Artelys | OPTIMIZATION SOLUTIONS

FOCUS STUDY ON GAS AND ELECTRICITY INTERLINKAGES

WEBINAR 3 ON TASKS 2, 3 AND 4

avr.-19

AGENDA

1. Recap on T1, T2 & T3
2. Interactions on hybrid consumption technologies
3. Summary of the findings and screening recommendations

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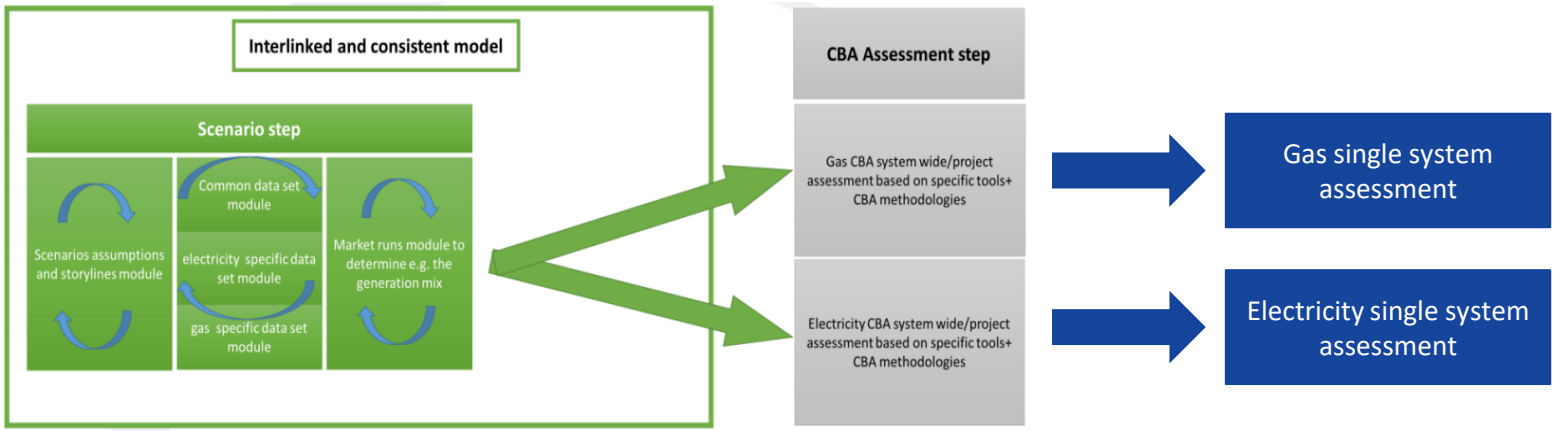
The overall objectives is to provide recommendations on a screening methodology to assess which projects should be subjected to a more thorough investigation of the gas-electricity interlinkages.



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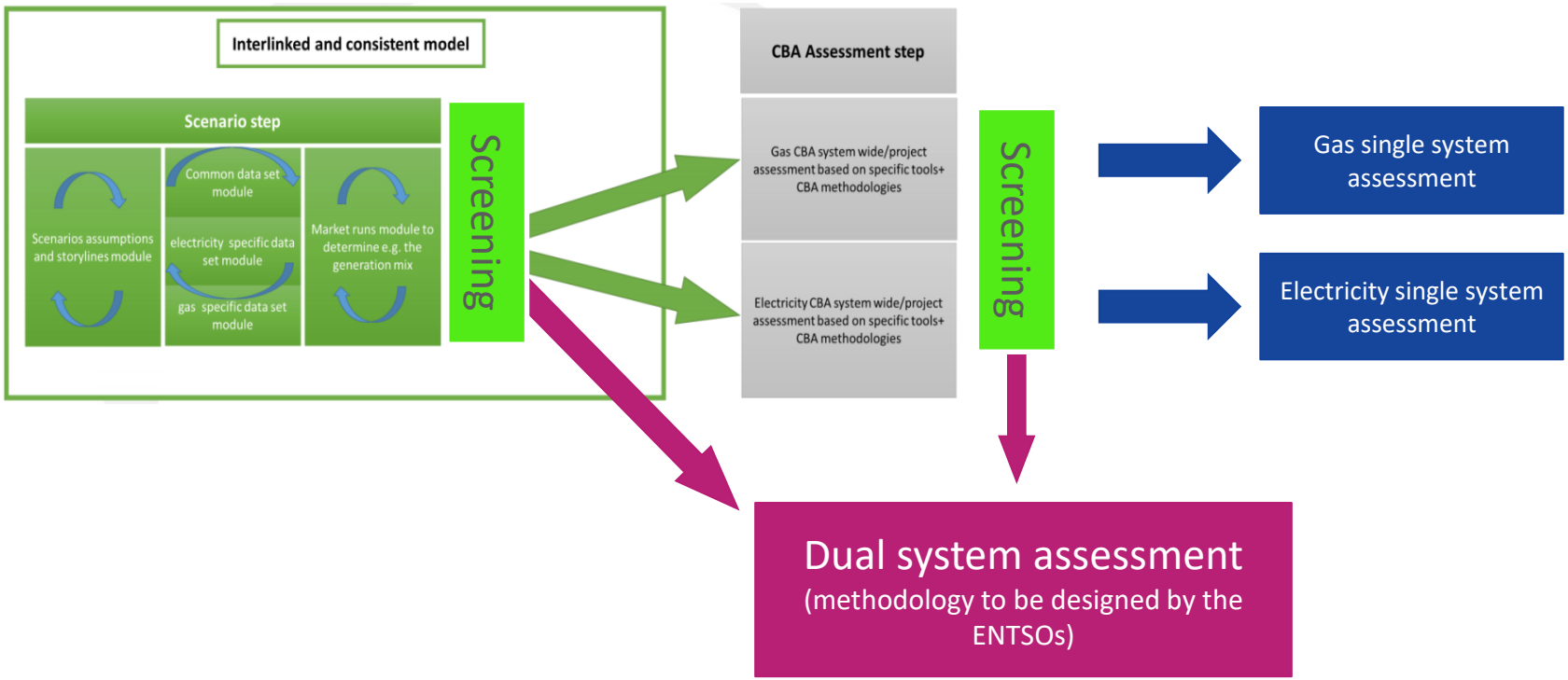

