The RES-induced Switching Effect Across Fossil Fuels: An Analysis of the Italian Day-ahead and Balancing Prices

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Aim of the Paper

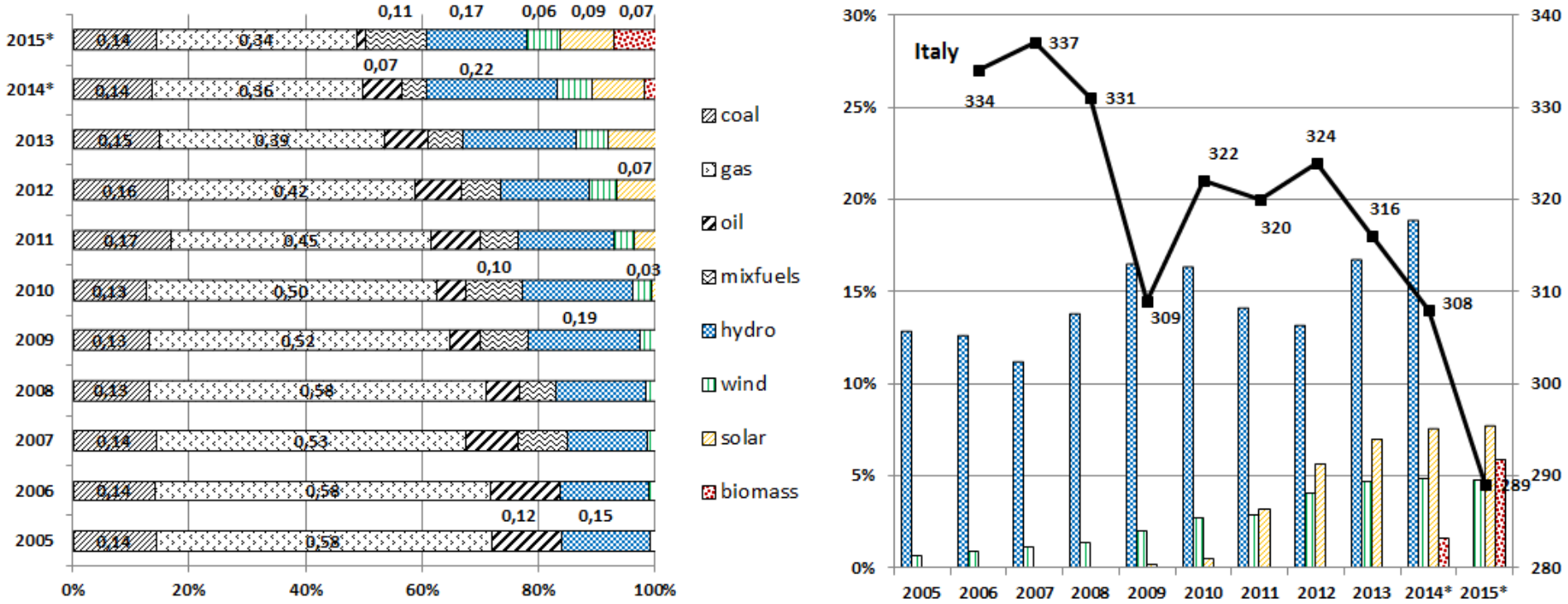
- The intermittent and unpredictable nature of wind and solar production has made the real-time balancing activities more complex and relevant for the continuous matching of supply and demand.
- We show how RES have affected the fuels-electricity nexus in Italy, considering the relationship between fuel prices, and between fuels and electricity prices (DAM & BAMs).
- In addition, we quantify the incurred costs for balancing needs across hours, technologies and market purpose.

Why balancing prices?

- High RES shares modify the shape of the aggregate supply function in DAM, misplacing gas-fired units.
- BAMs are dominated by conventional technologies (thermal, hydro and pumping) which have the required degree of flexibility and enjoy a higher degree of market power with respect to the DAM.
- In this scenario, we expect two distinct dynamics of the fuels-electricity nexus induced by the growth of RES (less relationship in DAM and a stronger nexus in BAMs)

Background – Evolution of the Italian generation mix

Identification of Two Scenarios: "low" (06-08) and "high" (13-15) RES

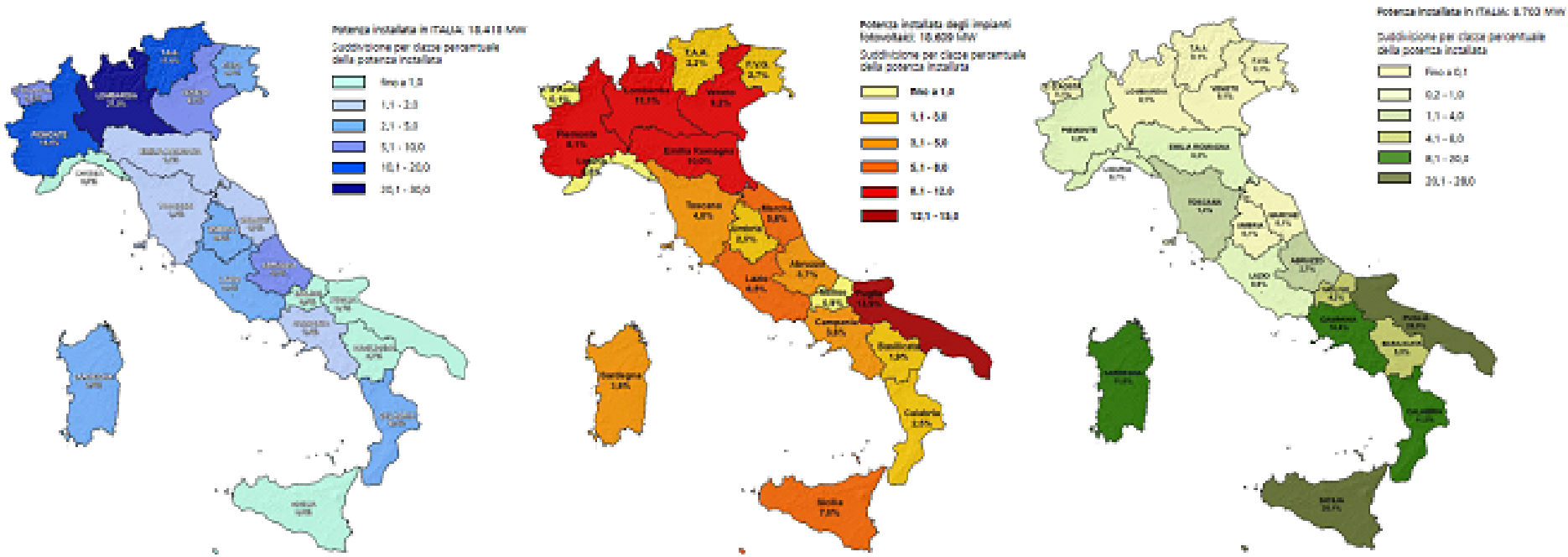


Italian shares by technology generation (on the left), and RES penetration together with Demand levels in TW (on the right)

