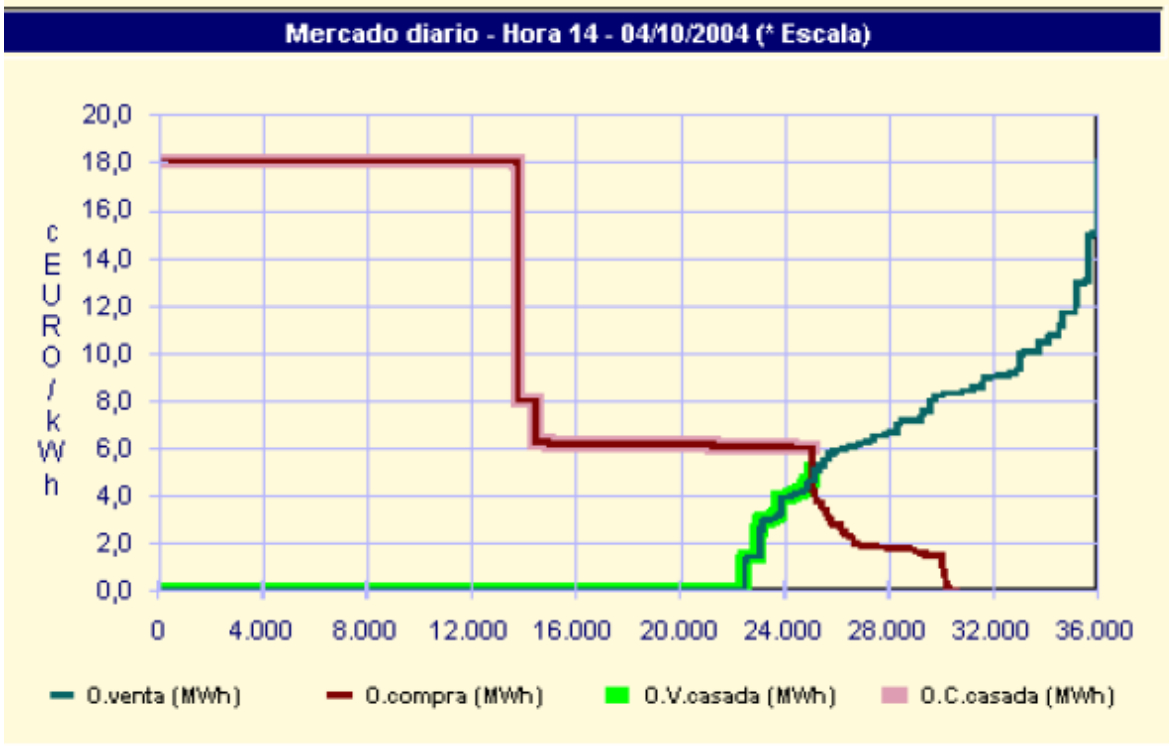
The Wholesale Market Design



The Wholesale Market Design

- Generators submit **supply schedules** and distributors and retailers submit **demand schedules** to the Market Operator (MO)
- The MO constructs the **industry supply and demand curves**, and determines the **market clearing price** (SMP)
  - Production (demand) allocated to units below (above) SMP
  - **Uniform-price auction**: all accepted units receive (pay) SMP
  - The System Operator studies the technical feasibility, and re-dispatches
- **Short-term markets** and markets for operational reserves:
  - Market participants can fine-tune their positions
  - The System Operator balances the system **close to real time**

