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Spanish (Iberian) Power Market

February 26, 2024

orge Bircher Aguirre

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- Main Characteristics of the Spanish Power Sector
- Brief Evolution of the Spanish Power Market
- Wholesale Electricity Market
- European Common Electricity Market
- Challenges and way forward

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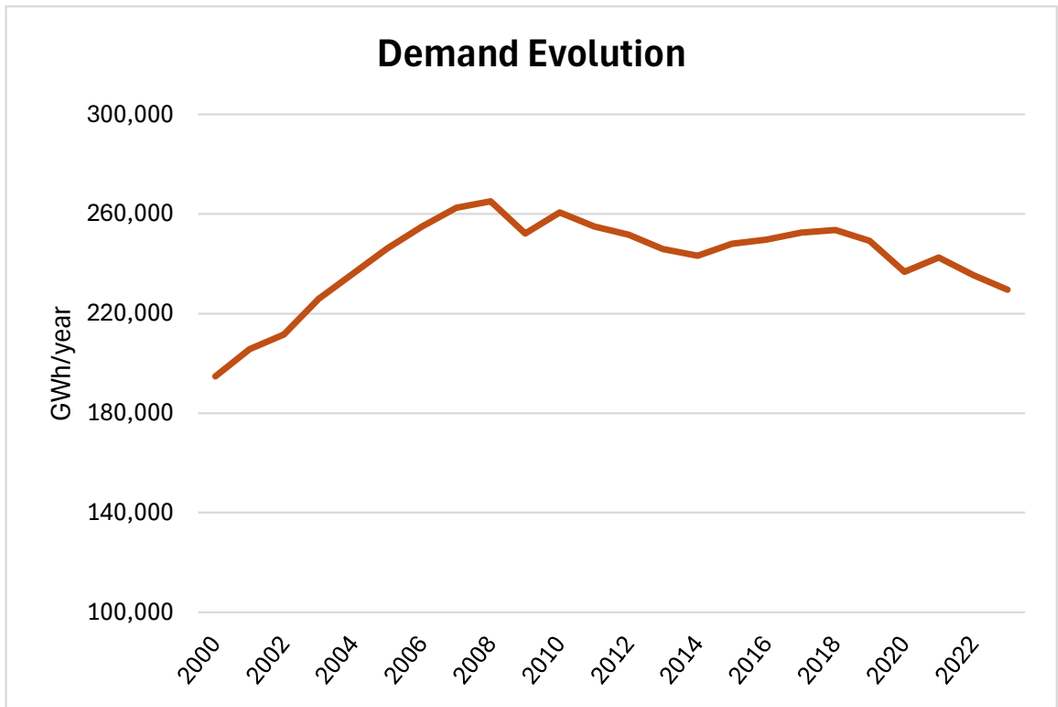
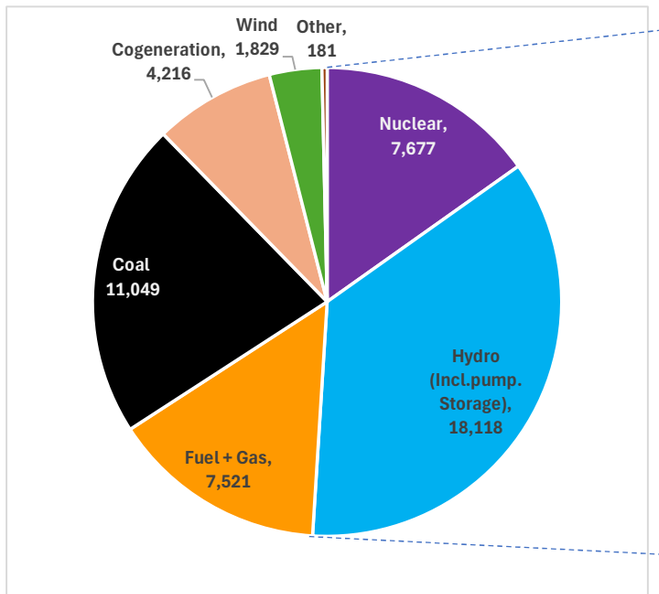
Spanish Demand Evolution (2000 - 2023)

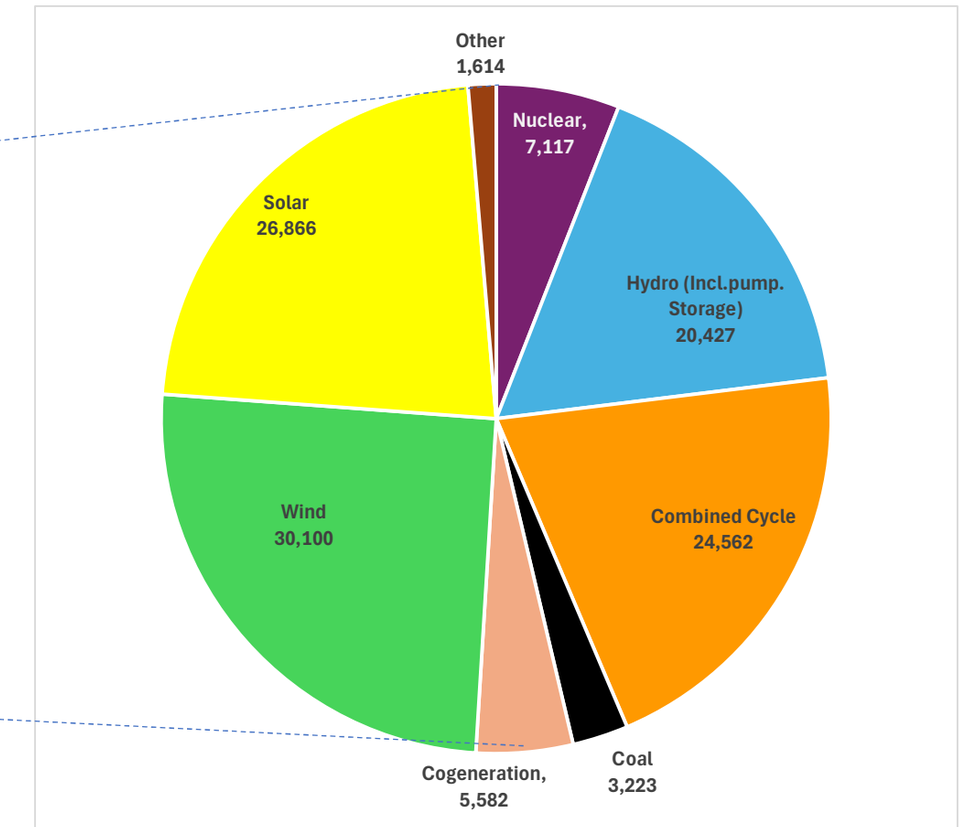


- Demand grew during 2000 and 2008 at a CAGR of about 3.9%/year
- In the last 10 years overall demand (seen by the power sector) is declining at a rate of about -0.9%/year.
  - Combined effect of increased energy efficiency and self-generation (mainly solar PV)
  - More pronounced in last 5 years (-2%/year declining)
  - It is expected that this tendency will continue in following years

Installed Capacity in Spain (Peninsular System)

