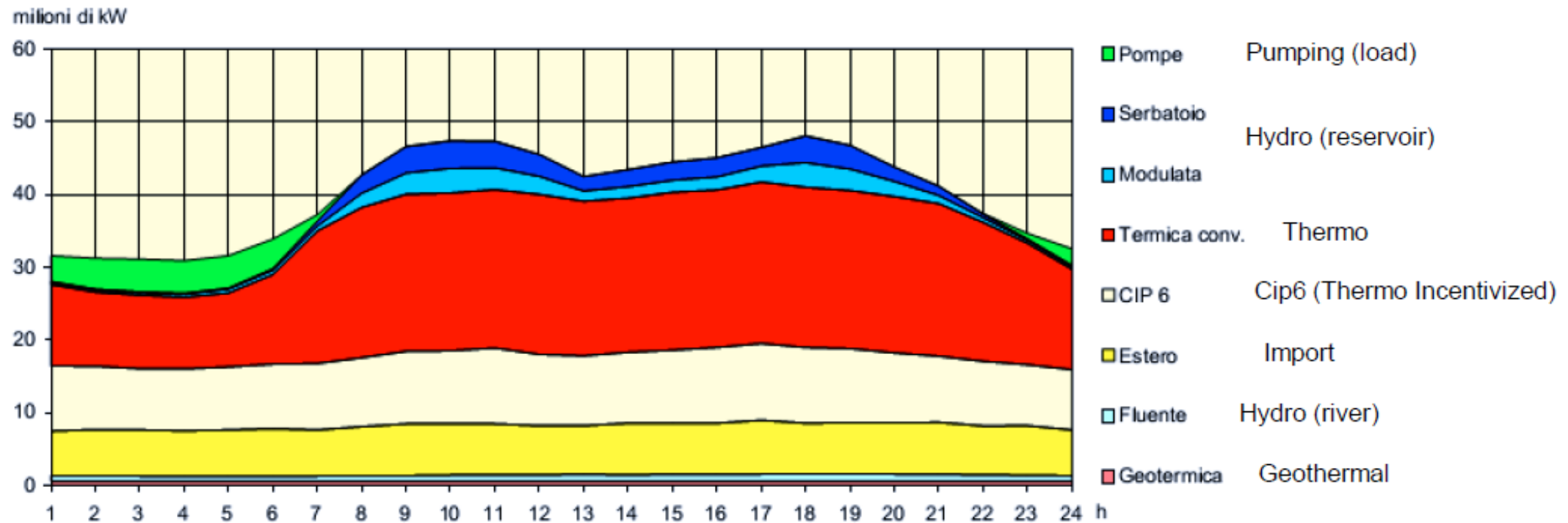


RES and Electricity market

RES production in Italy: winter 2005

DIAGRAMMA ORARIO DEL FABBISOGNO E RELATIVA COPERTURA DEL :

26-01-2005

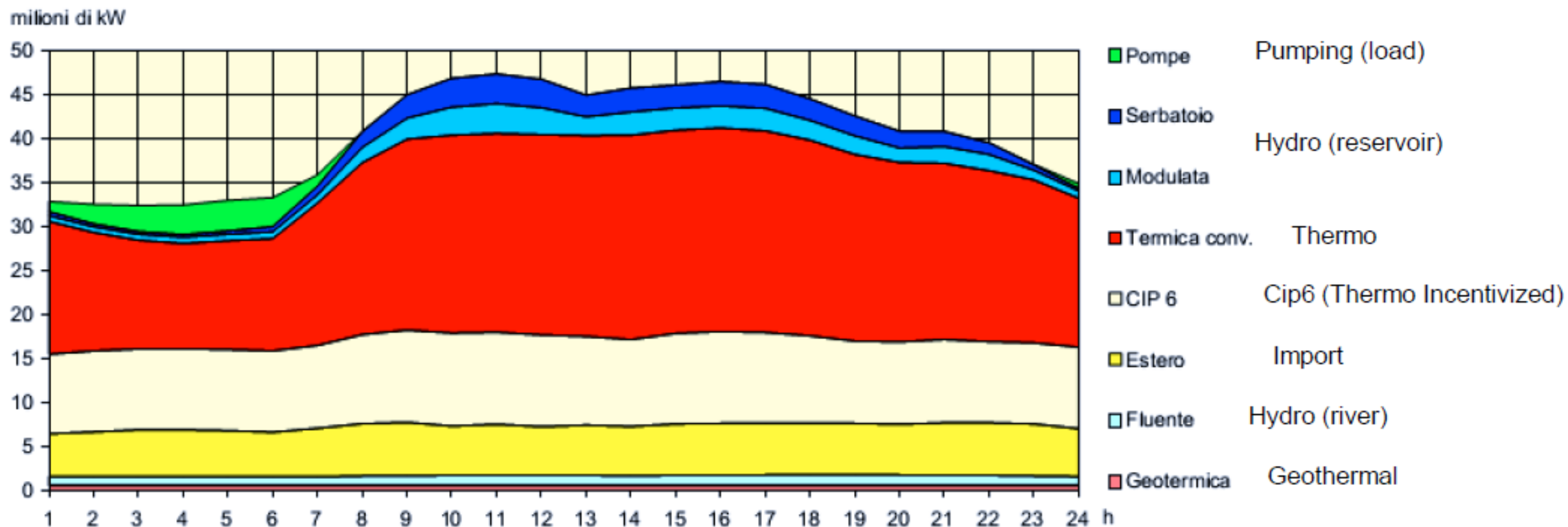


Largest contribution due to thermal plants
RES production limited to hydro plants

RES production in Italy: summer 2005

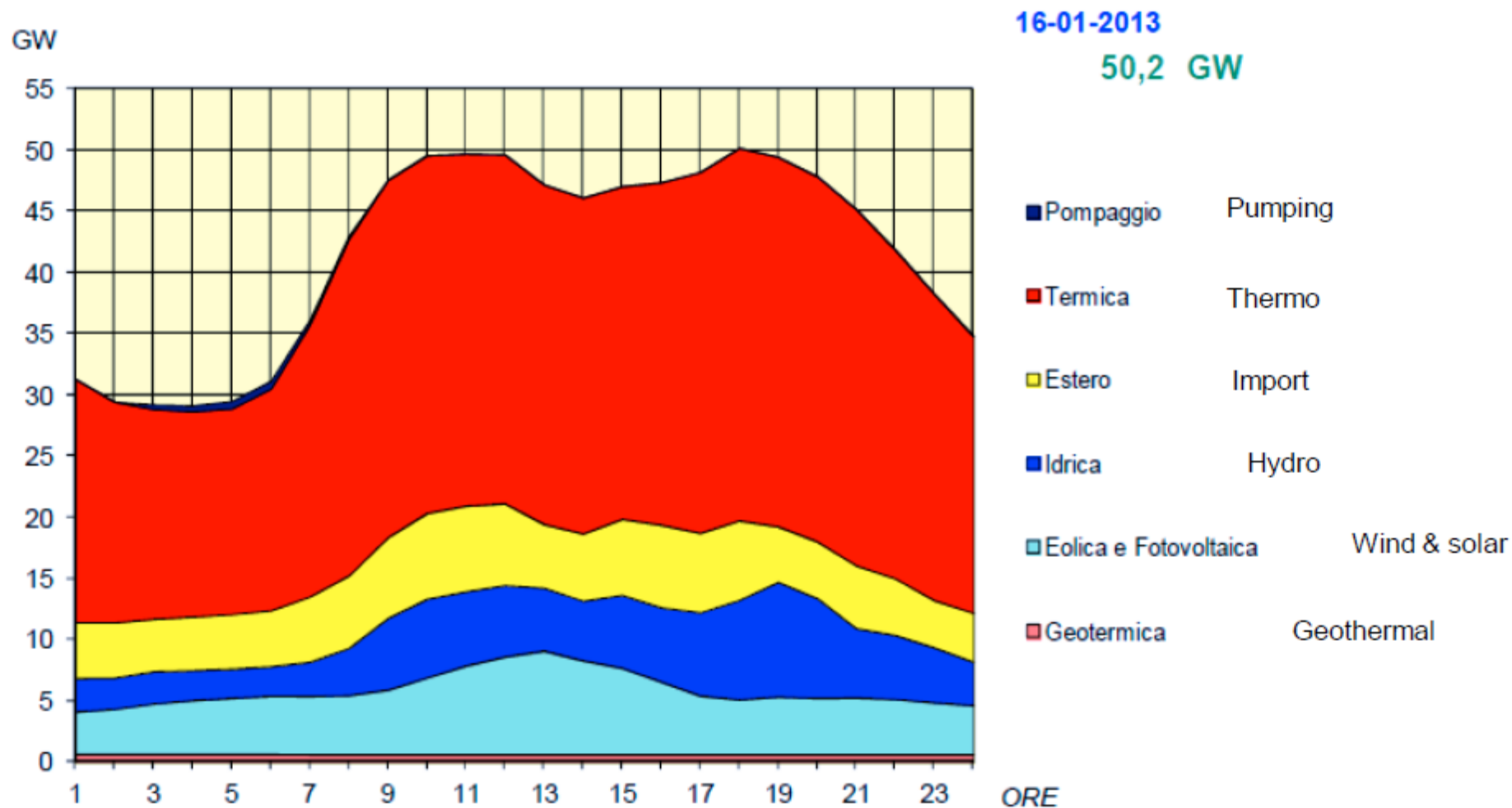
DIAGRAMMA ORARIO DEL FABBISOGNO E RELATIVA COPERTURA DEL :

