Hydrogen Europe's Reply to Consultation

TYNDP 2024 Scenarios Inputs Parameters Consultation

09/08/2023

Summary

The TYNDP 2024 Scenarios Inputs Parameters consultation offers a comprehensive and intricate examination of the optimal approach to modelling and evaluating the infrastructure needs of the European network. Hydrogen Europe has analysed its model and has acknowledged a wide array of positive elements while also identifying areas for enhancement in the modelling and methodology. This consultation response aims to provide constructive insights for a more robust and comprehensive TYNDP 2024 in order to facilitate a well-informed and effective decision-making.

1. <u>**Scenario Strategy & Storylines:**</u>

   - Firstly, there is a **need for distinct energy mix assumptions between the two scenarios to reflect infrastructure requirements effectively** since, currently, many of the crucial demand assumptions in the model are equal or at least very similar in both scenarios, which would not result in a significant variation of investments. Hence, it is strongly advised to these assumptions to have more differentiated variations.

   - There is also a need for a **higher inclusion of diverse hydrogen production pathways**, such as ATR+CCS and waste-to-hydrogen technologies, which are crucial for a more comprehensive analysis.

   - One of the most important points for improvement of the TYNDP Target analysis is to expand the **geographical granularity for modelling electricity demand and supply, going beyond bidding zone level; a country-level granularity is not enough to assess the sector coupling and local infrastructure development needs**. This is especially important <u>since hydrogen storage has not been implemented in a similar way to battery storage</u>, i.e., via assumed deployment scenarios, but <u>is rather a result of the modelling</u>.

2. <u>**Demand Figures for DE & GA Scenarios**</u>:

   - **Many of the crucial demand assumptions are equal or very similar among both scenarios, which would not result in a significant variation of investments**. We advise to revisit these assumptions so that a better alignment between demand projections and storyline objectives can be achieved.

3. <u>**Supply Figures for DE & GA Scenarios:**</u>

   - This section offers a very detailed study on the needs for every Member State regarding their renewable and battery trajectories, nuclear capacities, the cost of the technologies, the commodity and CO2 prices and extra EU import potentials. However, to enrich the TYNDP 2024 scenarios, we recommend a **more inclusive approach to hydrogen production pathways**. While the focus on renewable and low-carbon hydrogen is commendable, the scenarios would benefit from the inclusion of other **high Technology Readiness Level (TRL) methods, such as pyrolysis, ATR with CCS and waste-to-hydrogen technologies**. Furthermore, **acknowledging the potential exporting role of countries like the UK** could also prove a wider understanding of hydrogen imports.

4. <u>**Modelling Methodology and Assumptions**</u>:

- We think that **including hydrogen storage as an investment candidate rather than only a fixed investment** based on TSO-submitted projects, the TYNDP could become a more useful tool for evaluating future hydrogen storage needs, including seasonal storage to support the power grid. Increasing the granularity of the modelling would also be extremely beneficial, as well as considering UK exporting capacity.
- It is essential to **conduct a more in-depth evaluation of steel tanks' adequacy for storage capacity in the Zone 1 setting**, considering the relative inflexibility of consumption profiles in the industry and the implications of the RED delegated acts related to grid electricity use as well as in industrial applications.
- we would also highlight the importance of consistency and transparency in commodity prices. To avoid biases and ensure a level playing field, **commodities prices should reflect a uniform set of assumptions across the entire modelling exercise**.

In summary, Hydrogen Europe's insights underscore the critical need for refining and aligning key elements of the TYNDP 2024 scenarios, specially by enhancing the role of hydrogen in the TYNDP 2024 scenarios and modelling and how can it best be assessed.

Questionnaire

Scenario Strategy & Storylines

ENTSO-E and ENTSOG published the TYNDP 2024 Scenarios Storyline Report, that includes the scenarios frameworks, the storyline matrix and gap closing methodology for the NT+ energy mix. The storylines are considered final as they are built upon 2022 Storylines, stakeholders' feedback from last cycle's extensive consultation, and from the Storyline Update Webinar from July 2022. Any additional feedback will be considered for the 2026 cycle, except for the Annex-2 NT+ Energy Mix Gap Filling Methodology, which is part of this public consultation.

4) Please provide your comments about the TYNDP 2024 scenarios strategy.

While our overall assessment on the TYNDP2024 scenario building strategy is highly positive, we still have identified several areas that could benefit from improvement and further consideration:

Stronger differentiation between demand and supply patterns in 2024 scenarios strategy: The scenarios shall be used as boundaries to understand what kind of infrastructure would be needed and show different supply and demand patterns Currently, many of the crucial demand assumptions are the same or at least very similar, which would not result in a significant variation of investments. We would strongly advise revisiting these assumptions.

Inclusive Hydrogen Production Pathways:

- **Including additional hydrogen production pathways** in the modeling exercise such as ATR+CCS, pyrolysis, and waste-to-hydrogen technologies

- Scenarios should **consider the full scope of available technologies** and energy sources to reduce CO2-emissions at the lowest possible cost since in none of the demand sectors the transformation from natural gas to renewable and low carbon gases can be seen.

Decarbonization of demand should be achieved through a **wider scope of technologies** (especially those under the GA scenario). For instance:

- The path for the transition of the heating sector in many countries (for instance in Germany) excludes the use of renewable molecules.

- Consequently, methane/H2 Heat pumps and fuel cells are not considered although they are commercially available.

- Exploring the **potential decrease in adaptation costs associated with electrification** and reconversion of gas pipeline and associated industrial infrastructure may be cheaper on a systematic scale than applying electrification, especially for big industrial consumers.

