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Document Version
Final published version

DOI:
10.22439/csei.pb.017

Publication date:
2023

CSEI Policy Brief #017

DOI 10.22439/csei.pb.017

COPENHAGEN BUSINESS SCHOOL
COPENHAGEN SCHOOL OF ENERGY INFRASTRUCTURE

Conclusions on Integrated Network Planning in Europe – The STEERS Project

Christine Brandstätt[1], Manuel Llorca[1], Alexandra Lüth[1], Jens Weibezahn[1], Tooraj Jamasb[1]
[1]Copenhagen School of Energy Infrastructure (CSEI), Copenhagen Business School
This policy brief is further based on contributions by Theodoros Bechlivanis, Peter George, Leonard Göke, and Julius Meier.

Network planning is central to a future-proof energy system that is viable within the framework of the European Green Deal and suitable for energy systems integration. The new TEN-E regulation underlines this for European energy networks. The STEERS project aimed at aiding the implementation of its goals, i.e., system integration, the energy efficiency first principle, as well as the improvement of transparency and openness in the planning of energy networks in the European Union, and specifically in the TYNDP process. In this policy brief, we sum up the main conclusions.

The planning of cross-border network infrastructure in the European Union is carried out biannually by the European networks of transmission system operators (ENTSOs) for gas and electricity via their Ten-Year Network Development Plan (TYNDP). The objectives of this process comprise streamlining the planning of network interconnections in Europe, assessing planned projects, and pointing out remaining infrastructure gaps as per the current planning.

While initially, the challenge was to harmonize independent national planning processes, the focus has since shifted towards coordination between the electricity and gas sector, and between transmission and distribution networks. Figure 1 depicts the analytical steps of the TYNDP, namely scenario building, identification of system needs and infrastructure gaps, and cost-benefit analysis. This provides the basis for the subsequent selection of projects of common interest (PCIs). Based on their pan-European relevance, these projects are eligible for additional support as well as funding via the Connecting Europe Facility.

Over the course of the project, CSEI has assessed the current process against the state of knowledge, proposed incremental changes to the TYNDP process in view of the requirements from the TEN-E regulation recast and assessed the feasibility of the altered methodology. Throughout the project we have kept in close contact with stakeholders from the modelling community, the European network industry, policymakers and societal actors to continuously discuss the implications of our suggestions and findings in practice.

The TYNDP process in a nutshell

The TYNDP scenarios comprise data and assumptions regarding the future demands for different energy carriers (such as electricity, methane, hydrogen, and liquid fuels) along with domestic resources and import potentials. Other inputs into the scenario modelling include projections of energy prices and the current and reliably planned infrastructure levels for electricity and gas grids, as well as generation and storage capacity. As the first step towards integrated energy system planning, the scenarios and assumptions for the development of electricity and gas grids have been streamlined since 2018.

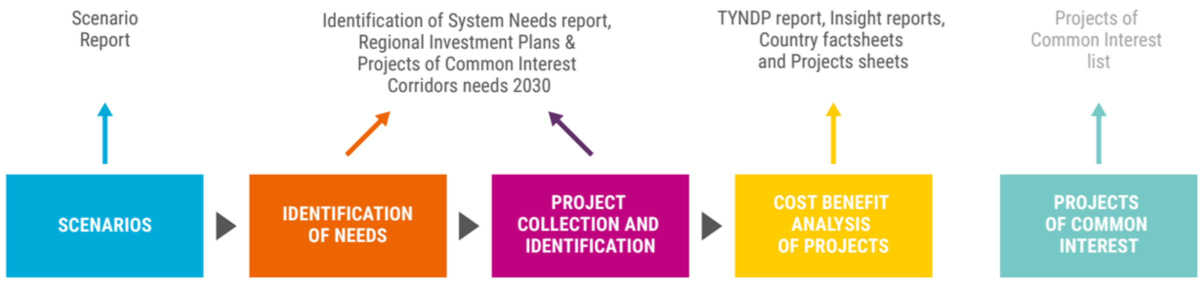

Figure 1: TYNDP process and PCI selection according to TEN-E, adapted from ENTSO-E.

The actual identification of infrastructure gaps occurs via a number of soft-linked tools and models to replicate the energy system, at the core of which are a market and a network simulation. Both feed into the evaluation of individual incrementally planned projects in a cost–benefit analysis. The benefit indicators for this are determined by the ENTSOs in line with criteria set out in the TEN-E regulation, such as sustainability, market integration, security and quality of supply, as well as smart sector integration.

