MIT Portugal

TÉCNICO LISBOA

Renewable Energy Resources (RER)

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THE POWER SYSTEM

Chapter 1

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STRUCTURE OF THE POWER SYSTEM

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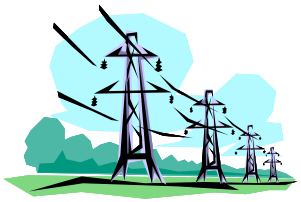
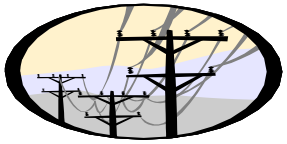
Hydro

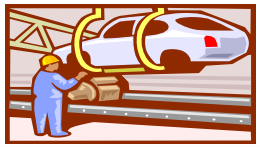
Thermal



Transmission Grid EHV

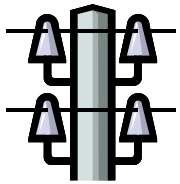


Distribution Grid
HV and MV



HV and MV Clients

LV Clients



Distribution Grid LV

Photovoltaic

Wind

Small-Hydro

MicroGeneration

Source: REN

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LEGAL FRAMEWORK

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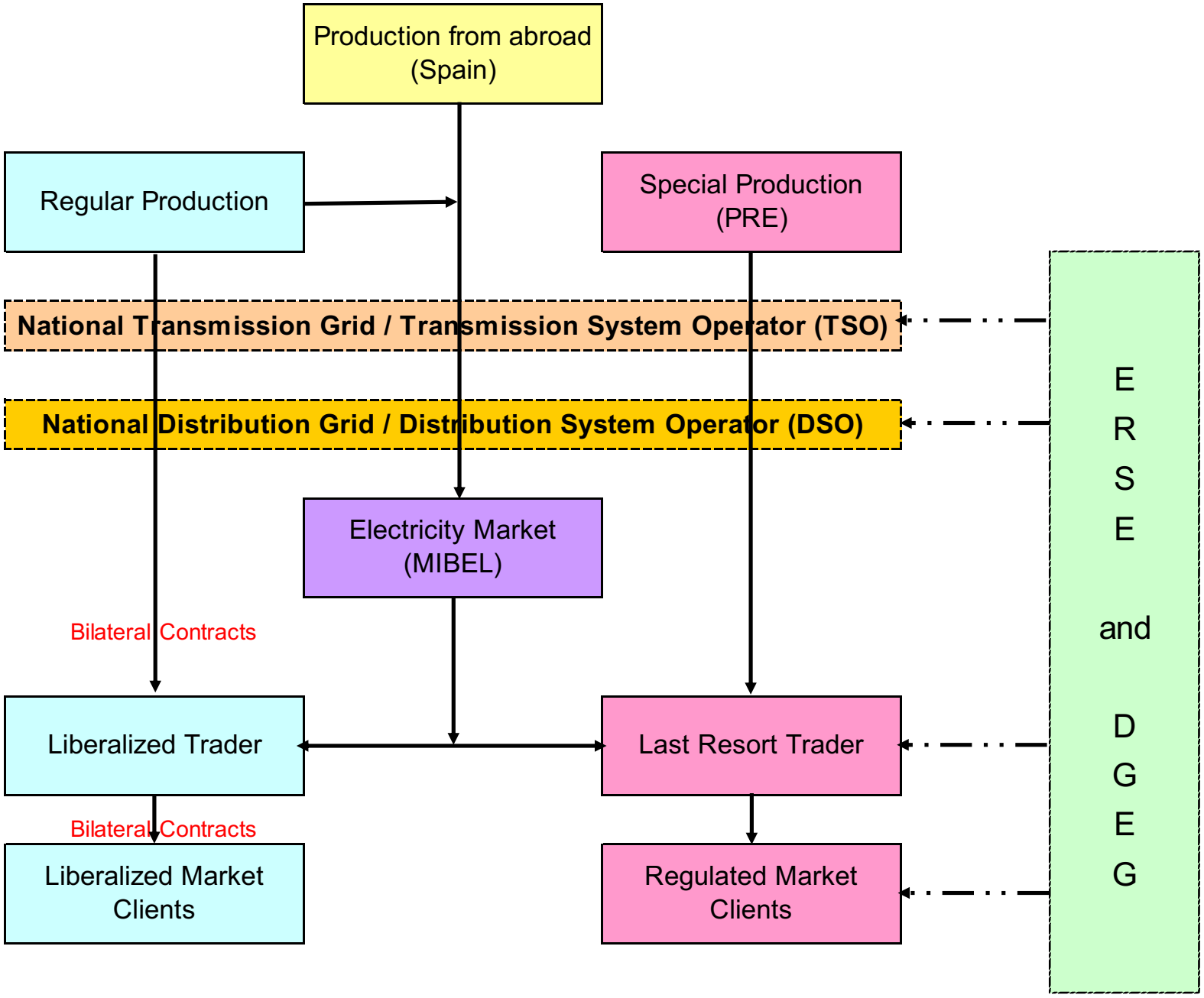
Production from abroad (Spain)
Regular Production
Special Production (PRE)
National Transmission Grid / Transmission System Operator (TSO)
National Distribution Grid / Distribution System Operator (DSO)
Electricity Market (MIBEL)
Bilateral Contracts
Liberalized Trader
Last Resort Trader
Bilateral Contracts
Liberalized Market Clients
Regulated Market Clients
E R S E and D G E G

General principles

- Production and Trading
  - Market driven
  - Participants must be certified
- Transmission and Distribution
  - Awarded as a public service concession

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Production

- Market Driven
- Role of the state
  - To ensure market equity and the availability of supply
- PRO – Regular Production
  - Turbogás, Tejo Energia, EDP Produção …
- PRE – Special Production
  - EDP Renováveis, Martifer, Catavento, Generg, Enersis (actual Iberwind), EEVM …

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Transmission

- The public service was granted to – REN
- Transmission System Operator (TSO) – technical management of the Portuguese Power System
- Utilization of the transmission grid – regulated tariff

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Distribution

- The public service was awarded to – EDP Distribuição
- Distribution System Operator (DSO) – management and operation of the Distribution System
- Utilization of the distribution grid – regulated tariff

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Trading

- Market driven activity carried by certified entities
  - EDP Comercial, Iberdrola Comercialização de Energia, Endesa Energia, Union Fenosa Comercial
- Last Resort Trader
  - EDP Serviço Universal
  - Guarantees the deliver of electric energy to the consumers that are not tied to market traders
  - Enforced to buy energy delivered by the PRE
  - Markets and Auctions

Regulation and Security

- Regulation
  - Transmission, Distribution, Last Resort Trading, Market equity
  - ERSE Portuguese Energy Regulatory Authority
- Security of supply
  - DGEG Directorate-General of Energy

