1. **Anonymous**

Feedback: The definitions in the Glossary section of the Scenario Storyline report could be improved for some term definitions:
- "DSR" should include upward demand response, too, e.g. as "... active role in softening peaks in energy demand, and in increasing energy use during surplus supply, by changing ..."
- "Indirect electricity demand" could be better defined e.g. as "electricity demand for production of other energy carries for replacing the use of fossil fuels". Besides industrial processes and hydrogen electrolysis, this could be e.g. heat pumps and elecric boilers for district heat production.
-P2G should include electrolysis-based ammonia production, too: ".... P2CH4) or to obtain synthetic ammonia (Power to Ammonia - P2NH3)"
-P2X should include power-to-heat, too: "Aggregation of power to gas, power to liquids and power to heat"
- "Synthetic fuel" can be produced without CO2 emissions also by e.g. nuclear electricity, i.e. "....is produced from electrical energy."

Response: In the final storyline report we have updated the glossary in order to provide more clarity on these definitions.

2. **Anonymous**

Feedback: The National Trend scenario includes 40% reduction of CO2 in 2030. Wouldn't it make sense to model also a scenario with -55% CO2 reduction in 2030? Now that the EU council has announced its position, this target will become an official commitment soon.
https://www.bbc.com/news/world-europe-55273004

Response: both Distributed Energy and Global Ambition storylines will be in line with at least 55% CO2 reduction in 2030.

Feedback: It is great that ENTS-E-ENTSOG has planned to release the data in an easy-to-read format. We researchers really appreciate that effort which enables us to dig deeper into the results and compare them with other models. Have you considered adding an open license to the results? Without the license, it is difficult, even impossible sometimes, to properly use the TYNDP results. Thanks!

Response: Together with the final storyline report we also have published the Excel with all figures. The data we published are deemed to be freely available and available to the public. The data can be downloaded and saved free of charge.

3. **Wind Europe**

Feedback: Currently the DE and GA scenarios present exclusive options (i.e. if there's an uptake of onshore wind there won't be an uptake of offshore wind). And the same is done for hydrogen – there should be a scenario in which there is a strong uptake of all renewables and production of domestic hydrogen.

Response: The dominance of solar PV and wind in the storylines matrix is expressed in terms of relative market share. Global Ambition will have relatively higher share of offshore wind, Distributed Energy will have higher share of solar PV and onshore wind. However in terms of absolute value (installed capacity), Distributed Energy will have more of everything (solar, onshore

and offshore wind) to enable direct electrification, P2X and further reduce energy imports.

Feedback: It is a very positive development that the carbon budget would take into account the equity and not only the population. However, the carbon budget is similar to the EC LTS but the ENTSO scenarios rely a lot on CCS in achieving that. And CCS capacity wasn't even up for discussion in the consultation.

Response: Third party scenarios are important benchmarks for us. This includes scenario studies released by the European Commission. Also in terms of CCS assumptions we aim to remain close to aforementioned studies.

4. **Anonymous**

Feedback: " Anonymous wants to point out:

- No 100% renewables scenario: The consideration of climate change impacts is missing. Climate change is already changing energy system needs.
- This Scenario Storyline Report is a non-suitable way of going forward.
- Global Ambition and Distributed Energy are very similar; a diversity of the scenarios is missing.
- The role of prosumers is not clear.
- Underlying numbers and assumptions in the storylines are partly unclear.

Anonymous would have welcomed the integration of one new storyline that describes a fully renewable energy system that is compatible with the Paris Agreement's 1.5°C target without relying heavily on CCS technologies.

Response: Both distribution Energy and Global Ambition storylines are designed to distinguish each other along the drivers we want to explore. This is also highlighted in the storyline matrix published as an annex of the draft storyline report.

The Distribution Energy storyline aims for high renewable combined with the minimization of CCS and nuclear power. Whether 100 percent renewables and zero percent CCS and nuclear is feasible we have yet to see with our scenario modelling. In the draft scenario report we publish later this year we will provide more information and data.

Feedback: Although we value the attempt to strengthen the variation of the storylines compared to the previous TYNDPs, there are still inconsistencies. The differences in industry's high-level driver "energy intensity", assuming a variation in its growth and raw material demand do suggest that the Distributed Energy storyline with its stronger direct use of renewable electricity leads to a lower raw material demand and to less growth. Regardless of the energy mix, the industry will continue to improve its competitiveness, optimise the efficiency of its processes and mobilise its energy savings potentials. Against this backdrop, it appears to be more coherent to assume these high-level drivers are similar. In contrast, it is surprising that the Distributed Energy storyline and the Global Ambition storyline with their higher importance given to gaseous energy carriers work with similar levels for small scale gas boilers in households.

Response: During the storyline consultations several stakeholders suggested that the draft storylines showed too much variation in terms of energy intensity (efficiency, circularity, etc.). As a

consequence, ENTSOG and ENTSO-E have adapted the storyline description accordingly. The final storylines for TNYPD 2022 show only limited difference on this scenario driver, Distributed Energy going only a little bit further than Global Ambition.

Feedback: The energy demand figures in the draft storylines lacks more substantial information. Given the importance of reducing energy consumption, assumptions should be made clear. In order to be consistent with EU policies and targets, the storylines need to reflect how the "energy efficiency first"-principle impacts the EU's energy system.

Response: As mentioned in the report the availability of quantitative data is rather limited at storyline level. This is because scenario modelling needs to be performed first. Energy demand is an example of modelling output, which is not yet technically available. The outputs of our modelling will be included in the draft scenario report to be published in summer 2021.

Feedback: In view of data transparency, we suggest to publish all data under an open data license. In order to ensure comparability, for instance with National Long-Term Strategies of Member States, we request that also country-specific data for all storylines beyond 2040 be published."

Response: Together with the final storyline report we also have published the Excel with all figures. The data we published are deemed to be freely available and available to the public. The data can be downloaded and saved free of charge. Country-specific data are not yet available at storyline level, but will be released in summer as part of the draft scenario report.

5. **German Watch**

Feedback: There should be a third scenario that uses "the best of both (all) worlds" and delivers a 1.5° climate target by employing both decentralized solutions and efficiency / sufficiency (as in the DE scenario) and imports of green hydrogen (as in the GE scenario). This scenario would leave out the options of new nuclear (economically infeasible) and CCS (as the scarce CCS potential is needed in other sectors more urgently, e.g. for sequestering industry emissions). This would be an internally consistent scenario from our point of view. Such a third scenario would build a good methodological bridge between the two very polar scenarios as DE and GA are narrated at the moment. Also the clear focus on electricity in the DE and gas in the GA scenarios would be alleviated in the third scenario. This would be very instrumental for both the stakeholder discourse and the task of infrastructure planning.