How is the focus study structured?

Task 1
- Generic mapping of all potential interactions between gas and electricity

Task 2
- Qualitative analysis of potential interactions between gas and electricity infrastructures projects

Task 3
- Quantification of interaction parameters

Task 4
- Recommendations on screening approach to identify projects to be retained for gas/electricity interaction assessment

Webinar 1

Webinar 2

Webinar 3

SUMMARY OF THE PREVIOUS WEBINARS

Main findings of the first two webinars

- In webinar 1, we identified and described 3 main sources of interlinkages between gas and electricity systems
  - Power-to-gas (P2G), Gas-to-power (G2P) and hybrid consumption technologies

- In webinar 2, we found that :
  - In the presence of G2P, there can be some interactions between gas/electricity system and infrastructure projects, in areas with a high G2P share if the gas consumption required for electricity purposes creates constraints on the gas system (congestions or security of supply issues)

  - In the presence of P2G, there can be some interactions between gas/electricity system and infrastructure projects, in areas with high price-driven P2G capacities and with a high share of low variable cost electricity generation (vRESe, nuclear), relatively to the consumption (including pumping)

OBJECTIVES OF TODAY'S WEBINAR

Objectives and scope of this webinar

The objectives of this webinar are:

- To present findings of Task 2 and Task 3 on hybrid consumption,
- To present Task4 (recommendations for the screening methodology)
- Obtain your feedback.

Your comments are very valuable, will be taken into account in the report.

The webinar will be divided in two parts:

- Presentation (circa 45 minutes)
- Exchanges based on your questions (first round of question, 10 minute pause, answers from ENTSOs and consultant)

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Hybrid consumption technologies

Hybrid consumption technologies refers to energy consumption means that can be satisfied by gas or electricity depending on their hourly prices.

In this section we have focused on hybrid heat pumps (HHP), which are currently one of the most developed hybrid consumption technologies and whose volume is planned to increase in the next years.

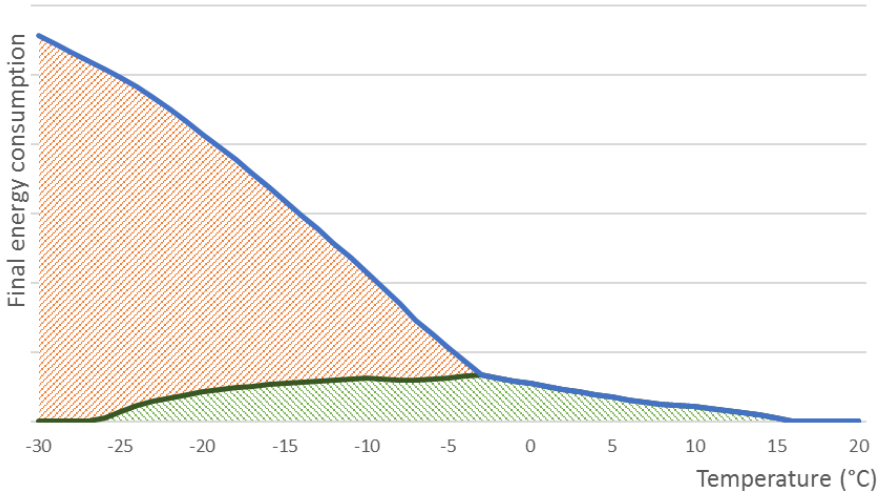
The findings on the interactions in the presence of HHP are then derived to all types of hybrid consumption we might encounter in the future.

