Feedback from the TYNDP Stakeholder Reference Group (SRG) on the preliminary 2024 TYNDP Scenarios Results

The Terms of Reference (ToR) of the Stakeholders Reference Group (SRG) – which build on the ACER's Scenarios Framework Guideline – define the tasks of the SRG:

ACER's Framework Guidelines require that the "development of scenarios shall follow as much as possible an open process to involve stakeholders, ensuring a broad participation".
*The SRG shall offer scrutiny, by performing a balanced internal discussion, independently from the ENTSOs, on the **inputs, assumptions and methodologies** proposed by the ENTSOs.*
To accomplish these goals, the SRG shall provide information and feedback throughout the scenario building process. The SRG's feedback will be guided by the ENTSOs' comprehensive process timeline and stakeholder engagement plan. The SRG will contribute to co-creating the process timeline, which shall include the steps, deadlines and the specific stakeholder engagement plan for the process as outlined in ACER's Framework Guidelines.

Background

The SRG was established in September 2023 to provide feedback to the 2026 TYNDP cycle. While the SRG was becoming more operational, the ENTSOs invited the SRG to provide feedback already for the results generated in the 2024 TYNDP cycle. SRG welcomed this invitation as a positive step contributing to the development of a fruitful collaboration with ENTSOs.

The modelling results were shared with the SRG on 12.01.2024 and the feedback was expected to be delivered by 8.02.2024. Considering the tight timeline and high workload, the SRG decided to use this feedback round primarily as a learning experience, with associated comments focused mostly on modelling aspects, for the 2026 TYNDP process.

The following pages present the results of the collaborative endeavor performed by the SRG. The chapters are divided thematically. All comments and recommendations presented in this document shall be treated equally important (independently whether the refer to the 2024 or 2026 TYNDP cycle), as the SRG believes that each of them can improve the quality of the modelling work. The feasibility of application of SRG's recommendations in the current 2024 TYNDP process, needs to be assessed directly by ENTSOs.

In case of any questions and clarifications needed, SRG is open to provide additional information and further support ENTSOs in realization of their task. At the same time, we invite ENTSOs to share with the SRG their feedback on the work performed by the group, both in terms of the content delivered as well as the process.

Data access

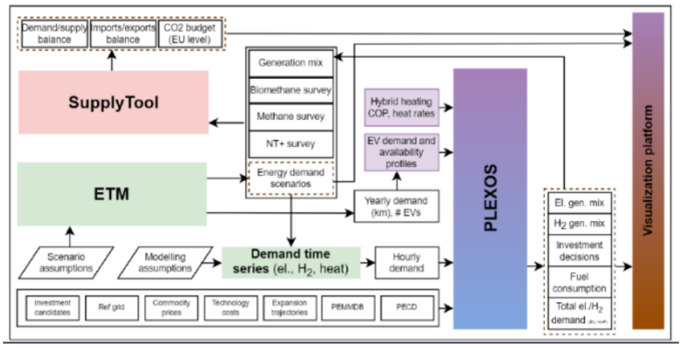
The SRG received extensive data:

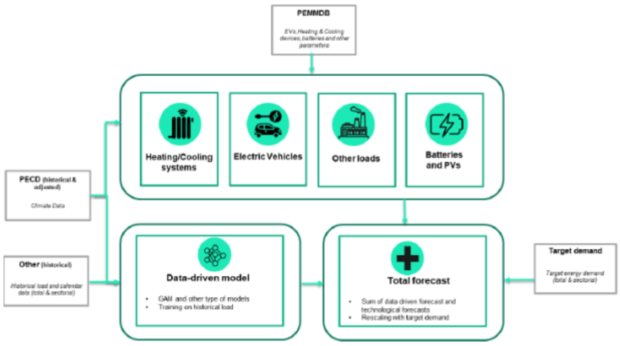
- Updated summary of the data output from the ETM model with parameters and annual loads
- Glossary
- 4 Scenario Models files: Output_Expansion, Output_Dispatch, Output Lines_Expansion, Output Lines_Dispatch
- Links to the visualization platforms: Expansion Results which looks at the capacities to be built and Dispatch Results for the flows, generation, imports etc.
- Hourly flow data, in total 584 files, each containing data for all countries split between the 4 scenarios DE and GA 2040-2050: Regions (180), Lines (92), Heat Plants (8), Generators (256), Batteries (48).

Models

The data delivered to SRG are plentiful and very detailed. In a half-day workshop held on 16.01.2024, the ENTSOs explained the tool architecture in use and the basics of the calculations. Also, a glossary was provided to allow a better understanding of the numerous files.

The model is highly complex and contains many different assumptions that are used in different tools. The SRG only had access to the ETM Tool. Providing the ETM model during the public consultations in summer 2023, allowed different stakeholders (including SRG members) to get acquainted with this tool and better understand the demand data. However, to understand the path from the annual demand to the hourly profiled supply and the flows between the countries much more information on the parameters and assumptions within the different tools are needed. Therefore, the SRG concentrated on the detailed feedback to the demand side and comments on selected other topics on a higher level.





The Pan-European Market Modelling Database – a granular view of the energy system

DATA TOPIC	DETAILS	REQUIRED
Generation (unit-by-unit & national trends)	Technical, economic and regulatory data Profile Curves Maintenance & Planned outages Reserve Requirements	For each generation type: • Thermal • Hydro (reservoirs) • Renewables • Batteries • DSR • Fuel cells • Electrolysers • H2 Storage
Hydro Inflows	Potential generation and storage capacity Uniform constraints	For each market zone with hydro power / storage
NTCs	Net transfer capacities and limits	For each market zone
Exchanges	Exchange curves with non ENTSO-E market zones	For each market zone with non ENTSO-E borders

Generic feedback on the process and data delivered

- **Timeline**

The timeline for delivering recommendations on the 2024 TYNDP Scenarios by the SRG was too short, to ensure a solid and sound technical feedback. However, since this was the first time ENTSOs were working with the SRG, the group understands and welcomes the opportunity to deliver recommendations.

*==> **Proposal 1 (2026 process):** For the upcoming cycle, SRG advises ENTSOs to plan properly with the group, so SRG members will get sufficient time to review the model files. We believe that the meetings foreseen to plan the modelling work and stakeholder engagement for the 2026 cycle are a step in the right direction.*

- **Quality of provided files and visualisations**

It was not easy to navigate through all the files provided by ENTSOs, although a lot of effort was made by ENTSOs to make the information available to SRG. This includes the innovative approach of providing a Tableau visualisation platform. Unfortunately, this time there were some issues with the quality of files that restricted SRG members from performing a proper review. These include for example the absence of a glossary of technical terms to understand the details of the modelling carried out. Another example is the poor quality of the visualisation platform shared by ENTSOs with the SRG to get familiarised with the data, which contained errors. The SRG understands that ENTSOs were also getting acquainted with the process.