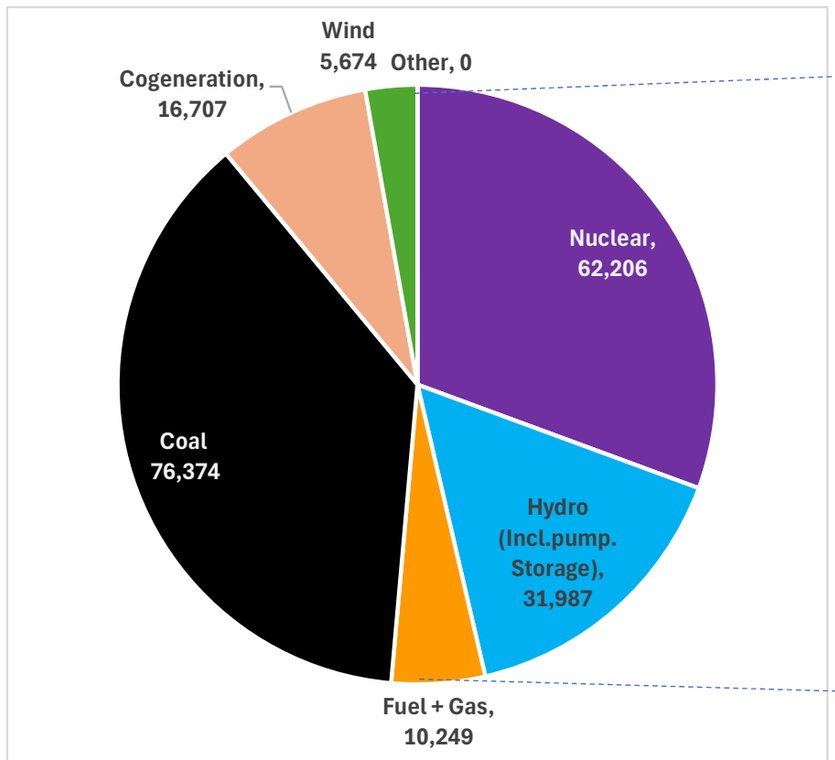


2000 – 50,594 MW

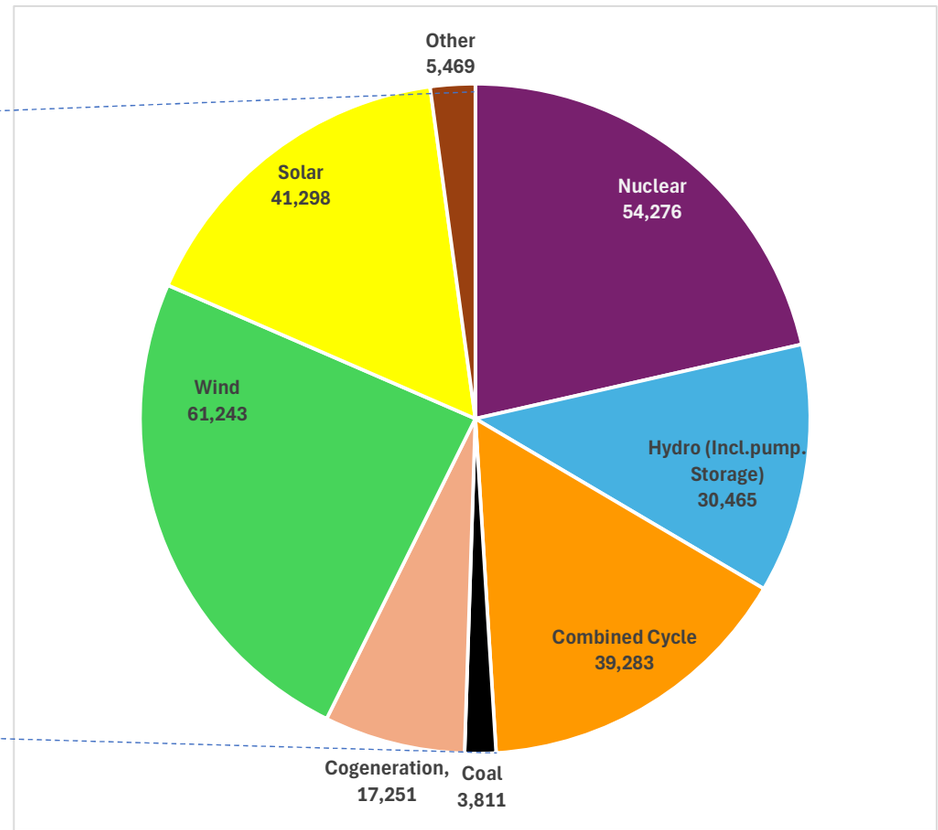


2023 – 119,491 MW

Energy Generated (Peninsular System)



2000 – 203,197 GWh



2023 – 253,095 GWh

Spanish Transmission System

Spanish Distribution Companies

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Regulatory Situation before Restructuring (1983-1998)

- 1983
  - Establishment of the “Legal Stable Framework” (Marco Legal y Estable – MLE)
    - Agreement between the private integrated companies and the goverment to establish a stable framework for the Spanish power sector
    - Maintained without significant variations until 1997
    - Main characteristics
      - Electricity companies remain privately owned
      - Creation of Red Electrica de España (owner of the transmission system and in charge of the economic dispatch)
        - ✓ Considered economic dispatch as a state responsibility
      - Agreement on the principles for establishing tariffs
        - ✓ The most important principle is that each company should be enabled to recover “standard costs”
      - Establishment of a National Energy Plan
        - ✓ Future developments of the generation system is decided by the state
        - ✓ “Beauty contest” among the different companies to implement the decided plan
      - Uniform tariff for the whole territory
        - ✓ Compensation system among companies to recognize the differential costs among them

Regulatory Reform (1997)

- 1997
  - A new electricity Law was passed, changing totally the existing regime
  - Most relevant aspects of the new electricity law
    - Competition in generation
    - Establishment of Open Access principle to the transmission and distribution networks (regardless ownership)
    - Accounting separation of the distribution and retail supply businesses
      - Later transformed into a legal separation
    - Generation expansion decided by the market agents
      - Subjected only to the energy policy and administrative authorizations
    - Creation of a new wholesale market (only energy market)
    - Establishment of a Capacity Payment mechanism
    - Gradual allowance of retail competition
    - Establishment of a Stranded Cost regime

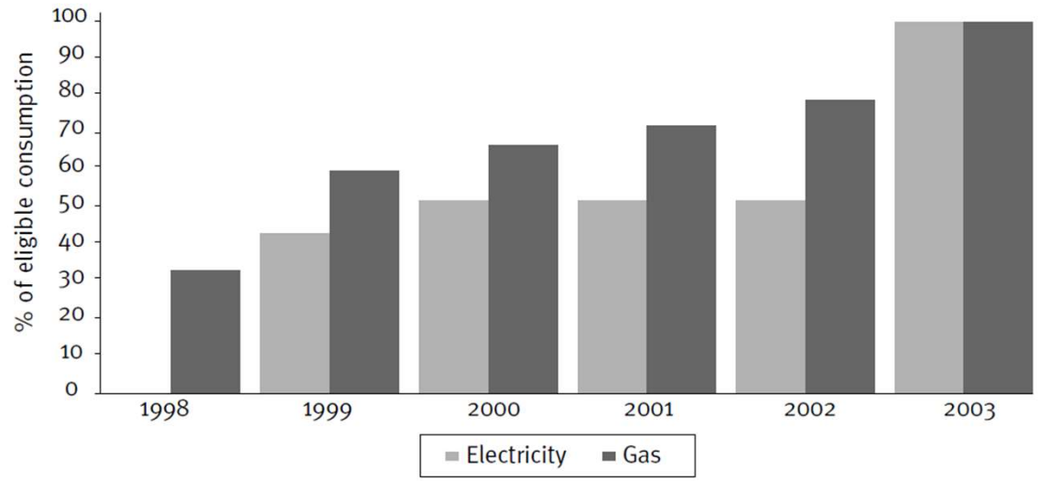
Market Configuration

- **Regulator**
  - Ministry of Energy
  - Electricity System National Commission – CNSE-
    - → Energy National Commission - CNE – (Electricity and Gas)
      - → Market and Competition National Commission (Electricity, Gas, Telecom, Transport)
- **Operators**
  - Market Operator (OMEL)
  - System Operator (Red Eléctrica – REE)
- **Agents**
  - Producers (Generators)
  - Self-producers
  - Distributors
  - Retailers (Traders)
  - Cualified Consumers

Retail Market

- The reform allowed certain customers to trade directly in the wholesale market and/or to negotiate their supply bilaterally with generators or retailers.

Date	Qualified Consumers
January 1, 1998	Yearly energy demand ≥ 15 GWh
January 1, 1999	Yearly energy demand ≥ 5 GWh
April 1, 1999	Yearly energy demand ≥3 GWh
July 1, 1999	Yearly energy demand ≥ 2 GWh
October 1, 1999	Yearly energy demand ≥ 1 GWh
July 1, 2000	All MV connected consumers
January 1, 2003	All consumers



Capacity Payments

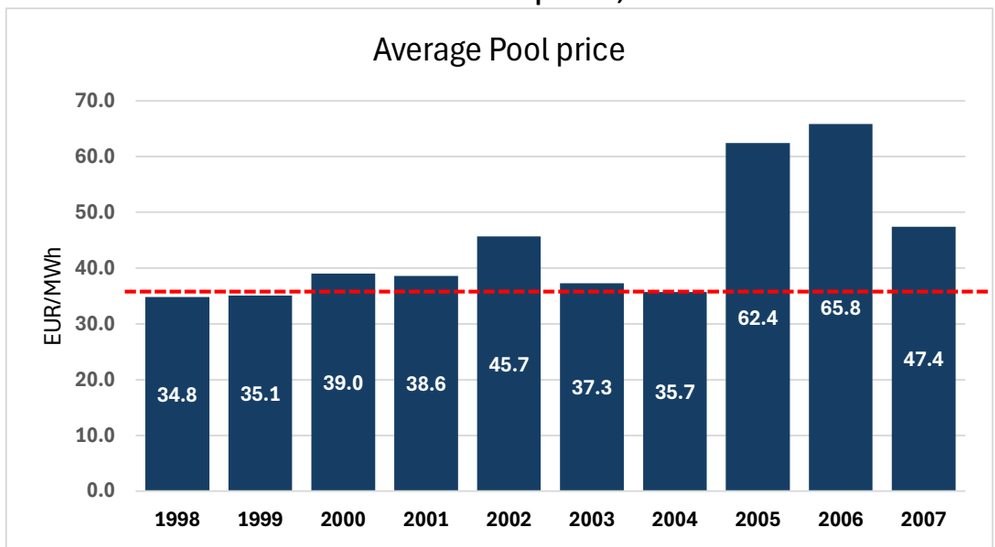
- At the initiation of the market a regulated capacity payment was established.
- The mechanism was divided into two parts:
  - **Determination of the total amount.** The yearly total amount that generators would be allowed to receive for capacity payments was established as the forecasted total demand multiplied by an administrative value (7.81 EUR/MWh)
    - This total amount will be paid monthly, taking into consideration the hours in which the system is more loaded.
  - **Distribution among generators:** The monthly amount is distributed among all generators which were available during the 4,500 hours of higher demand.
  - With due consideration to the characteristics of hydro and pumping storage power plants
- Capacity payments are distributed among all customers, regardless they obtain their supply through tariffs (regulated market) or through bilateral contracts.

Stranded Cost Regime (i)

- Introduced to compensate generators due to the change of the regulatory regime
  - The expected market results would be not enough for generators to obtain the revenues that they were supposed to obtain if the regime had no changed (*legitimate confidence principle*)
- Electricity companies (generation) existing at the moment the law was sanctioned were allowed to obtain additional revenues, up to a maximum global amount of 12 billion USD, over 10 years period (the Transition to Competition Costs –CTC-).
  - Such value was estimated based on simulations which compared the revenues the generators would obtain in the new market with the revenues they were obtaining in the previous regime.
- Following rules were applied for such compensation:
  - The total amount to be allocated to each generator every year was calculated as its total production multiplied the difference between a predefined value of 36 EUR/MWh and the yearly average market price obtained by such company (based on the day ahead market).
  - If the value was positive (market price < 36 EUR/MWh) the resulting amount was credited to such generator
  - If the value was negative, no compensation was applied, but such amount were deducted from the total amount allocated to such company.
  - The total amount obtained by the companies was used to determine the tariffs (therefore, the cost was transferred to all customers, either eligible or captive)

Stranded Cost Regime (ii)

- During several years this mechanism acted as a sort of “price cap” for the wholesale market price.
  - Companies had no incentives to increase such price, since in this case their future revenues would be reduced.