Background – RES generation in Italy

Selection of the Northern Zone

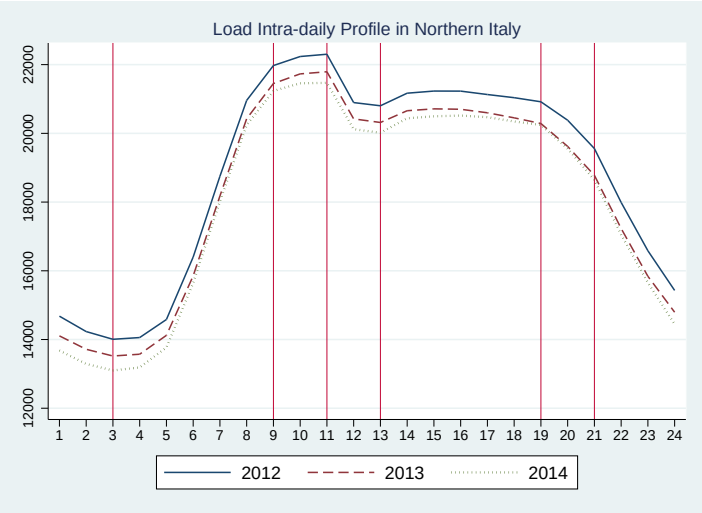
Hydro (left), solar PV (middle) and wind (right) generation

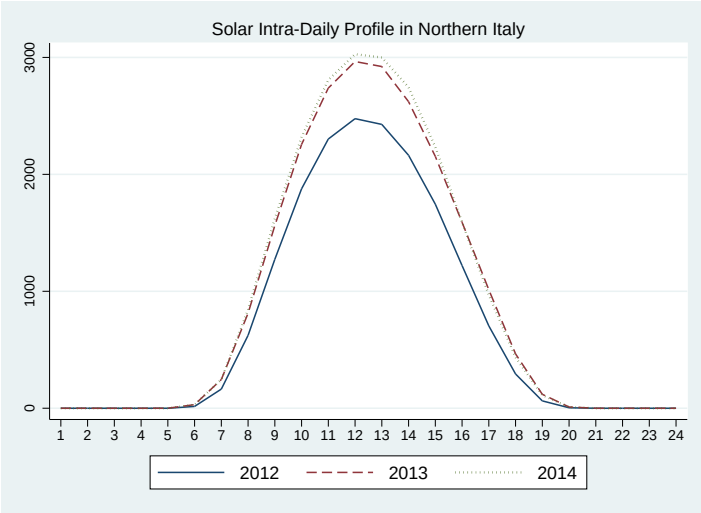


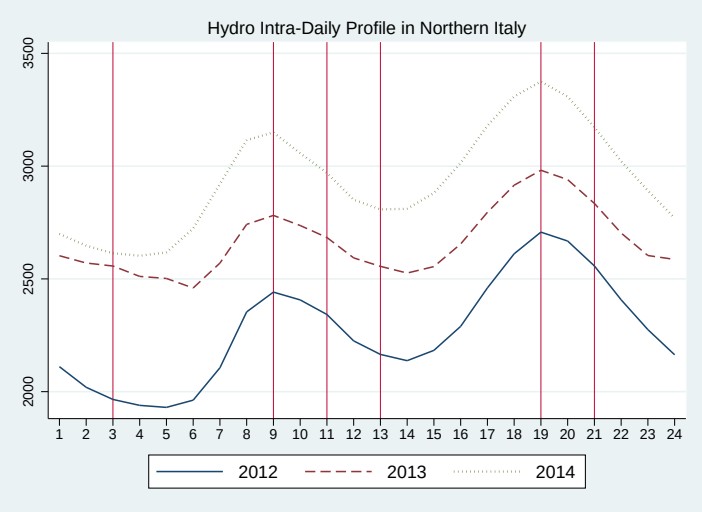
In Northern Italy, there is the majority of hydro and solar PV. Whereas, most wind power is generated in Southern Italy.
However, there are only few observations in Southern BAMs.

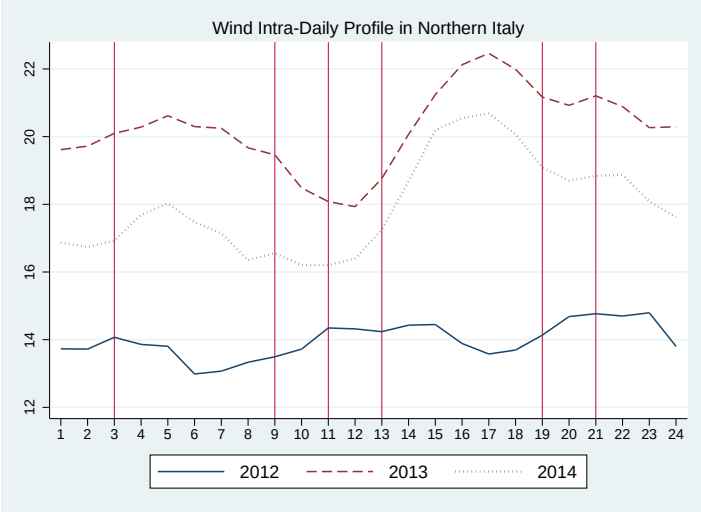
Inspection of Intra-daily Profiles

Selection of Hours: 3–9–11–13–19–21









Data Description and Providers

- Two samples: 2006–2008 and 2013–2015
- Zonal day-ahead electricity prices
- Balancing prices as weighted averages of awarded quantities under the 'pay-as-bid' rule (on both MSD & MB), and at disaggregated level
- Oil, Coal and ICE UK Natural Gas prices from Datastream.
- Actual Load* as proxy for Demand (only from 2010)

