Artelys | OPTIMIZATION SOLUTIONS

Focus study on gas and electricity interlinkages

TASKS 2&3 – QUALITATIVE AND QUANTITATIVE ANALYSIS OF THE INTERACTIONS BETWEEN ELECTRICITY AND GAS INFRASTRUCTURES - **PRELIMINARY RESULTS**

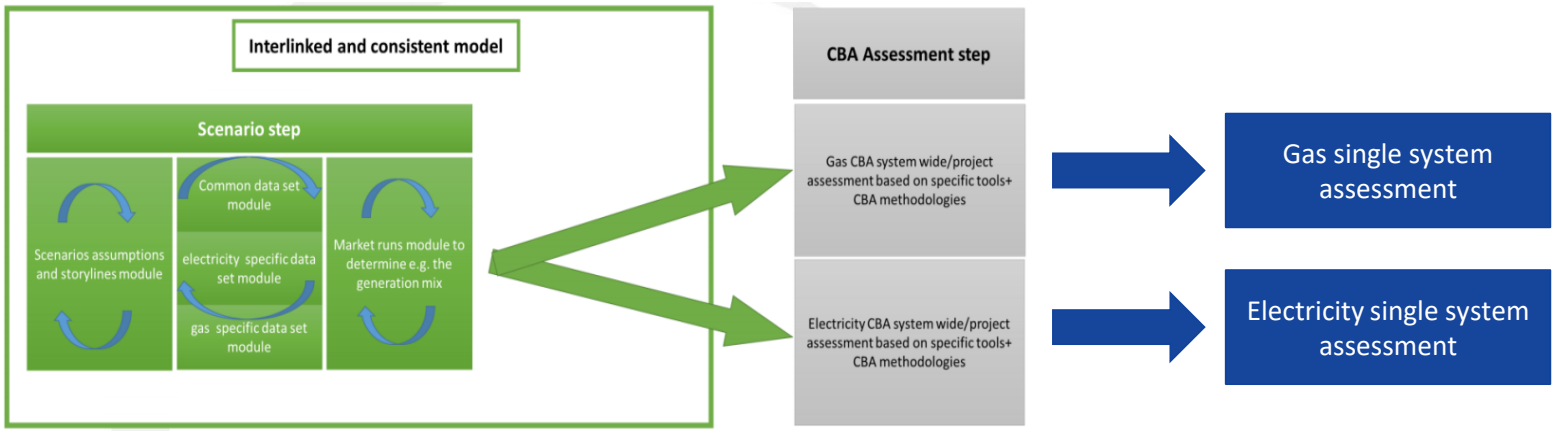
janv.-19

AGENDA

1. **Context: General objectives, what has already been delivered**
2. Tasks 2 & 3 – Objectives & Methodology
3. Tasks 2 & 3 – Interactions in the presence of G2P (preliminary results)
4. Tasks 2 & 3 – Interactions in the presence of P2G (preliminary results)

What is this focus study about?

