TEN-YEAR NETWORK DEVELOPMENT PLAN

2024

ANNEX D3
Hydrogen and Natural Gas System Assessment Methodology

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Content

Abbreviations

The lists of abbreviations of the TYNDP 2024 Implementation Guidelines[1] and the TYNDP 2024 Infrastructure Gaps Identification (IGI) methodology[2] are also valid for this document. Additionally, the following abbreviations apply:

CDF	**2-week Cold Dunkelflaute**
CR	**Curtailment Rate**
DC	**Demand Curtailment**
DE	**Distributed Energy**
EBA	**European Biogas Association**
GA	**Global Ambition**
GHR	**Regulation of the European Parliament and of the Council on the internal markets for renewable gas, natural gas and hydrogen, amending Regulations (EU) No 1227/2011, (EU) 2017/1938, (EU) 2019/942 and (EU) 2022/869 and Decision (EU) 2017/684 and repealing Regulation (EC) No 715/2009 (recast)**
GIE	**Gas Infrastructure Europe**
N-1	**Unavailability of a certain infrastructure element**
PD	**Peak Demand (Design Case)**
S-1	**Unavailability of a certain supply source**
SLID	**Single Largest Infrastructure Disruption for Natural Gas**

[1] Link to draft TYNDP 2024 Implementation Guidelines: link
[2] Link to the draft TYNDP 2024 IGI methodology: link

1 Introduction

ENTSOG's TYNDP 2024 consists of different deliveries. Certain parts of the TYNDP 2024 contribute to the PCI/PMI selection process governed by the TEN-E Regulation. Those are described in the TYNDP 2024 Implementation Guidelines (Annex D.1) that contribute to the project-specific cost-benefit analyses (PS-CBA) process and in the TYNDP 2024 Infrastructure Gaps Identification (IGI) methodology (Annex D.2) that contributes to the IGI report. The methodologies for any other parts of the TYNDP 2024 are described in this TYNDP 2024 System Assessment methodology (Annex D.3). Cross-references to the other documents are used whenever possible. All documents are based on the draft TYNDP 2024 scenario documents[3].

The draft versions of the three documents are undergoing a joint public consultation. Further details about the timeline can be found in section 1 of the draft TYNDP 2024 Implementation Guidelines.

This TYNDP 2024 System Assessment methodology specifies:

- the System Assessment approach of the hydrogen sector,
- the System Assessment approach of the natural gas sector,
- the Supply Adequacy Outlook including a biomethane progress report.

The hydrogen-related System Assessment approach thereby is complementary to the findings of the IGI report.

[3] Link to the draft TYNDP 2024 scenario documents: https://2024.entsos-tyndp-scenarios.eu

2 System Assessment

The model description contained in section 2 of the draft TYNDP 2024 Implementation Guidelines is also valid for this draft TYNDP 2024 System Assessment methodology. Exceptions from this validity and required specifications are described in this section.

The draft TYNDP 2024 System Assessment methodology is focusing on the Dual Hydrogen/Natural Gas Model (Dual Gas Model, DGM). The Dual Hydrogen/Electricity Model (DHEM) is only relevant to provide certain input data as further detailed below.

In contrast to the draft TYNDP Implementation Guidelines and the draft TYNDP 2024 IGI methodology, this draft TYNDP 2024 System Assessment methodology considers

- both natural gas infrastructure levels (i.e., Low natural gas infrastructure level and Advanced natural gas infrastructure level), and
- both hydrogen infrastructure levels (i.e., PCI/PMI hydrogen infrastructure level and Advanced hydrogen infrastructure level).

While the draft TYNDP 2024 Implementation Guidelines and the draft TYNDP 2024 IGI methodology only consider the National Trends+ (NT+) scenario and only consider 2030 and 2040 as simulation years, this draft TYNDP 2024 System Assessment methodology is valid for all TYNDP 2024 scenarios, i.e., NT+ 2030, NT+ 2040, Distributed Energy (DE) 2040, Global Ambition (GA) 2040, DE 2050, and GA 2050.

