Forecasting gas-to-power demand in Europe

Resolving the increasingly complex problem?

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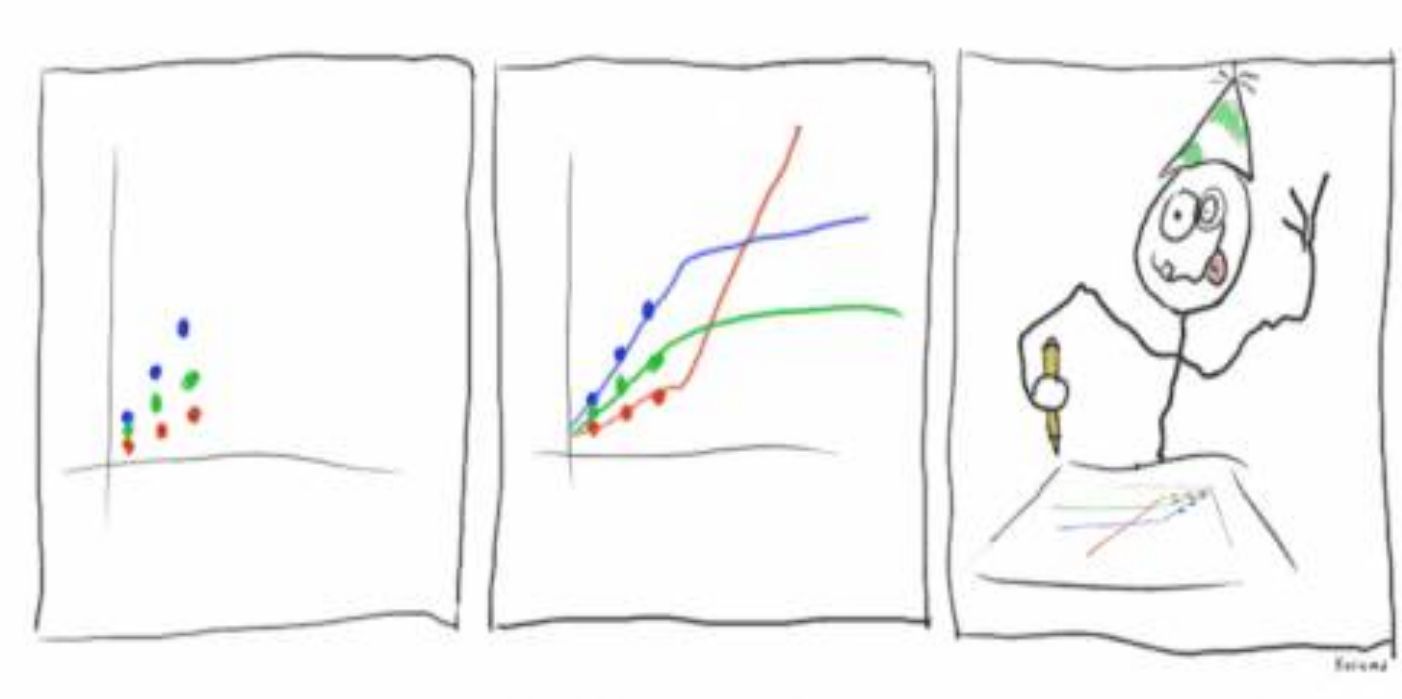
GAZPROM MARKETING & TRADING

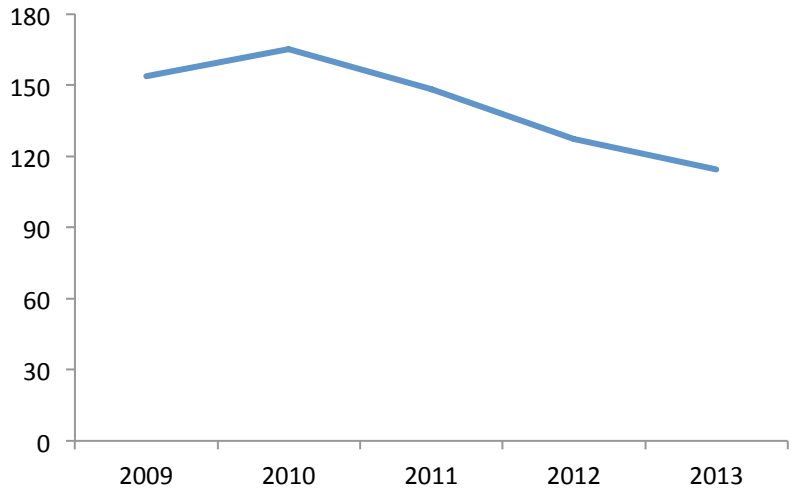
Forecasting European Power markets…….?



