Interaction between Natural Gas and Power Systems

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INTRODUCTION

- The future growth of renewable generation capacity [1] increases the complexity of natural gas and power systems management.
- The interaction between natural gas and power systems in presence of large penetration of renewables is quantified through comparing the coupled operation strategy of these systems to a decoupled model of the systems.

OPERATION OF NATURAL GAS AND POWER SYSTEMS

- Hour-by-hour dynamic capturing.
- In decoupled approach, in an iterative process, operation of natural gas system or operation of power system is optimized irrespective to the constraints on the other energy vector.
- In coupled approach, the operation of natural gas and power systems is simultaneously optimized, taking into account whole system constraints.

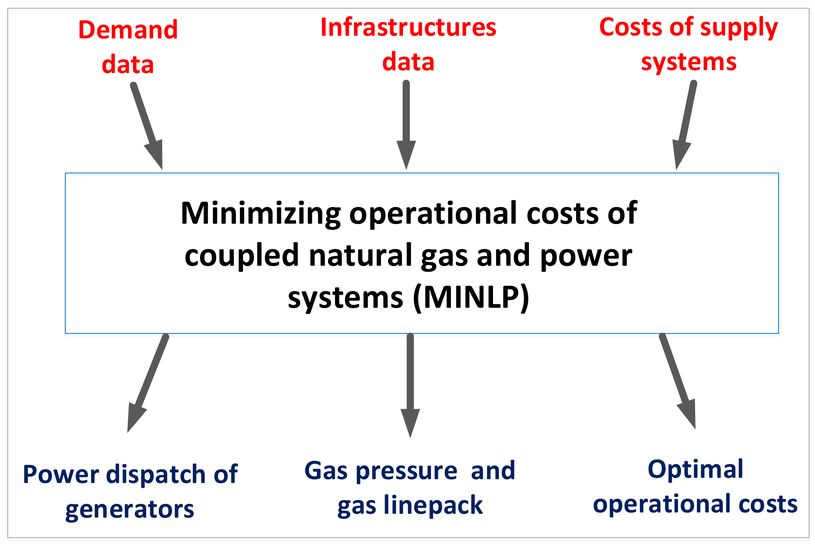

FIGURE 1. Structure of coupled modelling based on [2].

CASE STUDY

- The model is implemented on a Great Britain (GB) natural gas and power systems in 2030.

TABLE 1: Generation capacity mix in 2030 [1] .

Type	Wind	Solar	Gas	Interconnector	Nuclear	Coal with CCS	Pumped Storage	Hydro
Capacity (GW)	47.3	30.5	33.7	20	10.1	4.5	4.8	1.1
Cost (£/MWh)	-	-	2.3*+Gas price	100	7	22	NA	-

* £2.3/MWh is variable operating cost for gas-fired generating plants

- To highlight the importance of coupled operation of natural gas and power systems, a day is considered with an increase in demand during morning hours coinciding with reduction in wind generation.
- In the natural gas system, a contingency is occurred due to interruption in some gas interconnectors.