Hybrid heat pumps operation

Hybrid heat pumps systems are used to produce heat and composed of an electrical heat pump component and a gas boiler functioning as back-up.

Due to its costs, the heat pump component is usually dimensioned to cover only a fraction of the heat demand (typically 60% of the annual demand). It usually functions in priority given its low variable costs, while the gas back-up functions either when the heat pump alone is not sufficient to cover the heat needs or when the electricity price is high in the case of a price-driven heat-pump.

At very low temperatures, heat pump efficiency and capacity decrease.
The gas back-up covers most of the heat demand



At higher temperatures, the electric heat pump covers most or all of the heat consumption

Figure 6 – Operation of a temperature-driven hybrid heatpump. Back-up (red) and heat-pump (green) consumption. Source: Artelys

Hybrid heat pumps can create interactions between gas and electricity systems

If the hybrid heat pump is "temperature-driven", the electric heat pump always functions in priority. In this case, the interlinkage between gas and electricity systems is low as both consumptions can be considered independently from each other and are independent from the infrastructure.

If the hybrid heat pump is "price-driven", the gas back-up is activated in replacement of the heat pump as soon as the heat generation cost of the boiler is lower than the heat generation cost of the heat pump, i.e. when :

$$\frac{GasPrice}{boilerEfficiency} \leq \frac{electricityPrice}{heatpumpCoefficientOfPerformance}$$

This can happen at peak hours, when the electricity price is very high.*

In this case, switching to the gas back-up to avoid the additional electric consumption of the heat pump can be beneficial to the electricity system, by reducing the stress at peak electricity hours and thus reducing the needs for additional capacity (typically OCGT or interconnections). This however requires having enough gas to switch.

* With typical efficiencies of 90%, 300% and 40% for respectively, the gas boiler, the heatpump and a gas turbine, it is usually less costly to produce electricity with the gas turbine to use it in the heat pump, rather than use the boiler directly (excluding investment costs). The back-up is used preferably when the HP is at full capacity, or when the price is high or when the efficiency of the HP decreases (at very low temperatures)

HHP – What is the effect of new electricity interconnectors in an area with a large share of HHP?

- If the HHP is temperature driven, the power consumption cannot be dynamically adapted to the system. The consumption of the HHP has the same impact than any other gas and electricity consumption. A single assessment is enough to take into account the HHP in this case.

- If the HHP is price driven
  - When there are no constraints on the electric system and the electricity price remain low, the HP component can be used to its maximal capacity. Adding electricity interconnections will not affect the electricity consumption nor the gas consumption at these hours
  - At peak hours, if the electric supply is limited and the prices of electricity are high, the HHP is used in “full gas” mode (the HP component is too expensive due to electricity prices). In this case, an electric interconnector can enable the use of the electrical HP component by reducing the electricity prices in the area.
  - In areas where there are frequently high prices, the study of an electricity interconnector require a dual system assessment

HHP – What is the effect of new gas interconnectors in an area with a large share of HHP?

- If the HHP is temperature driven, the gas consumption cannot be dynamically adapted to the system. The consumption of the HHP has the same impact than any other gas consumption. A single assessment is enough to take into account the HHP in this case.

- If the HHP is price-driven,
  - In areas where high electricity prices are rare, the overall gas consumption of a price driven HHP will be similar to the one of temperature-driven HHP, and will not require a dual system assessment when assessing the interest of a gas interconnector
  - In areas where high prices are frequent, depending on the dimensioning of the HP component and of the gas back-up in the HHP, the volume of consumption transferred from electricity to gas could be important and create constraints on the gas system. In this case, there can be some interactions requiring a dual system assessment when assessing the interest of a gas interconnector

HHP – What are the meaningful parameters of the interactions?