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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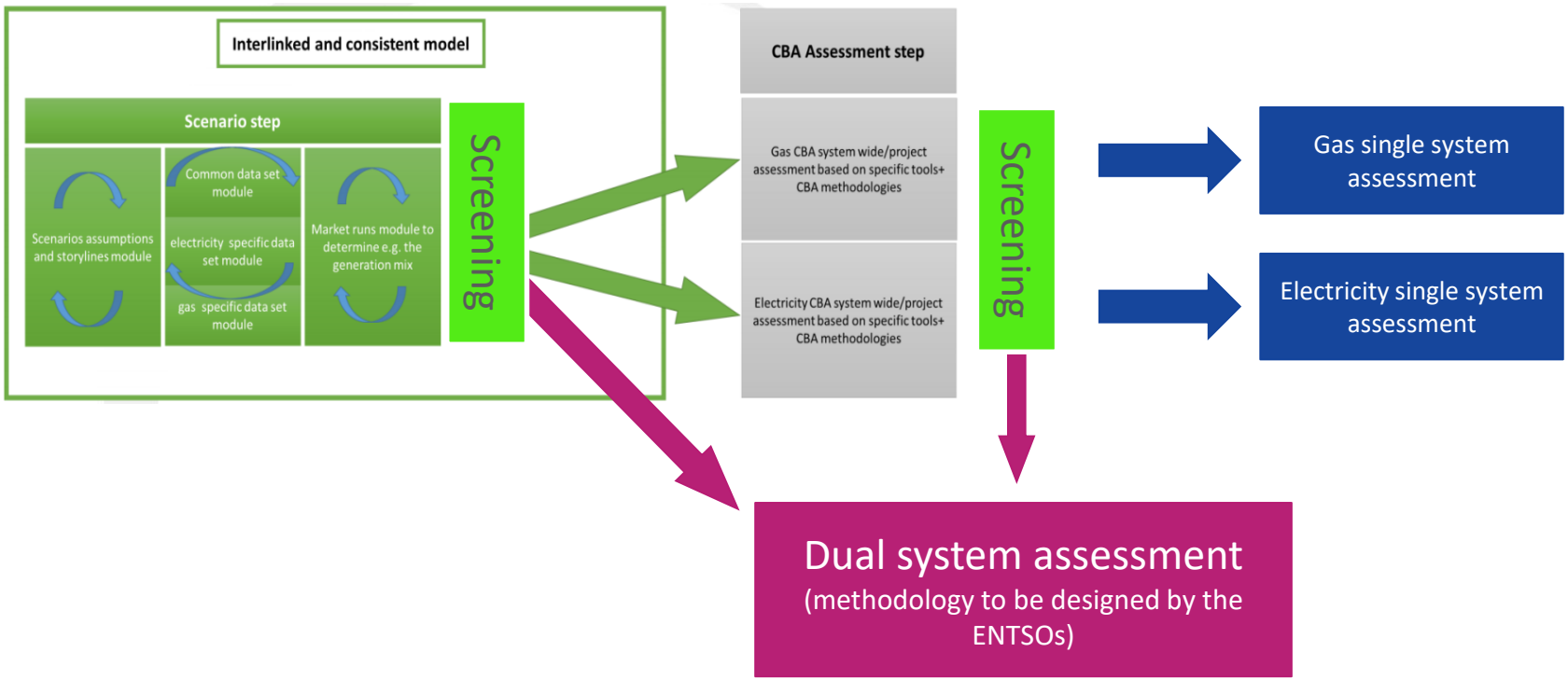
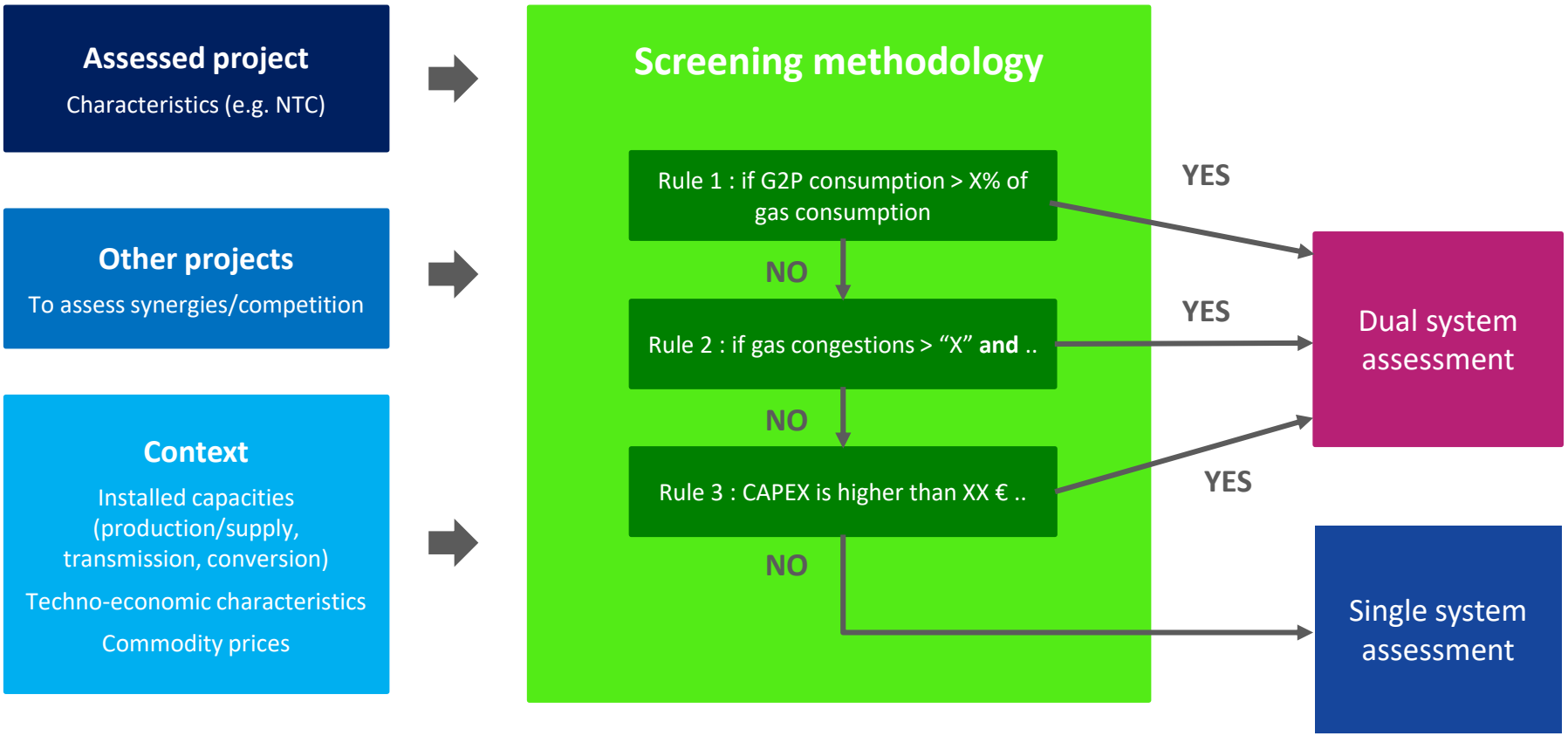