*==> **Proposal 2 (2026 process):** Ensure that units are labelled with the files even if it is an excel file, csv file or visualisation.*

*==> **Proposal 3 (2026 process):** Provide a detailed glossary with definitions of all the technical terms at the beginning of the process.*

*==> **Proposal 4 (2026 process):** Ensure that visualisation platform is error free.*

For this feedback process, although EU27 aggregated data was requested by the SRG and provided by ENTSOs in the visualisation platform, it was not ideal. The aggregated EU27 figure was still not available in Tableau. What was provided was just graphical stacking of all EU27 countries from which, again, a user had to manually sum up the numbers to obtain the EU27 figure. A user should be able to directly see the figure for EU27.

*==> **Proposal 5 (2026 process):** Provide EU27 aggregate both in the excel or csv files and visualisation.*

- **Comparability with European Commission's scenarios and output model**

According to the TEN-E Regulation and the ACER Scenario Guidelines, TYNDP scenarios are expected to be compatible with policy targets of the EU. Therefore, it would be relevant for SRG members (as well as other stakeholders), if the scenario results of TYNDP are easily comparable with the scenario results of impact assessment studies of the European Commission, as for example, the EC's 2040 targets impact assessment published at the beginning of February (please see the screenshot below).

It would facilitate stakeholders' interpretation, if the scenario results of TYNDP (figures, tables, and graphs) are comparable with different EC's scenario results as well as alternative scenarios developed by other stakeholders.
*==> **Proposal 6 (2024 process):** Provide key energy indicators for EU27 as in the EC's impact assessment.*

*==> **Proposal 7 (2024 process):** Ensure metrics like final energy consumption, gross available energy, primary energy consumption, GHG emissions for EU27 are available in the scenario results.*

Providing the above metrics for EU27 will improve the comparability and benchmarking of the scenario. Currently final energy demand (which is not equal to final energy consumption) is only given. Providing other metrics will make it easy to study the scenarios in the light of energy efficiency achieved. Since the EU will have emission reduction targets for every decade, it is important also to provide GHG emissions of each scenario both for the energy sector as a whole and the power sector.

	2030	2040			2050
		S1	S2	S3	S3
Policy relevant indicators					
Energy-related CO2 reductions vs 2005	-58%	-83%	-90%	-94%	-103%
RES share in Gross FEC	42.4%	65%	72%	75%	89%
FEC reduction vs 2015	-19%	-34%	-34%	-35%	-40%
Energy indicators - Supply					
Gross Available Energy (Mtoe)	1160	1022	1021	1018	1032
- Fossil fuels	663	375	311	275	150
- of which for non-energy use	*96*	*96*	*96*	*96*	*80*
- of which captured	*2*	*12*	*13*	*13*	*24*
- Nuclear	139	129	129	129	142
- Renewables	328	482	544	328	691
Net imports (Mtoe)	572	347	298	267	153
Import dependency (%)	50%	34%	29%	26%	15%
Hydrogen production (Mtoe) ([55])	9	60	76	100	185
e-Fuels production (Mtoe)	2	15	27	37	60
Energy indicators – Power generation					
Gross electricity generation (TWh)	3357	4563	4899	5212	6922
Net installed power capacity (GW)	1627	2181	2377	2525	3256
- Fossil fuels	241	172	164	156	142
- Nuclear	94	71	71	71	71
- Renewables	1292	1939	2142	2298	3027
Storage and flexibility options (GW)	172	213	254	275	238
Final Energy					
Final Energy Consumption (Mtoe)	764	622	614	604	555
Electricity share in FEC	33%	48%	50%	51%	62%
e-Fuels share in FEC	0%	1%	3%	5%	7%

- **Transparency and availability of modelling assumptions and methodologies**

To provide concrete technical feedback, the assumptions behind inputs (as concrete as possible) must be made transparent to SRG members. Preferably, this should be made without SRG members having to ask for it. The concrete examples of categories are represented by: (i) macroeconomic assumptions used for demand modelling like GDP, population etc. and (ii) methodology of GHG emissions calculation and how the scenarios built by ENTSOs achieve net zero. More examples related to specific and concrete assumptions and methodologies are mentioned in the following parts of the text.

*==> **Proposal 8 (2026 process):** All sources behind the assumptions and methodologies applied, shall be provided to the SRG members.*

- **Accessibility**

Further curate key data in an integrated manner to illustrate infrastructural choices for a wider audience, stakeholders, and the public. For example, as mentioned by ENTSOs, the calculation of the GHG emissions is part of the supply tool. The Energy Transition Model is another stand-alone tool, developed for visualisation purposes. Using multiple internal tools may create partial accuracy, but also modelling complexity. It would be important that for each scenario key energy indicators, with underlying data sources, as reference points, are illustrated and shown alongside science-based recommendations for +1.5 C, EU climate targets, and yearly emission pathways.

*==> **Proposal 9 (2024 and 2026 processes):** SRG recommends developing ways to provide key information publicly in an integrated manner. For each scenario to assist in evaluation of infrastructural choices, alongside energy infrastructure, EC 2040 energy and climate objectives, assumed emission pathways, and +1.5 C compatibility can be presented in compact fashion.*

- **Modelling approach**

As per information shared by ENTSOs, the data are modelled with 3 climate years. It is, however, unclear what this entails, whether average temperature, wind and sun data was taken and which impact this has on the numbers. Averaging also eliminates peaks, which are important in a simulation to understand their impact.

*==> **Proposal 10 (2026 process):** The SRG proposes to run the models with 3 different climatic years, relevant in the context of changing climate conditions in Europe, and the resulting differences shall be identified and discussed between the SRG and ENTSOs.*

The structure of the energy grids throughout Europe is very diverse: 1400 gas DSOs, 2400 electricity DSOs and numerous district heating grids. The local infrastructure has to be able to deliver the energy to the end-users or connect the various productions of energy. Households and non-residential buildings are connected 100% to the DSOs, agriculture and industry depending on the countries up to 100 %. Electrolyzers onshore will rather be connected to the DSOs, district heating production too. Splits between TSO and DSO should be well known by the operators.

*==> **Proposal 11 (2024 process):** Even if each country is only one node, the information on the annual and hourly numbers shall be split into distribution and transmission in gas, electricity and hydrogen.*

*==> **Proposal 12 (2026 process):** The results from the scenarios shall be checked against the national grid development plans in electricity, gas and hydrogen, but also against the grid development plans of the DSOs in gas/hydrogen/electricity and district heating.*

Demand

Every supply and flow simulation is only as good as the input data in the demand model. The impact on the outcome cannot be forecasted by the SRG, but for several topics it can be assumed that the impact is relevant. Alongside the following identified issues, it may be important to study the assumptions on demand later in more detail.