Higher Geographical Granularity: Enhancing the geographical granularity for modeling electricity demand and supply, as well as including the UK as a potential hydrogen exporting country, will ensure a more accurate representation of energy flows and potential export opportunities.

By addressing these points and incorporating the suggested improvements in the next cycle, the TYNDP will become a more robust and informative tool for evaluating energy scenarios, supporting effective decision-making, and promoting the advancement of sustainable energy systems in Europe.

5) Do you agree on one central scenario in 2030 aligned with ACER's Framework Guideline?

a) Yes

b) No

i) If you selected No, please specify

Generally, we agree with the approach of having one central scenario for 2030 aligned with ACER's Framework Guideline. Yet, we have some objections regarding the energy efficiency scenario assumption as well as the selected data and breakdown of demand/supply between various technologies.

One general aspect brought to our attention was that in the analysis it is being assumed that the energy consumption reduction achieved in 2022 is going to be maintained, due the unpredictable events of the Covid-19 pandemic and Ukraine's invasion. However it is **complicated to evaluate the exact energy efficiency gains over the past three years, and over the next couple of year, we might actually observe a slowdown in energy savings** as the economy and industrial activity have been restored in Europe post pandemic. This will impact indeed predictions regarding the demand reduction. The crucial link between demand reduction plans and infrastructure needs must be carefully considered to avoid potential gaps by 2030.

Regarding the calculation methodology of some data and factors, we wanted to point out the following discrepancies:

A. **Hydrogen emission factor:** in case of 'District Heating' and 'Electricity' applications the emission factor for hydrogen has been set at 57 kgCO2/GJ – which seems appropriate for natural gas, but it is not for low carbon hydrogen. We suggest changing it to 0 – like in other applications or at most at 28.2 kgCO2/GJ (i.e. the low carbon emission intensity threshold envisaged in the gas package and for Renewable Fuels of non-biological origin- RFNBOs).

B. **Efficiency of various applications:** it is not clear how the "Average Efficiency [%]" value should be understood. Is it a complete life cycle efficiency over the entire value chain (so for renewable hydrogen starting at renewable electricity generation) or just the efficiency of the final use of various carriers? If it's the former, then the efficiency of hydrogen use in some applications seems to be too high (e.g. 95% for heating in Belgium). If it's the latter then the efficiency of hydrogen use in some applications seems to be too low (e.g. 35% for mobility applications and for industry where hydrogen is going to be used, to a large extent as a feedstock and not as an energy carrier).

C. **Efficiency of hydrogen use in mobility applications:** the efficiency of hydrogen in mobility applications has been set at 35%, which is OK if one considers the full value chain efficiency from renewable energy generation. But if that is the approach, it is hard to understand why for e-methane the efficiency is set at 78%. It should be lower than the one of hydrogen to factor in additional conversion steps (methanation and compression/liquefaction).

D. **Efficiency of hydrogen use in district heating applications:** there are some ver significant discrepancies with regards to efficiency of hydrogen use in district heating between countries (from 52% in Estonia to 95% in Belgium). The reasons behind such differences are not explained

E. **Efficiency of hydrogen use in industrial applications:** It is not immediately clear what is the purpose of the efficiency value for hydrogen use in industry – especially since it is going to be used, to a large extent, as feedstock, where the notion of efficiency of use is hard to apply (100%).

F. **Efficiency of hydrogen supply:** efficiency for all considered hydrogen production methods is 0%. This suggests that hydrogen production efficiency has been included already in the various end-use applications. However, we think such an approach is questionable as it omits the differences in efficiency between various production methods. It would have been better to include efficiency of production technologies, and of the final use on the end use side;

G. **Demand type for hydrogen supply:** in case of Hydrogen Supply data, the demand type has been defined as "%" , the meaning of which i difficult to establish.

6) What are your views about the updates for the 2024 Scenarios Storylines Report?

a) Specify

ENTSO's efforts to enhance transparency through detailed calculations and a new tool are greatly appreciated, although further inquiries should be launched into:

- While the report helps comprehend the process, it **lacks in-depth descriptions of calculations in ETM and Plexos**.

- A **second workshop devoted to the post-consultation feedback analysis before simulation is actually initiatied** could be very helpful.

- **Feedback given in the 2024 consultation should be integrated into the 2024 TYNDP planning**, rather than deferred to 2026. This is because of the nature of infrastructure planning exercise, in which timely identification is crucial, as lengthy lead times for grid and generation units mean that any unaddressed infrastructure could remain non-operational by 2030.

- An exhaustive annex with country-specific pages elucidating assumptions and data sources would also be helpful to enhance clarity.

7) **What would be the other important drivers (please see the 2024 Scenarios Storylines Report, Figure 3) that you would like to see in the next cycle? (Please provide an explanation on how it could be included and differentiated among scenarios)**

In the next cycle, we believe that the following drivers should be considered as important additions to the TYNDP scenarios:

- **Hydrogen Production Pathways:** As mentioned in the 2024 Scenarios Storylines Report, different hydrogen production pathways, such as pyrolysis or waste-to-hydrogen technologies, should be included. These pathways have varying impacts on carbon emissions and overall energy system integration. Differentiating the scenarios based on the share of each production pathway will provide insights into the most sustainable and efficient hydrogen supply mix.

- **International Cooperation and Trade:** The role of international cooperation and hydrogen trade should be highlighted in the scenarios. This includes considering import and export dynamics, as well as the establishment of global hydrogen supply chains. Differentiating scenarios based on the level of international cooperation/integration and trade will shed light on the potential for cross-border collaboration and the impact on energy security and carbon reduction goals.