- Given the previous slides, there can be, in some limited cases, interactions between the operations of HHP and the electricity system.
- The meaningful parameters that affect the presence and strength of this interaction are the share of price-driven HHP in heat generation compared to the overall gas demand
  - If HHP are temperature-driven, HHP consumption can be considered as any other consumption → no interaction
  - If the share of price-driven HHP is important, the flexibility (dynamic switch from power to gas) could bring some value to the electric system
- The value of the flexibility of HHP only exists if there are constraints on the electricity system
  - If there are no significant constraints on the electricity system and the prices of electricity remain low, electricity consumption will be preferred in the HHP, and there will not be a switch to a gas consumption.
  - The constraints depend of the overall mix (production, consumption and transmission)

What about other hybrid consumption technologies?

- There are interactions when the hybrid consumption is dynamically operated, i.e. price-driven

- The meaningful parameters in the interaction are
  - The share of these price-driven hybrid consumption technologies
  - The volume of energy that can be switched between gas and electricity
  - The presence of constraints on electricity and gas systems that prevents the dynamic switching to be done

- To sum up, if the volumes transferred from gas to power or from power to gas can create either security of supply issues in both areas or a significant change in prices in electricity or gas systems, then there is an interaction requiring a dual system assessment

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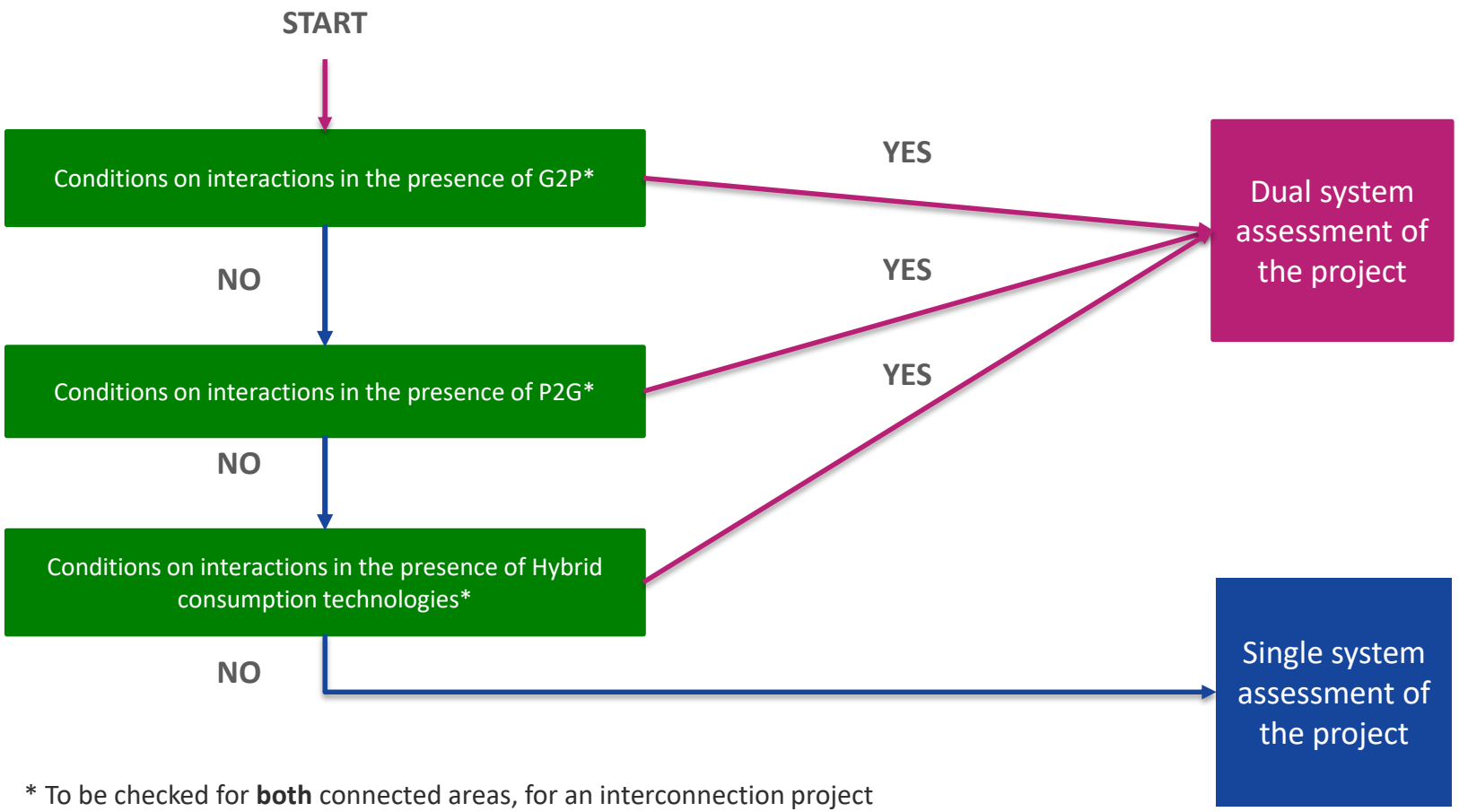
TASK 4 – SCREENING METHODOLOGY RECOMMENDATIONS