Methods: VECM

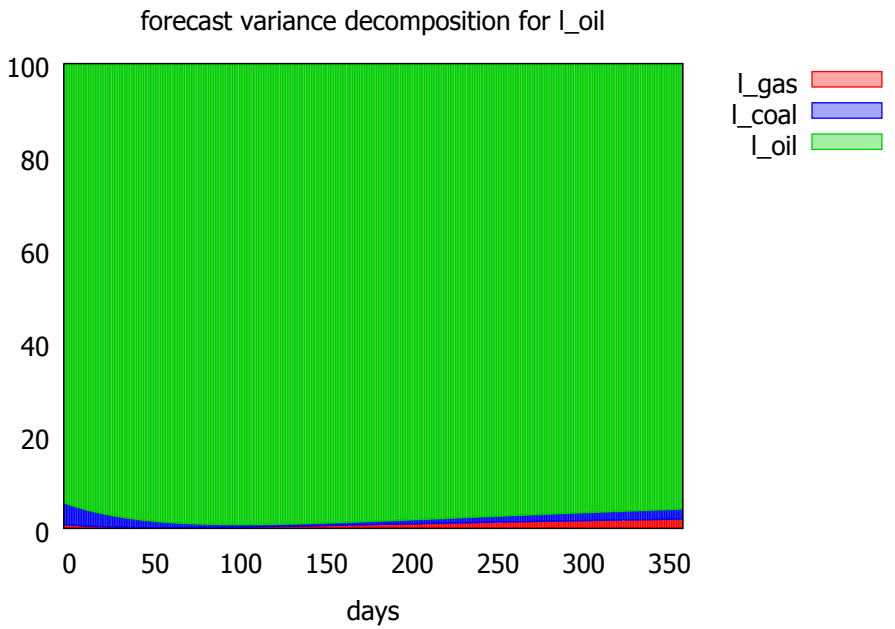
- We decided to keep all the time series at their original (daily) frequency and treat the seasonal components with a data pre-processing.
- All time series of electricity, coal and gas prices were tested for a unit root using the ADF test
- Johansen's test: for each considered hour and for each subsample, we tested for the presence of cointegration among the logarithms of electricity and fuels prices.
- We estimated a vector error correction model (VECM) for each hour, coherently with the number of cointegrating relations found by Johansen's test.

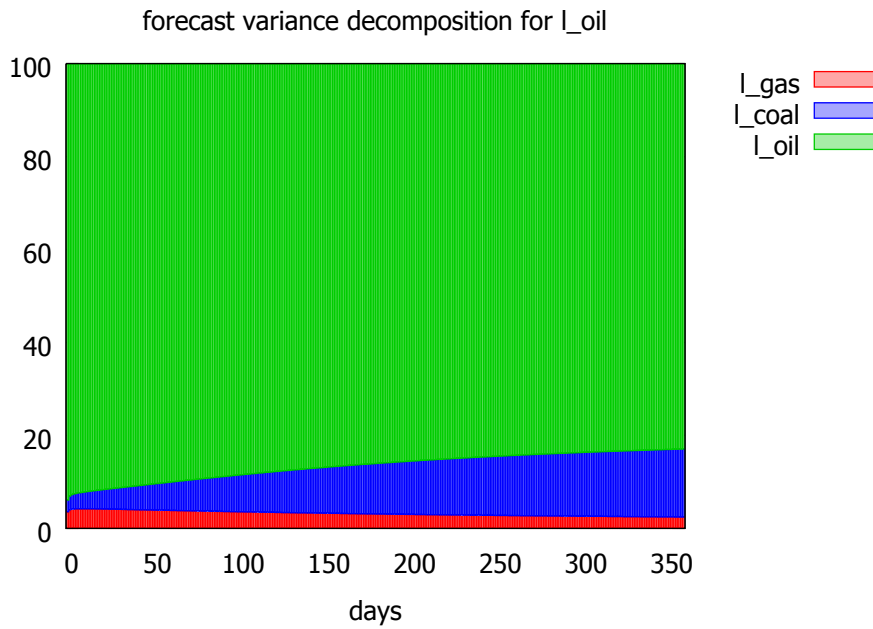
Methods: FEVD

- In the VECM, the best way to assess the role that fuel prices play in influencing electricity prices in the long-run is by the *forecast error variance decomposition*, (FEVD), which allows to determine how much of the forecast error variance of each variables can be explained by exogenous shocks to the other variables
- The relationship among fuel prices (oil, gas and coal) is firstly tested
- Then, the influence of fuel prices on electricity prices is considered at both the day-ahead balancing levels

Forecast Error Variance Decomposition: OIL

Oil prices became largely independent from shocks affecting other fuels.