- Several reasons explained why the “cap” loses efficiency after 2004
  - New entrants without the right to obtain CTCs
  - Declining of retail revenues as customers existed the regulated market
  - Uncertainties about the future regulatory regime
  - Some companies reached a point in which they have already obtained a significant portion of its initially allocated CTCs
  - The 36 EUR/MWh, over time, ceased to be a suitable benchmark for generation costs

Stranded Cost Regime (iii)

- There was important opposition from several stakeholders both to the mechanism itself and the way the total amount was effectively calculated
- The mechanism suffered modifications over time (most important in 2001)
  - Reduction of the total amount to be recovered (8.66 billion USD + 1.77 billion for national coal plants).
  - Allowing the national government to set a maximum amount to be recovered every year, determined at the same moment the regulated tariff was established
  - Deduction of the amount in case a company sells an asset at a price higher than the value it was used to determine the CTCs (simulations)
- In 2006 the mechanism was finally cancelled and the non-recovered amounts void.

Measures to dynamize the electricity market (i)

- 2006 - 2007
  - Abolition of CTCs (previously explained)
  - Creation of an Iberian Market (integrating Portugal)
    - Join of the two market operators
    - Spain in charge of the day ahead transactions (OMIE)
    - Portugal in charge of running the forward market
  - Establishment of mandatory Virtual Power Procurement Auctions (VPP Auctions)
    - Applied to the two largest incumbents (Endesa and Iberdrola)
    - Forced to sell part of their production virtually to other retailers
  - Establishment of the framework for procurement auctions by distributors to
  - Reformed capacity payments mechanism
    - Applied only to those generators which obtained little revenues from the wholesale market, required to maintain system security

Event	Date
Administrative price on "internal" trades in the electricity spot market	February 2006 (RD June 2007 (RD 8
Abolition of CTCs	June 2006 (RDL
Development of forward markets (OMIP/ OMIClear)	June 2006 (O ITC/2129/2006), 2006 (Orden ITC/3 June 2007 (O ITC/1865/2(
Tariff revision for 2007	December 200 1634/200
VPP auctions	December 200 1634/2006), May 324/2008), and Reso la Secretaría Genera
Procurement Electricity Auctions	February 2007 ITC/400/2007) and (Resolución de la General de En
Adoption of E.U. Directives	July 2007 (Ley 12/2 17/2007
MIBEL	July 200
Reform of capacity	September 2007

Measures to dynamize the electricity market (ii)

- 2006 - 2007
  - Measures intended to abolish (or reduce) the “tariff deficit”
    - Tariff deficit appeared due to two major reasons
      - The wholesale price estimations made by the Ministry to determine the retail tariffs significantly differed from the actual prices appearing in the market
      - The payments made to renewable energy generation developed under the feed-in tariffs (with prices significantly higher than market ones) had increased rapidly
    - This deficit created payment obligations from the government to the distribution/retail companies
    - It was considered that the same companies which have generation – distribution and retail benefited by such situations
    - A maximum ex-ante deficit was determined (which had to be recovered in the following years). If the wholesale price is higher, the difference is lost.
  - Deduction of windfall profits created by the Emissions Trading System
    - Generators internalized the costs of ETS even if they were awarded for free

The measures taken had relatively limited impact on the competition and reduction of tariff deficits

Renewable Energies Boom

- 2007 - 2012
  - The measures taken for promoting renewables, ensuring them an administrative price (feed-in-tariffs) created strong incentives in the development of these type of generation
    - Initially wind energy and later on solar PV
    - The installed capacity in this kind of generation increased from 11,663 MW in 2006 to 28871 MW in 2012
    - The energy produced by these plants were not incorporated to the market but included in the tariffs (either integral or wheeling tariffs) as a surcharge. The portion of such payments (which were not transferred to the ex-ante tariffs Tariff created payment obligations that lasted for many years in the future (until now)
- 2012
  - Full change in the regimes of renewable energies
  - Obligations to participate in the market as any other generator
    - Some of them exempted from this obligation due to legal constraints
  - Obligation of balancing (regardless of their variability)
- 2013 – 2023
  - Several regulatory changes, particularly in the market rules, without significantly impacting the prevailing philosophy

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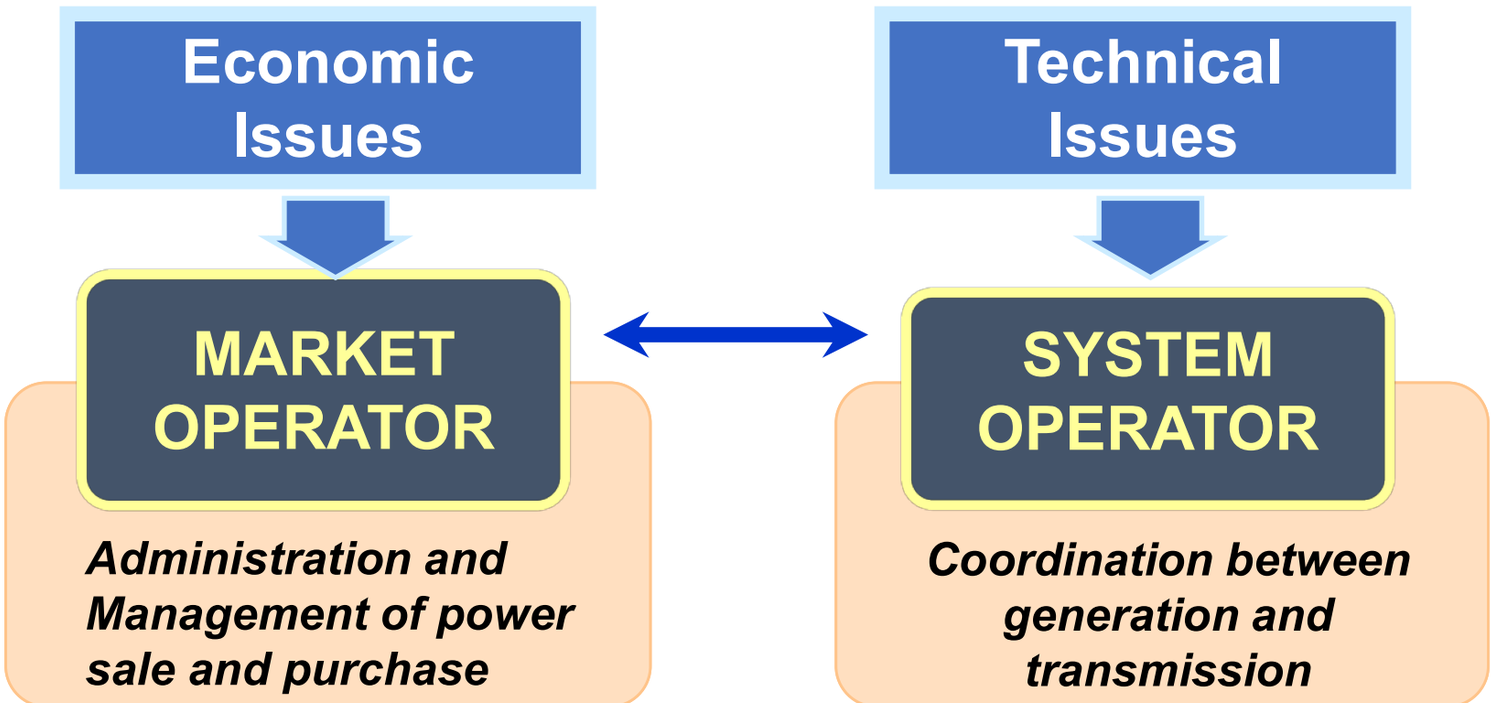
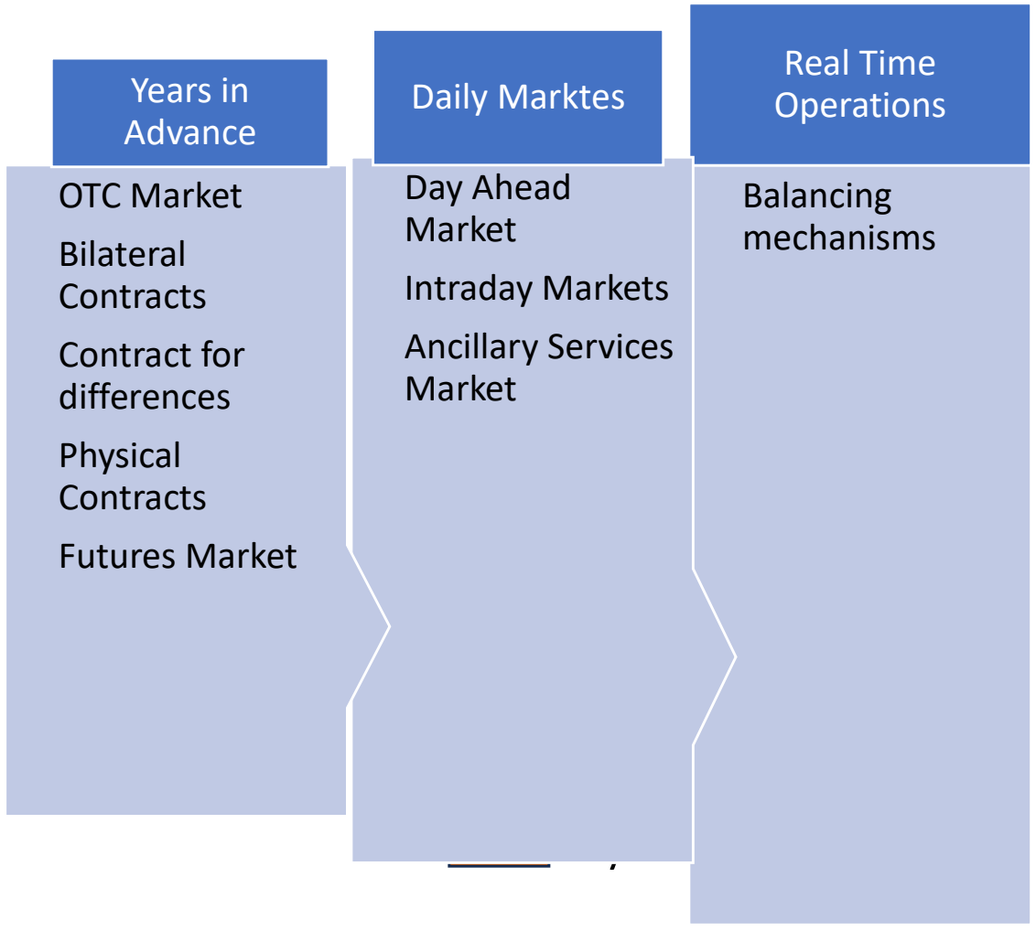
Economic and Technical Operators

