TYNDP // SCENARIOS

February 2025

Innovation Roadmap

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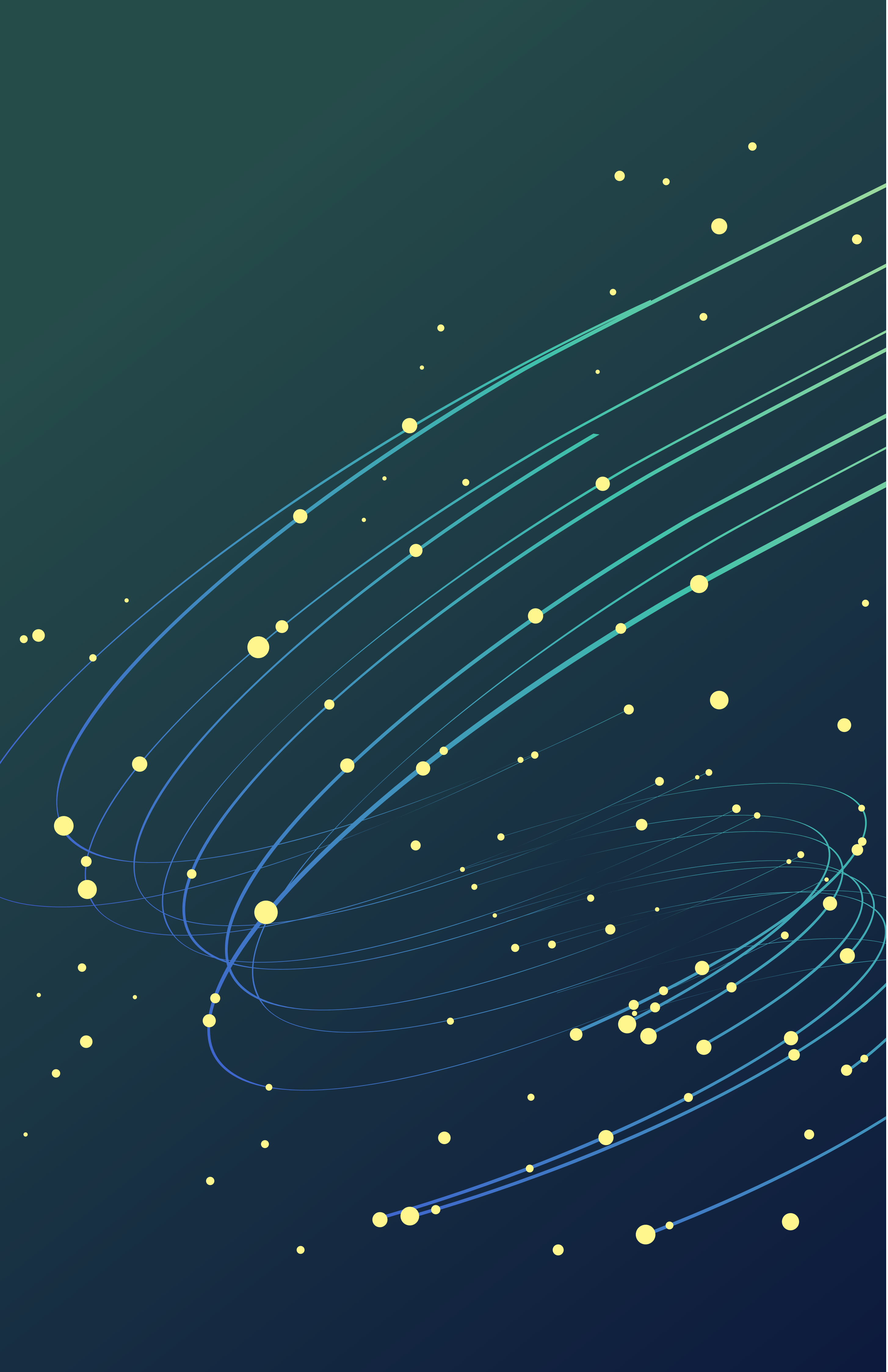


CONTENTS //

1 EXECUTIVE SUMMARY //

This report presents the innovation roadmap. It includes a review of the innovations that were not implemented during the 2024 cycle, essential model fixes for improving the TYNDP 2024 model, and newly proposed innovations for the TYNDP 2026 scenario cycle. These innovations are prioritised for implementation during the 2026 cycle.

In addition, the alignment and harmonisation of the entire TYNDP processes should be incorporated in the scenario building process. This roadmap also emphasises the need for consistency between successive TYNDP reports while accommodating emerging trends and expectations. Improvements in each cycle will be guided by prior evaluations and stakeholder feedback, and this roadmap will be released for consultation along with the 2026 input parameters to prioritise innovations.

The TYNDP 2026 cycle will be the first to fully comply with the ACER Framework Guideline, requiring adjustments in the scenario development approach. Given the compressed timeline for this cycle, there is a need to prioritise toolchain enhancements to ensure the timely development of scenarios. Experts will address critical model issues identified during consultations to ensure a high-quality baseline model.

Additionally, this report lists further requirements from the Stakeholders Reference Group (SRG), TSOs, and other stakeholders to complement and prioritise innovations for future cycles (TYNDP 2028 and TYNDP 2030). However, due to time and resource constraints, only a subset of these innovations will be prioritised for TYNDP 2026.

The initial version of this innovation roadmap has been prepared by ENTSO-E and ENTSOG's experts from the Working Group Scenario Building, reviewed by TSOs and SRG. The document will be then subject to the public consultation and will collect stakeholders feedback before publishing the second version and setting the priorities for the TYNDP 2028 cycle.

2 HIGH LEVEL APPROACH //

The high-level approach for developing the TYNDP 2026 innovation roadmap is depicted in the figure below. This roadmap is informed by feedback and guidelines from the following sources:

- Article 12 of Regulation 2022/869 (TEN-E Regulation) dated 30 May 2022
- ACER Framework Guideline
- European Scientific Advisory Board on Climate Change
- SRG Recommendations for TYNDP 2024

Prioritisation is given to items in Groups 1 and 2 as shown below. Group 1 looks at the development of methodologies, toolchain innovations and critical model fixes. Group 2 looks at mandatory innovations and data analysis tools. Should time and resources allow, initiatives from Group 3, New Innovations, will also be explored.