What is this focus study about?

The screening methodology could have the following structure.



How is the focus study structured?

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

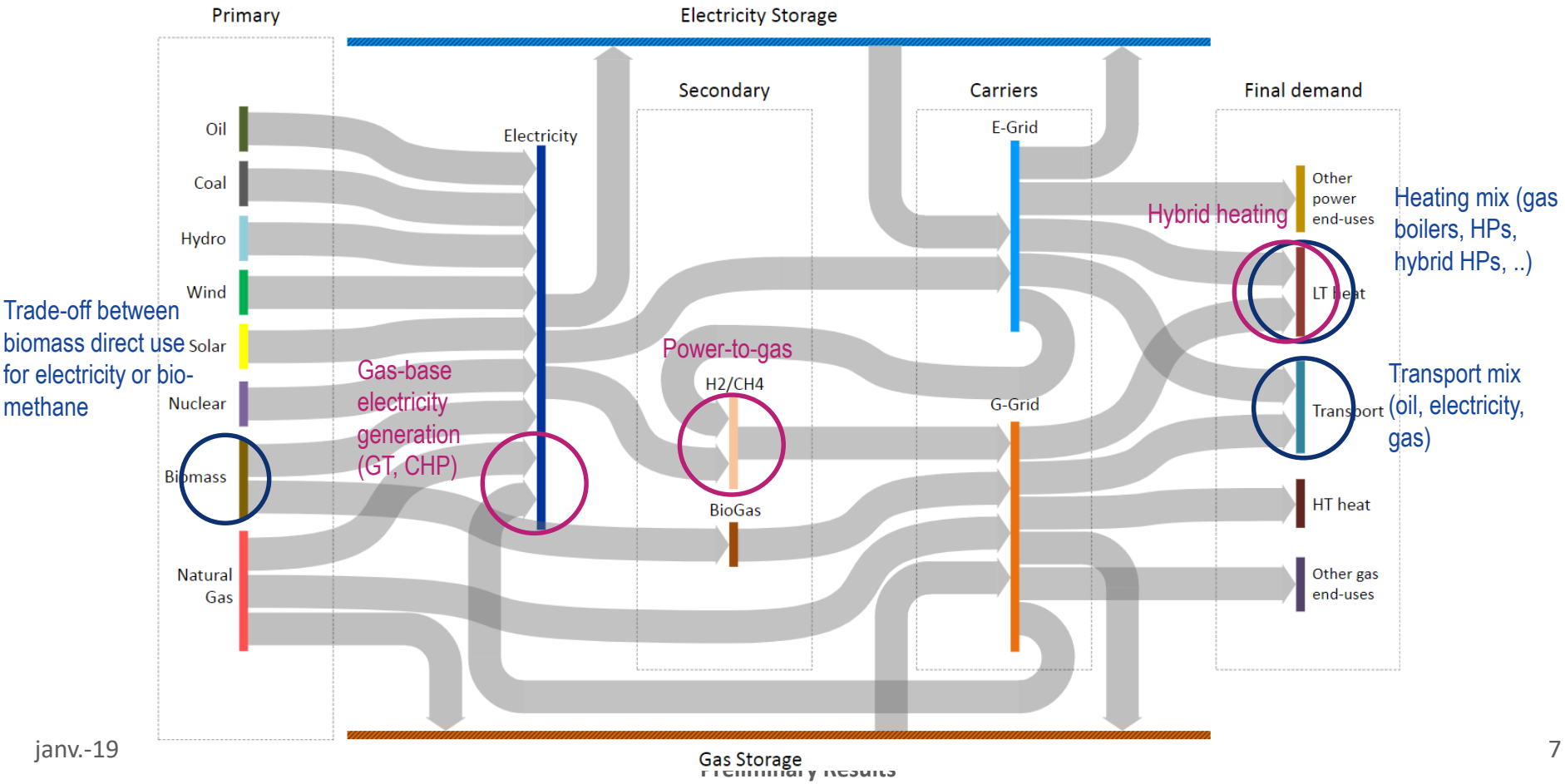
Task 2
- Qualitative analysis of potential interactions between gas and electricity infrastructures projects

Task 3
- Quantification of interaction parameters

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

Task 1 – Identification of interlinkages

Three main categories of direct interlinkages identified P2G, G2P, hybrid technologies (e.g. HPs).