20-07-2005



More or less the same fuel mix as in winter

RES production in Italy: winter 2013



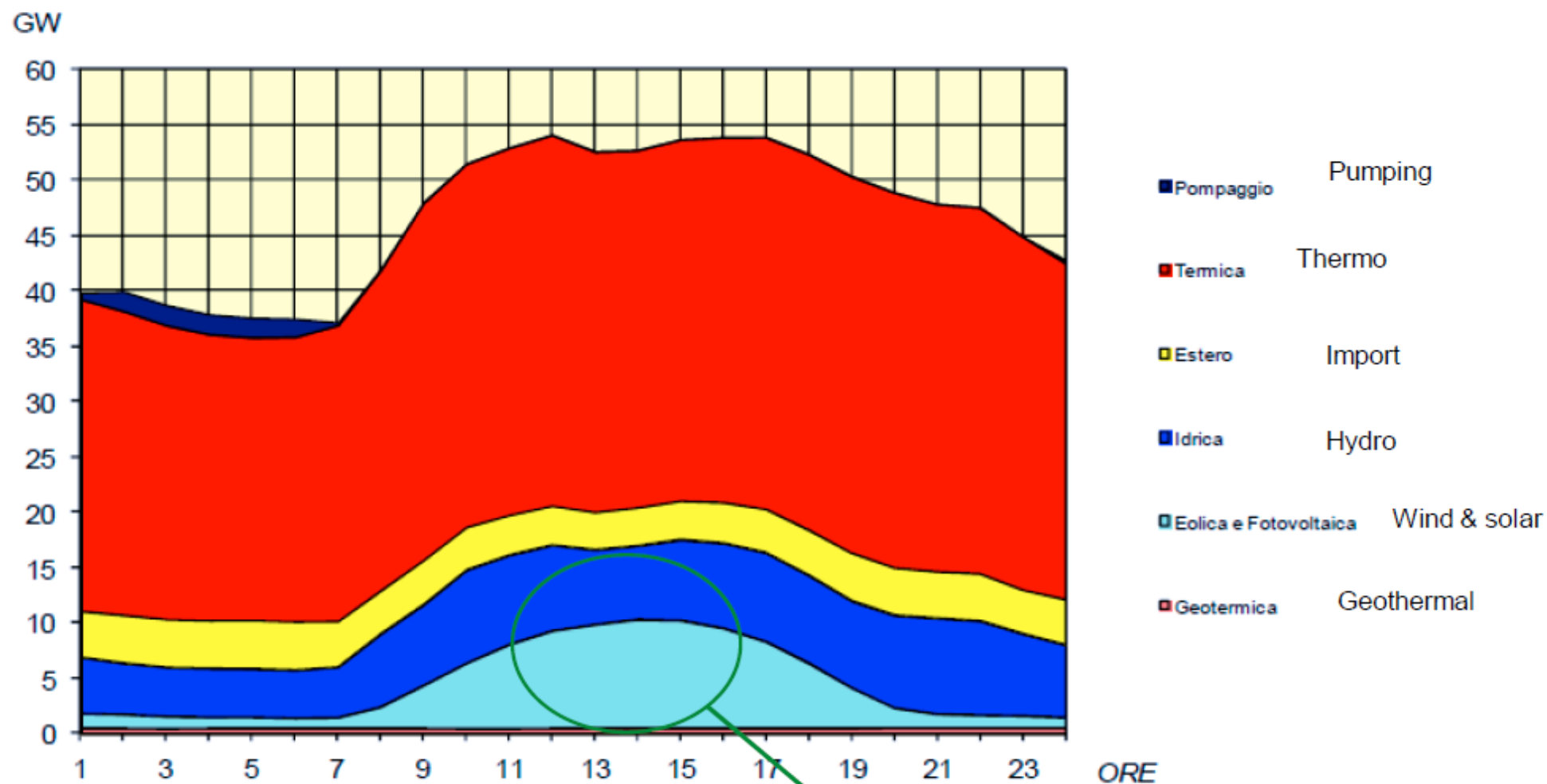
Large contribution from wind and solar plants;
improvement also in hydro plants

RES production in Italy: summer 2012

10-07-2012

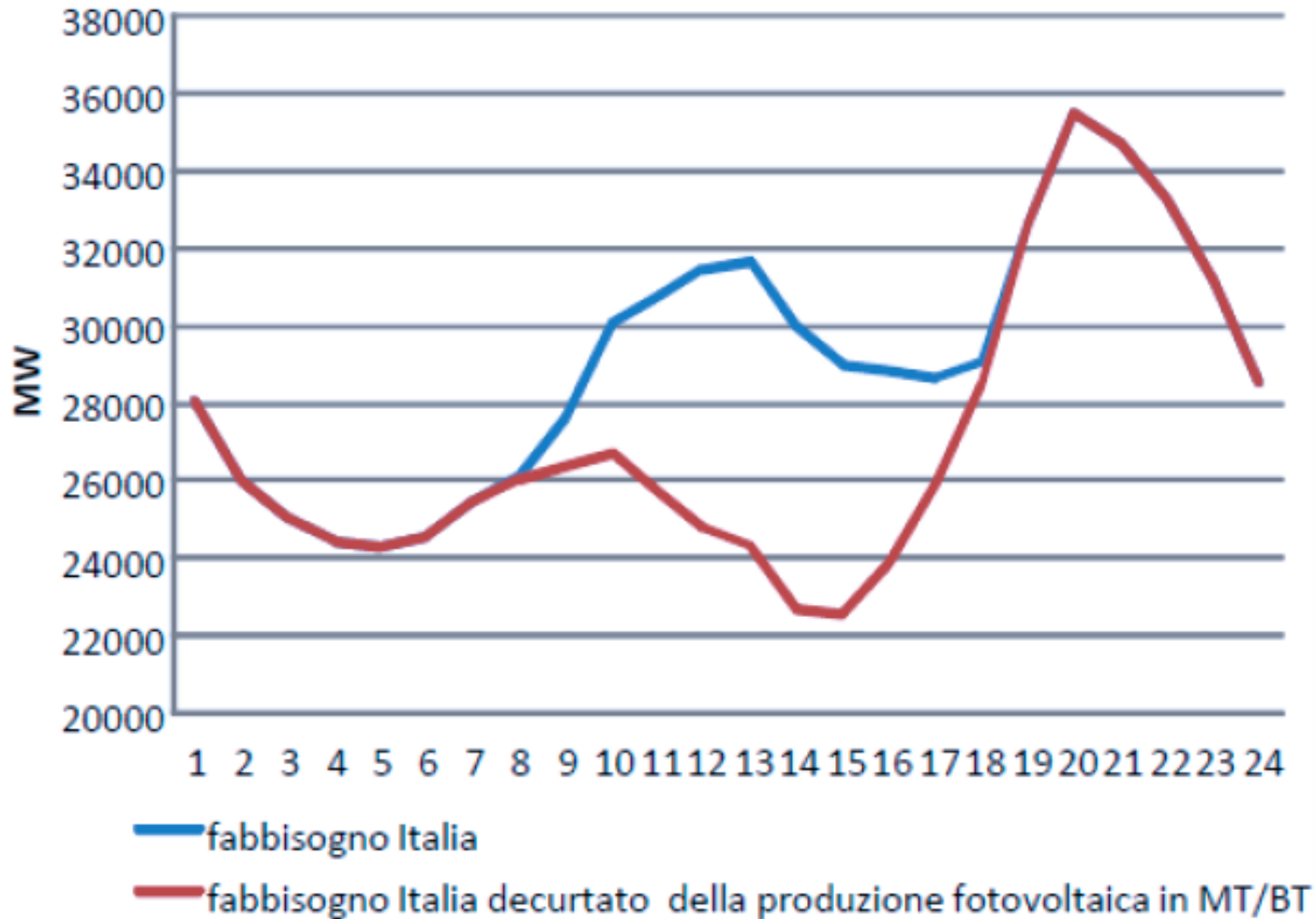
54,1 GW

Solar plants concentrated in daily hours



solar effect

Solar impact on demand - Sundays



Netting the solar effect, minimum load occurs in daily hours.