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SOME STATISTICS – PORTUGAL

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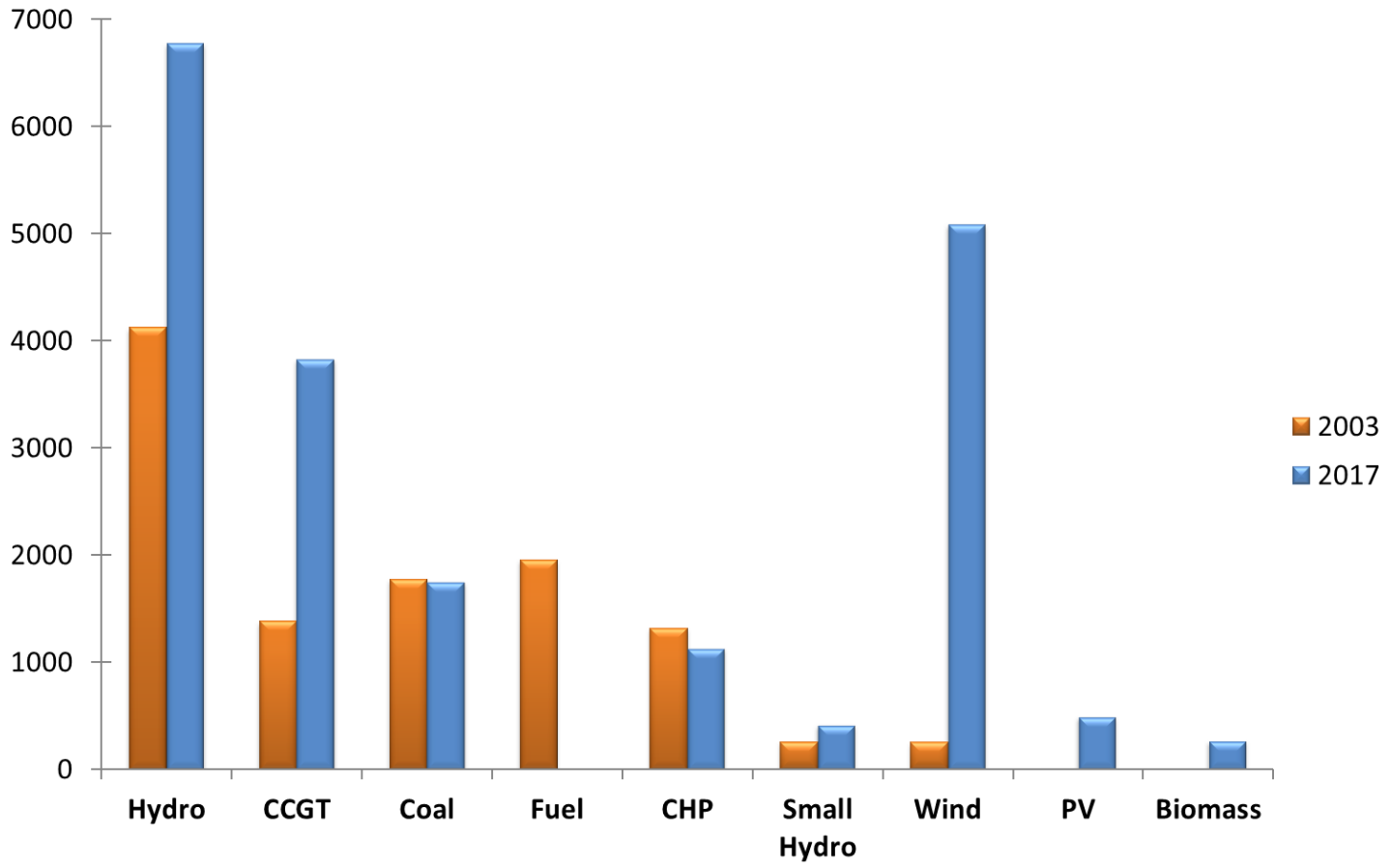
Installed capacity by source (MW), Portugal, 2003 and 2017



Source: REN

Installed capacity (2019)

- 7216 MW (36%) Hydro; Pumping: 2698 MW
- 6353 MW (31%) Thermal
- 6631 MW (33%) Special Production (Wind, Solar PV, Small-Hydro, Biomass)
- 20,200 MW Total

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Source: REN

Installed capacity by source Renewables, 2019

- 7216 MW (52%) Hydro
- 5208 MW (38%) Wind
- 693 MW (5%) Biomass
- 730 MW (5%) PV

- 13,847 MW Total RES (69% of total)

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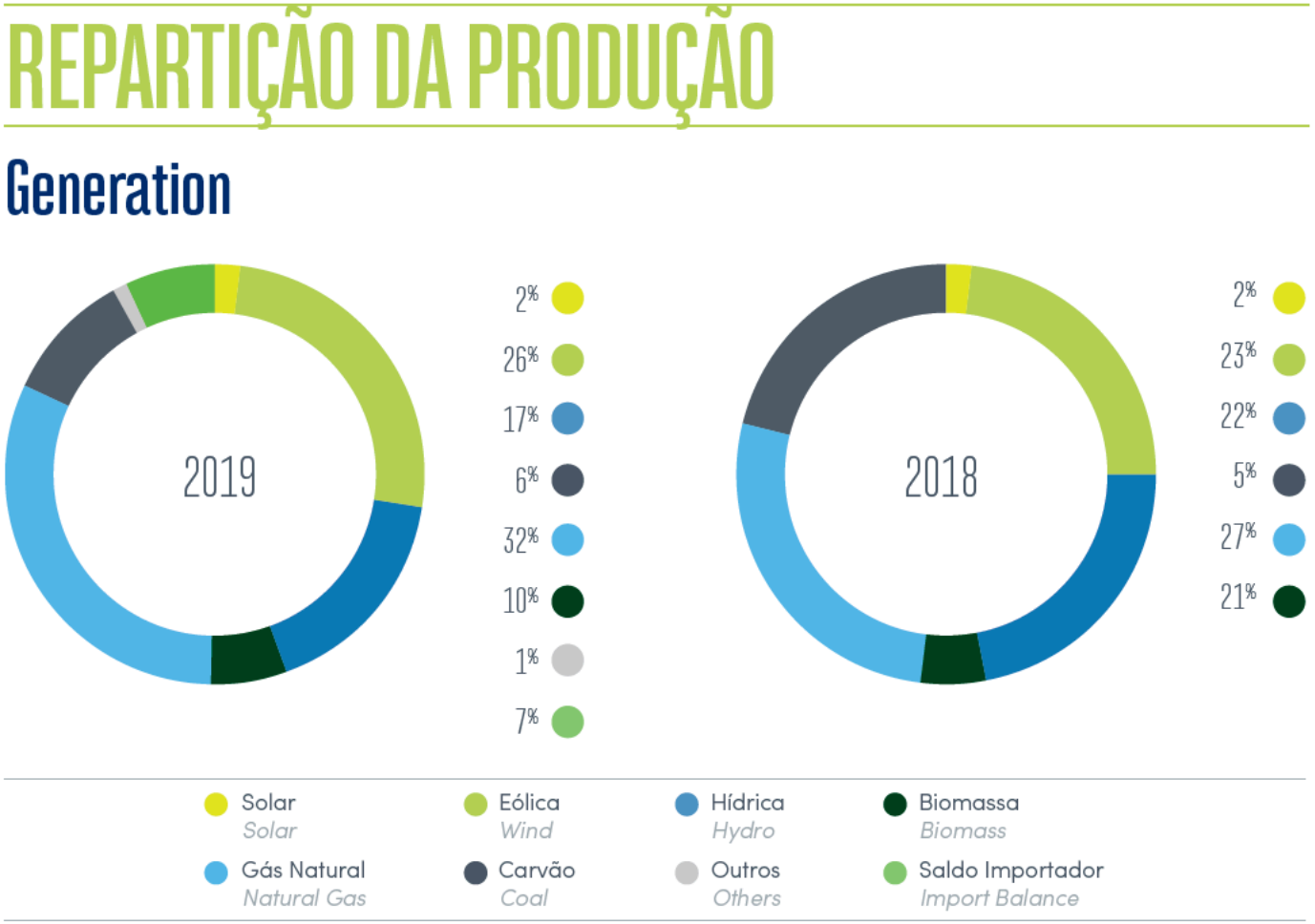
Source: REN