OBJECTIVES OF TODAY'S WEBINAR

Objectives and scope of this webinar

The objectives of this webinar are:

- To present Task 2 and Task 3, and preliminary results (impact of the presence of G2P or P2G on interaction between gas and electricity infrastructures projects)
- Obtain your feedback on the preliminary results.

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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T2&3 - OBJECTIVES

Tasks 2 & 3 – Qualitative and quantitative analysis of the interactions between electricity and gas infrastructure projects

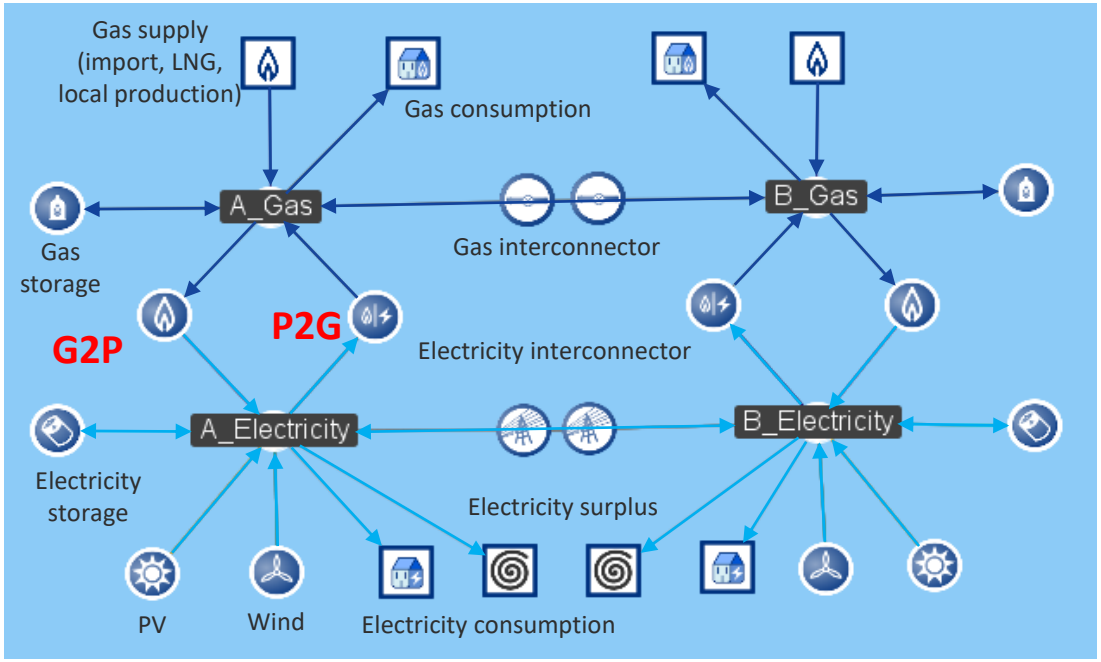
Based on Task 1, Tasks 2 & 3 aim at (a) identifying the *meaningful parameters* that impact the interaction between electricity and gas infrastructure projects, and (b) providing a *quantitative analysis* of the intensity of the interaction as a function of the meaningful parameters.

In the results we are going to present, we have included preliminary results of Task 3: **we present the impact of G2P (and P2G) on the interaction between gas and electricity infrastructure projects.**

Tasks 2 & 3 – Qualitative and quantitative analysis of the interactions between electricity and gas infrastructure projects

For both Task 2 and Task 3, we have built use-cases which focus on the three important categories of direct interactions identified in Task 1 (P2G, G2P, hybrid end-uses).

For the G2P and P2G use-cases that we will discuss today, we perform state-of-the-art simulations of the gas and electric systems, using the following configuration:



Tasks 2 & 3 – Qualitative and quantitative analysis of the interactions between electricity and gas infrastructure projects

We have first looked at the following questions from a qualitative point of view:

- How are G2P and P2G assets operated?
- What are the impacts of G2P and P2G on gas and electricity infrastructure projects?