It might seem a nonsense, but it is the real situation

RES and the market

Plants remuneration has to cover the production cost plus a margin

For RES:

- Variable cost is usually quite lower
 - Primary source is free
 - Only ordinary maintenance and employee costs are taken into account (low impact on plants greater than 1 MW)
- Fixed cost is quite high
 - Installation cost (PV panels, wind turbine, river flows and turbines)
 - Capital remuneration (i.e. the margin for the producer)
 - Utilization hours quite reduce

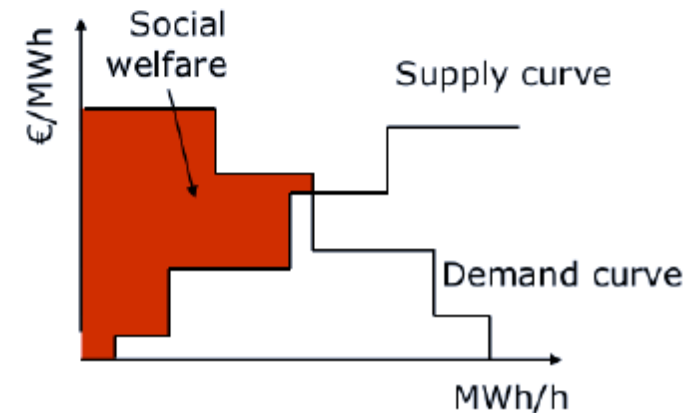
Total RES production cost is usually higher than thermal one due to high fixed costs

In a market environment RES have to be incentivized

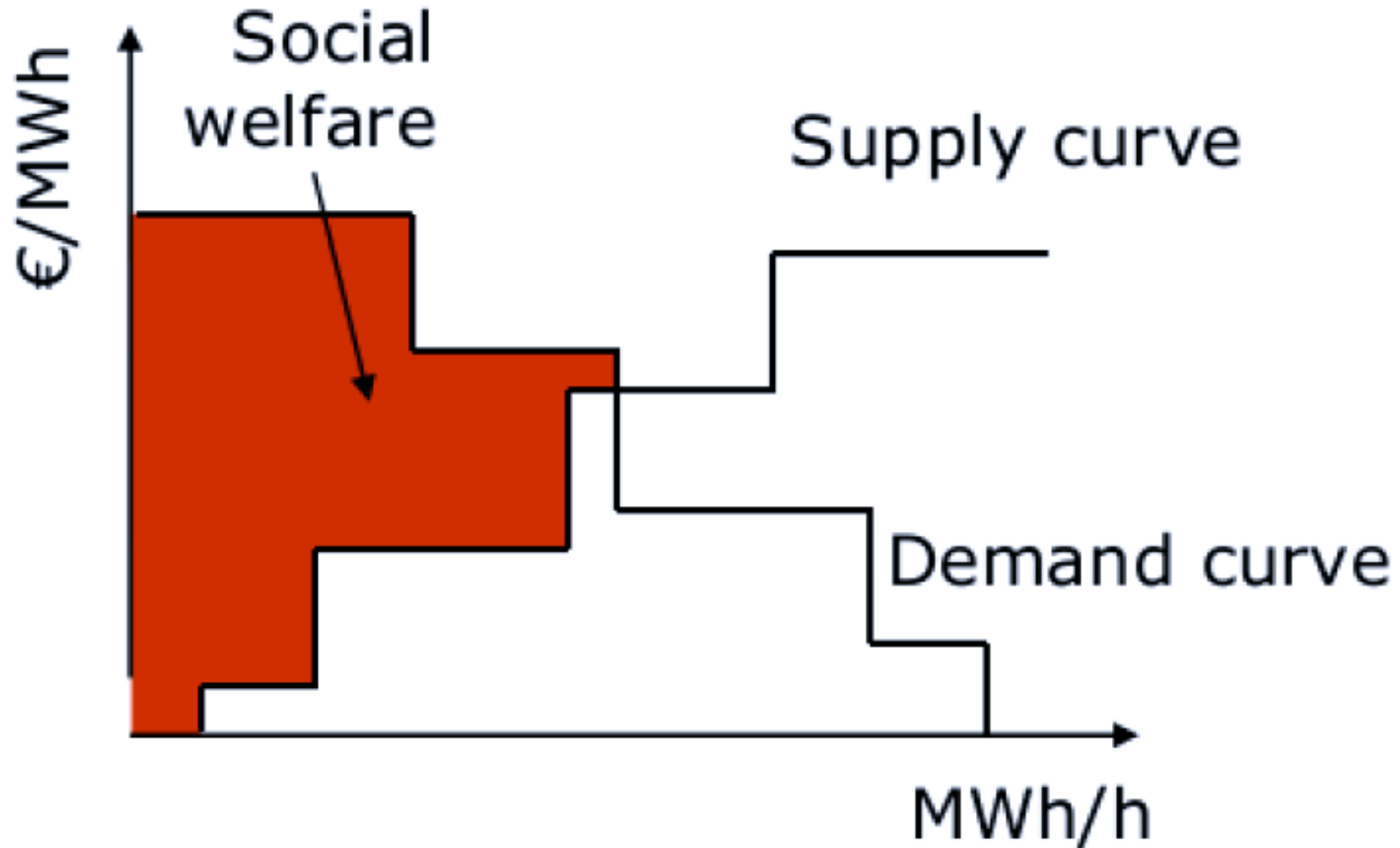
RES remuneration

- Two level
 - Commercial energy sold within the energy market
 - Incentives: granted to the energy produced

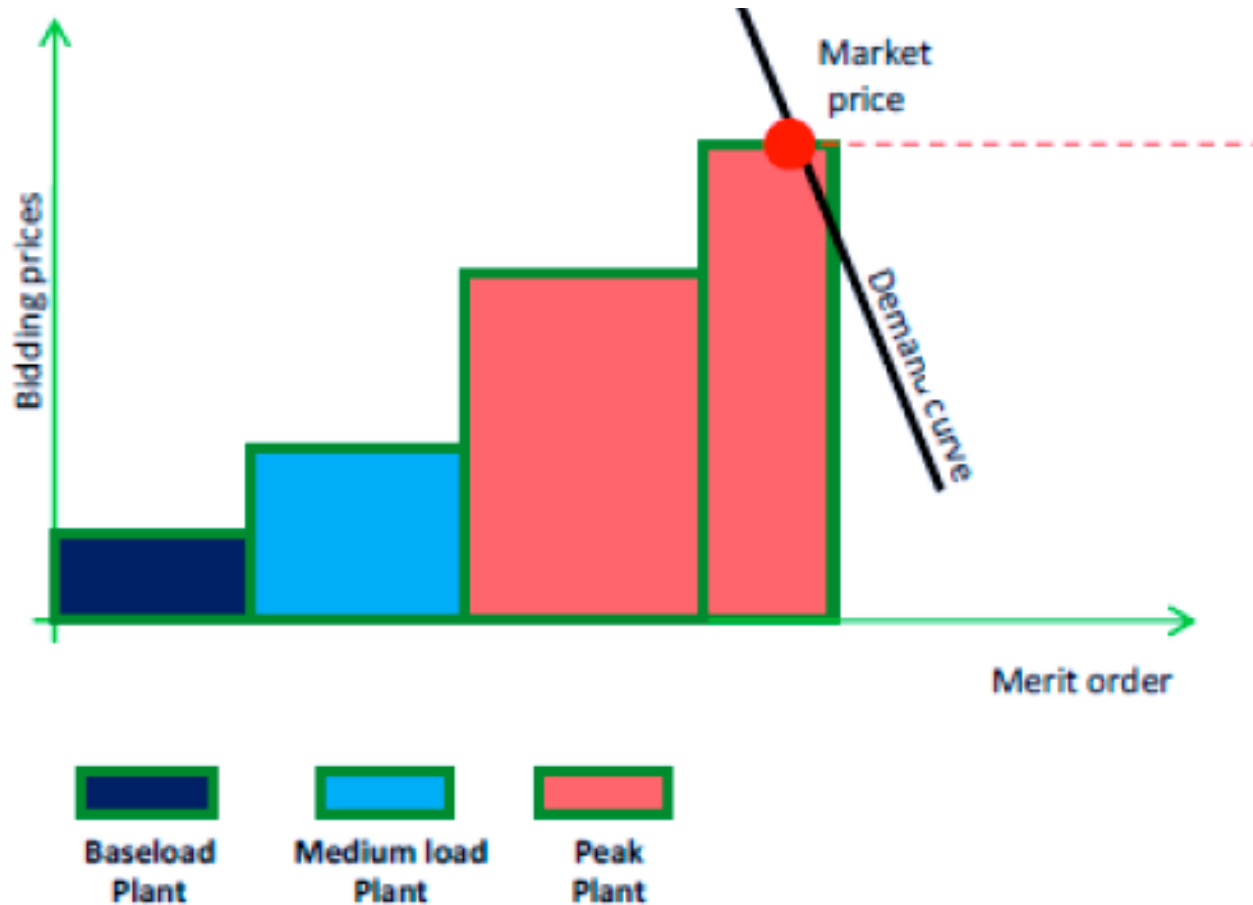
Can RES and market interact? That is the question!