Response: Due to the 2-year timeframe set by TYNDP process, we are unable to develop and assess a fourth scenarios. However, both CCS and nuclear power will be minimized in the Distributed Energy scenario. The exact level is still not defined as scenario modelling is still to be run.

Feedback: The storyline report is more instructive and useful than the last edition, so there is a clear improvement. Particularly helpful is the giving of explanations for the different motivations along with certain quantitative ranges within which the storyline assumptions will lie. This speeds up the discussion and allows a more focused consultation process.
However, a number of crucial explanations on assumptions remain nebulous. One particularly crucial explanation that is missing regards the intended range of methane imports in the 2022 storylines. This regards Figure 11 on page 24. The text does not state how the ranges for the 2022 storylines are relative to the 2020 scenarios. With regard to assessing the climate performance of the storylines,

this is a crucial aspect. In the workshop on December 2 the term „decarbonized methane“ was used in the third presentation. Upon request it was said that this was natural gas with CCS. However, it remains unclear which process. Is it combined-cycle gasification with post-combustion CCS for electricity generation?

Overall, the storyline report gives a good overview of the storylines. However, particularly for assumptions that are crucial for assessing the storylines' fitness in delivering climate mitigation targets, the explanations remain nebulous or are missing. The assumption for different industrial growth is not explicitly motivated. For us this ranges under "most important information". Also the transparency on the carbon footprint assumptions of bioenergy can be improved, see question 10. And finally with respect to what "decarbonized methane is" the report is also very vague.
The storylines are more different from each other than in the last TYNDP edition. This is a very good development from a methodological point of view as the resulting scenarios deal with a greater variety of challenges. The more different the storylines are, the more robust the resulting infrastructure planning will be against uncertainties, in theory. For this claim to be valid, however, it depends on which drivers are varied and which drivers are kept constant across the two scenarios. The storyline document explains that the idea was to tell internally consistent stories and vary the different drivers accordingly.

Response: Compared to the 2020 edition, some quantitative parameters have been introduced in the draft storyline report to provide more visibility. We acknowledge however that the availability of quantitative information is limited at storyline level. This is because we still have to perform our modelling. In the scenario report to be published in summer we plan to release an extensive dataset (e.g. CCS volumes, import per energy carrier and technology substitution along the time horizon).

Feedback: One driver for which we strongly disagree with the differentiation between the DE and GA scenario is [Energy Intensity/Industry/Growth of Industry (on shoring, export)] as listed in the appendix. This driver should be similar for both scenario storylines. From our point of view, the scenario storylines would still be internally consistent - both of them. The way the storylines read now is that the DE scenario is tantamount to a de-industrialization scenario. Why should this be the case?
The motivation for this differentiation is not explained explicitly in the storyline description. This differentiation causes resentment against the DE scenario as an implicit de-industrialization scenario. Also the challenge of delivering sufficient clean energy to industry is understated in the DE scenario if the assumption, that there will be less growth of industry, will not become true.
Another driver for which the differentiation is questionable is [Energy Intensity / Residential & Tertiary / Behaviour: Share of home office] Why would this be different in the two scenarios? It is very much outside of the realm of energy policy and a GA scenario with high shares of home office would from our point of view also be perfectly internally consistent. We think that a "similar" for both scenarios would be the more consistent choice.

Response: During the storyline consultations several stakeholders suggested that the draft storylines showed too much variation in terms of energy intensity (efficiency, circularity, etc.). As a consequence, ENTSOG and ENTSO-E have adapted the storyline description accordingly. The final storylines for TNYPD 2022 show only limited difference on this scenario driver, Distributed Energy going only a little bit further that Global Ambition.

Feedback: Finally, the assumption on CCS availability in the electricity sector is one that has been consistently criticised over the past TYNDPs. Why is the assumption on the CCS potential in the GA

storyline so high? It has been shown in numerous academic research that the CCS potential in Europe is scarce and for achieving a 1.5° target these sinks need to be available for sectors which have the least options for decarbonization. The electricity system is certainly not one of these sectors. On the contrary, the electricity system is the one with the largest set of technologies for decarbonization at the moment. So the GA scenario's heavy assumption on CCS is not acceptable and needs to be adapted or a third scenario needs to be calculated, see the response to question 22.
Finally, to the reader it appears as if the DE scenario is "the electricity scenario" and the GA scenario is "the gas scenario". Obviously both options are used in both scenarios. However, the setup through the assumptions is such that there are strong reasons to believe that the DE scenario will show a strong dependency on electricity and the GA scenario will show a strong dependency on gas solutions. Hence one scenario is the "ENTSO-E"-scenario and the other one the "ENTSOG"-scenario. See our suggestions in the answer to question 22 to alleviate this phenomenon.
Apart from these methodological choices, the storylines are constructed in a way that does permit a good overview of the challenges facing infrastructure development in the next thirty years.

<u>Response</u>: We did not meant to give the impression that Global Ambition relies heavily CCS. Regarding CCS (and nuclear) the Distributed Energy scenario will minimize these technologies, whereas Global Ambition still provided room for it. We will benchmark against other studies (including EC) to make sure that the technology levels we set are reasonable.

6. Anonymous

Feedback: Anonymous welcomes the work already done by ENTSO-E and ENTSOG on the scenario storylines, especially for having considered some proposals made during the previous TYNDP, that have improved the document. However, the following elements are worth mentioning. First, Anonymous would like to stress that the risk of a major curtailment in electricity is more and more a reality :

- ENTSO-E analysis shows that in case of a cold spell, Belgium and France would have risked supply shortages this past winter ;
- By 2022-2023, RTE (French electricity TSO) estimates that there is almost 100% probability that a 2012-type cold spell would lead to a Loss of Load situation in France.

Because ensuring security of electricity supply is an important issue, Anonymous believes that the elements contained in the E-Cube/EWI report on "2030 Peak Power Demand in North-West Europe" (published in September 2020) needs to be seriously considered in the analysis. Indeed, based on the same macro hypothesis than TYNDP 2020, this study has identified, for North-West Europe only, the possibility of a supply-demand gap by 2030 up to 70 GW of power during up to 250 hours. The cost of this curtailment that would affect large industrial sites as well as commercial and residential customers, could be estimated at to ~30 bn EUR, or ~0.4% of the annual GDP for North-West Europe.