Then, we have confirmed the results of the analysis by running a large number simulations to detect the interactions for many relevance values of the parameters entering the use-case:

- ✓ Presence of G2P and P2G
- ✓ Share of vRES-e in electricity generation
- ✓ Quantity of electricity storage (capacity of a 6hrs battery)
- ✓ Quantity of gas seasonal storage (capacity and volume)
- ✓ Presence of non-G2P gas demand in a zone
- ✓ Different level of gas and electricity interconnections
- ✓ In case of congestions in the gas interconnection, gas price difference between the two zones*

* While gas prices are exogenous (related to the price of gas imports), the electricity prices are an output of the simulations and depend on the generation mix, which varies in the simulations (share of vRES-e, G2P, storage)

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G2P creates interlinkages on different time scales

At the daily level, gas consumption for G2P can be very 'peaky' due to constraints on the power system (e.g. 0 in off-peak hours, at max capacity at peak hours). The variability of the gas consumption is not in itself a problematic constraint for the supply/demand equilibrium, as it can be absorbed to a large extent by linepack storage.

At a monthly or weekly scale, the variability of the gas consumption for G2P can be significant, in particular in an area where the electric system has a large share of wind power. Indeed, in the case of weeks with low wind, a significant gas storage capacity might be necessary. However, this need for storage is covered by seasonal storage assets.

The main concern for the G2P gas consumption is at an annual level, if the gas supply capacity is not sufficient to cover the additional gas demand for G2P (e.g. in the case of limited supplier or congested capacities), which can be non-negligible in areas with large share of G2P.
The G2P can also create a need for gas storage capacity to be able to cover the additional seasonal variability of the gas demand due to the G2P gas consumption.

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The G2P can also create a need for gas storage capacity to be able to cover the additional seasonal variability of the gas demand due to the G2P gas consumption.

→ Focus on annual constraints

G2P – What is the effect of new electricity interconnectors in an area with a large share of G2P?

- In a case with a limited gas supply in an area that has G2P, adding a power interconnection can improve gas and power security of supply
  - In this case, the interconnection can reduce the G2P use
  - The interconnection gets an additional value when considering the gas constraints
  - When the constraints are reduced (e.g. higher gas interconnection), the value of the power interconnection is reduced
- Similarly, in a case of gas congestions between areas leading to a difference of prices, adding a power interconnection can reduce gas consumption and reduce the costs of the system
  - In this case, the interconnection can reduce the G2P use, by using cheaper generation (gas-based or not) in another area
  - The interconnection gets an additional value when considering the gas constraints

G2P – What is the effect of new gas interconnectors in an area with a large share of G2P?

- In a case with a limited gas supply in an area that has G2P, adding a gas interconnection can improve gas and power security of supply
  - In this case, the gas interconnection allows G2P to be used more often
  - The interconnection gets an additional value from power constraints (SoS in particular)
  - The value is reduced when the flexibility of the power system is increased

- Similarly, in a case of gas congestions between areas leading to a difference of prices, adding a gas interconnection can reduce the costs of the system
  - In this case, the gas interconnection reduce the overall costs of gas imported, by using cheaper sources in another area
  - The interconnection gets an additional value when considering the gas constraints
  - The addition of power flexibility can reduce the value of the gas infra

G2P – What are the meaningful parameters of the interactions?

- The use of G2P in the system (in a non-constrained situation)
  - G2P capacity
  - The capacity and generation of lower variable cost technologies has an important role: share of RES-e, nuclear, and potentially coal generation
  - The existence of more expensive non-gas generation (e.g. oil, biomass, ..)
  - Power system flexibilities such as electricity storages (capacity and volume), electricity interconnections

- The share of G2P consumption compared to the overall gas demand
  - If G2P only plays a minor role in the gas system, the impact of the interaction on the assessment will be small

- The potential constraints on the gas system
  - The import capacity : the higher the import capacity the lower the gas constraints, which makes SoS issues less frequent
  - The gas storage capacity
  - The difference of gas price with the neighbouring area

G2P – What are the thresholds?

- Based on the first simulations with a limited gas supplier, interactions between gas and electricity systems/infra start occurring when
  - Condition on annual import capacity : Non-G2P yearly consumption + G2P yearly consumption > import capacity * 8760

    Or
  - Condition on storage volume : $StorageCapacity < \sum_t (gas\ consumption_t - import\ capacity)^+$

- In this case,
  - The value of new gas interconnection is reduced if power interconnections (or storage) are installed
  - The value of new power interconnection is reduced if gas interconnections are installed

G2P – What are the thresholds?

