Artelys | OPTIMIZATION SOLUTIONS

entsog european network of transmission system operators for gas

entsoe Reliable Sustainable Connected

Focus study on gas and electricity interlinkages

Task 1 – Generic mapping of all interlinkages

October 2018

AGENDA

1. **Context**
2. Task 1 – Objectives
3. Task 1 – Methodology
4. Task 1 – Findings

CONTEXT

Artelys is a software edition and consulting company specialised in decision support, modelling and energy systems optimisation

15+
Years of growth

60+
Members of staff

100%
Independent

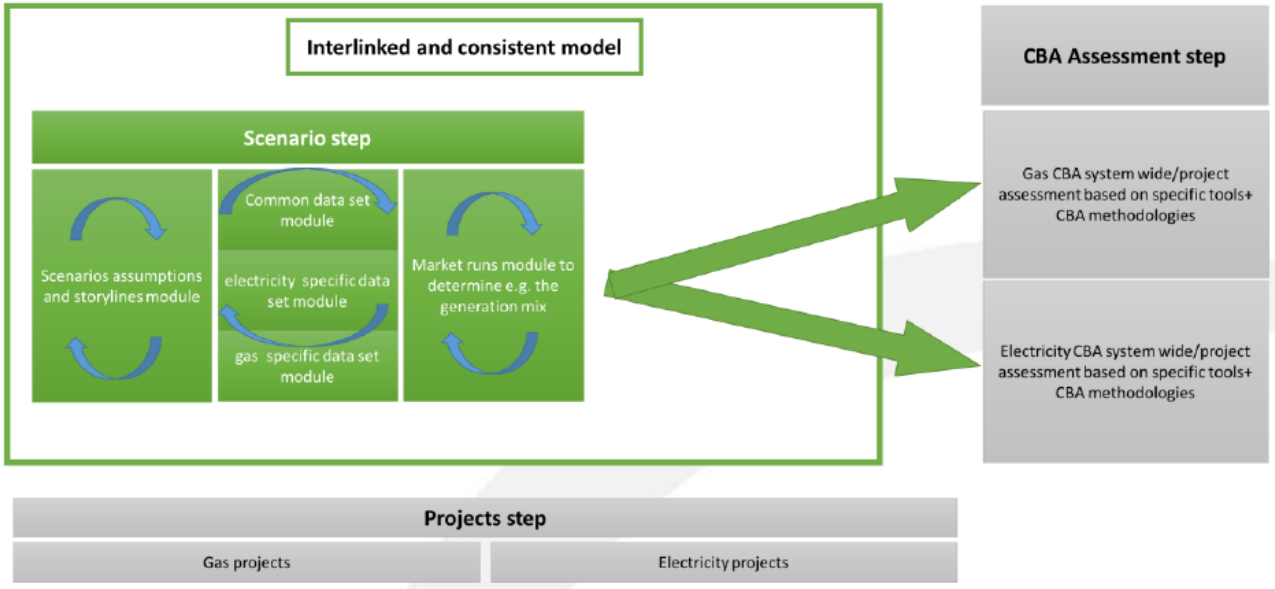
www.artelys.com

200+
Completed assignments

What is this focus study about?

The ENTSOs have been tasked - in Article 11(8) of Regulation (EU) 347/2013 - with the development of a **consistent and interlinked model**, which should be submitted to the Commission and ACER, and, after its approval by the Commission, used in the ENTSOs' methodologies.

The "Interlinked Model" proposal submitted to ACER by the ENTSOs describes the joint scenario development process developed by the ENTSOs.



What is this focus study about?

In its Opinion N°07/2017, while appreciating the consistency of the proposed scenario development process, ACER has expressed the view that further interlinkages should be investigated, notably the impacts on:

- Gas and electricity prices
- Interaction between gas and electricity infrastructure developments
- Cross-sectoral influence (e.g. impact of the localisation of power generation investments on gas infrastructure needs)

In other terms, this particular question raised by ACER can be rephrased as:

Are there situations where the use of a gas-only approach (gas CBA) or an electricity-only approach (electricity CBA) to perform the cost-benefit analysis of an infrastructure project fails to capture the impacts of the interactions between the two sectors (gas and electricity) on the value of the considered project?