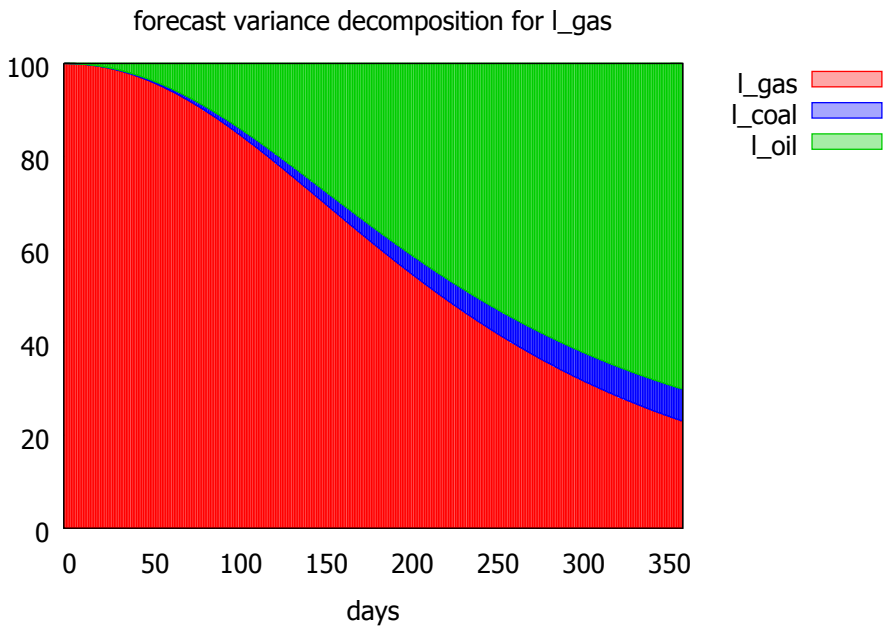


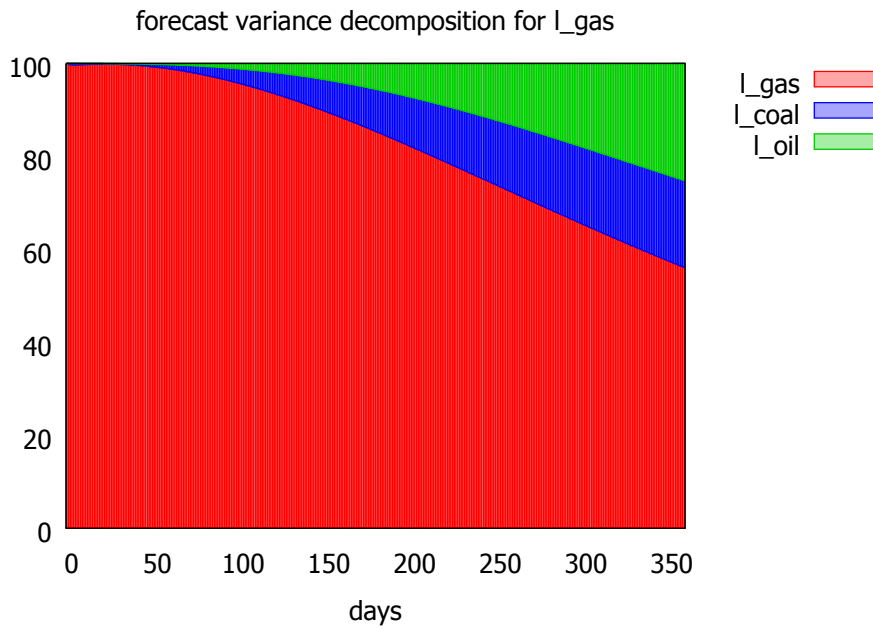


2006-2008 (left) and 2013–2015 (right)

Forecast Error Variance Decomposition: GAS

The role of OIL in explaining the long-run dynamics of gas prices largely decreased (decoupling).

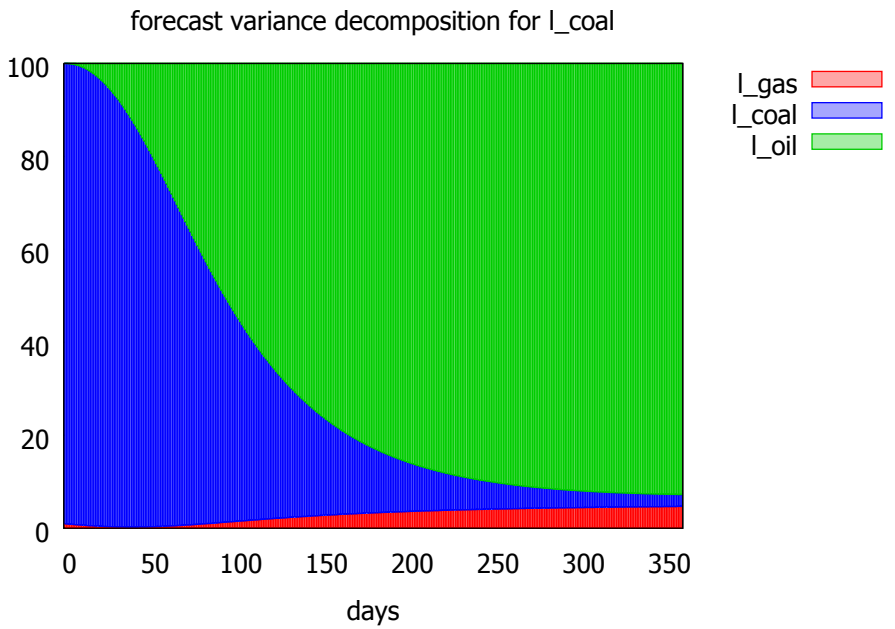


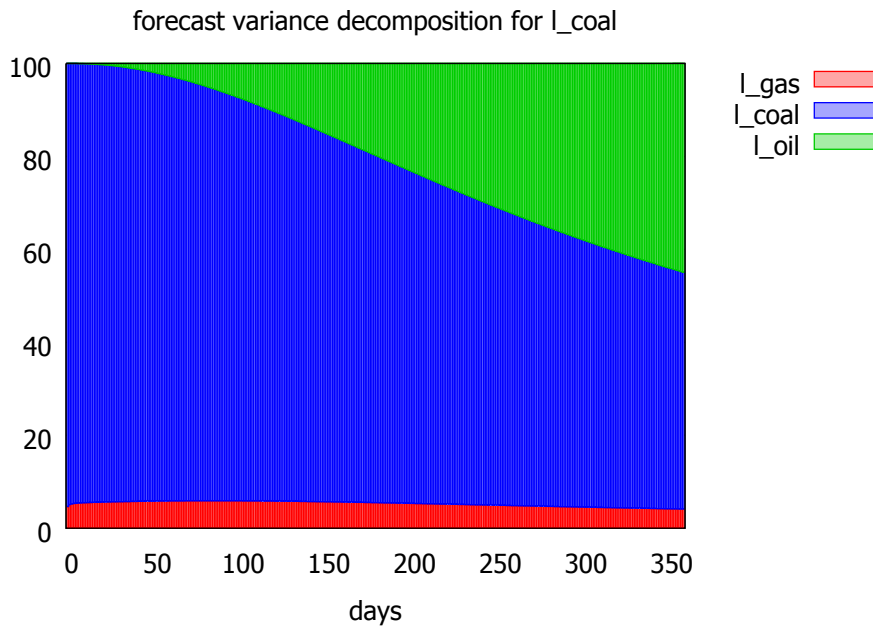


2006-2008 (left) and 2013–2015 (right)

Forecast Error Variance Decomposition: Coal

The role of OIL in explaining the long-run dynamics of coal prices largely reduced.