The scenarios build on the demand data developed within the ETM model, programmed by Quintel. During the consultation process on TYNDP 2024 Scenarios Input Parameters in August 2023 the public had access to the model. This enhanced transparency has been seen by the SRG members and the consultation participants as a very positive step, but also very time-consuming as the model has many layers and is not self-explanatory. Within the ETM model, many functions are not accessible and therefore the calculation algorithms can only in a small part be retraced.

During the more extensive analysis as part of the feedback exercise, some inconsistencies and incorrect baseline data were detected. The effects of these findings are documented and will be discussed in-depth during the preparation of the 2026 modelling. Whether this can be easily remedied within the model, remains to be seen.

*==> **Proposal 13 (2026 process):** The SRG is provided time to review historical data informing the ETM model, identify sectors or countries where the historical data does not appear representative, and take action to remedy these inputs.*

As the demand numbers (parameters and output) have been frozen in the beginning of January 2024, the results of the analysis will not change the demand data. But the knowledge can help to put the results of the supply simulation in context and maybe lead to an additional calculation. How big the impact could be on the supply side is unknown to the SRG, but if possible qualitative information shall be documented.

From this analysis we propose in which areas of the ETM a much stronger emphasis on correct and more recent data shall be put within the 2026 process.

<u>Households</u>: the statistical data within the ETM model for the year 2019 do not correspond with other statistics. For example, for Germany the statistic[1] shows, that 0,9 Mio. Households are heated with heat pumps (2,2 %) whereas the ETM model builds on 6,188 Mio. households heated with heat pumps (14,83 %). The EHI statistics from 2021 show similar numbers for appliances in 10 countries[2]. Even if the EHI statistic is not directly comparable to "households heated with" as it builds on the number of heating systems installed, the difference in numbers is much too high in the different heating technologies to be easily justified. The ETM model builds in 2019 on 22,74 Mio. heat pumps for 10 countries (AT, BE, DE, DK, ES, FR, IT, NL, PL, SE) whereas EHI shows 4,3 Mio. heat pumps. Due to the steep increase in heat pump technology within the ETM model the gap between model and reality will be large. This may lead to a too low electrical capacity planned for the next 10-15 years in the grid and also in generation in winter.

Also, for other application the source of data is unclear. In Germany, for example, only 6 % of households cook with gas, but 2/3 of the energy consumption for cooking is set with gas in the ETM. Austria is supposed to heat 13,5% of the households with district heating, but the country statistics indicate 30%, which is far higher than the numbers planned for 2040 and 2050. Also, in Germany the share of households heated with district heating in 2019 was at 13,9% whereas ETM states 8,3%. The 18% for GA or 21,8% planned in 2040 and 2050 will be reached sooner, since already in 2023 15,2% of the households are heated with district heating.

The choice of heating technologies in the 4 different scenarios is not explained in the ETM model and does not follow any logical path. NL has a strong increase in hybrid heating, whereas in Italy – where the market is very strong for hybrids – this heating technology is only marginally planned.

==> Proposal 14 (2024 process): *The data shall be checked. Even if the demand figures are frozen, errors should be corrected. The ramp-up of heat pumps in the first 10 years in some countries may be unrealistic if 2019 and 2023 are too far off. The impact on the planning would be significant.*

==> Proposal 15 (2026 process)*: A group is set up between the DSOs in gas and electricity and EHI and informed stakeholders to collect the most recent national statistical reports on the heating technologies installed to have reliable and current data for the reference year.*

The average heat consumption per heating technology and household in the ETM model does not make a distinction between renovated and unrenovated homes. The consumption decreases in time due to efficiency. This heat output is quasi-equal between the different heating technologies, which is correct as buildings are renovated across all types. From the data given it must be assumed, that the ETM model does not take into account whether buildings are renovated or not. This is not correct, as the efficiency of heating technologies differs between buildings with traditional radiators and floor or ventilo-convector heating (see, e.g., the diagrams from the referenced study of Ruhnau et al. (2019)[3]). According to the explanations given in the ETM the COP is modelled according to the air or water temperatures but assumes in all households' floor heating systems at 35°C which is too low for traditional radiator heating.

From the ENTSOs tool "demand time series" we have understood, that the heat pumps are not modelled explicitly for the supply but rather included with the rest of the load. As the electricity consumption only for the households in DE 2040 adds to 804 TWh this is crucial and should be changed in 2026. The modelling of the heat pumps should be equal between ETM and the ENTSOs tool in regard to temperature and the different COPs (heating renovated/unrenovated and hot-water production), otherwise the annual consumption does not match anymore.

Any assumptions behind heat pumps and hybrid heat pumps modelling shall be explained. This includes again demand parameters, power (kW) specifications, type of heat pumps, type of boilers, their COP or efficiency etc. We would also like to be able to extract the implicit heat-pump capacity from the ETM model – this is key in order

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[1] Studie: Wie heizt Deutschland 2023? | BDEW
[2] https://ehi.eu/wp-content/uploads/2022/09/EHI-2021-Heating-Market-Report.pdf
[3] https://www.nature.com/articles/s41597-019-0199-y

to benchmark against historical data, energy scenarios and market outlooks. This is important particularly for proper estimation of peak loads, especially if the assumption is that a large share of CHP-plants output will be replaced with electricity grid-connected heat pumps.

==> Proposal 16 (2026 process)*: Differentiate in the ETM model between renovated and unrenovated houses and model the hourly loads for the supply calculation separately and disaggregated. The hourly load of electric heat pumps should be modelled explicitly in Plexos in order to simulate the potential of demand shifting – similar concept to the current way EVs are modelled.*

Non-residential buildings**:** also here the source of the heating statistics is unclear. For this consumer group the national heating statistics are as important as for the households. Non-residential buildings include many different building types and a huge variety of applications and appliances, which have a large influence on how the energy is used and how it can be produced.

The buildings are calculated with different annual consumptions. This leads to the situation, that a school or a hotel with a gas heating has a heat demand as presented in the ETM model, of 86.000 kWh/a, but if this building switches to district heating it suddenly has a heat demand of 27.500 kWh/a or with an air heat pump of only 2.564 kWh/a. It is also unclear whether the standardized average consumptions in the ETM correspond to the kind of non-residential buildings which can be anything from a large hospital to a school to an auto repair shop with large halls that have to be heated. In contrast to the residential buildings, the utilization of the building and the structure of the buildings – big halls in contrast to offices – has a much bigger influence on the heating technology that can be used. Larger halls cannot be heated with floor heating systems.

==> Proposal 17 (2024 process): *The data needs to be checked. Even if the demand figures are frozen errors should be corrected.*

==> Proposal 18 (2026 process)*: Collect national statistics with building stock and energy consumption, take into account for the planning the different building types (hotels, schools, hospitals, office building, shops, crafts businesses, etc.) for the choice of fuel and heating technology, also model the COP according to the temperatures in these different types of buildings. Also, for the buildings the hourly load profiles should be calculated specifically and disaggregated to show the peak loads (analogically to the suggested approach to households).*

Industry: It is unclear from the ETM model where the numbers for the reference year were taken from as no reference to national statistics is given. This also includes the information how the choice of energy was derived for the future 2040/2050.

