Annex 7 - Other Comments

---Fortum Power and Heat Oy---

Feedback: *It is unclear why the final demand of electricity turns downwards in both scenarios from 2040 to 2050 at least for Finland, although electrification would most probably be a cheaper way than hydrogen to replace most of the still remaining fossil fuel use.*

The upward demand response possibilities (e.g. in electrolysis and by electric boilers in district heat production, incl. heat storage) and the flexibility potential in biomass power generation are not sufficiently included, which has resulted in too big curtailments of e.g. nuclear generation.

Response: Compared to the draft COP21 scenarios, final electricity demand further increases between 2040 and 2050. The impact of further direct electrification outpaces the downward effect of renovation in the space-heating sector.

The draft COP21 scenarios already modelled thermal storage in district heating, flexible biomass power generation and electrolysis. For the updated scenarios hydrogen storage management has been reviewed as well as the level of battery capacity. It results in a more flexible demand which indeed translates into lower RES curtailment and higher nuclear load factor.

---Germanwatch---

Feedback: *At the core of the narratives at the moment is the decarbonization of the electricity and gas system. However, from a climate-perspective the core aim of the narrative should be the efficient and socially just achievement of climate neutrality - and what kind of electricity and gas infrastructure we need for this. It would be great if this shift of perspective could be incorporated in the future.*

The role of gaseous energy carries seems to be overestimated from our point of view. We doubt that the amount of sustainable biomass assumed can actually be produced.

The expansion of nuclear capacities in the GA scenario is a very problematic political signal.

It remains unclear to what extent the future electricity and generally energy demand of the industrial sector has been looked at in detail.

Response: The narratives are tools to differentiate the two COP21 scenarios in terms of their effect on the need of infrastructure. To achieve the climate targets, we need decarbonisation of all energy including the electricity and gas system as well as increasing the efficiency and societal decisions, as the EU energy system will be increasingly shaped by the societal decisions and innovation. The two drivers of the COP21 Storylines 'driving force of the energy transition' and 'energy intensity' focusing on this narrative. Further details of the drivers can be reached on Final Storyline Report.

The role of gaseous energy carriers (methane and hydrogen) is in line with the scenarios of the European Commission Impact Assessment. Based on stakeholder feedback, the level of biomass consumption has been reduced in the updated Distributed Energy scenario. As a result, both COP21 scenarios are now below the Impact Assessment.

The expansion of nuclear in the Global Ambition scenario is in line with the storyline of the scenario which relies on a more diverse approach in terms of decarbonisation technologies. It also helps to cover the range of possible national policies. In addition, new reactors have been considered only in countries where actual projects exist, and no phase-out policy has been decided. The resulting level in 2050 is within the range of European Commission Impact Assessment scenarios.

Demand in the industry sector has been divided into 5 subsectors: low enthalpy heat, steam processes, electric appliances, other processes and non-energy use. The evolution of energy carriers in each subsector is based on the JRC Central Scenario and TSOs contribution on country specifics. It translates into energy shifts:

- from oil and coal to methane, hydrogen, biomass, electricity and distributed heat;
- from methane to hydrogen and electricity.

The shift towards electricity processes also results into higher end-use efficiency.

---WindEurope---

Feedback: *The flexibility options from renewable power plants and collocated power plants (wind/solar and potentially storage) were not mentioned. In the case of wind turbines new technologies and new capabilities are expected to be brought to the market soon (e.g. grid forming capabilities, storage directly integrated at wind turbine level). Wind farms can provide local downward flexibility (flexible connections e.g. Belgium, France, Netherlands) balancing or frequency regulation (e.g. UK, Ireland, Germany, Ireland, Belgium), voltage control and later other commodities related to inertia and black start (e.g. stability pathfinder in the UK). Offshore, next-generation infrastructure such as hybrid (wind farms connected to interconnectors or grid hubs) will also enable additional flexibility.*

Furthermore, the share of DSR as a flexibility source is too low. The scenario doesn't say what is included in the DSR. In the scenarios DSR is estimated at around 5 TWh in 2050 or just over 0.1% of final electricity demand. However, numerous different sources for flexible/responsive demand already exist, for example in heating, various residential uses and from the industry. A more flexible demand side will support building out the large, required amounts of variable renewable power and be a very important balancing tool in addition to flexible power generation, batteries, and grid/interconnection expansions.

ENTSO-E and its TSO members need to consider non-grid solutions also in order to achieve the 55% target in 2030 and carbon neutrality in 2050.

Response: The TYNDP Scenario report only investigate hourly adequacy at bidding zone level. As a result, frequency regulation and grid-forming capability are beyond the scope of the scenarios for all technologies. In addition, the methodology does not assume any specific location and connection of

RES. For example, wind, solar and battery capacity connected to a given bidding zone can cover both collocated and non-collocated assets.

The DSR category only covers pure demand shedding. Its role has been reviewed upward through a decrease in the activation cost. In addition, COP21 scenarios explicitly model V2G and prosumer batteries and thermal storage is taken into account in district heating. The use of downstream flexibility will be made more explicit in the updated **TYNDP 2022 Scenarios Report.**

---Enel SPA---

Feedback*: We appreciate the improvement made in terms of transparency and clarity, but our issues and perplexities are the same than in previous consultations. We notice that the scenarios remain quite unvaried and static in terms of assumptions, results and overall path building compared to previous exercises.*

Response: Thank you very much for the appreciation of the improvement on transparency and clarity. The COP21 scenarios aim at a meaningful differentiation based on their respective storyline. As a result, some storyline drivers may counteract each other (e.g. higher hydrogen demand in Global Ambition resulting from a wider range of technologies does not result in higher electrolysis capacity as it is compensated by higher hydrogen imports).

As a difference from other publications, COP21 scenarios do not intend to promote a specific technology. Nevertheless, it achieves a significant contrast on some key parameters:

- Final electricity demand in 2050 is 12% higher in Distributed Energy than in Global Ambition (16% higher when taking also into account electrolysis)
- Final methane and hydrogen demand in 2050 is 30% higher in Global Ambition than in Distributed Energy
- Wind and solar (resp. battery) capacity in 2050 is 40% (resp. 70%) higher in Distributed Energy than in Global Ambition

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--- Climate Action Network (CAN) Europe---

Feedback: *The widespread roll-out of hydrogen and partly the reliance on carbon capture and storage technologies contradicts the TYNDP's 'Energy Efficiency First' claim. One of the two top-down scenarios should have assessed the costs and benefits of a more ambitious direct electrification with renewable electricity instead of allowing high losses from the introduction of hydrogen in sectors where more efficient alternatives for decarbonisation could be used. The presentation of hydrogen as a 'game changer' that 'can unlock the full potential' of renewables is questionable because the growth of variable renewable electricity generation is the driver of energy transition that alone allows for the production of hydrogen with a climate benefit at all. Renewable hydrogen is without any doubt an important energy carrier in certain hard-to-decarbonise sectors but hydrogen as such it is not a prerequisite for deploying renewable energy resources.*

CAN Europe would have welcomed the integration of one new storyline that describes a fully renewable energy system. That storyline would be compatible with the Paris Agreement's 1.5°C target without relying heavily on CCS technologies and on nuclear power (see Climate Analytics' 1.5°C pathways for the EU and its Member States, building on CAN Europe's Paris Agreement Compatible (PAC) scenario, October 2021, https://climateanalytics.org/publications/2021/15c-pathways-for-europe-achieving-the-highest-plausible-climate-ambition).