Second, the proposed TYNDP 2022 scenario storyline includes quantitative ranges for some of the key storyline parameters for establishing scenarios that are very contrasted. Nevertheless, some of these key parameters remain quite qualitative at this stage although they have an extremely significant impact on the peak demands. They shall therefore be quantified.

<u>Response</u>: In the draft storyline report we wanted to include some quantitative parameters to illustrate the storyline. We acknowledge however that the availability of quantitative information at storyline level is rather limited. This is because we still have to perform our modelling. In the scenario report to be published in summer we plan to release more figures and more information.

This will in include an analysis of peak load. We like to point out that an assessment of security of supply part of scenario building, but rather in the scope of TYNDP.

Feedback: Heat pumps are critical since their performance (COP) and power output significantly decrease with low temperatures, which results in higher electricity demand. The real-life performance of heat pumps is of course difficult to assess, yet important (according to E-Cube/EWI report, lowering the COP of all heat pumps by 0.5 adds ~5 to 10 bn EUR to the cost of Energy Not Served).

Therefore, in order to have the best estimation of the COP, several important parameters should be made transparent and discussed as early as possible in the TYNDP process :

- The number of (electric) heat pumps and hybrid heat pumps and their unitary power ;
- For electric heat pumps, the temperature under which an electric resistance is needed to deliver additional power, thus impacting heavily the peak efficiency, and the efficiency in real conditions (with variable external temperatures) ;
- The share between air/air, air/water, and other heat pumps and their respective efficiency. For air/air heat pumps, the additional electric heating required for rooms that are not equipped with a split.

Response: In the draft storyline report we gave specific ranges for both all-electric and hybrid heat pumps. In the final storyline report we included some more specific information the relative shares of ground source and air source heat pumps within the all-electric category.

Feedback: The temperature dependence of electricity consumption (GW/°C) is expected to increase in all countries by 2030, especially at low temperatures. Indeed heat pumps will account for a higher share of electricity consumption vs resistance heaters and it is well known that their efficiency decreases at low temperatures. For this reason the choice of a relevant climatic set of scenarios is crucial. Gas industry is used to be dimensioned against a 2% or a 5% scenario (i.e. the worst case over 50 or 20 years). For the TYNDP 2022, a scenario containing Dunkelflaute events, at least as severe as the 2012 cold spell, should be considered and modelled to stress-test the scenario results.

Response: For electricity several climatic years are assessed to ensure security of supply. A dunkelflaute event is covered in the selection of climatic years. Gas demand is assess for yearly average, 2 week cold spell, dunkelflaute and design case (one in 50 or 20 years high demand). The demand levels for these climatic conditions will be provided in the scenario report to be released in later this year. The infrastructure assessment is part of TYNDP.

Feedback: Although, electric vehicles contribute less than electric heat pumps to peak demand during cold spells, an hypothesis should be taken regarding the fast charging infrastructure e.g. on highways, and the required constraints on drivers' behavior.

Response: Fast charging is considered in the electricity modelling.

Feedback: With the expected massive development of electric renewables (cf. figures announced in the offshore renewable energy strategy), energy flows are to change dramatically over the next years, with huge electricity generation sites far from main consumption centers. Because the deployment of this strategy may have a huge impact on grid losses during specific periods, considering that these losses are flat whatever the configuration of the networks is could be

considered as an optimistic working hypothesis. Anonymous believes that the roll-out of the offshore renewable energy strategy (but also the other strategies linked to the EU Green Deal) should be better taken into account and, more specifically, that this assumption on losses should be revised.

Response: The electricity grid losses taken into account in the scenarios derive from the historical situation of each country. The potential impact of new electricity flows linked to the energy transition is beyond the scope of the TYNDP 2022 scenarios. Nevertheless, the scenario report will highlight the approach use at this stage for transparency sake.

Feedback: Rural areas are assumed to accept major modifications of the landscape with the deployment of onshore wind and solar farms. Preserving the environment by using underground infrastructures, like pipelines (which might already be existing) transporting renewable and decarbonized gases, instead of overhead lines should be given a value and the lengths and footprints of new overhead transmission and distribution lines should be an output of the TYNDP 2022."

Response: Public acceptance is indeed a challenge to overcome in any transition path. Moreover, public acceptance is an important prerequisite for any technology participating to the decarbonization. As stated in the draft storyline report each storyline will face its 'own' challenges in this respect. Distributed Energy for example requires the public acceptance of energy infrastructures and hosting of massive RES deployment associated with the maximization of RES development across the whole Europe; Global Ambition on the other hand will require public acceptance and economic competitiveness of nuclear and CCS technologies within Europe.

7. Enel

Feedback: Enel welcomes that ENTSO scenarios are aligned with the European Commission impact assessment for increased ambition debate and net-zero emissions by 2050.
The increasing RES penetration and the digitalization of the energy system are essential processes to achieve the carbon neutrality by 2050, as deep electrification of end-use (transport, buildings and industry sectors) is an unprecedented opportunity to decarbonize the uses of energy.
Decarbonization targets are possible in 2030 and 2050 thanks to:

- recent technology improvement and reduced system cost
- increased RES deployment, flexible technologies and significant gains on energy efficiency
- smartening of infrastructure

Clean and smart electrification is the most cost-effective route to decarbonize large portions of total final energy uses. This is already valid for light-duty transport, domestic and water heating and cooling and many industrial and manufacturing processes.
The integration of electricity with final electric uses should be promoted more strongly as it provides much needed additional flexibility to manage increasing volumes of variable RES. When smartly integrated in a power grid, EVs, heat pumps and electric boilers can help by adjusting their demand profile based on price signals and providing a source of energy storage as well as demand response.
Direct electrification can be complemented by indirect electrification (Hydrogen and P2X technologies) to decarbonize hard-to-abate sectors. Green hydrogen produced by RES power via electrolysis is the only future proof sustainable solution. Hydrogen needs to be produced on a 100% RES basis and must be produced mainly locally.
The energy infrastructure needs to be enhanced and digitalized in order to exploit cross-sector synergies, leveraging on increased decentralization, electrification of end-uses and increasingly active consumers, ensuring at the same time adequacy, security and resilience.