Stakeholder participation in the TYNDP process is focused mostly on the development of storylines and scenarios. The ENTSOs hold a sequence of webinars with interested and concerned parties, such as companies with commercial interests and non-governmental organizations. The process results in several versions of a scenario report and guidelines, along with spreadsheet data and a visualization platform. After the publication of an initial draft, stakeholders can submit written feedback, to which the ENTSOs reply and which they consider for subsequent versions.

Scenario building and energy system modelling are at the core of the TYNDP process. The main outcomes regarding infrastructure gaps and cost-benefit evaluation, as well as the usability and acceptance by the manifold stakeholders, rely heavily on a suitable design of the modelling features. The methodology applied for the TYNDP evolves with each new edition along with the state of knowledge. This is particularly evident regarding the integration of gas and electricity systems and with respect to the representation of flexible and cross-sectoral technologies.

The STEERS methodology

The STEERS methodology outlines potential improvements. It highlights the need for varied scenario storylines to address uncertainties regarding the future development of the energy system. The methodology is based solely on energy balances that comply with politically agreed greenhouse gas budgets and proposes targeted improvements for constructing demand profiles for flexible demands and renewable generation. And furthermore, the STEERS methodology focuses on openness and traceability and promotes the use of publicly available, non-commercial tools.

	STEERS Methodology	Δ to Current TYNDP	Options for Future Improvements
Scenario Storylines	varied storylines, interpreted in the context of descriptive and normative aspects	additional storylines (direct electrification, flexibility) all compliant with climate targets, compared and interpreted thoroughly, time horizon of ten years and beyond	Improvements and increased automation/interoperability in tool chain to streamline the analysis of varied storylines and sensitivities
Energy Balance	scenarios build on sectoral activity, supply potentials in line with common studies and emissions targets	base all scenarios on the same methodology, disclose all relevant assumptions and input modifications	explore and communicate sensitivities in a structured manner
Profiles			
Wind & Solar	exogenous profiles for weather dependent renewables	lower full load hours instead of higher investment cost for less favourable sites	reflect climate change in input weather data
Hydro Reservoir	modelled as storage systems with exogenous charging profile	currently modelling and its aggregation somewhat unclear	reflect climate change in input weather data
District Heating	dispatch CHP and heat pumps to reduce residual load and include an energy balance for district heat	endogenous dispatch instead of exogenous assumptions	reflect regulatory uncertainty regarding incentives for system-friendly operation of district heating
Electric Vehicles	optimisation of charging based on exogenous grid-connection profiles	endogenous charging instead of exogenous assumptions	reflect system-friendly charging, vehicle-to-grid options, battery swapping and individual vs. fleet vehicles
Power to X	endogenously determined demand for different consumer types	--	--

DOI 10.22439/csei.pb.017

	STEERS Methodology	Δ to Current TYNDP	Options for Future Improvements
Dispatch & Expansion			
Prosumers	transparent, exogenous assumptions for expansion	exogenous assumptions instead of endogenous expansion based on consumer prices and deviating from the social planner perspective	reflect regulatory uncertainty regarding incentives for prosumers
Storage	capture the full flexibility of short- or medium-term but also seasonal storage for capacity expansion	differentiate investments between energy and power capacity of storage, simulate more than a few representative weeks	--
Multi-temporal Planning	combine a first optimisation covering the entire timeframe but only few years with a second step expanding the system in between those years with the previous results as boundary conditions	improvement from reduced foresight and rolling horizon, preventing stranded assets	reflect disruptions in assets' lifetime beyond the scenario horizon, initially qualitatively and eventually via extended modelling horizon or a dedicated effect in residual valuation or annualization of investment cost
Sectoral Scope	capture other sectors by exogenous assumptions and ideally endogenously via shared expansion planning	extension of the sectoral scope, e.g., following the example of hydrogen, at least to district heating and ideally also to individual flexibility	--
Grid Simulation	employ open modelling tool uniformly across the entire area	transparent methodology for transfer of zonal dispatch to grid nodes (similar as for transfer from scenarios to market simulation), publication and discussion of results for all scenarios and time horizons	include potential effects on redispatch within zones, depict flow-based market coupling in CWE region
Beneift Indicators	streamlined indicators for electricity and gas (as far as possible) cover all aspects of the TEN-E recast, evaluated and discussed for all scenarios and time horizons, see details in methodology report	see details in the methodology report	recurring revision to capture emerging aspects such as hydrogen leakage or innovative types of flexibility, deployment of more sophisticated stochastic analysis (instead of analysis +/- project) to capture interrelations between the proposed projects, links to assessment of other PCI categories
Transparency			
Stakeholder Process	Targeted communication along the process, expert consultation, feedback loops	broader exploration space to reflect stakeholders' positions in the analysis	--
Openness of Data, Code, and Publications	complete and easy access to data and tools for reuse and validation	complete input, intermediary and output data in line with FAIR principles, use of open tools as far as possible, stepwise improvement of transparency	recurring structured comparison of open tools for process steps that are still closed, use of open-source and openly licensed solvers