Figure 1: Prioritisation of innovations

3 SCENARIO DEVELOPMENT METHODOLOGY //

The TYNDP 2026 scenario framework has been updated to align with the ACER Framework Guideline, emphasizing the creation of a central National Trends+ (NT+) scenario alongside economic variant scenarios. While this framework aims to simplify the process and enhance transparency regarding scenario assumptions, transitioning to this new methodology will take time and may present challenges.

The NT+ scenario will be modelled based on input parameters agreed upon by both gas and electricity TSOs, with a strong focus on alignment and implementation within the Energy Transition Model (ETM) tool. This represents a new approach to NT+ scenario development.

In previous cycles, the NT+ scenario was primarily based on a collection of final energy demand volumes, generation, grid data, and flexibility capacities provided by TSOs. For the TYNDP 2026 cycle, more granular and detailed scenario input parameters will be required, with agreement between gas and electricity TSOs, which may extend the development timeline.

Further details on the development approach, including the economic variant scenarios, will be outlined in the Scenario Development Methodology document.

4 TOOLCHAIN INNOVATIONS //

Transitioning to the new scenario development methodology involves a more detailed quantification of the National Trends+ scenario while maintaining efficiency and high transparency in all scenario assumptions.

Toolchain overview

An overview of the foreseen toolchain for the TYNDP 2026 scenarios is provided below. The following tools are utilised within the toolchain to quantify the TYNDP 2026 scenarios:

- **Energy Transition Model (ETM):** A comprehensive energy system model is used to simulate the energy balance within and across different countries. For TYNDP , this model determines yearly sectoral energy demand volumes per energy carrier.
- **Supply Tool:** An Excel based tool. The supply tool gathers supply data from the ETM tool and the modelling results. Based on different assumptions the tool determines the final supply of each energy carrier and also determines imports. Based on the supply of energy carriers and use of CCS/CCUS the CO_2 emissions, and carbon budget is calculated.
- **DFT:** historical demand behaviour and projections from statistical indicators and bottom-up demand calculations. Tool to model hourly electricity demand timeseries by means of statistical model based on historic demand and climate data as well as deterministic models regarding EVs and HP contribution of the future
- **PLEXOS:** A cost-optimisation model used to determine minimise energy costs at European scale.
- **Visualisation Platform:** A web application designed to collect and publish relevant TYNDP scenario input assumptions and results.
- **Data Files:** A comprehensive and clear set of data files to ensure accessibility and understanding of the scenario assumptions and results. The visualisation platforms will be fed by this data, with the aim of downloading data from the view.

Data interfaces are being defined to efficiently translate information between the different steps of the toolchain. These interfaces will be transparently documented and made available in a clear and understandable format, ensuring that the assumptions and data flow between the tools are fully traceable.

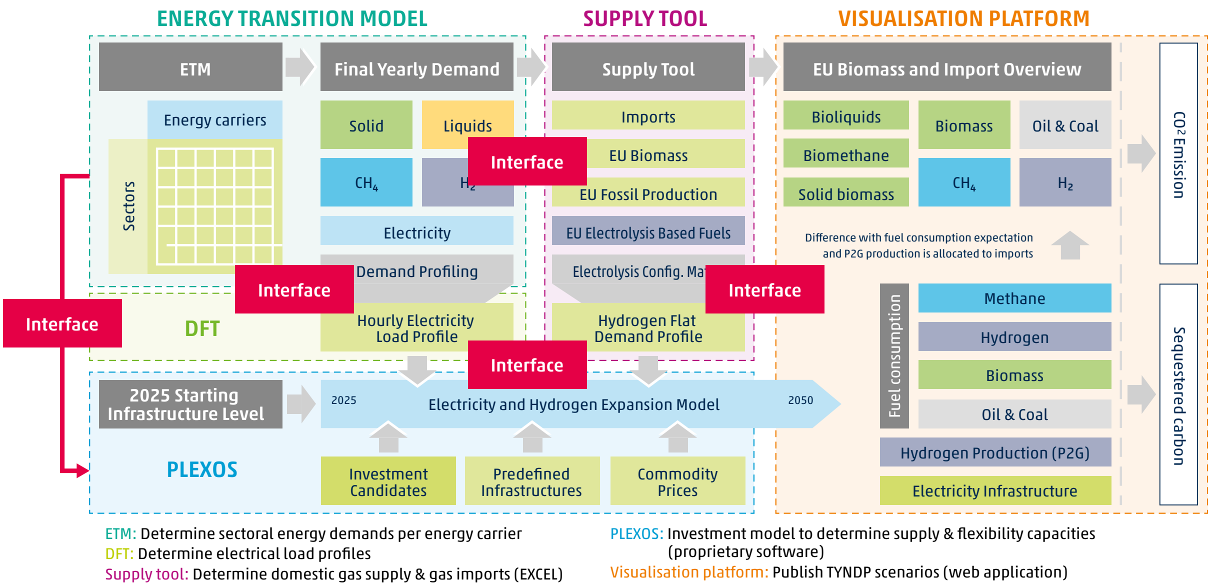


Figure 2: Building blocks for NT+ scenario

5 INNOVATIONS ON THE ETM //

In the TYNDP 2026 scenario quantification cycle, the ETM will play a pivotal role. To ensure that all scenario requirements are met, a list of model innovations has been identified. These innovations aim to enhance the model's functionality and accuracy in representing the future energy landscape. The details of these innovations are elaborated upon in the following sections.

5.1 Dashboard

Graphs necessary for the report will be integrated in the Dashboard. The Dashboard will allow for an easy visualisation of the final values by integrating values calculated outside of the ETM when necessary (for instance Electric Vehicles, hybrid heat pumps and electricity losses). Quantities according to the European commission definitions will be displayed as well as objectives indicators at EU level.

The Dashboard will contain no link to external files and no circular references.

Formulas that are not too computationally intensive will be used to make the Dashboard reactive enough.

5.2 Improvement of reference values

Based on a request from the SRG, an update is needed for the technology shares related to space heating and hot water in the residential sector within the reference year datasets of the ETM. Currently, much of the reference year (2019) data per country is based on EUROSTAT energy statistics, but the granularity of EUROSTAT's data has been insufficient to fully capture the details of the reference year energy balance.

To address these gaps, Quintel has made additional assumptions; however, the SRG has determined that some of these assumptions (e.g. heating technology shares) are not aligned with other national energy statistics.

As a result, the SRG has recommended that the starting values for the ETM be updated by replacing Quintel's estimates with data sourced from national statistics. Throughout this process, maintaining consistency and uniformity across all modelled countries within the ETM remains a critical requirement.