- **Hydrogen Infrastructure Development:** The level of hydrogen infrastructure development, including distribution networks and refueling stations, should be factored into the scenarios. Differentiating scenarios based on the extent of infrastructure deployment will offer insights into the challenges and opportunities for scaling up hydrogen adoption across different regions.

8) **What are your views about the gap closing methodology for NT+ scenario? (Please see the TYNDP 2024 Scenarios Storyline Report, Annex 2)**

    a) **Specify**

Demand Figures for DE & GA Scenarios

The TYNDP 2024 Demand Scenarios are now quantified with Quintel's Energy Transition Model (ETM) tool, which is open source and available for the general public. The spreadsheet 20230704 – Draft Demand Scenarios TYNDP 2024 provides all the country links where interested stakeholders can transparently see all relevant input and output parameters. Please note that a dedicated version of the ETM (https://tyndp2024.energytransitionmodel.com/) is created for the TYNDP 2024 scenarios to ensure stability and transparency throughout the whole scenario development process.

Please note that only the demand-side of the ETM has been configured. All other values have been left at their default values and do not represent the vision of the authors. For the analysis of the final energy demand per sector, per carrier and market shares of technologies please visit the Visualisation Platform available on our website.

9) **What are your views about the added value of this transition to the new tool (ETM) for the transparency of the scenarios building process? (1 - no added value ; 10 very high added value)**

10

10) Do you think the demand figures within DE & GA scenarios are consistent with their storylines?

a) No

i) If you selected no, please explain

General remark: the model contains thousands of data points that result in the demand numbers which are very complex and can only be evaluated to a certain extent. Therefore, the most difficult aspect when assessing the scenarios of the Storyline Report, is to evaluate whether the demand figures proposed are built on legislation and national specifications of the demand sector – rather than focusing on consistency with the storylines.

Regarding the latter, the demand figures within the DE & GA scenarios appear to exhibit inconsistencies and discrepancies across different sectors and countries. In some cases, there are significant variations in hydrogen demand between the two scenarios for the same sector in the same country. Also, it is especially difficult to establish how all the multiple assumptions were set for 2040 und 2050 in de DE and GA scenarios. This lack of consistency raises concerns about the alignment of demand figures with the intended storylines of each scenario.

For example, the demand for hydrogen in agriculture burners and heat pumps shows inconsistent patterns between the DE and GA scenarios for different countries. Similarly, the share of coal and hydrogen in buildings space heaters exhibits unexpected changes, which might not be entirely coherent with the narrative of each scenario.

To improve consistency, it would be essential to review the assumptions and methodologies used to estimate demand figures within each scenario. The demand projections should be revised and aligned more closely with the specific characteristics and objectives of each storyline. By doing so, the TYNDP 2024 scenarios would better reflect the intended narrative and provide a more reliable basis for decision-making.

11) Do you think the market shares of technologies within DE & GA scenarios are consistent with their storylines?

a) No

i) If you selected no, please explain

The market shares of technologies within the DE & GA scenarios also exhibit discrepancies and hard-to-understand differences between countries. Some key assumptions regarding demand are quite similar, which could hinder the ability to explore more diverse demand scenarios with different approaches and different use of technologies.

To improve consistency, the modeling methodology should be thoroughly reviewed, and assumptions revised to better represent the technology adoption trends and policy targets envisioned in each scenario. Aligning the market shares with the intended narrative will enhance the credibility and relevance of the TYNDP 2024 scenarios.

Identified issues with the market share of technologies include:

1) Data for The Netherlands in many cases seems to be corrupted (#N/A)

2) Agriculture burner hydrogen share: there seems to be an inconsistency in approach. In some countries (LU, BE) demand for hydrogen only occurs in the DE scenario, while in others only in the GA one. In Germany, in GA scenario the demand grows to 57% in 2050 from 0% in 2040, while in the DE scenario, it is already 8% in 2040.

3) Agriculture burner network gas share: in some countries (ES, HR, PL, RO, PT, BG) there is a planned increase of gas share in 2040 and then 2050. It is not clear how that can be achieved without significant new gas infrastructure deployment. Is this envisaged for in the TYDP2024?

4) Agriculture heat pumps share: some assumptions are hard to understand and hence to justify:

    a) In Denmark (DE), the share increases from 0% in reference year to 15% in 2040, and then falls back to 0% in 2050.

    b) In Spain (GA), the share grows to 50% in 2040 only to fall back to 0% in 2050.

5) Buildings space heater coal share : In Germany, the (GA) share of coal seems to increase from 0% now to 0.2% in 2040. This won't change much but it is difficult to understand the reasons for such prediction; .

6) Buildings space heater combined hydrogen share: the share for hydrogen in Germany (GA) seems to grow from 0% to 11% in 2040 and then falls to 8.2% in 2050.

7) Buildings – district heating share: the share of district heating in some countries seems to fall quite significantly (e.g. from 56% currently to only 20% in 2040). While we agree that in many cases the fuel for district heating would have to be changed, it is difficult to see the district heating systems being replaced by individual heating to such an extent.

8) Buildings – heat pump share: the share of Air-Water heat pumps in Austria (DE) is expected to grow from 5% in 2019 to 70% in 2040. That does not seem very realistic (in other countries the growth is around 25% on average).

9) Buildings – hybrid hydrogen heat pump share: in several countries (BE, DK, EE, ES, FI, FR, MT), the share of hybrid heat pumps has been set at 0% in both scenarios for the entire period until 2050.