Example: In Germany, in case of the paper industry, 21% of the industrial heat is supposed to come from the district heating grid. This is improbable, as it is common in Germany that the paper industrial sites operate their own industrial CHP to produce heat, steam and electricity. The sheer amount of load that the district heating grid would have to deliver at one point of the grid is too high aside from the temperature level. There are many more examples which show that the industrial demand sector should be planned more in detail.

In some countries the industrial sites are connected to the gas and/or electricity distribution grid and not the transmission grid, e.g. Austria gas 100%, Germany gas 99%. The conversion of these industrial sites with loads of several hundred MW from gas to electricity, district heating or hydrogen would have a large impact on all levels of the grid and would have to consider geographical restrictions. Often these sites operate their own power plants or CHP plants as the electricity load is too high and could not be delivered through the grid. Depending on the country the industry can be concentrated in clusters like ports or can be scattered around the country. The national structure has led to an existing infrastructure today that cannot be ignored. Due to the impact of the industrial needs, the planning of the TYNDP and the national grid development plans, and the DSO planning and in the future the heating and cooling plans, shall be taken into account.

The annual consumption in hydrogen, electricity and heat is converted into the hourly load with unspecified profiles. The impact of industrial demand (in 2019 36%; and in 2050 45% of the total demand) on the grid and generation infrastructure is very high, the level of information and detail is not sufficient. In electricity, the eMarket hourly demand loads are the aggregate of industry, energy transformation sector, agriculture and non-passenger cars (as per information delivered to SRG by the ENTSOs). However, these four demand sectors build on completely different planning logics and their hourly load patterns are not comparable. For this reason, they shall be planned separately to understand their impact on the system and test sensitivities.

The industry consumption patterns vary across the different industrial sectors. The hourly load profiles of the different industries are known to the TSOs in gas and electricity as usually these end-users are metered every hour. It should not be forgotten that in many countries up to 100% of the industrial consumers in gas and electricity are connected to the distribution grid. Their knowledge should be brought into the planning process and contribute to the SRG work.

==> Proposal 19 (2026 Process)*: Setting up a working group between grid operators for gas, electricity, hydrogen, heat + industrial association + shippers/suppliers + any member of the SRG with technical knowledge on industrial processes. This group can be used not only for the planning of the industry, but also for the planning of demand response and waste heat as it goes hand in hand.*

==> Proposal 20 (2026 Process)*: The hourly profiles in electricity and hydrogen should be planned disaggregated for the 4 different end-user groups.*

==> Proposal 21 (2026 Process)*: Technical and commercial viability of conversion of large industrial gas offtakes to other energy carriers needs to be verified before plans are made for network development.*

Hydrogen

Any assumptions behind innovations done on modelling P2X shall be made available to the SRG members. This includes electrolysers' parameters, hydrogen demand profile, technical parameters of hydrogen storage and others.

- **Production technologies** shall be expanded to include pyrolysis/Thermolysis, ATR+CCS and waste-to-hydrogen, photo catalytic etc. The scenarios are planning up to 2050, but none of the current new production methods are considered. With the advantage of being largely independent of the electricity grid they bring hydrogen with different profiles to the grids and are less dependent on weather conditions. Furthermore, these technologies can be built locally and deliver the hydrogen close to the end user.

- **Setup with Zone 1 and Zone 2**: H2Z2 flows for e-fuels production: The hourly variability of flows of hydrogen for e-fuels production is not reasonable, e-fuels production processes are relatively inflexible and it is not possible to turn on and off a Fischer-Tropsch installation for e-kerosene production for just a couple of hours at a time. This should be treated as industrial off-takers with little to no flexibility for variable H2 supply.

- **H2 underground storage:** the size of the underground storages seems to be driven by the very flat offtake profiles with 8500 h/a full load hours. At least for Germany these profiles are in comparison to existing industrial profiles for gas industrial end users too flat. The split of the hydrogen consumption in Zone 1 and 2 leads to high investments at the end user sites in the beginning for electrolyzers and steel tanks that later are not necessary anymore, as the end users are connected to the national hydrogen backbones. This model does not seem neither cost efficient nor realistic. An end user with a consumption of 500 GWh in hydrogen (not unusual for industrial sites, even connected to the gas DSO) would need several thousands of H2 pressure bottles or massive steel tanks of 10*10*10 m. In addition it is not clear which patterns the industrial consumers for onsite renewable hydrogen would drive as until 2030 50% of existing H2 consumption would be converted to renewable hydrogen, but the SMR´s would still be in place for the other 50%. It can be assumed, that the electrolyzer would not run 8500 hours, but rather be optimized according to electricity prices, gas prices, load, etc. In the countries where decisions for hydrogen backbones have been taken already, such as Germany, Belgium and the Netherlands, and most likely soon Austria and Italy, the concept of the Z1 has to be adapted at least in the percentages split Z1/Z2. Still, it is very likely that large industrial sites operate also in the future their own electrolysers to optimize between make or buy of hydrogen and for security of supply reasons.

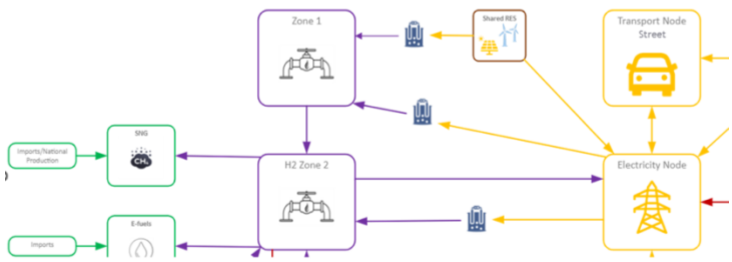
==> Proposal 22 (2026 process): *The whole Z1 Z2 concept should be discussed in a group between grid operators gas/electricity/hydrogen TSO&DSO + Industry + EFET and others*

- **H2 storage – zone 1**: H2 storage sizes are unreasonably small. For example, for Germany to maximum available storage capacity is just short of 6 GWh, which is 0.1% of annual H2 native load in that zone. If the supply would be based purely on renewable hydrogen the expected storage capacity would be around 10% of annual demand. It would be possible to reduce that storage capacity requirement, if the electrolyser operator could just use grid electricity whenever the contracted RE source is not available. However, the EU regulatory framework (i.e., temporal correlation requirement and the GHG allocation rules) are effectively prohibiting such an operational strategy in most EU countries (where the share of RES < 90%).