The draft TYNDP 2024 System Assessment methodology assesses demand curtailments for various stress cases that go beyond those stress cases proposed in the draft TYNDP 2024 Implementation Guidelines or the draft TYNDP 2024 IGI methodology. These stress cases either apply for a whole year or for less than a year. Curtailment and any results derived from stress cases will be the result of imbalances between supply and demand due to hard constraints like capacities. The stress cases are expressed in terms of demand curtailment (DC) for the assessed duration (i.e., 1 day for PD, 2 weeks for CDF, and full year for S-1, SLID) in energetic terms (MWh), each for natural gas (NGDC) and hydrogen (HDC). It can be displayed on node level, country level, European Union level, or European level. It can also be displayed in relative terms (%) as curtailment rate (CR) for the mentioned levels, representing the share of total demand that is curtailed during the considered duration. The curtailment rates are labelled as hydrogen demand curtailment rate (HCR) or natural gas demand curtailment rate (NGCR). The natural gas system and the hydrogen system are thereby inter-depending, as i) hydrogen can be produced from natural gas, so hydrogen supply may depend on natural gas availability, and ii) repurposing of natural gas infrastructure may put additional stress on the natural gas system. The following stress cases are proposed by this draft TYNDP 2024 System Assessment methodology:

- Normal (climatic) conditions

- Climatic stress conditions, i.e., 2-week Cold Dunkelflaute (CDF) and Peak Demand[4] (PD)
- Supply stress conditions as import source dependency (S-1) for natural gas sources and for hydrogen sources
  - This case intends to identify dependence to a specific supply source and allows to identify cases where this dependence is related to an infrastructure bottleneck (physical dependence). The lower the value of the S-1 indicator, the lower the dependence. The supply dependence to source S is calculated as follows (the steps are repeated for each source): First, the availability of source S is set down to zero. Second, the availabilities of the other sources remain in line with the defined supply assumptions. The supply source dependence $S\text{-}1_{Z,S}$ of the country Z to the source S is defined as the demand curtailment (in MWh) in Z when S is not available divided by the demand of Z (in MWh).
- Infrastructure stress conditions (N-1) as Single Largest Infrastructure Disruption for natural gas (SLID) during PD
  - This case intends to investigate the impact of the disruption of the single largest natural gas infrastructure entering a given country (excluding storages and national production) of the different countries to measure the impact of such disruptions at a European level during a day of PD. The SLID is computed in a peak demand situation, with the associated supply and national production in this configuration. This computation allows to identify potential bottlenecks for the considered country and the other European countries. The list of SLID capacities will be published as an Annex to the TYNDP 2024.

For the yearly DGM simulations of the NT+ 2030 and NT+ 2040 constellations, the inputs about supply and demand are sourced from the DHEM simulations as described in sections 2.4.5 and 2.4.6 of the draft TYNDP 2024 Implementation Guidelines.

- The DHEM market assumptions listed in section 3.2.4 and Annex III as well as the infrastructure information provided by Annex I and II of the draft TYNDP 2024 Implementation Guidelines are also valid in this context for this TYNDP 2024 System Assessment methodology. The same applies to the alternative fuel approach described in section 3.2.5 of the draft TYNDP 2024 Implementation Guidelines. The remaining parts of section 3, section 4, section 5, section 6.2, Annex IV, and Annex V of the draft TYNDP 2024 Implementation Guidelines are not relevant for this draft TYNDP 2024 System Assessment methodology as they are related to project-specific assessments.

For yearly DGM simulations of the DE 2040, GA 2040, DE 2050, and GA 2050 constellations, the inputs about supply and demand are sourced similarly as for the DGM simulations of the NT+ 2030 and the

[4] Peak demand is the maximum level of demand used for the design of the network to capture the maximum transported energy and ensure consistency with national regulatory frameworks. The day of highest consumption in the year (also referred to as design case) is a key input that represents one of the most stressful situations to be covered by the infrastructure (transmission, distribution and storage).

NT+ 2040 constellations. The difference is however that the data that is sourced from the DHEM for the NT+ 2030 and NT+ 2040 constellations is instead sourced directly from the simulation outputs of the respective TYNDP 2024 scenario models. This way, no extra DHEM simulations are required for these DGM simulations. The DGM modelling assumptions as described in section 2 of the draft TYNDP 2024 Implementation Guidelines and in the points above are sufficient to describe the yearly DGM simulations.

