# What drives balancing prices? The North-Italian case

Angelica Gianfreda[1] Lucia Parisio, Matteo Pelagatti [2]

[1]Faculty of Economics and Management, University of Bozen, ITALY

[2]Department of Economics, Management and Statistic, University of Milan- Bicocca, ITALY

AIEE 2017
LUMSA University, Rome

# Background

Electricity generation from renewable sources (RES) increased significantly in a short time span. At the same time, the share of conventional thermal units production dropped from 80% to 48% in period 2012-15.

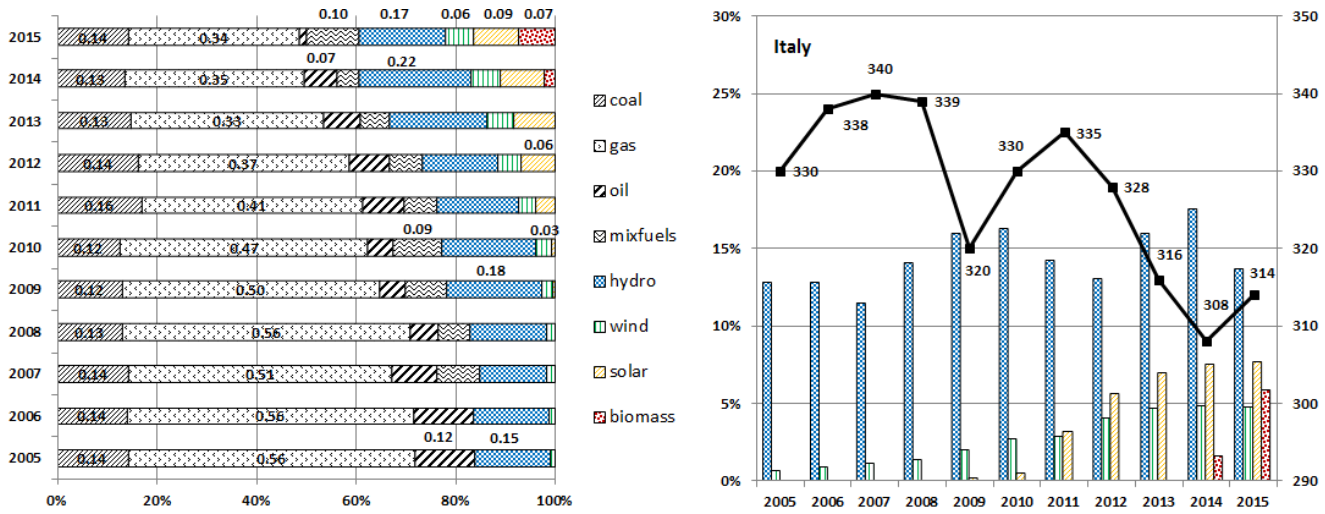



Figure 1: Italian shares by technology generation (left) and RES penetration with demand (right)

# RES penetration in Italy

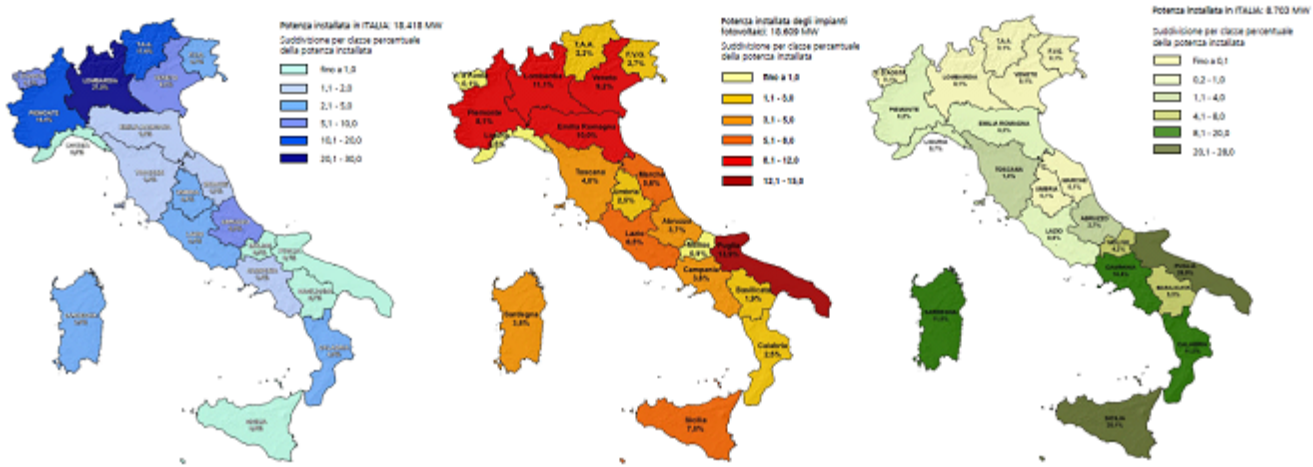


Figure 2: Zonal mapping of RES in Italy

In North Zone solar units account for 30% of RES production and hydro units the remaining 70%. Wind power is concentrated in South and Center-South. North zone has the largest portion of demand (160 TWh out of a total of 318 TWh in Italy) and it is characterized by the largest impact of RES during our second sample.

# Background

- Priority dispatch granted to a large and increasing share of RES-E sources in DAM resulted in the well known "merit order effect"
- Empirical evidence shows a partial decoupling between day-ahead prices and fuel prices (especially gas).
- On the other hand, when RES share increases, flexible production units become necessary to maintain system balance: some sort of alliance is expected among interruptible RES and gas units
- The role of thermal units should be relevant in balancing market sessions: as RES share increases, balancing prices should be lead by gas (or other fuels, like oil and coal).

# Aim of the Paper

- Using cointegration analysis, FEVD and IRF, we investigate the effect of crude oil, coal and natural gas price dynamics into balancing prices
- The analysis is performed for selected hours using data from MSD and MB market sessions for zone North of Italy.
- Referring to FIG. 1 we consider two sample periods: 2006-08 with low RES penetration and 2013-15 with high RES penetration
- We expect two distinct evolutionary dynamics of the fuel-electricity nexus driven by the different degree of RES penetration
- Our claim is that the high share of RES sold in upstream sessions may have influenced results of downstream sessions.