The clearing process in the spot market



Supply curve and market clearing

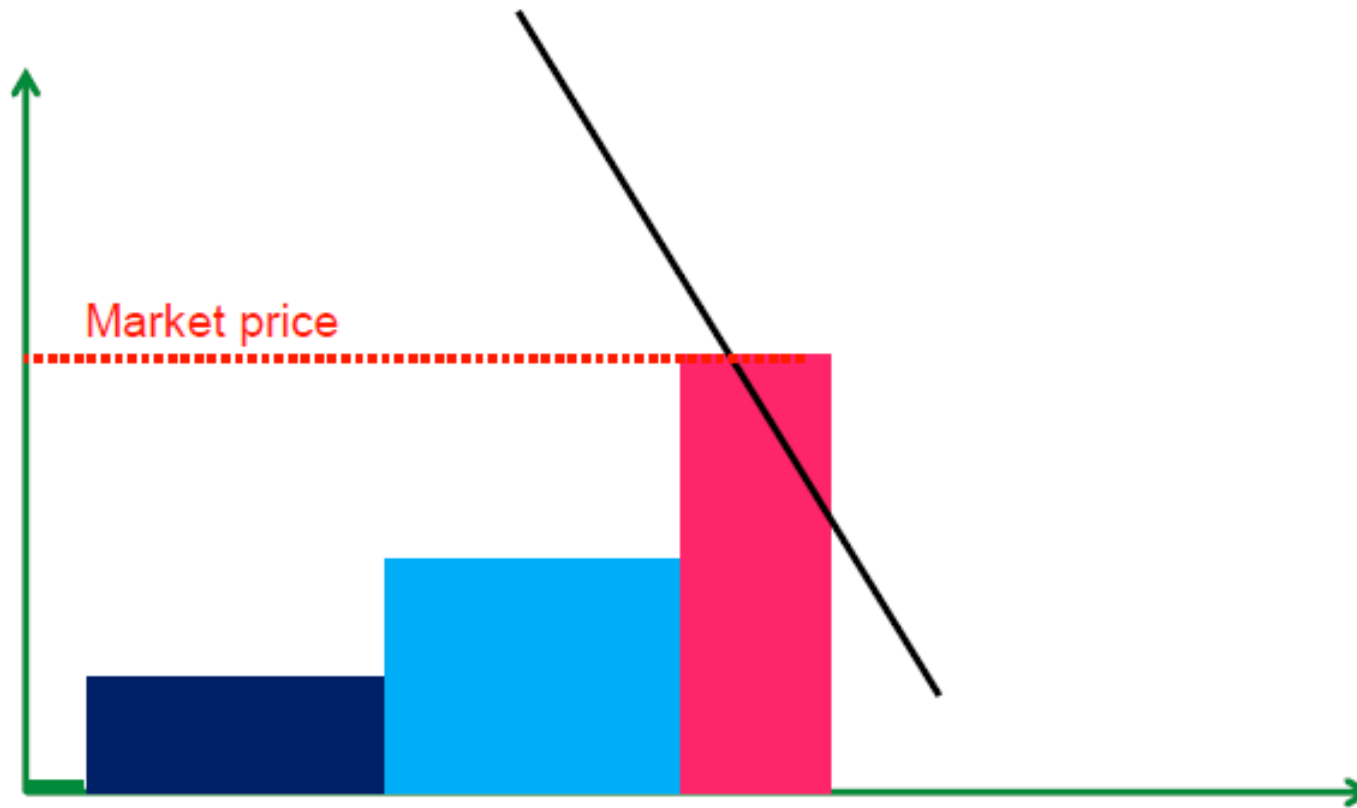


Without RES the price is given by peak thermal plants

RES and supply curve

- Not programmable RES:
 - The goal is to fully exploit the primary source, without wasting anything.
 - All the production has to be dispatched: in a market environment this means to offer at a very low price
 - Not programmable RES usually bid at 0 €/MWh to be sure to be selected
 - They act as a price taker
- Programmable RES
 - The production is planned ex-ante in order to try to get the highest market prices
 - When planned, the plant has to be on, i.e. it has to be dispatched
 - Even programmable RES bids at 0 €/MWh
 - Due to RES presence, supply curve moves rightward
- Market clearing price is modified

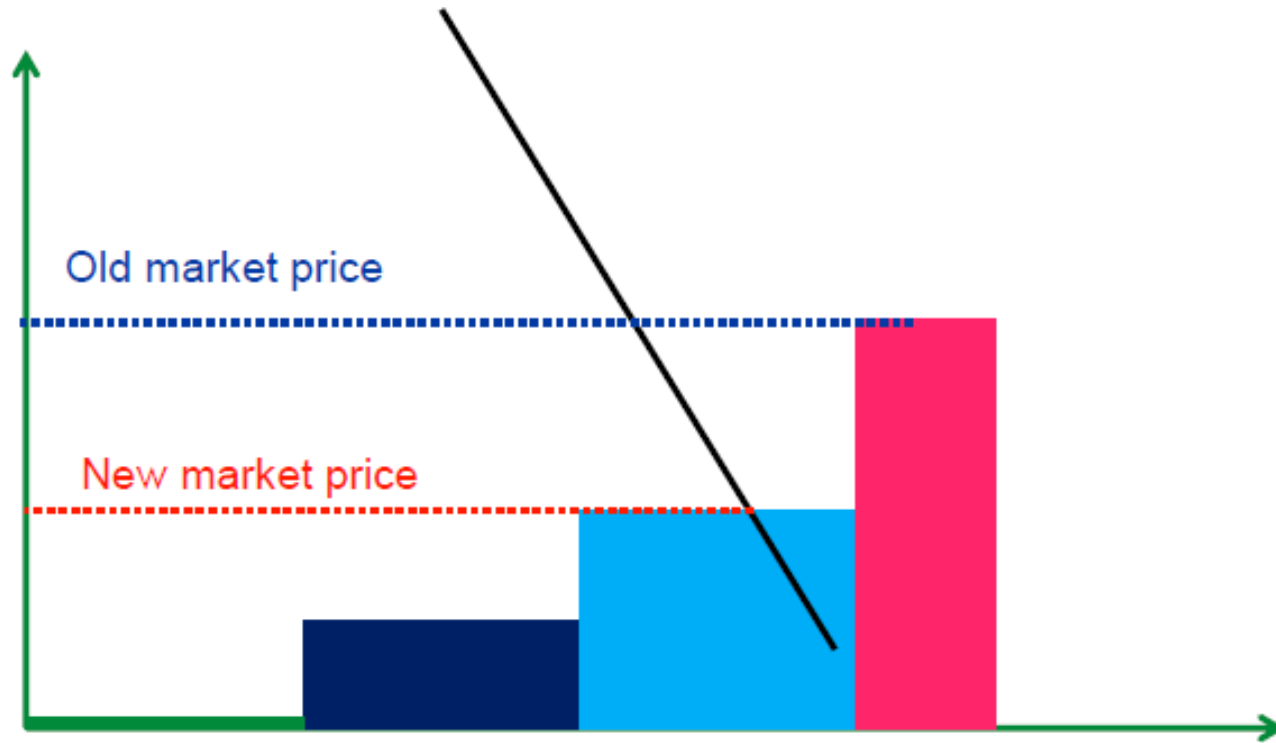
Supply curve and market clearing with low penetration on RES



Peak plants are still used, but with a reduced volume



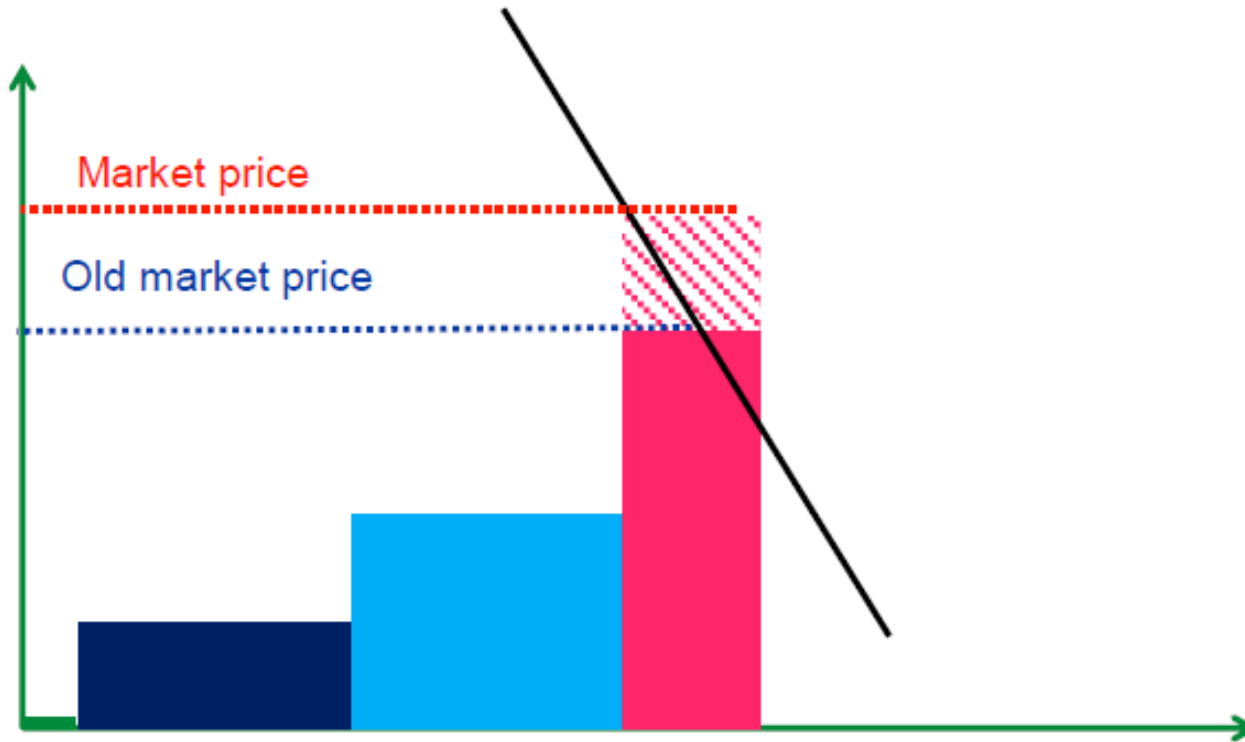
Supply curve and market clearing with high penetration on RES