The year 2019 may be outdated due to the pace of development of the European energy landscape. This will be an innovation to be addressed in a future scenario development cycle.

5.3 Addition of climate year functionality

Parts of the energy balance are influenced by climate and weather conditions, meaning that both energy supply and demand can vary from year to year based on climatic factors such as temperature, solar radiation, and wind speeds. For example, electricity demand from heat pumps or heat boilers can fluctuate significantly depending on temperature. In the TYNDP 2024 demand quantification process, only one weather year from the past was used as a reference. However, the goal is to show the impact of different weather years and also climate change scenarios on the energy balance. Since in the new PECD apart from different historical weather profiles, also profiles from different climate change scenarios and climate models are available, this provides a much larger set of data to select from and stress the models. Particularly the effect of climate change should be tested in future scenarios.

Given that weather conditions change rapidly, the weather year dependent modelling within the ETM may be carried out , potentially generating a detailed set of sectoral energy demand profiles per scenario. This would provide information currently not delivered by ETM. To better address Emission Computation across all sectors, especially civil sector (residential and tertiary) final energy consumption of all vectors should be affected by the future climate conditions. This process will lead to different energy consumption and mixes based on the climate condition assumed.

In order to take a unified approach, for future studies a joint weather year selection guideline will be provided. Additionally, TSOs will be able to stress their scenarios with other weather years of their choice. Once the scenarios with variation of weather years are developed in the ETM, the energy profiles can be downloaded from the ETM website or accessed via the Scenario Toolkit.

For integration of demand profile modelling into ETM please refer to section 5.7.

5.4 Addition of countries to ETM

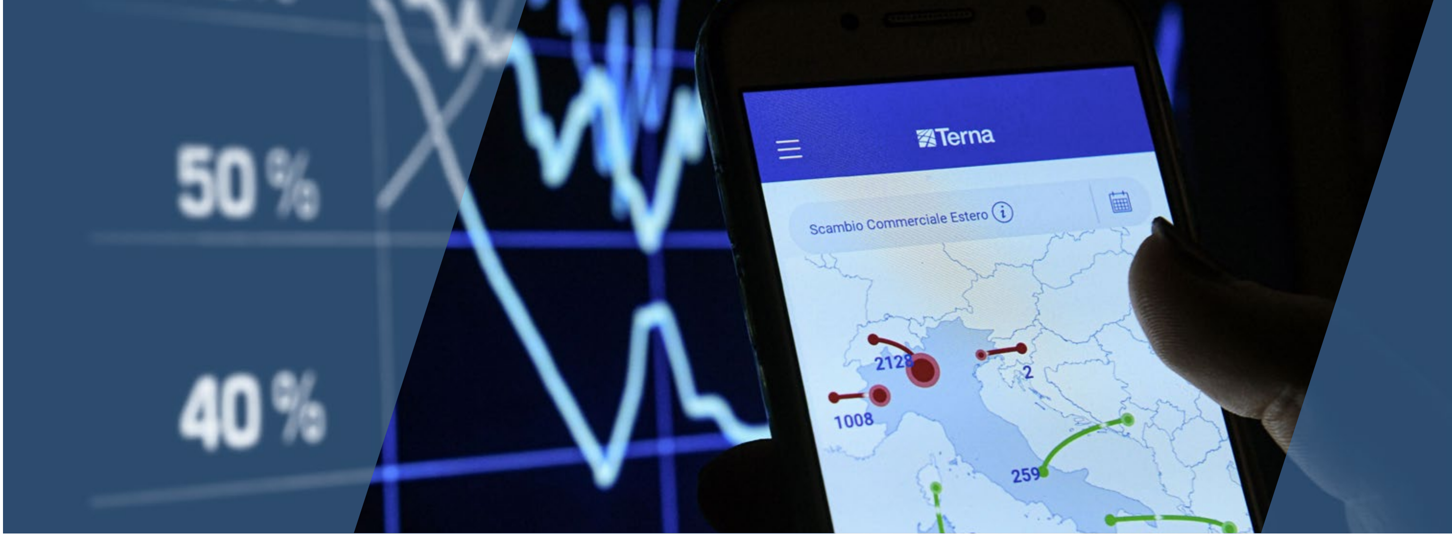
Due to the scope of European energy statistics such as EUROSTAT, the current ETM modelling covers only EU member states and the UK (as a former EU member state). However, the TYNDP requires consistent modelling across all interconnected European countries. This innovation project aims to include missing non-EU countries such as Norway, Switzerland, and Serbia in the ETM, and to split the United Kingdom into separate datasets for Great Britain and Northern Ireland to better align with TYNDP modelling requirements.

These enhancements will ensure a more comprehensive and consistent representation of all interconnected European countries within the ETM.

5.5 Stable ETM server for 2026 cycle

In response to user requirements, the ETM is continuously updated, which can sometimes lead to changes in the energy balance of previously built scenarios. To ensure stability for the scenarios developed as part of TYNDP 2026, a dedicated TYNDP server will be established. This server will host a stable version of the ETM, ensuring that the model used for TYNDP 2026 remains consistent over a defined period.

Only the features and functionalities available at the time of creating the dedicated ENTSO model copy will be accessible for TYNDP 2026. This approach guarantees that ongoing ETM updates will not affect the scenarios already built for the TYNDP process.



5.6 Integration of supply tool features in ETM

In the TYNDP 2024 cycle, the ETM was primarily used to quantify energy demand within the scenarios. However, the ETM is a comprehensive energy system model that covers all relevant aspects of the energy system. To reduce the need for multiple model interfaces, provide a transparent overview of the energy system scenarios, and enable benchmarking against energy and climate targets, this innovation aims to integrate the features of the previously used "supply tool" directly into the ETM.

As part of this effort, any potential supply modelling gaps in the ETM—compared to the capabilities of the former "Supply Tool"—will be identified and addressed where necessary. This will streamline the modelling process, ensuring a more complete and coherent representation of the entire energy system.