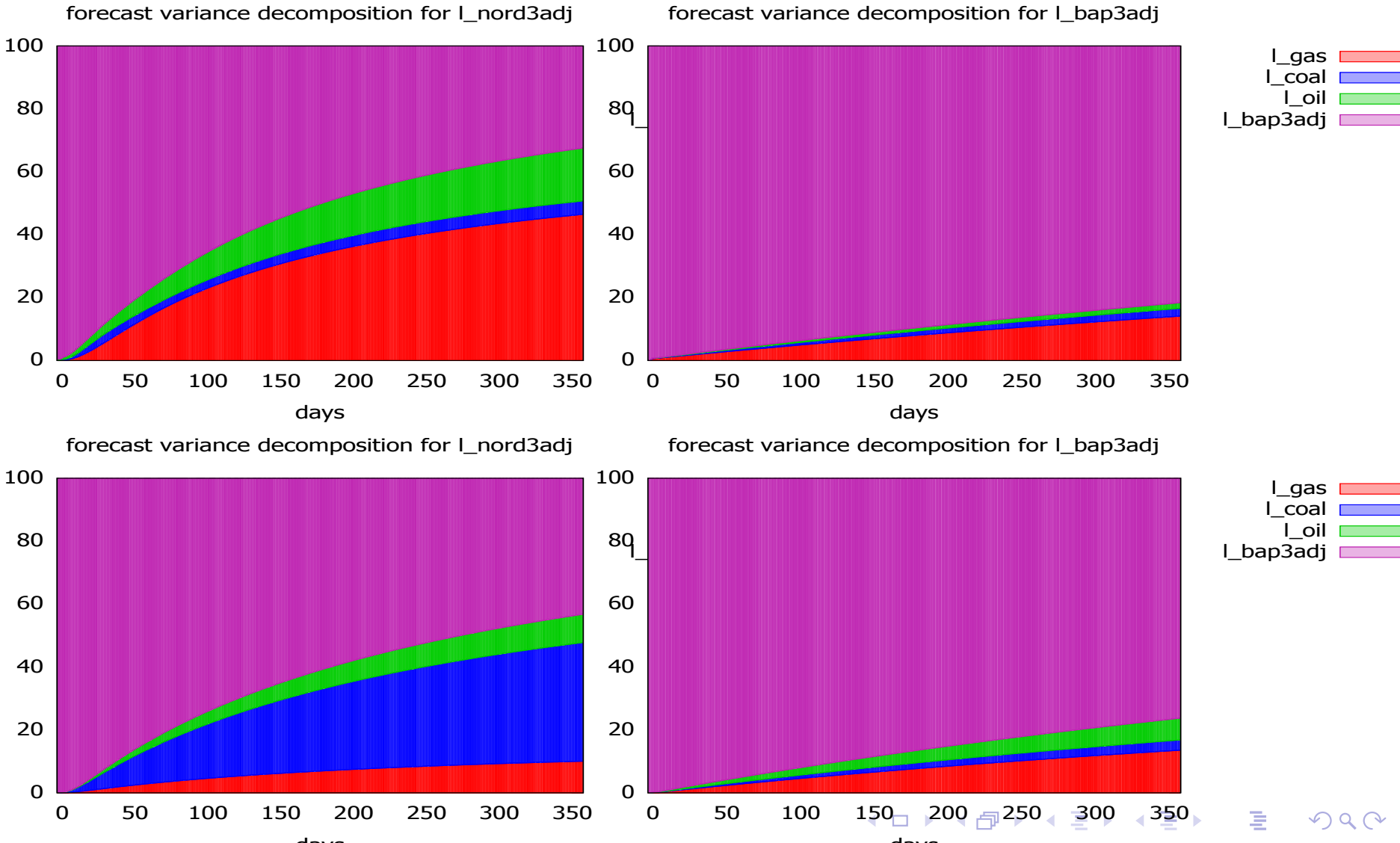




2006-2008 (left) and 2013–2015 (right)

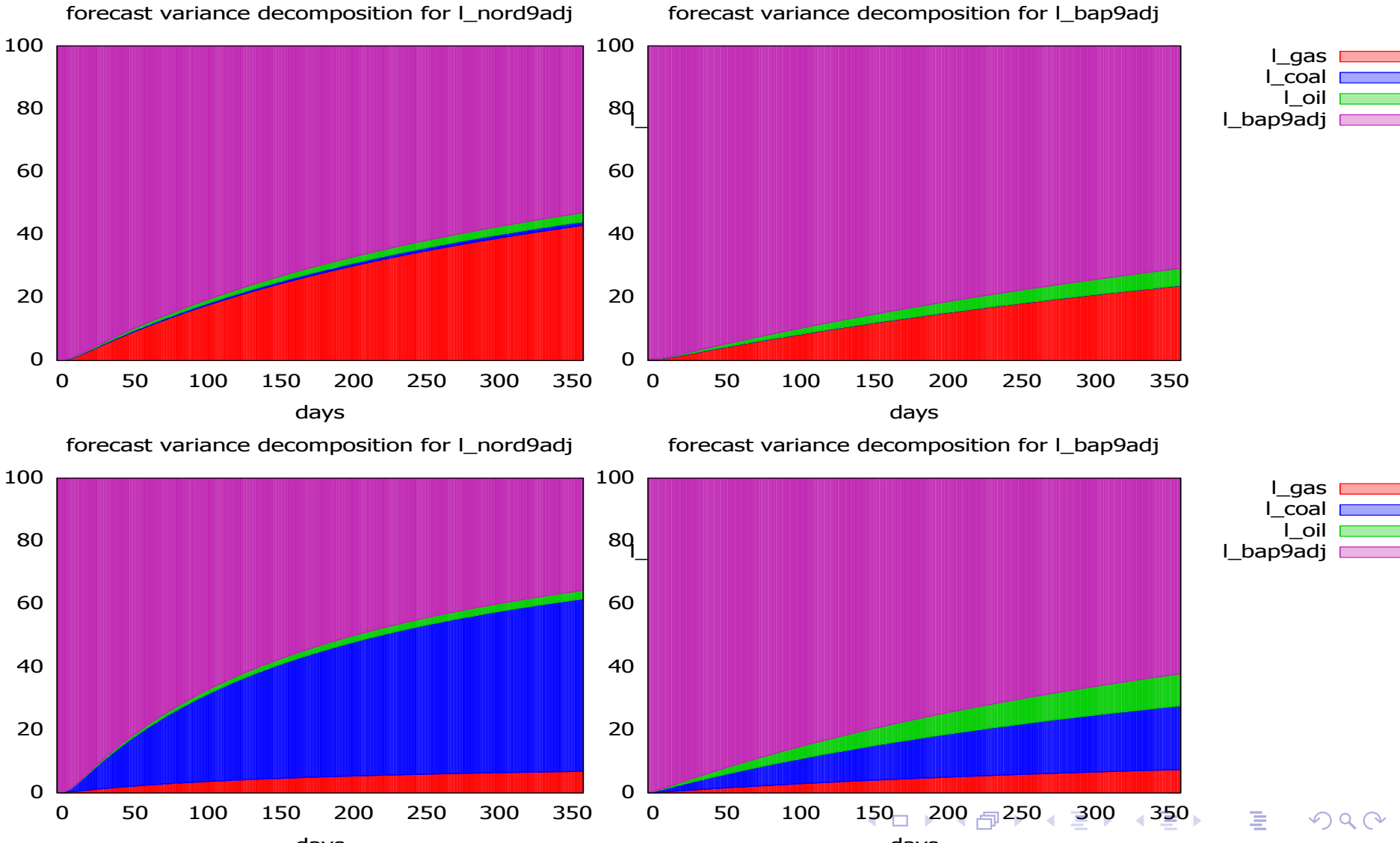
Forecast Error Variance Decomposition: H3

DA (left), BA (right), 1^{st} sample (top), 2^{nd} sample (bottom)