# Market sessions

- Market sessions includes Day-ahead market (MGP) and 7 sessions of Intraday market (MI). The number of MI sessions increased from 5 in 2012 to 7 from Feb 2017.
- Ancillary services are procured through organized market sessions with predefined gate closure times.
- The Italian real time market is structured in a programming phase (MSD) and a balancing phase (MB). Terna acts as central counterpart and accepts bids for up and down regulation. Accepted bids are remunerated on a pay-as bid basis.
- A reference price is calculated as the weighted average of all accepted bids (for up and down regulation)
- Conventional technologies (thermal, hydro and water pumping) have the required degree of flexibility. MSD shares

# Selected hours for the analysis

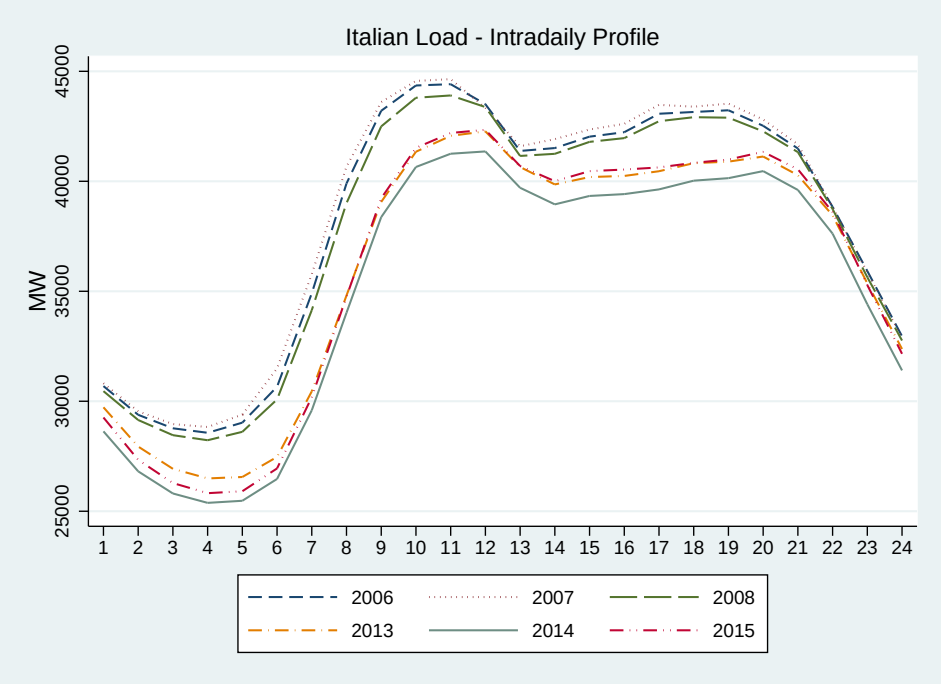


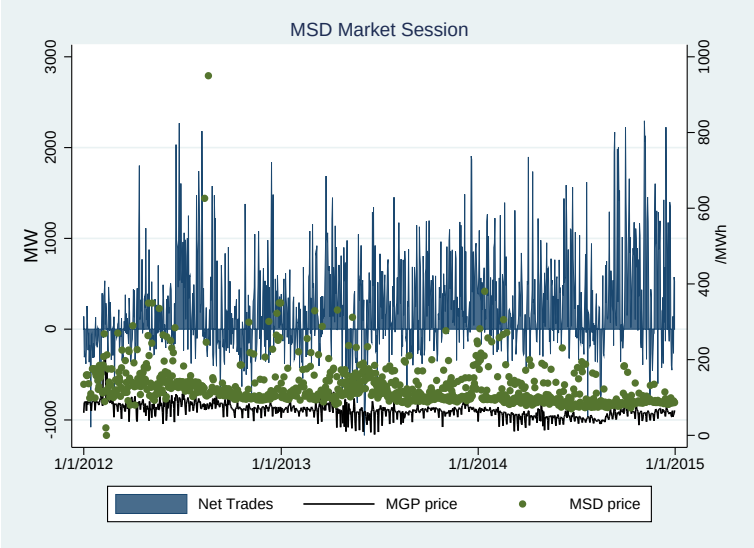

Figure 3: Italian load profiles

We analyze h: 3 (minimum load), 9 (ramping-up), 11 (maximum load), 13 (maximum load plus solar effect), 19 (evening peak with decreasing or null solar effect), 21 (ramping down).

# Sample

- We consider samples 2006-08 and 2013-15.
- Zonal prices collected from GME (day-ahead market) and from TERNA
- We conduct our analysis at different levels of data aggregation:
  1. Balancing prices calculated as weighted averages of all awarded values for FEVD
  2. Hourly weighted accepted bids for thermal units for IRF.
- Fuel data: Brent (OIL), CIF ARA (Coal) and ICE UK (gas).