The objective of this focus study is to provide qualitative and quantitative elements to the ENTSOs, which will be used by the ENTSOs when updating the Interlinked Model.

What is this focus study about?

- **Task 1** — Generic mapping of all potential interactions between gas and electricity
- **Task 2** — Qualitative analysis of potential interactions between gas and electricity infrastructures
- **Task 3** — Quantification of interaction parameters
- **Task 4** — Recommendations on screening approach to identify projects to be retained for gas/electricity interaction assessment

Objectives and scope of this webinar

The objective of this webinar is :

- To present task 1 methodology and findings
- Get your feedback on the identified interactions between gas and electricity sectors

The report will be updated following your remarks.

The webinar will be divided in two parts :

- Presentation (~45min)
- Exchanges based on your questions

AGENDA

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OBJECTIVES OF TASK 1

Task 1 – Systematic mapping of interactions between gas and electricity systems

The objectives of Task 1 are to present a generic and as exhaustive as possible **mapping of all the potential interactions between the gas and electricity sectors**.

For each of the interactions, the relations to
- The ENTSOs' Scenario Building exercise,
- The gas and electricity prices,
- Gas and/or electricity infrastructure projects

are to be qualitatively assessed.

These relations are looked at from the following perspectives :
1. Sustainability: electricity and gas RES integration
2. Competitive energy: complementarity and optimising infrastructure needs
3. Security of energy supply: complementarity in ensuring or reinforcing security of energy supply

This mapping is to be based on internal expertise, literature review and stakeholder engagement.

AGENDA

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Task 1 – Systematic mapping of interactions between gas and electricity systems

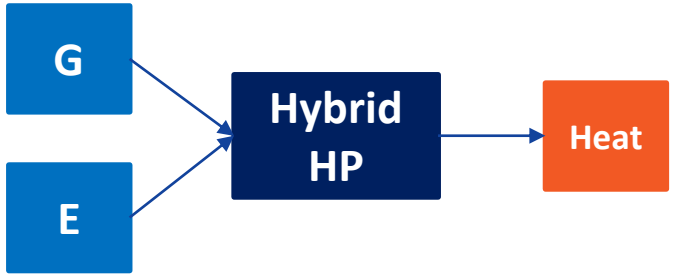
We have determined that in order to produce a **mapping of all the potential interactions between the gas and electricity sectors**, a bottom-up approach was the best-suited.

In a bottom-up approach, the objective translates into the identification of all possible direct and indirect interactions between the electricity and gas sectors. These interactions can be seen as building blocks: a storyline/scenario involves a combination of building blocks.

Direct interactions

The direct interactions between the gas and electricity systems are technologies that directly involve both energy carriers.

Examples:

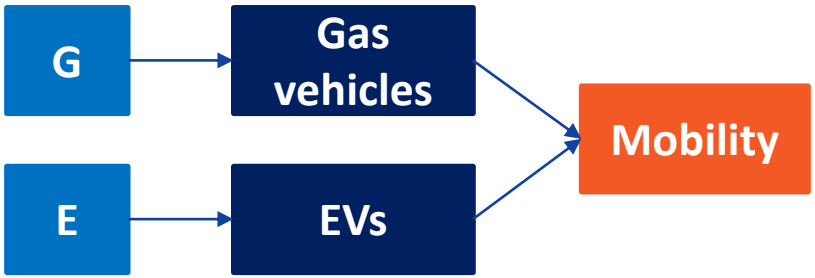


Task 1 – Systematic mapping of interactions between gas and electricity systems

Indirect interactions

The indirect interactions between the gas and electricity systems are linkages that involve both energy carriers *via* a third sector.