- **H2 storage – zone 2**: H2 storage in Zone 2 is limited only to a subset of EU countries (DE, DK, ES, FR, GR, IT, LV, NL, PL, SK). How is hydrogen supply and demand balanced in other countries? Even in countries which are included, the storage capacity is unreasonably small (< 0.1% of annual H2 demand in those zones).

- **H2 Load Profile**: In Zone 1 the load profile is relatively flat throughout the year for most countries (with the average >90% of annual maximum). This makes sense only, if hydrogen is used for industrial purposes and only as feedstock and is understandable given the zone 1 definition. For Zone 2, the load profiles are more difficult to understand. For some countries (incl. FR, ES, DK) the load profile in Zone 2 is similar as in zone 1 – i.e., flat with peak demand in summer. While for other countries (incl. DE, IT, PL, NL) the load profile is much more variable with peaks in the winter.

- **Hydrogen production Z1**: Even if the concept is clear, the electricity load from the electricity node and the SRES to the Zone 1 are inconsistent. For example, the hourly files for "SRES to Z1" are 0 for all countries in GA 2040, which would mean that all the electricity for the electrolyser would have to come from the grid. Due to the high number of hourly files, it is impossible to find the fitting hourly load profiles from the electricity node to the SR1. This is just one of the examples, why the presentation of the data should be reorganized. Annual data is as important as hourly data. Only on the hourly data flows can be calculated and infrastructure planned.



==> Proposal 23 (2026 process): *A flow model shall be created where all Inputs (in electricity generation, batteries, demand response and in hydrogen electrolyzers or other hydrogen production forms, import and storages), Outputs (in electricity disaggregated loads for each end user sector as industrial, residential, buildings, EV, batteries, demand response, agriculture, electrolyzers and district heating production) and in hydrogen (industrial, residential, buildings, transport, electricity production, CHP, storages) can be visualized and compared on the hourly basis. Otherwise, each files stands alone and cannot be put into context.*

Prices

Hydrogen market pricing seems to be based on marginal hourly prices. This is not how the market is likely to develop. Maybe after 2050 one can imagine a fully fluid hydrogen market to develop with an hourly/daily wholesale market. However, at least for the next couple of decades the more likely market arrangement for price settlement would be long term PPA between RES and electrolysers on one side, and long term HPA between electrolyser operators and H2 offtakers on the other side, with price at both ends fixed based on LCOE/LCOH. The average annual H2 prices are still roughly in line with some expectations[4], but it needs to be further explored of whether the impact of hourly price setting has a material impact on the results. For industrial H2 consumption it most likely does not.

Import

It is understood that imported ammonia prices reflected in model outputs (presumably the same as model inputs) include transport costs (shipping or pipeline) as delivered at EU borders. These vary from 70-79 Eur/MWh (~2.1-2.4 Eur/kg) in 2035 to 53-66 Eur/MWh in 2050 (across the scenarios), similar to the prices at H2 Zone 1 and Zone 2. These import prices appear unrealistic – both in terms of absolute cost, but also the relation between imported ammonia and extra-EU imported hydrogen (presumed via pipeline). As an example, Agora's 2023 study[5] presents the following comparison of hydrogen import options for Germany:

	H2 pipeline	**Shipping H2 carrier (ammonia, liquid H2 LOHC, methanol)**
Total costs in 2030 (Eur/kg H2) *[with transport distances of 10,000 km ship and 660 km pipeline; including hydrogen production costs]*	4.8	5.9 - 9.2
Transport costs in 2030 (Eur/kg H2) *[including conversion costs and excluding hydrogen production costs]*	< 1	~ 2- 5

The H2 pipeline costs are similar to those presented in the BCG white paper[6] published in October 2023, which puts expected H2 wholesale prices in Europe at 5-8 Eur/kg in 2030.

==> Proposal 24 (2024 process): *Prices for ammonia imports shall be amended to better reflect the additional transport and conversion costs, which are clearly higher than those associated with pipeline transport.*

==> Proposal 25 (2024 process): *As the prices setting mechanism for hydrogen is one of the most relevant parameters for the simulation, a sensitivity is needed. The SRG will provide a proposal for the price setting.*

==> Proposal 26 (2026 process): *Experts from the SRG work together with ENTSOs on cost assumptions relating to hydrogen (both imports and produced in H2 zones) to ensure these better reflect recent trends, and insights on infrastructure.*

- Ammonia imports seem to be included exclusively for the H2 market demand only. While e-fuels are used to satisfy e-fuels demand directly. Ammonia can, however (and will in most cases), also be used to satisfy ammonia demand directly (in future expected to grow beyond the current use of ammonia in fertilizer and chemical sectors and expand to maritime e-fuels sector).
- UK is still missing as one of the potential H2 import directions. UK occurs in several output files as one of the nodes modelled in detail, so maybe the reason it is not shown explicitly in the H2 import files is that the flows

[4] https://about.bnef.com/blog/2023-hydrogen-levelized-cost-update-green-beats-gray/ or https://hydrogencouncil.com/wp-content/uploads/2023/12/Hydrogen-Insights-Dec-2023-Update.pdf (p.19).
[5] https://www.agora-energiewende.org/fileadmin/Projekte/2022/2022-10_H2_SNG_imports/A-EW_312_SNG_Imports_EN_Summary_WEB.pdf
[6] https://media-publications.bcg.com/Turning-the-European-Green-H2-Dream-into-Reality.pdf

to/from UK are modelled in a similar way as flows between EU countries? Which would be OK, but then the "X_flow_H2Z2_reference" files show no flows from and to UK. In short – it is unclear if the role of UK, as a potential H2 exporter to the EU, is modelled properly.

Wind energy

When it comes to the Scenario Model Outputs for installed wind capacity, both in the Distributed Energy and Global Ambition scenarios, we noticed a large divergence between the REPowerEU targets for onshore and offshore wind capacity in 2050. There is also a large divergence between the model outputs and specific country targets for 2050. The reasons leading to this divergence are not clear. It is also not clear, whether the capacity factors used for the simulation are an input or an output of the model and which is the methodology or reference for their estimation.

==> Proposal 27 (2026 process): *Organising a workshop to explain the generation capacity calculation in detail, including the estimation of capacity factors and the way that weather data are being considered for the different types of generators.*

Electricity production

- Prices

It is unclear whether commodity prices are part of the SRG consultation for the TYNDP 2024. These were shared for the public consultation on the 2024 Storylines, but were not made available to the SRG following that. We continue to express significant concern regarding the commodity prices proposed for fossil fuels. While we understand that the prices are taken from a reputable source (IEA 2022), we do not believe them to be realistic for Europe. Indeed, price projections from the European Commission, provided to capitals in 2022 for their use in the updated National Energy and Climate Plans, are more than double compared to those included in the draft TYNDP 2024 Storylines. The former are listed in Annex 2 of certain NECP updates as €473/toe in 2030 and 2040, and €494/toe in 2050. This works out to about €11.30-11.80/GJ, much more than the prices proposed for the 2024 TYNDP of €6.3-5/GJ.