# MSD prices: H11



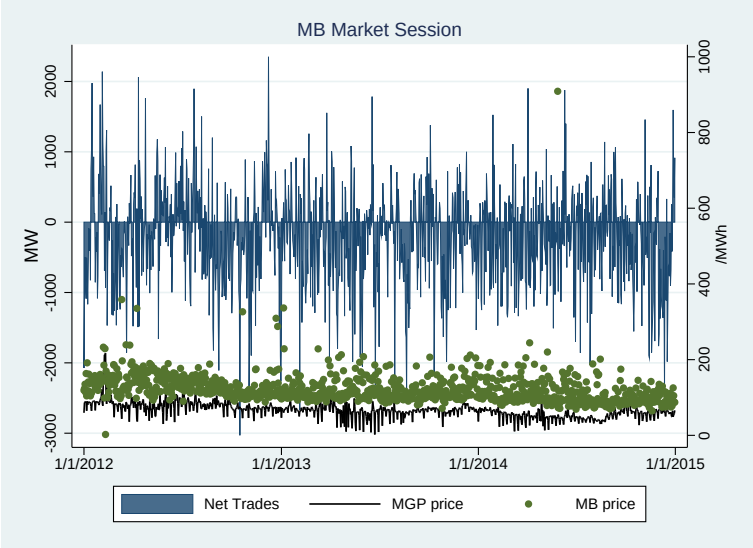
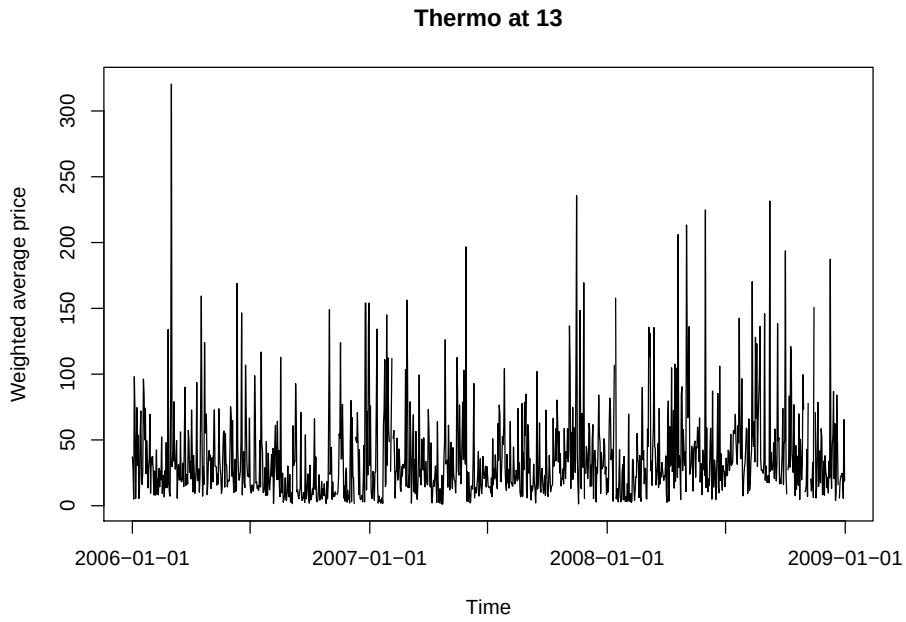




Figure 4: MSD (left panel), MB (right panel)

The Northern zone of Italy is in a persistent situation of excess demand after the closure of MGP market (import from foreign zones and South)
Regulation prices (weighted averages) are higher than MGP prices.
Evidence of peaks.

# MSD price series for thermal units



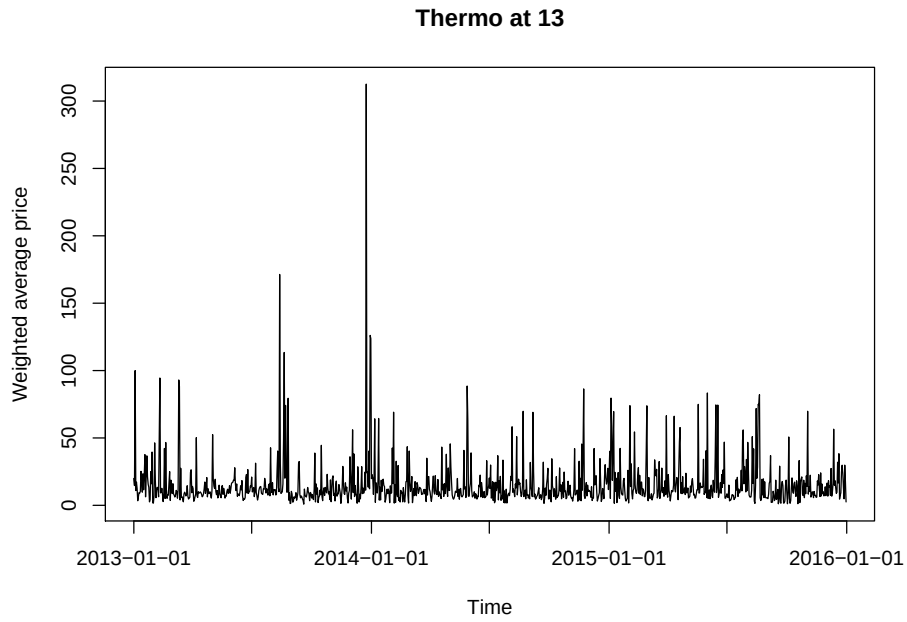




Figure 5: Weighted (accepted) bids for thermal units at H13.

# VAR/VECM for forecast error variance decomposition

- We aggregated all accepted bids (weighted for the corresponding quantities) for all technologies participating in balancing sessions
- We decided to keep all the time series at their original (daily) frequency and treat the seasonal components with a data pre-processing.
- Pre-processing is necessary in order to remove leptokurtic noise determined by short term shocks that could partially alter the causal relation among series
- Johansen's test: for each considered hour and for each subsample, we tested for the presence of cointegration among the logarithms of electricity and fuel (i.e., oil, gas, coal) prices.

# FEVD

- We estimated a VAR/VECM model for each hour, coherently with the number of cointegrating relations found by Johansen's test.
- The model we consider is four dimensional (3 fuels and BA price)
- To assess the role that fuel prices play in influencing balancing prices in the long-run we refer to *forecast error variance decomposition* (FEVD), which allows to determine how much of the forecast error variance of each variable can be explained by exogenous shocks to the other variables.

# Cointegration analysis

- In the sample 06-08 we found two cointegrating relationships: one linking fuels dynamics (gas, oil and coal), the other linking fuels and electricity prices
- In the sample 13-15 we found just one cointegrating relationship: since in another paper we found that long run common dynamics among fuels vanished in that sample, we conclude that the surviving relationship links fuels to BA prices
- We estimated a four dimensional VECM (one for each sample) and we performed FEVD analysis. We find that fuels maintain the same relevance in explaining the long-run dynamics of BA prices, which is approximately of 20%.
- Shares of single fuels exhibit only slight changes and sometime we observe an increasing relevance of coal.