Electrical energy production by source, Portugal, 2018-19



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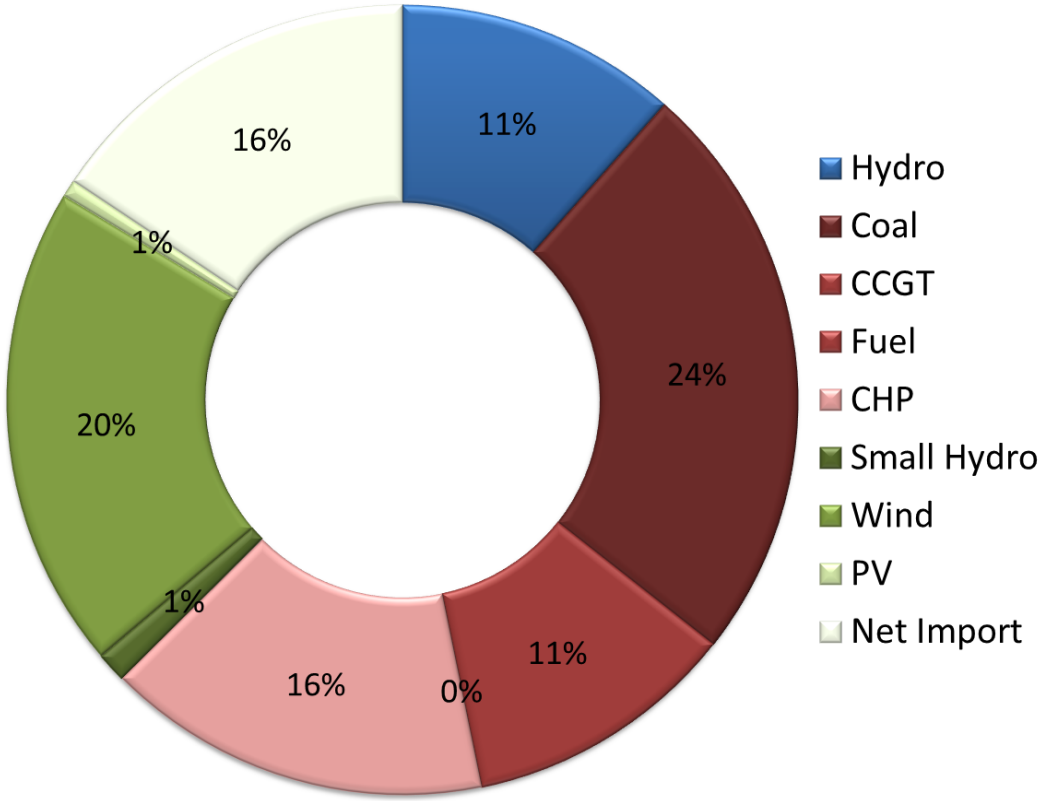
Source: REN

Electrical energy production by source, Portugal, 2012



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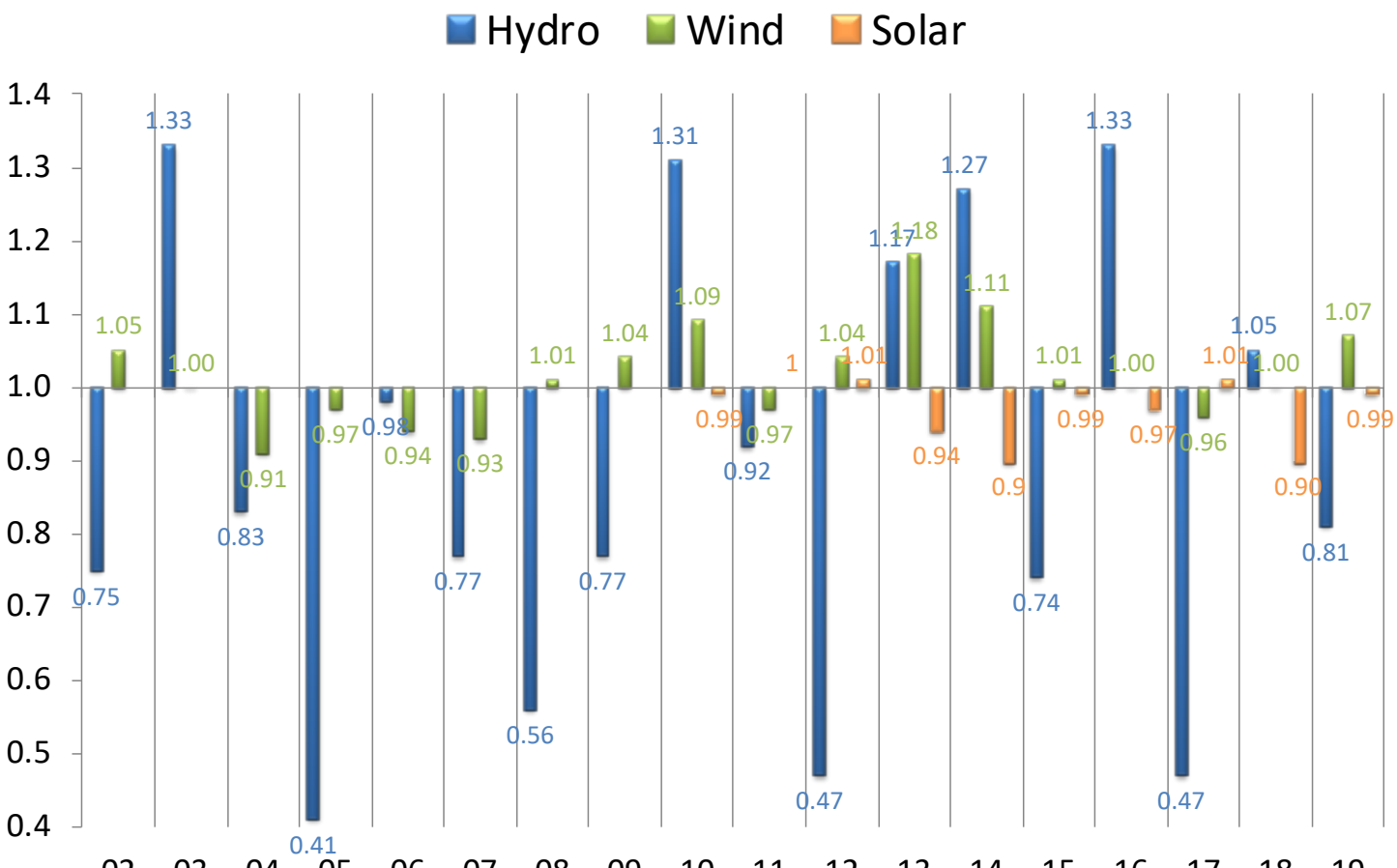
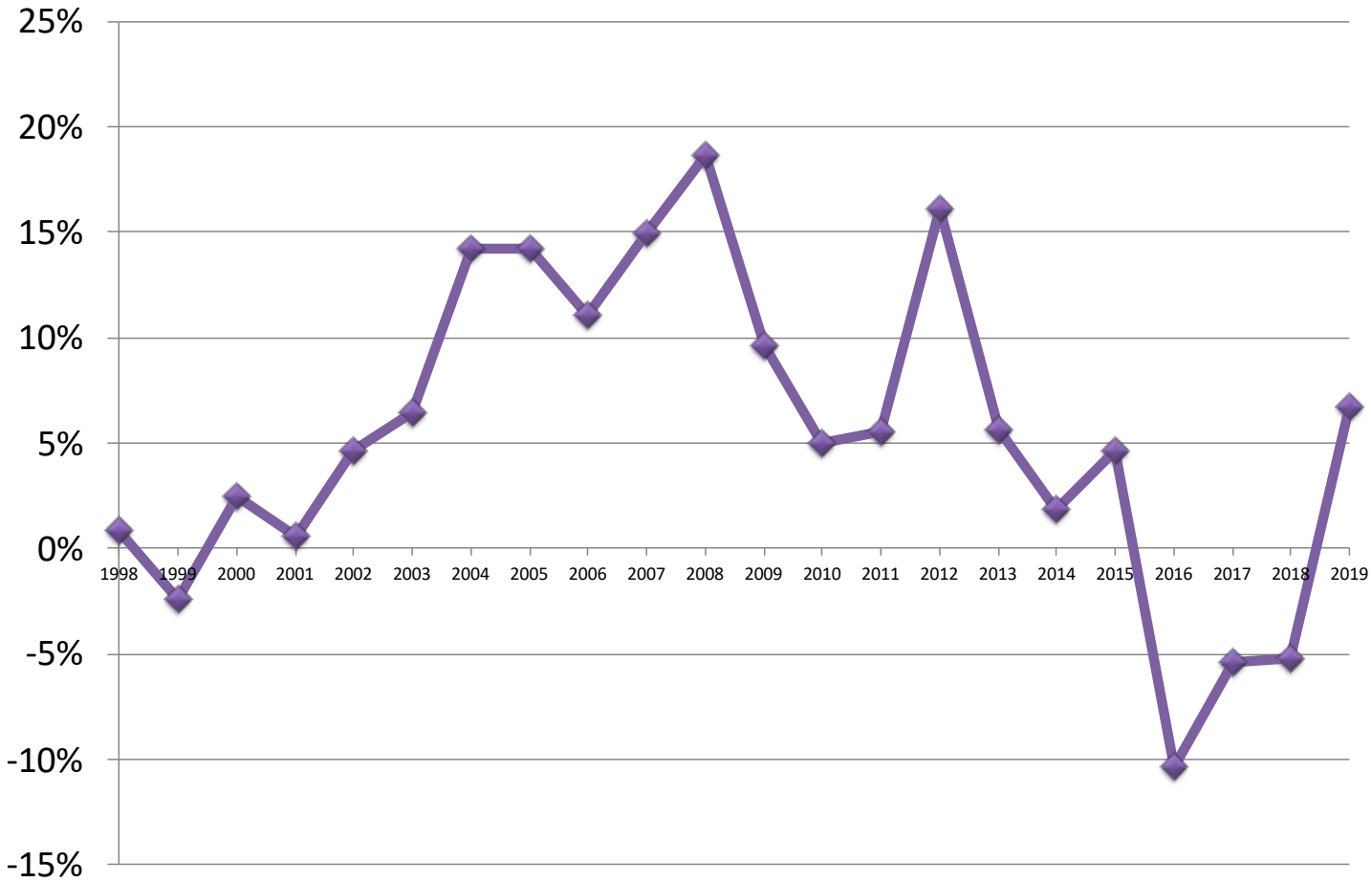
Source: REN