Example:



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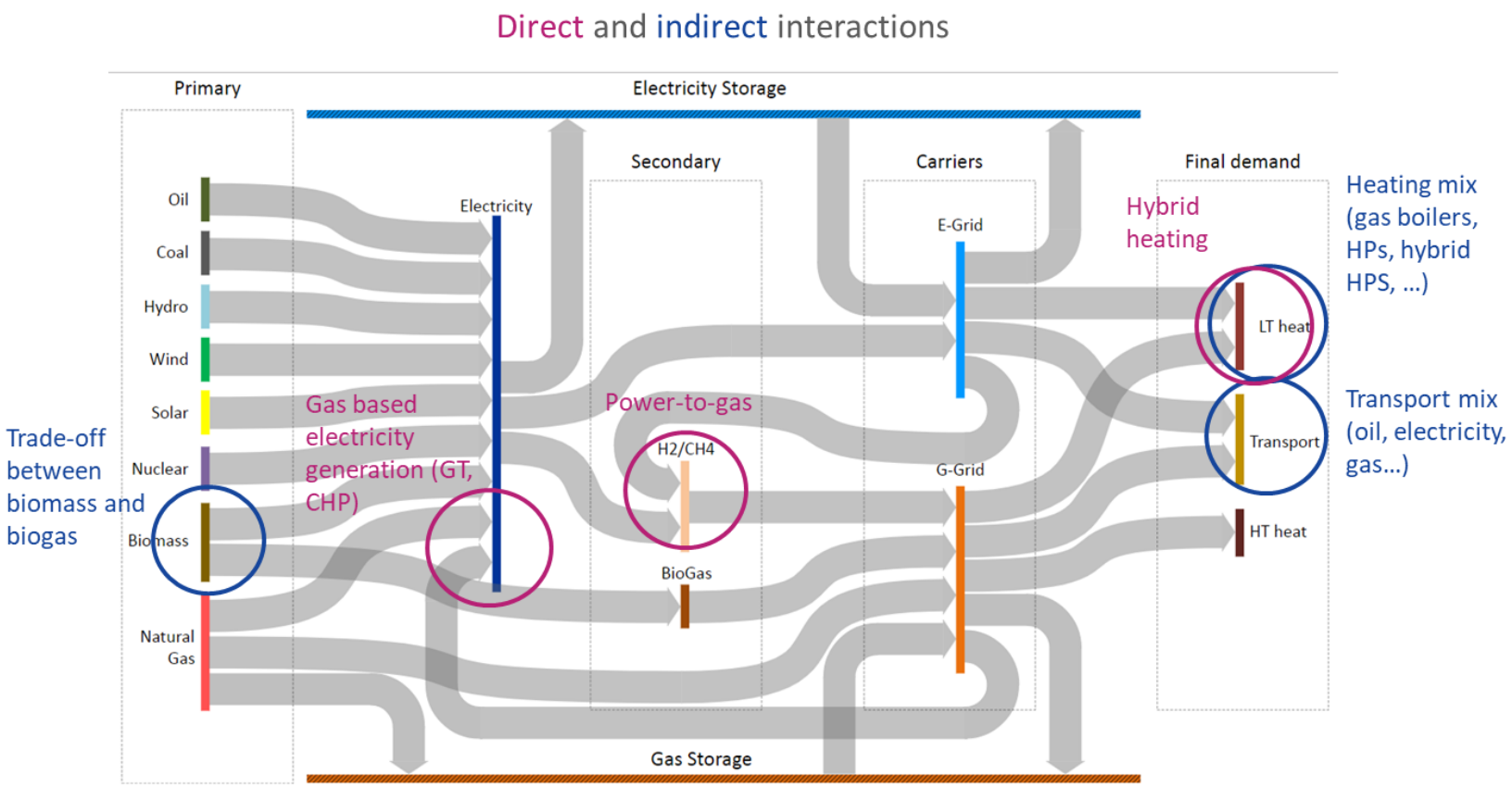
Task 1 – Systematic mapping of interactions between gas and electricity systems



Task 1 – Systematic mapping of interactions between gas and electricity systems

Direct interactions

1. ***Conversion***
   a. Gas-to-power
      i. Open Cycle and Combined Cycle gas turbines
      ii. Gas combined heat and power
   b. Power-to-gas
      i. Power-to-hydrogen for direct use
      ii. H2/CH4 injection into gas grid
2. ***Assistance***
   a. Electricity-driven gas compressors
   b. Hybrid heating technologies
      i. Hybrid gas/electric generation of industrial heat
      ii. Hybrid heating (residential, tertiary, district heating)
   c. Hybrid transport (if any)

Indirect interactions

3. ***Competition***
   a. Mobility: electric mobility vs gas mobility
   b. Heating: gas heating vs electric heating
   c. Biogas: Direct electric use vs upgrade to biomethane

Task 1 – Direct interactions

OCGTs and CCGTs

As gas-based electric generation technologies, they are typical direct interactions that affect day to day management of gas and electricity systems. In 2016, there were 233 GW of gas-based generation capacity in the ENTSO-E area.