# FEVD: Balancing session H3

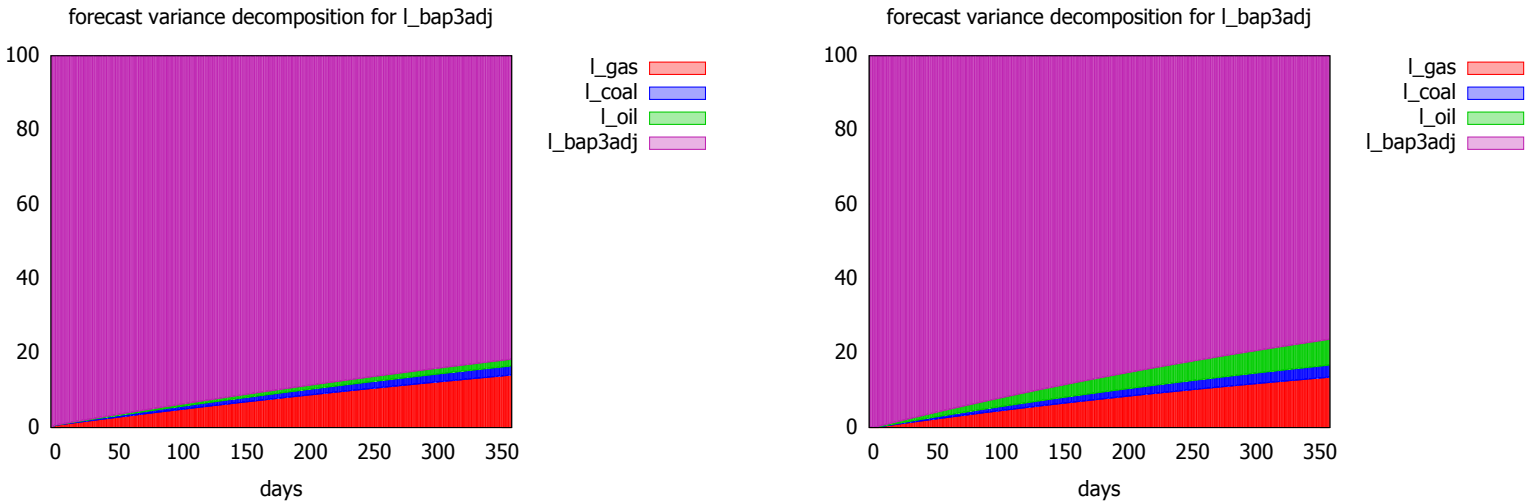



Figure 6: Hour 3: 2006-08 left, 2012-15 right

# FEVD: Balancing session H9

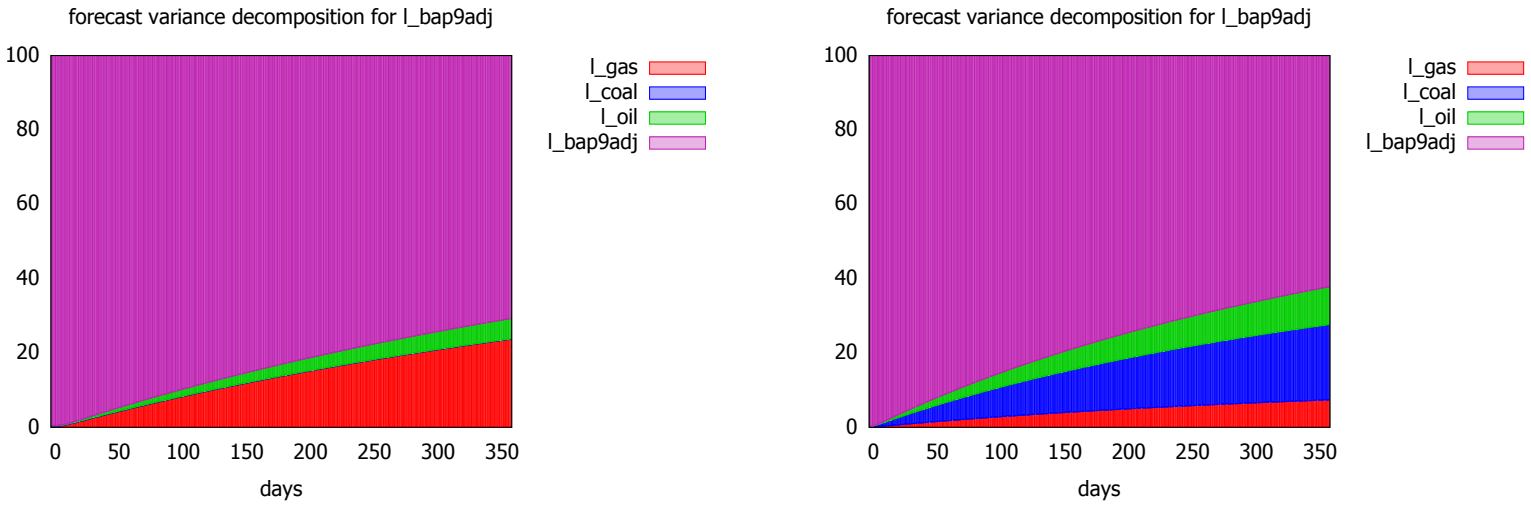



Figure 7: Hour 9: 2006-08 left, 2012-15 right

We notice a slight increase in the role of fuels and a switch from gas to coal as a leading fuel.

