



A scenario analysis of the Italian Electricity Market: emissions and compliance with the EU targets

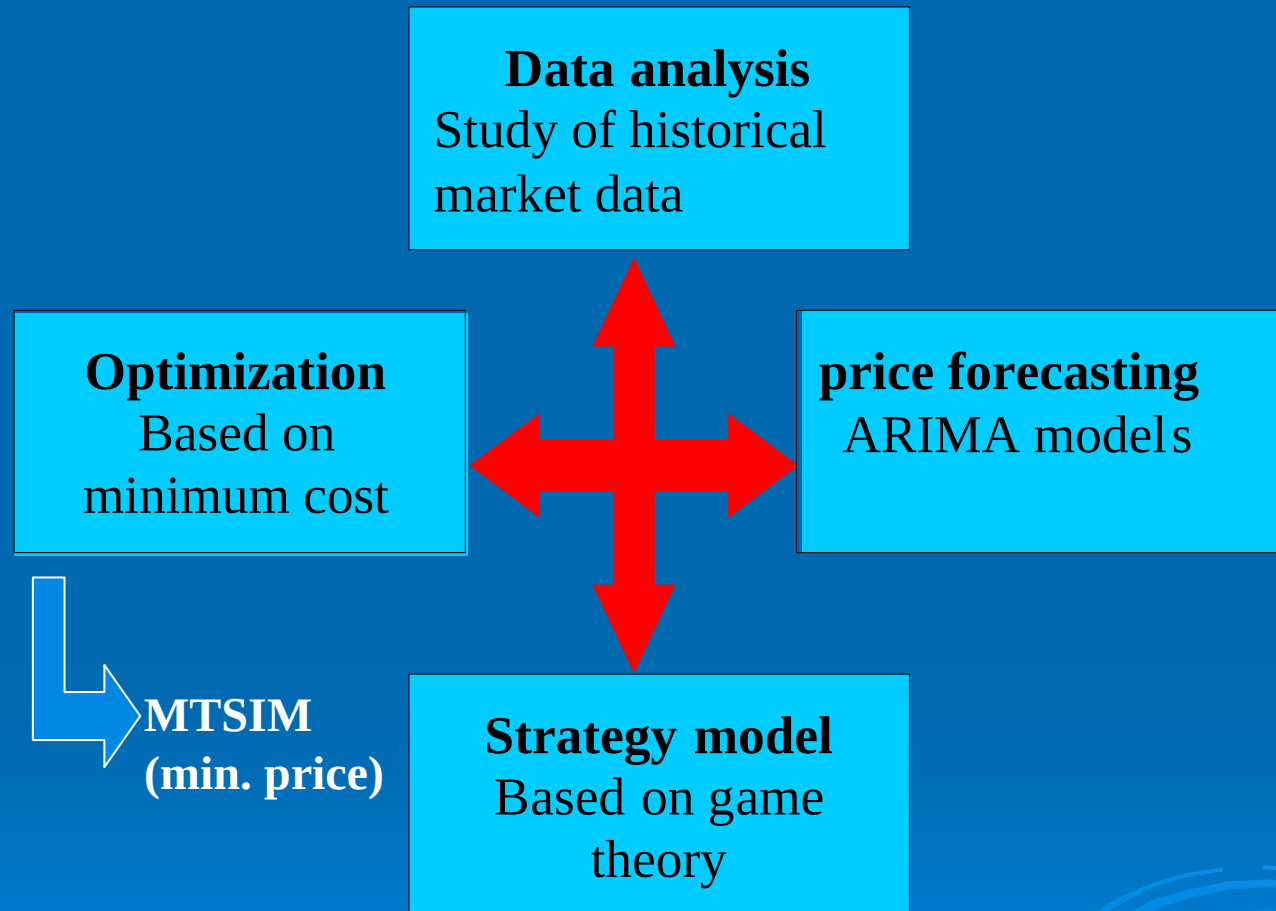
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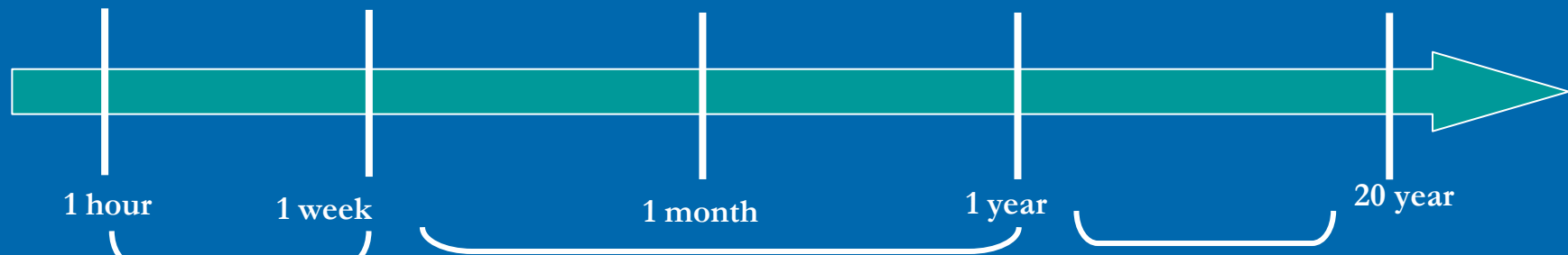
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- 