Building on T2 and T3, the screening methodology of a given project in a given scenario could be structured as follows:



* To be checked for **both** connected areas, for an interconnection project

Conditions on interactions in the presence of G2P

For electricity or gas assets

IF G2P yearly consumption >= 5% of gas yearly consumption — **Size of G2P in the gas system**

AND G2P creates gas SoS issues or congestions — **Presence of gas constraints**

AND Presence of electricity capacity margins — **Electricity system flexibility**

THEN Dual system assessment of the project

G2P yearly consumption >= 5% of gas yearly consumption

An interaction is more likely to appear if the G2P share is significant in the gas consumption.

The threshold on this condition has been qualitatively assessed but could be reviewed after the use of the screening methodology on real projects.

Presence of electricity capacity margins

If the flexibility of the electricity system can avoid to use G2P (possibly at a higher cost) there is an interaction between gas and electricity systems that requires a dual system assessment for a new asset.

One possibility to assess this flexibility could be to use simulation results of the TYNDP scenario building step and the indicators provided in this exercise. For instance, if LOLE is already high when using G2P, it means there is no available flexibility.

G2P creates gas security of supply issues or congestions leading to gas prices differences

An interaction occurs between gas and electricity only if there are constraints on the gas system (SOS or price difference beyond the tariffs) due to the additional gas consumption.

These constraints can come from :

- A lack of import or production capacities to cover the yearly demand creating either SoS issues or price differences

OR

- A lack of storage capacities (withdrawal and volume) to cover the seasonality of the consumption

These issues could be checked for instance in the simulations results of the TYNDP scenario building steps (i.e. before a single system assesment)

Conditions on interactions in the presence of P2G

For electricity assets

IF MarketDriven P2G capacity >= 5% of (Nuclear + vRESe) capacity **AND** $\frac{\text{vRESe yearly Generation} + \text{Nuclear yearly Generation}}{\text{Electricity yearly consumption (incl. pumping)}} \geq 60\%$ **THEN** Dual system assessment of the project

Size of P2G in the gas system

Structure of the generation mix

MarketDriven P2G capacity >= 5% of (Nuclear + vRESe) capacity

An interaction is more likely to appear if the P2G share is significant compared to the capacities of low-variable costs electricity generation.

The threshold is based on quantitative analyses using Crystal SuperGrid modeling. The case simulated cover a wide range of possibilities but are not exhaustive so the threshold could be reviewed after the use of the screening methodology on real projects.

Share of vRESe and Nuclear in the electricity demand (incl. pumping)

An interaction occurs when the share of low variable costs generation (vRES-e or Nuclear) is significant in comparison with the consumption, taking into account the consumption of storages.

This condition could be assessed using the results of energy mix of the TYNDP scenarios building step.

For gas assets

IF The 2 previous conditions **AND** P2GGasProduction ≥ yearlyGasDemand + StorableVolume + ExportableVolume **THEN** Dual system assessment of the project

Surplus of P2G gas production in comparison to the demand and the exportable or storable volume of gas

Even with the 2 previous conditions, P2G has an effect on the assessment of gas interconnections only if there is a very significant volume of P2G generation, requiring additional exports capacities.

Conditions on interactions in the presence of hybrid consumption technologies

For electricity or gas assets

IF Gas (or electricity) consumption of price-driven hybrid technologies >= 5% of yearly gas (or electricity) consumption

Deployment of price-driven hybrid consumption technologies

AND Electricity SoS issues when the hybrid technologies function as electricity consumers

OR

Gas SoS issues or congestions when the hybrid technologies function as gas consumers

Constraints on gas and/or electricity systems

THEN Dual system assessment of the project

Gas (or electricity) consumption of price-driven hybrid technologies >= 5% of yearly gas (or electricity) consumption

An interaction is more likely to appear if the share of price-driven hybrid consumption technologies is significant in the total consumption.

The threshold is based on qualitative analyses but might need to be reviewed after the use of the screening methodology on real projects.

Constraints on gas and/or electricity systems

There is an interaction only when the volume that can be transferred from electricity to gas (or from gas to electricity) creates gas (or electricity) constraints.

For the electricity side, this can be assessed for instance by looking at LOLE when in “full electricity” mode.

For the gas side, this can be assessed by comparing import/LNG/production yearly capacities (in TWh) to the total consumption taking into account the gas consumption of hybrid assets when operating in “full gas” mode.

Thank you for your attention!

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