2nd PAC Modellers' Exchange Workshop

Protocol

Date: Tuesday, 16 October 2019, 10:00-16:00,
Location: Tennet Office, Rue des Deux Églises 29, 1000 Bruxelles, Belgium

Summary
The second Modellers' Exchange Workshop focused on the question of how to manage carbon neutral synthetic fuels in energy models. 17 experts from research institutes, grid operators, NGOs, consultancies and think tanks discussed key assumptions, which role synthetic fuels will play in the different sectors and what are the technologies to focus on.

Initial input from Dante Powell (ENTSO-e) - The TYNDP and modelling climate neutral synthetic fuels: Open questions

Dante Powell (ENTSO-e) explained the current TYNDP process and how there are currently some blind spots in their modelling, especially related to climate neutral gases.

RGI Explainer - How does the TYNDP currently deal with P2G? - Gas demand is set externality in line with DG Ener "Gas Infrastructure 2050" study: Scenarios are optimised different, Import dependency minus EU Gas production is used as one driver for PtX. Using the following equation: ***Power (P2G) = ("Gas demand"*"(1-Import Dependency)" – "EU Natural Gas production" – "Biomethane production")/η*** *see: EC Study "Gas Infrastructure 2050". The PtH2 production will only use curtailed renewable electricity, to reach the PtH2 target, renewable energy production will be increased.*

Currently, the taking into account and interactions of the impact on the markets of P2G are missing. Dante suggested that it would be good to develop a model that looks at how price interactions affect infrastructure requirements (grid expansion compared to P2G compared to Demand Side Response) by comparing prices of different gases (and the cost of their imports), so that the optimisation in the model can choose between the different solutions.

Additionally, a better understanding of the optimisation options between gas and different technologies would be needed. This includes how to picture sectoral integration, changing sources (e.g. heat pumps instead of gas) and sector coupling to get to a better understanding of the interaction of electricity and gas. This is still an ongoing internal discussion amongst TSOs.

Questions and comments on initial input:

- It was noted that the results of modelling depend on which electricity one would like to use for P2G: only curtailed renewable electricity? Surplus power from nuclear?
- ENTSO-e considers that producing H2 with gas or coal does not make sense, so an exclusion of these technologies would need to be integrated in the modelling.
- The importance of renewable gas and decarbonised gas (CCS) as technology options was mentioned by ENTSOG.
- It was stated by CAN Europe that fossil gas was not part of the solution and that using fossil fuels in P2G was not acceptable.
- ENTSO-e stated that different storage technologies' flexibilities should be taken into account to see what the best cost options are and to check whether costs for upgrading electricity grids would not become astronomic with the existing gas grid rather used as 'low hanging fruit'.
- Terna stated that H2 is needed in energy intensive industry and in long-distance transport and that you will likely need a lot of renewable energy (up to 70 GW solar PV forecast in Italy) if you want to just use curtailed RES. Import from Northern Africa would be an alternative.
- A discussion on biomass followed. Biomass is a direct variable of how much P2X is needed in the TYNDP methodology (see green box above). RGI asked: Is biogas really the most efficient way to use biomass? Or should biogas production be limited to biowaste?
- The Öko-Institute stated from their perspective there is only limited potential of biogas from biowaste for decarbonising the gas sector.
- ENTSOG stated that they assessed 14 different biomass feedstocks to check sustainable potential and that tapping biowaste potential reduces emissions.
- Artelys stated that they try to build a holistic picture. Optimising renewables AND P2G at the same time and let the model decide whether to electrify directly or indirectly through renewable gases.

Presentation 1 - H2 utilisation pathways and their climate impact - Matthias Koch (Öko-Institut)

Matthias Koch started with an overview on different technologies to produce an energy carrier based on hydrogen. He showed that today the overall efficiency decreases from 61% for E-hydrogen down to 45% for E-fuels. The losses accrue with additional process steps, e.g. CO2 production from Direct Air Capture (DAC) or Fischer Tropsch Synthesysis. There is a trade-off between flexibility and efficiency (PEM electrolysis with 60-70% efficiency and with only water as input is more flexible but less efficient compared to high temperature electrolysis with 80% efficiency and water vapour as input).

The key conclusion was that beyond 200g CO2/kWh for the emission factor of electricity mix, PtX will not reduce emissions compared to conventional H2 production (and beyond 140g CO2/kWh for producing e-fuels). Additionality of renewables is essential and there is a need to go beyond the established EU and national targets. PtX plants need to be flexible for fluctuating renewables and the differences of country's energy mix have to be taken in to account.

Questions and comments;

- It was noted that the hourly energy mix should be taken into account when comparing emissions.
- When scaling up PtX plants with industrial e-hydrogen production, locations with industrial hydrogen demand will be forced to start the ramp up of electrolysis due to the high cost efficiency of on-site production. It would be logical to start with the sector where the highest climate impact could be achieved and where relatively low further infrastructure investment is needed, e.g. replace coke in steel production or for aviation fuel.
- An important consideration was that additional German demand for PtX (from surplus RES) would lead to multiplied renewable electricity demand (up to 1,000 TWh for producing PtX, while only 5 TWh of renewable electricity is curtailed currently).The potential of curtailed renewable electricity will therefore not be that high.
- It was considered that it would be better to go for efficiency first to reduce demand, use electricity directly and *then* use PtX where there's no other possibility and where it is most efficient (e.g. aviation).
- Potentially demand for e-fuels will have to be covered by imports from outside Europe. In this context, it was noted by Öko-Institut that we should not repeat the mistakes that have been made in the case of biofuels where European quotas lead to environmental impacts in other places.
- RGI made the point that PtX may be limited by the limited rare earths needed for the catalysers and fuel cells (cobalt etc.).