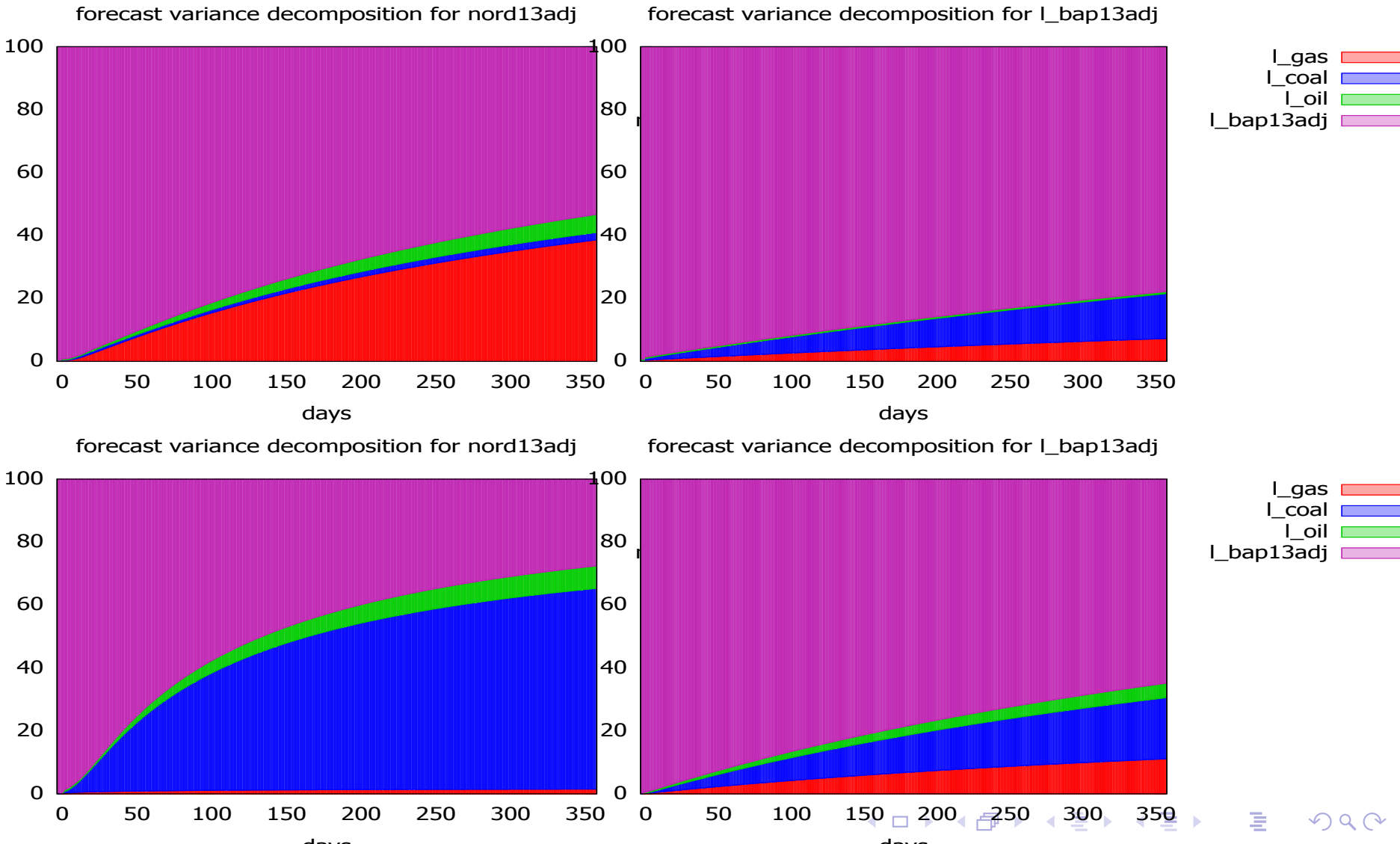
Forecast Error Variance Decomposition: H9

DA (left), BA (right), 1^{st} sample (top), 2^{nd} sample (bottom)



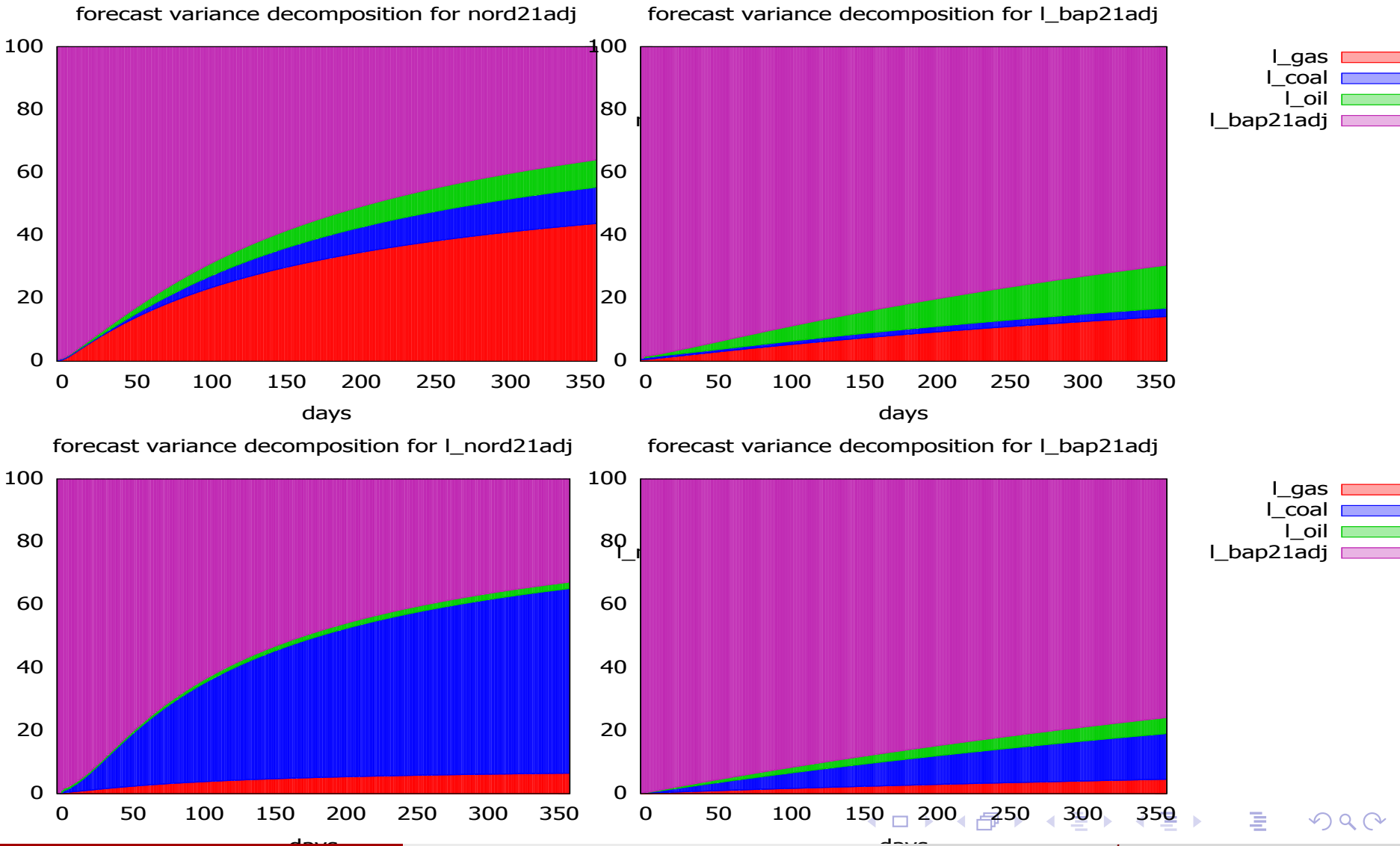
Forecast Error Variance Decomposition: H13