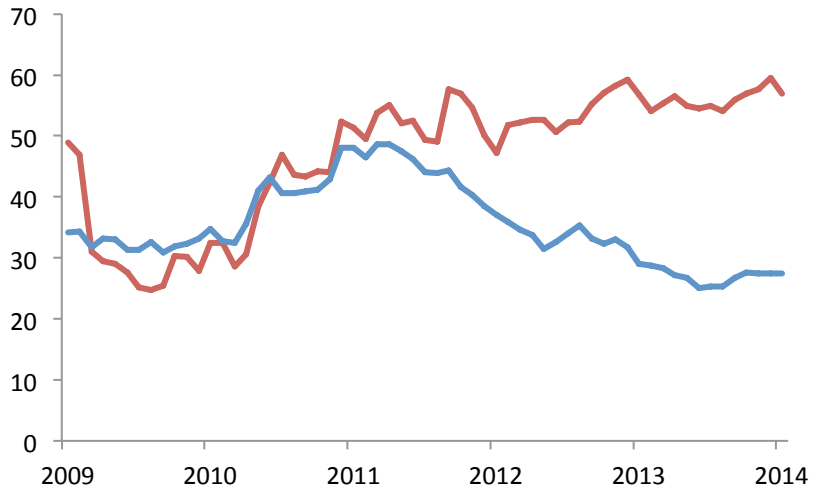
European gas-to-power demand: short history

- Out of all European gas-consuming sectors, the power sector has historically been most sensitive to fuel price fluctuations due to the possibility to easily switch to alternative fuels (coal).
- Strong gas demand from the European power sector was observed for the period 2000 to 2008, followed by strong drops and four consecutive years of decline. Total drop for the 2010-13 period was 40bcm.
- This is the result of fuel switching driven by the improving economics of coal vis-a-vis gas-fired generation, as well as reduced power demand due to the recession.

European power sector gas demand (bcma)



Coal (blue) versus gas (red) marginal cost (€/MWh)



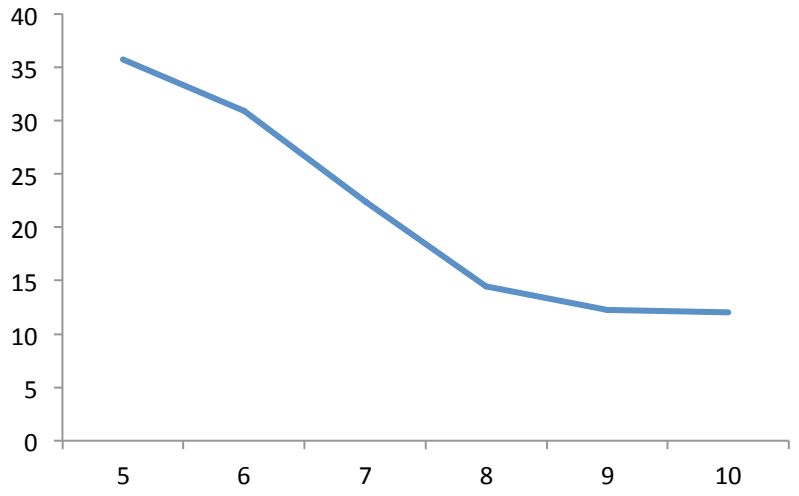
Note: gas conversion to bcma @40MJ/m^3. SRMC based on month-ahead TTF gas and API-2 coal price. Efficiency: gas - 49.13%, coal – 38%. Carbon intensity: gas - 0.3765, coal - 0.96.

Source: GM&T internal data

Price sensitivity of demand:
The simple part…….

- Historically, forecasting power sector gas demand has been relatively straightforward, as it was a function of GDP/power demand and gas and coal prices. As recently as 2010, intermittent installed capacity in the UK was only about 6% of total installed capacity, compared with ~15% in 2014.
- The UK power sector alone has a swing of over 20bcm driven singularly by gas prices fluctuating in the range between $5 and $10/MMBTU *(ceteris paribus)*.
- For a given power stack, this relationship is fixed and would therefore give a good basis for forecasting demand.

