TECHNO-ECONOMIC MODELLING OF HIGH ADMIXTURE LEVELS OF HYDROGEN IN NATURAL GAS GRIDS

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HIGGS Hydrogen in Gas Grids

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Introduction

- The HIGGS project aims to pave the way to the **decarbonization of the natural gas grid** and its usage, by **covering the gaps of knowledge** of the impact that **high levels of hydrogen** could have on the gas infrastructure, its components and its management.
- A techno-economic model was built, consisting of a **numerical- and economical** part. An intersection of the pipelines TENP/MEGAL was modelled.
- Numerical model determines **pressures, temperatures, and flows** which in turn are indicators for **CAPEX and OPEX** of the subsystems: **pipelines**, **compressor,** and **pressure regulating stations.** Eventually, **levelized costs for transport of hydrogen** in a retrofitted natural gas grid can be determined
- **Different scenarios** have been developed, which represent various development stages of hydrogen use in Europe. For these scenarios, the costs for the transport of hydrogen are to be determined

The techno-economic model

- The techno-economic model consists of 3 main steps: numerical model, post-processing of results coming from numerical model, and impact on economics.
- Further, the gas grid is divided into 3 main subsystems that affect the costs. Namely being pipelines, compressors, and regulator stations.

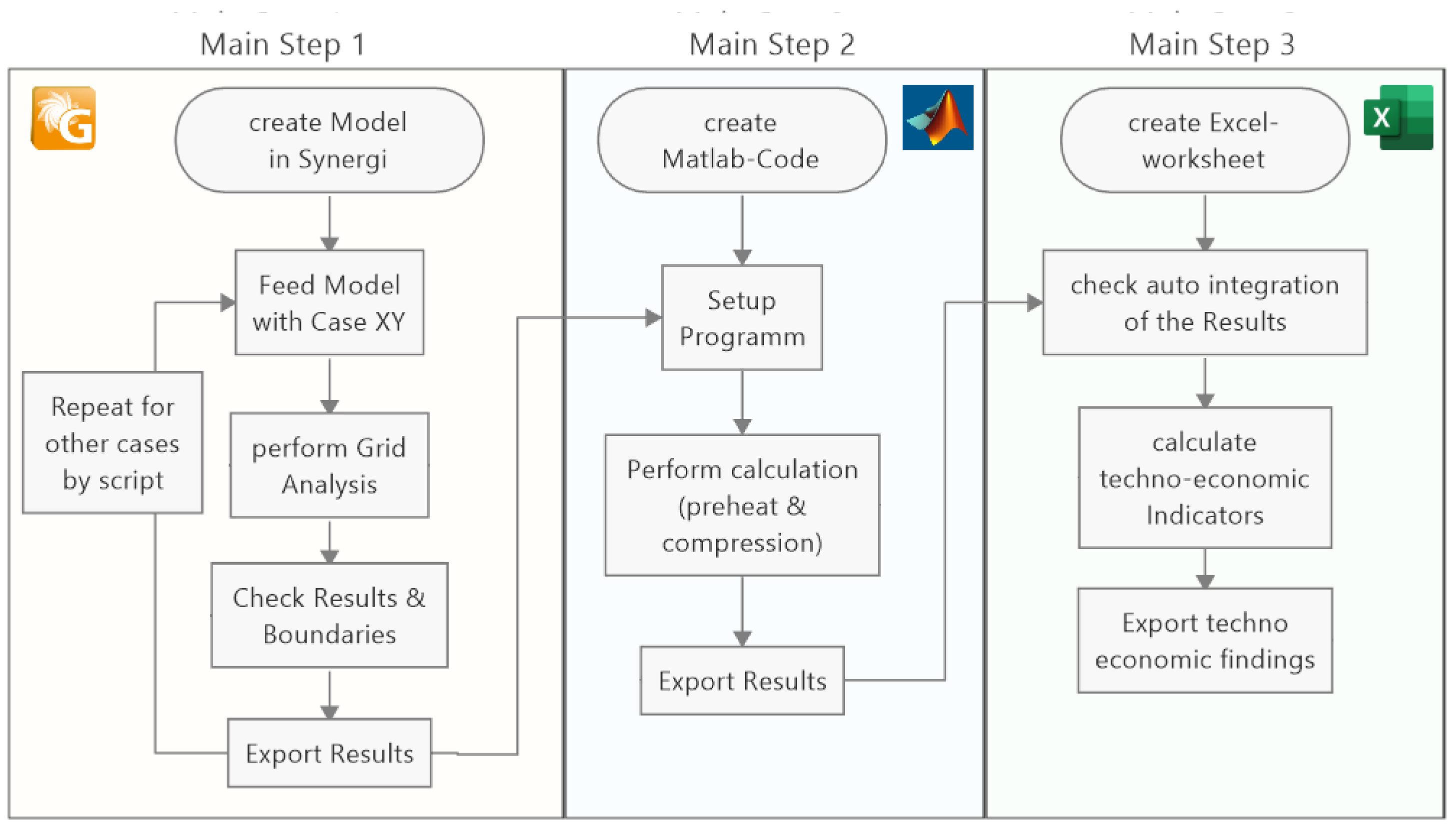

Figure 1. Workflow techno-economic model

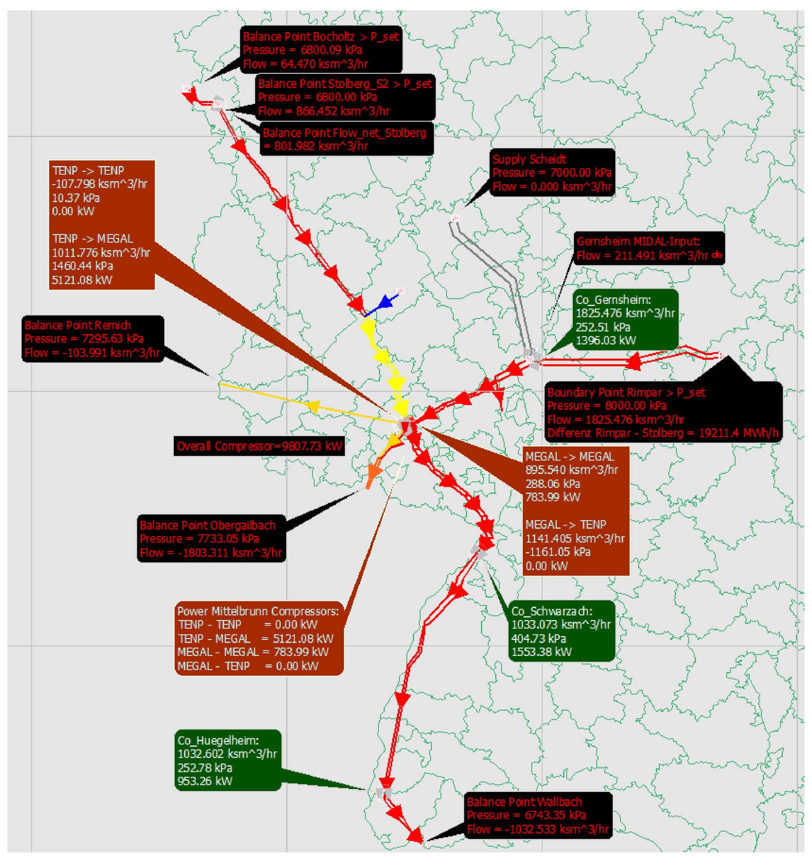

Figure 2. Modelled grid section

Capacity of a **pipeline** (Darcy-Weisbach-Equation):

$$p_1^2 - p_2^2 = \frac{16}{\pi^2}\cdot\lambda\cdot\frac{\rho_n\cdot p_n}{T_n}\cdot\frac{T}{d^5}\cdot K\cdot\dot{V}_n^2$$