# FEVD: Balancing session H11

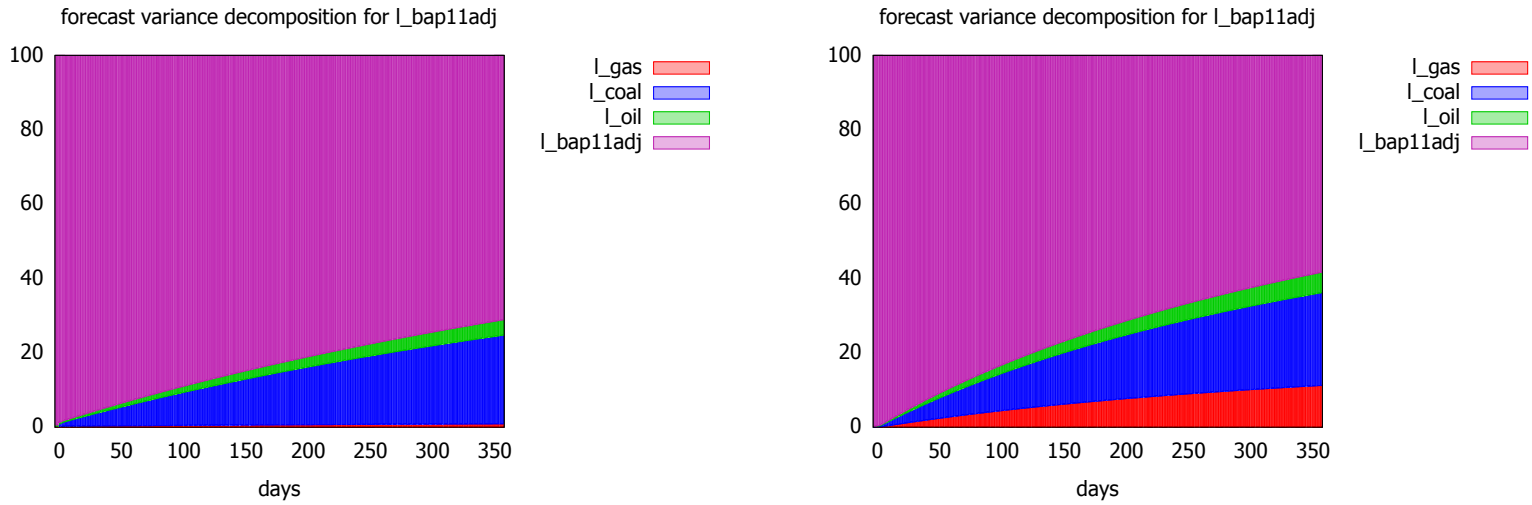



Figure 8: Hour 11: 2006-08 left, 2012-15 right

$\Rightarrow$ We observe a slight increase in the role of gas

# FEVD: Balancing session H13

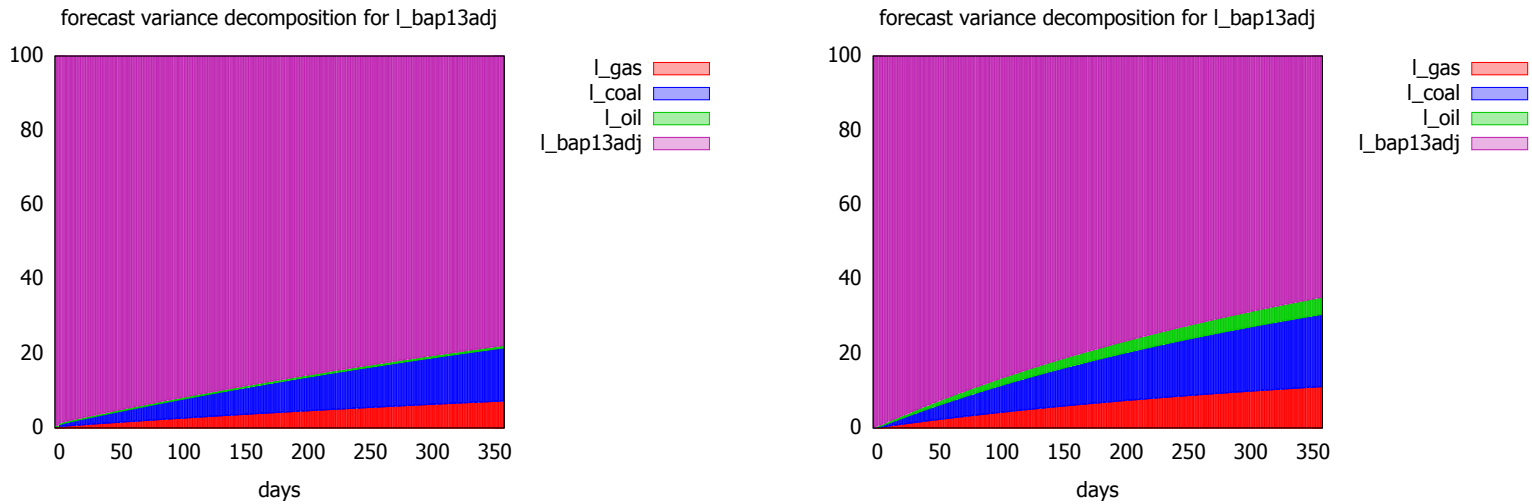



Figure 9: Hour 13: 2006-08 left, 2012-15 right

Same hour in DAM Example

# FEVD: Balancing session H19

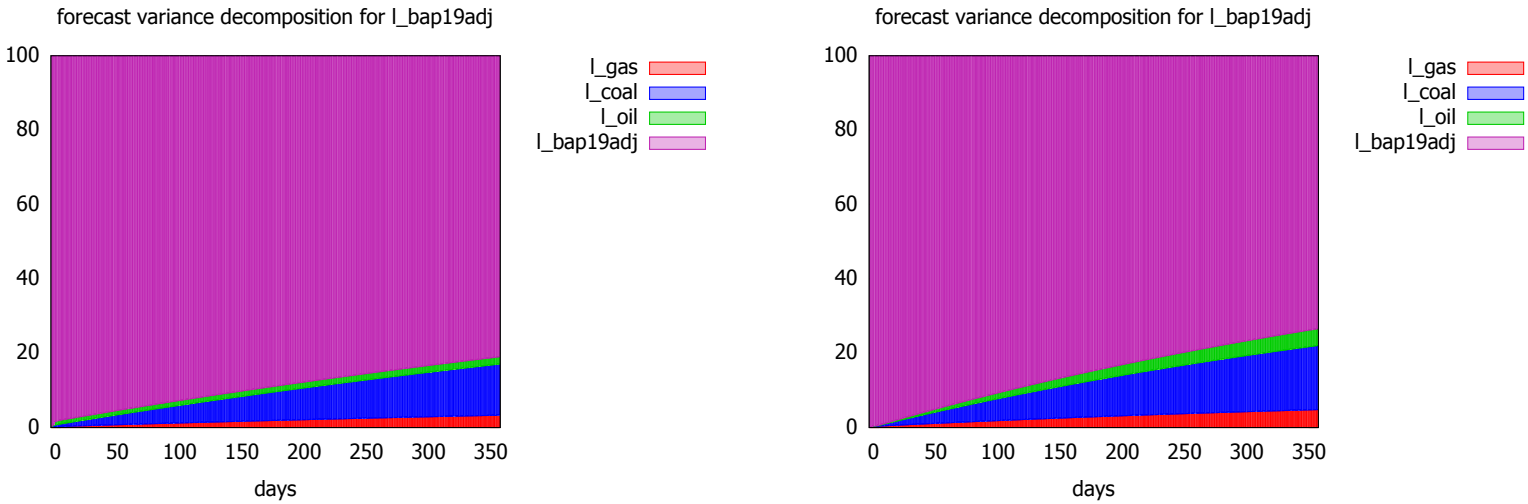



Figure 10: Hour 19: 2006-08 left, 2012-15 right

# FEVD: Balancing session H21

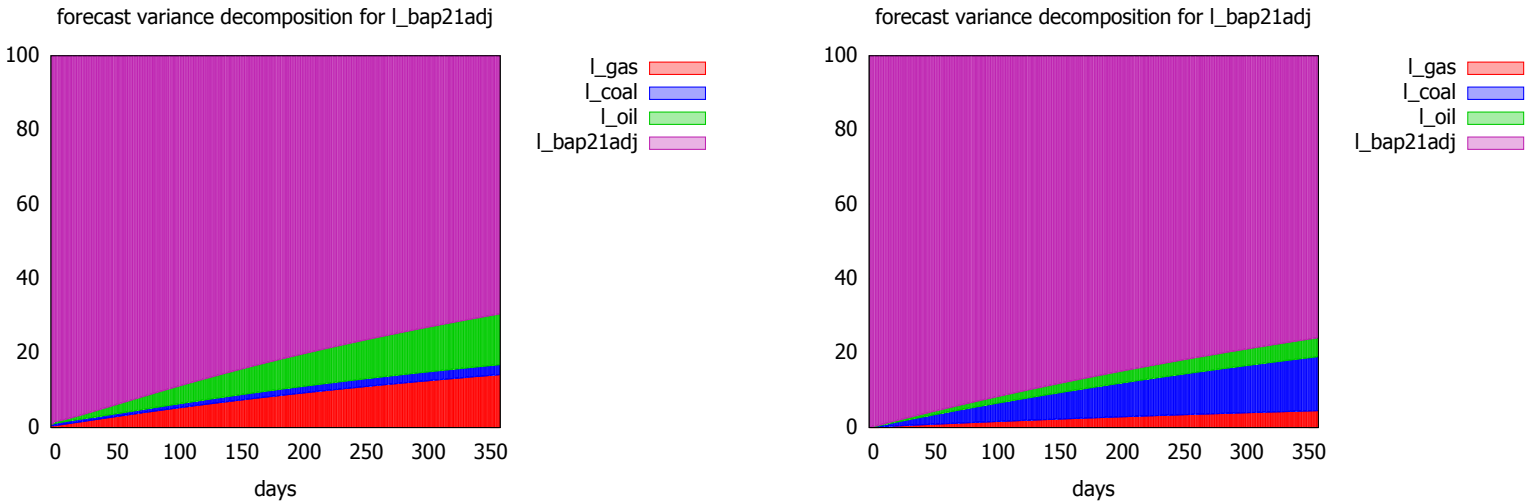



Figure 11: Hour 21: 2006-08 left, 2012-15 right

# Impulse Response Function

- Now we focus on accepted bids from thermal units only, since they are largely dominating balancing sessions, in particular during the second sample
- We conduct a bivariate analysis (balancing price vs one fuel at time)
- We performed the cointegration analysis as before
- We estimate the impact on BA prices of a positive shock with one standard deviation magnitude (IRF)