5.7 Demand profile modelling in ETM

In the TYNDP 2024 cycle, the ETM was primarily used to quantify energy demand volumes within scenarios. However, ETM also has the potential to model hourly demand profiles for various applications, sectors, and energy carriers, including electricity, methane, hydrogen, and heat. This innovation can be divided into the following key areas:

- **Modelling of Methane & Hydrogen Profiles:** In the TYNDP 2024 cycle, hydrogen demand profiles were developed using an internal ENTSOG tool. For TYNDP 2026, hourly demand profiles for both methane and hydrogen will be needed. These profiles could be generated directly in the ETM, ensuring full consistency with the scenario assumptions and eliminating the need for additional conversion steps between tools. This will enhance process efficiency by reducing complexity and increasing transparency for stakeholders.
- **Modelling of Electricity Demand Profiles:** Similarly, for electricity, converting energy volumes into hourly demand profiles is necessary for the investment modelling step in PLEXOS. In TYNDP 2024, electricity demand profiles for the National Trends scenario were collected from individual TSOs, using various tools, while profiles for European-focused scenarios like Distributed Energy and Global Ambition were centrally generated using the DFT.

To improve consistency in electricity demand profile modelling across countries, reduce data interfaces between tools, create a stronger link between scenario parameters and demand profiles, and increase stakeholder transparency, the ETM could be used to generate electricity demand profiles for TYNDP . However, given the varying requirements across countries, the expertise developed with the DFT in previous cycles, and the ETM's current lack of experience with profile modelling on a European scale, the ETM may be offered as an optional tool for TSOs.

The final decision on which tool to use for electricity demand profile modelling will be left to the respective country TSOs.

6 TRANSITION TO PAN-EUROPEAN MARKET MODELLING DATABASE (PEMMDB) APP //

The transition to the Pan-European Market Modelling Database (PEMMDB) App is an important step in streamlining data management for TYNDP scenarios. The Innovation Team should maintain a close connection with the WG Data & Models (ENTSO-E) to stay informed of the latest updates to the App and to ensure seamless integration. The focus should be on anticipating how to efficiently transfer data into the PLEXOS model, for example, by leveraging API queries to automate and simplify the data transfer process. This approach will help enhance the efficiency and reliability of the overall market modelling workflow.

7 QUALITY CONTROL INNOVATIONS //

Develop a 'Quality Assurance Tool (QAT)', a tool that performs predefined sanity checks for each scenario. These checks include preventing simultaneous dispatch of electrolysers and H_2/gas-fired power plants, ensuring appropriate volumes of Energy Not Served and RES curtailment, and comparing the contribution margins of generators, cross-sector assets, and storages against investment costs.

8 SYSTEM MODELLING INNOVATIONS //

8.1 Hydrogen Storage

There are key limitations in current hydrogen storage models that need to be addressed, including differentiating between short-term and seasonal storage needs, better representing operational constraints of storage facilities like salt caverns and aquifers, addressing discrepancies in storage capacities between models and national studies, accounting for techno-economic constraints of hydrogen supply sources, and improving pipeline modelling to reflect the flexibility of hydrogen transportation.

- **Impact on Modelling:** Refining the modelling of hydrogen storage systems will improve the accuracy of supply and demand balancing, enabling more precise predictions for hydrogen availability across different time scales and usage patterns.
- **Improvement:** Incorporating operational characteristics and feasible storage capacities into models will lead to better investment decisions and more accurate scenario planning, ensuring that hydrogen storage solutions are properly aligned with real-world conditions and energy system needs.

8.2 Integration of Hybrid Heat Pumps

Assumptions regarding the capacity of hybrid heat pumps may have been too simplified in the TYNDP 2024 cycle, which may not accurately mirror real-world operations. These assumptions could lead to discrepancies between expected and actual performance, impacting overall system efficiency and reliability.

Hybrid systems should be correctly sized for the applications they are meant to serve. This sizing must consider peak demand scenarios.

Finally, the impact of assumptions based solely on economic factors should be explored, with the aim to identify any potential misalignments or inefficiencies that could arise from economic assumptions that do not consider user behaviour.

8.3 Grid Topology

In previous models, the simplified nodal topology may have led to the underutilisation of key hydrogen corridors due to internal bottlenecks within the network structure. This could affect the model's ability to accurately represent hydrogen flow across the network, which could lead to inaccurate simulations of hydrogen distribution and usage. On the other hand, no modelling assumptions had previously been implemented that approximated the physical H_2 IC flow. A balanced representation of physical characteristics and flow granularity for hydrogen and electricity systems is important.

- **Impact on Modelling:** Introducing a more detailed topology with additional sub-nodes and IC (physical) H_2 flow constrain approximations will enhance the granularity of the model, allowing for more precise simulations of hydrogen flow. This improvement will help capture the physical and operational dynamics of the hydrogen network, ensuring that key corridors and infrastructure are accurately reflected.
- **Improvement:** By refining the model to align with the latest hydrogen TYNDP , incorporating sub-nodes and IC flow constraints will lead to better grid flow simulations. This will also allow for more accurate identification of potential bottlenecks and their impact on hydrogen system operations.

8.4 Gas Turbine Usage and peaking unit utilisation

The focus on the day-ahead market in previous models may have led to an underestimation of gas turbine demand, particularly during peak periods. This oversimplification does not capture the dynamic operational needs of gas turbines, which provide crucial flexibility to the grid, especially in an energy landscape dominated by variable renewable energy sources. Additionally, assumptions regarding the retrofitting of gas-fired power plants to hydrogen have shown discrepancies, as these retrofitted plants have struggled to compete effectively in real-world markets.

- **Impact on Modelling:** By conducting a more detailed assessment of the competitive landscape for both , models can better reflect the flexibility gas turbines provide, especially during peak demand. For the utilisation of hydrogen-based power generation the coupling between electricity and hydrogen markets within the model is of importance. An improved representation of gas and hydrogen-based power generation will help balance the grid more effectively as the energy mix shifts toward renewables and hydrogen.
- **Improvement:** Further analysis and review of gas turbine operations and peaking unit utilisation under consideration of their importance for market coupling will allow models to better reconcile theoretical assumptions with real-world outcomes. This refinement will lead to more accurate demand forecasting and infrastructure planning.

8.5 EV Modelling

In the current approach to EV modelling, instances have been identified where electricity flows directly to EV demand from the grid, bypassing the charging and discharging cycle of EV batteries. This indicates a gap in accurately capturing the real-world charging behaviours of electric vehicles.

- **Impact on Modelling:** Improving the EV model will allow for a better understanding of the interaction between EVs and the grid, leading to improved simulations of energy demand fluctuations and charging behaviours. This will enhance the accuracy of predictions regarding the impact of EVs on electricity demand at different scales.
- **Improvement:** By introducing a more granular approach, the model will be better suited for grid planning, optimizing infrastructure for future EV integration, and ensuring that both grid stability and energy demand are accurately forecasted.