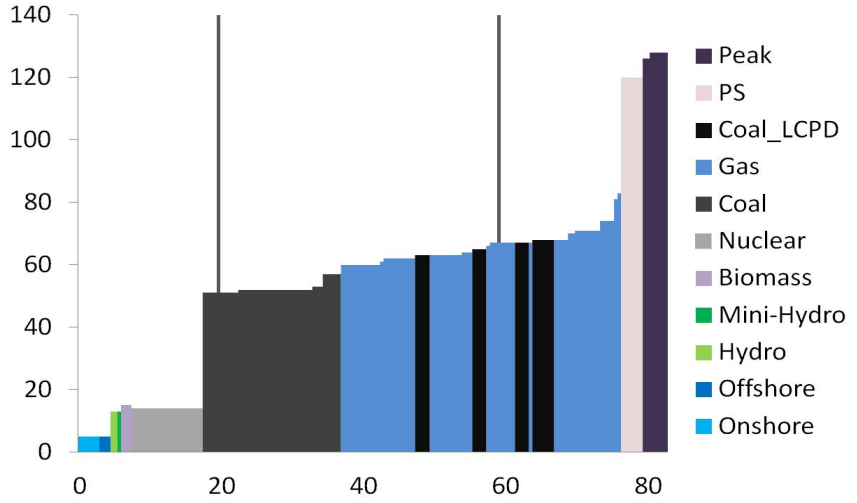
2012 UK power sector gas demand price sensitivity



Vertical axis: demand, bcm; horizontal axis: gas price levels, $/MMBTU

Source: GM&T internal data

2010 UK power sector stack (€/MWh)

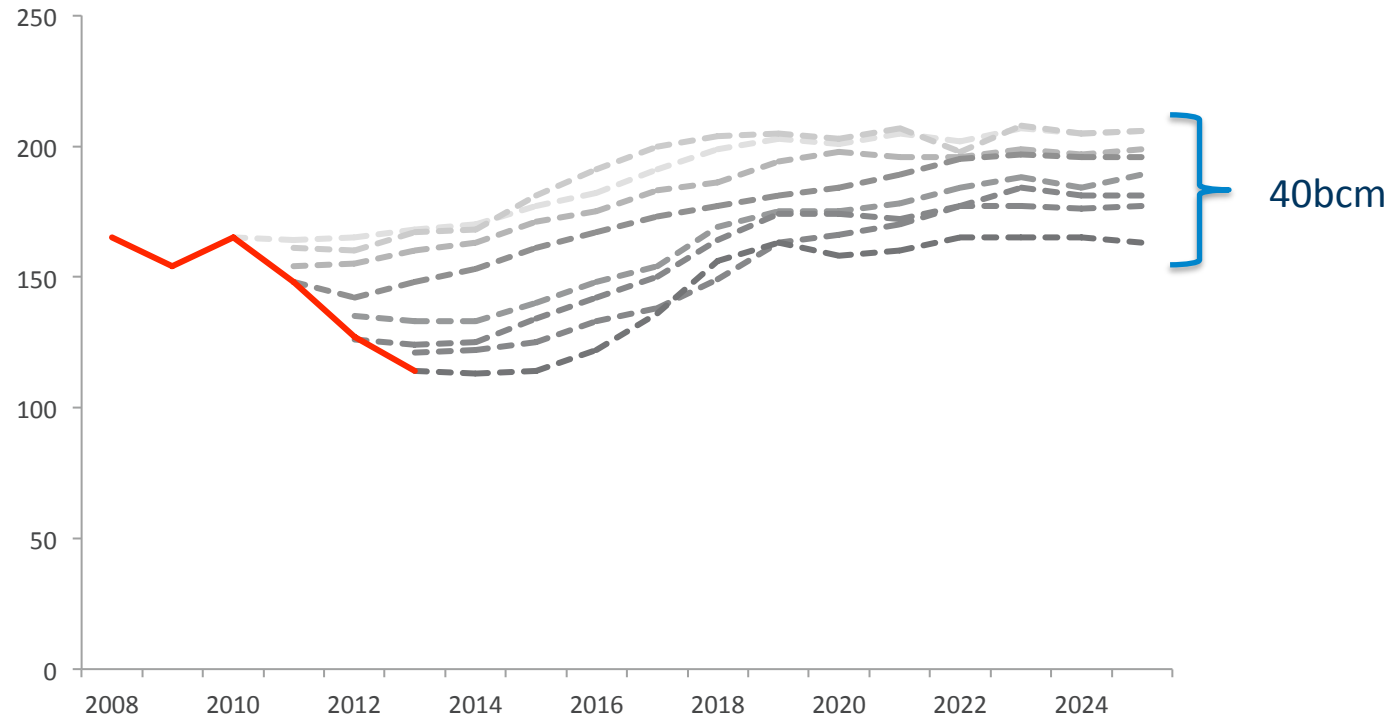


Vertical axis: SRMC, €/MWh; horizontal axis: capacity, GW. End-2010 historical input prices.