Compression work:

$$\Delta h_s = \frac{k}{k-1}\cdot Z_1\cdot R_s\cdot T_1\cdot\left[\pi^{\frac{k-1}{k}}-1\right]$$

Preheating in **regulator stations**:

$$\dot{Q} = \dot{V}_n\cdot\left[\int_{p_1}^{p_2}\left[\frac{\partial T}{\partial p}\right]_h dp + (T_2-T_1)\right]$$

Figure 3. Modelling of subsystems

Set of preliminary results

- The first results were calculated without considering any required separation technologies. By doing so, the plausibility of the model was checked for the first time. Hence, this are by no means definitive findings. The emphasis is on “preliminary”.
- The 3 - 6 €/MWh hydrogen seems to be a relatively small premium compared to the production costs of 25 - 50 €/MWh assumed for green hydrogen in the medium and long term.

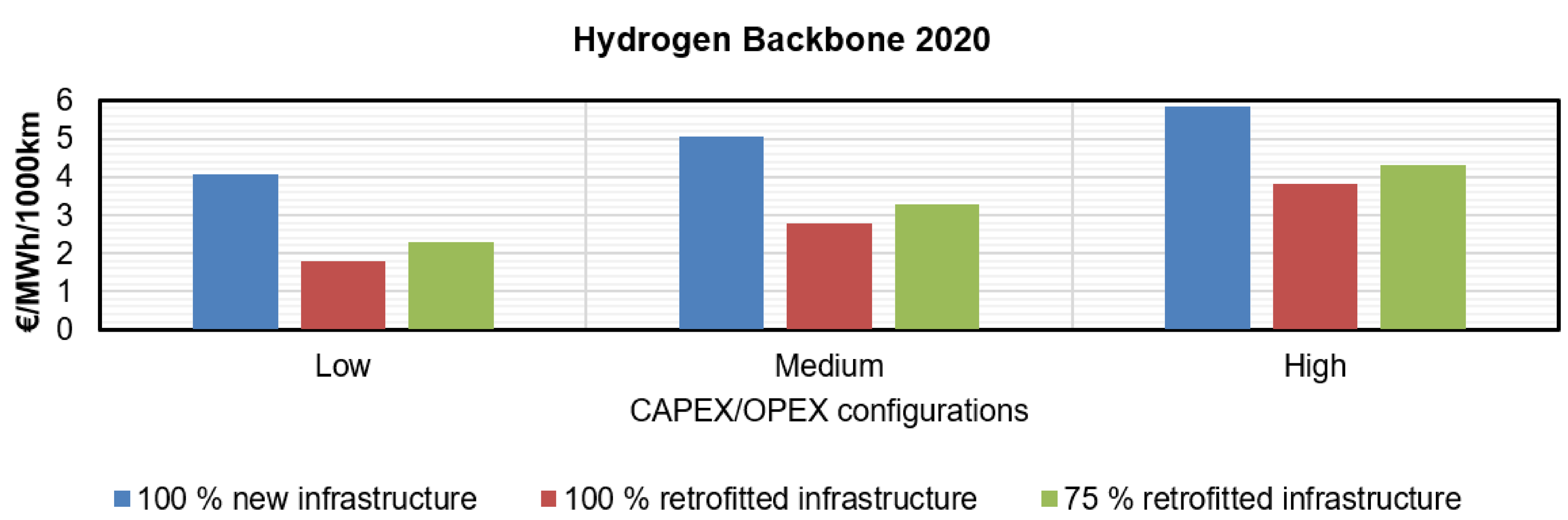

Figure 5. Backbone study results regarding the levelized costs of hydrogen transport

- The preliminary results are roughly in the same range as those of the backbone study for retrofitted infrastructure. Therefore, it indicates an acceptable level of accuracy and plausibility so far.