- Even without security of supply issues, an interaction between gas and electricity systems/infra can occur if the gas interconnection between 2 areas A and B is congested, especially if prices in both areas differ significantly
  - Congestion between A and B (in the direction from B to A)
  - Gas_price_in_A > Gas_price_in_B + transmission_tariff_BtoA

- In this case,
  - New gas interconnection can have a value (8760*price difference), regardless of G2P and the electricity system
  - New power interconnection can have a value, depending on how much the G2P is used in both areas
    - The value of the power interconnection can be affected by the gas system in situations where the removal or displacement of the G2P consumption could remove the congestion

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The interaction created by P2G differs depending on P2G operation

- Power-to-gas can be operated based on the electricity wholesale market price. In this case its capacities are activated when the electricity price is lower than the price of gas in the gas network times the efficiency of the P2G technology (and including the potential savings in CO2). This creates a direct interlinkage between both systems which can lead to several constraints / issues on volume, gas exports/imports or storage.

- Power-to-gas can/could be operated with a dedicated electricity generation capacity (e.g. in North Sea, directly below wind projects). In this case, the project can be considered as a pure gas production. As such, it is independent from the electricity wholesale market and does not constitute a relevant gas/electricity interlinkage.

- Power-to-gas can/could be operated to satisfy a given need of gas (e.g. a given hydrogen consumption in a specific industrial complex). In this case power-to-gas activation is driven by the needs of the industry and the installation can be considered as a pure electricity consumer (with specific characteristics depending on the gas use). As such it does not create a relevant interlinkage between gas and electricity systems.

P2G – What interactions occur between P2G and power interconnectors?

- In an area with cheap available electricity, some additional electricity interconnection can bring value, by allowing to export this cheap electricity to neighbouring areas
- Power-to-gas is also a way to use the cheap electricity by converting it into gas. Indeed, market-driven P2G is used when electricity prices are cheap (and when electricity marginal CO2 content is nil).
- P2G and electricity interconnections can be seen as competitors for the use of cheap electricity: the presence of P2G will reduce the opportunities for exports and could decrease the value of electricity interconnections

P2G – What are the meaningful parameters of this interaction?

- Many variables affect the competition between exports and power-to-gas :
  - The volume of cheap electricity available in the area, depending on the share of vRES-e in the system and on the flexibilities in the electricity system (storages, interconnections with other countries)
    - RES technologies are a source of electricity with low variable costs, their presence increase the opportunities for P2G and for exports
    - Existing flexibilities can help integrating the cheap electricity. The higher the existing flexibilities, the lower the room for P2G and additional electricity interconnectors
  - The value and limitations of electricity exports (if any), depending on the vRES-e share in the neighbour area and the electricity price in the neighbour area
    - The value of exports depends on the neighbouring electricity system. If electricity spreads are high, the value of the additional interconnection capacity will be higher.
    - If there is already high RES generation in neighbour areas, export opportunities can be lower
  - The value and limitations of P2G gas system in the area (if any), in particular the presence of non G2P gas demand, the marginal price of gas in the network (conventional or renewable gas).
    - P2G value depends on the gas price
    - P2G opportunities depends on if there is a local demand or if there are export capacities

P2G – What interactions occur between P2G and gas interconnectors?

- Power-to-gas can be an additional gas source. In this sense it can reduce the needs for additional import capacities in the area with P2G.

- On the contrary, if the production of power-to-gas cannot be used locally (e.g. low local gas consumption), this additional gas source can create new opportunities for gas interconnections to export the gas produced.