DA (left), BA (right), 1^{st} sample (top), 2^{nd} sample (bottom)



Forecast Error Variance Decomposition: H21

DA (left), BA (right), 1^{st} sample (top), 2^{nd} sample (bottom)



Computations

- We compute the actual balancing costs[1] multiplying the awarded prices for corresponding awarded quantities at unit level;
- then, we aggregate the information across technologies, hours, years and market 'purpose'
  - "sales" are situations in which Terna buys quantities incurring in 'costs' for the system (represented with negative values) – "up-regulation"

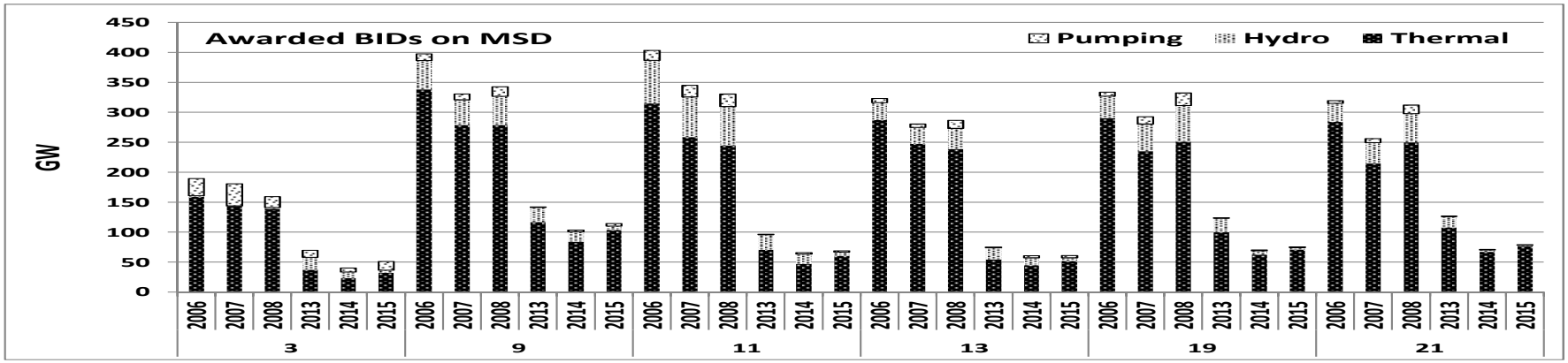
    $\Rightarrow$ general increasing yearly mean prices across the two samples
  - whereas by "purchases" are situations in which Terna sells quantities obtaining instead 'profits' (depicted with positive values) – "down-regulation"

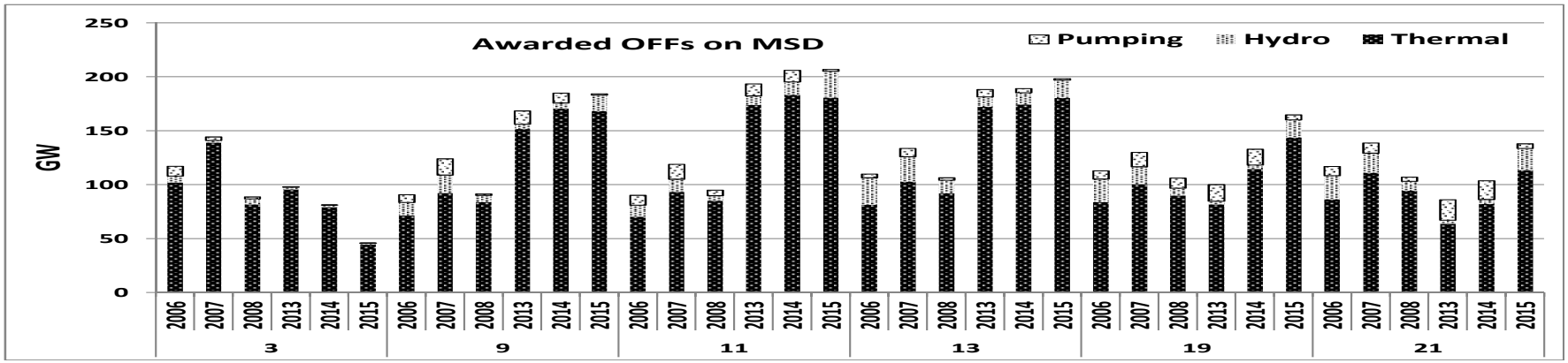
    $\Rightarrow$ decreasing yearly mean prices across the two samples

[1] Focusing only on two components of the of the *uplift*: the first component is the *planning of services*, which concerns the ex-ante MSD sessions, and the second one is the *energy component* which takes into account all the realized imbalances.