Different approaches to electricity market simulation



Time horizon of simulators



Short term

- high detail level
- bids optimizations

Medium term

- medium detail level
- scenario analysis
- Fix generation park

Long term

- low detail level
- generation park is not fixed

MTSIM

Time horizon:
One year

Information about
generation park

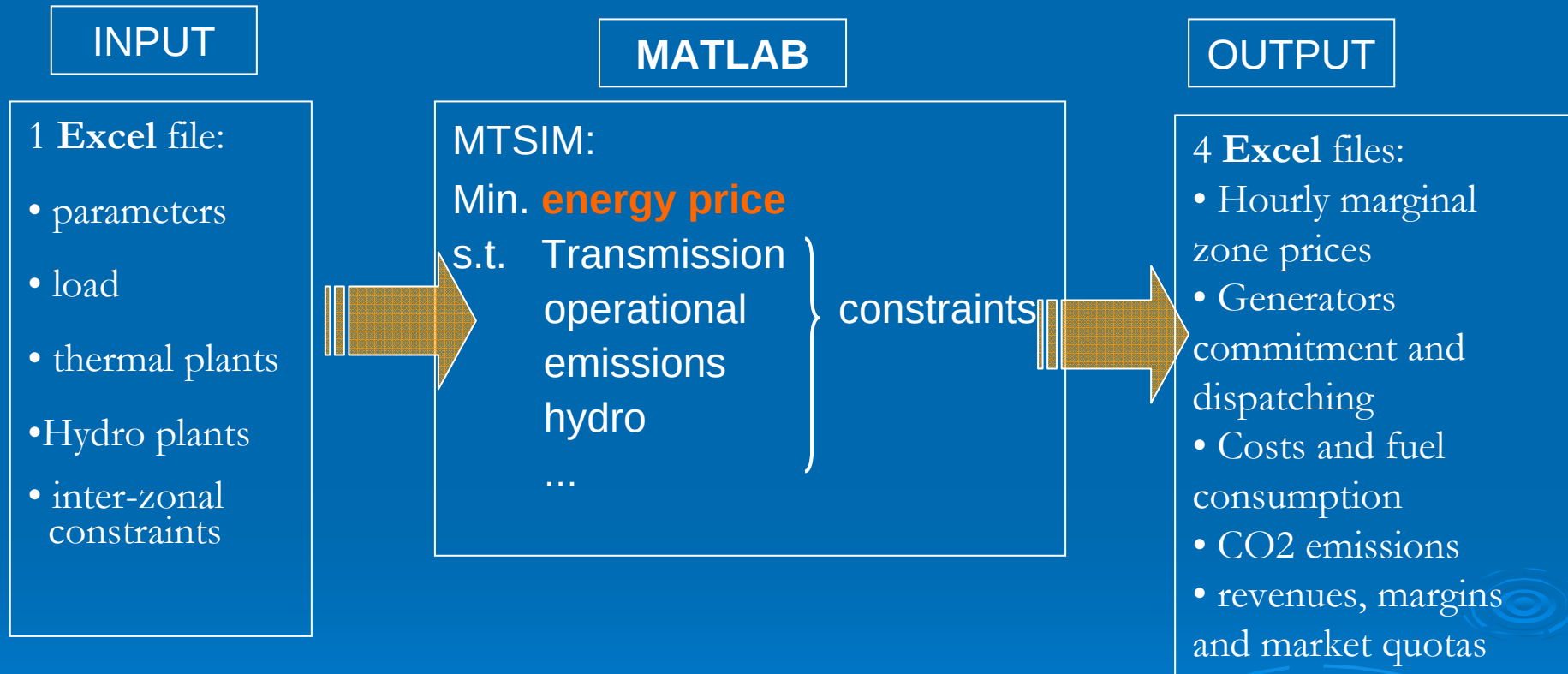
Main characteristics of MTSIM

- MTSIM simulates a generic **day-ahead** zonal market.

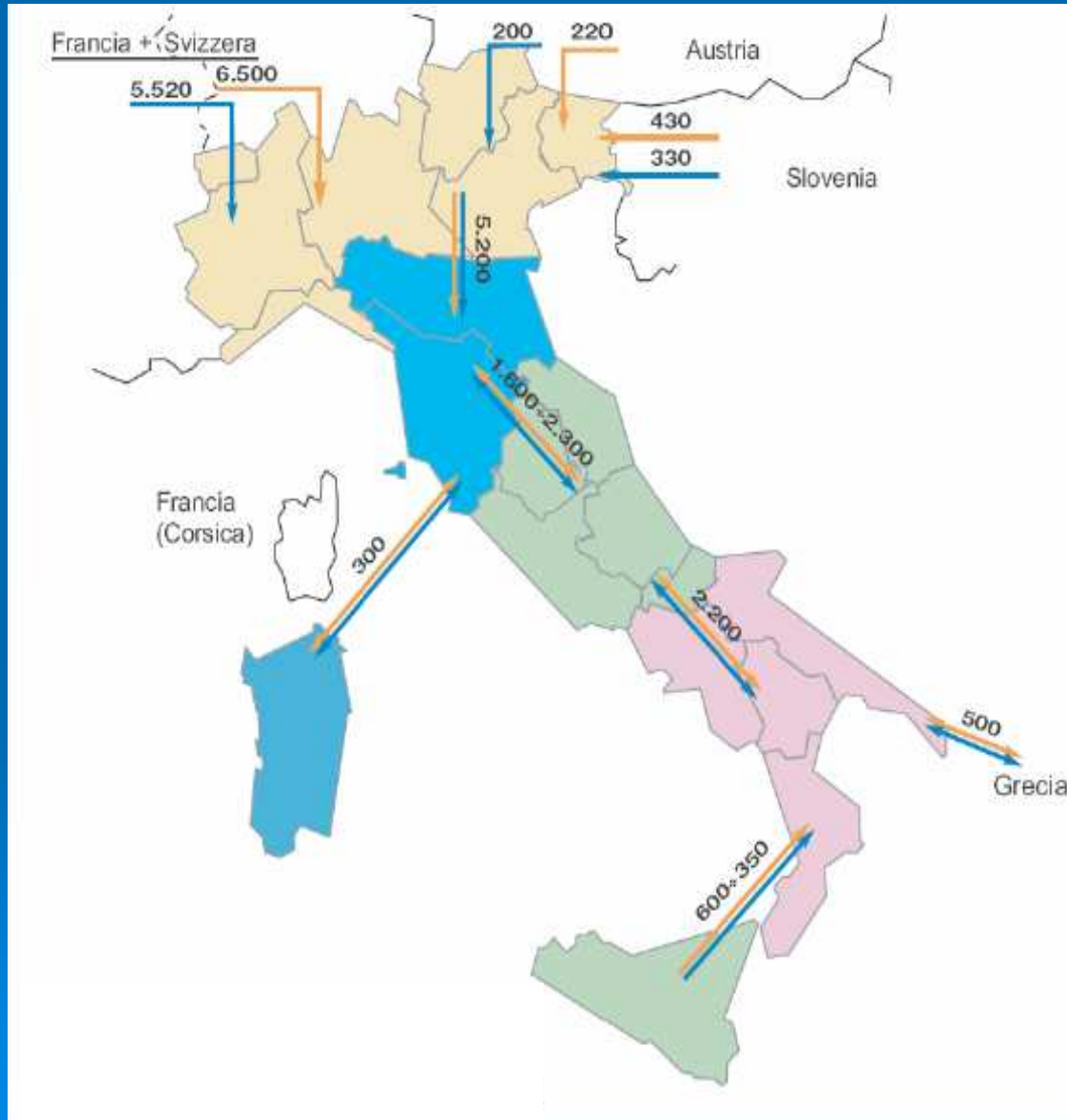


- The model is devised to carry out:
 - system-wide energy evaluations (i.e. zonal prices)
 - emission evaluations (CO₂ and other pollutants)