*==> **Proposal 28 (2024 process):** We propose that the TYNDP 2024 uses the commodity price projections provided by the European Commission.*

- The use of biomethane is not planned separately.

Demand response

It is unclear how demand response is modelled, with which end users, and according to which rules. For many industrial users only, a partial load can be ramped up and down, e.g. assembly lines in car factories, or the heating of a glass melter. It is unclear how the demand response potential was defined and how its activation is planned (including price and capacity). Thus, the assumptions behind the demand response shall be made available to the SRG members. Industrial consumers need clear rules when, how often and how long the activation is planned, otherwise they would not sign a demand response contract. Electrolyzers have a very large potential for demand response, but it is unclear whether this has been used in the calculation.

==> Proposal 29 (2024 process): *If demand response is used in the simulation in a relevant amount, the parameters should be delivered to the SRG. A sensitivity should be calculated as in demand response the end user decided whether it delivers, and not the TSO. And the demand response plant has to be in an operations state to ramp up and down which has to be taken into account (because of multiple factors, such as: holidays, strikes, crisis like Covid, etc.).*

*==> **Proposal 30 (2026 process):** Setting up a working group to understand the demand response calculation together with the industrial members, the shippers and the grid operators.*

Batteries and EV's

- passenger cars

Charging prices for EVs at the prosumer node are higher than prosumer prices (using DE scenario, FI 2040 as an example: 157 Eur/MWh and 177 Eur/MWh, respectively). This indicates that passenger cars charging at home are not cost-efficiently charging when renewables at the prosumer node are generating, which would presumably create low or even negative prices at that time. This warrants further investigation and possibly improvements for the 2026 cycle, to be undertaken by the SRG and ENTSOs.

- batteries

The rationale behind the modelling of the passenger EV is unclear. It seems complex and detailed, but the results are very important as the batteries are used on a large scale as a flexibility source to the electricity market.

Results for generation/installed battery capacity in the expansion model appear to be exactly the same in DE and GA in each timestep. This is unexpected given the different storylines and assumptions behind each scenario. Additionally, there are three countries where the resulting 2035 battery capacity is below the latest official targets for 2030 – based on NRRP or draft NECPs. These are:

Country	Latest official target for 2030 (GW)	TYNDP 2024 Draft modelling results 2035 (GW)
Bulgaria	6.4	1.2
Hungary	1	0.2
Portugal	1	0.8

*==> **Proposal 31 (2024 process):** We recommend the modelling driving battery expansion is double checked, as it seems unlikely that the two scenarios would have the same resulting battery capacity in all timesteps.*

As the impact of the EV modelling on the electricity infrastructure seems to be very high, the assumptions have to be further understood. This includes the demand parameters leading to the total EVs and the technical supply parameters like efficiency, type of chargers, power (kW) specifications, charging profiles etc. The impact of failing assumptions on the results should be discussed and also modelled (e.g., cars not connected to the grid, percentage of owners willing to accept external dispatch, non-passenger vehicles not willing to accept that they cannot be charged, charging capacity along streets rather 400 kW than 22 kW, and others). We would also like to see more discussion on the fact that EV storage dispatch is significantly higher than utility-scale and prosumer batteries, and better understand how the fraction of EVs that are V2G is being calculated.

*==> **Proposal 32 (2026 process):** Setting up a working group to understand the EV modelling assumptions. Clarity needs to be provided in the scenario report regarding the cut-off date for data collection to explain discrepancies between updated national targets and the modelling results.*

E-Fuels

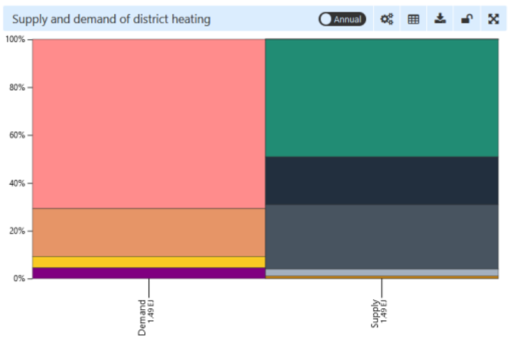
The imports prices of e-fuels changing hourly is not how the market will likely operate in the short – to medium term. We would rather expect supplies being supported with long term contracts underpinning both the renewable energy supply (PPA) as well as hydrogen supplies for e-fuels production.

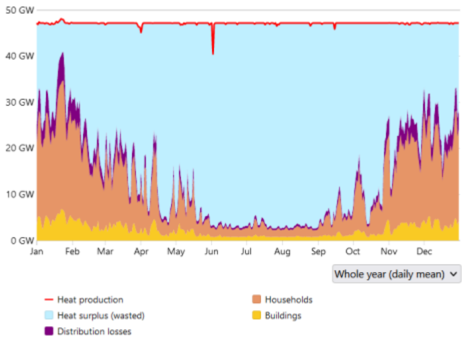
The prices for imported e-diesel, e-kerosene and e-SNG are set at almost exactly the same level per MWh (+/- 1 EUR/MWh), which is hard to understand as the production processes for those fuels and H2 / CO2 feedstock inputs quantities are quite different.

District heating

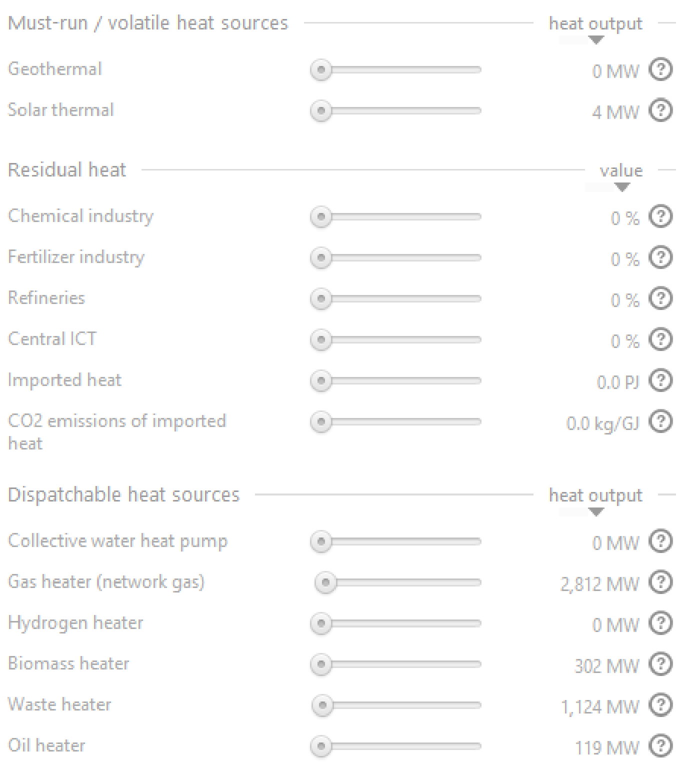
According to ENTSOs, district heating demands for different carriers are provided in the exogeneous demand profiles.