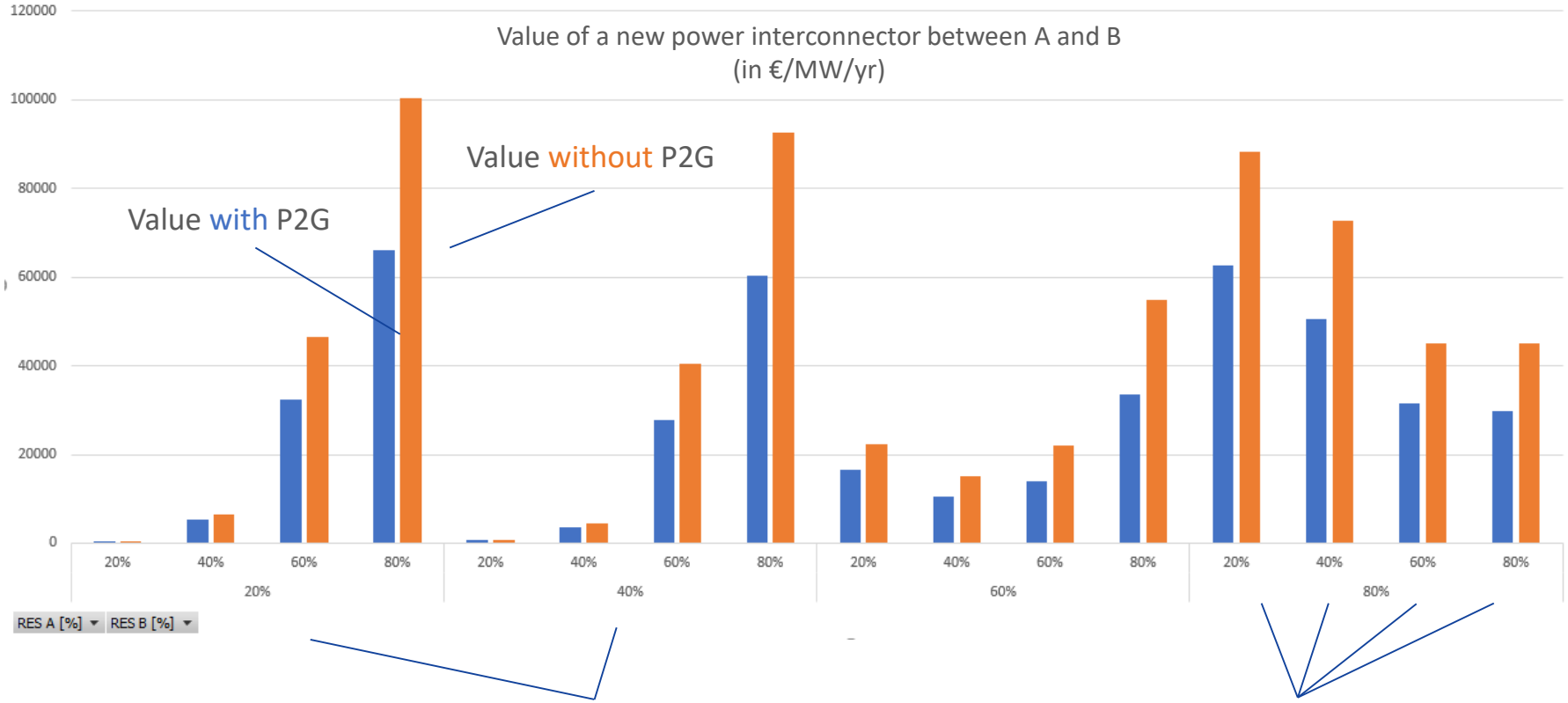
P2G – What are the meaningful parameters of the interactions?

- The interaction of P2G and gas interconnection depends on many variables:
  - The gas demand in the area
    - If there is no gas demand, P2G production has to be exported
  - The existing gas interconnection capacities
    - If there is enough gas capacities to export the P2G generation, P2G will not increase the value of new gas interconnections
  - The P2G gas production profile, which depends on many parameters :
    - The share of vRES-e in electricity in the area,
    - The flexibilities of the local electricity system (storage, export capacities)
    - The share of vRES-e in neighbour areas and the gas price, which affects the competition between P2G and electricity exports

P2G – What are the thresholds for the interaction with power interconnections?

- Based on simulations performed for a large range of parameters, we have the following findings:
  - Power-to-gas has an effect on the value of power interconnections as soon as the RES share is higher than around 60%, which leads to potential surplus of electricity
    - Condition on vRES-e capacity : vRES-e share >= 60%
  - In this case,
    - P2G reduces the value of power interconnections, the reduction being lower with lower RES shares
    - This effect does not seem to be impacted by the gas infrastructure
  - On the other hand, if there is a gas price difference between areas, the power interconnection value can increase significantly