8.6 Economic Assessment

An economic assessment is required to ensure the viability of technologies not included in the investment model. Key assets (e.g. Steam Methane Reformers (SMR), nuclear plants, ammonia regasification terminals, etc) need to be evaluated for their long-term economic sustainability.

- **Impact on Modelling:** Performing economic assessments for these technologies will assess the ability of assets to compete effectively in the under the modelling constraints and are accurately represented in long-term energy planning.
- **Improvement:** Including this evaluation will enhance the realism of the model by ensuring that non-investment model assets are properly accounted for, making scenarios economically viable and aligned with market dynamics.

8.7 Methane Pricing Structure and Formation

The current approach to modelling synthetic gases (SNG) and hydrogen production has revealed inconsistencies in pricing between SNG, biomethane, and hydrogen. These inconsistencies need to be addressed to ensure a stable and predictable market environment. Furthermore, the investment costs for hydrogen production should be aligned globally to reflect actual production costs across different regions.

- **Impact on Modelling:** Correcting these pricing inconsistencies will provide a more accurate representation of market dynamics, ensuring that investment decisions and policy planning are based on balanced cost structures.
- **Improvement:** Refining the methane supply mix methodology and incorporating gas blending techniques for integrating synthetic natural gas into methane networks, will be crucial as hydrogen plays an increasingly significant role in the energy transition.

8.8 Ammonia Import Costs

The costs of importing ammonia should reflect the entire supply chain, including hydrogen production costs in export countries, ammonia production, and transportation expenses. A comprehensive cost calculation will provide a practicable view of ammonia importation expenses.

- **Impact on Modelling:** Accurately modelling the full costs of ammonia imports will lead to more precise predictions for ammonia's role in the energy market and improve long-term investment strategies for ammonia infrastructure.
- **Improvement:** Additionally, adjusting the model's assumptions around Europe's hydrogen production will ensure that the model reflects achievable quotas for hydrogen imports and domestic production, aiding in better alignment with policy goals and infrastructure capabilities.

8.9 Distinction in Hydrogen Usage

A distinct separation between hydrogen used as a gas and hydrogen used as a feedstock for producing synthetic fuels such as methanol, ammonia, e-methane, and e-kerosene is required. Currently, the models conflate combines the demand for hydrogen for these two distinct purposes, which can mispresent results. Given the infrastructure and costs associated with producing synthetic fuels locally, occasionally it may be more economical to import synthetic fuels directly rather than producing them from imported hydrogen.

- **Impact on Modelling:** Distinguishing between these hydrogen uses will result in more precise demand projections for both hydrogen and synthetic fuels, influencing supply chains and investment in production infrastructure.
- **Improvement:** By reflecting the real-world dynamics of importing versus local production, models will be aligned with the economics of hydrogen and synthetic fuel markets, supporting more informed decisions regarding infrastructure development and fuel trade.

8.10 Flexibility of Heat Pumps

The flexibility of heat sources, especially electric heat pumps, needs to be specifically modelled, incorporating thermal inertia and heat storage. This flexibility allows for load shifting, where heat demand is moved from peak electricity times to periods when renewable generation is higher. It also applies to hybrid systems that utilise heat tanks for better load management.

- **Impact on Modelling:** Accurately capturing the flexibility of heat pumps will help models simulate demand response more effectively, improving grid stability and renewable integration.
- **Improvement:** This will result in achievable demand forecasts and enhance the efficiency of heat pumps within the broader energy system, reducing peak demand and increasing the use of renewable energy sources.

8.11 Modelling of E-Fuels

The assumption that e-fuels (e-methanol, e-methane, e-kerosene) cannot be transported by pipeline, ships or tanker trucks should be reconsidered. These fuels are critical for decarbonizing sectors like shipping and aviation, and the logistics of transporting them must be modelled precisely. Additionally, techno-economic factors, such as the required full load hours for refinery viability, must be considered when determining the location of e-fuel refineries and associated electricity and hydrogen supply infrastructure.

- **Impact on Modelling:** Including practical transportation options for e-fuels will enhance the model's ability to forecast supply chains and production infrastructure needs. The techno-economic parameters will provide more accurate assessments of refinery locations and energy supply logistics.
- **Improvement:** This will result in better infrastructure planning, ensuring that refineries are placed where they can economically operate, aligning with hydrogen and electricity sources.

8.12 Higher Granularity Topology

Improving the spatial resolution of energy models by adding more nodes per country can help address internal bottlenecks and regional differences in renewable energy availability. For example, solar potential in southern France differs from that in the north, and offshore wind conditions in northern Germany differ from inland regions. Capturing these variations in the model will better inform investment decisions for renewables, grid expansions, storage, and electrolysers.

- **Impact on Modelling:** Higher granularity allows for an accurate consideration of regional energy demand and renewable potential, optimizing resource allocation and infrastructure development.
- **Improvement:** It will also identify potential grid constraints and allow for more targeted investments in areas like wind and solar capacity, hydrogen production, and grid enhancements to reduce bottlenecks and increase overall efficiency.

8.13 Improved Modelling of Prosumer Demand

Not all households are prosumers (those who generate and store their own energy), and models must differentiate between prosumer and non-prosumer households. Prosumers can significantly reduce grid dependence and may export excess energy, whereas non-prosumers rely entirely on the grid. Differentiating between these behaviours is essential for accurate demand projections and grid interaction modelling.

- **Impact on Modelling:** Differentiating between prosumer and non-prosumer households will lead to detailed demand forecasts and better guiding investments in smart grids and flexibility solutions.
- **Improvement:** This distinction will also improve the planning for renewable integration and grid resilience, ensuring a more balanced and efficient energy system that accounts for varying consumption patterns across different household types.

8.14 Consider Peaking Units as Expansion Candidates

Peaking power units, traditionally viewed as backup facilities, should be considered for system expansion to manage peak loads and ensure grid stability as the energy system integrates more variable renewable energy sources like wind and solar. These renewables fluctuate in availability, and expanding peaking units can provide the necessary flexibility to respond to demand spikes or renewable energy shortfalls. Evaluating the role of peaking units for expansion can reduce reliance on carbon-intensive generation sources, improving grid flexibility and better balancing supply and demand.