The role of nuclear power is in line with the assumptions laid out in the TYNDP Storyline Report. We however would like to question again the assumption that an important number of new reactors would be added to the EU grid as unrealistic. With higher shares of variable renewable electricity generation, the economic attractiveness of existing nuclear capacities will decline while operation costs will rise. Investment in modernisation and maintenance costs are higher than the expected future income from wholesale markets. The likeliness that nuclear power could benefit from sufficient national support schemes appears to be small and limited to a minority of Member States. Against this backdrop, an earlier and stronger decrease of capacities is realistic. This should be reflected in the TYNDP 2022 scenarios. The TYNDP 2022 assumptions on investment costs for new nuclear power capacities and their construction time are not clear. The assumption that nuclear fuel costs despite an accelerated addition of capacities remain on a stable level also deserves further analysis.

Regarding the modelling on the gas side, it is not clear whether the emissions from methane leakage in particular along the methane extraction, transmission and distribution chain have been integrated appropriately in the assessment of greenhouse gas emissions. As methane (including its imports) plays an important role in both the Distributed Energy scenario and the Global Ambition scenario, the relevance of the leakage from the gas infrastructure should be made transparent.

The strong increase of hydropower capacities in the EU27 until 2050 does not appear to be realistic as the potential for additional hydropower capacities is limited by space, regulatory frameworks and by the impact of climate change on water availability.

Response: All together the two COP21 scenarios aim to capture contrasted path for energy demand and supply towards carbon neutrality and to provide insight on challenges that infrastructures will face during energy transition. They also need to reflect the European Commission latest scenarios available when building scenarios in order to support enhanced consistency between infrastructure project assessment and European strategy. For this edition, the main benchmark is therefore the EC Impact Assessment REG and CPRICE scenarios.

Regarding direct electrification and the level of hydrogen (being for final demand, power generation and upgrade to synthetic fuels), the COP21 scenarios are consistent with European Commission assumptions. Following stakeholder feedback on further electrification especially for the heavy truck segment, direct electrification in the updated Distributed Energy scenario is 52% which is above REG scenario and draft report level.

While European wind and solar generation is at the basis of the decarbonisation of the energy sector, the level of curtailed energy increases with their penetration. In that respect, hydrogen provides a solution to decarbonize sectors where for example energy density is key, and it can also provide a significant amount of flexibility mitigating the curtailment challenge.

The prolongation of existing nuclear fleet and the construction of new reactors is an option kept opened in some Member States which goes beyond the sole power plant economics. The Global Ambition scenario reflects this situation while reflecting phase-out policies were decided and it only considers new reactors where such projects exist. Regarding the presence of a residual fleet of existing nuclear reactors in 2050 in Distributed Energy, it supports RES development by giving more time to reach a fully renewable electricity system if desirable and by providing a low carbon flexibility source at least at seasonal level through maintenance scheduling. Considering the benchmark with the EC Impact Assessment, nuclear capacity in Distributed Energy level is five time lower than the lowest EC Impact Assessment scenario while Global Ambition and REG scenarios see the same level.

Non-CO2 emissions, including methane ones, are taken from the EC Impact Assessment study. Taking into account that the overall methane consumption in COP21 scenarios is lower than in European Commission scenarios, the selected approach could result in an overestimation of those emissions.

Hydropower capacity increases by 10% between 2025 and 2040 with no development taken into account beyond this time horizon. Such evolution reflects national plans and seems to be a reasonable challenge when looking at the value of low carbon flexibility beyond few hours. Power generated from hydro plants increases faster (up to 20%) due to a higher number of pumping-turbining cycles of pump storage to support wind and solar development.

--- Oeko-Institut---

Feedback*: Our main remark that summarises our comments is that at least one scenario should be considered that foresees higher electrification supplied by a strong increase of wind and pv installation, with less biomass and nuclear in the system and a minor role of CCS technologies. From our perspective this is necessary to consider all possible developments in the European infrastructure planning.*

Response: The Distributed Energy scenario reflects in many aspects such pathway. On the mentioned criteria it exceeds the EC Impact Assessment scenarios (higher direct electrification and RES production, lower use of biomass, nuclear and CCS).

Based on stakeholder feedback direct electrification and RES capacity have been increased compared to the draft scenario while the use of biomass has decreased. This energy source continues to have a significant role as it contributes to energy autonomy based on European renewable which is one of the storyline drivers.

--- Eurelectric---

Feedback: *It is unclear why the final demand of electricity turns downwards in both scenarios from 2040 to 2050, although electrification would most probably be a cheaper way than hydrogen to replace most of the still remaining fossil fuel use.*

The upward demand response possibilities (e.g. in electrolysis and by electric boilers in district heat production, incl. heat storage) and the flexibility potential in biomass power generation in certain countries are not sufficiently included, which has resulted in too big curtailments of e.g. nuclear generation.

One key element of the energy transition is that the market players across sectors (electricity and gas, but also heat and other industrial sectors) will be the driving forces for these industrial changes. The infrastructures will have to be adapted to their needs, in a cost-efficient way (and not the other way round). The current practice of ENTSO-E and ENTSO-G might not be fully in line with such a market-driven view. They focus on the needs for their own infrastructure (electricity and gas) without strong requirements for the economic viability of the underlying market-related assumptions (existing assets, business development based on market signals…).

*The cost dimension is also missing: the financial impacts of choices made (separately) by ENTSO-E and ENTSO-G in the their exercise on the consumers (residential, services and industrials) is **under-considered** (e.g. impacts on peak demands, optimized use of existing infrastructure). Consequently, the cost benefits of a sound complementarity of energy systems are not sufficiently investigated. For instance, the electricity and gas systems are complementary for managing some stress events (e.g. Dunkelflaute events) and, more generally, for building up a cost-efficient and resilient energy system (cfr energy system adequacy, not only electricity or gas).*

Response: Compared to the draft COP21 scenarios, final electricity demand further increases between 2040 and 2050. The impact of further direct electrification outpaces the downward effect of renovation in the space-heating sector.

The draft COP21 scenarios already modelled thermal storage in district heating, flexible biomass power generation and electrolysis. For the updated scenarios hydrogen storage management has been reviewed as well as the level of battery capacity. It results in a more flexible demand which in deed translates into lower RES curtailment and higher nuclear load factor.

While the role of TYNDP scenarios is to support the assessment of energy infrastructures (not only transmission but also storage ones), the scenario building process focuses on the driving forces of the energy transition. It is not achieved through an economic overall optimization as it is beyond the capability of ENTSO-E and ENTSOG as part of a 2-year process and that many aspects are only partly cost-driven (public acceptance, prosumer behavior, energy autonomy...). For this reason, a cooperative and iterative process has been put in place to build storylines then scenarios with stakeholders (market players, NGOs, technology providers…). Such process defines the main drivers of scenario quantification: energy demand, downstream flexibility and RES range. Electricity and gas transmission only intervenes as second order factors in the expansion model used to build scenarios.