Two different entities were created to cope with the operation of the sector, ensuring its adeaquacy, security and safety

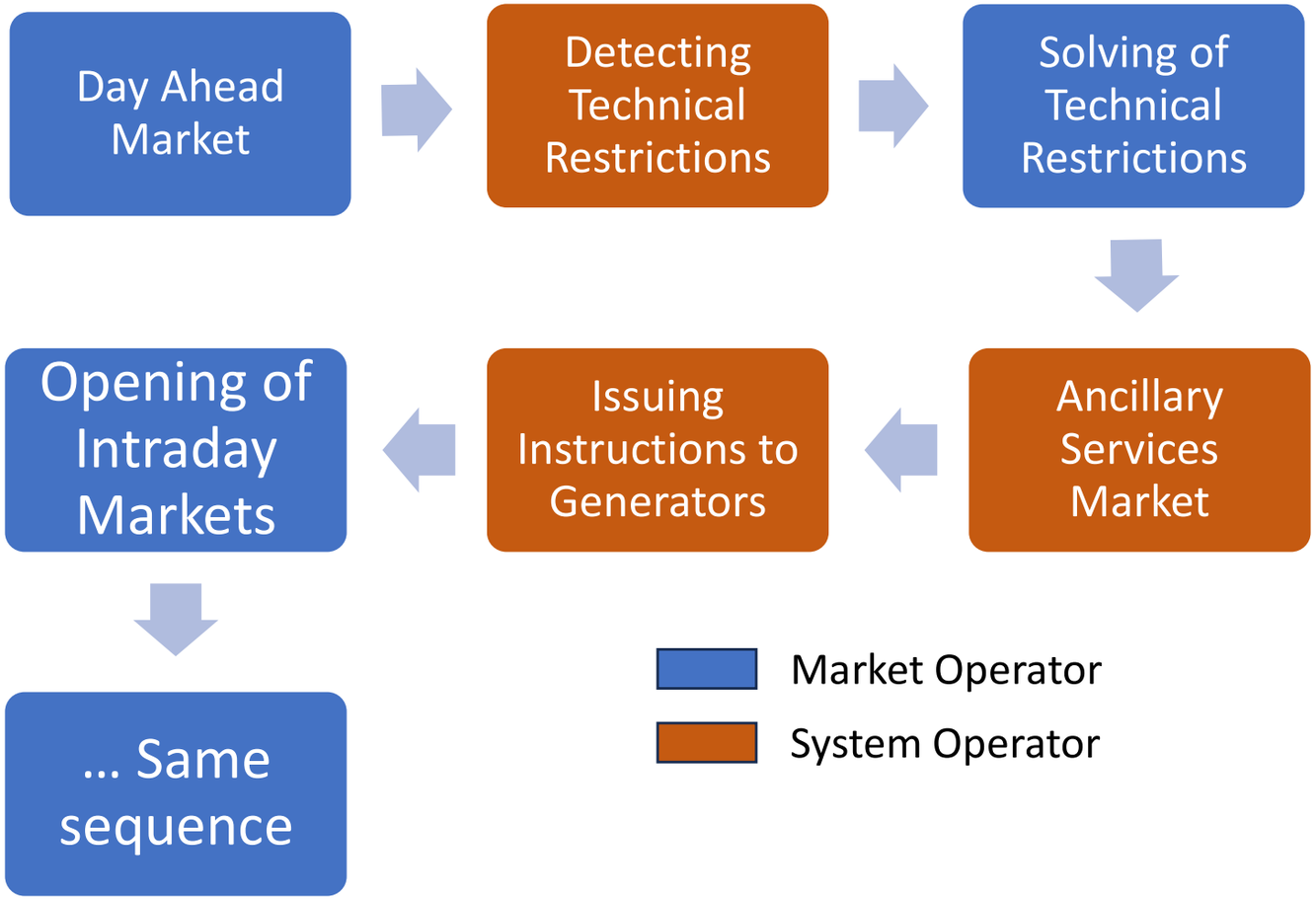


The “frontier” was problematic during several years

Markets Time-frame



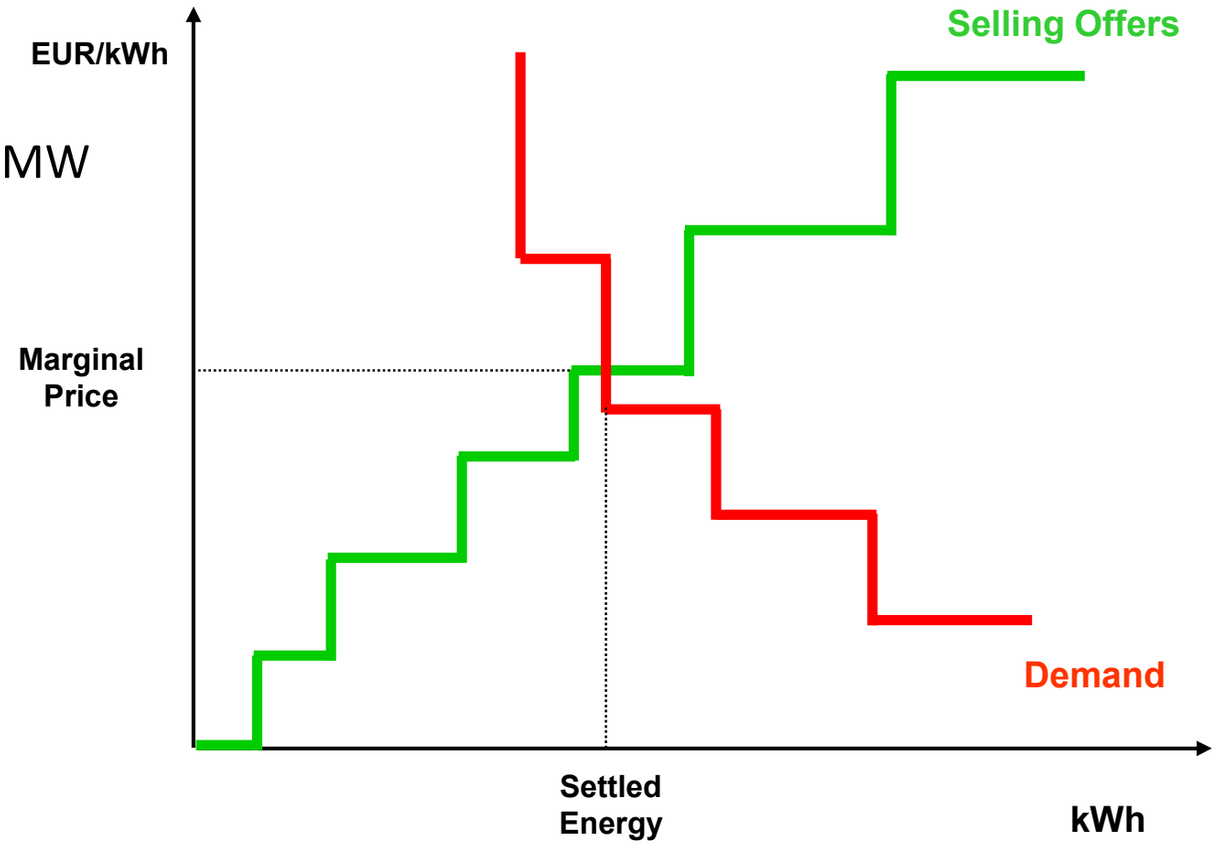
Daily Markets Timeframe



- 8:30 SO publishes demand and unavailabilities
- 10:00 Closing of selling/purchase offers
- 11:00 Market settlement (Functioning Base Program)
- 12:00 Market Agents submits bilateral Contracts and details of hydro dispatches
  - System and Market Operator solve technical restrictions
- 14:00 REE publishes the Provisional Feasible Program and Ancillary Services Market starts (secondary reserve and tertiary reserve)
- 15:30 Ancillary Services market closes (secondary reserve)
- 16:00 Definitive Feasible Program.
- Starting of Intraday Markets

1 - Day Ahead Market

- By far the most relevant market (by size)
- Run by the Market Operator
- **Mandatory** for all generation units above 50 MW
- Simple / Complex Offers
  - Simples Offers: Energía / Precio
  - Complex Offers:
    - Non divisible offers
    - Minimum Income
    - Ramping
    - Programmed stop



2 - Solution of Technical Constraints

- Since the day ahead market does not consider network technical constaints, it can't be ensured its results are fully implementable.
- The MO submits the results to the SO, and the SO performs technical analysis to ensure the final results are acceptable.
  - In case they are not, it identifies the actions that should be taken to avoid the detected problems.
  - It submits the results of its analysis to the MO, for it to produce the least cost modifications using the offers submitted to the day ahead market
    - To avoid zonal market power
- The result is a dispatch that is feasible and economic
- Immediately after communicating such results, the ancillary service market starts