The challenge of forecasting gas demand remains

- However, correct gas demand forecasting clearly remains a challenge;
- Over the last four years, consultants have consistently underestimated the depth of the contraction.
- Are there further factors at play, apart from unpredictable GDP/power demand and gas-to-coal price ratios?

Evolution of demand projections for Europe, (bcm)

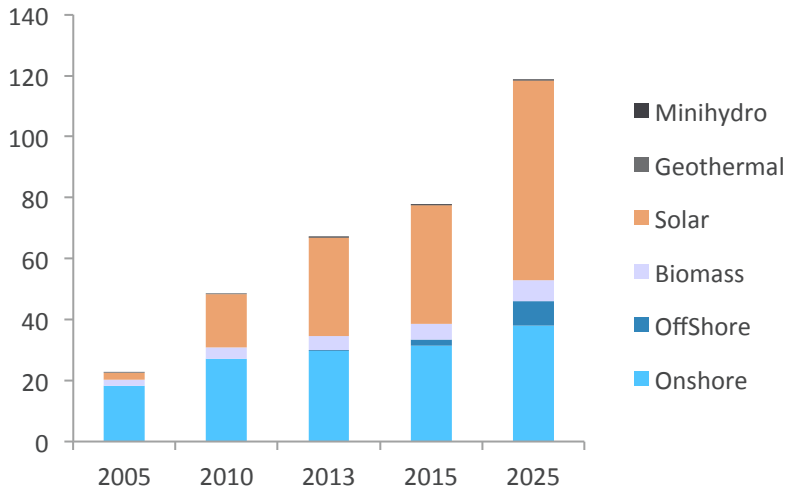


Source: Wood Mac gas demand forecast data

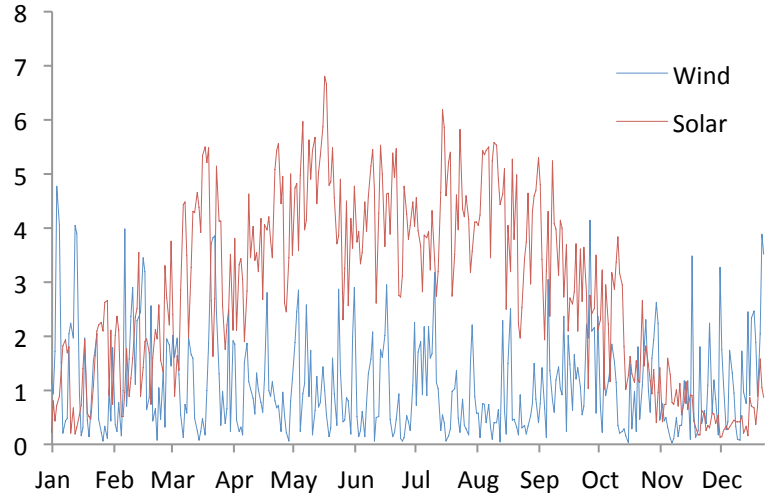
Increasing complexity of the forecast; Introduce the Renewables

- Over the last five years, growth of RES installations in Europe has intensified, due to support at both the EU and national level.
- Germany has been the strongest RES proponent, with above 70GW of RES installed as of early 2014.
- The vast majority of installed RES is intermittent and unpredictable in nature. This, coupled with regulated priority RES despatch has meant that increasing amounts of system flexibility are needed.