Supply and Demand Functions



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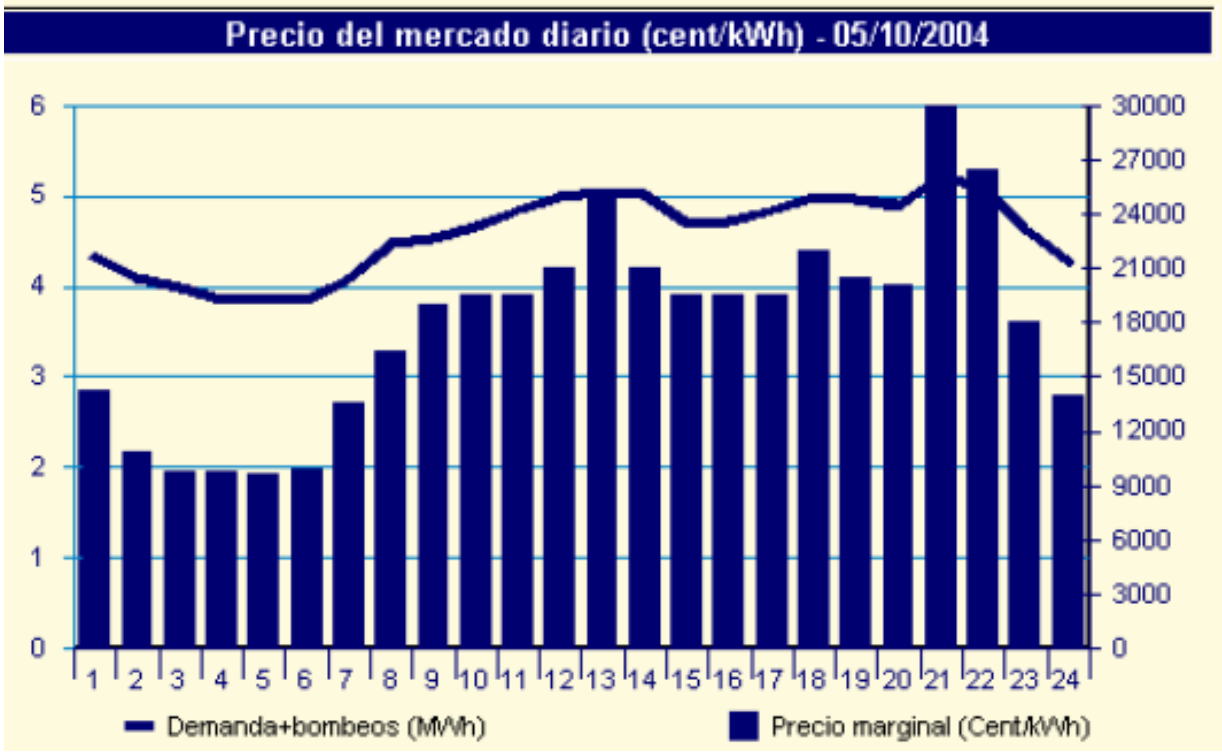
Demand and SMP over a Day