10) Bunkers_allocated_ percentage_aviation: It is not clear from the documents available what is the meaning of this data field and its impact on the modelling. Furthermore, the value has been set at 100% for almost all countries, except for Czechia, where it is 0% in 2040 (DE), and Luxemburg, where the values are between 15-50%. It is difficult to understand why those differences exist for only those two countries.

11) Bunkers_allocated_ percentage_shipping: The meaning of this data field and its impact on the modelling is again unclear. Furthermore, the value has been set at 100% for almost all countries, except for Malta, where it is 5%; Sweden, where its 0% and Luxemburg, where it's between 5-20%. It is difficult to understand why those differences exist for those abovementioned countries .

12) Bunkers_ship_using _ammonia_share: it is hard to see the reasons behind the current variation between Member States: for most countries this has been set at 0% with the exception of Denmark, Spain and even Austria (especially curious for a landlocked country) with up to 100%. In Germany (the only other country where it is not 0%), the values have been set at 3%. In Spain the value grows (in the DE scenario) from 0% in 2019 to 75% in 2040, and then falls back again to 35% in 2050. Those differences should be made explicit. .

13) Bunker fuels in shipping share: the bunker fuels seem to include HFO, ammonia, hydrogen and LNG. Shouldn't the list include methanol as well?

14) Capacity_of_industry_ chp_turbine_hydrogen: this has been set at 0 MW until 2050 for all EU countries, which seems too conservative. While for Finland (the only exception), it is 159 MW starting from 2040 in both scenarios. Hard to see the reasoning behind it.

15) Capacity_of_industry_ heat_burner_ hydrogen: as in the case of CHP, this has been set at 0 MW until 2050 for all EU countries, which seems too conservative. While for Finland (the only exception) it is 159 MW starting from 2040 in both scenarios. Hard to see the reasoning behind it.

16) Capacity_of_industry _other_food_ flexibility_p2h_ electricity: the values have been set at 0 MW in all countries with the exception of the Netherlands where, from 0 MW in 2019 it grows to 750 MW in 2040… only to fall back again to 147 MW in 2050 (DE scenario).

17) In GA scenario the growth until 2040 is 800 MW, and the following decrease ends up with 221 MW in 2050. Hard to comment but it is difficult to understand the rationale behind such choice.

18) Capacity_of_industry _other_paper_ flexibility_p2h_ electricity: the values have been set at 0 MW in all countries, except for the Netherlands where, from 0 MW in 2019 it grows to 190 MW in 2040… only to fall back again to 43 MW in 2050 (DE scenario).

19) In the GA scenario the growth until 2040 is 195 MW, and the following decrease ends up with 65 MW in 2050. Hard to comment but it is difficult to understand the rationale behind it.

20) Efficiency of hydrogen electrolysis: **the efficiency has been set at a constant 66% until 2050. The value for 2019 is already rather pessimistic but with the expected efficiency improvements, assuming only 66% in 2050 is extremely conservative**.

21) industry_aggregated_ other_industry_ electricity_share: the share of electrification in most of the countries is growing, even up to 90% in some cases… Apart from Denmark, where in the GA scenario it falls to only 5% (from 25.5% currently). This is hard to understand.

22) industry_chemicals_ fertilizers_burner_ hydrogen_share: the share of hydrogen consumption for industrial heat is relatively comparable in all countries, with the exception being Belgium, where it is 10-20 pp. lower than in other countries. It is difficult to understand why Belgium has been singled out in such a manner.

23) industry_chemicals_ fertilizers_hydrogen_ network_share and SMR share: the hydrogen supply seems to be divided into either SMR or hydrogen delivered via pipelines. To complete the picture, we suggest including also at least two other hydrogen supply alternatives: local in situ hydrogen production and imports of low carbon ammonia (displacing local ammonia manufacturing).

24) industry_chemicals_ other _burner_ hydrogen_share: for other chemicals industry the share of hydrogen in industrial heat generation has been set on a relatively uniform level across the EU (12-16%) – with the only exception being France where it is zero until 2050. Why?

25) industry_other_ paper_burner_ hydrogen_share: For other chemicals industry the share of hydrogen in industrial heat generation has been set on a relatively uniform level across the EU (17-34%) – with some exceptions:

    a) 0-9% in Belgium

    b) 3-7% in France

    c) 2% in Sweden

    While in some other selected countries (Spain and Germany), the shares significantly higher. Why?

26) Steel_DRI_ hydrogen_share: the share of H2 DRI for steel manufacturing is relatively uniform across the EU (36-50%). However, there are some hard-to-understand exceptions.

    a) In France it is only 15-18%

    b) In Italy it is only 6-30%

    c) In Sweden the share in 2040 is up to 11 pp lower than in other countries while Sweden is the country with some of the most advanced green hydrogen DRI projects in Europe (although the difference might be a consequence of the assumed market growth which in Sweden is expected to soar by 300% by 2050)

    d) In Poland, hydrogen DRI reaches 36% in 2040 (in GA scenario) – only to fall back to 25% by 2050

27) Share of hydrogen buses -In most countries, the share in 2040-2050 is 20-50% with some exceptions:

    a) 5-20% in Austria and Belgium

b) 0% in Spain (the GA scenario)

c) 0% in Croatia

d) 7.5 – 23% in Poland

e) 0% in Sweden (the DE scenario)

It is difficult to understand why those countries are chosen as outliers. Especially Spain, where cheap renewable hydrogen should make hydrogen road mobility an attractive option.