While there is no cost estimation of the demand and distribution part of the scenarios, the expansion loop used to build the electricity and hydrogen part is based on a cost optimisation infrastructure candidates. Such process ensures the complementarity of energy systems and take into account demand-side flexibility such as V2G, prosumer batteries, thermal storage on district heating, electrolysers... The updated report also provides a view of the adequacy of the energy system under stresses situation such as a Dunkelflaute event.

---EDF---

Feedback: *The production of biomethane in France in 2030 is between 69 TWh (GA) and 85 TWh (DE). These levels of production are much higher than the previous TYNDP. Moreover, the French NRA (CRE) has just launched a public consultation concerning the ten-year development plan for French gas network and the assumption of production of biomethane for 2030 is between 30 TWh (consistent with*

French strategy) and 49 TWh. The French regulator considers that the highest scenario is not justified enough from an economic point of view. Therefore, it is surprising that both scenarios of the TYNDP have such high trajectories, also much higher than defined in the French energy strategy.

EDF regrets that the cost dimension is not explored as it should: the financial impacts of choices and assumptions made by ENTSO-E and ENTSO-G in their demand exercise (on residential, services, transport and industry) lead to think that it was under-considered or not sufficiently investigated. A TCO analysis on some of choices (on heating options, for example) would have been more than welcomed.

Response:

The TYNDP scenarios do not aim at selecting a preferred pathway to carbon neutrality which would require an overall cost estimation. Scenarios aim at providing contrasted paths to be used for infrastructure assessment in TYNDP and CBA.

Based on your feedback, we have revised the biomethane production in France and reduced it in the Distributed Energy scenario for 2030 down to 54 TWh. This figure represents the vision from French gas network operators.

--- smartEn (Smart Energy Europe)---

Feedback: *smartEn welcomes the invitation by ENTSO-E to comment on the TYNDP 2022 Draft Scenario Report. We appreciate the work done and the progress made. However, smartEn has identified a series of issues in the current proposal and scope of the report that need to be addressed.*

Scenario building

smartEn appreciates the effort gone into creating different scenarios by ENTSO-E and ENTSO-G for the TYNDP 2022. However, the justification why the chosen scenarios are required is not always understandable. While the final targets in both scenarios are a logical conclusion of the Paris Agreement, it is not very clear why the two different scenarios are necessary for the network planning, instead of working towards one common path that reaches the targets.

If we are to reach 55 % GHG emission reductions by 2030 and net zero by 2050, a combination of electrification, use of distributed flexibilities and low carbon energy will be required, rather than separate pathways as the scenarios seem to imply.

smartEn urges ENTSO-E and ENTSO-G to agree on a single scenario that focuses on reaching the Paris Agreement targets using the most cost-efficient and effective technologies already available today.

Cost-comparison between scenarios

The presented scenarios have a significantly different approach as to which technologies will be used and what kind of levers will help reach the change required to reach the COP21 targets. While the Distributed Energy scenario relies seemingly more on electrification and relying on decentralised technologies that already exist and are competitive, the Global Ambition scenario seems to rely on the use of decarbonised technologies and a heavy investment in decarbonised hydrogen, a technology that will require significant amount of investments to become competitive.

If both separate scenarios are continued to be used, ENTSO-E and ENTSO-G should provide a comparison of what the energy transition will cost in each of the scenarios. This goes beyond the energy costs already presented in the TYNDP 2022 Draft Scenarios, and should also reflect on system costs incurred, and the impact different technologies could have in reducing those costs.

<u>Scenario drivers</u>

The driving forces between both COP21 compliant scenarios seem to place the responsibility of change on wildly different parties, with different levels of resources and levers to enact that change. The Distributed Energy scenario relies heavily on way-of life changes, local initiatives by citizens, communities and businesses and willingness to change to RES. While the Global Ambition scenario focuses on change driven by the European Union. Comparing the potential to enact change from both these actors is unreasonable. While behavioural changes are necessary, legislative action is necessary at EU and national levels for both scenarios. Market parties will be able to provide innovative services to help consumers change their patterns and actively participate in all energy markets. However, the burden of change should not only be on the market and consumers, to avoid a slow-moving pace and a lack of coordination between countries. Legislation needs to accompany and remove barriers still limiting market access.

The driving forces of both scenarios should be a robust regulatory approach by the European institutions that work together with Member States taking into account their specificities, to facilitate market parties in providing innovative services to encourage both behavioural changes and easy market access by the end consumer. This should facilitate peer-to-peer trading within and among energy communities, which will lead to greater individual investment in renewable resources, more optimal use of these resources, and reduced burden on the grid.

<u>Gas-centric scenario</u>

In a context of high energy prices caused majorly by the volatile gas prices, continuously relying on the import of natural gas in the Global Ambition scenario is unrealistic, contrary to a system efficiency perspective and seemingly contrary to the EU interests of affordable energy supply. In this context, the European Commission in its Communication on the 13 of October 2021 "Tackling rising energy prices: a toolbox for action and support" expressed the importance of using demand side flexibility tools to address this crisis.

Any future scenarios should fully value already available and competitive technologies like storage, smart charging, V2G, and demand response and use them as the primary flexibility tool for a clean and affordable energy transition. Furthermore, strong reliance on gas imports assumes that a large part of burden of decarbonisation is transferred to countries located outside of Europe, while keeping similar, or slightly reduced, gas consumption patterns as today.

<u>Setting the right electrification priorities</u>

The current assumptions in both COP21 compliant TYNDP scenarios are lower than the 60% electrification reached in other organizations' scenarios (e.g. Eurelectric and Wind Europe). The Distributed Energy scenario assumes a 46% of final energy demand in 2050 and 39% for the Global Ambition scenario. smartEn believes that the TYNDP should explore all options, including a much higher level of electrification. This should include a more ambitious smart electrification level to ensure the achievement of emissions reduction targets while relying on flexible end-users, including at community level. This would also allow the demand side to play a more important role in decarbonising *the energy system. It should be clearly recognised that – opposed to other energy conversions - direct electrification, supported by the flexibility from DERs, is typically the most efficient and cost-effective solution in an increasingly renewables-based energy system, wherever it can be applied.*

smartEn remains at your full disposal to further discuss our concerns with the TYNDP 2022 drafting of the scenarios process, and encourage ENTSO-E to continue with a thorough stakeholder involvement process that reflects in an improvement of the scenarios.

Response:

We thank you SmartEn for the appreciation of the progress and also for valuable feedbacks.

Scenario building and drivers

TYNDP Scenario report intends to provide a robust basis for infrastructure assessment. Taking into account on the one hand the wide range of opinions from market players, civil society and policy-makers across Europe and on the other hand the high uncertainty inherent to the energy transition, there is the need to defined several pathways. The actual path will certainly combine many aspects of the TYNDP Scenario report. In any case, the COP21 scenarios all rely on a higher electrification fostered by a strong RES development and the development of demand-side flexibility. Scenarios activates the same levers, only their relative magnitude differs from one scenario to the other (e.g. V2G development, nuclear capacity, energy imports...).