- Results:
  - We found no cointegration among variables in the first sample 2006-08
  - We found cointegration among couples in the second sample 2013-15

# Dynamic analysis for thermo BA prices vs coal price

| | | 2006-2008 | | 2013-2015 | |
|---|---|---|---|---|---|
| | | coint rank (trace) | coint rank (Lmax) | coint rank (trace) | coint rank (Lmax) |
| thermo h3 | coal | 0 | 0 | 1 | 1 |
| | gas | - | 0 | 1 | 1 |
| | oil | 0 | 1 | 1 | 1 |
| thermo h9 | coal | 1 | 1 | 0 | 0 |
| | gas | - | 0 | 1 | 1 |
| | oil | 1 | 1 | 1 | 1 |
| thermo h11 | coal | 0 | 0 | 0 | 0 |
| | gas | 0 | 0 | 1 | 1 |
| | oil | 0 | 0 | 0 | 1 |
| thermo h13 | coal | 1 | 1 | 1 | 1 |
| | gas | 0 | 0 | 1 | 1 |
| | oil | 0 | 0 | 1 | 1 |
| thermo h19 | coal | 1 | 1 | 1 | 1 |
| | gas | - | 0 | 1 | 1 |
| | oil | 0 | 0 | 1 | 1 |
| thermo h21 | coal | 0 | 0 | 1 | 1 |
| | gas | 0 | 0 | 1 | 1 |
| | oil | 0 | 0 | 1 | 1 |