3 – Ancillary Services – Secondary Reserve Market

- Three main ancillary services
  - Primary Reserve → Mandatory for all generators (Grid Code)
  - Secondary Reserve → Subject to daily offers. Only enabled generators (capable to operate under AGC) can participate
  - Tertiary Reserve → Subject to offers
- For secondary reserve, the SO communicates the necessary requirements and receives hourly band offers [EUR/MW] and associated generation prices [EUR/MWh]
  - Possibility to offer different bands (“up” / “down” relation)
  - Offers conditioned to modification of the issued dispatch (Provisional Feasible Program)
- SO runs an optimization model which minimizes the total cost associated with the provision of secondary reserve.
  - The accepted offers create an obligation for each of the agents awarded (Balancing Responsible Party)
  - The dispatch is adjusted accordingly (Definitive Feasible Program)
- The SO monitors effective provision of the services and may penalize in case the generators performance is inadequate

3 – Ancillary Services – Tertiary Reserve

- Run also by the SO
- The only market in which the offers are permanently active, until they are accepted or changed by the agent
- All available generators are obliged to submit offers. They shall offer the maximum energy that they can supply / absorb in 15 minutes.
  - Market closes at 10:00 pm of D-1 and its execution starts at 0:00 am of day D
- Used reserves are paid at the marginal price (most expensive used reserve)
- The SO utilizes tertiary reserves to :
  - Recover secondary reserve margins.
  - Solve technical problems which appears in real time operations

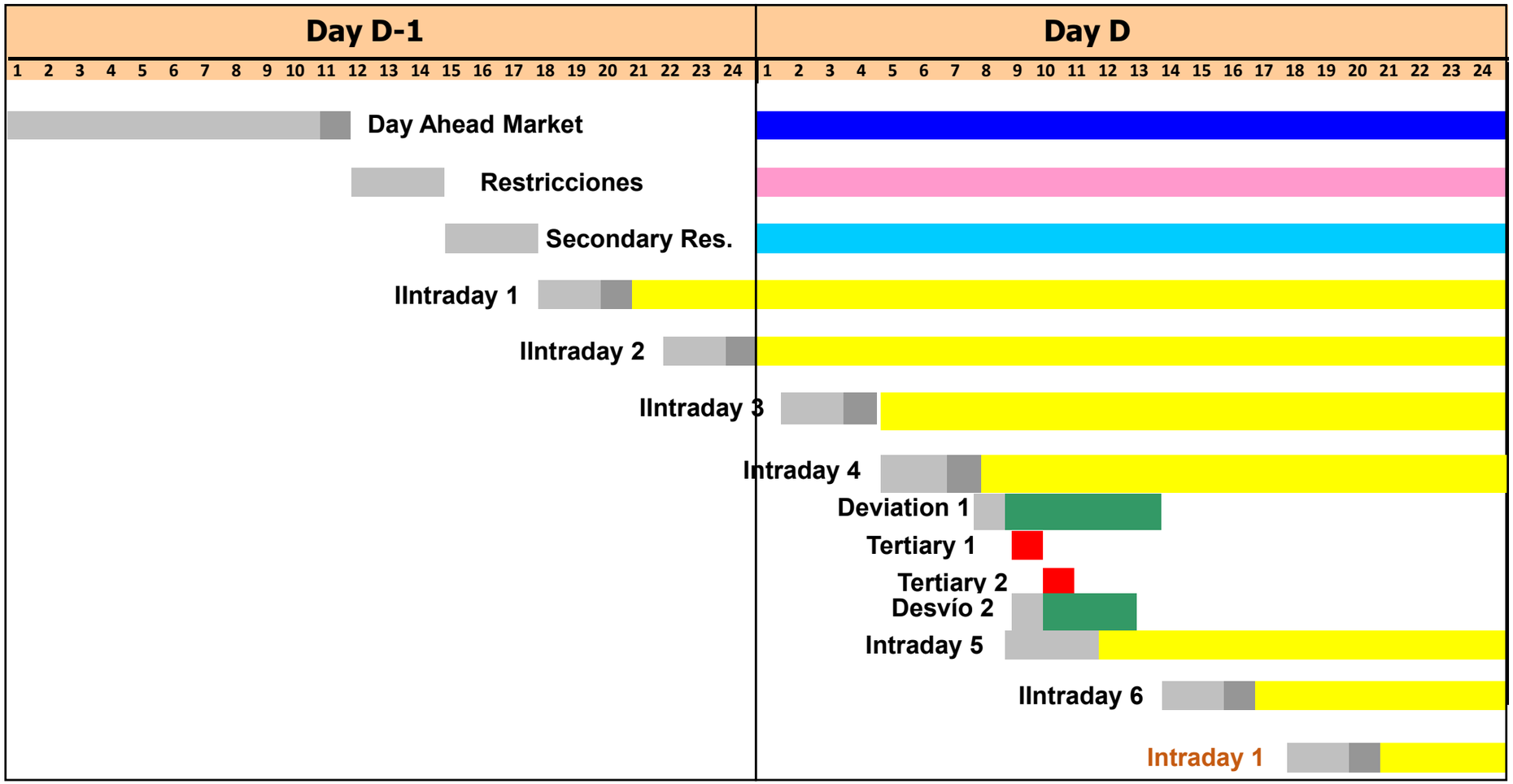
4 – Intraday Markets

- Managed by the MO
- Voluntary Market (no obligation to submit offers)
- Generation and demand can submit selling or purchase orders indistinctly
- It was mainly an adjusting market (to solve unexpected problems and/or to take advantage of upcoming opportunities)
- There were 6 intraday sessions
- Offers can be simple or complex as in the case of the day ahead market
- Retailers and cualified consumers should have participated in the day ahead market to be able to participate in the intraday markets

5 – Deviations Market

- Managed by the SO
- The SO starts this exceptional market when it detects significative deviations between forecasted generation and demand
- The SO request offers for a predefined energy profile Voluntary market. Not mandatory to submit offers
- Sequence
  - It can only be called for a period between two intraday market
  - Quick market, with little time for preparing and submitting offers

Market Sequence



Evolution of the Wholesale Market

- The Market Rules had suffered numerous variations in the last 20 years
  - However, the basic rules has been maintained over time.
    - Day ahead market and intraday markets
    - The treatment of ancillary services and tertiary reserve
    - The separation of the two operators (market and system)
  - Some of the changes related to:
    - The integration of the Spanish and Portuguese markets
    - The harmonization of certain rules with those prevailing in Europe
    - The exclusion/inclusion of certain technologies in the clearing price determination
    - The management of international interconnections
    - The gradual transformation of a gross pool to a net pool
    - Etc.
  - Some of these changes (due to their relevance) are shown below

From a “mandatory” pool to a net-pool scheme

- In purity, the wholesale market (since its creation) was never a “mandatory pool”
  - The obligation to submit bids applied only to those generators without a bilateral physical contract
  - However, there were practically no such contracts.
  - Therefore, at its initiation the day ahead market was a “de-facto” mandatory pool.
    - More than 90% of the total demand was traded in this market
- Gradually, the rules for managing the bilateral contracts were changed (simplified) and more bilateral contracts registered.
  - The rest of Europe had chosen a conceptually different approach (the net-pool approach)
- Currently, although the obligation for generators to bid if they are not covered by a bilateral contract still exists, the Spanish Wholesale Market constitute a “de-facto” Net Pool
  - Approximately 50% of the total energy is traded in the day-ahead market and the other 50% through bilateral contracts (nominations)

The “Special Regime”

- At the moment the Wholesale Market was established, there existed generators which were exempted to participate in it. The so called “Special Regime Generators”.
  - Generators below 50 MW, which generation were mandatory purchased by the distribution companies
    - In 1998, mainly co-generation plants and some small hydro
    - In total representing less than 10% of the total generation in Spain at that moment.
  - The policy of promotion of renewable energies, through a feed-in-tariff mechanism, increased the number and size of projects for which the wholesale market did not apply.
  - By 2012, this generation represented around 40% of the market.
    - The “size” of the wholesale market was significantly reduced
    - These generators had practically no obligations in terms of balancing or provision of Ancillary Services.
    - Both effects distorted the “signals” of the wholesale market
  - In 2012-2013 the Special Regime was eliminated and the same rules apply both for conventional and non controllable generation

Transmission Rights (i)

- Spain is interconnected with France, Portugal and Morocco
  - Most relevant, the interconnection with France
- The issue was how to allocate the capacity of such interconnection among market participants. The system varied over time.
  - Initially, allocated only to those participants which have bilateral physical contractsVoluntary Market (no obligation to submit offers)
  - Later, allowing the so called “external agents” to trade in the Spanish Market.
    - To hedge their position, a regime was introduced in 2005.
      - The available capacity was auctioned through long term contracts.
      - The agents awarded had the possibility of either:
      - Nominate generation/demand to utilize it; or
      - Obtain the “congestion rents” in case the link(s) were saturated
    - The system was not totally successful, with some cases in which the energy flows circulated from high prices areas to low prices ones.

Transmission Rights (ii)

- The issue was how to allocate the capacity of such interconnection among market participants. The system varied over time.
  - After several changes, currently the interconnection capacity is managed, in the short and long term, following the European Rules
    - In the long-term, the capacity (in each direction) is awarded to market agents by the SO/MO through an auctioning process
    - In the short term, the principle “use it or lose it” applies:
      - The awarded agents have the right to utilize the capacity obtained, making nominations in the day ahead market
      - The non utilized capacity can be used by the other participants, through an European coordinated bidding process (described in following section)
      - The congestion rents are perceived by the market/system operators, and not by the market agents.
      - There are secondary markets for those awarded participants which wants to sell rights acquired.