Capability index



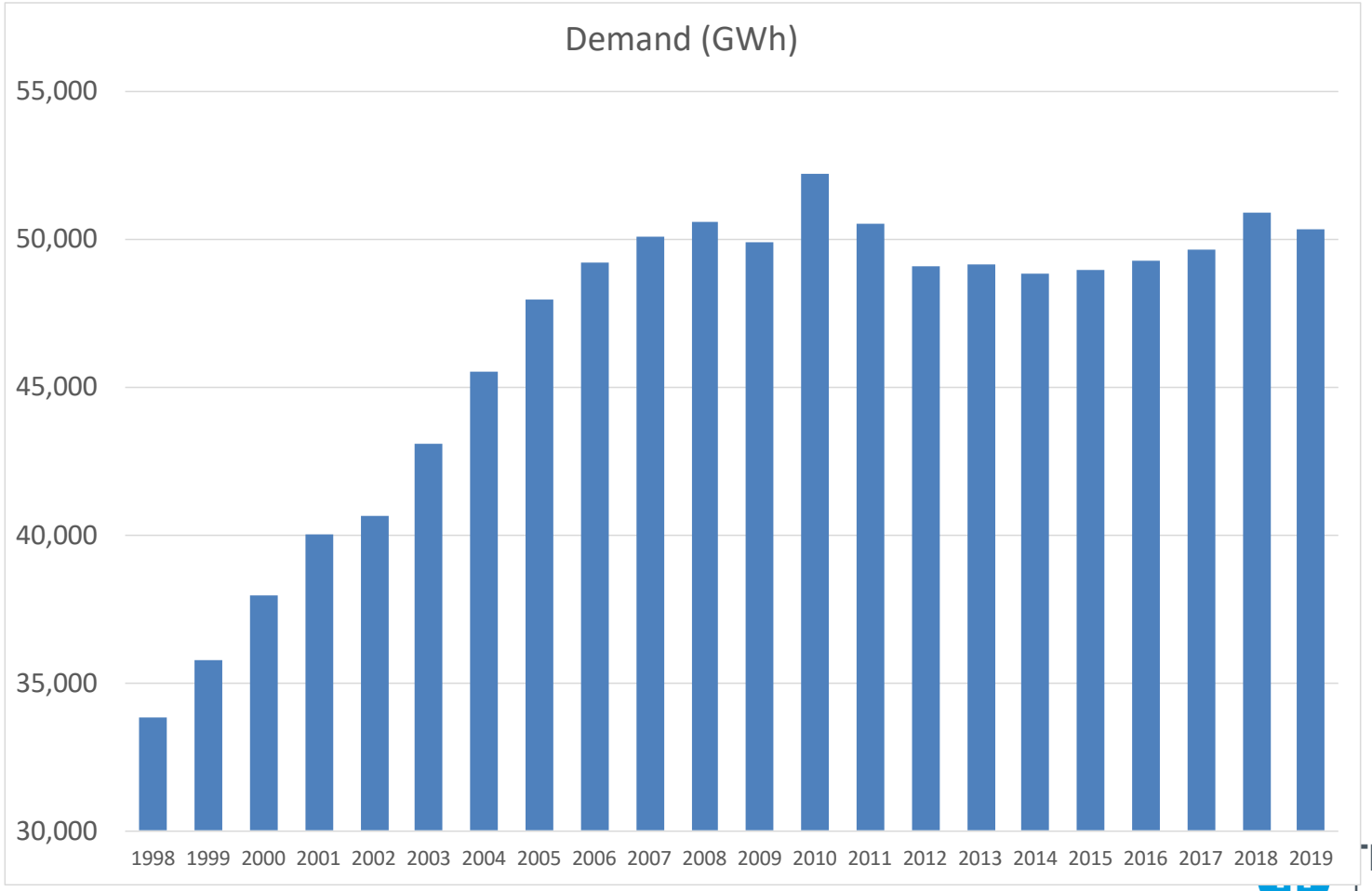
Source: REN

Portugal imports electricity (used to…)