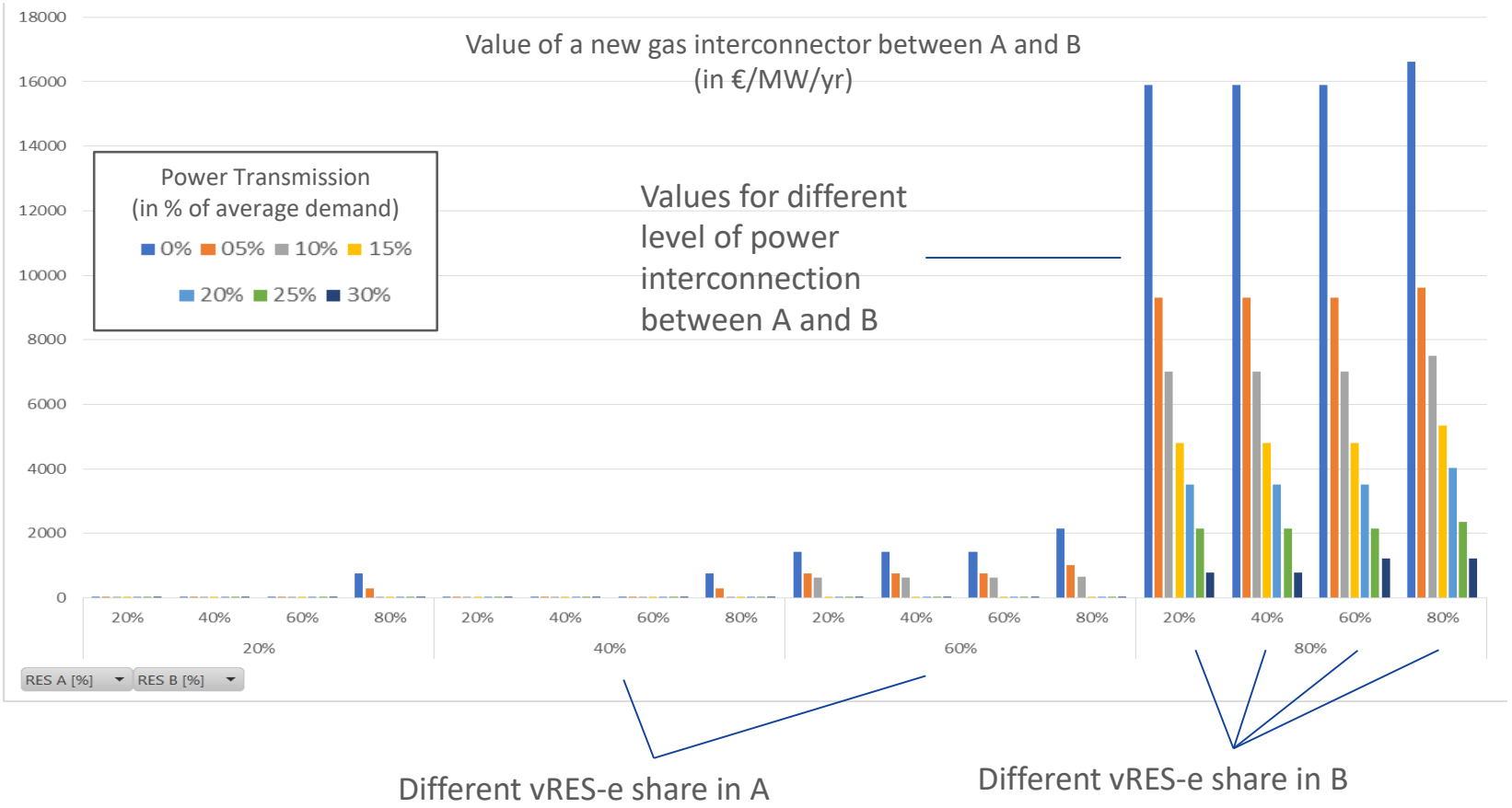
P2G – Example of simulations results : Value of a power interconnector depending on the presence of P2G



P2G – What are the thresholds for the interaction with gas interconnections?

- Based on simulations performed for a large range of parameters, we have the following findings:
  - Power-to-gas may have an impact on gas interconnections value when RES share is high (above around 60%) and when there is no local gas demand
    - Condition on vRES-e Share: vRES-e share >= 60%
    - Condition on local gas demand : No non-G2P gas consumption
  - In this sense, P2G does not systematically trigger other gas investments if there is a local market.
  - In these cases, the value of the gas interconnection depends on the level of P2G production and thus on the electric interconnection

P2G – Example of simulations results : value of gas interconnection depending on the power interconnection level



Next steps

- Interactions in the presence of hybrid gas/elec consumption technologies to be studied
- Interactions in the presence of G2P and P2G to be further investigated

- Webinar 3 will present the final results for T2 and T3

- Webinar 4 will present recommendations for the screening methodology taking into account these results

Thank you for your attention!

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CONSIDERATIONS ON CAPEX

How to take CAPEX into account in order to focus on relevant cases?

Several options can be considered to take CAPEX into account during the screening methodology:

1. Rule of thumb based on results of **previous TYNDP exercises**

2. Additional layer in the screening process based on an **estimation of the potential benefits** of the project. Examples:
   - For an electricity interconnector: CAPEX/MW *vs* Capacity of the interconnector x price difference (i.e. the revenues of the interconnector)
   - For a P2G asset: CAPEX/MW *vs* Number of hours with RES surpluses x P2G Efficiency x Price of gas (i.e. the revenues of P2G)

3. Pre-screening process based on the result of the **single system CBA** (in this case the single system CBA would have to be carried out *before* the screening)

These options will be refined in Task 4, where we will provide our recommendations on the screening methodology.