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European Union Single Electricity Market

- During the last 30 years the European Union has been working towards the objective of creating a single electricity market in Europe.
- With such objective, the European Commission has issued several directives to push the different countries to adapt common rules for organizing their power sector. Among them:
  - 1996/92/EC: Introduced common rules for the internal electricity markets
  - 2003/54/EC: Unbundling of network companies, and requiring access to markets by industrials by 2004 and full competition by 2007
  - 2009/72/EC: Required legal separation of networks, introduced EU Regulator (CEER) and ENTSO-E
- Subsequent efforts were aimed to create an environment in which several countries/regions share common rules for developing their electricity markets, through the so called “Market coupling (MC)”
  - The objective of this project was to gradually harmonize the rules under which the European Power Exchanges operate.
- MC is a way to join and integrate different energy markets into one coupled market. In a coupled market, demand and supply orders in one market are no longer confined within the country but, subjected to network constraints, may trade with coupled countries.
- The main benefit of Market Coupling lies in improving market liquidity combined reducing volatility in electricity prices.

Towards Single European Market: History of Market Coupling 2006 - 2015

- 2006: Nordic Price Coupling: The three Nordic markets coupled in Noordpool
- 2007: Trilateral Market Coupling, integrating the Netherlands, Belgium and France
- 2009: MIBEL market started coupling Spain and Portugal
- Czech Republic and Slovak Republic Market coupling started
- 2010: Central West European Market Coupling (CWE); integrating the Netherlands, Belgium and France with Germany
- 2011: Interim Tight Volume Coupling (ITVC) between the CWE region and the Nordic – Baltic region
- 2012: Italy and Slovenia Market coupling / 3M MC project integrating Czech Republic, Slovak Republic and Hungary
- 2014 : Launch of common synchronised operation of NWE and SWE regions Day Ahead Market / Full Coupling of NWE and SWE regions launched
- 2015: 4M MC project replaces the trilateral Coupling now integrating the markets of Czech Republic, Slovakia, Hungary and Romania / The Italian-Austrian, Italian-French and Italian-Slovenian borders have been coupled with the Multi-Regional Coupling (MRC), linking the majority of EU power markets– from Finland to Portugal and Slovenia.

Price Coupling Regions (PCR)

- PCR was a project initially implemented by seven Power Exchanges: EPEX SPOT, GME, Nord Pool, OMIE, OPCOM, OTE and TGE, open to other European Power Exchanges wishing to join.
- PCR nowadays is used to couple practically all countries of the European Union

The parties involved are:

- Transmission System Operators (TSOs):
  - 50Hertz Transmission, ADMIE, Amprion, APG, AST, ČEPS, Creos, EirGrid, Elering, ELES, ELIA, Energinet, ESO, Fingrid, HOPS, Litgrid, MAVIR, PSE, REE, REN, RTE, SEPS, SONI, Statnett, Svenska Kraftnät, TenneT DE, TenneT NL, Terna, Transelectrica, and TransnetBW.
- Nominated Electricity Market Operators (NEMOs):
  - BSP, CROPEX, SEMOpx (EirGrid and SONI), EPEX, EXAA, GME, HEnEx, HUPX, IBEX, Nasdaq, Nord Pool, OMIE, OKTE, OPCOM, OTE, and TGE.

Key Aspects of PCR

- The PCR is based on a sophisticated clearing model, named **Euphemia** (Pan European Hybrid Electricity Market Integration Algorithm), that selects the offers (supply and demand) that maximises the social welfare.
- Main features of Euphemia include:
  - Cope with highly complex products involving many offer and bid configurations which are used in all P/X
    - Supporting a wide range of restrictions:
    - Ramping limit for individual or sets of lines between consecutive hours.
    - Line tariffs.
    - Line losses.
    - Hourly and daily net position ramping limits for bidding areas.
  - Implemented on all trading platforms (Power Exchange, P/X)
  - Provides traders with a large number of options when submitting bids on the platforms
  - Euphemia is also programmed with the network architecture so that it can detect and manage system constrains
- **Because the algorithm is common, the results of any trading session on any platform would be identical**

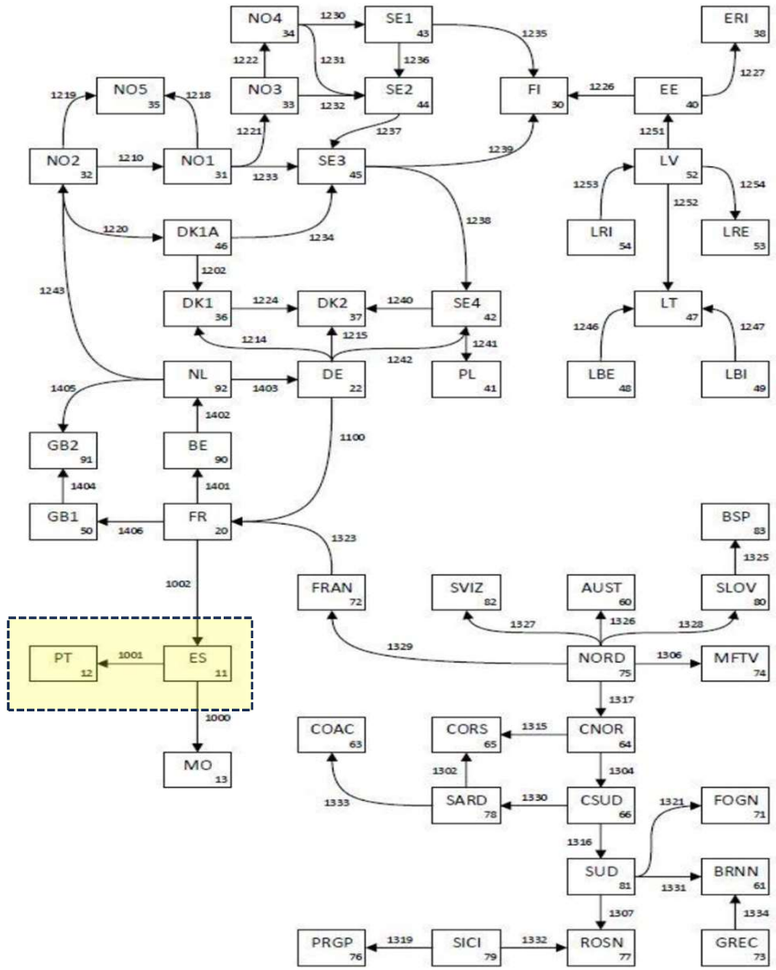
Euphemia's Balance

- The energy balance concept is defined as : The global supply minus the losses must be equal to the global demand of all markets involved. Depending on the manner the interconnections are modelled, there are the following possibilities:
  - ATC network model: The network is described as a set of lines interconnecting bidding areas. The nomination of the line can be made up to its Available Transfer Capacity (ATC).
  - Flow-based network model: Also known as PTDF model, with all bidding areas connected in a meshed network. It expresses the constraints arising from Kirchhoff's laws and physical elements of the network in the different contingency scenarios considered by the TSOs. It translates into linear constraints on the net positions of the different bidding areas.
  - Hybrid network model: Some bidding areas are connected using the Flow-based network model; the remaining using the ATC network model.

Coupling Process

- Once a result has been derived in each country (or control area), EUPHEMIA re-process the results of the individual exchanges to obtain an optimised result across the PRC domain
- If there are no constrains on the international interconnectors, prices will be equalised in the adjacent areas
- Where there are constraints, price zones will be created on each side of the constraint
- Transient constraints may require re-dispatch. This means that the daily market results may be altered slightly, affecting around 4-5% of the energy, in response to an analysis of the technical limitations conducted by the System Operator, giving rise to a viable daily programme.
- Congestion rent deriving from the price differential is utilised according to the relevant EU legislation
- Buyers and sellers are anonymous; they are indifferent to the source or recipient to the trades.

Areas Coupled in Euphemia Algorithm

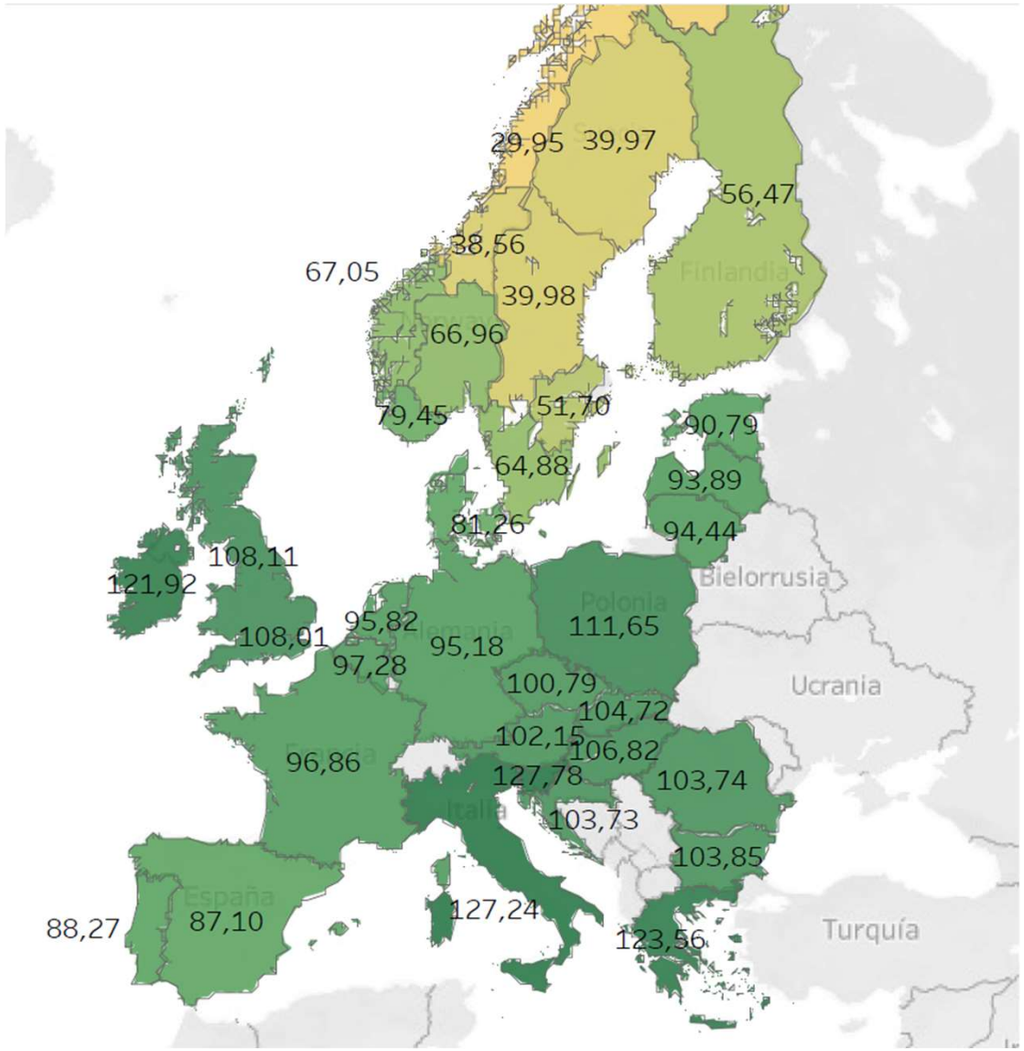


- Each PX (Market) operates several bidding areas.
- All bidding areas are matched at the same time.
- A different price can be obtained for each bidding area.
- The price for the bidding area must respect maximum and minimum price market boundaries.