Source: REN

Stable demand



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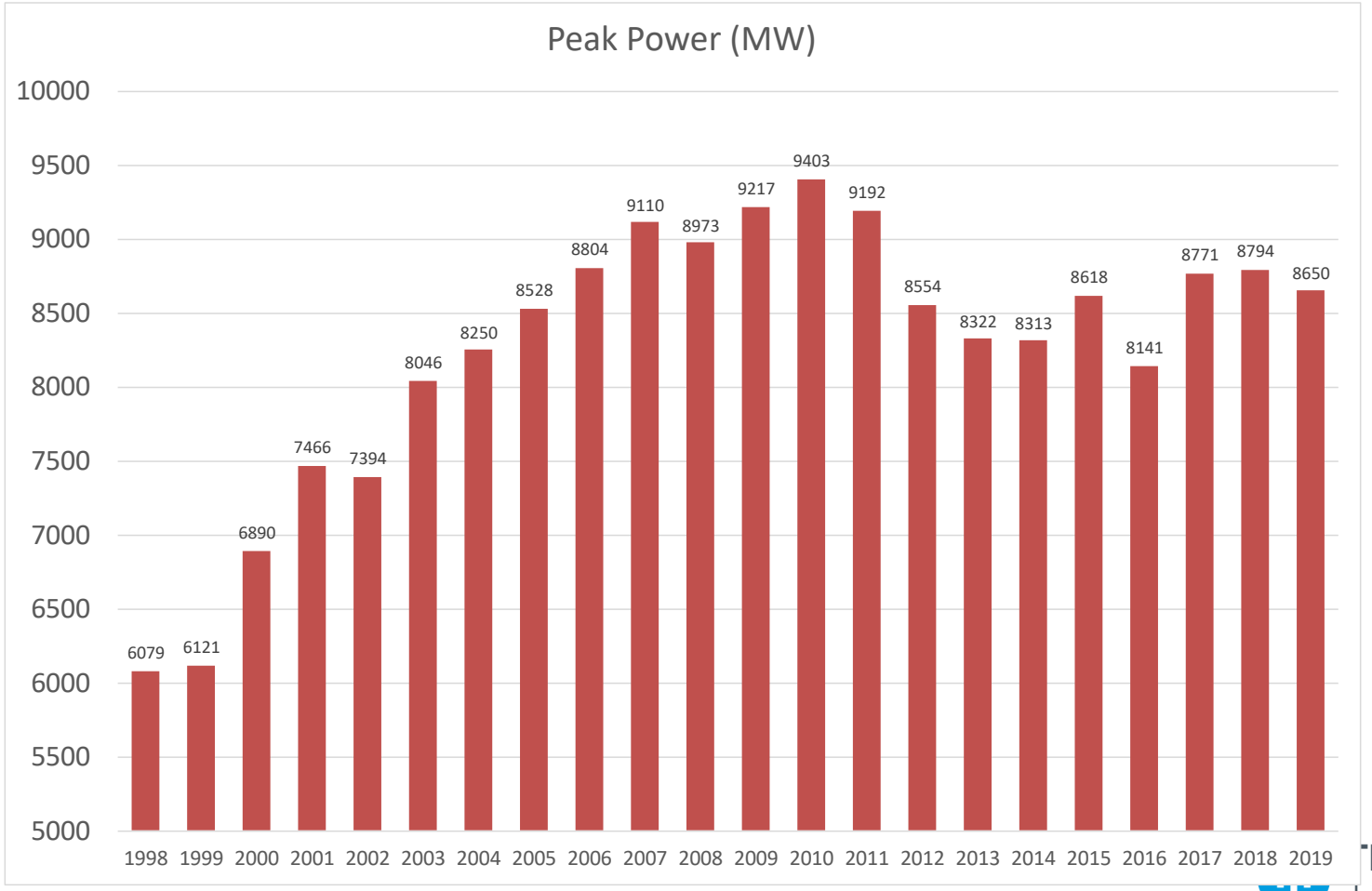
Source: REN

Stable peak



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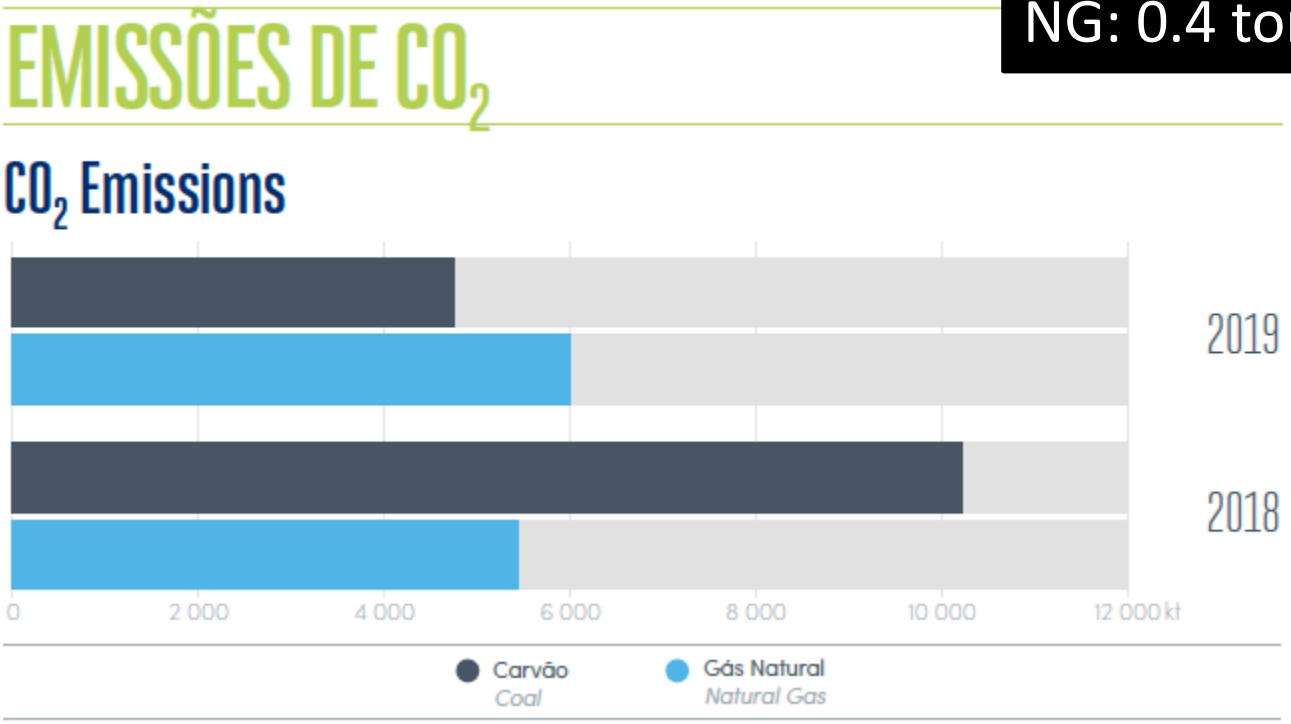
Source: REN