In the end, effective EU policy design can support a clean and affordable energy transition and enhance the potential technologies have to increase EU decarbonization ambition.

Response: We fully agree

8. **Eurelectric**

Feedback: As a general comment, the quality of the report has improved compared to the previous one for the TYNDP 2020. ENTSOs are providing more explanations on the way to develop the storyline and are also clearer in the different concepts used. However, there are still room for improvement with regards the definition of the scenarios, and the matrix provided to illustrate the storylines which is hardly readable.

Eurelectric considers that the proposed storylines provide two stress test cases: on one hand, "Distributed Energy" Scenario which is extremely decentralized and utmost focus on energy "self-sufficiency" and on the other hand, "Global Ambition" which depicts a strongly centralized system and biased. While stress tests can be of interest to assess the resilience of the energy infrastructure, Eurelectric believes that none of them describes what could be the most probable scenario, which will likely be a combination of the two proposed scenarios (extreme cases that do not represent the alternatives in discussion across the energy system).

Response: It is not the task of the ENTSOG and ENTSO-E to define the most probable scenario. Instead energy infrastructure should be fit for purpose to support the energy transition while facing associated uncertainties. The storylines are designed in such a way that they capture a reasonable range of pathways covering the main uncertainties. Infrastructures are subsequently assessed against these different pathways to ensure their suitability independent of policy choices.

Feedback: Nonetheless, Eurelectric considers that the narrative of the scenarios should be neutral, as both are subject to similarly strong hypothesis on technology development and both lead to very different infrastructure deployment to assess through a CBA which is a critical step to define the feasibility and appropriateness of any alternative.
Eurelectric wonders whether the storylines have been developed and are in line with the EC strategies on Energy System Integration, Hydrogen or on Offshore Renewable Energy.

Response: EC strategies will be taken into account in the quantification of the scenarios.

Feedback: With regards the alternative "Prosumers or global synergies", Eurelectric believes that any source of flexibility in the future green electricity system is most welcome, so excluding either demand or supply side flexibility from one or the other scenario is from that point of view surprising. Therefore, Eurelectric kindly suggests a third scenario with best guess for extensive flexibility on both supply and demand sides, i.e. combining the best from the two scenarios.

Response: When we quantify our scenarios we will ensure sufficient flexibility in both scenarios. Purpose of the storylines is to highlight which flexibility options will be predominant in each of the scenarios. The other flexibility option not prescribed in the respective storylines will be limited but not (necessarily) excluded. Establishing and assessing a fourth scenario (in addition to NT, DE and GA) will not be feasible due to time and resource constraints.

Feedback: With regards the "energy intensity development", Eurelectric acknowledges that it is of utmost importance for the future requirements of the electricity system. However, the suggested implementation of energy intensity development in the scenarios may reduce their clarity rather than enhance it. Therefore, Eurelectric suggests for energy intensity to be moved to sensitivity analyses so that resilience of the scenarios with regards to energy intensity developments can be stress tested.

Response: During the storyline consultations several stakeholders suggested that the draft storylines showed too much variation in terms of energy intensity (efficiency, circularity, etc.). As a consequence, ENTSOG and ENTSO-E have adapted the storyline description accordingly. The final storylines for TNYPD 2022 show only limited difference on this scenario driver, Distributed Energy going only a little bit further that Global Ambition.

Feedback: With regards the matrix in annex, Eurelectric would like to comment on two risk factors:
o "Aviation and shipping - Synthetic liquids" are chosen as "Lower" in Scenario Global Ambition. But these fuels are produced centrally and may thus yield supply side synergies and flexibility. Shouldn't this be set to "Higher" for GA and "Lower" for DE?

Response: This is a fair point, therefore we adapted the storyline matrix in the Final Storylines report.
Feedback: "Low temperature heat demand – District heating (circularity)" is chosen as "Lower" in GA. District Heating may in many cases be seen as a central technology yielding synergies (CHP, storage) with other supply. Thus, Eurelectric wonders if it should be set to "Higher" for Scenario Global Ambition and "Lower" for Scenario "Distributed Energy".
Consequently, Eurelectric suggests revisiting these choices for these two risk factors in the scenarios, either by changing the choices made or by clarifying these choices.

Response: District heating is considered to be a technology option which is very region specific. Its development is often triggered by local authorities taking into account the energy potential of the surroundings (biomass, geothermal, solar, excess heat from industry, data centers…).

For this reason in terms we consider it as better fitting the Distributed Energy storyline. Beyond district heating supply shares, the scenarios could be differentiated based on the energy source of district heating. Distributed Energy could give a higher priority to local energy sources when Global Ambition could provide a higher share to electricity and gas coming from the European energy networks.

9. Oeko

Feedback: We would have welcomed the integration of one new storyline that describes a fully renewable energy system that is compatible with the Paris Agreement's 1.5°C target without relying heavily on CCS technologies or nuclear power.
It is surprising that the Distributed Energy storyline and the Global Ambition storyline with its higher importance given to gaseous energy carriers work with similar levels for small scale gas boilers in households.

Response: Both CCS and nuclear power will be minimized in the Distributed Energy scenario. The extent of this minimization will be defined at scenario level. The level of gas boilers are similar in both scenarios because market share is (close to) zero by 2050.

Feedback: We miss more substantial information regarding the energy demand in the draft storylines. Given the importance of reducing energy consumption, assumptions should be made clear. In order to be consistent with EU policies and targets, the storylines need to reflect how the energy efficiency first principle impacts the EU's energy system.

Response: As mentioned in the draft report the availability of quantitative data is rather limited at storyline level. That is because we first have to perform our modelling. Energy demand is an example of modelling output, which we currently cannot share yet. The outputs of our modelling will be included in the scenario report to be published in summer 2021.

Feedback: In view of data transparency, we suggest to publish all data under an open data license. In order to ensure comparability, for instance with National Long-Term Strategies of Member States, we request to publish also country-specific data for all storylines beyond 2040.

Response: Together with the final storyline report we also have published the Excel with all figures. The data we published are deemed to be freely available and available to the public. The data can be downloaded and saved free of charge. Country-specific data is not yet available at storyline level, but will be released later this year as part of the draft scenario report.