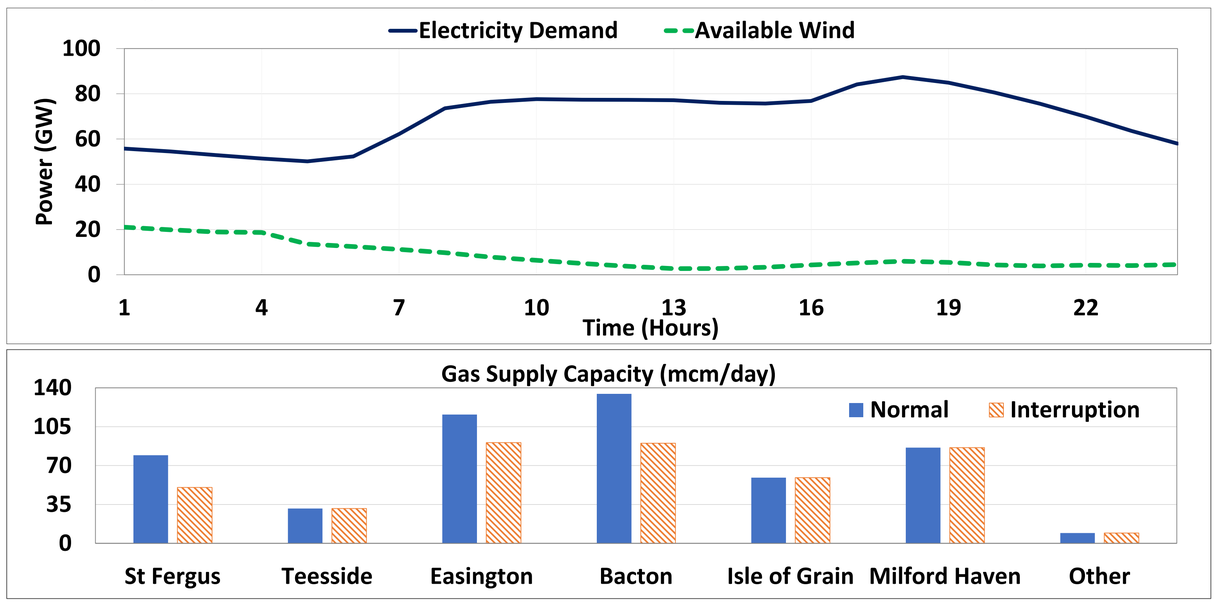

FIGURE 2. Hourly available wind and electricity demand - Gas terminal capacity in day of supply interruption.

RESULTS AND DISCUSSIONS

Hourly analysis

- During morning hours in the decoupled model, gas plant generators are scheduled to produce to meet net demand without consideration of gas supply security constraints.
- Considering the location of majority of gas plants in GB, which are not very close to the gas supply points, gas may not be delivered in time due to limitations in speed in transporting gas through natural gas transmission grid.
- In order to compensate for limited electricity production by gas plants, electricity from coal plants, characterized by high emissions and imports from interconnection (more expensive) is required.

- In the coupled approach, generation scheduling of gas plants is changed to eliminate usage of coal plants throughout the day.

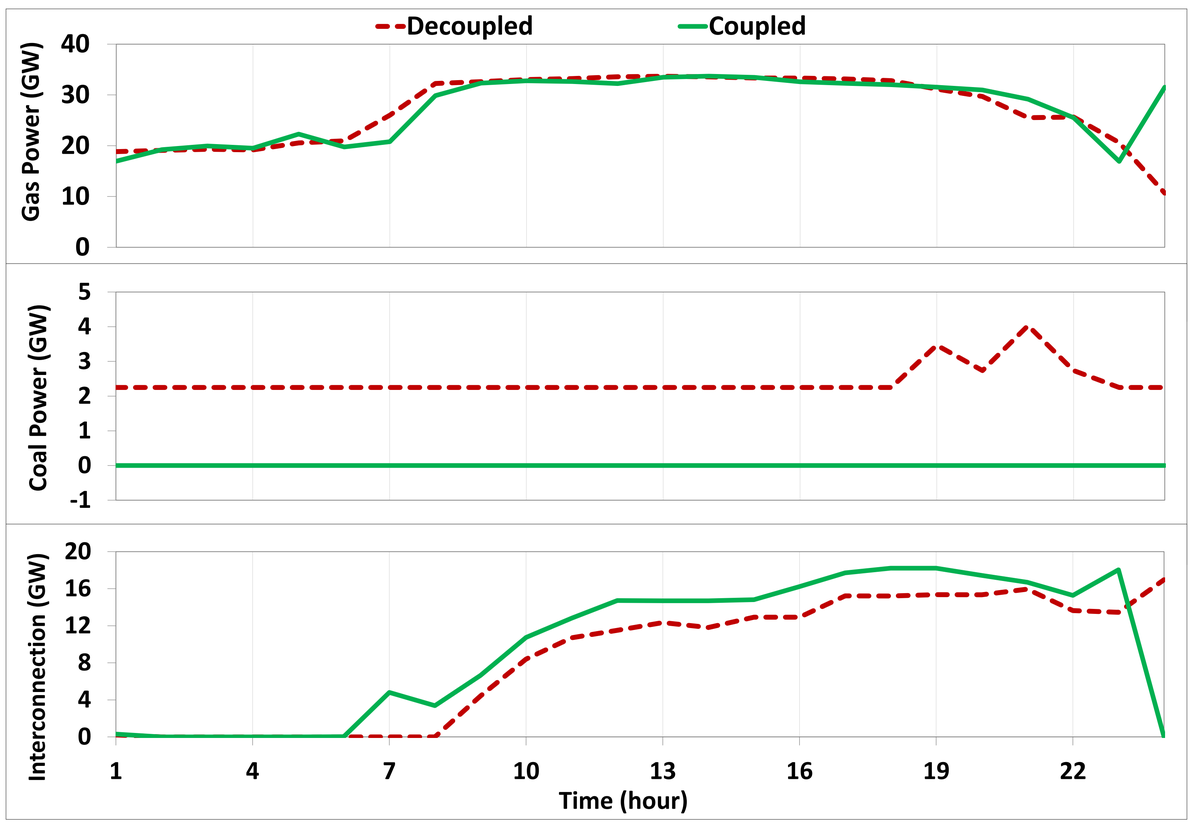

FIGURE 3. Hourly power generation by: gas plants, coal plants, and Interconnections.