Main characteristics of MTSIM



Modelling the network

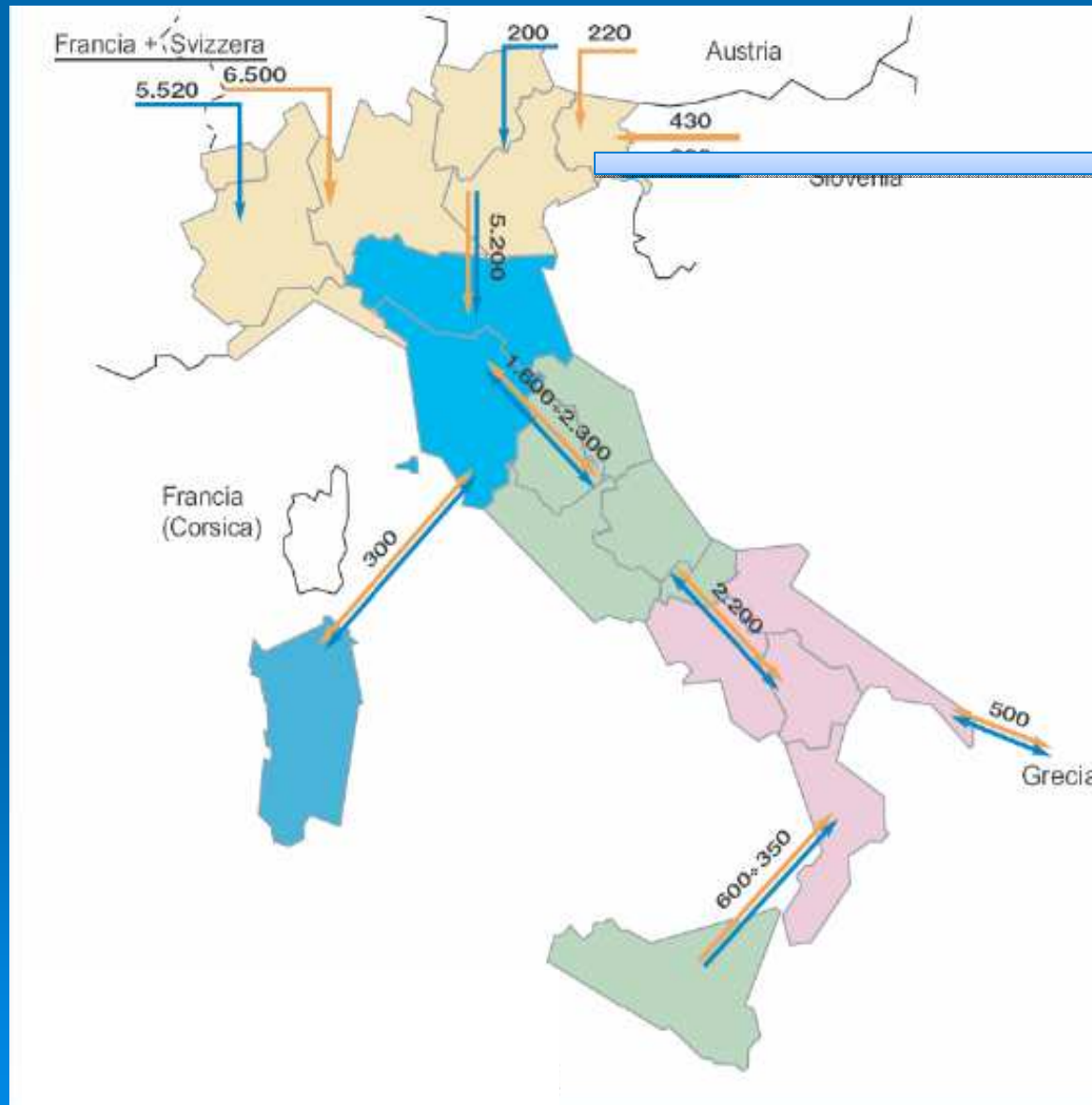


- Day-ahead Italian electricity market is based on a **zonal transmission model**
- higher prices should give an **economic signal** in order to stimulate the installation of new generation in zone where the prices are high.

PTDF matrix

[illegible]