10. Iberdrola

Feedback: The construction of scenarios is a key tool to discuss potential long term outcomes and define the most efficient path to deploy the energy infrastructure. The elaboration of TYNDP 2022 incorporates the challenge of elaborating a joint vision for gas and electricity and deal, for the first time the issues of energy system integration and the future development of hydrogen facilities. However, the basic requirements stand globally the same. Independently of the definition of base scenario (BAU, current policies, etc.) and one or several extreme cases (not seemingly in this report for the moment), the scenarios for discussion should consist in equally plausible alternatives representing current views among stakeholders and regulators. This approach could build robust approaches to expected infrastructure based on consensus assumptions and finally to relevant CBA, to support their investment and construction through EU funds and consumer rates.
The scenarios presented in this storyline do not follow this scheme. The scenarios Distributed Energy (DE) and Global Ambition (GA) stand primarily on a hypothetical different focus as regards "energy self-supply" (DE) and "market imports openness" (GA), Such dichotomy is currently inexistent in the UE energy discussions. In addition, the market and import openness scenario (GA) is associated with a net bias towards gas.
In addition, the presentation of the narrative of scenarios is not complete if a tentative GHG emission profile and a first evaluation of the future infrastructure needs is not attached.

Response: We can only assess the impacts on GHG after we have performed our modelling. Such assessment will be part of the scenario report to be released in summer 2021. Assessment of infrastructure will be part of TYNDP.

The level of import dependency greatly affects energy infrastructure. As such it is concerned a very imported driver to be explored in the scenarios for TYNDP. Today almost 60% of gross inland energy consumption the EU comes from energy imports. How the import share will develop in the future is uncertain. Investments in domestic solar and wind capacity could decrease import dependency in the long run. However up until now that has not yet been observed. It is considered at least possibility that (part of) current import dependency will remain in the long run. This is

captured in the Global Ambition storyline. Global Ambition will see higher import compared to Distributed Energy. But most likely much lower imports than today.

11. **Anonymous**

Feedback: Anonymous appreciates the transparency efforts made by the ENTSOs and invites them to continue. This report aims to provide further quantitative information. However, this information is very imprecise, and it is difficult to identify trends.
The two envisaged scenarios are "extreme" scenarios which lead to a lot of use of the infrastructures. In order to identify the issues facing infrastructures, these scenarios are interesting to study. However, a more credible scenario, such as those presented in the LTS, could also be studied.

Response: Both Distributed Energy and Global Ambition storylines represent rather different pathways. However as presented in the report, the parameter levels proposed for the scenarios are taken from EC ETS and other third-party studies. As such they can be seen as credible extreme pathways. In addition, we will also develop a scenario based on national energy and climate policies for TYNDP (National Trends)

Feedback: ENTSOs should also provide more details regarding the competitiveness between energies. Finally, Anonymous wonders about the consistency between all the hypotheses presented. Indeed, the sources used are diverse and are each valid for a corpus of coherent assumptions. ENTSOs should explain how the reconciliation between these different sources is carried out. Anonymous also considers that more parameters related to the economic rationale should be included (merit-order, competitiveness of the various solutions, etc.). Anonymous would also like to draw the attention on possible connected vessels effect in the approach because there are coupled constraints between various fundamentals (for example taking values for biomass that could be used to other purposes).

Response: We plan to release the economic parameters used in our modelling as part of the scenario report to be published in summer 2021.

Feedback: Regarding Q6, the format and the level of explanation improves but room for improvement remains. These should be based on reliable references.

Response: We agree and we will continually learn and look for improvements.

Feedback: Regarding Q7, Anonymous would like to stress that the scenarios should explore to what extent the LTS objectives, which are a reliable reference, are not achieved. In fact, scenarios should not only be linked to a political objective but cover usual expectations so as to identify the no-regret options.

Response: Once we have performed our modelling, we will benchmark the outcomes against EC LTS and other studies.

Feedback: Regarding Q9, Anonymous observes that certain approaches remain partial () and that there should be trends.

Response: In the storyline report we wanted to include some quantitative parameters to illustrate the storyline. We acknowledge however that the availability of quantitative information at storyline level is rather limited. This is because we still have to perform our modelling. In the scenario report to be published in summer we plan to release more figures. We will than also show the trends from 2022 up to 2050.

Feedback: Regarding Q11, A 15% market share in passengers car segment for the FCEV is a very high limit. In addition, the Storylines report does not provide figure on the heavy vehicles while there are strong decarbonisation issues in this segment.

Response: FCEV for heavy duty transport will be considered in our scenarios. We will release more information in the upcoming scenario report.

12. **Edison**

Feedback: We would welcome a higher level of precision on gas imports (methane and hydrogen) until 2030 and between 2030 and 2050 even at the scenario stage.

Still it is very difficult to answer the question on the level of satisfaction of the ranges proposed, without having more detailed data (questions 17 to 21).

When some data are disclosed on the TYNDP 2020 basis, we would like to understand how these figures will evolve and potentially be modified in the TYNDP 2022 scenario.

The different scenarios proposed by the ENTSOs, Global Ambition and Distributed Energy are the two extreme pathways allowing to reach the objectives of zero net carbon emission by 2050. They rely on new technologies that are still not totally mature either from a technological point of view or an economical one. Therefore, there is always a risk to assess that the development of the technologies on a large scale does not occur as forecasted. In this case, not desirable, it should be considered the potentiality of a shift in the energy transition that could be illustrated by the introduction of a back-up scenario (comparable to the Italian “Business as usual” one, or the "current trend" scenario the ENTSO-e refers to, in its TYNDP 2020 document.

The importance of CCS/U should be better detailed. For example, some general principles should be addressed:

- will the CCS/U be implemented close to the consumption point or at the border?
- How the cost will be allocated?

Some technology substitution can allow to make important carbon saving as it is described in the ENTSOG TYNDP 2020 document recently published (for example substituting carbon intensive fuel like coal or oil with methane). This possibility should be mentioned in the scenarios’ development.

Response: In the storyline report we wanted to include some quantitative parameters to illustrate the storyline. We acknowledge however that the availability of quantitative information at storyline level is rather limited. This is because we still have to perform our modelling. In the scenario report to be published in summer we plan to release more figures and more information. For example of CCS, import and technology substitution in time. We will also benchmark our figures against TYNDP 2020 to illustrate changes in scenario editions.

The main role of scenarios is to be used at TYNDP and CBA level to support infrastructure assessment in line with the European energy policy. A scenario not reaching the carbon neutrality in 2050 would induce a lower stress on the energy infrastructures and therefore not help to identify the new projects required to achieve the climate and energy objectives.