28) Share of H2 passenger vehicles - The shares of H2 FCEVs vary quite significantly between countries, with some where the market share is zero even in 2050 (AT, BE, ES, NL, SE, FR), while in others, the share in 2050 is on average around 12% (in the DE scenario). In NL (the DE scenario), the share is 3.8% in 2040, and then falls to 0% in 2050. In France, the share remains 0% even in the GA scenario, while in other countries it is on average around 20-25%. We find those numbers hard to agree with. While we do not question that BEV share will be higher than hydrogen, for passenger vehicles, 0% by 2050 is extremely bearish and not realistic.

29) Share of H2 in aviation: Share of hydrogen in aviation is between 10 – 50% in some EU countries while it remains at 0% in some others. Why?

30) Share of ammonia as a fuel for ships: the share is 0% in an overwhelming majority of EU countries, while in Spain it is at 60% already in 2040 and grows to 91.5% in 2050. Yet, in Austria, in the GA scenario it grows to 80% ? Why – especially since Austria is landlocked. Why no mention of methanol?

31) Share of trucks using hydrogen: There are some hard-to-understand differences between countries:

a) In most countries the share grows from 0% in 2019 to around 10% in 2040 and then to around 20-25% in 2050 (the DE scenario) or to 30%-50% (the GA scenario)

b) In Spain, in the DE scenario it remains at 0% even in 2050 (when Spain is one of the countries with the lowest expected costs of hydrogen production, which would suggest higher than elsewhere market penetration of H2 vehicles)

c) In Croatia it remains close to zero even in the GA scenario

d) Also, in Sweden the share is zero even in 2050 (the DE scenario)

32) Similarly, hard to understand differences exist also in the vans sector.

12) Do you think the amount of biomass in the scenarios is sustainable?

a) Yes

b) No

i) **If you selected no, please explain.**

We are unable to discern the link between the ETM model's outcomes and the content of the Demand Draft report. Moreover, the term "biomass" lacks clarity in the context of the query. Is the reference to biomass inclusive of the feedstock for biogas/biomethane, the foundation for biofuels, or the source for wood pellets? If the biomass pertains to feedstock for biomethane plants, we affirm that the projected biomethane quantity appears feasible for sustainable production.

The ETM model incorporates technologies involving wood pellets, yet these are notably absent from the roster of energy sources enumerated in the ETM's per-source demand outputs. Additionally, these technologies are absent from the Draft Demand Scenario.

Supply Figures for DE & GA Scenarios

The draft supply figures and their methodologies can be reached via 20230704 – Draft Supply Inputs for TYNDP 2024 Scenarios for consultation and 20230704 – Draft Supply Tool (EU-level). The first spreadsheet includes the country specific renewable and battery trajectories, nuclear capacities, the cost of the technologies, the commodity and CO2 prices and extra EU import potentials. Please note that the Best Estimate figures within the trajectories are not part of the consultation as they represents TSOs' best estimate for the upcoming NECPs whose draft version should be submitted to the EC in summer of 2023. The Draft Supply Tool excel quantifies the supply details for the total energy demand of each energy carrier.

ENTSO-E and ENTSOG also published their electricity and hydrogen reference grid for information within 20230704 – Electricity and Hydrogen reference grid and investment candidates. Please note that this document also includes the project candidates for electricity whose CAPEX are according to ENTSO-E's proposal, and project candidates for hydrogen whose CAPEX are calculated according to ENTSOG's proposal. These draft cost methodologies and figures are part of this public consultation.

13) In your view, are the RES trajectories (wind, solar, battery) & nuclear capacities reasonable?

- Solar PV Installed Power Trajectories:
    - a) Some countries have identical estimates for "LOW," "BEST," and "HIGH" scenarios, requiring higher differentiation between scenarios.
    - b) The differences in solar PV deployment trajectories between countries, like the Netherlands having x2 more utility solar PV than Spain, and Germany having more than the rest of EU + NO + UK combined, Sweden with more solar PV than Romania etc., raise concerns and requires clarification.
- Onshore and Offshore Wind Installed Power Trajectories:
    - a) Similar to solar PV, some countries have identical estimates for "LOW," "BEST," and "HIGH" scenarios, necessitating better distinction between scenarios.

- b) Specific data points for offshore wind installations, such as NL031 and DE011, seem unclear and need further explanation (capacities grow and then start to fall by 2050).

- Nuclear Installed Power Trajectories: The trajectory for the UK does not align with the government target of 24 GW of installed power by 2050, prompting a need for adjustments or clarification (or both).

- Prosumer Battery Trajectories:

    - a) In the "HIGH" scenario, prosumer battery installations follow the Prosumer Battery/Rooftop Solar ratio in most countries. However, the "LOW" and "BEST" scenarios show disproportionate ratios in some cases, requiring further explanation. (In AT in LOW scenario the ratio is twice as high as in HIGH scenario; In SE01, the ratio is almost 9 times higher in the LOW than in the HIGH scenario)

    - b) Installed prosumer batteries in HU reaching zero capacity by 2050 need clarification.

- Utility Battery Trajectories:

    - The installed battery capacity for ITSI, ITCA, ITS1, and ITSA seems higher than expected based on the proposed Utility Battery/Utility PV ratio, while the opposite is true for ITN1

Overall, the TYNDP 2024 scenarios strategy needs **more clarity and differentiation between scenarios**, especially **for solar PV and wind deployment trajectories**. It is crucial to address discrepancies and provide comprehensive explanations for each country's trajectory to ensure transparency and credibility in the planning process.

14) In your view, are the technology costs appropriate?