Balancing Quantities in the "ex-ante MSD"

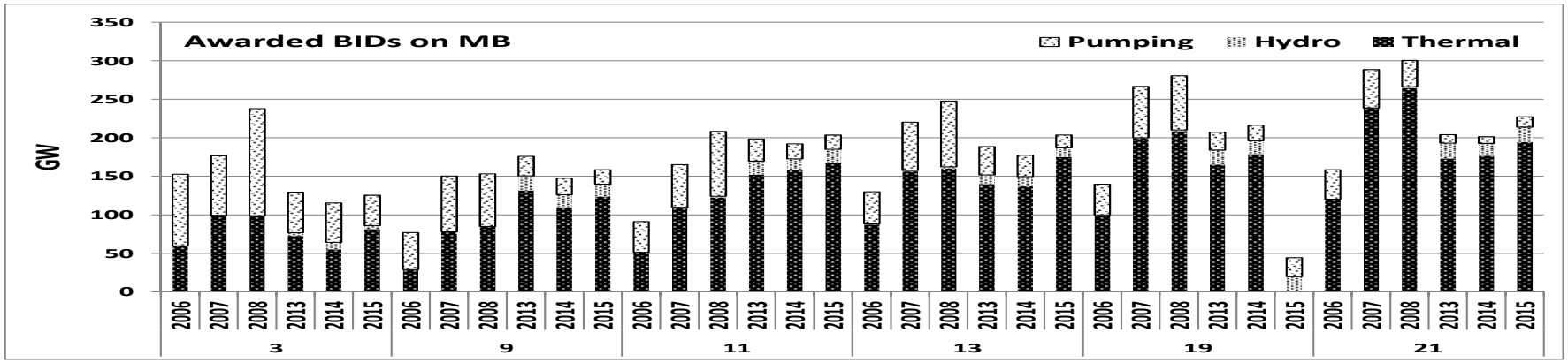
Yearly Sum of Awarded Purchased (on the first row) and Offered or "Sold" (on the second row) Quantities across hours and technologies

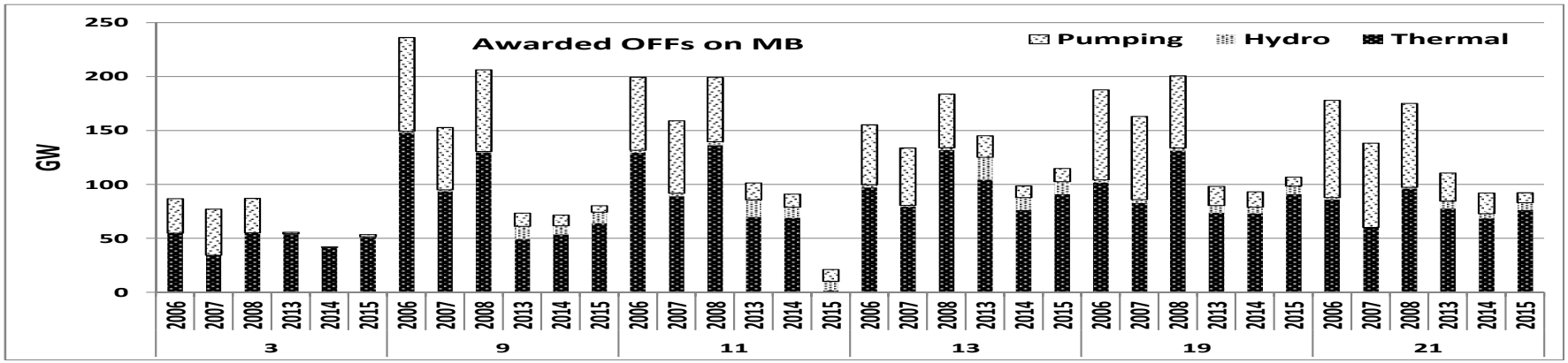




Balancing Quantities in "MB"

Yearly Sum of Awarded Purchased (on the first row) and Offered or "Sold" (on the second row) Quantities across hours and technologies

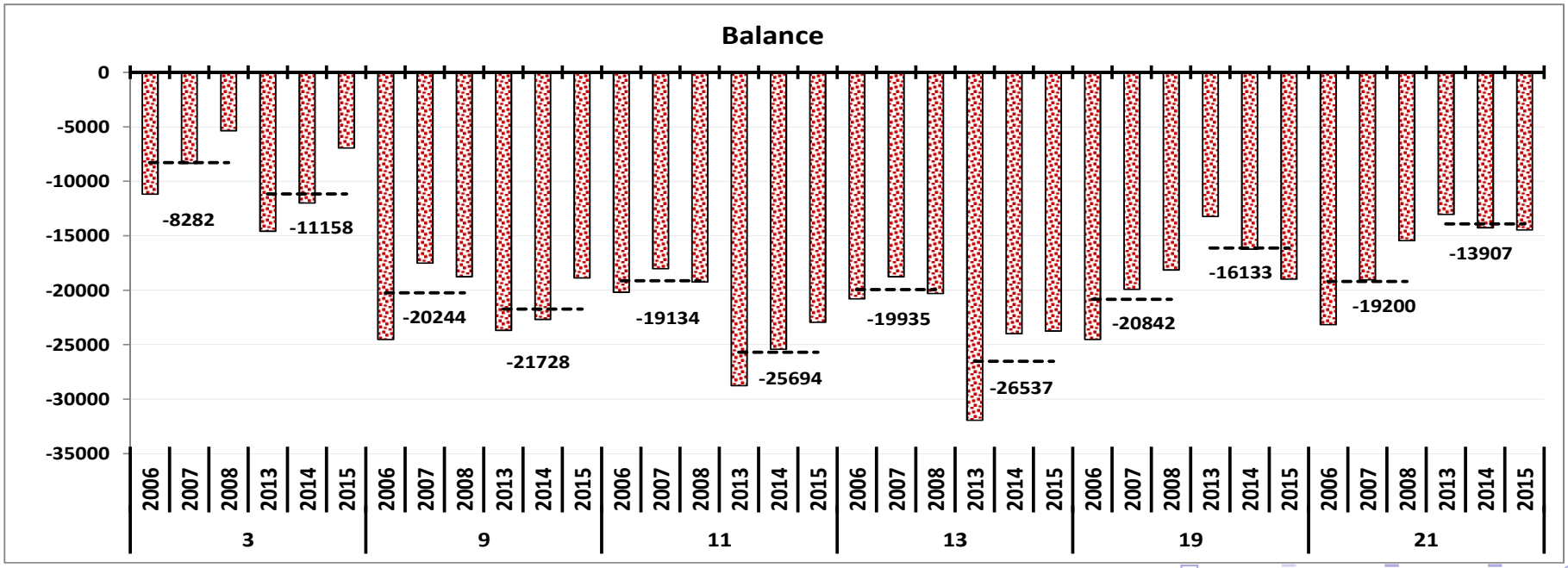




Overall Balance (in thousands of €)

as the difference between profits and costs, faced by the Italian TSO for the Italian Northern zone

We quantify the overall profits/costs as sum across technologies on both market sessions within a year. Clearly the activities of planning resources and dispatching balancing power are highly costly



Conclusions

- We documented a decoupling between oil and gas prices in our second sample (2013-15) with respect to the first sample (2006-08)
- We documented a switching effect among fuels in influencing electricity prices
  - the switching effect is remarkable in the day-ahead market
  - the same effect is observed in balancing prices but with a reduced size
- Balancing costs are higher in the second sample
- The planning activity executed in MSD is actually a substantial part of computed costs and a migration towards a "capacity market" may be of help for the system