Table 1: Overview of the STEERS methodology.

Relevance and feasibility of improvements

Subsequently, the project validated the feasibility of these improvements. To facilitate the verification of future TYNDP versions in view of the STEERS methodology, the project provides a comprehensive checklist with specific questions related to the critical aspects of each step in the TYNDP process. In a final assessment, we distinguish improvements of the TYNDP methodology which seem more relevant to comply with the TEN-E criteria and with transparency objectives from others that constitute relatively minor improvements. We also acknowledge that some changes require relatively low, maybe only a one-off effort, whereas other entail substantial and recurring additional efforts. Particularly some basic improvements regarding transparency and stakeholder involvement along with some basic implementation of open data and open modelling come at medium effort but have a high relevance according to this framework. The use of more varied storylines to reflect the impact of flexibility better seems highly relevant, and at least to some degree can be realized at moderate effort.

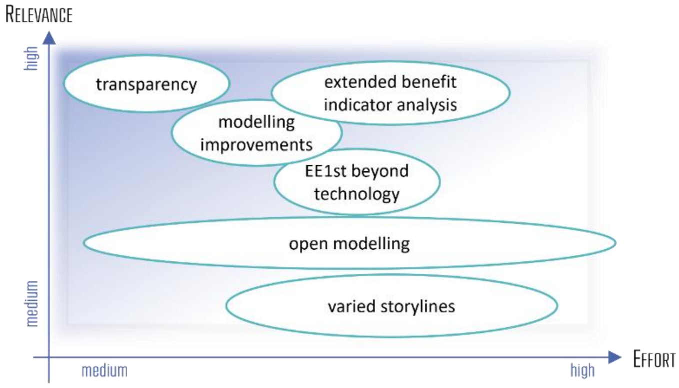

Figure 2: Summary of the feasibility analysis for future developments.

A concrete example of 'low-hanging-fruit' with respect to transparency, is the improvement of data publication. To showcase the shortcomings of the current procedure in detail, we have compiled a list of all input data and assumption variables for the scenario building. This exercise points out precisely what kind of data is not yet published as accessible and transparent as it is common practice in energy system modelling.

To provide further inspiration, this report includes a list of good practices that have provided valuable insights for the project and cover all the different steps of the TYNDP process. The list includes a number of open models and tools which can either be employed directly in the TYNDP process or can inspire open solutions to be used in the future. We also feature promising instances of stakeholder engagement and some references of indicators included in cost-benefit analysis.

While the STEERS assessment sees the TYNDP process tackling many of the improvements necessary in view of energy system integration, the project also still identifies shortcomings with respect to transparency and openness. The material provided in this report and the input provided throughout countless discussions and consultations throughout the project ideally help to bring the process closer to the state of knowledge and common good practices in those dimensions as well.

Improving the TYNDP process is a continuous and ongoing task. For several desirable improvements, such as reconciling long- and short-term perspectives better in the modelling or assessing additional dimensions like cybersecurity, we have not been able to identify relevant references in the current state of knowledge. Ideally, these aspects will be covered better in subsequent assessments. In the future, the TYNDP process might grow closer to the planning and assessment of other infrastructures covered by the TEN-E regulation. For this, it will be very desirable to streamline the methodologies for gas and electricity networks as far as possible with those assessing electrolysers, smart grids, and CO2 networks. As the energy system and its regulatory framework evolve further, the STEERS methodology and the conclusions from the project will merit revision and updating in the future.

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