CO2 emissions

Coal: 0.9 ton/MWh
NG: 0.4 ton/MWh



Source: REN

Renewables and market price

Market price
2016: 39.4€/MWh
2017: 52.5 €/MWh

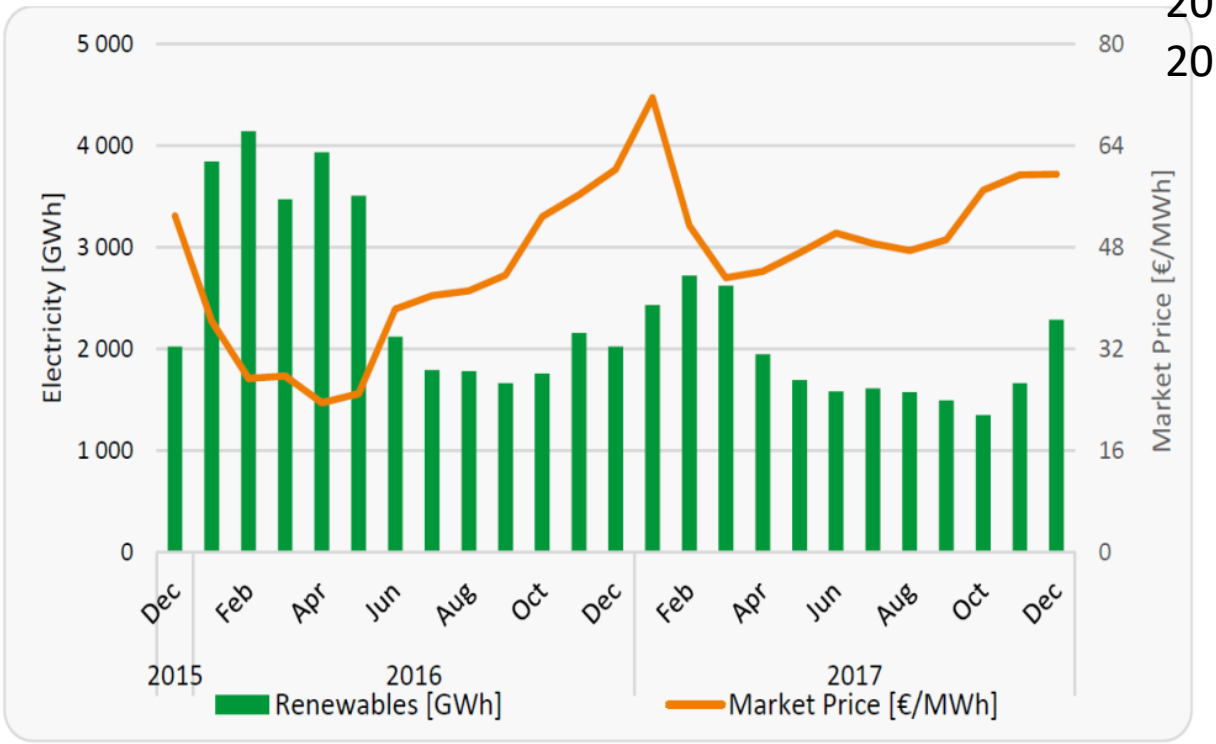
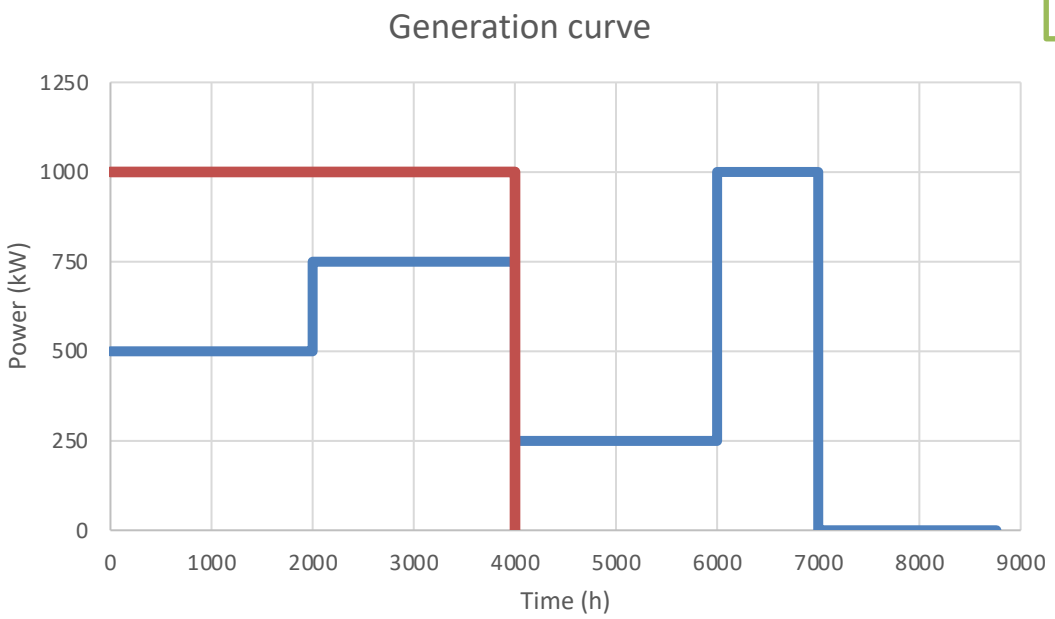


Figure 2: Evolution of the Renewable Electricity Production and of the Iberian Wholesale Electricity Price. (December of 2015 until December of 2017)

Source: OMIE, REN; APREN's Analysis

Capacity factor and utilization factor

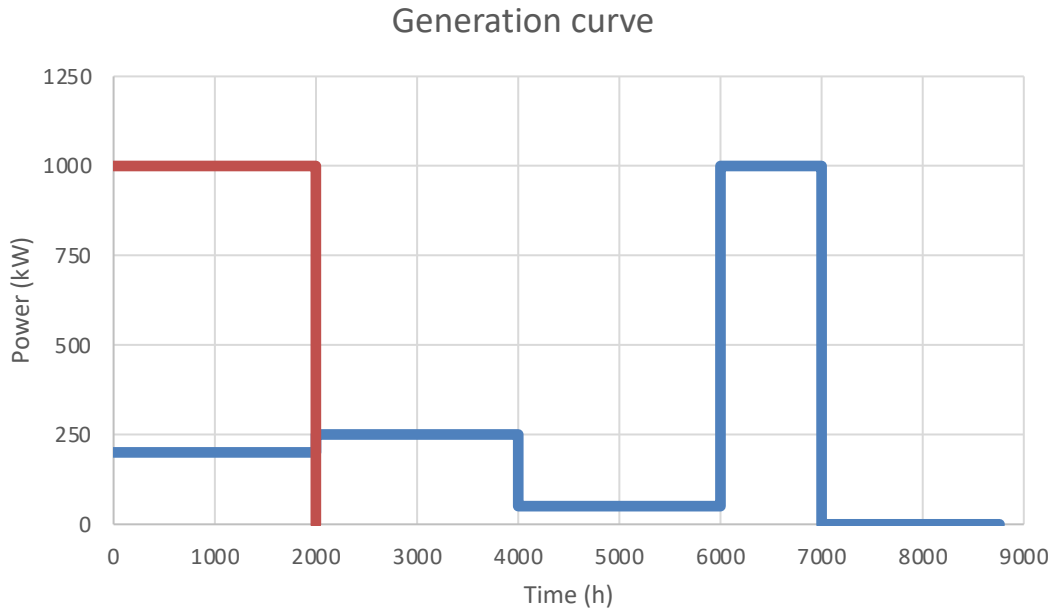


$$P_{inst} = 1000\text{kW}$$

$$W_a = 4\text{GWh}$$

$$h_a = \frac{W_a}{P_{inst}} = 4000\text{h}$$

$$a = \frac{P_{avg}}{P_{inst}} = \frac{\frac{W_a}{8760}}{P_{inst}} = 0.46 = \frac{h_a}{8760}$$