Modelling the network



North

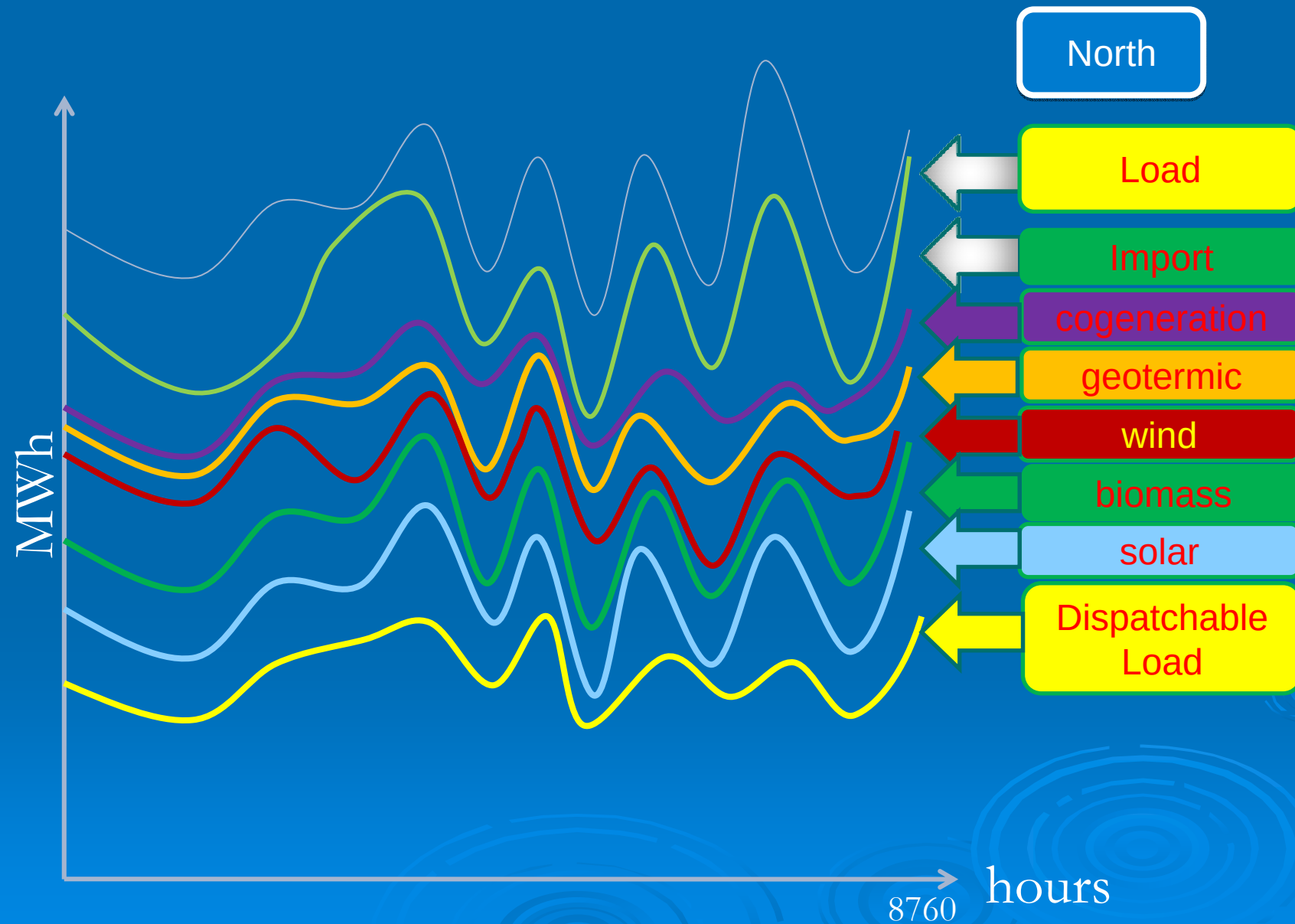
Load

imports

Dispatchable plants

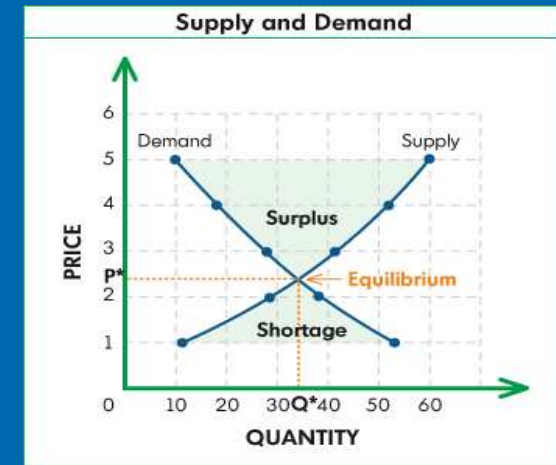
Generation profile of undispatchable plants

Modelling the Load



Having the dispatchable load...

Plants compete in the market...



What does the bid-up model?



Main characteristics of the simulator

HYDRO PLANTS

Zone

Generation company

Minimum power (can be negative)

Maximum power

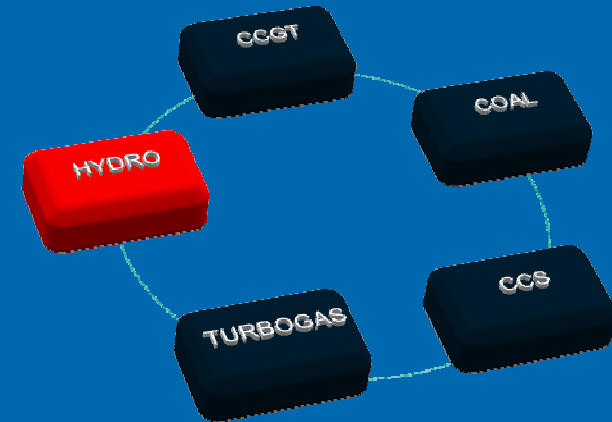
Programmed unavailability

Accidental unavailability

Initial volume constraints

Final volume constraints

Efficiency (pumping)



Main characteristics of the simulator

THERMAL PLANTS

Zone

Generation company

Minimum power

Maximum power

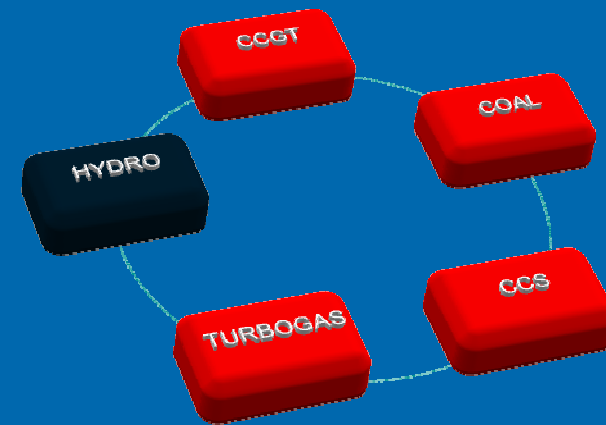
Programmed unavailability

Accidental unavailability

Simple production constraints (e.g. must run)

Integral constraints (productions, fuel consumptions, CO2 emissions)

Fuel mix



Main characteristics of the simulator

THERMAL PLANTS

Fuel-dependent emissivity factor

If the total CO₂ production exceeds the quota admitted for the system, exceeding quantities can be bought in the emission markets (ET or CDM). Prices on the emission markets are input for the model.

Exceeding quotas can be sold in the same markets.