Germany - RES installed capacity (GW)



2012 German RES capacity factors (3pm)



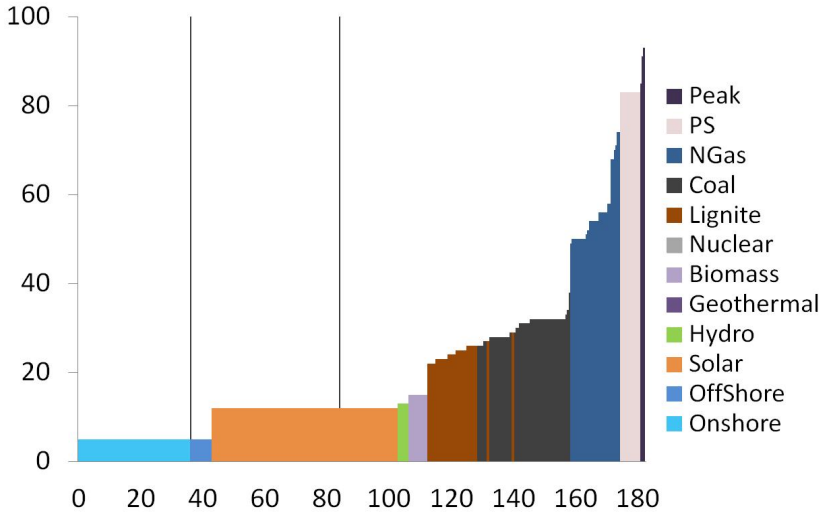
Note: Capacity factor is the ratio between the actual and average load factor

Source: GM&T internal data

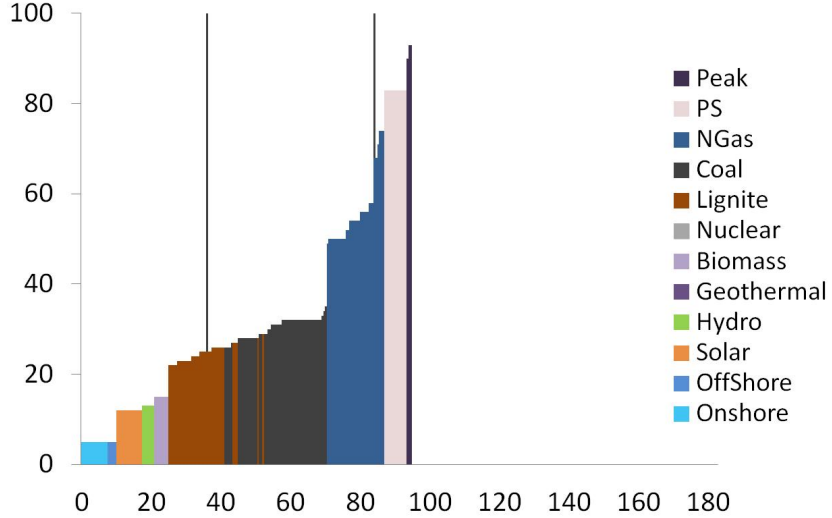
Increasing complexity of the forecast;
Expected German supply stack and merit order in 2023

- The German installed capacity generation stack in 2023, after the retirement of baseload nuclear, shows the predominance of RES (over 100GW), as the generation source with the cheapest SRMC.
- However, in terms of reliable capacity, (adjusted for load factors), RES has a much lower share of total capacity.
- Therefore, detailed knowledge of the impact of RES on the power system is needed, in order to accurately forecast gas burn. The impact of intermittency also needs to be considered.