ENTSO-E and ENTSOG share your view regarding the role of policy-makers in addressing many of the energy transition challenges. It is explicitly identified as part of the first highlight of the report Executive Summary.

Cost comparison between scenarios

There is no overall cost estimation of the scenarios as it goes beyond the remit of ENTSOG and ENTSO-E as part of the TEN-E regulation, and it would exceed the 2-year timeframe set by regulation. For this reason and to ensure the consistency of infrastructure development with EC strategy, COP21 scenarios are kept close from EC Impact Assessment scenarios.

Gas-centric scenario

In both COP21 scenarios the amount of natural gas imports reduces sharply over the years. As Distributed Energy focusses on energy autonomy the natural gas imports reduce to zero in 2050. In the Global Ambition storyline energy imports play a bigger role. However also in this scenario the natural gas import is only a fraction of todays' level. Furthermore, the natural gas imports in 2050 are below the level in the EC Impact Assessment benchmark.

Setting the right electrification priorities

Both COP21 scenarios rely on the development of electrification, distributed flexibilities and low carbon energy production. Regarding electrification, draft Distributed Energy and Global Ambition achieved a direct electrification above EC Impact Assessment respective benchmark. The 45% of the draft Distributed Energy include ambient heat captured from heat pumps as part of the overall energy. Without the inclusion of ambient heat, direct electrification would reach 49%. Based on stakeholder feedback, the updated Distributed Energy sees a higher direct electrification reaching 52% disregarding ambient heat.

Such levels are consistent with the Wind Europe scenario where the 62% electrification rate includes electrolysis-based fuels.

Demand-side response are included in both scenarios and cover V2G, prosumer battery combined with rooftop PV, demand shedding, thermal storage on district heating and electrolysers. Distributed Energy puts a stronger emphasis on those technologies and the udpated scenario report will help to better identify their role in the system adequacy.

--- Environmental Action Germany (Deutsche Umwelthilfe e.V., DUH) ---

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Feedback: *The widespread roll-out of hydrogen and partly the reliance on carbon capture and storage technologies contradicts the TYNDP's 'Energy Efficiency First' claim. One of the two top-down scenarios should have assessed the costs and benefits of a more ambitious direct electrification with renewable electricity instead of allowing high losses from the introduction of hydrogen in sectors where more efficient alternatives for decarbonisation could be used.*

The presentation of hydrogen as a 'game changer' that 'can unlock the full potential' of renewables is questionable because the growth of variable renewable electricity generation is the driver of energy transition that alone allows for the production of hydrogen with a climate benefit at all. Renewable hydrogen is without any doubt an important energy carrier in certain hard-to-decarbonise sectors but hydrogen as such it is not a prerequisite for deploying renewable energy resources.

DUH would have welcomed the integration of one new storyline that describes a fully renewable energy system. That storyline would be compatible with the Paris Agreement's 1.5°C target without relying heavily on CCS technologies and on nuclear power (see Climate Analytics' 1.5°C pathways for the EU and its Member States, building on CAN Europe's Paris Agreement Compatible (PAC) scenario, October 2021, https://climateanalytics.org/publications/2021/15c-pathways-for-europe-achieving-the-highest-plausible-climate-ambition).

The role of nuclear power is in line with the assumptions laid out in the TYNDP Storyline Report. We however would like to question again the assumption that an important number of new reactors would be added to the EU grid. Except from those nuclear power plants that are currently under construction, it is not realistic to expect important additions of capacities. With higher shares of variable renewable electricity generation, the economic attractiveness of existing nuclear capacities will decline while operation costs will rise. Investment in modernisation and maintenance costs are higher than the expected future income from wholesale markets.

The likeliness that nuclear power will benefit from sufficient national support schemes is appears to be small and limited to a minority of Member States. Against this backdrop, an earlier and stronger decrease of capacities is realistic. This should be reflected in the TYNDP 2022 scenarios. The TYNDP 2022 assumptions on investment costs for new nuclear power capacities and their construction time are not clear. The assumption that nuclear fuel costs despite an accelerated addition of capacities remain on a stable level also might deserve further analysis.

Regarding the modelling on the gas side, it is not clear whether the emissions from methane leakage in particular along the methane extraction, transmission and distribution chain have been integrated appropriately in the assessment of greenhouse gas emissions. As methane (including its imports) plays *an important role in both the Distributed Energy scenario and the Global Ambition scenario, the relevance of the leakage from the gas infrastructure should be made transparent.*

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Response: All together the two COP21 scenarios aim to capture contrasted path for energy demand and supply towards carbon neutrality and to provide insight on challenges that infrastructures will face during energy transition. They also need to reflect the European Commission latest scenarios available when building scenarios in order to support enhanced consistency between infrastructure project assessment and European strategy. For this edition, the main benchmark is therefore the EC Impact Assessment REG and CPRICE scenarios.

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While European wind and solar generation is at the basis of the decarbonisation of the energy sector, the level of curtailed energy increases with their penetration. In that respect, hydrogen provides a solution to decarbonize sectors where for example energy density is key, and it can also provide a significant amount of flexibility mitigating the curtailment challenge.

The prolongation of existing nuclear fleet and the construction of new reactors is an option kept opened in some Member States which goes beyond the sole power plant economics. The Global Ambition scenario reflects this situation while reflecting phase-out policies were decided and it only considers new reactors where such projects exist. Regarding the presence of a residual fleet of existing nuclear reactors in 2050 in Distributed Energy, it supports RES development by giving more time to reach a fully renewable electricity system if desirable and by providing a low carbon flexibility source at least at seasonal level through maintenance scheduling. Considering the benchmark with the EC Impact Assessment, nuclear capacity in Distributed Energy level is five time lower than the lowest EC Impact Assessment scenario while Global Ambition and REG scenarios see the same level.

Non-CO2 emissions, including methane ones, are taken from the EC Impact Assessment study. Taking into account that the overall methane consumption in COP21 scenarios is lower than in European Commission scenarios, the selected approach could result in an overestimation of those emissions.

Hydropower capacity increases by 10% between 2025 and 2040 with no development taken into account beyond this time horizon. Such evolution reflects national plans and seems to be a reasonable challenge when looking at the value of low carbon flexibility beyond few hours. Power generated from hydro plants increases faster (up to 20%) due to a higher number of pumping-turbining cycles of pump storage to support wind and solar development.

---Ørsted---

Feedback: To summarize, here are our 5 key messages:

1. Lack of vision for future infrastructure such as offshore grids and hybrids

It is becoming ever clearer that offshore grids, hybrids and hubs (energy islands) are a crucial part of future infrastructure. This has been acknowledged in EU Offshore renewable e nergy strategy Of course, the approach used in the TYNDP report may not forecast grid capacity needs. However, the report is used for infrastructure and grid planning. As a result, the report must not forgo the vision of future offshore electricity infrastructure. Instead, the TYNDP has the unique potential to incorporate trends such as offshore grids and hybrids.