Regarding the technology costs, it is necessary to carefully assess the CAPEX for electrolysis (both onshore and offshore) in the 2030 projections. Clearer definitions and boundaries are required to ensure the appropriateness and reliability of the CAPEX assumptions.

1. **Electrolysis:**

    - It is not clear if CAPEX figures for electrolysis include grid connection costs – which would vary between different options (none for directly connected electrolysis and potentially significant for grid connected electrolysis).

    - Discrepancy in the lifetime of onshore electrolysis for 2040 set at 18 years only (likely a typographical error, which should be corrected for consistency).

    - Fixed O&M costs for onshore electrolysis are indicated in kEUR instead of EUR, needing clarification for accurate evaluations.

2. **Hydrogen CCGT:**

    - CAPEX projections for hydrogen CCGT seem reasonable, with a 10% increase compared to standard natural gas CCGT, justified by larger pipe diameters and additional SCR/water injection.

3. **Other:**

    - Assumptions for some technologies (e.g., steel tanks for hydrogen storage) are missing from the modeling and need to be incorporated for comprehensive analysis.

    - Clean hydrogen production methods in the modeling are limited to electrolysis, while other important pathways (e.g., ATR+CCS, pyrolysis, waste-to-hydrogen) should be considered to present a holistic assessment of clean hydrogen generation.

15) In your view, are the prices (presented in the 20230704 – Draft Supply Inputs for TYNDP 2024 Scenarios.xlsx, sheet 3) appropriate?

In our view, the prices presented in the 20230704 – Draft Supply Inputs for TYNDP 2024 Scenarios.xlsx, sheet 3, **seem appropriate.** However, **special care must be taken to ensure that commodity prices based on external sources align with the assumptions used in the internal modeling.** This is crucial to avoid any potential bias towards a particular commodity due to differences in price estimation arising from varying assumptions. For instance, if blue hydrogen is considered a commodity without explicit modeling, **its key assumptions, like WACC, should be consistent with those used for other commodities in the internal modeling exercise, such as renewable hydrogen costs.** Ensuring this alignment will maintain the integrity and accuracy of price estimates and support informed decision-making in the TYNDP 2024 Scenarios.

16) In your view, are the extra-EU methane import potentials reasonable?

a) Yes

b) No

i) If not, please provide us an alternative source (should be reliable and cover 2050 time-horizon)

17) In your view, are the extra-EU H2 import potentials & prices reasonable?

a) Yes

b) No

i) If not, please provide us an alternative source (should be reliable and cover 2050 time-horizon)

In our view, the extra-EU H2 import potentials & prices appear reasonable to a certain extent. However, we would like to highlight some considerations regarding the methodology.

1. Inclusivity of Import Potentials: The amounts of hydrogen imports have been established based on the RePowerEU targets. We would however like to point out that RePowerEU mentions ammonia as an example and is open also to other derivatives. While we agree that using ammonia for calculating imports costs is a prudent approach, we would still welcome a more inclusive take on in the applied wording. This isespecially since a techno-economic comparison of various options is beyond the scope of the TYNDP, the scenarios reports should clearly state that what is modelled as ammonia imports could also take form of other derivatives (like liquefied hydrogen or LOHC).

2. Inclusion of UK as an Exporting Country: The import potentials for hydrogen seem to be missing regarding the UK as a potential hydrogen exporting country. It is crucial to include it in the assessment, considering its potential role as a net exporter, especially with recent national policy development.

3. Further clarification on Norway's import's methodology: When referring to the import potential analysed on the basis of the TYNDP 2022 PCI projects collection, it should be clarified why the imports of hydrogen from Norway to Germany do not increase from 2030 to 2040 and the values are stagnant (similarly from 2040 to 2050). When referring to the import potential analysed on the basis of the European Hydrogen Backbone (EHB) study, it should be clarified why the imports from Norway (TWh/year) increase significantly from 2030 to 2040 (from 39 to 134), but then decrease from 2040 to 2050 (from 134 to 88).

4. Clarity on Import Origins: It is mentioned that the model calculates costs for ammonia imports based on an average from "Maximum 22,4 TWh (2030), from the 6 cheapest countries." However, it remains unclear what the approach is for subsequent years. It is essential to clarify whether the maximum amount per country is increased to ensure all imports are still satisfied by those six cheapest countries or if additional import origins are considered.

5. Limited Options for Imports: The modelling only considers the option of reconversion to hydrogen for ammonia and other derivatives imports. Exploring additional pathways for these imports, beyond reconversion, might provide a more comprehensive and realistic assessment of the potential import costs.

Incorporating these considerations into the analysis will improve the robustness and accuracy of the extra-EU H2 import potentials & prices estimation, ensuring a more informed basis for decision-making in the TYNDP 2024 Scenarios.

18) Do you agree with the methodology on how the demand is supplied per energy carrier and how the conversion factors are used? (See 20230704 - Draft Supply Tool (EU-level).xlsx)

a) Yes

b) No

i) If you selected no, please explain.

In our assessment, the demand supply methodology and conversion factors in the TYNDP are well-structured. However, some key considerations should be addressed:

- **Efficiency of PtL Processes:** The PtL process efficiencies (around 72%) appear low, possibly excluding by-products like LPG or Naphtha. While this is correct if total demand of hydrogen is to be estimated for a given demand of e-fuels, we should be careful not to double count the same hydrogen twice in different sectors (LPG by-product from e-kerosene production could be used in road or maritime mobility).