- **Impact on Modelling:** Including peaking units as expansion candidates enhances the models ability to accurately simulate grid reliability during periods of renewable energy shortfalls.
- **Improvement:** This will support better planning for energy supply security as the transition to renewables accelerates, ensuring that the grid can meet peak demand without relying on less flexible power sources.

8.15 Check on Remaining CO_2 Emissions in 2050

A thorough review of projected CO_2 emissions for 2050 is crucial to evaluate whether current policies and technologies are sufficient to meet long-term decarbonisation goals. By analysing multiple emission scenarios, any discrepancies between policy targets and actual outcomes can be identified, revealing areas that need additional policy measures or technological innovations. Regularly reviewing CO_2 projections ensures the energy system is on track to achieve net-zero emissions and aligns with global climate targets.

- **Impact on Modelling:** Regular assessments will help identify gaps and provide a robust view of whether current energy transition strategies are adequate.
- **Improvement:** This will provide insights into the effectiveness of existing technologies and policies, helping to adjust plans to meet 2050 emissions targets.

8.16 Implementation of Hybrid Electrolyser Plants

Hybrid electrolyser plants, connected to both dedicated renewable energy sources (DRES) and the electricity grid, optimise the use of renewable energy by allowing for hydrogen production during periods of high renewable output while accessing system-wide renewable energy sources (SRES) when additional energy is needed. This dual approach improves the efficiency and reliability of hydrogen production, maintaining a stable hydrogen supply even when dedicated renewable generation is low.

- **Impact on Modelling:** Incorporating hybrid electrolyser plants will enhance the model's ability to simulate hydrogen production and grid interaction. Electrolysers also couple electricity and hydrogen markets within the model, hence their impact on market coupling shall be assessed under consideration of the EU Delegated Acts on renewable hydrogen.
- **Improvement:** It enhances system flexibility by ensuring hydrogen production can continue during periods of low renewable generation, maximizing the integration of renewables into the hydrogen supply chain. Hybrid electrolysers can further refine the market coupling between electricity and hydrogen within the model.

8.17 Hydrogen Imports and Pipeline Assessment

Hydrogen imports via pipelines should be modelled to reflect practical annual volumes and prices, considering both security of supply and energy dependence within the EU. Accurate simulation of hydrogen imports will help in planning for stable energy supplies while ensuring economic and operational efficiency. Understanding the balance between domestic hydrogen production and imports is vital for strategic long-term planning.

- **Impact on Modelling:** Including accurate representations of pipeline imports allows for better evaluation of supply routes and the impact on energy security.
- **Improvement:** This will help policymakers make informed decisions about infrastructure development and ensure supply chains align with the EUs energy transition goals.

8.18 Geographical Correlation in Hydrogen Production

The EU Delegated Act on renewable hydrogen, under RED II, mandates geographical correlation, ensuring that renewable electricity used for electrolysis is generated in the same bidding zone or an interconnected zone. This prevents congestion in grid interconnections and avoids inefficiencies from long-distance electricity transmission. The regulation also enforces temporal correlation and additionality to ensure hydrogen production is aligned with new renewable installations.

- **Impact on Modelling:** The geographical correlation requirement improves the accuracy of grid efficiency simulations, ensuring that hydrogen is produced locally using renewable sources.
- **Improvement:** Aligning hydrogen production with local renewable generation reduces the need for fossil-based backup power, enhancing both grid efficiency and energy security.

9 STAKEHOLDER REFERENCE GROUP //

A series of proposals have been submitted by the SRG and external entities, addressing a range of topics from synthetic fuel integration to the refinement of existing models to better accommodate evolving energy demands and climatic conditions.

9.1 Synthetic Fuels

The SRG proposes incorporating methanol as a key synthetic fuel in the maritime sector for the next modelling cycle. Methanol has been identified as a crucial element for reducing maritime emissions, as it can serve as a low-carbon alternative to conventional fossil fuels. Incorporating methanol into the models can help simulate its impact on global maritime transport emissions, align with decarbonisation goals, and identify the infrastructure investments required for methanol-based shipping fuel deployment.

- **Impact on Modelling:** Incorporating methanol in the energy models would refine predictions of shipping sector emissions, which can inform policies and guide investment in ports and fuel infrastructure. It can also simulate the logistical and economic aspects of its production, storage, and transportation within Europe.
- **Improvement:** Methanol's inclusion in the model would enhance the ability to reflect accurate transitions in fuel use in the shipping industry and promote the adoption of synthetic fuels in the energy transition.

9.2 Climatic Variability

The SRG suggests running the models with three different climatic years to better assess the impact of climate variability on energy systems. The analysis of multiple climate conditions will provide deeper insights into how renewable energy production, energy demand, and grid stability are affected across different weather patterns. Collaborating with ENTSO-E and ENTSOG on these outcomes could lead to enhanced regional energy planning.

- **Impact on Modelling:** This approach would significantly enhance the accuracy of renewable energy projections and the effectiveness of demand-side response, allowing planners to optimise systems for varying weather patterns, such as prolonged periods of low wind or solar generation.
- **Improvement:** Incorporating climate variability will increase model robustness, ensuring energy security even under extreme weather conditions.

9.3 Industrial Applications

This proposal emphasises the need to verify the technical and commercial viability of converting large industrial gas offtakes to alternative energy carriers before advancing with significant network development plans. This is critical to ensuring that the proposed energy carrier is sustainable and compatible with the existing industrial infrastructure.

- **Impact on Modelling:** By focusing on technical feasibility and economic assessment, the model will better capture investment decisions for industrial conversions, reducing the risk of inefficient network expansions.
- **Improvement:** This adds rigor to the decision-making process by aligning industrial energy transitions with the broader energy network strategy.

9.4 Sector-Specific Modelling

The SRG recommends a comprehensive discussion on the Z1 Z2 concept, which involves collaboration between grid operators, TSOs, DSOs, and other stakeholders. The goal is to streamline grid management across multiple sectors—gas, electricity, and hydrogen—for more efficient and integrated systems.

- **Impact on Modelling:** This proposal aims to improve the interoperability of multiple energy sectors, optimizing how grids are managed. It will enhance the ability to coordinate the use of different energy carriers in tandem, especially as sector coupling becomes a key part of the energy transition.
- **Improvement:** The integration of this concept can lead to better energy flow management across sectors, reducing redundancies and improving overall system efficiency.

9.5 EV Modelling Techniques

The SRG proposes establishing a working group to refine assumptions around electric vehicle (EV) modelling. By reviewing current models, the group would ensure that the impact of EVs on the power grid is accurately assessed, especially considering factors such as charging behaviour and grid integration.