2. 'National Trends' is not compliant with the Paris Agreement and EU law

The European Climate Law "writes into law the goal set out in the European Green Deal for Europe's economy and society to become climate-neutral by 2050, and to reduce net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels." (European Commission 2021). However, NT is not compliant with this law as the emissions trajectory exceeds any pathway for carbon neutrality by mid-century. Since NT is used for planning, it could become a self-fulfilling prophecy in which planning and funding would go towards a non-compliant scenario, which would in turn make it even more difficult to reach that target. Therefore, it is of utmost importance that NT is only used as a baseline scenario, and not for planning. For planning use, a scenario compliant with the European Climate Law and the Paris Agreement must be developed. If one of the DE or GA scenarios are used for planning purpose, there is also a risk that planning based on one for them excludes elements from the other one.

3. Limited Electrification

Electrification rates should be more in line with the trajectories identified by the European Commission. To begin with, methane demand (0.5-1 PWh in 2050) is estimated to be overoptimistically high due to use in residential and industry - where already today the potential for direct electrification is enormous. Furthermore, ~50% of heavy trucks in 2050 are still internal combustion engine, while there is slow uptake of BEVs in the passenger cars in the 2020s and 2030s. This both stands in contrast to carbon-neutrality, and fails to reflect rapid developments in vehicle electrification (direct and in-direct).

A solution could be having one of the scenarios focused on electrification as the main measure for decarbonizing in order to show that direct electrification will be more energy efficient than indirect electrification through other means.

4. Almost no role for Demand side response (DSR)

The potential for demand side response should be higher. In the scenarios DSR is estimated at around 5 TWh in 2050 or just over 0.1% of final electricity demand. However, numerous different sources for flexible/responsive demand are likely to exist, for example EV charging, heating, various residential uses and from industry. A more flexible demand side will support building out the large, required amounts of variable renewable power and be a very important balancing tool in addition to flexible power generation, batteries and grid/interconnection expansions.

5. Low Electrolyser capacity and high load factors

Installed electrolyser capacity is assumed to be below the EU impact assessment scenarios (over 500 GW) at 324 GW in DE and 285 GW in GA by 2050. Most of this capacity is expected to be grid connected with only a fraction being connected to dedicated renewable capacity. Hydrogen supply is close to

1600 TWh in DE and around 1400 TWh in GA. This implies a load factor of the electrolysers would need to be around 80% on average.

Electrolysers will be grid-connected, but our assessments (happy to share) suggest that electrolysers are playing a larger role in RES integration. That implies load factors that are typically lower than 80%, since the dispatch of the electrolysers is price-sensitive. We would also recommend to have a look at the EC work on how an energy system in 2050 with mainly variable generation could look like. (METIS Studies, Study S14). With a load factor of around 80% it is hard to see that this could be met with solar and wind power alone with the consequence that the electricity used may in period have to come from thermal plants.

Response:

Offshore - The scenario report identifies a level of offshore capacity in each national area without predefining the connection design. This will be analysed at the TYNDP stage of the process.

National Trends – As set by the TEN-E regulation the set of scenarios should reflect national policies and strategies. It is the role of the National Trends scenario capturing national vision as stated end of 2020. For some countries, such scenario is already in line with carbon neutrality in 2050. The regulation also requires consistency with European climatic ambition, for this reason National Trends is completed with the COP21 scenarios achieving carbon neutrality in 2050. As such the TYNDP Scenario report enables the assessment of infrastructure projects for all three scenarios. It will be up to the Regional Groups to define the most meaningful approach for the assessment of Project of Common Interest candidates.

Limited electrification - The overall level of methane (final demand and power generation use) is lower than in EC Impact Assessment scenarios (see benchmark in §6.4.1). COP21 scenarios assume a more direct use of gas in final demand while the adequacy of the electricity system relies less on methane than in European Commission scenarios.

On the 2020-2030 period, last edition of scenarios was criticized for the unrealistically high uptake of BEV. It has resulted in a lowering of the 2030 target as indicated during the storyline process while increasing the 2050 target. For heavy trucks there is indeed a low contrast between scenarios at vehicle engine level. Based on stakeholder feedback, the updated Distributed Energy scenario shows a higher direct electrification of heavy trucks (54% in 2050, including hybrid vehicles). COP21 scenarios are more electrified than their European Commission counterfactuals. Such contrast is reinforced for the updated Distributed Energy reaching a 52% direct electrification (disregarding ambient heat from heat pumps).

Demand side response - The DSR category only covers pure demand shedding, in addition COP21 scenarios model explicitly V2G and prosumer batteries. In addition, thermal storage is taken into account in district heating. The use of downstream flexibility will be made more explicit in the updated scenario report.

Low Electrolyser capacity and high load factors – Electrolyser are modelled along 4 configurations supplied either by:

- electricity from the wholesale market;
- a combination of local RES and wholesale market;
- dedicated RES.

The different sources help to combine fully RES supply (dedicated RES) and high load factor supporting the economics of the electrolyser. For the updated COP21 scenario, the average load factor of the electrolyser is 60% in 2050.

---- currENT Europe----

Feedback: ENTSO-E needs to take its own Technopedia into account when it comes to the Needs report, the scenarios and the TYNDP.

We would appreciate cross-reference and consideration of the technologies mentioned in Technopedia.

As illustrated by the Climate Action Tracker, 4.2 times more efforts are needed to reach Net Zero/ 2030 targets. Additional recent climate reports and reactions to the results of COP26 underline the need to meet climate goals more quickly.

At the same time, recent price increases in energy have added to the general public's increasing sensitivity to the potential costs of the energy transition.

currENT appreciates the Report's embrace of technological innovation, but we urge ENTSO-E to look to a broader range of possibilities. Innovative grid technologies such as dynamic line rating modular power flow technology, and superconducting high voltage technology can play an important role in furthering the Report's scenarios by optimizing our energy networks. While grid expansion will be necessary to meet the needs of electrification and the expansion of renewable generation, innovative grid technologies can help mitigate the volatility of renewable energy sources, allow them to be integrated faster into the grid, and free up more grid capacity more quickly and at lower cost than other alternatives. See, e.g., WindEurope, Making the most of Europe's grids – Grid optimisation technologies to build a greener Europe, September 2020 (https://windeurope.org/wp-content/uploads/files/policy/position-papers/20200922-WindEurope-Grid-optimisation-technologies-to-build-a-greener-Europe.pdf); The Brattle Group, Unlocking the Queue with Grid-Enhancing Technologies – Case Study of the Southwest Power Pool, February 1, 2021 (https://watt-transmission.org/wp-content/uploads/2021/02/Brattle__Unlocking-the-Queue-with-Grid-Enhancing-Technologies__Final-Report_Public-Version.pdf90.pdf); THEMA Consulting Group, Effects of Higher Available Capacity and Increased Market Integration, August 11, 2021 (https://heimdallpower.com/wp-content/uploads/2021/08/Report_Thema_Consulting_Group.pdf). On December 8th, currENT also plans to unveil a forthcoming study by Consentec which will describe how the deployment of grid-enhancing technologies can reduce congestion costs by up to 90%. See currENT, Benefit of Grid Enhancing Technologies: Make Europe Fit for 55 – Launch of the Consentec Study, December 8, 2021 (https://us06web.zoom.us/webinar/register/WN_AqzXHHkBQU6lvT5ex-glUg).