Peak plants are not dispatched: market price is reduced



Supply curve and market clearing with high penetration on RES



Baseload
Plant

Medium load
Plant

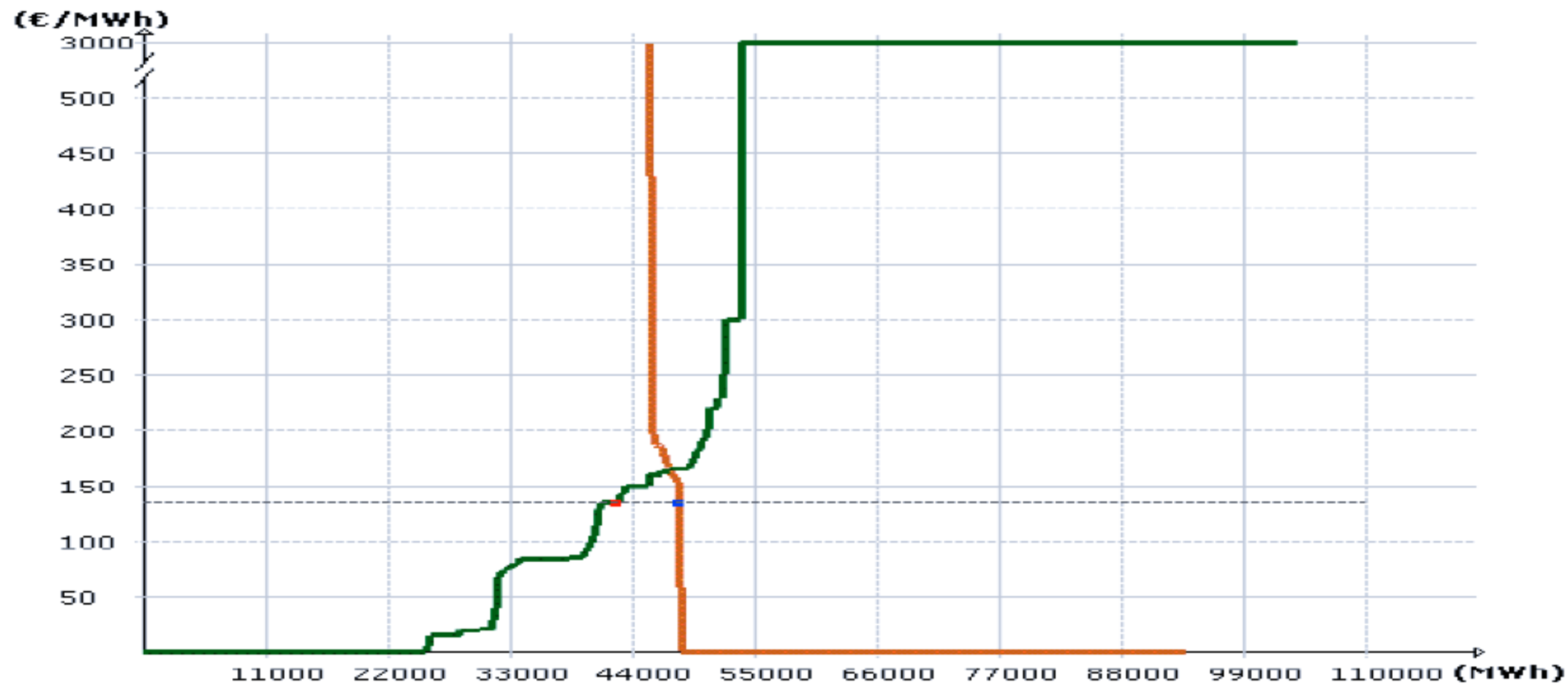
Peak
Plant

Renewable
Plant

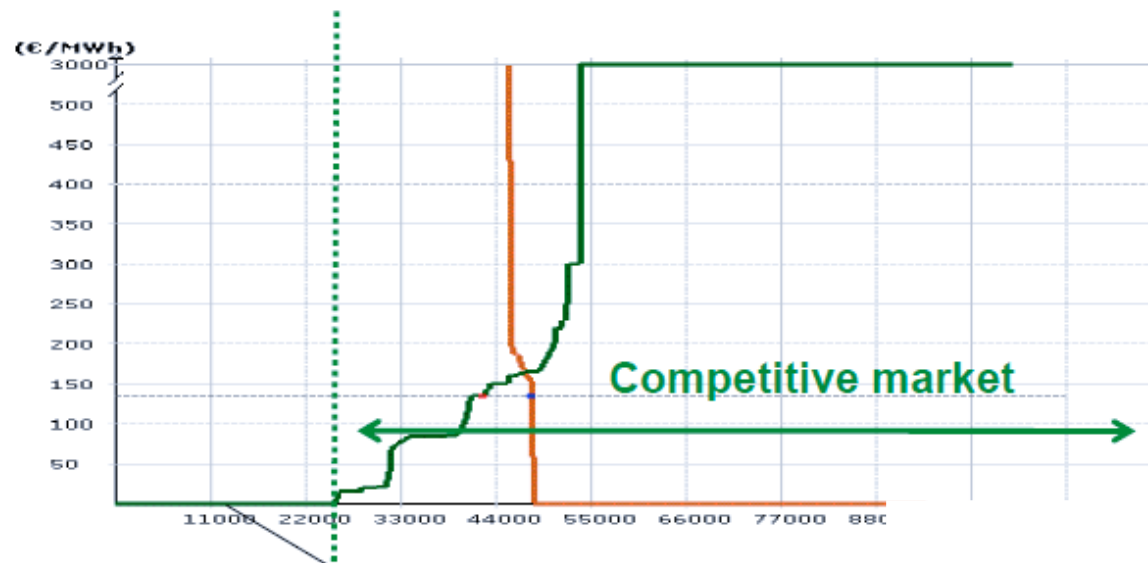
Due to reduced working hours, peak plants bids may be increased: market prices may become even higher