13. Anonymous

Feedback: We are partly satisfied with the level of explanation in the Storyline Report. We understand that data is missing in this report because it will be presented at latter stages of the TYNDP 2022. Nevertheless, we would have found it useful to have the following information now:
- The exact sources of numbers used to produce the different figures;
- In the Decentralised energy scenario, you underlined that citizens would need to change their consumption habits. We would appreciate more details on how those changes in behaviours are modelized (heating temperatures, kilometer.vehicles, kilometer.tons, etc…);
- The mobility sector, hypothesis need to be completed to better understand the storyline:
1. On mobility, hypothesis related to heavy duty transport (passengers & goods) for both scenarios have to be indicated. Indeed, even if heavy duty transport is a much smaller market in term of number of vehicles, its energy consumption is anything but negligible, even more when most of passenger cars will be EV.
2. The market shares for gas mobility, separated by NGV and LNG, and the energy mix used in heavy duty transport should be indicated, as well as the emissions factors used.
3. We would like to see appear in the report the % of rapid charging station, and the number of vehicles by household. Have those questions been integrated in the grid constraints?

Response: In the Final Storyline Report we have included some additional information heavy goods transport. Please refer to the quantitative ranges chapter in the report. We can however not yet give a full energy picture or emissions at storyline level. This is because we still have to perform our modelling. In the scenario report to be published in summer we plan to release more figures and more information.

Feedback: We are partly convinced that these storylines provide a good overview of the challenges facing infrastructure development in the next thirty years.
- On one way, we strongly welcome the place given to hybrid heat pumps in the scenario, however its role as a demand side response technology should be better underlined. Hybrid heat pump is a flexibility option allowing to optimise the energy system and reducing grid investments;
- The current storylines do not present the role of gas and biogas mobility in the future despite being a strong solution for heavy duty transport and being pushed by the renewable energy target in RED II (advanced biofuel sub target);
- The figure 12 highlights the development of electrolysers (e-fuels and hydrogen), but we do not know how much of those electrolysers will be dedicated to Power-to-H2 and Power-to-CH4. It is essential to know the development potential of Power-to-CH4 because synthetic methane and hydrogen have different impacts on the development of infrastructures. On one side, retrofitting pipelines is necessary to welcome H2 whereas synthetic methane can be easily injected in existing networks, and;
- We believe that the National Trends scenarios should not stop to 2040 but to 2050 if we want to plan our infrastructures for next thirty years. If this plan do not present a vision after 2040, an indicative extrapolation should be considered.

Response: we had to strike a balance on which figures we could and could not include in the report. As you also mentioned it is not possible to provide a full dataset at this stage. However

more information of methane for mobility and (dedicated) electrolysis will be released later when we publish our draft scenario report in summer 2021.

Feedback: In the 2020 TYNDP scenario report, we had details figures with the gas mix (H2, P2G, P2M, biomethane). We would really appreciate seeing those figures in the next draft report.

Response: Yes, we will.

Feedback: In order to assess the strengthness of the 2 scenarios, we expect the final report to display some sensitivity analysis on main parameters, such as:

- Number of renovations
- Share of HHP vs HP
- share of HP vs condensated gas boilers
- Share of gas solutions in transportation (heavy duty)
- Available volumes of biomethane/H2 (both produced in Europe and/or imported)
- Possibly including a parameter modelling the social acceptance of renewable that could hinder the production goals in some countries.
- etc…

Response: In the draft storyline report we wanted to include some quantitative parameters to illustrate the storyline. In the final storyline report we have added some additional information on heavy goods vehicles to further illustrate the storylines. We acknowledge however that the availability of quantitative information at storyline level is rather limited. This is because we still have to perform our modelling. In the scenario report to be published in summer we plan to release more figures and more information.

Feedback: To further illustrate the role of hybrid heat pumps in reducing the electricity peak demand, we strongly suggest taking into consideration the conclusions of the E-Cube EWI study "2030 Peak Demand in North-West Europe". This study, in replicating the TYNDP hypotheses, has highlighted the risk for up to 70 GW of unanswered power demand and blackout risks over a period of several days with climate scenarios used by ENTSOE.

We think it could be very useful to provide "reality check" comparisons on some hypothesis, outside the pure energy world. It could provide an order of magnitude to the reader, of the transformation of the energy system needed to reach the modelled scenarios. For different renewable production, the goal would be to compare the current installed capacity to the projected one in an illustrated unit of measurement. For instance, for wind production, the study could provide an equivalent of projected production in number of mast/ land use, and for solar production a distinction between centralized PV/ land use and integrated to buildings PV. Eventually, a local acceptability constraint could be added.

Response: analysis of peak demand will be provided in the Scenario Report to be released in summer. Assessment of security of supply is part of TYNDP.

Feedback: Finally, to further develop the scenario, it would be interested to see how electricity and methane losses are considered in the scenarios.

Response: The electricity grid losses taken into account in the scenarios derive from the historical situation of each country. The potential impact of new electricity flows linked to the energy

transition is beyond the scope of the TYNDP 2022 scenarios. Nevertheless, the scenario report will highlight the approach use at this stage for transparency sake.

For gas the transmission and distribution losses are less than 1% of the gas demand. For that reason, these losses are not considered in the scenario energy balances. We will however consider methane leakage in the assessment of carbon emissions.

14. **Anonymous**

Feedback: With regards to question 7, we strongly urge the development of a most likely, central scenario with sensitivities on the parameters that are used to build the two 2050 scenarios. The current approach does not indicate a clear direction for steering investment projects. It is questionable why certain parameters (e.g. circularity improvements) have been attributed to a larger extent to one scenario rather than another.

Response: Due to the 2-year timeframe set by TYNDP process, we are unable to develop and assess a fourth scenarios. Within this constraint we have combined all relevant uncertainties in just two district storylines. Together with the National Trends scenario in line with national policies this scenario framework will cover the reasonable extremes.

Feedback: With regards to question 9, we are happy to see how the ranges have increased from the previous TYNDP scenario report. We strongly recommend studies that anticipate higher solar shares in line with stronger EU climate ambition.

Response: we are happy to have a look at all available studies. But please keep in mind that our quantitative ranges are based on more than one study in order to reflect consensus and avoid outliers. That is because our scenarios are in essence technology neutral and open to a wider range of technology inputs, rather than leaning on one particular technology or energy carrier.