The ETM model calculates the annual demand for district heating. The production of the heat can be found, but the results are inconsistent: for example, for Germany GA 2040 the supply side shows 70% of waste heat production (left), as if the heat production would run continuously even without demand. The heat is produced with lignite, coal and incinerators, which is not planned in this timeframe. Today already most of the CHP run either on natural gas, biomethane or biomass.



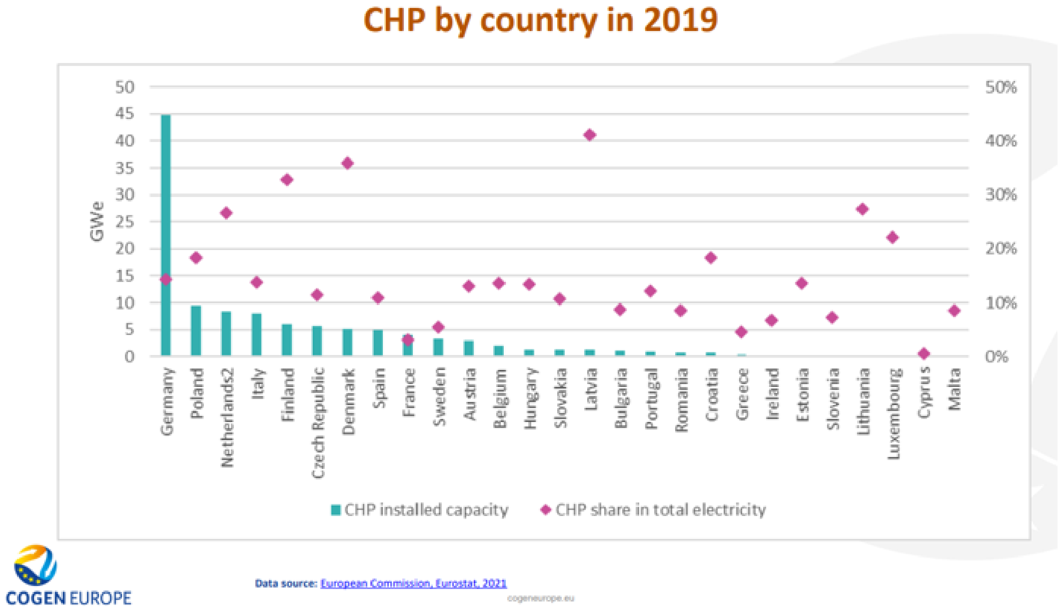


In the explanation given to the fuel mix different energy sources are listed for the production and they do not add up to the peak production of approx. 40 GW. Why the production line is set with approx. 47 GW is not explained.



It is unclear which production capacities and technologies are used from the ETM model for the supply modelling and where they were taken from. It was explained that the district heating demands for different carriers were embedded in the exogeneous demand profiles, but it is unclear in which technologies. The production of district heating is an important part of the demand and shall be planned in a disaggregated way.

District heating is and will be produced with a variety of technologies. Depending on the countries it can be CHP producing the heat and electricity with a variety of fuels, as presented in the data taken from Eurostat.



- As it seems – at least according to the glossary, the explanations given at the workshop and the name of the files, CHP does not exist anymore from 2035, not even with renewable fuels. If this is correct, the impact on the electricity distribution grids will be considerable as in winter no local electricity production will be available anymore. Wind generation does not exist in the cities, nor does it always exist in the vicinity, and PV is rather small or with snow on the panels quasi zero. If in addition the district heating is planned in the scenarios with large heat pumps (if geothermal energy is not available or sufficient), additional grid capacity is needed. The electricity demand has to be transported through the transmission grid to the cities. The TYNDP does not model distribution infrastructure or national TSO infrastructure. Still the national grid development plans shall be checked, if these extra loads are planned to the cities. And the loads shall be taken into account in the adequacy scenarios.

- If CHP is substituted by large heat pumps, the temperature levels shall be taken into account. Large district heating systems are operated at higher temperatures up to 90°C which cannot be changed easily, as the heating systems in the apartment blocks are depending on certain temperatures (radiators) and hot water is also produced from the heat that needs to be higher than 55°C for sanitary reasons (legionella). Every customer, also at the ends of the system, has to be served properly. Ultimately the energy transported in the grid is a function of the temperature and the diameter of the pipe. This could be partially modelled with a different COP Formula (not the one used for the hybrid heating), but the necessity to invest into an enlargement of the heating grids stays.

- CHP is not only used for district heating systems, but also for large scale industrial sites to produce high temperature heat and steam and electricity. If these industrial CHP are also substitute with high temperature heat pumps (with different COP), the electricity demand significantly increases. It is unclear if this has been considered. As these end users often are connected to the gas distribution grid, the impact will be on the electricity DSO to deliver the loads.

*==> **Proposal 33 (2024 process):** Mention already any possible limitations of heat profiles, in case not shown. Check the heat planning and supply calculation, what the reason for the high amount of waste heat is, how the heat is produced, and whether technology and temperature of the heating grid fit together.*

*==> **Proposal 34 (2026 process):** The production of district heating should be modelled in a separate tool and not taken from the ETM model. Set up a working group including specialists for district heating production encompassing different technologies.*

CO2 supply

Focus has been given to biogenic CO_2 although models and projections show that this will be one, but not the only source of CO_2 in the future (see below from the Impact Assessment of the Industrial Carbon Management Strategy that was published on 06/02/2024[7]). It would be helpful if units of CO_2 supply are presented in $MtCO_2$ and not in MWh of fuel offtake.

Table 6: Industrial carbon capture and use

	2040			2050
Carbon Captured – MtCO2/year	**S1**	**S2**	**S3**	**S3***
By Source	**86**	**222**	**344**	**452**
Industrial Processes	37	123	137	136
Power (fossil fuels)	26	41	32	55
Power (biomass) and DACC**	16	54	153	232
Biogenic (upgrade of biogas into biomethane)	7	4	22	30
By Application (use and storage)	**86**	**222**	**344**	**452**
E-fuels	43	75	101	147
Synthetic materials	0	0	0	59
Underground storage	42	147	243	247

Note: *S1 and S2 values for 2050 are similar to S3 and represented in more details in Annex 8. **Includes carbon for storage (DACCS) and use.

Source: PRIMES.

Comparable numbers have been published by CO2 Value Europe[8] with 320 $MtCO_2$ being captured by 2050, of which 87 $MtCO_2$ will be used for fuels and another 86 Mt for synthetic chemicals and materials.