- **CO2 Needed for PtL Processes:** On the other hand, the amount of around 0.265 kgCO2/kWh of product estimated for the PtL processes, seems to have been done including also by-products from F-T synthesis. Yet, if the purpose is to estimate demand for CO2 to produce synthetic liquid fuels, and that value is multiplied only by amount of e-kerosene, then the total demand for CO2 would be underestimated.

- **Domestic Hydrogen Production in National Trends+ Scenario:** The domestic hydrogen production values for 2030 (12 TWh) and 2040 (64 TWh) seem undervalued, with the latter even lower than implied demand by 2030 RED targets for RFNBOs.

- **Hydrogen Supply in the DE and GA Scenarios:** Total hydrogen demand values in 2040 and 2050 differ in the 'EU' sheet from the data in the 'DE Total' and 'GA Total' sheets, primarily relying on imports. The meaning of data in the 'EU' sheet needs clarification.

19) Do you think the preliminary supply figures are differentiated according to the storylines?

a) Yes

b) No

i) If you selected No, please specify

It appears that the preliminary supply figures in the TYNDP may lack sufficient differentiation according to the storylines. Concerns raised, such as the undervalued domestic hydrogen production in the National Trends scenario, and ambiguity in hydrogen supply values in the DE and GA scenarios, indicate potential issues with differentiation.

For a more comprehensive scenario planning and accurate representation of the storylines, it is crucial to align the supply figures with the unique characteristics and assumptions of each scenario. Addressing these concerns and refining the supply figures will enhance differentiation in the TYNDP, to better establish each Member State's targets.

20) What are your views on the cost methodology of H2 investment projects? I.e., 75% repurposing and 25% new build, European Hydrogen Backbone report as cost basis, 15% distance between capitals?

There is a need for clarification in the methodology concerning the specific sources used for the timeframe spanning from 2035 to 2050, as both information provided by Member TSOs and information included in the TYNDP 2022 project collection is mentioned. However, it would be beneficial to also outline **whether these sources are subject to updates following the TYNDP 2024 project collection**.

21) What are your views on the cost methodology to for electricity investment candidates? I.e., to use submitted candidate projects as electricity investment candidates?

a) Specify

It is to be clarified why hydrogen interconnections with Norway are not included in the datasets 2. H2 Reference Grid and 4. Investment candidates, as Norway is included in the other sets on projections on H2 imports to the EU included in other tables and documents for the 2024 TYNDP under consultation. It is advised to provide consistency on this point to better address and understand the modelling and assumptions behind this dataset.

Modelling Methodology and Assumptions

The innovations implemented in the TYNDP 2024 Scenarios seek to improve those already implemented in TYNDP 2022. The aim is to enhance the representation of a fast-changing energy system and the integration of its different sectors. The TYNDP 2024 scenarios presents five main innovations which are EV Modelling, Hydrogen (P2G) Modelling, Offshore Modelling, Hybrid Heat Pump Modelling and Expansion Modelling. For the details, please check 20230704 – Modelling Methodologies & Draft Assumptions, 20230711-H2 Steel Tank Methodology and 20230711 - Carbon Budget Methodology documents under the download section.

22. In your view, is the carbon budget methodology appropriate?

23. What do you think about the EV innovation & its relevance to the scenario model? (rank 1 to 10 - 10 most satisfactory)

24. In your view, are the assumptions on the EV methodology reasonable?

25. How could the methodology be improved for the next cycle?

1. **Hydrogen Storage:** Include hydrogen storage as an investment candidate rather than only a fixed investment based on TSO-submitted projects. This will make TYNDP a more useful tool for evaluating future hydrogen storage needs, including seasonal storage to support the power grid.

2. **Expanded Hydrogen Production Pathways:** Broaden the scope of hydrogen supply by including other high Technology Readiness Level (TRL) methods for hydrogen production, such as pyrolysis or waste-to-hydrogen technologies. Consider including pink hydrogen as well. This will provide a more comprehensive and accurate representation of potential hydrogen sources.

3. **Geographical Granularity:** Increase the geographical granularity in modeling electricity demand and supply to go beyond bidding zone level. Modelling hydrogen and gas on a country level is insufficient to capture the benefits of sector coupling and local infrastructure development needs. Adopt a more detailed approach to recognize significant local demand and infrastructure requirements. This is especially important since hydrogen storage has not been implemented in a

similar way to battery storage, i.e. via assumed deployment scenarios, but is rather a result of the modelling. Hydrogen storage will be a function of its several capabilities : (i) providing seasonal energy storage and flexibility to the power system, (ii) balancing inflexible demand for hydrogen in industrial applications and intermittent renewable hydrogen supply, (iii) ensuring strategic reserve for imported hydrogen, (iv) helping avoid renewable energy curtailment. Most of the above applications for hydrogen storage will be heavily influenced by local issues, including underground storage capacity, industrial H2 demand, RES supply, local grid congestion, etc. A model evaluating these issues on a Member State (or bidding zone) level is at risk of underestimating the actual needs for hydrogen storage.

4. **Regulatory Framework Consideration:** In zone 1 setting, consider the implications of the RED delegated acts, particularly for industrial applications with relatively inflexible consumption profiles. This would necessitate exploring solutions such as high-capacity storage, oversizing of corresponding RES generating assets, complementing renewable hydrogen with low carbon hydrogen sources, or a combination of these options.