Presentation 2 - Synthetic gas in a 100% RES European energy system - Felix Frischmuth (FhG IEE)

In his presentation, Felix pointed out that direct use of electricity in the heating and transport sector is the most efficient solution for both energy use and decarbonisation. Heat pumps need only a third of the primary energy needed for electrode boilers and a fifth of gas heaters fed by power-to-gas. Battery electric vehicles need about a half the energy of fuel cell vehicles running on hydrogen and about a fifth when electricity is first converted into a gas or liquid fuel to then feed a combustion engine as is the case with high speed trains for example.

Questions and comments:

- Global warming potential of methane (CH4) needs also to be considered, because CH4 contributes around 20% to global anthropogenic climate gas emissions and the methane concentration has risen significantly in the last century.
- Methane leakage of fossil gas extraction and its supply system must be observed.
- It was questioned by ENTSOG if these technologies (battery electric vehicle etc) are more cost-efficient, given the higher investment costs needed. It was suggested that a hybrid solution might be cheaper in the medium term and that you would need to check and compare total system costs and fixed costs.
- It was noted by FhG IEE that you need to differentiate the macro-economic and micro-economic view and that electrified motorways are more efficient for heavy trucks than fuel cell-based solutions. It should be considered to use biomass in the heating sector in district heating instead of decentralized heating to support the ramp up of decentralized heat pumps and district heating. The use of biomass for industrial high temperature applications and in materials could also be considered.
- An additional point was made regarding the merit order for storage in case of oversupply of renewable electricity: firstly, you would fill the cheapest storage or use the alternatively cheapest option e.g. to export. It was commented that P2G is always last in the merit order because it is the most expensive technology to store renewable electricity besides curtailing renewables.
- FhG IEE; PtX imports will become cheaper as production will be preferred at renewable energy regions (Latin America, Africa). Prices would be 1.6 to 1.4 times cheaper than in Europe, transport costs however would need to be included. Example given of 1 TWh PtL from Morocco = 334 MW wind or 371 MW PV with >6,200 FLH.
- How to achieve negative emissions? Considerations on CCU/CCS/BECCS (carbon capture and useage/storage/bioenergy with carbon capture and storage) vs. land-use change (AFOLU – Agriculture, Forestry and other land use → afforestation) and Direct Air Capture (DAC) or carbon from industry's CCU or BECCS (bioenergy with

carbon capture and storage)? Point made that we shouldn't simply rely on CCS technologies as a joker.

- It was commented by ENTSOG that methane leakage is mainly happening at the production site (extraction) and at processing and less during transport (0.5% during production in Russia, 0.2% during processing and 0.015% during transport, distribution between 0.4 and 1.0%) LNG: 0.1-0.2% from conventional gas extraction, up to 9% for shale gas.
- Other participants considered these number on methane leakage as too low.
- Öko-Institut commented that only a 2.5% methane leakage (with 86 times GWP) increases fossil gas emissions to the level of hard coal fired power plants.
- The participants did agree that the data situation on methane leakages is bad and that independent measurements are urgently needed. Nevertheless, it has to be assumed that there is a relation between the extraction of fossil gas and the rapid rise in methane concentration in the atmosphere.

RGI explainer - On the climate impact of fossil gas. The main impact is methane leakage. GWP_{20} 84 (x CO2) GWP_{100} 28 (86 / 34 ***without of climate–carbon feedbacks) see IPCC*** *Fifth Assessment Report (AR5) Table 8.7 page 714*

Presentation 3 - How do local factors influence Power-to-X deployment? - Holger Loew (RGI)

During the first Modellers' Exchange Workshop, a variety of factors such as excess renewable electricity, hydrogen infrastructure and proximity to industrial hydrogen consumers were identified to understand the regionalisation of PtX locations. To understand the structure of this regionalisation, a decision-making process was presented by RGI. This process helps to assess locations and to find out where PtG plants could be foreseen. A base assumption within this process is that, for efficiency reasons, H2 is the only reasonable fuel to consider.

- It was commented by ENTSOG that they see (in their modelling regions) where H2 is being converted, that harbours and ports could act as potential clusters.
- It was also discussed by participants what you need H2 for: for decarbonisation only or also to provide flexibility services?
- Costs and the decision to use it for flexibility depends on different factors. These are, for example, lead time/advance notice, duration of retrieval, frequency of retrieval (voltages), amount of the required performance etc.
  There is no good tool to reflect these variables yet.

- ENTSOG stated that different technologies will interact, e.g. batteries to increase full load hours of P2G, you have to run your model much more gradually (short vs. long-term).

From the discussion it was concluded that the next workshop could focus on the following topics:

- "Merit order of flexibility"
- "Optimal portfolio of flexibility solutions"
- "Flexibility modelling for long-term scenarios"