German 2023 generation stack - installed capacity



German 2023 generation stack - effective capacity



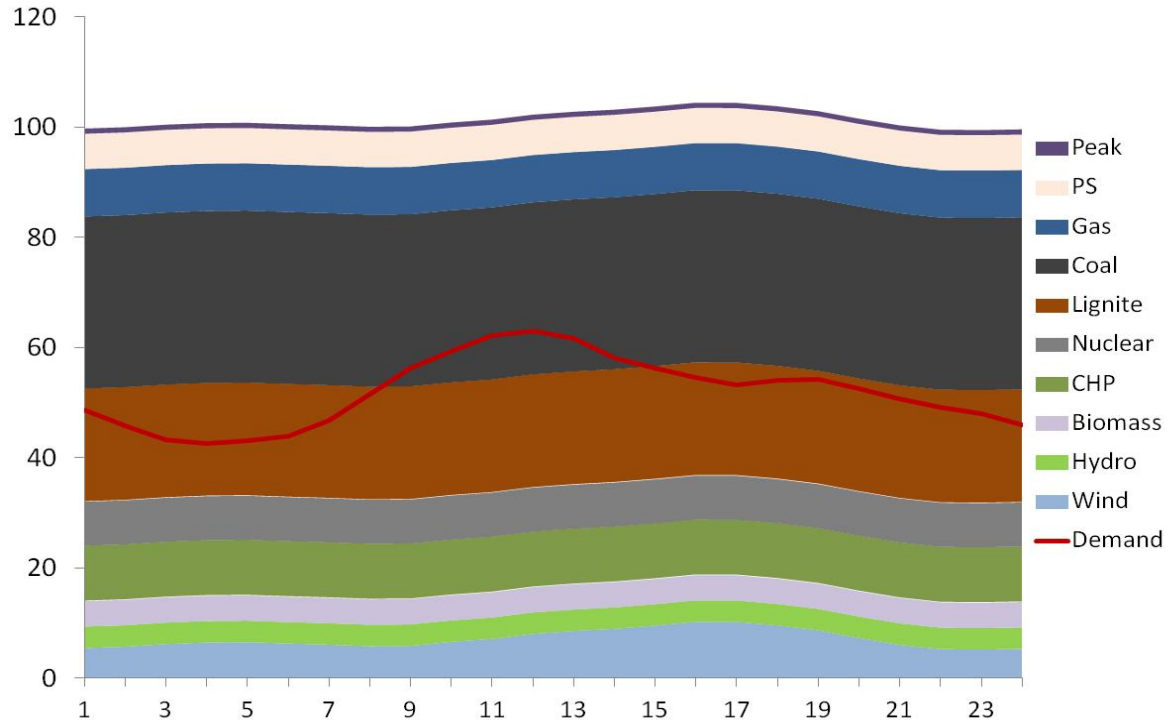
For both charts: vertical axis: SRMC, €/MWh; horizontal axis: capacity, GW. Spot input prices as of end-Feb 2014 used for the stack SRMC, including TTF for gas and API-2 for coal.

Source: GM&T internal data

Increasing complexity of the forecast; Flexibility over economics?

- PV output will lead to significant cuts in running hours for baseload generators such as lignite and coal assets;
- High PV ramp rate will therefore require responsive dispatchable capacity to keep the grid in balance;
- The stronger growth of intermittent RES will therefore lead to high requirement for flexible gas-fired generation, thus positively affecting gas burn.

The impact of solar PV on the German power system – summer 2020



Hourly generation for a specific summer day, GW

Source: GM&T internal data

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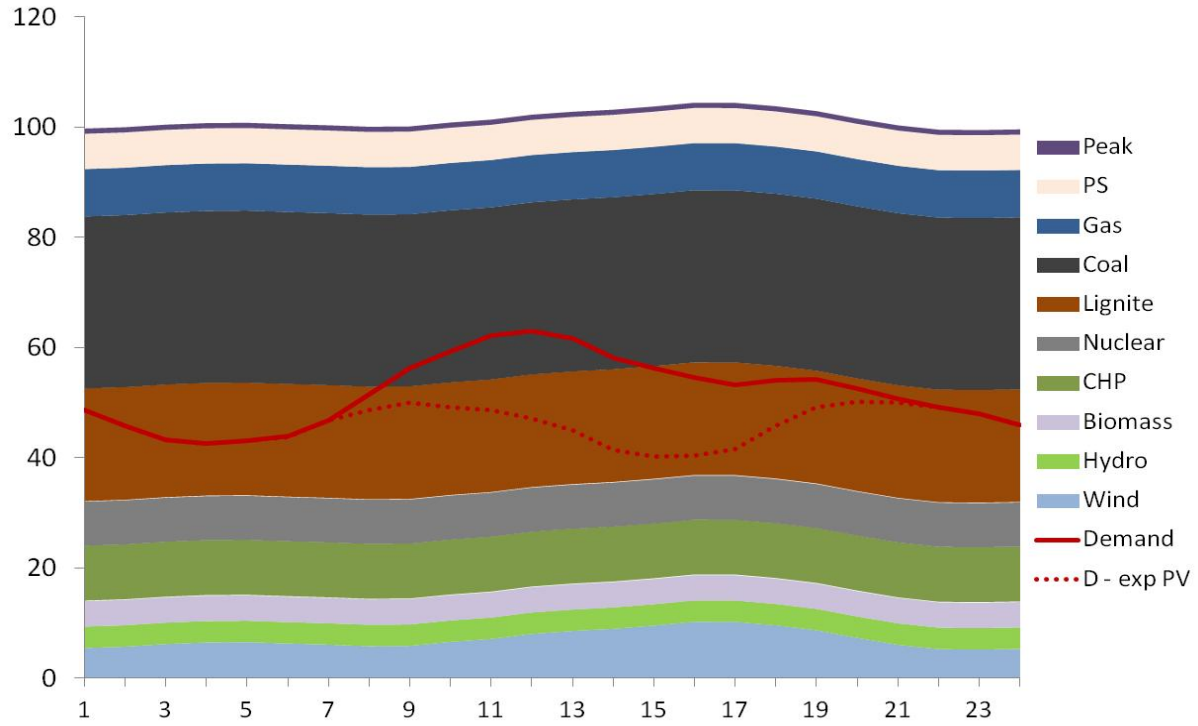