26. What do you think about the P2G innovation & its relevance to the scenario model? (Rank 1 to 10 - 10 most satisfactory)

7

27. In your view, are the assumptions on the P2G methodology reasonable?

Yes

No

if not please provide us an alternative source (should be reliable and cover 2050 time-horizon)

28. How could the P2G methodology be improved for the next cycle?

P2G modelling could also consider the synchronous generation that also provides grid's balancing services needed by the electricity system in those nodes where decommission of fossil and nuclear energy plants are decommissioned and incentivize that part of it should be covered by H2 P2G plants (which can also provide balancing services due to being a synchronous technology). This is also to make sure that not only CCGTs are going to be reconverted, but also H2P2G facilities could be installed in those nodes where synchronous generation is needed.

It is also to be remarked that there is a P2G Hydrogen Insufficiency; Power-to-Gas (P2G) hydrogen was mentioned in the plan, but its incorporation is not sufficient to meet the future energy demands effectively.

29. What do you think about the offshore innovation & their relevance to the scenarios model? (rank 1 to 10 - 10 most satisfactory)

30. In your view, are the assumptions on the offshore methodology reasonable?

31. How could the methodology for offshore be improved for the next cycle?

32. What do you think about the Hybrid Heat Pump innovation & its relevance to the scenario model? (rank 1 to 10 - 10 most satisfactory)

The Hybrid Heat Pump offers a potential solution for older, non-renovated homes or those with higher temperature demands where the heat pump can meet a portion of the baseline consumption. Given that a significant portion (85%) of the building stock remains non-renovated, making them unsuitable for conventional electric heat pumps, Gas/H2 pumps emerge as a more suitable alternative. Hence, that is why prioritizing innovation and investment in these solutions is highly critical to endorse a quicker implementation of energy efficiency and energy transition measures.

33. In your view, are the assumptions on the Hybrid Heat Pump methodology reasonable?

The Hybrid Heat Pump methodology could be rather improved by considering the following aspects:

- The **rate of heating electrification in some countries (e.g. Austria) could be considered rather unreasonable** since it which would require very high buildings renovation rate beyond what can be observed happening in the market.

- The **heat pump COP seems to be assumed on the same level for each country** - while in countries with harsher winters, the average COP should be expected to be lower than 3.0.

- The **heat pump COP seems to be set at a level fixed for the entire year**. While COP of 3 is fine as an annual average (with the caveat from the point above), it is not the most suitable approach to assume that it will be 3,0 during the whole year. During times of low temperature, the COP could be close to or even less than 1.0, if this is not taken into account the demands which electrification of heating will put on infrastructure will be significantly underestimated**.**

34. How could the methodology for hybrid heat pumps be improved for the next cycle?

By taking into account the wrong assumptions mentioned in point 33

35. Do you find the assumptions on the H2 steel tanks methodology appropriate?

No

If not, please provide us an alternative source (should be reliable and cover 2050 time-horizon)

Regarding the assumptions on the H2 steel tanks methodology, there are some considerations to be addressed:

- **Adjusting Storage Capacity Evaluation:** The assumption that local storage of hydrogen will be needed for industrial applications (those with local in-situ production of hydrogen) is a correct one. But it should be noted that 24h storage capacity will not provide much resilience. It is therefore essential to conduct a more in-depth evaluation of the adequacy of such storage capacity compared to the needs of the industry in the Zone 1 setting. This evaluation should take into account the relative inflexibility of consumption profiles in the industry and the implications of the RED delegated acts concerning the use of grid electricity.

- **Excessive Optimism regarding Industrial Supply Storage:** The assumption that only 25% of industrial supply in the Zone 1 setting would require such storage might be too optimistic. Especially, in the initial phase of market development (i.e. before the hydrogen infrastructure is in place), when a sizeable share of hydrogen projects will produce hydrogen locally – close to consumption sites, the need for storage might be more important . To ensure accuracy, it is necessary to reevaluate this assumption based on a more comprehensive understanding of industrial demand patterns and their actual storage requirements.

Addressing the above points will enhance the appropriateness and reliability of the assumptions on the H2 steel tanks methodology, ensuring a more informed basis for decision-making in the TYNDP 2024 Scenarios.

36. What are the most important modeling innovations that you would like to see in the next cycle?

In the next cycle of modeling, as Hydrogen Europe, we would like to see the following important innovations:

1. **Inclusive Hydrogen Production Pathways:** We recommend expanding the hydrogen supply modeling to include other high Technology Readiness Level (TRL) methods, such as pyrolysis or waste-to-hydrogen technologies. These pathways are essential to present a comprehensive and accurate representation of potential hydrogen sources.

2. **Geographical Granularity:** Increasing the geographical granularity for modeling electricity demand and supply is crucial. Adopting a more detailed approach beyond bidding zone level and modeling hydrogen and gas on a country level will better capture sector coupling benefits and local infrastructure development needs.

3. **Hydrogen Storage as an Investment Candidate:** We suggest considering hydrogen storage as an investment candidate rather than solely a fixed investment based on TSO-submitted projects. This enhancement will make TYNDP a more useful tool for evaluating future hydrogen storage needs, including seasonal storage to support the power grid.

4. **Clear Assessment of Storage Capacity**: It is essential to conduct a more in-depth evaluation of steel tanks' adequacy for storage capacity in the Zone 1 setting, considering the relative inflexibility of consumption profiles in the industry and the implications of the RED delegated acts related to grid electricity use. This will provide a more accurate estimation of the storage requirements.

By incorporating these modeling innovations, the TYNDP will be better equipped to support informed decision-making and policy development in the energy transition, leading to a more sustainable and integrated hydrogen economy across Europe.

HYDROGEN EUROPE
Avenue Marnix 23
1000, Brussels / Belgium

secretatariat@hydrogeneurope.eu
www.hydrogeneurope.eu