- **Impact on Modelling:** Enhanced EV modelling will provide a more detailed understanding of how charging patterns affect grid demand and potential bottlenecks. This is crucial for planning EV infrastructure and ensuring that the grid can handle increased electrification without compromising reliability.
- **Improvement:** This will lead to enhanced projections for EV-related investments in grid reinforcement and charging infrastructure, supporting the larger goals of decarbonizing the transport sector.

9.6 District Heating

The SRG calls for a dedicated tool, distinct from the ETM model, to simulate the production of district heating. This tool would be developed by a specialised working group with expertise in various heating technologies.

- **Impact on Modelling:** This dedicated tool will enable a precise and specialised simulation of district heating networks, accounting for the unique characteristics of heat distribution and the different sources of energy involved (e.g., biomass, geothermal).
- **Improvement:** Specialised district heating modelling will improve the heat demand projections and guide investments in thermal infrastructure.

9.7 Liquefied Hydrogen

The SRG proposes exploring different hydrogen import methods, such as liquefied hydrogen (LH_2), to understand the potential and constraints of these approaches. By considering LH_2 imports, models can provide a clearer picture of the logistical requirements, storage needs, and costs associated with hydrogen transportation.

- **Impact on Modelling:** Modelling hydrogen imports, including LH_2, will help assess the feasibility and cost-effectiveness of long-term hydrogen supply chains, which are crucial for meeting decarbonisation goals.
- **Improvement:** By integrating this import method, the model will more comprehensively reflect the hydrogen supply landscape, including infrastructure and storage considerations.

9.8 H_2 Imports Quotas

The SRG suggests revising the current hydrogen import quotas to align with Repower EU targets. The existing projections significantly exceed domestic production capacities, which may lead to overestimated supply in current models.

- **Impact on Modelling:** Recalibrating the model to reflect realistic hydrogen imports will avoid overestimations that could distort energy planning and investment in hydrogen infrastructure.
- **Improvement:** Ensuring that import quotas are achievable will lead to better-aligned models and investments in the hydrogen economy.

9.9 Electric Heat Pumps

The SRG recommends moving the modelling of electric heat pumps to Plexos to simulate their flexibility, particularly considering the thermal inertia of buildings. This will help optimise load shifting and ensure that heat pumps are better integrated into energy systems.

- **Impact on Modelling:** By improving the representation of heat pump flexibility, models will better capture the interaction between heat demand and electricity systems, allowing for more dynamic load management.
- **Improvement:** This will lead to detailed planning for demand response and energy storage solutions, particularly in heating-dominated regions.

9.10 Optimisation Across Energy Vectors

The SRG recommends expanding optimisation in the models to integrate electricity, gas, and potentially hydrogen systems within Plexos. By optimizing across multiple energy vectors, models can better capture the interdependencies between these systems and ensure more efficient sector coupling. This approach allows for the integration of energy carriers to be managed holistically, improving load balancing, storage, and flexibility across energy types.

- **Impact on Modelling:** This will result in detailed simulations of energy flow and utilisation across sectors, providing deeper insights into where investments are needed to support cross-sector infrastructure.
- **Improvement:** Expanding optimisation will support a resilient energy system capable of meeting demand across different carriers, while enhancing renewable energy integration and optimizing storage capacity across electricity, gas, and hydrogen.

9.11 Transmission System Losses

The SRG proposes reassessing how transmission system losses are modelled, with an emphasis on reflecting actual power flow dynamics more accurately. Transmission losses occur due to resistance in electrical lines, and inaccurately modelling these losses can lead to over- or underestimation of the actual energy delivered to consumers.

- **Impact on Modelling:** A calculation of transmission losses will provide more specific data for grid management and infrastructure investments, reducing the risk of overcompensating with unnecessary generation or grid upgrades.
- **Improvement:** More accurate representation of losses will improve the overall efficiency of the energy system, reducing waste and unnecessary costs related to transmission.

9.12 Additional Hydrogen Production Pathways

The SRG suggests integrating additional hydrogen production methods, beyond traditional water electrolysis and Steam Methane Reforming (SMR) with CCS. These methods could include methane pyrolysis and waste-to-hydrogen processes, which offer alternative pathways for producing hydrogen with potentially lower emissions or resource consumption.

- **Impact on Modelling:** By incorporating alternative hydrogen production technologies, the model can provide a more comprehensive view of hydrogen supply chains, offering flexibility and innovation in meeting hydrogen demand.
- **Improvement:** Expanding the model to include a broader range of hydrogen production methods supports a diversified approach to hydrogen development, improving supply security and reducing carbon intensity.

9.13 Flexibility in Modelling

The SRG emphasises the need for models to focus not only on load reduction but also on load displacement, capturing dynamic shifts in energy use. Load displacement refers to moving energy demand from peak times to periods of lower demand, which helps balance the grid and maximise renewable energy use.

- **Impact on Modelling:** This focus will allow models to simulate precise grid operations, helping to manage peak loads more effectively and integrate renewable energy more efficiently.
- **Improvement:** By modelling load displacement, the system can optimise the use of renewable generation, reduce strain on the grid, and better utilise demand-side flexibility measures.

9.14 Price Setting for Hydrogen

The SRG proposes revising the methodology for setting hydrogen prices, ensuring it reflects real-world contractual arrangements and includes costs such as dehydrogenation. This change will provide a precise reflection of hydrogen pricing across different supply and consumption scenarios, taking into account all relevant economic factors.

- **Impact on Modelling:** A specific hydrogen pricing mechanism will improve the economic modelling of hydrogen projects, ensuring investments are aligned with actual market dynamics and pricing structures.
- **Improvement:** Revising the pricing methodology will support the development of a more competitive hydrogen market, promoting transparent pricing and investment in hydrogen infrastructure.

9.15 Sensitivity to Commodity Prices

The SRG recommends conducting sensitivity analyses to determine how fluctuations in commodity prices (e.g., natural gas, oil, hydrogen) affect energy models. Commodity price volatility can significantly impact the cost-effectiveness of various energy technologies and supply chains.

- **Impact on Modelling:** Sensitivity analyses will allow for more robust scenario planning, helping to understand the potential risks and rewards of investments in energy infrastructure under different commodity price conditions.
- **Improvement:** This approach will improve the resilience of energy models by accounting for market fluctuations, ensuring that planning and investment decisions are based on a wide range of potential market conditions.