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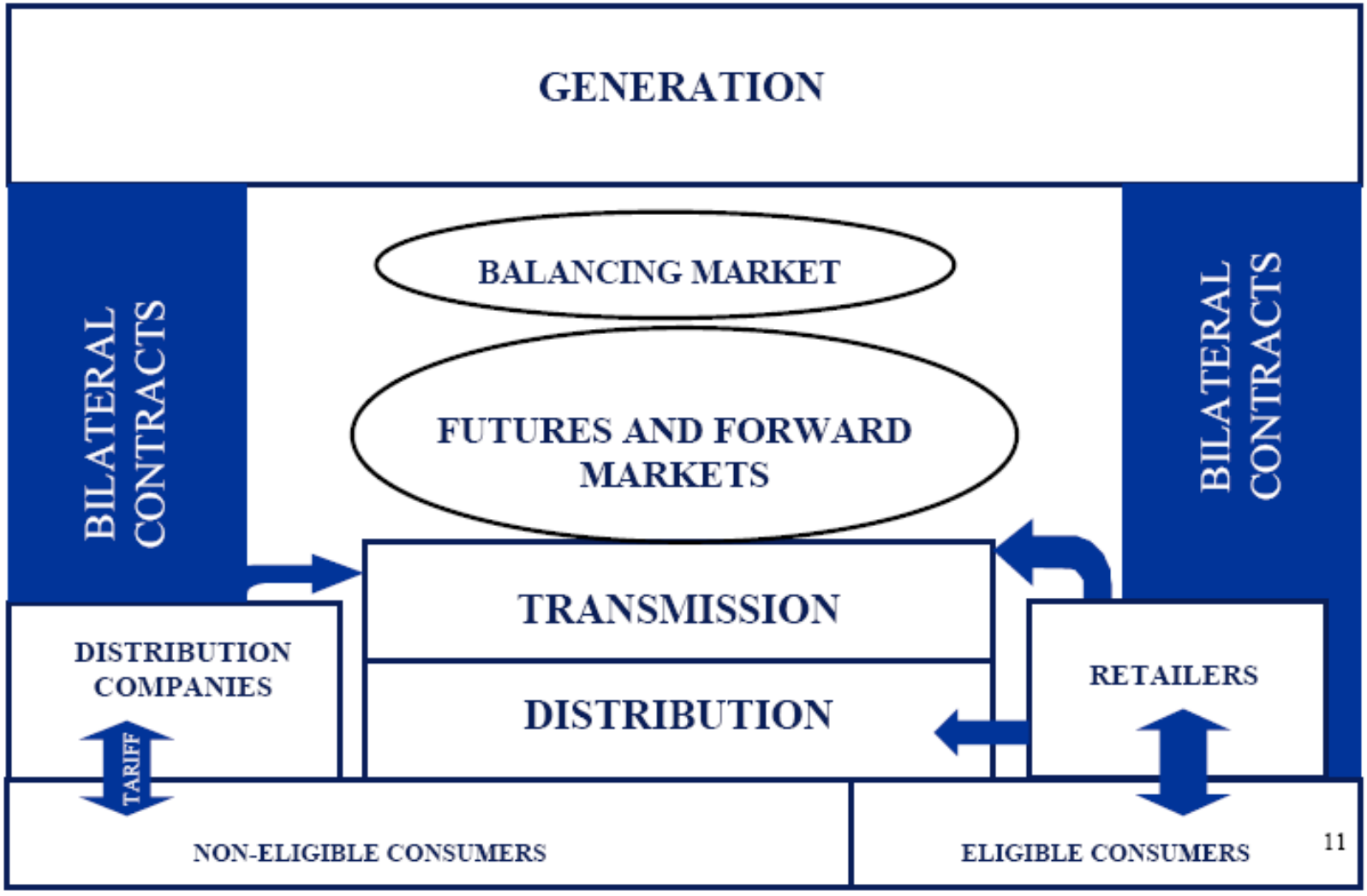
The Bilateral Trading Design



The Bilateral Market Design

- Based on bilateral trading between generators, suppliers, traders and customers:
  - Physical contracts
  - Forward and futures markets (even years ahead)
  - Short-term power exchanges
- **Balancing Mechanism:**
  - The System Operator, accepts Offers and Bids to balance the system
  - In the UK, the auction format is of the discriminatory type
  - Settlement Process for charging participants for deviations

Suggested Readings

- Borenstein, S. (2002) "The Trouble with Electricity Markets: Understanding California's Restructuring Disaster," *Journal of Economic Perspectives* 16.
- Borenstein, S. (2000) "Understanding Competitive Pricing and Market Power in Wholesale Electricity Markets," *Electricity Journal* 13(6), 49-57.
- Griffin, J. and Puller, S. (2005) "A Primer on Electricity and the Economics of Deregulation" Electricity Deregulation: Choices and Challenges, Griffin and Puller, eds. University of Chicago Press.
- Joskow, P. (2007) "Lessons Learned from Electricity Market Liberalization," mimeo, MIT.
- Newbery, D. (2005) "The Quest for a Satisfactory Wholesale Market Design," *Energy Journal, 43-70.*
- *Newbery, D. (2011) "Reforming Competitive Electricity Markets to Meet Environmental Targets," *EPRG Working paper.*
- *Wolak, "Regulating Competition in Wholesale Electricity Supply," NBER Working paper.

Suggested Readings (Reports)

- DECC (2011) "Planning our electric future. A White paper for secure, affordable and low-carbon electricity," available at www.decc.gov.uk.
- EU Commission (2011) "A Roadmap for moving to a competitive low carbon economy in 2050"
- OFGEM (2009) "Project Discovery," available at www.ofgem.gov.uk.