Hourly generation for a specific summer day, GW. **D – exp PV** is daily demand minus expected average solar generation.

Source: GM&T internal data

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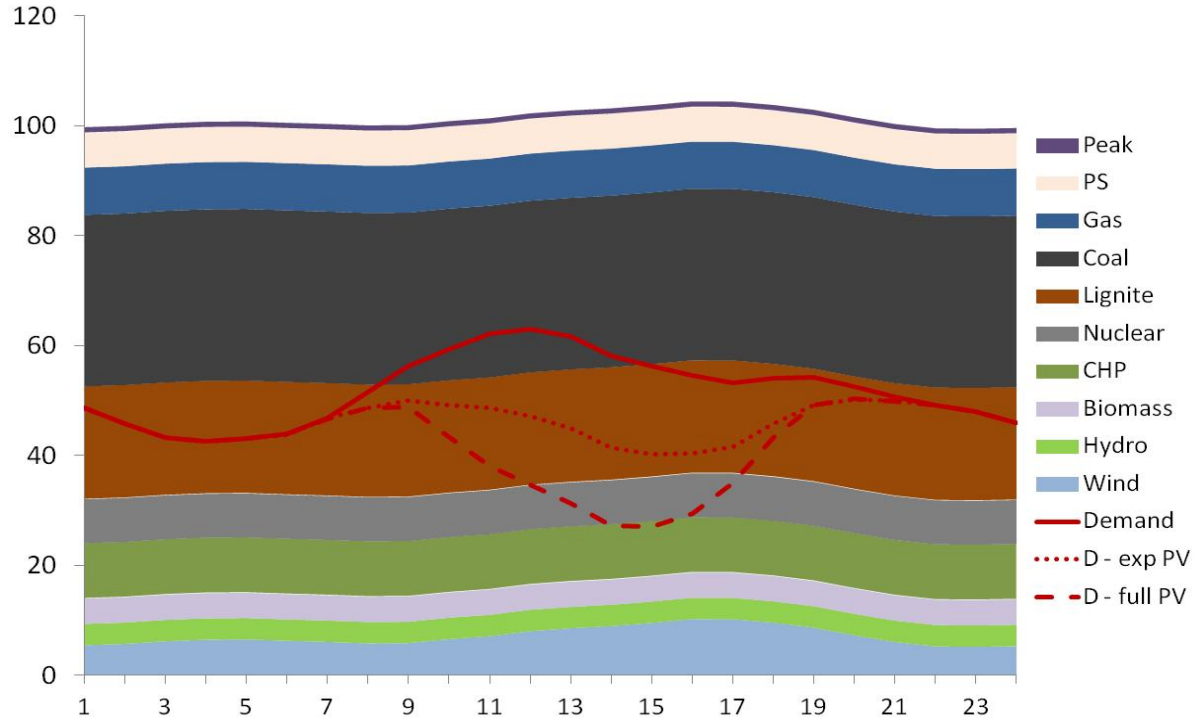