$$P_{inst} = 1000\text{kW}$$

$$W_a = 2\text{GWh}$$

$$h_a = \frac{W_a}{P_{inst}} = 2000\text{h}$$

$$a = \frac{P_{avg}}{P_{inst}} = \frac{\frac{W_a}{8760}}{P_{inst}} = 0.23 = \frac{h_a}{8760}$$

SOME STATISTICS – IBERIA & EU-27

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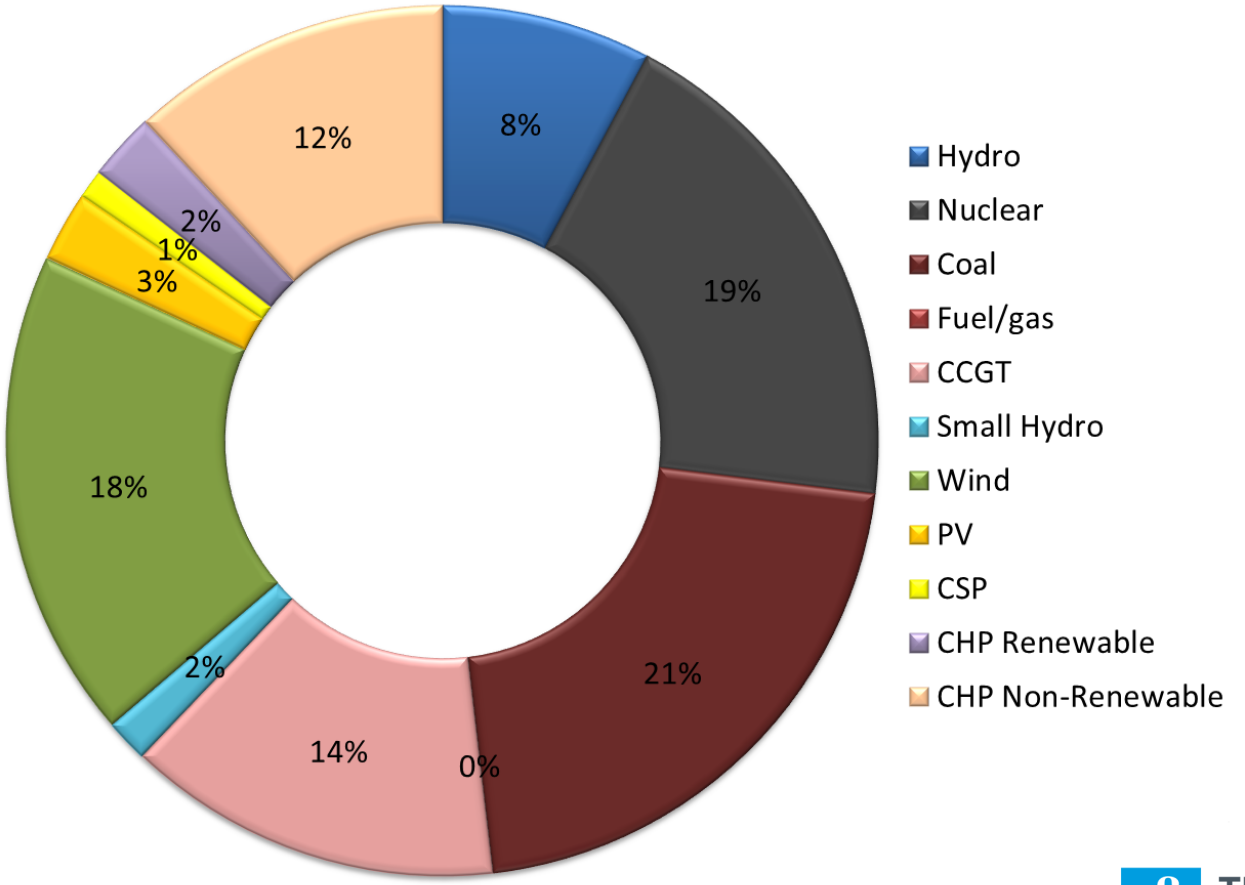
Iberian electricity mix, 2012



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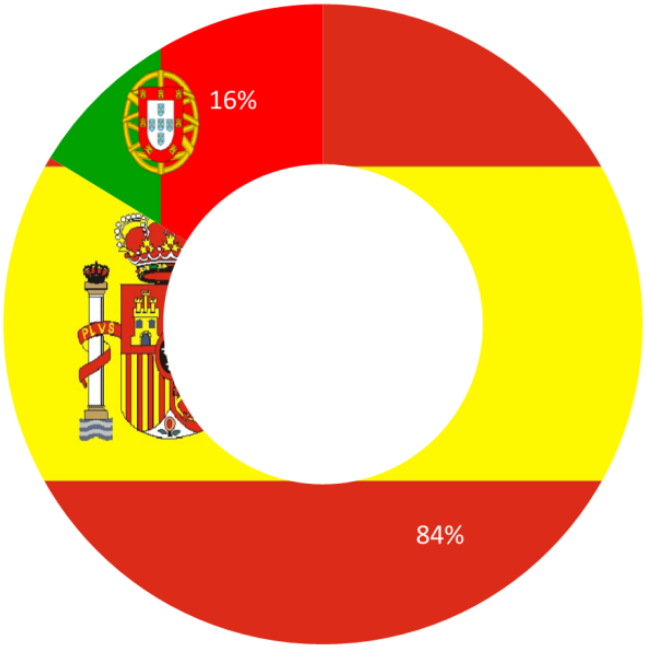
MIBEL – Iberian Electricity Market