It is possible to add a penalization factor for the CO₂ production or other pollutants (environmental internalization/opportunity costs)

Can be defined the type of flexibility:

Weekly	min on-hours: 60	min off-hours: 20
Daily	min on-hours: 12	min off-hours: 6
Hourly	min on-hours: 1	min off-hours: 1



Coal:
0,094 t CO₂/GJ

Gas-oil:
0,073 t CO₂/GJ

Oil:
0,077 t CO₂/GJ

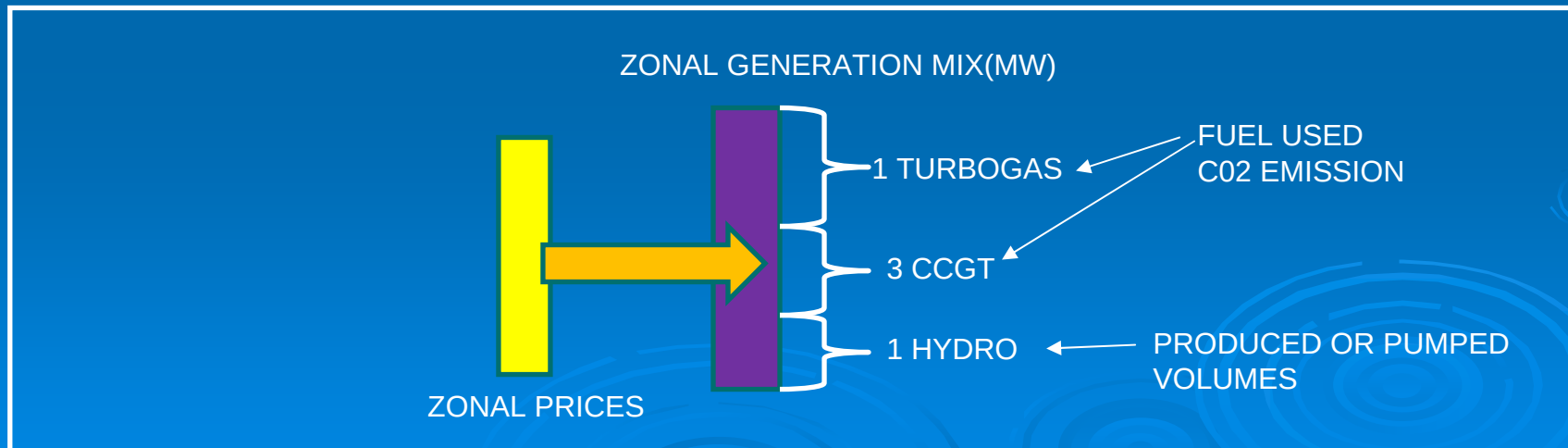
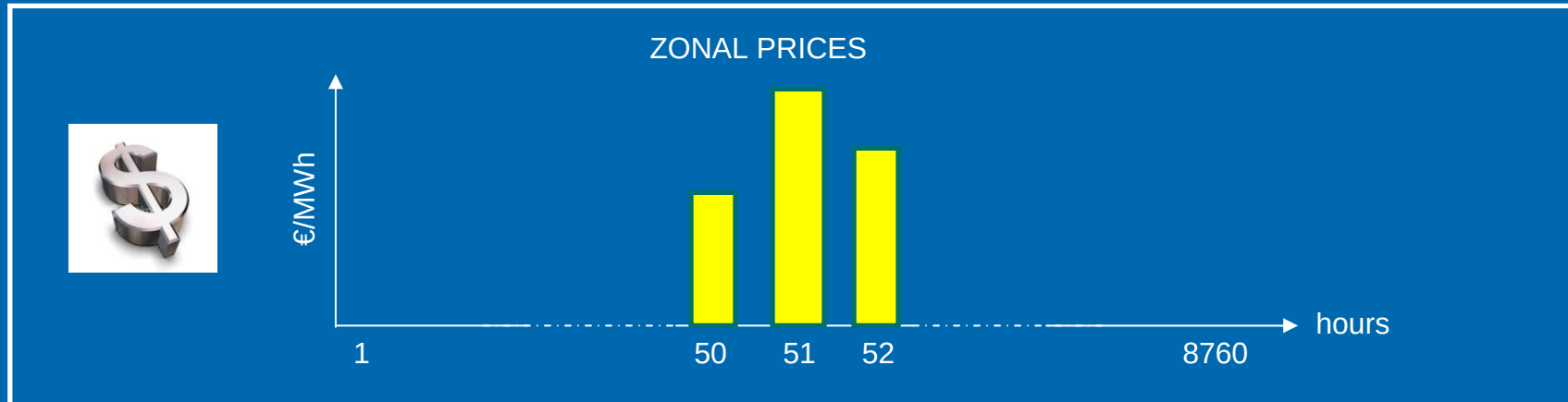
Natural gas:
0,056 t CO₂/GJ

The output files

- **Thermal:** data related to thermal generation
 - unit commitment, dispatched hourly power, fuel quantity and mix (if any), revenues, CO2 emissions, marginal generator in each zone every hour
- **Hydro:** data related to hydro generation
 - produced and pumped hourly power, revenues and (pumping) costs, reservoirs volumes, spill-overs
- **System:** system-wide results
 - yearly target optimal (cost) value, zonal prices, transits, ENP. EIE, purchases on emission markets (ET, CDM)
- **Synthesis:** synthetic overviews
 - yearly producers shares, yearly production and cost balances, zonal hourly balances, hourly fuel consumptions, hourly fuel shares, hourly GenCo data (revenues, variable costs and production), hourly plant emissions, marginality hourly percentage (operator and technology).

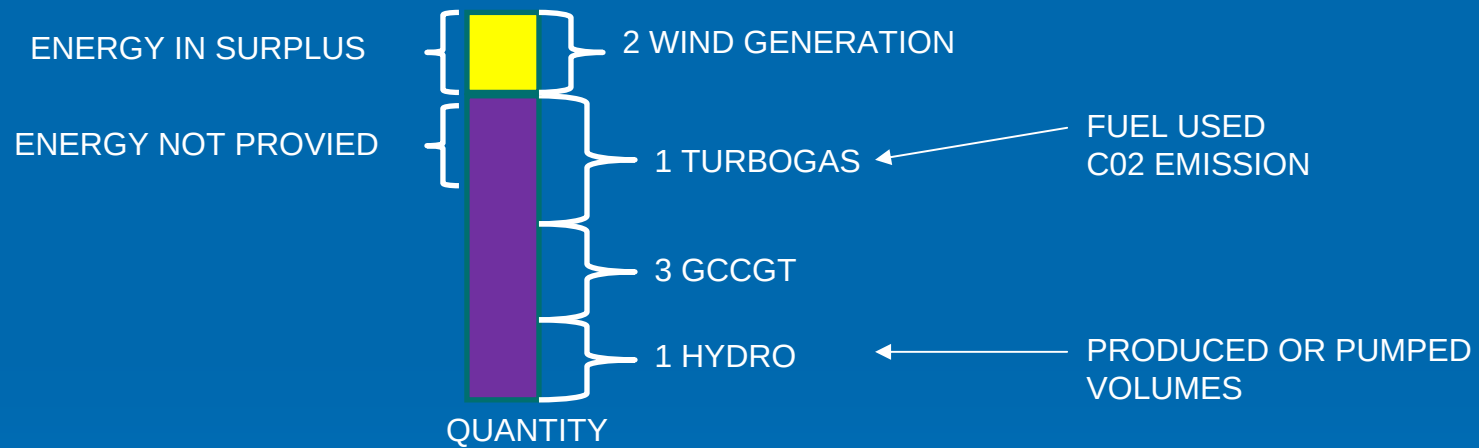
The output files

For each zone..