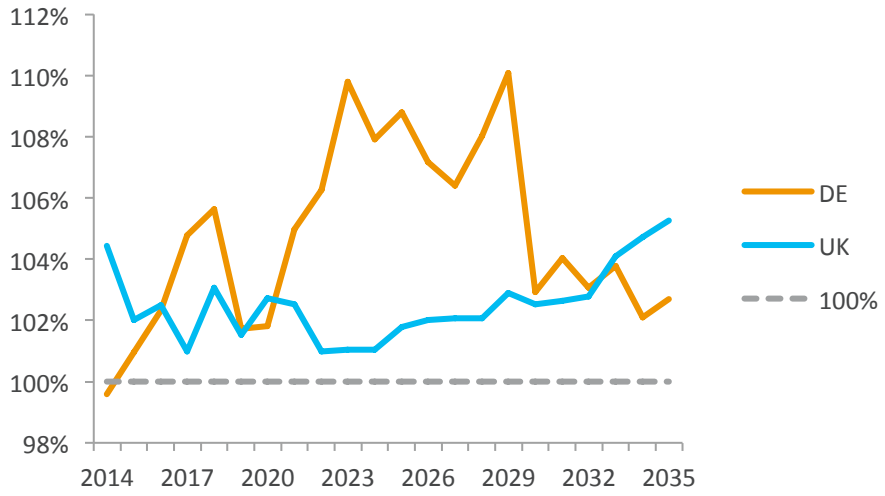
Hourly generation for a specific summer day, GW. **D – exp PV** is daily demand minus expected average solar generation. **D – full PV** is daily demand minus maximum historical PV generation.

Source: GM&T internal data

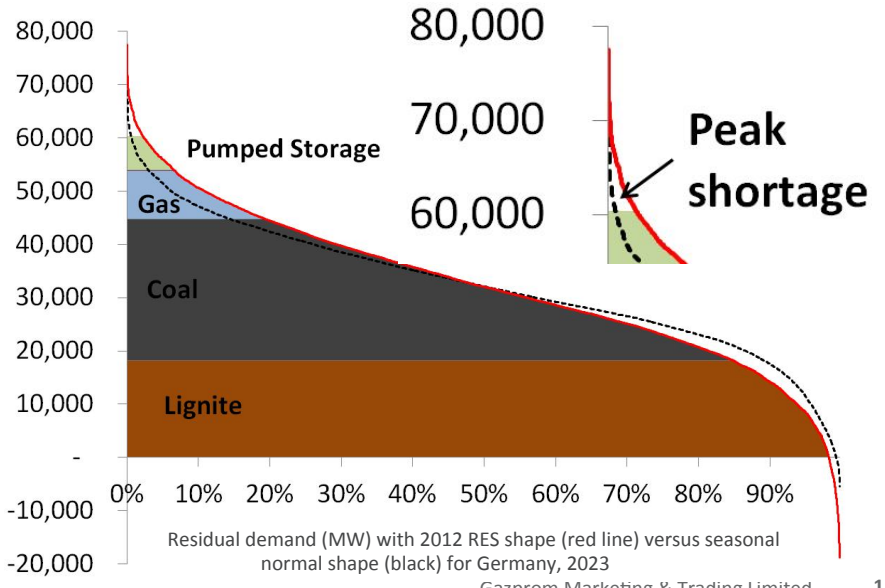
Thermal generation as a function of residual power demand

- A flexibility-enhanced despatch model run uses actual RES and demand shape, as opposed to the averaged characteristic week shapes of otherwise used to minimise model running time.
- For Germany, the residual demand load duration curve, with actual RES and demand netted off, is steeper than the normal load duration curve, with higher levels at the peak 1% hours of the year, due to RES unavailability.
- 2023 German gas demand in a flexibility run is ~10% higher than the respective non-flexibility run.
- Therefore it can be concluded that RES impacts gas burn through two main factors:
  - Overall depressed load factors as RES crowds out gas generation;
  - However, the RES backup requirement acts to boost GT/CCGT gas demand.

Gas demand, 2010 actual RES vs. seasonal normal



Residual demand: actual vs. seasonal normal



Residual demand (MW) with 2012 RES shape (red line) versus seasonal normal shape (black) for Germany, 2023

For both charts: hourly generation for a specific winter/summer day, GW

Source: GM&T internal data

Modelling power sector gas demand

- **Simple stack model:** presents gas demand as a direct function of gas/coal prices and the power demand.
- **Energy-only S&D modelling:** based on a despatch model, but with averaged-out characteristic week RES and demand profiles, for ease and speed of computation
- **Flexibility-enhanced modelling:** As above, but with actual hourly demand and RES input data

Which input parameters do different models factor in?

Factors/ Models	Gas/coal price relativity	Power demand	Different plant ramp rates	Real-life demand variability	Real-life RES variability
Simple stack model	✓	✓	✗	✗	✗
Energy-only despatch model	✓	✓	✓	✗	✗
Flexibility-enhanced despatch model	✓	✓	✓	✓	✓

Choice of modelling approach will influence the gas demand forecasts

THANK YOU FOR YOUR ATTENTION

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