*==> **Proposal 35 (2026 process):** Adding methanol in the next modelling cycle, as one of the most important synthetic fuel options for the maritime sector.*

PEMDB (Pan-European Modelling Database)

The PEMDB was not made available to the SRG for input and feedback during the 2024 process.

*==> **Proposal 36 (2026 process):** Given that PEMDB constitutes one of the primary inputs to Plexos and a key driver of modelling outcomes, it is proposed that this database is made available to the SRG at an early stage in the 2026 TYNDP process, allowing enough time for members to input and gather the most up-to-date information that will feed into this database, without sacrificing the confidentiality of any business critical files.*

[7] https://climate.ec.europa.eu/document/download/768bc81f-5f48-48e3-b4d4-e02ba09faca1_en, page 38, Table 6.
[8] https://co2value.eu/wp-content/uploads/2024/01/FINAL-LAYOUT_CVEs-EU-Roadmap-for-CCU-by-2050.pdf

List of SRG recommendations

- Proposal 1 (2026 process): For the upcoming cycle, SRG advises ENTSOs to plan properly with the group, so SRG members will get sufficient time to review the model files. We believe that the meetings foreseen to plan the modelling work and stakeholder engagement for the 2026 cycle are a step in the right direction.
- Proposal 2 (2026 process): Ensure that units are labelled with the files even if it is an excel file, csv file or visualisation.
- Proposal 3 (2026 process): Provide a detailed glossary with definitions of all the technical terms at the beginning of the process.
- Proposal 4 (2026 process): Ensure that visualisation platform is error free.
- Proposal 5 (2026 process): Provide EU27 aggregate both in the excel or csv files and visualisation.
- Proposal 6 (2024 process): Provide key energy indicators for EU27 as in the EC's impact assessment.
- Proposal 7 (2024 process): Ensure metrics like final energy consumption, gross available energy, primary energy consumption, GHG emissions for EU27 are available in the scenario results.
- Proposal 8 (2026 process): All sources behind the assumptions and methodologies applied, shall be provided to the SRG members.
- Proposal 9 (2024 and 2026 processes): SRG recommends developing ways to provide key information publicly in an integrated manner. For each scenario to assist in evaluation of infrastructural choices, alongside energy infrastructure, EC 2040 energy and climate objectives, assumed emission pathways, and +1.5 C compatibility can be presented in compact fashion.
- Proposal 10 (2026 process): The SRG proposes to run the models with 3 different climatic years, relevant in the context of changing climate conditions in Europe, and the resulting differences shall be identified and discussed between the SRG and ENTSOs.
- Proposal 11 (2024 process): Even if each country is only one node, the information on the annual and hourly numbers shall be split into distribution and transmission in gas, electricity and hydrogen.
- Proposal 12 (2026 process): The results from the scenarios shall be checked against the national grid development plans in electricity, gas and hydrogen, but also against the grid development plans of the DSOs in gas/hydrogen/electricity and district heating.
- Proposal 13 (2026 process): The SRG is provided time to review historical data informing the ETM model, identify sectors or countries where the historical data does not appear representative, and take action to remedy these inputs.
- Proposal 14 (2024 process): The data shall be checked. Even if the demand figures are frozen, errors should be corrected. The ramp-up of heat pumps in the first 10 years in some countries may be unrealistic if 2019 and 2023 are too far off. The impact on the planning would be significant.
- Proposal 15 (2026 process): A group is set up between the DSOs in gas and electricity and EHI and informed stakeholders to collect the most recent national statistical reports on the heating technologies installed to have reliable and current data for the reference year.
- Proposal 16 (2026 process): Differentiate in the ETM model between renovated and unrenovated houses and model the hourly loads for the supply calculation separately and disaggregated. The hourly load of electric heat pumps should be modelled explicitly in Plexos in order to simulate the potential of demand shifting – similar concept to the current way EVs are modelled.
- Proposal 17 (2024 process): The data needs to be checked. Even if the demand figures are frozen errors should be corrected.
- Proposal 18 (2026 process): Collect national statistics with building stock and energy consumption, take into account for the planning the different building types (hotels, schools, hospitals, office building, shops, crafts businesses, etc.) for the choice of fuel and heating technology, also model the COP according to the temperatures in these different types of buildings. Also, for the buildings the hourly load profiles should be calculated specifically and disaggregated to show the peak loads (analogically to the suggested approach to households).

- Proposal 19 (2026 Process): Setting up a working group between grid operators for gas, electricity, hydrogen, heat + industrial association + shippers/suppliers + any member of the SRG with technical knowledge on industrial processes. This group can be used not only for the planning of the industry, but also for the planning of demand response and waste heat as it goes hand in hand.
- Proposal 20 (2026 Process): The hourly profiles in electricity and hydrogen should be planned disaggregated for the 4 different end-user groups.
- Proposal 21 (2026 Process): Technical and commercial viability of conversion of large industrial gas offtakes to other energy carriers needs to be verified before plans are made for network development.
- Proposal 22 (2026 process): The whole Z1 Z2 concept should be discussed in a group between grid operators gas/electricity/hydrogen TSO&DSO + Industry + EFET and others.
- Proposal 23 (2026 process): A flow model shall be created where all Inputs (in electricity generation, batteries, demand response and in hydrogen electrolyzers or other hydrogen production forms, import and storages), Outputs (in electricity disaggregated loads for each end user sector as industrial, residential, buildings, EV, batteries, demand response, agriculture, electrolyzers and district heating production) and in hydrogen (industrial, residential, buildings, transport, electricity production, CHP, storages) can be visualized and compared on the hourly basis. Otherwise, each files stands alone and cannot be put into context.
- Proposal 24 (2024 process): Prices for ammonia imports shall be amended to better reflect the additional transport and conversion costs, which are clearly higher than those associated with pipeline transport.
- Proposal 25 (2024 process): As the prices setting mechanism for hydrogen is one of the most relevant parameters for the simulation, a sensitivity is needed. The SRG will provide a proposal for the price setting.
- Proposal 26 (2026 process): Experts from the SRG work together with ENTSOs on cost assumptions relating to hydrogen (both imports and produced in H2 zones) to ensure these better reflect recent trends, and insights on infrastructure.
- Proposal 27 (2026 process): Organising a workshop to explain the generation capacity calculation in detail, including the estimation of capacity factors and the way that weather data are being considered for the different types of generators.
- Proposal 28 (2024 process): We propose that the TYNDP 2024 uses the commodity price projections provided by the European Commission.
- Proposal 29 (2024 process): If demand response is used in the simulation in a relevant amount, the parameters should be delivered to the SRG. A sensitivity should be calculated as in demand response the end user decided whether it delivers, and not the TSO. And the demand response plant has to be in an operations state to ramp up and down which has to be taken into account (because of multiple factors, such as: holidays, strikes, crisis like Covid, etc.).
- Proposal 30 (2026 process): Setting up a working group to understand the demand response calculation together with the industrial members, the shippers and the grid operators.
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