# Impulse response function

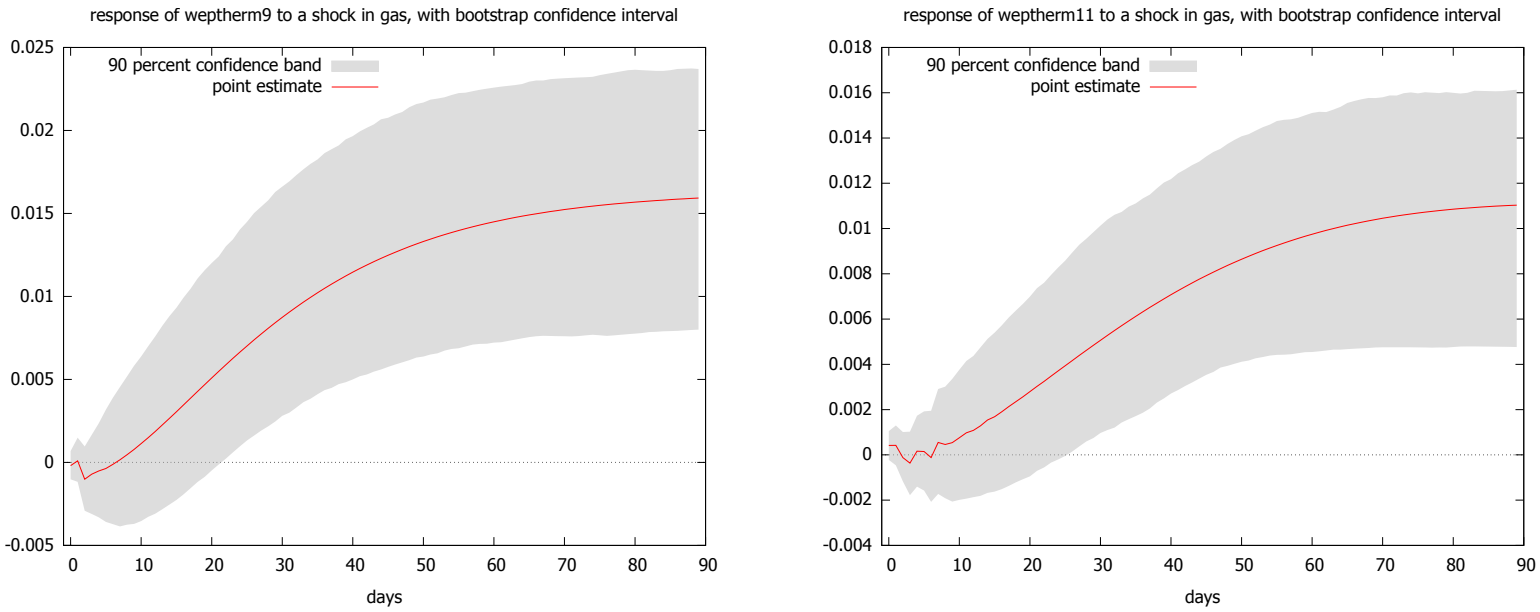



Figure 12: Hours 9 (left) and 11 (right)

# Impulse response function

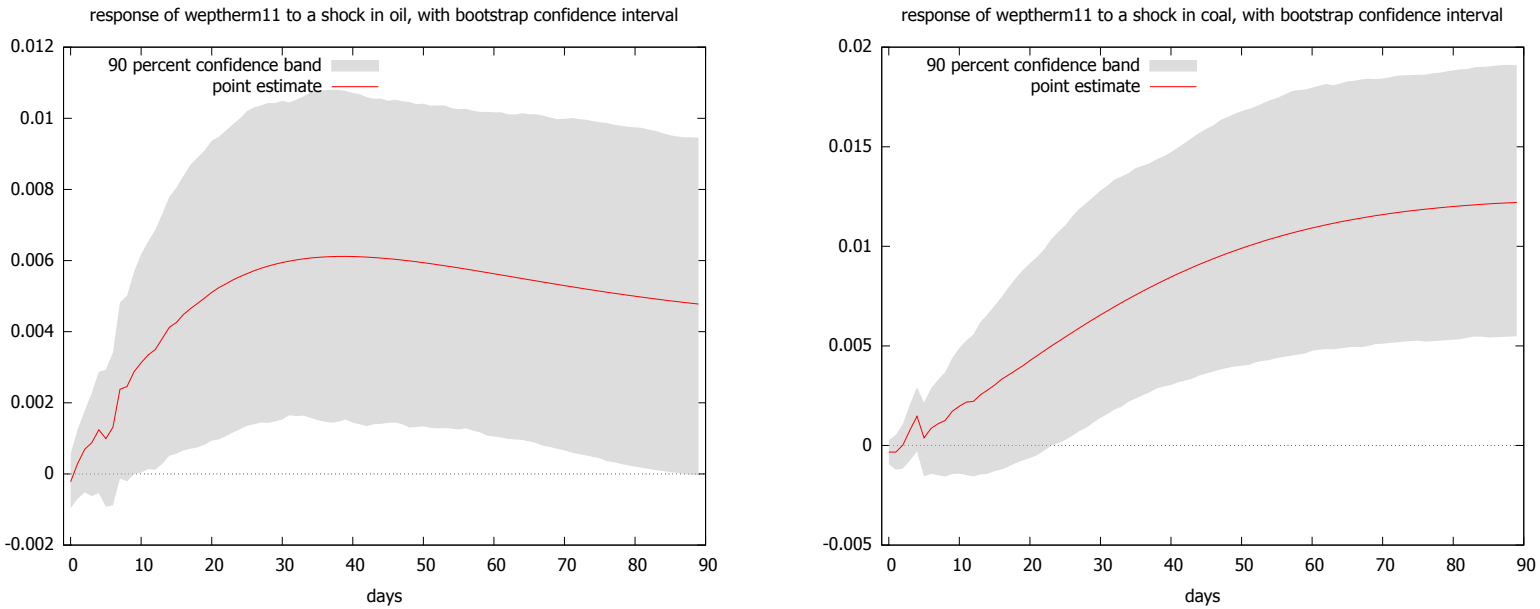



Figure 13: Hours 11: oil (left) and coal (right)

Fuels shocks are likely to influence balancing prices at peak time (H11, all fuels) and at ramp-up time (h9, gas only).