Feedback: In regard to question 13, we generally agree with the technology selection, however we believe a larger roll out of batteries and distributed renewables should be shown in the scenario.

Response: The Distributed Energy storyline is designed to explore a high roll out rate of distributed renewables like for example solar pv. In the Final Storyline report we have increased the upper range for solar PV to give more flexibility to the investment loop defining the electricity generation capacity. The updated upper range is more in line with Energy Watch Group and PAC scenarios. More information can be found in the quantitative ranges chapter of the report.

Flexibility is slightly different to other key parameters in that the development of each flexibility technology is dependent from a wide range of other parameters still to be quantified. The amount flexiblity options including batteries is an output of the electricity market models used to help quantify in the next step of scenario building. In the scenario report to be published in summer we plan to release more figures and more information.

15. **National Grid Vent**

Welcome the fact that offshore wind capacity across all scenarios has been revised upwards and all scenarios point to exploring the pathway to achieving carbon neutrality by 2050

The evolution of offshore wind goes hand in hand with the network's capability to support larger influx of wind generation. Cross-border power links, multi-purpose interconnectors, and offshore wind hubs can play a vital role in facilitating the deployment of offshore wind at larger scale and meeting the climate targets. Consequently, we would like to suggest creating a separate section in the Storyline to provide wider coverage of key assumptions around network options to integrate larger amounts of offshore wind. A sub-section addressing the role of multi-purpose interconnectors in the North Sea Region would be an equally useful addition. This would provide greater level of detail about the optionality and flexibility the underlying transmission infrastructure can provide.

Additionally, we would like ENTSOE to shed more light on the rationale new low carbon technologies have been added. Are new technologies being adopted on the grounds of lower LCOE (cost-driven approach) or based on the fact that they can be dispatched profitably in a competitive market? Are there any adjustments need to be made to the current market design for those assets to be profitable and what is ENTSOE's view on market design under each scenario to facilitate the addition of more renewables and carbon-free technologies?

What is the metric for adding new technologies – is it purely cost driven (reducing LCOE/ Capex) or do they look at the assets' economics and make sure that they make money. Given the growth on renewable sources, do they assume changes on the current market design for those assets to be profitable – what are their views on market design under each scenario.

Concerning the significant increase in renewable energy capacity assumed in TYNDP 2022 we would like to make a proposal to extend the number of climate years taken into account in the modelling work (TYNDP 2020 modelling was based on three climate years). The increase in climate years could better quantify the challenges associated with intermittent electricity generation and help us extract more insightful modelling results.

Response: RES capacity in National Trends derived from the latest development at national level as reported by TSOs. For the Distributed Energy and Global Ambition scenarios, the deployment of wind and solar capacity is based on an investment loop taking into account the LCOE, low and high trajectories for each technology. These trajectories are the ones illustrated in the storyline report. Our approach does not make specific assumptions on the market design and the tool should select the technologies the most profitable from a system perspective.

The system resulting from the investment loop will be benchmark against a larger number of climatic years in order to ensure the adequacy of the electricity system.

Feedback: Ensuring future alignment and inclusion of third countries in the current and future planning of offshore wind infrastructure in the North Sea will provide benefits to the Member States. This will reduce the cost of infrastructure and maximise the social and economic benefits for all consumers on all sides of the North Sea. The wider integration and increased connectivity of the European energy network will help achieve the EU energy goals.

Projects such as multi-purpose interconnectors (MPIs), but also hydrogen (via steam methane reformer and electrolysers) and carbon capture and storage, will highly contribute to the achieving of UK & EU energy and climate targets. This would require further cooperation with European partners and alignment on the MPIs connecting clusters of offshore wind to cross-border electricity interconnectors, as they facilitate the delivery of renewable energy to market and serve as an interconnector when wind is not blowing.

Response: Cross-border alignment will be an important aspect of Europe's future energy infrastructure. The scenario building process is modelling the integration of various RES technologies across Europe. However, identification of system needs is part of the TYNDP rather than the scenarios. The Offshore Study in ETNSO-E TYNDP 2022 will be investigating the optimal configurations for offshore wind farm clusters, including MPIs and cross-border interconnection.

16. E3G

Feedback: Overall, as E3G already flagged in previous consultations' responses, the TYNDP process would hugely benefit from greater transparency. This should include:

- Publication of all input data (incl sources) and ideally an open-source model.
- Publication of network utilisation rates
- Academic peer review of the model and infrastructure gap analysis
- Publish all consultation response and your responses.
- Performance of energy infrastructure and evolution of energy needs under different paths of global warming, in particular regarding cooling and heating needs (see EEA and JRC modelling on this).

TYNDP scenarios should run a cross-sectoral optimisation of infrastructure needs by comparing costs and availability of all options, be it on the generation side, on the demand side (building renovation, appliance efficiency,…) or related infrastructure solutions (e.g. heat networks).

Response: The primary role of scenarios is to create a consistent dataset that can be used by the TYNDP process to assess infrastructure projects. Our work with the ILM will provide further evidence on the synergies and insights into competition between infrastructure needed to enable the energy transition to net-zero. Consultation responses will be published, including answers to the questions raised. All data sources have been stated in the report. Shall we also publish data used in the figures?

Feedback: The modelling does not give clarity over at what point which parts of the network switch over to hydrogen and what some of the critical success factors around that are (e.g. switch over of end-use appliances, ramp-up of H2 production capacity incl CCS if blue hydrogen is included). We recommend the TYNDP scenarios and infrastructure analysis to include these aspects going forward.

Response: Network utilization and infrastructure gap analysis are part of TYNDP assessment.

17. CAN Europe

Feedback: CAN Europe would have welcomed the integration of one new storyline that describes a fully renewable energy system that is compatible with the Paris Agreement's 1.5°C target without relying heavily on CCS technologies and on nuclear power.

Response: Both CCS and nuclear power will be minimized in the Distributed Energy scenario. Whether levels of zero are feasible we have yet to see with our modelling.

Feedback: Although we value the attempt to strengthen the variation of the storylines compared to the previous TYNDPs, there are still inconsistencies. The differences in industry's high-level driver

"energy intensity", assuming a variation in its growth and raw material demand do suggest that the Distributed Energy storyline with its stronger direct use of renewable electricity leads to a lower raw material demand and to less growth. Independently from the energy mix, industry anyway will continue to improve its competitiveness, optimise the efficiency of its processes and mobilise its energy savings potentials. Against this backdrop, it appears to be more coherent to assume these high-level drivers are similar. In contrast, it is surprising that the Distributed Energy storyline and the Global Ambition storyline with its higher importance given to gaseous energy carriers work with similar levels for small scale gas boilers in households.