A RES paradox: prices might increase, at least in some hours

The Italian case

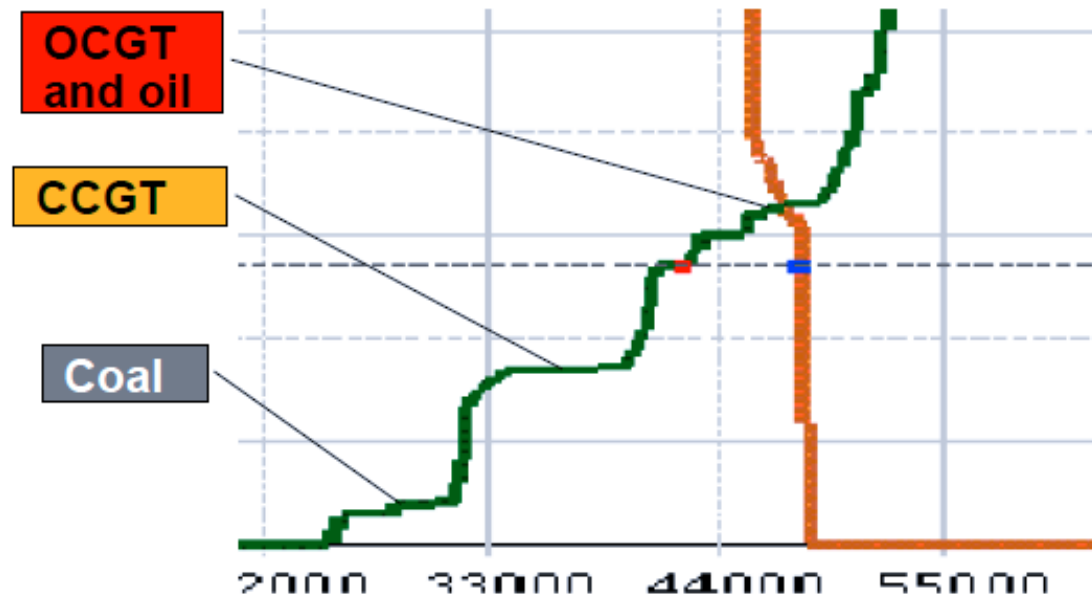


The year 2008: low RES penetration

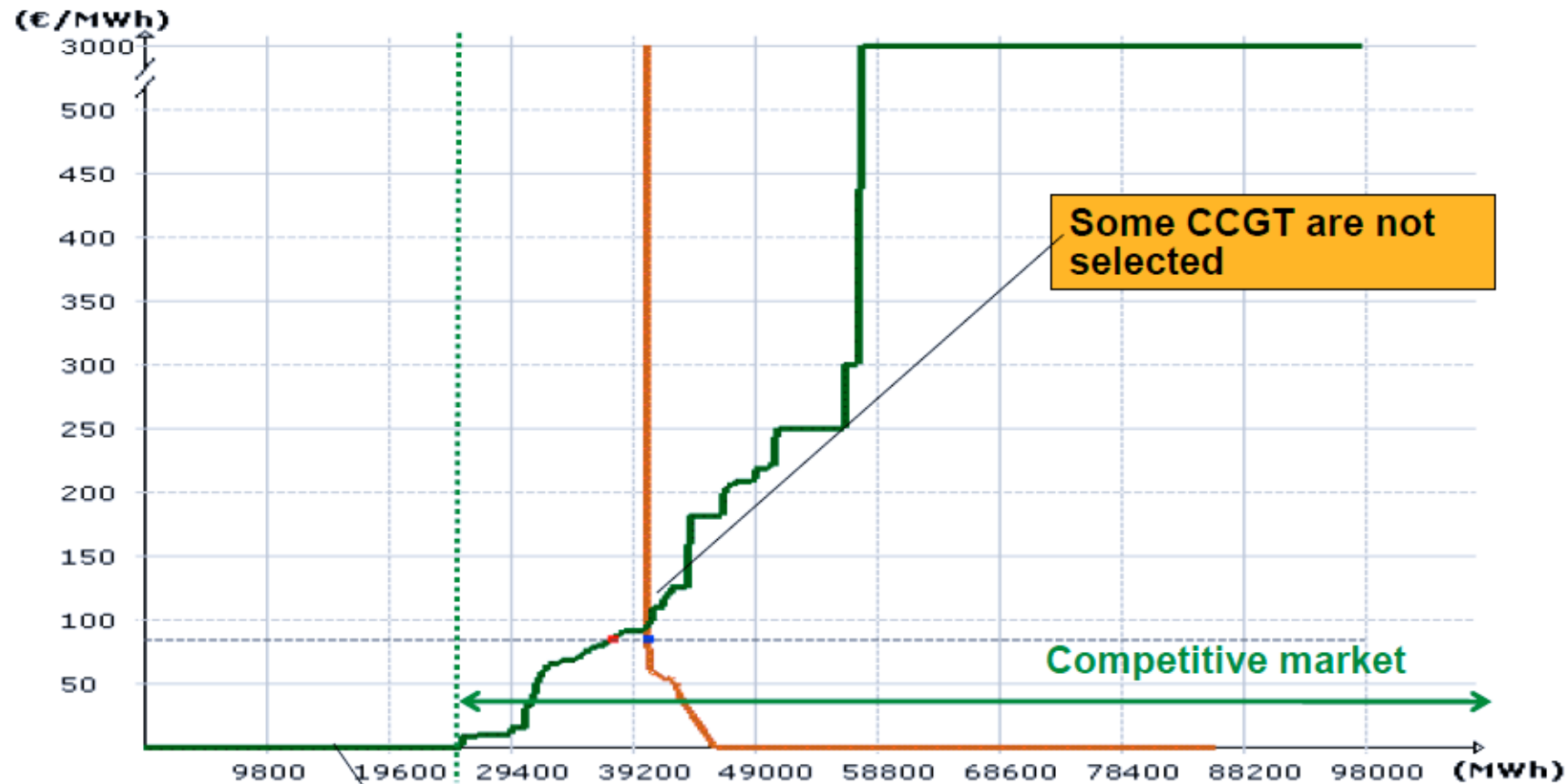


Bid price 0 €/MWh

Mostly not dispatchable thermal plants (cogeneration, plants connected to industrial process) and hydro plants (both river and reservoir)