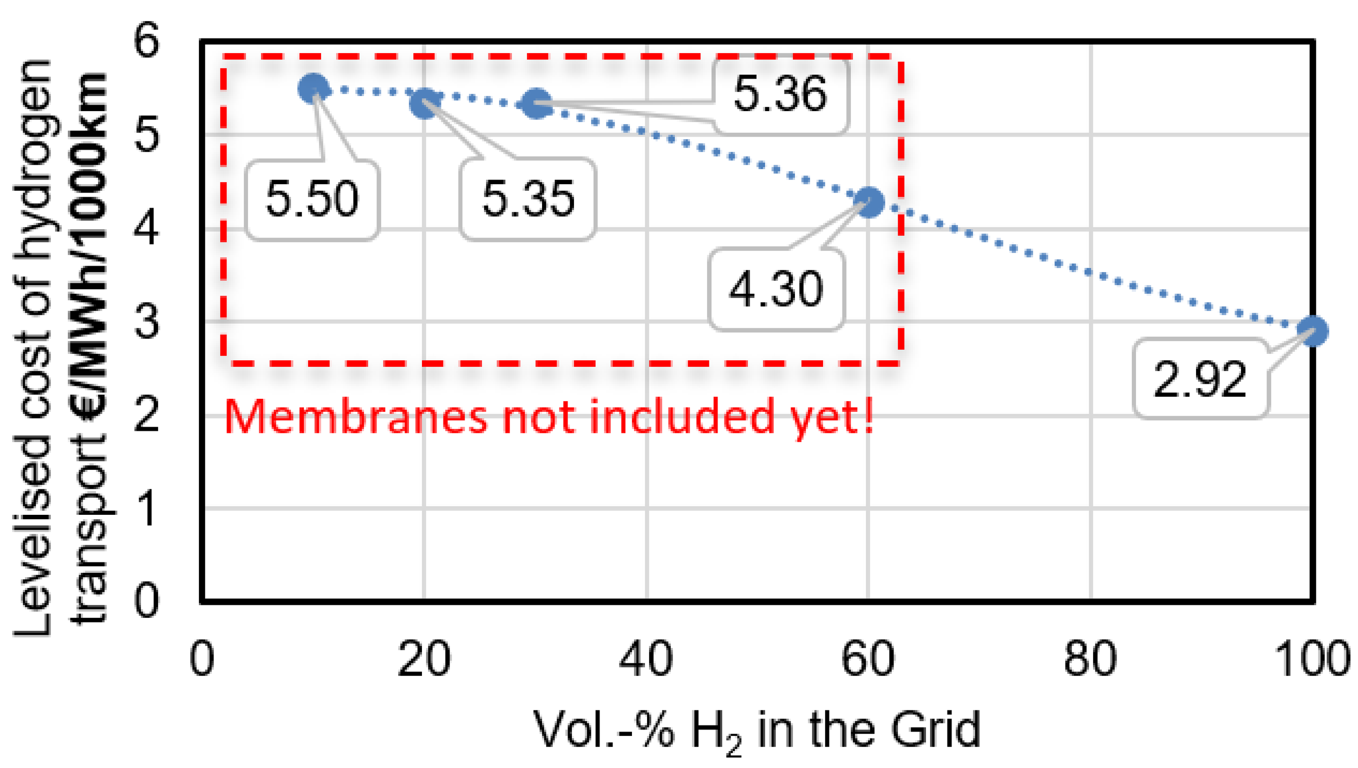

Figure 4. First set of results for levelized hydrogen transport costs via existing pipeline transmission system (retrofitted) at different admixture levels

Conclusions

- With the work done it has been possible to approach a technical-economic model and apply it to a defined network structure that is very relevant in Europe.
- One of the biggest challenges is the availability and accuracy of data for modelling the grid. Hence, simplifications and assumptions were made where reasonable.
- It was possible to determine the absolute and levelized costs for different blending stages based on the model inputs (both numerical- and economical inputs).

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Clean Hydrogen Partnership