- Portugal: 50 TWh
- Espanha: 250 TWh
- Total: 300 TWh

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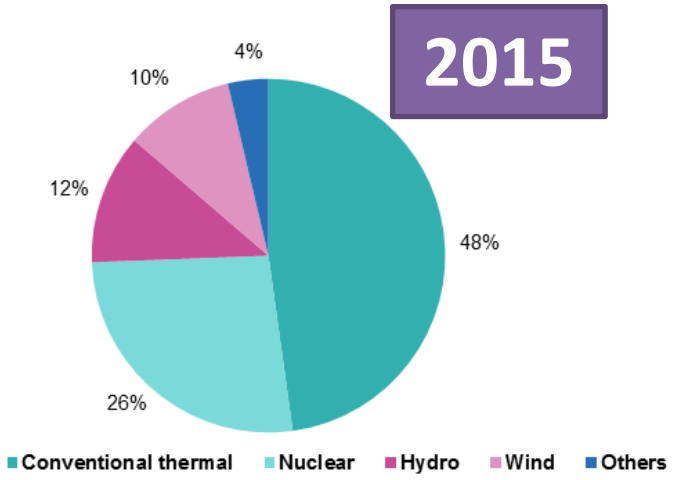
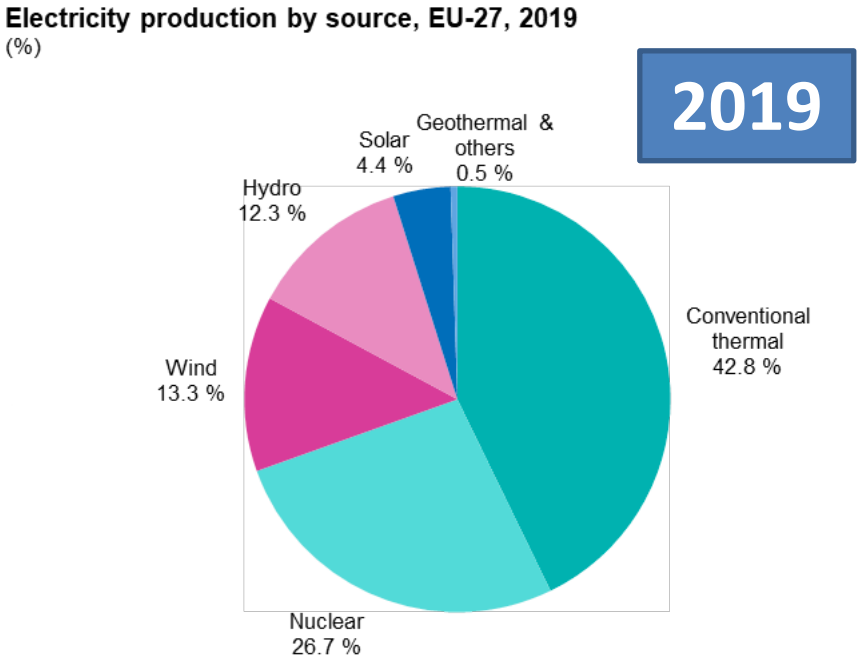
European electricity mix (GWh), 15-19





Source: Eurostat (online data code: nrg_cb_pem)

eurostat

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Source: Eurostat

THE FUTURE POWER SYSTEM

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Electricity Grid

- Aged
  - Designed in the 50s, installed in the 60s and 70s, before the era of the microprocessor
- Centralized
- Still some manual operations
- Fragile

GOAL

– **Upgrade** the grid in **Smart** way

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Smart Grid Attributes

- Be able to heal itself
- Motivate consumers to actively manage electricity usage
- Resist attack
- Provide higher quality power
- Accommodate all generation and storage options
- Enable distributed electricity markets to flourish
- More efficient operation
- Enable intermittent power generation sources

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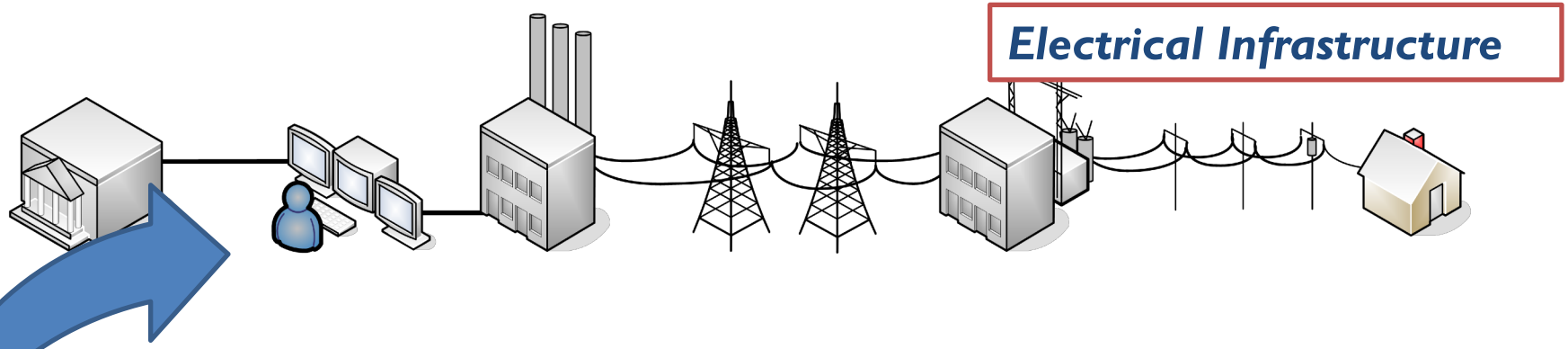
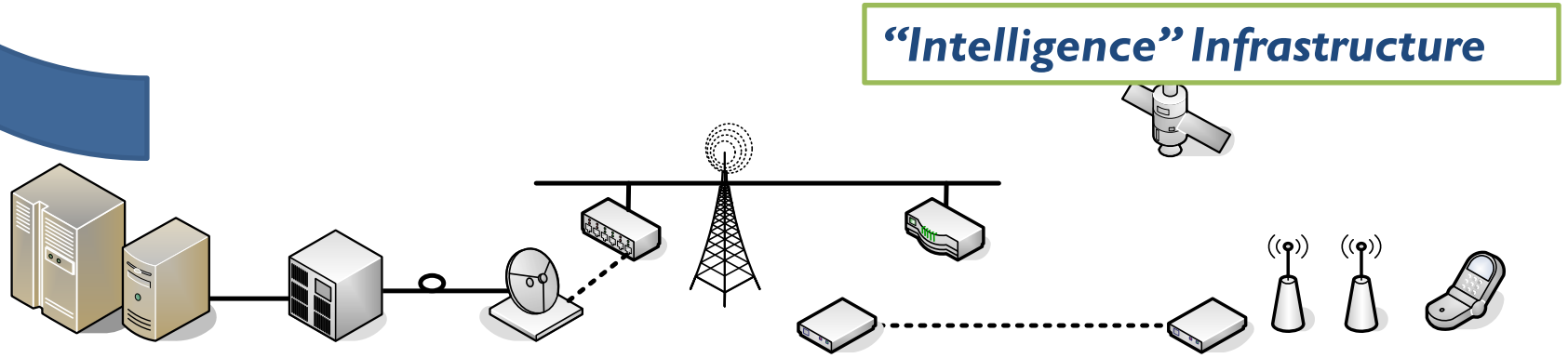
Smart Grid: The Energy Internet



A smart grid puts ICT into electricity generation, delivery, and consumption, making systems cleaner, safer, and more reliable and efficient.
A smart grid integrates advanced sensing technologies, control methods, and integrated communications into the current electricity grid.



Smart Grid Goals

- **Improve power generation and distribution system**
  - Integration of electric infrastructure and ICT infrastructure
  - More efficient and better management of power infrastructure
- **Increase use of renewable energy sources**
  - Alternate energy sources – Wind, solar, storage
  - Integration of distributed energy sources into power infrastructure
- **Better management of energy usage**
  - Use of smart meters and Demand Response systems to reduce and balance energy usage
  - Enable use of plug-in electrical vehicles – more friendly to environment, also as energy storage

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What Will the Smart Grid Look Like?