# Balancing costs

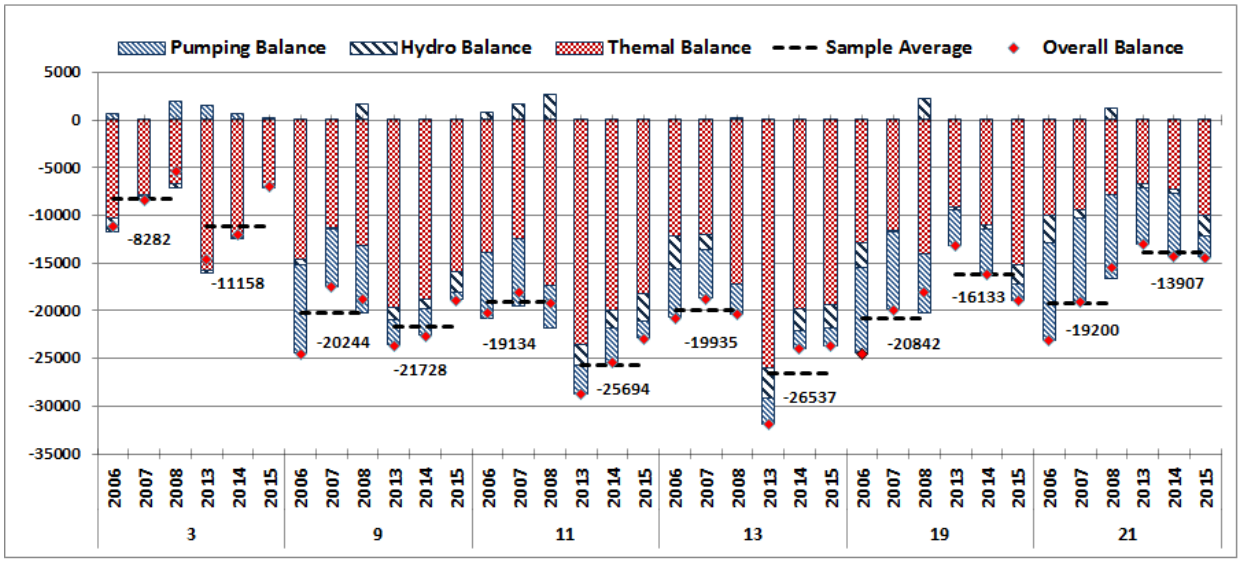
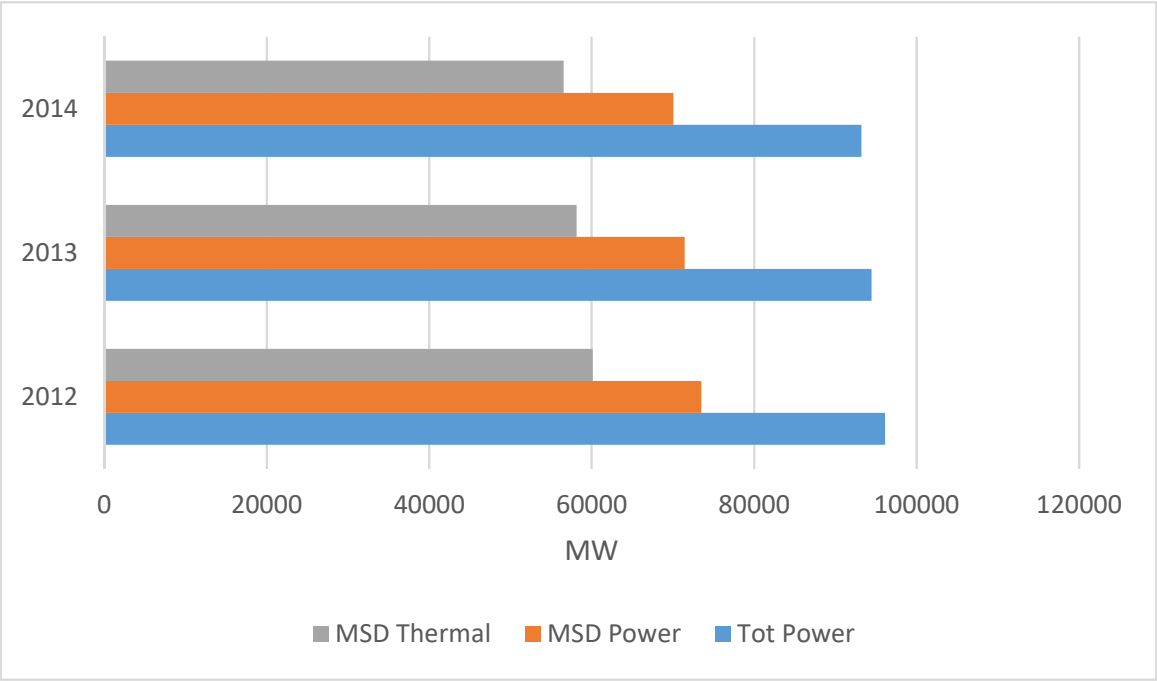



Figure 14: Balancing costs

# Conclusions

- We investigate the effect of fuel prices in explaining the dynamics of balancing prices (Northern zone of Italy for selected hours in sample 2006-08 and 2013-15)
- We found that the increasing share of RES in DAM influences downstream sessions: BA price series for thermal units have a common dynamic with fuels prices, especially with gas prices, in the second sample
- The dynamic we capture however, holds in the long run whereas short run prices are more likely to be determined by local shocks and strategic behavior.

# MSD market shares



# Day ahead market example

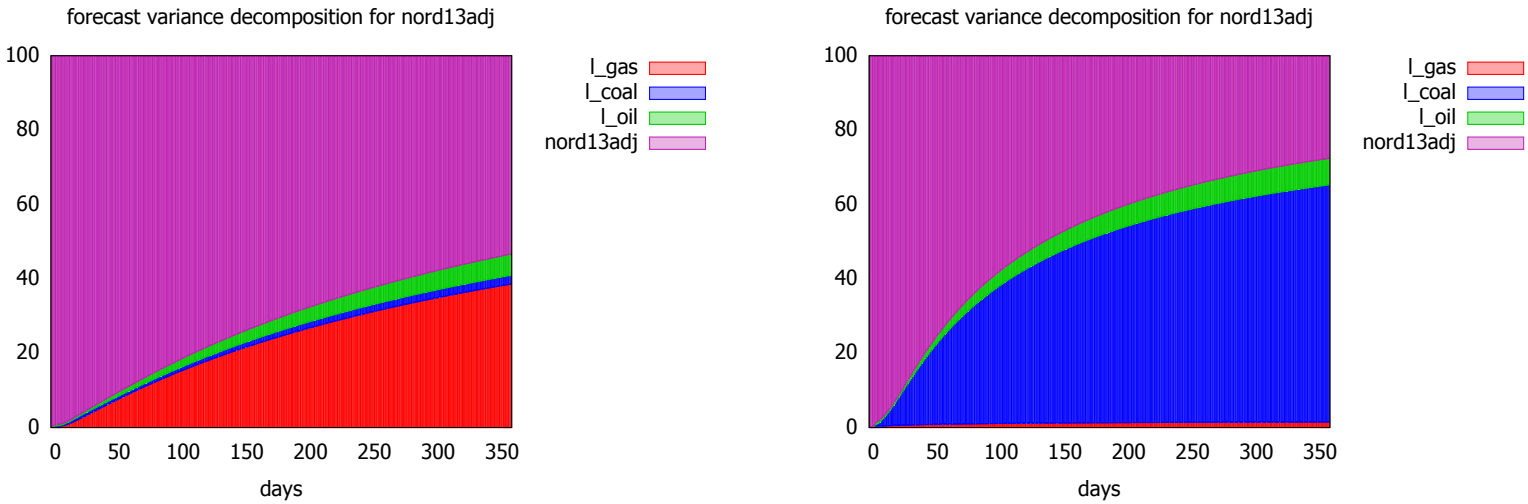



Figure 15: 2006-08 left, 2012-15 right