9.16 Inclusion of Emerging Technologies

The SRG proposes developing a transparent process for including new technologies or features in the modelling exercises, ensuring they are evaluated fairly. This would create a structured approach to incorporating innovations, allowing for emerging technologies to be tested and integrated into energy models as they develop.

- **Impact on Modelling:** Including a formal process for emerging technologies ensures that models remain up-to-date with the latest technological advancements, such as new storage systems, carbon capture methods, or renewable energy solutions.
- **Improvement:** This will promote innovation within the modelling framework, providing the flexibility to adopt new solutions as they become commercially viable, ensuring that models are forward-looking and reflective of technological progress.

9.17 Out of scope innovations

- **Carbon Capture and Utilisation:** Incorporate modelling of different energy carriers and CO_2 sources, including CCS (Carbon Capture and Storage) and CDR (Carbon Dioxide Removal) to better capture these processes implicitly (WG4).
- **Innovative Grid Technologies:** Model advanced grid technologies such as Dynamic Line Rating and Modular Power Flow Control to improve the accuracy and responsiveness of the grid models (WG3).

10 PRIORITISATION OF INNOVATIONS FOR THE TYNDP 2026 PLANNING CYCLE //

Not all innovations can be carried out in the 2026 scenario cycle due to significant changes in the scenario development architecture. The items below show a brief overview of the innovations/fixes that will be explored in the 2026 cycle.

Advancements in Hydrogen Modelling

- Differentiating short-term and seasonal needs for storage and flexibility
- Flow speed in pipelines and cross-border flows,
- Aligning hydrogen import quotas with current numbers
- Hybrid electrolyser production methods to optimise hydrogen pricing.

Enhancing EV Modelling

- Simulating accurate charging and discharging patterns accurately by 2026
- Grid flexibility.

Other Innovations

- Methanol modelling for maritime will be explored as a synthetic fuel.

Leveraging Geographic and Climate Data

- improving climate assumptions in modelling.

Upgrading Scenario Modelling Tools

- non-EU countries like Norway and Switzerland by 2026,
- developing web-based interfaces for transparent scenario sharing in data visualisation.

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ENTSOG

European Network of
Transmission System Operators
for Gas

Avenue de Cortenbergh 100
1000 Brussels, Belgium

www.entsog.eu

ENTSO-E

European Network of
Transmission System Operators
for Electricity

Rue de Spa, 8
1000 Brussels, Belgium

www.entsoe.eu

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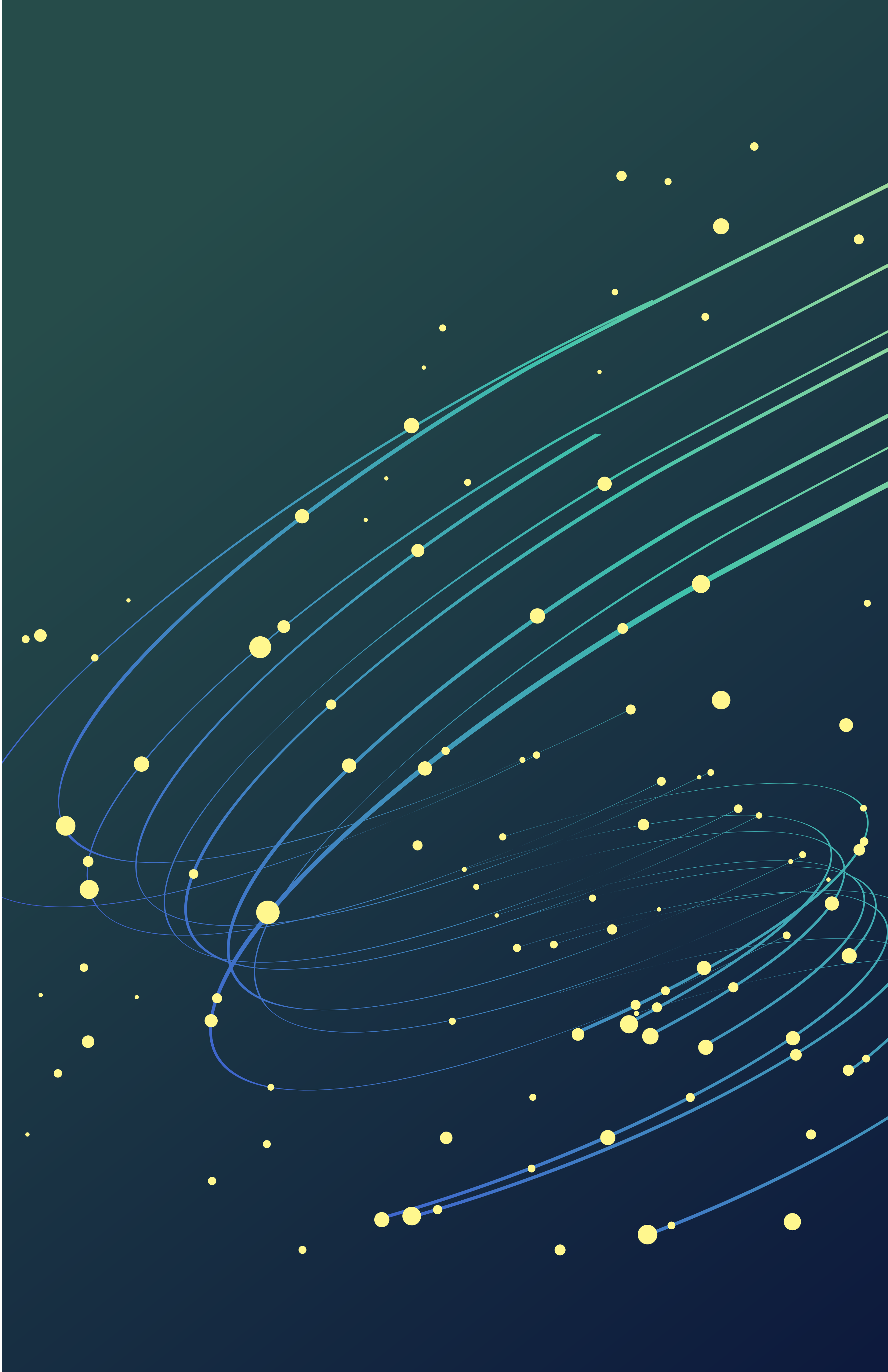

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