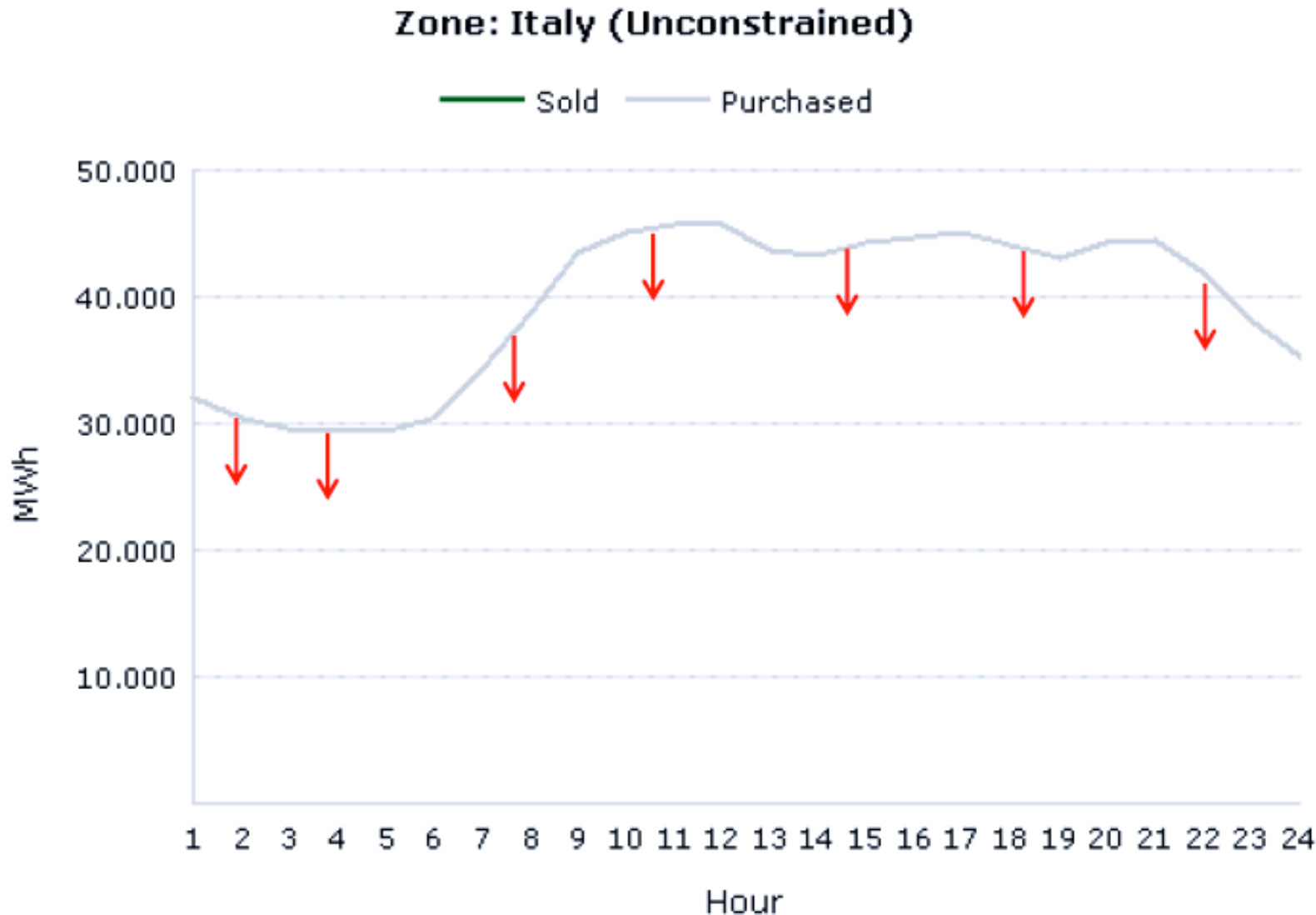
The year 2008: high RES penetration



Bid step at zero price is larger due to the contribution of RES plants

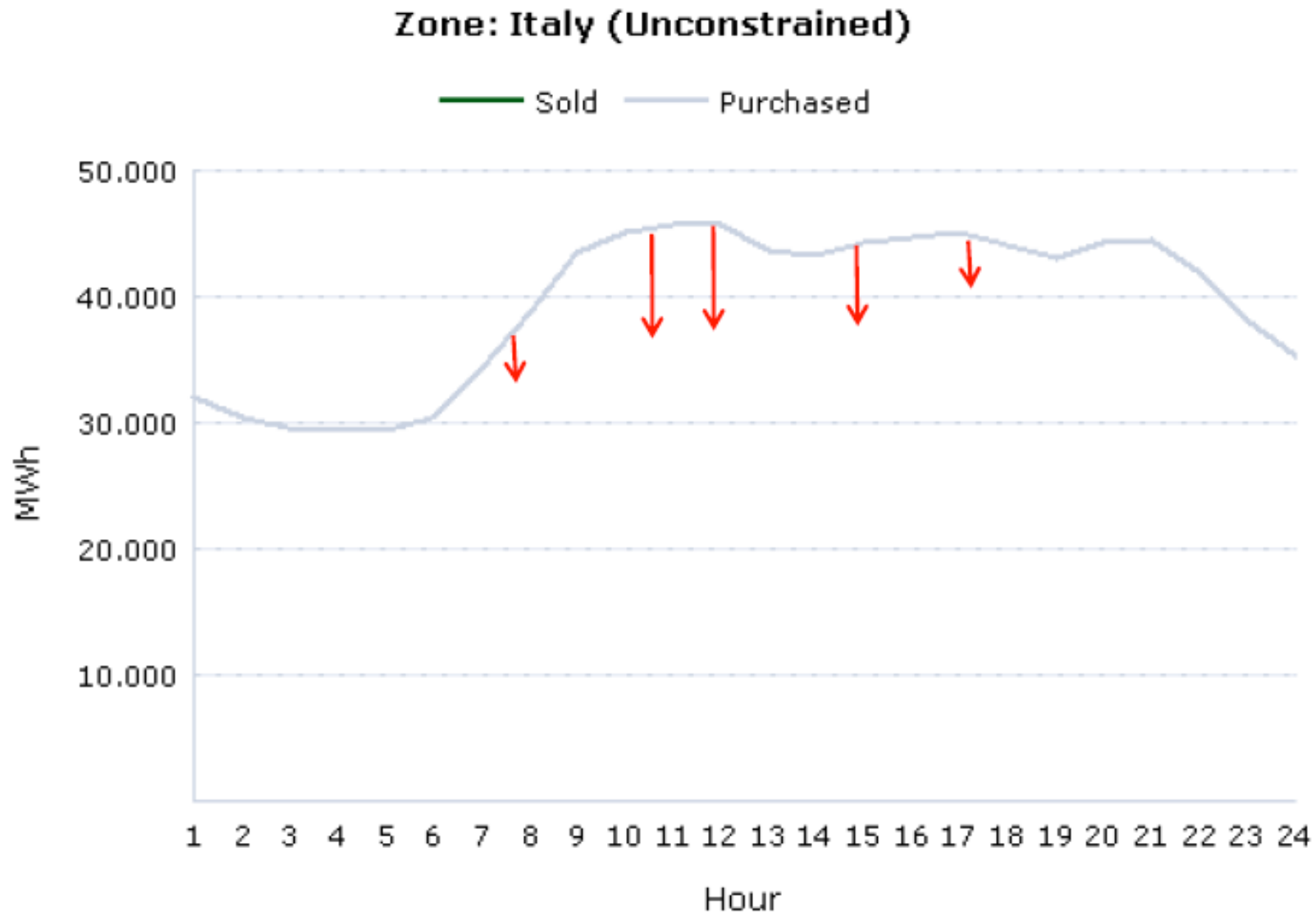
Competitive market volume is reduced

Wind and competitive market



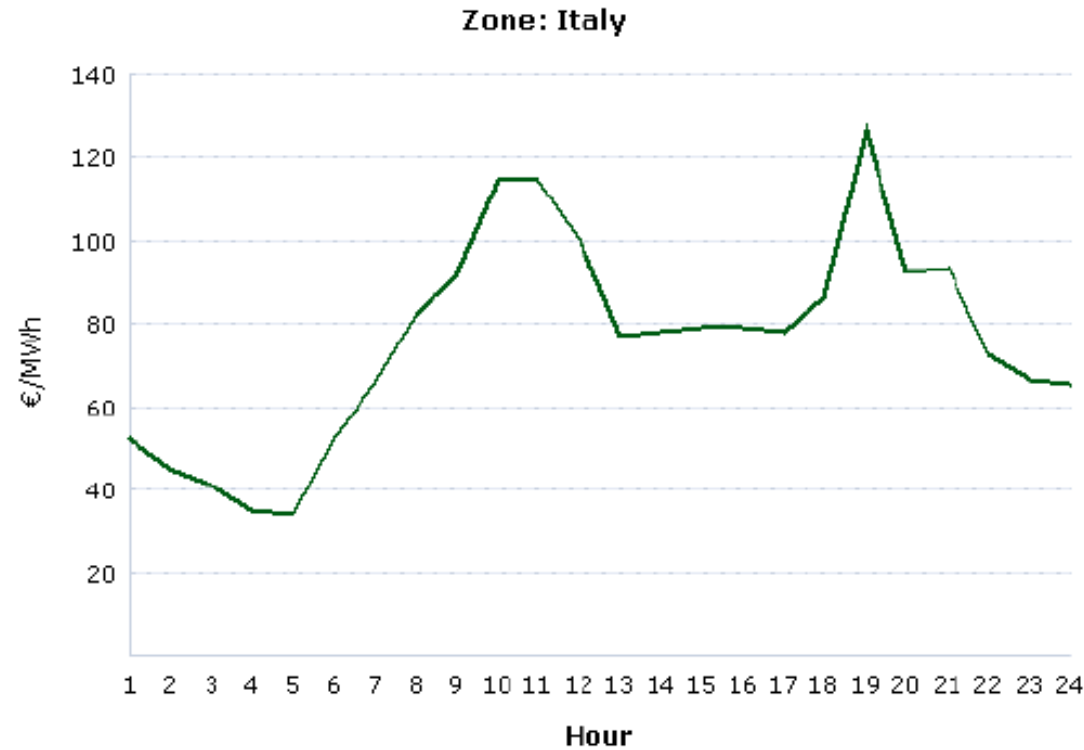
- Wind theoretically can reduce competitive market in all the hours.
- The effect is nonetheless not predictable due to the intermittency

Solar effect

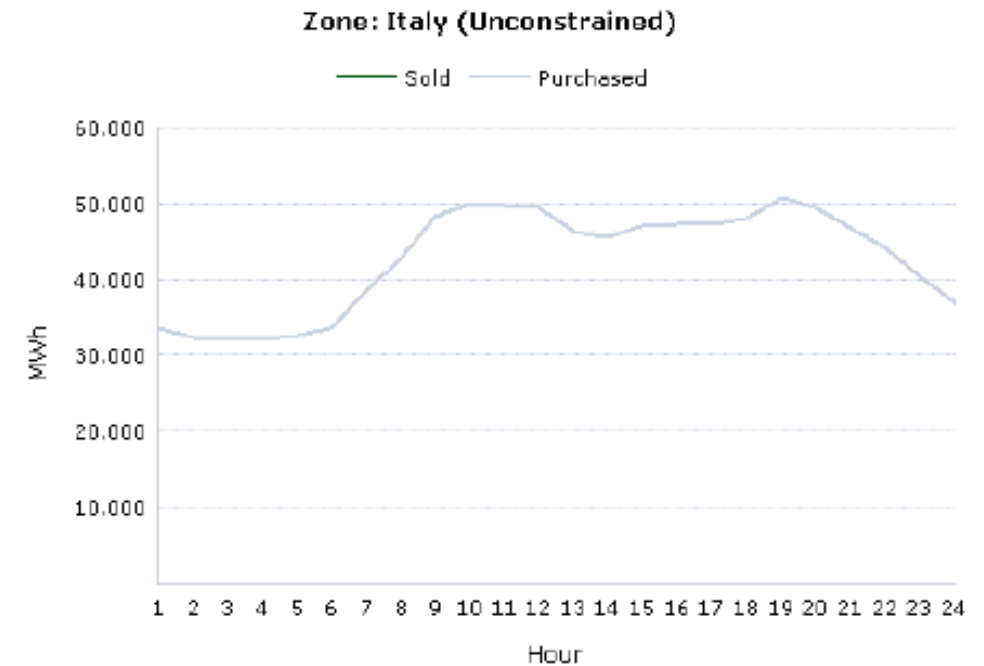


- Solar can reduce competitive only in day hours.
- The effect is nonetheless not predictable due the intermittency

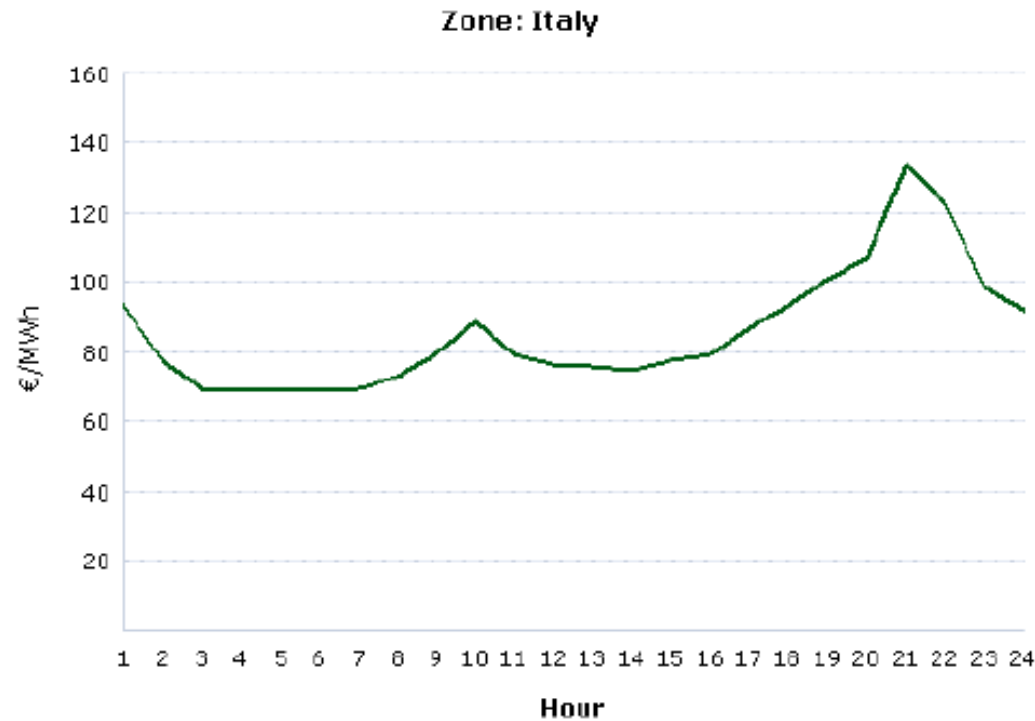
Energy price in 2008



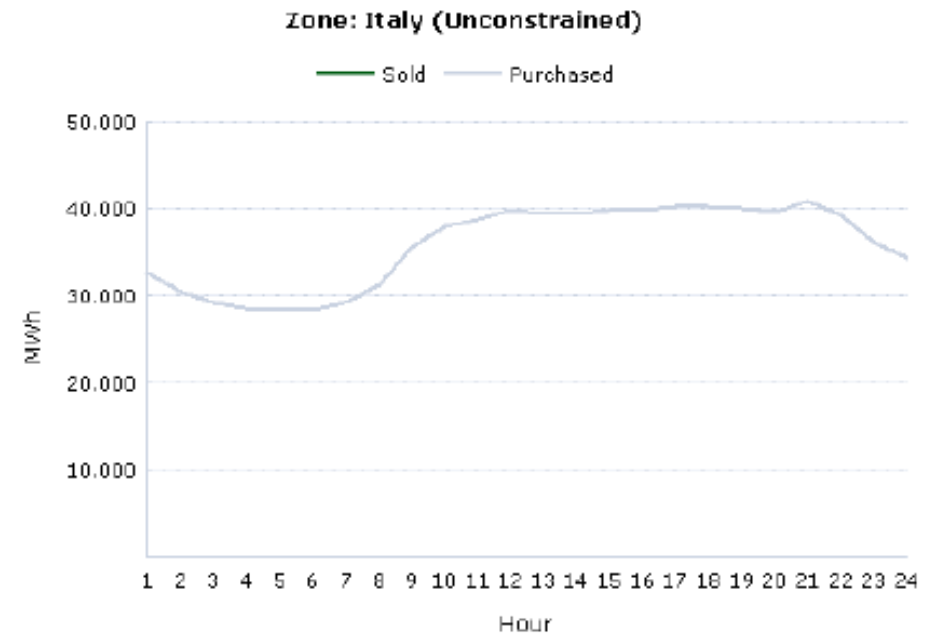
- Double peaks: morning and evening
- Generally, price correlated tot eh volumes