Relation with ENTSO's scenario building exercise	CCGTs and OCGT capacities (and techno-economic characteristics) are part of the assumptions made in the Scenario Building Exercise.
Impact on electricity prices	As semi-base or peak fleets, they are today used mostly in winter and affect prices mostly during this period. Depending on the evolution of the energy system (RES deployment, commodity prices, coal phase-out), their generation can have an even higher impact on electricity prices.
Impact on gas prices	As a gas consumption, they can have an impact on gas price, especially in scenarios with low gas demand for heating.
Impact on infrastructure	They affect both gas and electric infrastructures : they can replace power generation or interconnections and they require gas infrastructure for their gas supply

Task 1 – Direct interactions

Gas combined heat and power (CHPs)

CHP use gas to generate electricity and heat. They are used for district heating, in the industry, in the domestic or tertiary (micro-CHP). Today they represent 120GWe.

Relation with ENTSO's scenario building exercise	CHP capacities and generation are part of the assumptions made in the Scenario Building Exercise.
Impact on electricity prices	CHPs operational planning is often driven by the heat demand, which is usually during winter but can be all year long (e.g. for the industry). Their generation thus affect the price during these periods, especially if CHP capacity is high.
Impact on gas prices	As a gas consumption, they can have an impact on gas price, especially in scenarios with low gas demand for heating.
Impact on infrastructure	Similarly to OCGT and CCGT, they have an impact on both gas and electric infrastructures.

Task 1 – Direct interactions

Hydrogen production for direct use (Power-to-H2)

Hydrogen production for direct use (industry or mobility) has a direct impact on electricity and gas. This is especially true since hydrogen is usually produced with SMR (which consumes methane).

Relation with ENTSO's scenario building exercise	Power-to-H2 should be a part of the assumptions for the Scenario Building Exercise.
Impact on electricity prices	Depending on the role of power-to-hydrogen in the scenario, P2H2 capacities may be of different sizes which will affect or not prices. The operational management of P2H2 is also important : if P2H2 is only activated when there are variable e-RES surpluses, in poorly connected areas, the impact on electricity price will be important at these hours but marginal at others.
Impact on gas prices	As a gas production, they reduce the needs for gas and could have an impact on gas price in scenarios with high P2H2 deployment.
Impact on infrastructure	P2H2 could decrease the needs for gas imports and reduce electricity exports.

Task 1 – Direct interactions

Hydrogen or methane production for the injection in the network

This is the production of synthetic gas by electrolysis of water and methanation. This process can be renewable if the electricity consumed comes from RES. In this case methanation is also CO2 neutral since it consumes the same CO_2 quantity that is released upon combustion.

A lot of demonstrators are ongoing (CO2-SNG, STORE&GO, Méthycentre, HELMETH)

Relation with ENTSO's scenario building exercise	Power-to-gas capacities are part of the assumptions for the Scenario Building Exercise. Consistency between thes capacities and electricity demand, power generation installed capacities, gas supply, etc. have to be consistent.
Impact on electricity prices	Similarly to P2H2, the production of synthetic gas can affect electricity prices
Impact on gas prices	As a gas production, they reduce the needs for gas imports and could have an impact on gas price in scenarios with high P2G deployment.
Impact on infrastructure	The deployment of P2G will decrease the needs for gas imports and reduce electricity exports which will thus affect the assessment of new and existing infrastructures.

Task 1 – Direct interactions

Electricity-driven gas compressors

Electricity compressors are used when operating gas infrastructures such as storages or pipelines.