Response:

We thank you for appreciation for technological innovations and provided feedbacks.

The Scenario building guidelines published together with the Draft Scenario report includes technical assumptions used in the scenario building process. ENTSO-E and ENTSOG welcome any quantitative feedback on those assumptions.

At scenario report level, interconnection capacity expansion is used to ensure the meaningfulness of generation capacity and location. It does not indicate actual infrastructure needs that will be assessed at TYNDP level where projects may consist either in the optimisation of existing assets (e.g. through dynamic line rating) or new ones (e.g. regular AC lines or any other technology such supraconductor).

---ENGIE---

Feedback*: As stated in the report, the role of gases in the energy transition is expected to be critical for the resilience of the European energy system (p.19: "As electrification increases significantly in Global Ambition and to a greater extent in Distributed Energy, the structure of the gas demand evolves as the demand for electricity becomes more seasonal and variable, requiring more flexibility from the gas system. (…) Furthermore, as the energy system relies on variable renewables to produce electricity and gas, the gas supply becomes sensitive to climatic events as well as the energy demand. This combined climatic sensitivity increases the need for flexibility. (…)"). Nevertheless, no question is raised in the consultation on the future of gases (with the exception of hydrogen).*
The demand for natural gas in 2030 seems to be underestimated, both at aggregated EU level and at the level of single countries. Considering France for instance, peak gas consumption in 2030 decreases in both scenarios of TYNDP 2022 by approximately one third versus the previous estimations done in TYNDP 2020. On the one hand, this steep decrease appears unjustified in the report. On the other hand, this assumption is critical as it could impact security of energy supply (cfr the dimensioning of needs for gas storages). We believe that a more realistic view (for instance, the previous view from TYNDP 2020) should be retained as a reference in order to correctly assess the need for gas storages, with a view to avoid tightness/scarcity periods and all its negative consequences for EU consumers (as experienced recently with the rise in commodity prices across Europe).
Even with considering the higher ambition embraced by the European Union in its very much welcomed Green Deal and Fit-for-55 package, we do not believe that a higher decarbonization ambition for 2030 should translate into a such lower demand for gas. We believe instead that gas (which will include more and more renewable and low carbon gases) has a key role to play in the transition towards a fully decarbonized energy system while guaranteeing to security of supply, in particular in the electricity system that has to cope over the next decade with the double challenge of integrating a huge amount of RES, while several Member States will phase-out coal and nuclear power plants.
As far as hydrogen is concerned, while it is undoubtedly the missing link to decarbonize the hardest-to-abate sectors after 2040, we believe that by 2030 and 2040 the amount of hydrogen in both COP21 compliant scenarios is overestimated. For the 2030 and 2040 horizon, we rather believe that e-methane should be considered as an important element of the energy mix, contributing to the decarbonization of gas usages and to the integration of RES in the power system, replacing coal and nuclear.
To make an illustrative example, in Germany, where discussions about the anticipation of coal phase-out to 2030 are taking place, the installed capacity and generation of gas-fired power plants should significantly increase (up to 74 GW and 194 TWh in 2030 according to the very recent BCG study for BDI) to guarantee system adequacy in the most cost-efficient way. On the other hand, according to the figures retrieved through the Data Visualization Tool of the TYNDP 2022, the share of gas in the German power system seems rather flat over the decade (27 GW and +/- 80 TWh), and even below the current levels.

As far as biomethane is concerned, we share instead the ENTSOs' view about the important role of biomethane (almost 400 TWh in 2030 and around 900 TWh in 2050 in the TYNDP DE scenario).
More in general, the TYNDP process (scenario + analysis) was set up in the early 2010s, before the further developments promoting renewable integration and further decarbonization (Clean Energy Package, Green Deal, etc.) and all the subsequent legislative proposals. For this reason, the current process (methodology and approaches used) lacks some fundamental elements to cope with the structural changes required by increased decarbonization targets (2030 / 2050), the greater electrification / hybridization of heating, the requirement for energy efficiency and the underlying need for sector integration (which requires a real and comprehensive interaction between energy systems, incl. at the modelling/prospective stage).
One key element is that the market players across sectors (electricity and gas, but also heat and other industrial sectors) will be the driving forces for these industrial changes. The infrastructures will have to be adapted to their needs in a cost efficient way (and not the other way around). The current practice of ENTSO-E and ENTSO-G is not in line with such a market-driven view as they focus on the needs for their own infrastructure (electricity and gas) without strong requirements for the economic via bility of the underlying market-related assumptions (existing assets, business development based on market signals…).
The cost dimension is also missing: the financial impacts of choices made (separately) by ENTSO-E and ENTSO-G in the their exercise on the consumers (residential, services and industrials) is under-considered (e.g. impacts on peak demands, optimized use of existing infrastructure). Consequently, the cost benefits of a sound complementarity of energy systems are not sufficiently investigated. For instance, it is often overlooked that the gas system is complementary to the electricity system for managing some stress events and, more generally, for building up a cost-efficient and resilient energy system (cfr impacts on peak electricity demand and the related risks on electricity system adequacy can be mitigated with gas solutions).
Some concerns on the electricity side, which were identified in the previous TYNDP, seem to be still present :
- *Peak electricity demand is presented without reference to a specific climate. 1995, 2008, 2009 climatic data, all average climatic years: the impact of a cold snap on the electricity system is not discussed and, similarly, the Dunkelflaute exercise is reported only for gas, not for power.*
- *Limited information on heat pump efficiencies, despite their importance on peak demand.*
- *The assumptions for losses on electricity grid are not transparent.*

Assessing resilience of the energy system to stressful events should ideally be at the core of the TYNDP exercise (and seems to be rightly done for the gas part), especially since the level of dispatchable power generation is very low (e.g. for Germany, in comparison with this study for the BDI : Boston Consulting Group (October 2021) - Climate Paths 2.0: a Program for Climate and Germany's Future Development) and since the electrification of heating demand is high.
Finally, additional elements that would deserve some attention are as follows:
- *Uncertainty around energy efficiency and technological development are insufficiently reflected in the long term scenarios.*
- *The relation/complementarity between transmission and distribution networks remains unexploited.*
- *The side-effects of (separate) decisions and modelling choices at the quantification stage could lead to an underestimation of system costs. For instance, the added value of complementary energy systems on their resilience w.r.t. assumptions not materializing, external shocks, etc. is probably worth considering.*
- *Besides a set of scenarios, the analysis should also consider some sensitivity analysis on structural elements (either direct or indirect) to assess the robustness of each scenario w.r.t. its storylines, assumptions and modelling.*

Response: The TYNDP 2020 Scenario report scope was larger as including the UK and gas values were provided in Gross Calorific terms. When comparing scenarios and historic situation along consistent metrics, the natural gas demand in the new scenarios are is much lower than in the TYNDP 2020. A comparison of figures is provided as part the downloadable Excel file with all figures used in the report.
.
The emphasis on hydrogen in Distributed Energy derives from the need to assess on time the need of infrastructure taking into account the lead time for building or retrofitting assets. The hydrogen demand level in 2030 is consistent with the 10 million of tonnes of renewable hydrogen as stated by the Hydrogen strategy for a climate-neutral EU from the European Commission. In a scenario reaching carbon neutrality in 2050, the main challenge for methane in 2030 is to sufficiently switch to carbon neutral sources. In any case National Trends and Global Ambition scenarios having a higher methane demand support the assessment of storage infrastructures.
Regarding gas-fired power generation, the updated COP21 scenarios show higher values deriving in particular from the application of a security of supply script as detailed in the updated Scenario building guidelines. As an example, gas-fired power generation capacity in Germany is now between 33 and 42 GW in 2030 compared to the 32 GW in 2018. Next edition may offer the opportunity to factor an earlier coal phase-out if confirmed.