Energy price in 2012



Only evening peaks: price not so far correlated with the volumes



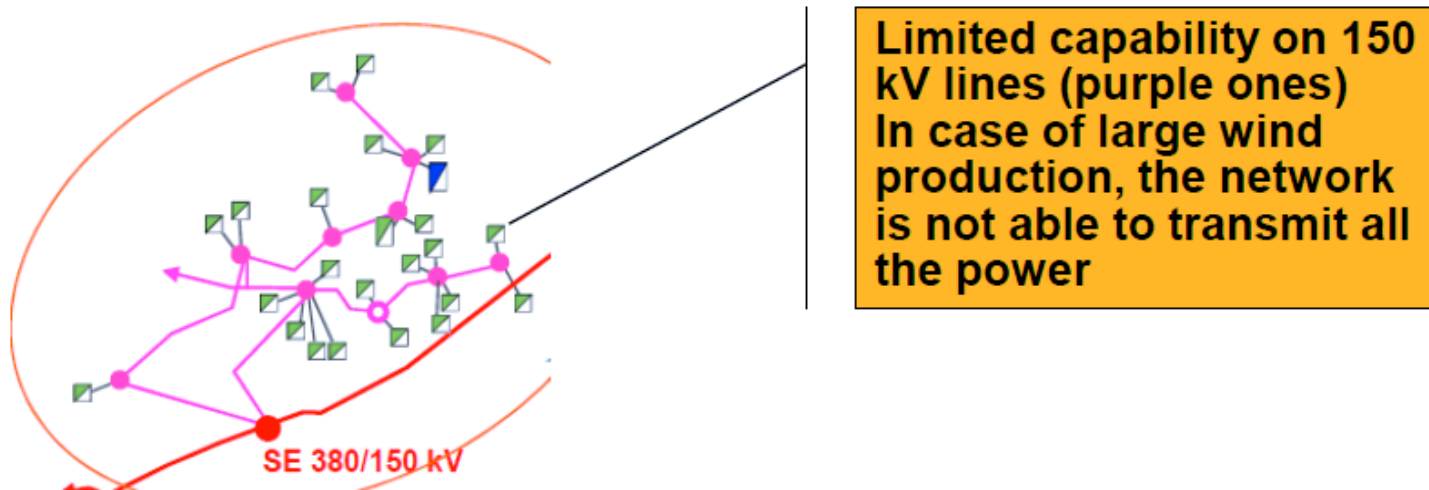
RES and MSD

Reserve margin

- Minimum tertiary reserve margin is a combination of:
 - Tripping of the largest thermal unit on service
 - Maximum error for load and RES production forecast (99.7 percentile)
- Secondary reserve band
 - Dependent on load
 - Computed according to UCTE policy
- RES increase the reserve margin
 - The larger is the solar and wind production, the more reserve margin is required in order to deal with the intermittency
 - No problem arises with reservoir or pumping storage plants

Congestions

- RES plants significantly affect the distribution of power flows within the transmission network
- In some areas specific congestions may arise:
 - Main problem is with wind production concentrated in small areas with limited network capability



Balancing

- Real time dispatching orders compensate the volatility of load and RES production with respect to the forecast
- RES production may increase this volatility, requiring the activation of larger balancing resources
- The larger is the solar and wind production, the larger are the balancing resources to deal with intermittency
 - No problem arise with reservoir and pumping storage plants (on the contrary they are precious balancing resources)

RES and MSD markets: a summary

- Only programmable RES plants take part with MSD
- Other RES plants are not allowed to MSD, nonetheless they have a strong impact on this market
 - Reserve margin and balancing resources are increased to deal with intermittent solar and wind production
 - Congestions may arise if RES production is concentrated in small areas

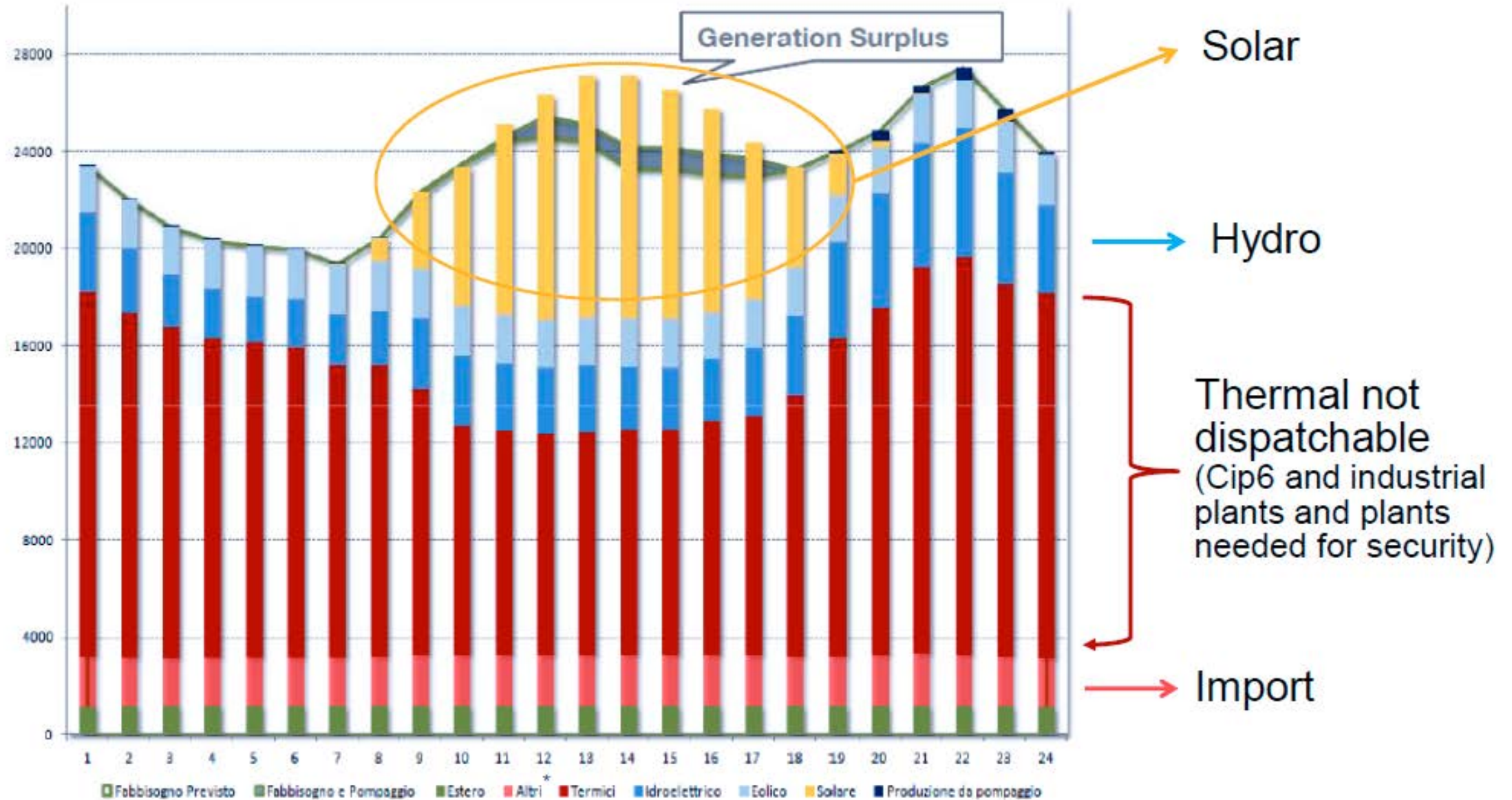
RES induces an extra cost in MSD: this is a critical issue correlated to the integration of RES in the energy market.

A problem arises: who pays for this extra cost?

RES production curtailment

- As told before, Terna may issue a dispatching order also for plants not admitted to MSD
 - Not programmable RES may be affected by this issue
 - So far the problem is correlated mainly with wind production due to congestions
- Wind relevant units ($>10\text{MVA}$)
 - The producers rebuys the energy sold in the day-ahead market at day-ahead price: in other words, he gives back all the income received in the energy market
 - A compensation for lost production is granted
- Wind not relevant units ($\leq 10\text{MVA}$)
 - Plants are settled in an aggregated manner
 - Energy cut leads to a negative unbalance settled at unbalance price
 - A compensation for lost production is granted

Over generation risk (August Sunday and bank holidays)



Over generation risk (August Sunday and bank holidays)

- At minimum load, not dispatchable generation might be greater than dispatchable one
- Measures should be adopted:
 - Import reduction
 - Res production curtailment
 - Reduction of thermal plants needed to grant system security

This is dramatically changing the operating of electrical system