Relation with ENTSO's scenario building exercise	Their consumption has to be accounted in the electric demand, but will remain limited
Impact on electricity prices	They have a low structural impact on electricity prices, except during peak electricity demand periods, when the gas demand is high (for power generation and heat).
Impact on infrastructure	The presence of electricity-driven gas compressor in a system is unlikely to have a significant impact on the assessment of an infrastructure project except for security of supply. Indeed, a blackout can make gas facilities that are relying on electric compressors inoperable, which could trigger gas and power curtailments.

Task 1 – Direct interactions

Hybrid heating equipment for domestic or district heating use

Hybrid heating technologies such as hybrid heat pumps can switch from electricity to gas consumption in situations of low temperature and high power consumption.

Relation with ENTSO's scenario building exercise	Heat pumps and hybrid heat pumps numbers are part of the Scenario Building Exercise. The overall heat supply mix has to be consistent in itself and with the evolution of the system: power generation capacities, electricity and gas demand, etc.
Impact on electricity prices	Hybrid heat pumps can significantly impact power prices during very low temperature episodes by shaving electricity consumption peaks, compared to a situation where heating is only relying on heat-pumps.
Impact on gas prices	When temperature driven, additional infrastructure do not change their management. If price-driven and in high capacity, the switch between carriers could lead to changes in prices.
Impact on infrastructure	Hybrid HPs may impact the need for network reinforcements and may impact the assessment of infrastructure projects.

Task 1 – Direct interactions

Hybrid generation of industrial heat

Hybrid technologies for HT heat generation could develop in the future for industry which is an important consumer of heat.

Relation with ENTSO's scenario building exercise	Hybrid heating in the industry could be a useful addition to hybrid heating in domestic/tertiairy if hybrid HT heat generation becomes a reliable option.
Impact on gas and electricity prices	The presence of hybrid equipment can significantly impact gas and electricity prices by dynamically adapting to electricity and gas prices, although the inertia of the various hybrid solutions may reduce the ability to react to price signals.
Impact on infrastructure	Unless hybrid technologies in industry develop considerably, their impact on infrastructure will remain very limited.

Task 1 – Indirect interactions

Mobility

Electricity and gas-powered vehicles (hydrogen, liquefied or compressed methane) will see their share increase in the coming years and progressively replace vehicles using high-carbon fuels.
In 2016, there were around 200k electric vehicles and 1300k gas vehicles in Europe.

Relation with ENTSO's scenario building exercise	The deployment of electric and gas vehicles is a choice that has to be made in the scenario development phase, and has to be consistent with infrastructure in electricity generation, gas supply, etc.
Impact on gas and electricity prices	A different portfolio of vehicles will have a very important impact on both prices. The impact of electric vehicles is however complex to apprehend as it also gives flexibility to the electric system.
Impact on infrastructure	The assessment of a given infrastructure project will be impacted by the assumptions related to mobility. However, as noted above, the choice of mobility solutions made at the Scenario Building stage should be coherent with other assumptions, and in particular with the gas and electricity infrastructure

Task 1 – Indirect interactions

Biogas

Biogas can be used either directly for electricity generation or upgraded to bio-methane for injection into the gas network.

Relation with ENTSO's scenario building exercise	Assumptions related to the way biogas is being used (share being injected into the gas network and share being dedicated to electricity production) should be part of the assumptions that are made during the Scenario Building Exercise
Impact on gas and electricity prices	Choosing a portfolio of biogas applications rather than another one will have a very important impact on gas and electricity prices.
Impact on infrastructure	The assessment of a given infrastructure project can be considerably impacted by the assumptions related to biogas. Indeed, biogas direct use in electricity can decrease the needs for power generation and reduce imports. The injection of biomethane in the network will also reduce gas imports.

Task 1 – Indirect interactions

Heating

A wide range of technologies can supply heat, some are using electricity, others are using gas, and then some can use either gas or electricity.

Relation with ENTSO's scenario building exercise	The deployment of electric and gas heating technologies is a choice that has to be made during the scenario development phase, in a consistent way with the gas and power infrastructure.
Impact on gas and electricity prices	A different portfolio for heating will have a very important impact on both prices. A high share of electric heating will also increase the seasonality of electric prices.
Impact on infrastructure	The assessment of a given infrastructure project can be considerably impacted by the assumptions related to heating.

Thank you for your attention!

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