Since the early days of the TYNDP process, the scenario building process has continuously evolved. We would be happy to further discuss the aspects you consider as no longer capturing the dynamics of the market.

While the role of TYNDP scenarios is to support the assessment of energy infrastructures (not only transmission but also storage ones), the scenario building process focuses on the driving forces of the energy transition. It is not achieved through an economic overall optimization as it is beyond the capability of ENTSO-E and ENTSOG as part of a 2-year process and that many aspects are only partly cost-driven (public acceptance, prosumer behavior, energy autonomy...). For this reason, a cooperative and iterative process has been put in place to build storylines then scenarios with stakeholders (market players, NGOs, technology providers…). Such process defines the main drivers of scenario quantification: energy demand, downstream flexibility and RES range. Electricity and gas transmission only intervenes as second order factors in the expansion model used to build scenarios.

Regarding the detailed concerns you have expressed, the updated scenario report should provide answers to most of them:

- Electricity results are provided on the Visualisation Platform and as Excel files for each climatic years (1995, 2008 and 2009). Hourly demand profiles are now released these years.
- As indicated in the Scenario Building Guidelines, the 3 selected climatic years combine the benefit of well-picturing the range of climatic situations met over last 30 years. They also cover the second most severe Dunkelflaute event (after 2012). The assessment of the resilience of the European energy system is at the core of gas and electricity TYNDP rather than at scenario building stage.
- The heat-pump profile used in the COP21 scenarios is defined as part of the Scenario Building Guidelines.
- Electricity losses represent in average 7% of the final electricity demand in absence of sufficient information about their evolution.
- The uncertainties related to technological and way of life evolution are indeed predominant factors in long term scenario development. The first highlight of the Executive summary,

identifies political, societal and economic framework as a key factor in mitigating such uncertainty.

- The scenarios take into account a wide range of development occurring at distribution level: V2G, prosumer, RES development, electrolysis... As the methodology is based on the bidding zone as the basic block, it does not presuppose any particular location for demand and assets between transportation and distribution grid. It also assumes a perfect coordination between those grids. Joint work has been initiated with DSO associations as part of the 2022 scenario building process. It is supposed to further develop and to contribute to scenario enhancement.
- As the scenario modelling for TYNDP is a very time-consuming exercise, the use of sensitivity analyses is beyond the scope of the joint scenario building process.

--- Edison S.p.A.---

Feedback: *As an additional comment Edison would like to emphasize the role of the energy efficiency in reaching the net zero emission: as demonstrated by the scenario report this solution should be the most reliable both from a technical and an economical point of view.*

Then, TYNDP scenarios should consider the different starting points, and the technical and commercial availability of all the other key transition technologies, ensuring always a level playing field among the technologies. Edison is aligned with the fact that the transition will require both centralized and decentralized options, that may be adjusted depending on the initial energy mix of the member State as well.

Edison would also welcome more details on the use of LNG / BIO LNG and what it means in term of infrastructure. This vector will be essential in particular to reduce emissions in the heavy transport sector

Regarding the use of CCS, Edison wonders how the CO2 would be expected to be removed: whether before or after the gas is imported.

Finally, more clarification is needed regarding the assumptions on feasibility and cost.

Last but not least, Edison would like to underline again that role of gas (in the form of decarbonized gas in 2050: hydrogen but also bio-methane, synthetic methane, etc) in the transition towards a fully decarbonized energy system should not be under evaluated, while guaranteeing security of supply, in particular in the electricity system that will have to cope over the next decade with the challenge of integrating an important amount of RES and the phase out of more polluting energy sources (coal for example).

Response: The updated scenarios based on stakeholder feedback have offered the opportunity to further improve energy efficiency in particular for Distributed Energy scenario.

Indeed, the energy transition is likely to rely on a wide range of technologies in order to maximize the likelihood of reaching carbon neutrality. This is why at demand level the Ambition Tool is based on storyline mitigating the risk of a too narrow focus on a limited scope of technologies as it could result from an overall cost-optimisation. Such optimization would be driven by cost assumptions not always reflecting the uncertainty on a 30-year range. Regarding the electricity mix, the investment model combines cost optimisation with trajectories in order to compensate the all-or-nothing trend of optimisation.

Scenarios use existing energy mix of each Member States which enable to factor country specifics which partly fade away along the time horizon.

Together with the updated scenarios, an extended dataset will be published with more details on the technology and fuel breakdown for heavy mobility.

The scenarios combine the use of CCS at consumption location in the industrial sector and close to natural gas import points for blue hydrogen production.

Finally the updated COP21 scenarios include a security of supply script as defined in the new Scenario Building Guidelines. It results in an improved adequacy and stronger role of gas-fired power generation.

---Gas Infrastructure Europe (GIE)---

***Feedback**: Electricity :*

The concerns about electricity peak assessment points identified in the previous exercise are still present :

- Peak electricity demand is presented like last year, without reference to a specific climate. The dunkelflaute exercise is presented only for gas, not for power. Data include 1995, 2008, 2009 climatic data, all average climatic years. Assessing the robustness of the system to a climatic stressful event should be at the core of the TYNDP exercise (and is rightly done for the gas part).

No assessment of the reaction of the electricity system to a cold snap is presented.

- No information on heat pump efficiency, despite the importance of this parameter on the peak demand

- No discussion on losses on electricity grids despite reliance of RES located much further from demand center, and massive increase of electricity distribution grids and role especially in DE scenario.

Peak resilience is all the more important since the level of dispatchable power is very low (e.g. comparison between the data provided for Germany and the need for dispatchable power provided by the following study for the BDI : Boston Consulting Group (October 2021) - Climate Paths 2.0: a Program for Climate and Germany's Future Development), and the electrification level of heating demand is high.

Hydrogen :

- Beyond hydrogen imports, a scenario with significant e-methane imports, given its potential to improve affordability and security of supply should be considered.

- *Low carbon imported hydrogen : all sources should be considered.*
- *The development of storage capacities is paramount to allow the hydrogen development.*

CCS : Whether to prolong the lifespan of CCS assets in Distributed Energy scenario could be a question.

Costs :

To allow a fair comparison between different energy vectors, integration costs into the system must be included.

Transparency :

To properly assess the scenarios, a complete set of data could be very useful (for instance, the number of heating appliances, with their efficiency, …), as well as downstream infrastructure costs linked to electrification (distribution, appliances).