- In the decoupled approach, during last hour of the day, due to linepack balance (imposed by the system operator), gas for power generation is reduced.
- The analysis of the amount of the linepack indicates more availability of the within-pipeline storage capability of the natural gas system when the natural gas and power systems are modelled as an integrated energy system.
- This enables the gas system operator to manage rapid changes in the gas demand in short term, and consequently provides more flexibility to support the power system.

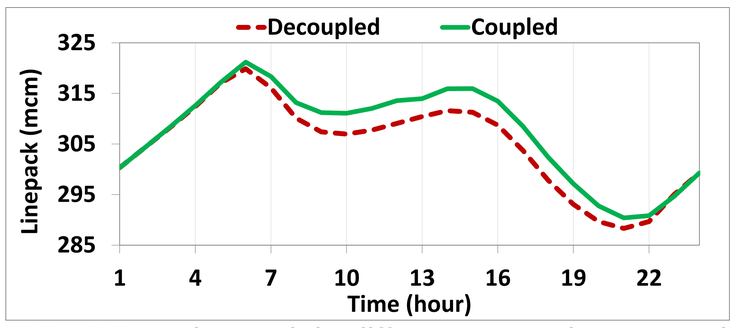

FIGURE 4. Linepack in different operation strategies.

TABLE 2. Total gas load shedding.

Modelling	Gas Load Shedding (mcm)
Decoupled	3.85
Coupled	0.00

- As a contingency is occurred, in the decoupled approach, the gas cannot be delivered to some demand centres → **Gas load shedding**
- In Fig. 5, the larger radius of the circle, the higher the amount of gas load shedding (South of England).

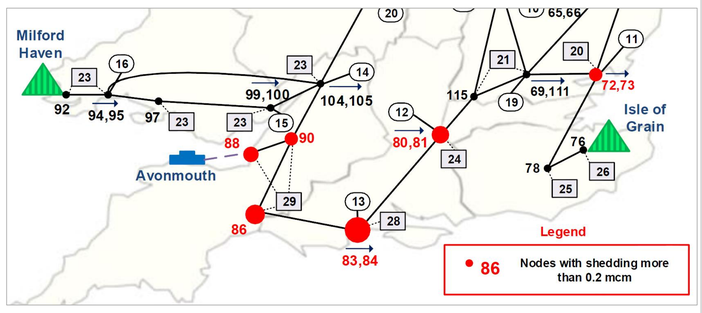

FIGURE 5. Location of gas load shedding.

Annual analysis

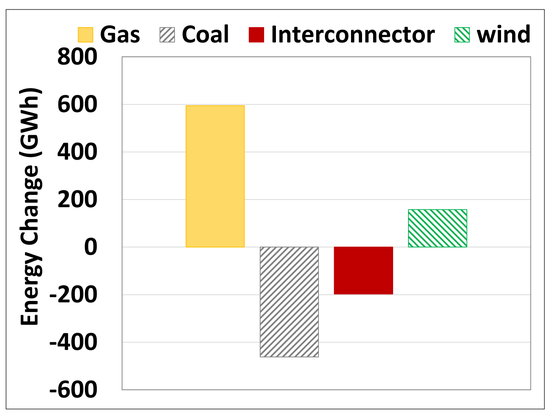

FIGURE 6. Energy change in coupled strategy in respect to decoupled strategy.

- If the operation of natural gas and power systems is modelled coupled, it is possible to deliver more gas to the gas plants. Consequently, the supply through coal and imports from interconnection is reduced.
- This would deliver reduction in annual operating cost of £673m and about 552 ktonnes of CO2.

CONCLUSIONS

A coupled operational modelling of natural gas and power systems:

- Provides better management of linepack (i.e., form of flexibility) to support the power system.
- Enhances the system security and leads to operational cost savings and CO2 emission reductions compared to a decoupled approach.

REFERENCES

1.National Grid, Future energy scenarios, 2016, Online at: http://www2.nationalgrid.com/UK/Industry-information/Future-of-Energy/FES/Documents-archive/

2.H. Ameli, M. Qadrdan, and G. Strbac, “Value of gas network infrastructure flexibility in supporting cost effective operation of power systems,” Applied Energy, 2017, 202, 571-580.

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