European Traded Electricity Markets

- Following Markets are run on the PCR under Euphemia
  - Day Ahead Trading (DAM)
    - Sellers offer and buyers bid prices at which they are prepared to trade electricity. Offers and bids are made through **one of the trading platforms** dealing in the European community
    - Offers and bids are made throughout the day at varying degrees of complexity, but transactions are not created at this stage. The Day ahead market runs until 12.00PM on the day before delivery
    - Once the market closes, the bids and offers are processed to find the intersection of price and volume which represents the clearing price of the market(s)
  - Intraday
    - The Intraday market opens at the close of the DAM
    - There are six trading sessions based on auctions such as those described for the daily market. Each trading session lasts 2 hours, and then is cleared to provide a spot price for that session
    - Enables all the participants to adjust their positions in response to changes in demand forecasts easily. The intraday market records similar prices to those arising in the daily market, but with more volatility
    - The Intraday market closes 4 hours before real time
  - Continuous
    - Some MO (e.g. NEMO) offer continuous trading in the local intraday market. This means that orders and will be matched as soon as they are entered into the order book as opposed to waiting for gate closure as for auctions. The benefit of continuous trading is that market participants will be able to adjust their position as close to real time as possible. In this case a single spot price will be used based on the last matched order

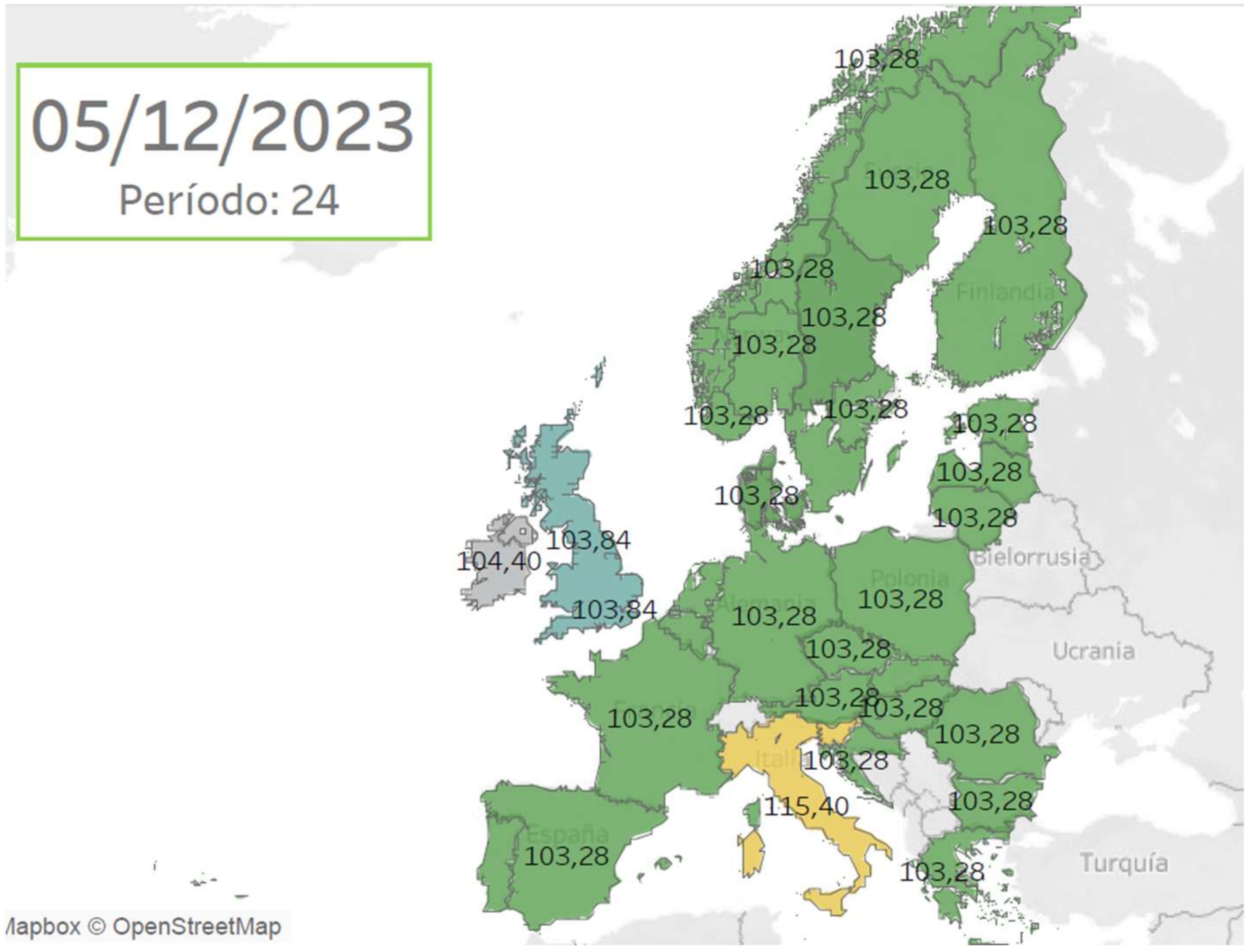
2023 - Average Wholesale Prices (€/MWh)



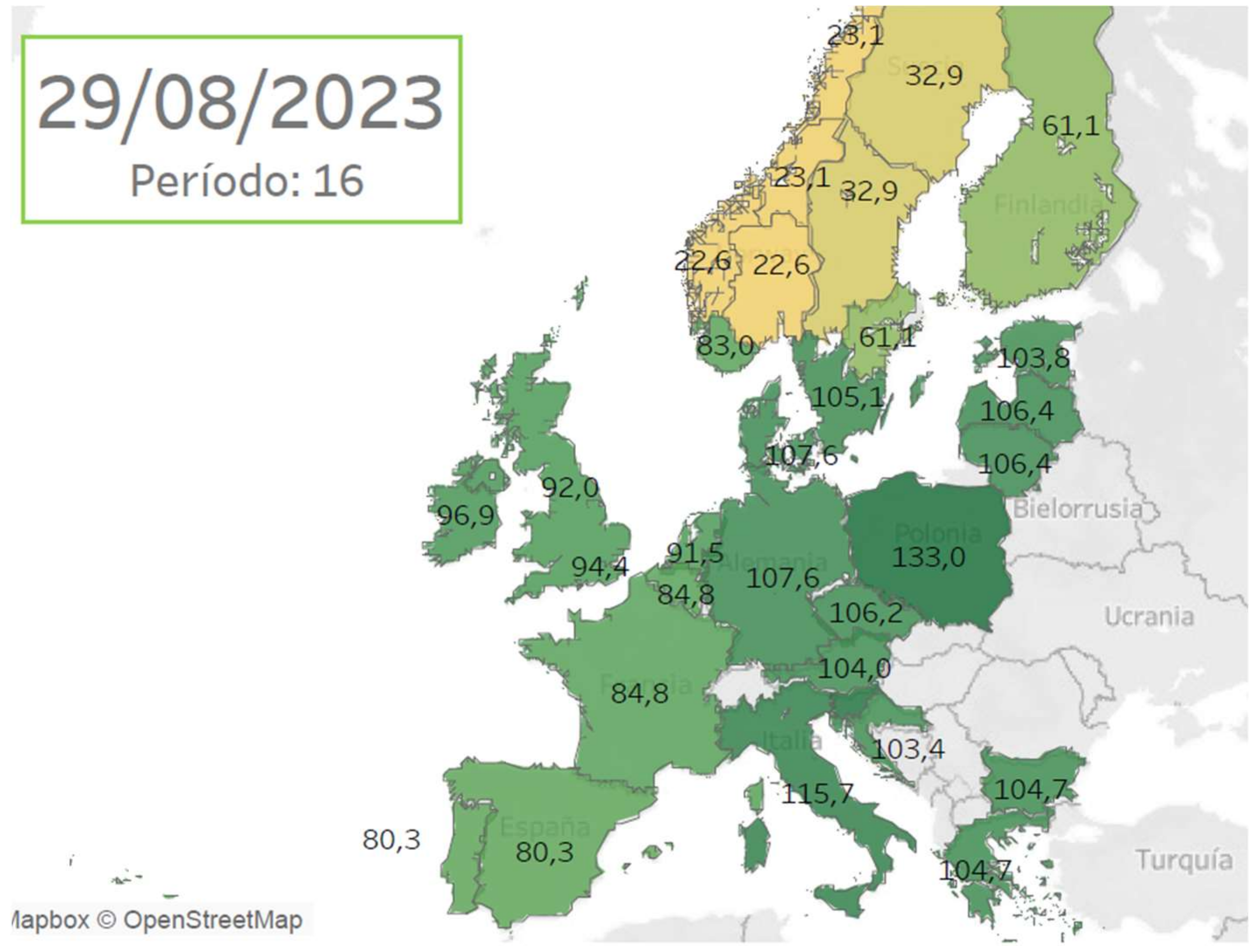
- Despite the efforts made to integrate the electricity markets across Europe, transmission constraints still have a significant impact on the overall energy prices:
  - North Sweden and Norway show average prices in the order of 38 €/MWh
  - Spain and Portugal around 88 €/MWh
  - Central Europe above 100 €/MWh