The output files

For each zone..



Case Study: Italian electricity market at 2020

EU27 TARGETS

20%

LESS GHG EMISSIONS

20%

MORE RENEWABLE

20%

MORE EFFICIENCY

w.r.t 1990

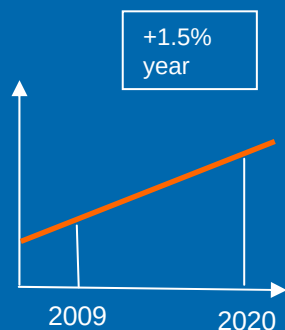
Issues and challenges for Europe and for Italy. Position paper of the Italian Government - 10 September 2007- Repubblica Italiana, Presidenza del Consiglio dei Ministri

technologies	Power (MW)	Energy (TWh)
Hydro power plant > 10MW	16000	30,72
Hydro power plant < 10MW	42000	12,43
TOTAL HYDRO SOURCE	20200	43,15
Wind plants on-shore	10000	18,40
Wind plants off-shore	2000	4,20
TOTAL WIND SOURCE	12000	22,60
Building integrated PV plants	7500	9,00
Power PV plants	1000	1,20
Solar thermodynamic	1000	3,00
TOTAL SOLAR SOURCE	9500	13,20
Traditional geothermic	1000	7,48
New generation geothermic	300	2,24
TOTAL GEOTHERMIC SOURCE	1300	9,73
Plants using biomass	769	5,00
Plants using biodegradable part RSU	800	4,00
Plants using landfill gas, sewage treatment plant gas and biogas	492	3,20
Plant using dedicated Energy crops	354	2,30
TOTAL BIOMASS	2415	14,50
Wave and Tidal energy	800	1,00
TOTAL	46215	104,18

Case Study: Italian electricity market at 2020

Scenario Hypothesis

Demand (MWh)



Fuel Cost [€/GJ]

Oil	14,43
Natural gas	16,44
coal	5,81
CCS	6,29
Gas-oil	25,07

Emission factor [tCO₂/GJ]

Oil	0,077
Natural Gas	0,056
Coal	0,094
CCS	0,009
Gas-oil	0,073

Generation profiles

Historic profiles:

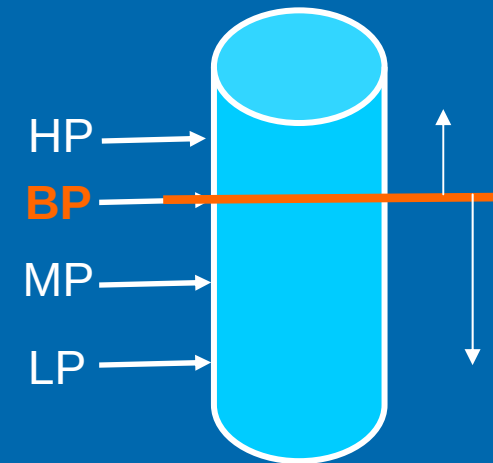
- wind
- hydro
- solar
- geothermic

Case study: four scenarios

Scenarios diversified by:

❑ Wind penetration (TWh)

- ❑ High penetration (HP): 27,2
- ❑ Base penetration (**BP**): 22,6
- ❑ Medium Penetration (MP): 21,8
- ❑ Low Penetration (LP): 19,4



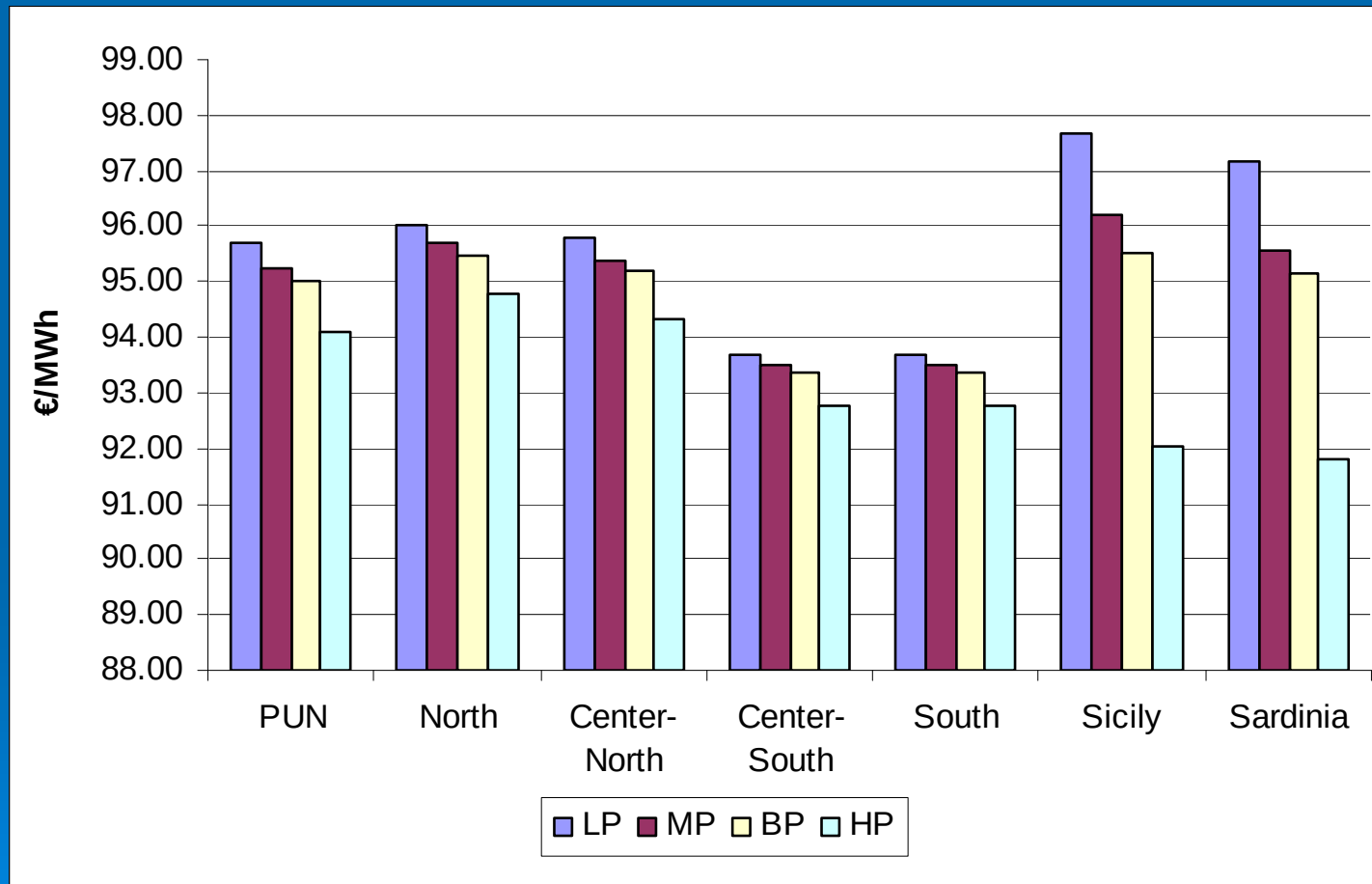
❑ CO₂ - cost:

- ❑ from 10 €/t to 50 €/t
- ❑ Extremes values: from 100 €/t to 250 €/t



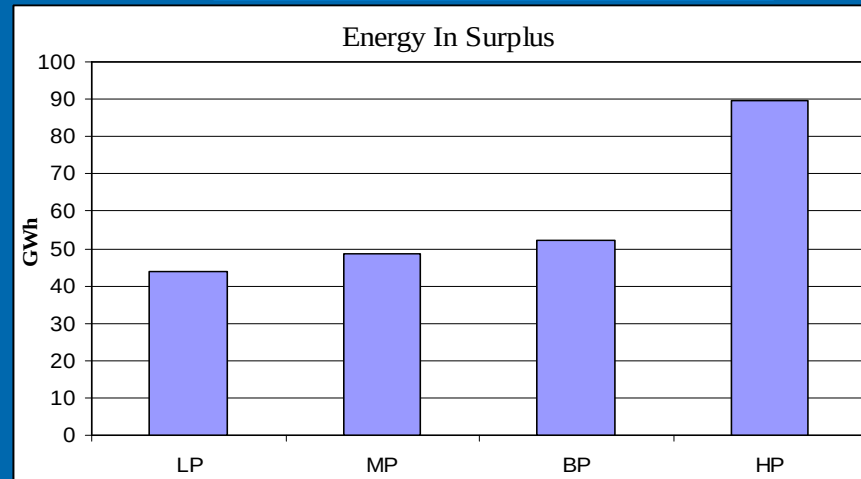
Case study: Results

PUN and zonal-prices

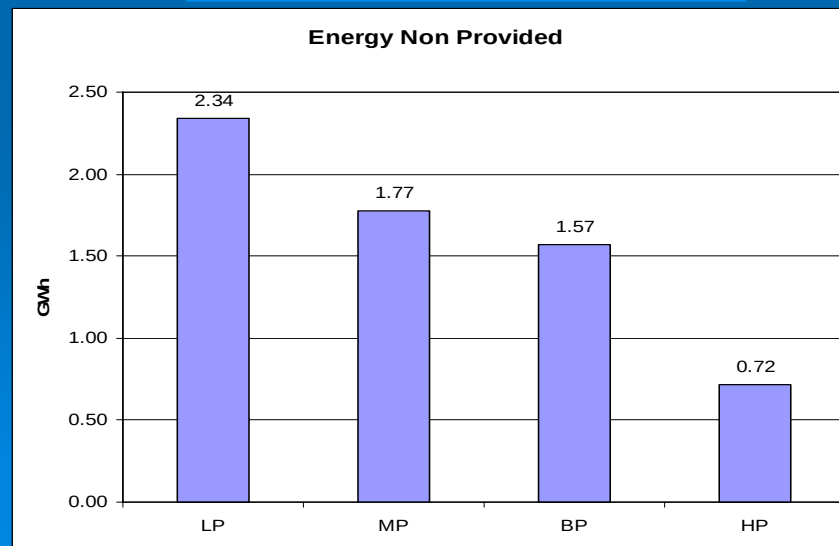


Case Study: Results

Energy In Surplus

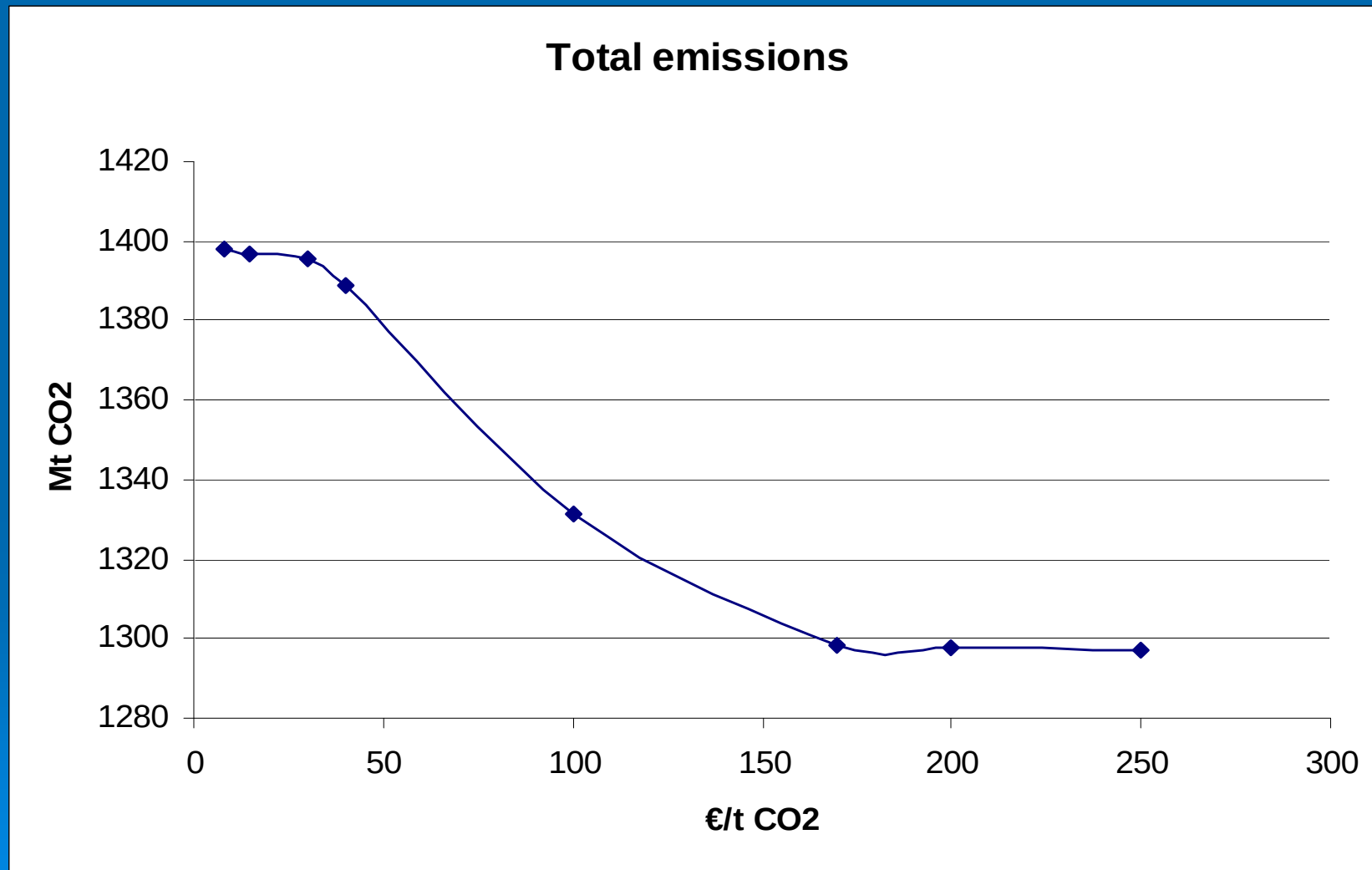


Energy Not Provided



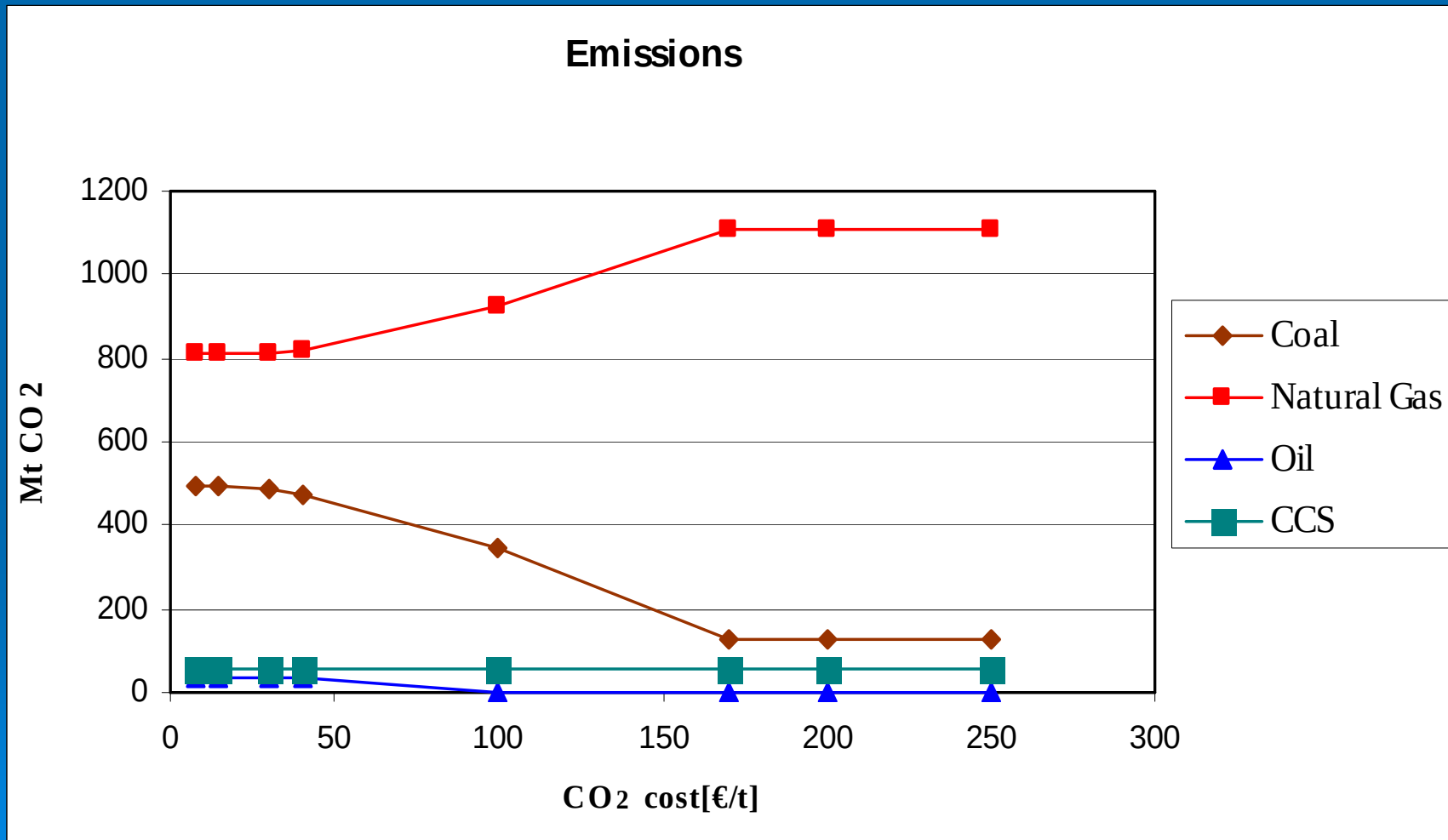
Case Study: Results

emission-mix



Case Study: Results

emission-mix



Case Study

Conclusions

- The **high penetration of RES-E in Italy is essential** for the attainment of the objectives at the year 2020.
- The high penetration create problems for the system to follow the great variability of this generation: the **system is not able to respond to high speed load variation** (Sicily e Sardinia).
- The massive RES-E penetration impact significantly on the **intra-daily market (pay as bid)**, that in Italy has a high cost and on which it is necessary to guarantee:
 1. More reservoir;
 2. Real time balancing;
- Concerning emissions: in order to reduce the overall level, **Italy needs not only to exploit its whole potential for RES-E generation**, but also to take into account solutions that promote efficiency, demand-side management, smart grid generation, coal to gas switch, nuclear technologies or CCS.

Thank you...

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