Response: During the storyline consultations several stakeholders suggested that the draft storylines showed too much variation in terms of energy intensity (efficiency, circularity, etc.). As a consequence, ENTSOG and ENTSO-E have adapted the storyline description accordingly. The final storylines for TNYPD 2022 show only limited difference on this scenario driver, Distributed Energy going only a little bit further that Global Ambition.

The level of gas boilers is similar in both scenarios because market share is (close to) zero by 2050.

Feedback: We miss more substantial information regarding the energy demand in the draft storylines. Given the importance of reducing energy consumption, assumptions should be made clear. In order to be consistent with EU policies and targets, the storylines need to reflect how the energy efficiency first principle impacts the EU's energy system.

Response: As mentioned in the report we availability of quantitative data is rather limited at storyline level. That is because we first have to perform our modelling. Energy demand is an example of modelling output, which we currently cannot share yet. The outputs of our modelling will be included in the scenario report to be published in summer 2021.

Feedback: In view of data transparency, CAN Europe suggests to publish all data under an open data license. In order to ensure comparability, for instance with National Long-Term Strategies of Member States, we request to publish also country-specific data for all storylines beyond 2040.

Response: Together with the final storyline report we also have published the Excel with all figures. The data we published are deemed to be freely available and available to the public. The data can be downloaded and saved free of charge. Country-specific data is not yet available at storyline level, but will be released later this year as part of the draft scenario report.

18. Anonymous

Feedback: Anonympus would like to highlight that the 'value of time' and the 'cost of delay' are very important when developing scenarios. The Green Deal will lead to substantial increase in RES deployment requirements in all EU member states (from current 32% to 38-40% by 2030: this will mean that networks, that are planned for 2035 or 2040 have to be available already by 2030). It is critical that all scenarios align with the expected implications of the Green Deal.

Response: Both storylines will be compliant with the Green Deal.

Feedback: Both the DE and GA scenarios require continuous progress to be made over the next 10- and 30-year time horizons to ensure the grid is capable of supporting the forecast levels of demand

and RES generation. This requires essential projects to be delivered on time, and flexible solutions that can be adapted over time as the actual system needs change over time. The scenarios should take into account the impact that such rapidly deployable and flexible solutions have on the forecasted results of the GA and DE scenarios over the next decades.

Response: Rapid deployment of renewables and flexibility options will be considered in the storyline, most prominently in Distributed Energy.

Feedback: Finally, it should be considered whether the uptake of E-mobility is reflected sufficiently in the current scenarios.

Response: We will benchmark our figures (including E-mobility) against other third party studies.

19. Eurogas

Feedback: For the electricity grid losses, some assumptions are needed for considering some configurations of the network and electricity flows given the massive development of renewable production far away from main consumption centers.
Market players and end-consumers must be informed of the limits of the future grids, that will become more sensitive to climate events, both because of the generation side development (surge of renewables) and the demand development (expected surge of electric heating). In practical terms, this means identifying stress scenarios. These scenarios should include cold winter periods without wind, and periods when production is concentrated in an area located far from demand. These scenarios should reveal where bottlenecks arise, the likelihood of curtailments and the level of demand response required including individual behaviour changes if pertinent. In addition, assumptions on public acceptance should be clearly explained, as the fact people understand the energy system better may not mean they are willing to provide flexibility to it voluntarily at all times as some DSR assumptions seem to hint at.
Sensitivity and robustness analyses should be done to test infrastructures resilience to possible futures for gas and power systems.

Response: analysis of peak demand will be provided in the Scenario Report to be released in summer. Assessment of security of supply is part of TYNDP. For electricity several climatic years are assessed to ensure security of supply. A dunkelflaute event is covered in the selection of climatic years. Gas demand is assessed for yearly average, 2 week cold spell, dunkelflaute and design case (one in 50 or 20 years high demand). The demand levels for these climatic conditions will be provided in the scenario report to be released in summer 2021. The infrastructure assessment is part of TYNDP.

Public acceptance is indeed a challenge to overcome in any transition. Moreover, public acceptance is an important prerequisite for any technology participating to the decarbonization. As stated in the draft storyline report will each storyline face its 'own' challenges in this respect. Distributed Energy for example required the public acceptance of energy infrastructures and hosting of generation technologies associated with the maximisation of RES development across the whole Europe; Global Ambition on the other hand will require public acceptance and economic competitiveness of nuclear and CCS technologies within Europe.

Response: The electricity grid losses taken into account in the scenarios derive from the historical situation of each country. The potential impact of new electricity flows linked to the energy

transition is beyond the scope of the TYNDP 2022 scenarios. Nevertheless, the scenario report will highlight the approach use at this stage for transparency sake.

For gas the transmission and distribution losses are less than 1% of the gas demand. For that reason, these losses are not considered in the scenario energy balances. We will however consider methane leakage in the assessment of carbon emissions.

20. EMBER

No. Thank you for the opportunity to feedback. We look forward to enaging further in discussions about Europe's energy future, which will be pivotal in determining whether Europe achieves its climate goals.

21. AIGET

Feedback: We would welcome a higher level of precision on gas imports (methane and hydrogen) until 2030 and between 2030 and 2050 even at the scenario stage.
The importance of CCS/U should be better detailed. For example, some general principles should be addressed:

- will the CCS/U be implemented close to the consumption point or at the border?
- How the cost will be allocated?

Some data are disclosed on the TYNDP 2020 basis, we would like to understand how these figures will evolve and potentially be modified in the TYNDP 2022 scenario.
Some technology substitution can allow to make important carbon saving as it is described in the ENTSOG TYNDP 2020 document recently published (for example substituting carbon intensive fuel like coal or oil with methane). This possibility should be mentioned in the scenarios development.

Response: In the storyline report we wanted to include some quantitative parameters to illustrate the storyline. We acknowledge however that the availability of quantitative information at storyline level is rather limited. This is because we still have to perform our modelling. In the scenario report to be published in summer we plan to release more figures and more information. For example, for CCS, import and technology substitution in time. We will also benchmark our figures against TYNDP 2020 to illustrate changes in scenario editions.