2023 – Periods of maximum and minimum coupling

Maximum Coupling



Minimum Coupling

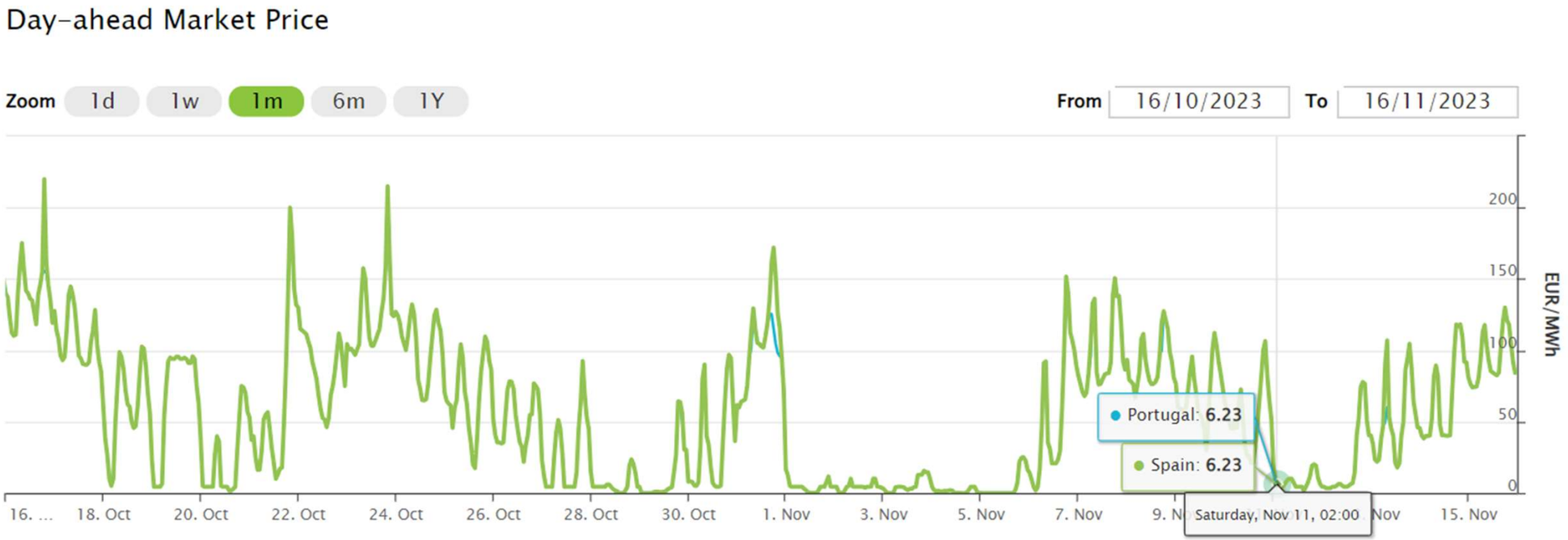


Index

- Main Characteristics of the Spanish Power Sector
- Brief Evolution of the Spanish Power Market
- Wholesale Electricity Market
- European Common Electricity Market
- Challenges and way forward

Major Challenges (i)

- High Volatility of Marginal Prices
  - High penetration of renewables heavily impact market prices, introducing enormous volatility
  - Prices oscillate between zero and more than 200 EUR/MWh in few hours

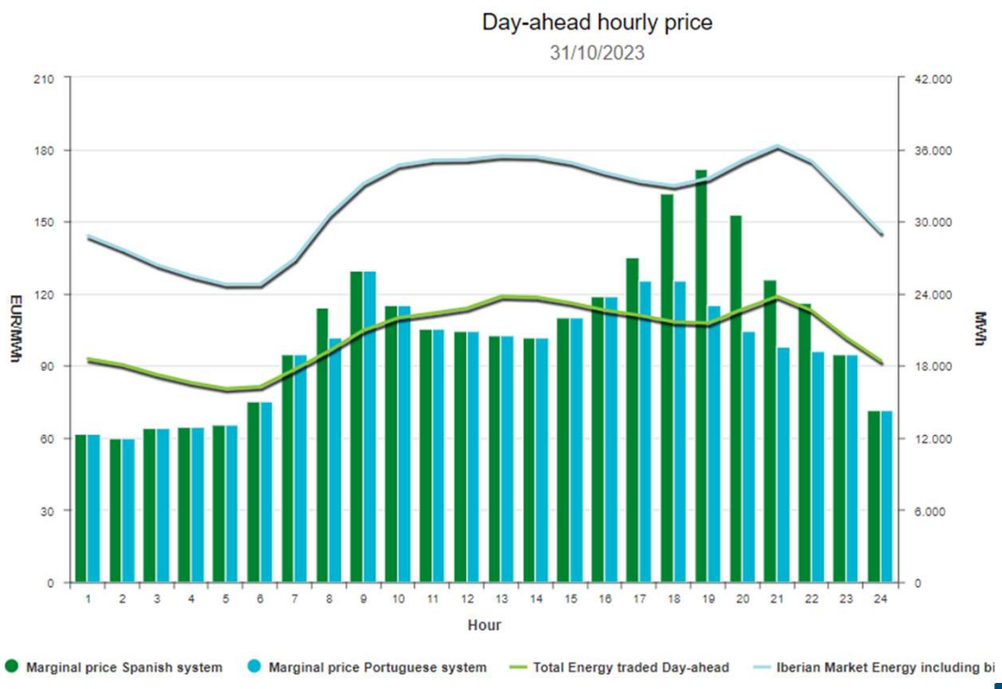


Major Challenges (ii)

- High Volatility of Marginal Prices
  - This volatility makes difficult its use as a benchmark to develop projects
  - More difficult to obtain banking finance if not linked to other type of contracts

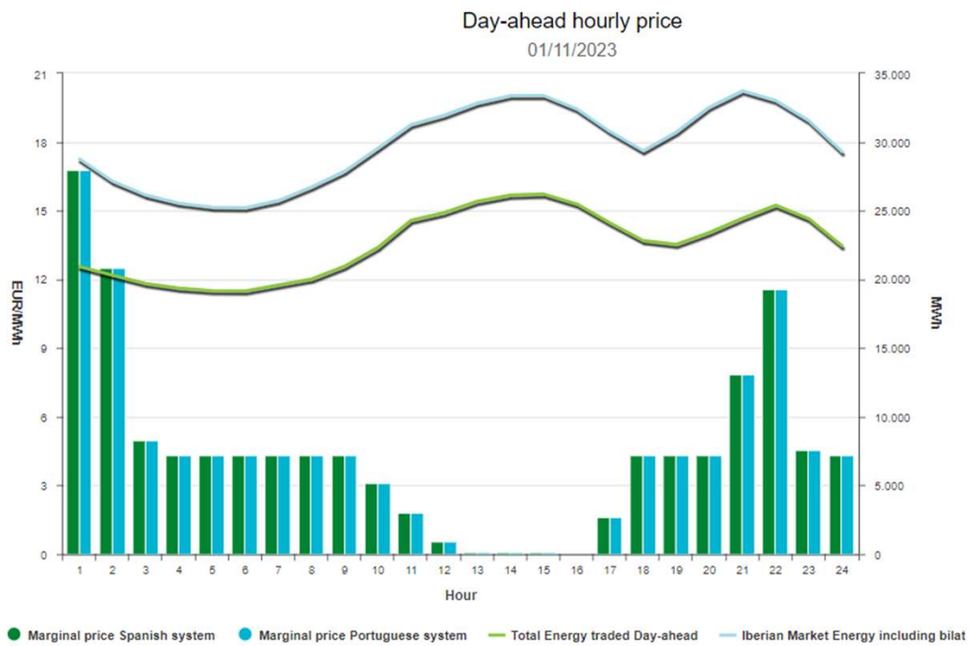
October 31, 2023

Practically the whole day with prices above 120 €/MWh



November 1, 2023

Prices drop to 10 €/MWh and they are zero for 5 hours



Major Challenges (iii)

- Reduction in revenues of conventional power plants
    - The massive introduction of RES has:
        - Significantly reduce the utilization of other power plants (mainly thermal power plants)
        - Reduced the marginal prices (at least during many hours during the day)
    - The revenues obtained by such plants may not be enough to keep them connected to the system
        - But they are needed to maintain system reliability and security
    - Another source of income would be required.
- Requirement of BESS
    - The incorporation of significant amount of power in solar PV creates operational problems in the system
        - The so-called duck curve
        - Difficulties with ramping up and ramping down
        - Out of merit dispatch and/or ancillary services costs increase significantly
    - Storage may be the solution, but…
        - Revenues obtained through arbitrage are, usually, not enough to justify their costs (at least in case of BESS)
        - Associate them to renewable projects is also possible, but profitability of the project is severely reduced

Major Challenges (iv)

- Self-generation (prosumers) is developing fast
    - The “size” of the conventional markets is gradually reducing
    - Smart grids are also developing fast
    - A new paradigm in relation with aggregators is emerging
        - Not clear how it will evolve

Which is the solution?

- Not totally clear yet…
    - General consensus about the necessity of the introduction of some kind of capacity payments :
        - The time of “energy only market” seems to be ending
        - Less in relation about how this mechanism should look like
    - Gradually, more long-term contracts are being signed as a way to secure long term revenues

- Some scholars are claiming the end of marginalism in power systems
    - But not clear alternative theory has yet been developed (and tested)
- It seems that the (near) next future will be dominated by “patches” to the market rules, to solve some of the problems detected, but not a global change of the paradigm

- Later on… We will see…

Thank You