Response:

Electricity:

- Electricity results are provided on the Visualisation Platform and as Excel files for each climatic years (1995, 2008 and 2009). Hourly demand profiles are now released these years.
- As indicated in the Scenario Building Guidelines, the 3 selected climatic years combine the benefit of well-picturing the range of climatic situations met over last 30 years. They also cover the second most severe Dunkelflaute event (after 2012). The assessment of the resilience of the European energy system is at the core of gas and electricity TYNDPs rather than at scenario building stage.
- The heat-pump profile used in the COP21 scenarios is defined as part of the Scenario Building Guidelines.
- Electricity losses represent in average 7% of the final electricity demand in absence of sufficient information about their evolution.
- The addition of a security of supply script, as defined within the Scenario Building Guidelines, have resulted in an increase of gas-fired power generation. In Germany capacity level reached between 33 and 42 GW in 2030 compared to the 32 GW in 2018. Such capacity further increases beyond 2030.

Hydrogen:

- COP21 scenarios include synthetic methane imports and the updated version also includes European production of synthetic methane. When defining the amount of synthetic methane in the scenarios, it has been necessary to take into account the availability of biogenic carbon and the additional energy losses compared to the direct use of hydrogen.
- The scenarios take into account a wide range of hydrogen supply being from imports, methane reforming or electrolysis. We would invite you to contact us to discuss which additional source should be taken into account.
- Hydrogen storage capacity both as the form of salt caverns and steel tanks have been taken into account as part of the scenario development. The role of the hydrogen salt cavern storage capacity will be further investigated as part of the ENTSOG TYNDP.

CCS:

- Distributed Energy storyline advocates for a minimum use of CCS as a contrast with Global Ambition.

Cost:

- The aim of the COP21 scenarios is not a comparison on an overall system cost to select a preferred pathway or to compare scenarios on a total cost basis. It aims at defining contrasted path to carbon neutrality in order to be used in TYNDP and CBA for infrastructure assessment. Regarding investment candidates for wind and solar, CAPEX increases with the level of capacity to capture the challenge of RES development (see Scenario Building guidelines).

Transparency:

- The updated version of the scenario report includes an extended set of data. EU aggregated market share figures have also been added in the updated scenario report. As mentioned, the scenarios do not aim at a cost optimisation or an overall cost estimation, they intend to provide a basis for infrastructure assessment especially for the scope of PCI candidates. The scenarios do not quantify distribution and end-user appliances cost being for electricity, hydrogen or replacement cost by 2050 for methane.

--- Anonymous---

Feedback: *The TYNDP2022 draft scenario report shows remarkable improvements compared to the TYNDP2020 scenarios. The developments towards distributed technologies/prosumer and sector integration are positive and a great step forward.*

Nevertheless, additional and relevant improvements are needed for this edition, especially considering the paragraph about "consultation on hard data - not just concepts":

1. Additional information regarding numbers of electric heat pumps, electric vehicles, etc., would improve the document. So far just shares were published in the scenario storyline report, where some ranges were provided.

2. Consultation on climatic years is not effective if all climate dependent time-series (e.g.: RES, load) are not publicly available nor consulted

3. There is no information regarding assumptions for RES technologies (e.g. tower height, rotor size, PV technology, etc.) so they have not been consulted. A proposal could be to have a description of technologies like on this website: https://atb.nrel.gov/electricity/2021/land-based_wind

4. It is not clear how different outage patterns and climatic conditions were considered in the disinvestment options

5. Adequacy of the system is an inherent part of the scenario and it is not clear if scenarios are adequate

6. There is not enough detail on the other non-res category and how they are modelled. If they are CHP, how does the climatic data influence them? do they have a strike price? if yes, what is their price? how do you model the heating market?

7. Not enough information regarding how Demand Side Response was modelled. Do they have a strike price? if yes, what is their strike price?

8. In the chapter "4.7 Investment Candidates" the following parameters are mentioned but they have not been published for consultation:

- Maximum development level for each time horizon, based on country specific potentials: It should be clear if the potential is technical (and if it is justified because of land constraints, or internal grid, etc), economical. Justifications or references should be provided

- Minimum expected development level for each time, horizon on a country level: It should be clear if the potential is technical, economical, etc. and justifications or references should be provided

- Maximum building rate by year: It should be clear if the potential is technical, economical, etc. and justifications or references should be provided

- Variable OPEX

- Weighted average cost of capital (WACC)

- Build-out rate as the maximum capacity that can be built in one year: It should be clear if the potential is technical, economical, etc. and justifications or references should be provided

9. Additionally, the cost of interconnections and technical parameters of power plants by country have not been published nor consulted (e.g.: maintenance parameters, forced outage rate, etc.)

10. No consultation of National Trends 2040

11. Not clear how land constraints were considered in the scenarios

All the parameters above are relevant. ENTSOs should consider to publish a similar workbook compared to the AEMO "2020-21 Planning and Forecasting Consultation on Inputs, Assumptions and Scenarios". Link to workbook: https://aemo.com.au/-/media/files/major-publications/isp/2021/2021-inputs-and-assumptions-workbook.xlsx?la=en

Link to main website: https://aemo.com.au/consultations/current-and-closed-consultations/2021-planning-and-forecasting-consultation-on-inputs-assumptions-and-scenarios

Response:

We thank you for the appreciation of improvements and for your inputs.

I. The Visualisation Platform provides the share of most of the technologies as defined by the scenarios. The updated scenario report provides additional information regarding efficiencies of electric heat pumps and vehicles.
II. We will publish hourly time series with the updated scenarios.
III. Assumptions regarding RES technologies were taken from the Danish Energy Agency's Technology Catalog for Generation of Electricity and Heating. More information including references can be found in the updated TYNDP 2022 Scenario Building Guidelines (page 39**)**
IV. Investment and divestment decisions made by the expansion model follow the same logic of minimising the cost based objective function. At this stage of the process, security of supply is managed through a value of lost load set a 10k €/MWh. The updated version of the scenarios includes a security of supply script resulting into a higher level of thermal power

generation and battery capacity in order to ensure less than 3 hours of energy unserved in each country. The details can be found in updated TYNDP 2022 Scenario Building Guidelines.

V. The scope other-res and other non-res categories are explained in the updated TYNDP 2022 Scenario Report in glossary section. Other non-res categories are categorised and analysed depending on their fuel type (coal, lignite, oil). Beyond 2030, they operate on market price. Regarding the heating market, the TYNDP 2022 Scenario Building Guidelines provide details on district heating modelling.

VI. The DSR category only covers pure demand shedding, in addition COP21 scenarios model explicitly V2G and prosumer batteries. In addition, thermal storage is taken into account in district heating. The use of downstream flexibility will be made more explicit in the updated TYNDP 2022 Scenarios Report.

VII. RES trajectories are based on external scenarios (e.g. EC Impact Assessment, Wind Europe …) as stated in the storyline report rather than potential. In addition, RES costs increase with the capacity in order to capture the challenge of RES development therefore land constraints are indirectly taken into account.

VIII. The expansion loop takes into account a 6% WACC and no variable OPEX were taken into account, just fixed ones.

IX. The National Trends scenario is based on national policies and strategies of the Member States as such it is not submitted to European consultation. The 2040 time horizon is included in the updated version of the TYNDP 2022 Scenario report.

X. See VII.