For non-yearly DGM simulations, the demand inputs are directly sourced from the TYNDP 2024 draft Scenario Report. For the non-yearly simulations, the following additional assumptions are needed on top of the specifications provided in the points above:

- LNG tanks' flexibility in the PD and the CDF cases: Flexibility from the LNG tanks is used as additional supply for the PD and during both weeks of the CDF. In the first week, the global LNG flows are limited to the level observed in February from the previous modelling of the whole year. In the second week, additional cargos can arrive allowing supply to reach the daily maximum supply potential of 2-week DF. No tanks of hydrogen import terminals have been considered for additional hydrogen supply.
- Storage filling levels in the PD and the CDF cases: All storages' filling levels are assumed to be at a level of 35% of the working gas volume. Through the storage-specific curves that define the maximum withdrawal capacity from a storage as a function of its filling level (i.e., withdraw deliverability curves), this filling level of 35% determines how much energy the storages can deliver. The working gas level, the withdrawal capacities and the withdrawal curves therefore define the constraints for the storage use during high demand situations. The actual use of storages is a result of the model taking into account these constraints.

The results of all DGM simulations are interpreted by identifying infrastructure bottlenecks by assessing which demand curtailments are caused by all relevant transmission infrastructure being used at their maximum capacity. By comparing the results of different combinations of infrastructure levels for simulations that are identical concerning all other parameters, the effect of including additional infrastructure can be identified. For example, the Advanced hydrogen infrastructure level contains the exact PCI/PMI hydrogen infrastructure level as well as additional projects. If a bottleneck is observed in the PCI/PMI hydrogen infrastructure level but is not observed in the Advanced hydrogen infrastructure level, the additional projects contained in latter infrastructure level removed the bottleneck.

A summary of the normal year and stress cases proposed be considered in the DGM is provided by Table 1:

Stress cases per combination of scenario, modelling year, and combination of natural gas and hydrogen infrastructure levels	Duration	Results	Granularity options
Normal year with no specific stress case[5]	Full year	HDC	Node,

[5] For the simulations based on the NT+ scenario, inputs are sourced from the DHEM simulations for the reference weather year.

Stressful weather year[6]		HCR NGDC NGCR	Country, European Union, or Europe
S-1 for natural gas from Russia for 2030[7]			
S-1 for each non-EU hydrogen supply source, i.e., Ukraine, North Africa, Norway, and imports by ship[8]			
PD	1 day		
PD with S-1 for natural gas from Russia for 2030[9]			
PD with S-1 for each non-EU hydrogen supply source, i.e., Ukraine, North Africa, Norway, and imports by ship[10]			
PD with SLID for natural gas for each Member State individually			
CDF	2 weeks		
CDF with S-1 for natural gas from Russia for 2030			
CDF with S-1 for each non-EU hydrogen supply source, i.e., Ukraine, North Africa, Norway, and imports by ship[11]			

Table 1: Overview of stress case options for the DGM.

[6] Only for the simulations based on the NT+ scenario.
[7] The case can be omitted if no Russian gas is used in the normal year with no specific stress cases.
[8] For the simulations based on the NT+ scenario, inputs are sourced from the DHEM simulations for the reference weather year. Cases can be omitted if the respective hydrogen supply source is not connected with the investigated hydrogen infrastructure level.
[9] The case can be omitted if no Russian gas is used in the regular PD case.
[10] Cases can be omitted if the respective hydrogen supply source is not connected with the investigated hydrogen infrastructure level.
[11] Cases can be omitted if the respective hydrogen supply source is not connected with the investigated hydrogen infrastructure level.

3 Supply Adequacy Outlook

The GHR mandates ENTSOG to include in its TYNDP a European supply adequacy outlook which shall cover the overall adequacy of the natural gas system to supply current and projected demands for natural gas for up to 10 years from the date of that outlook.

Consequently, ENTSOG aims to produce the Supply Adequacy Outlook based on the comparison of the different demand scenarios on the one side with the supply input data, including non-EU natural gas supply potential and the different forms of national production, on the other side to identify the import needs. The final Supply Mix is an output of the DGM after taking into account the maximum supply potentials and all the capacity constraints. Therefore, the Supply Adequacy Outlook is based on the DGM simulations described in the previous section. Thereby, the TYNDP 2024 scenarios that were established together with all gas TSOs, is representing the national supply outlooks that shall feed into the assessment.

The GHR furthermore states that the European supply adequacy outlook shall specifically include a monitoring of the progress on the annual production of sustainable biomethane. For this purpose, i) the European biomethane production forecast for 2030 from the TYNDP 2024 draft Scenarios Report, ii) the biomethane-related target of the REPowerEU communications[12] for 2030, and iii) other benchmarks for 2030 are evaluated against the expected new biomethane production capacities to be commissioned before 2030. Information about these projects will be collected by Gas Infrastructure Europe (GIE) and/or the European Biogas Association (EBA) and provided to ENTSOG. From these projects, it can be estimated whether the European Union is on track to reach the listed targets (see Figure 1).

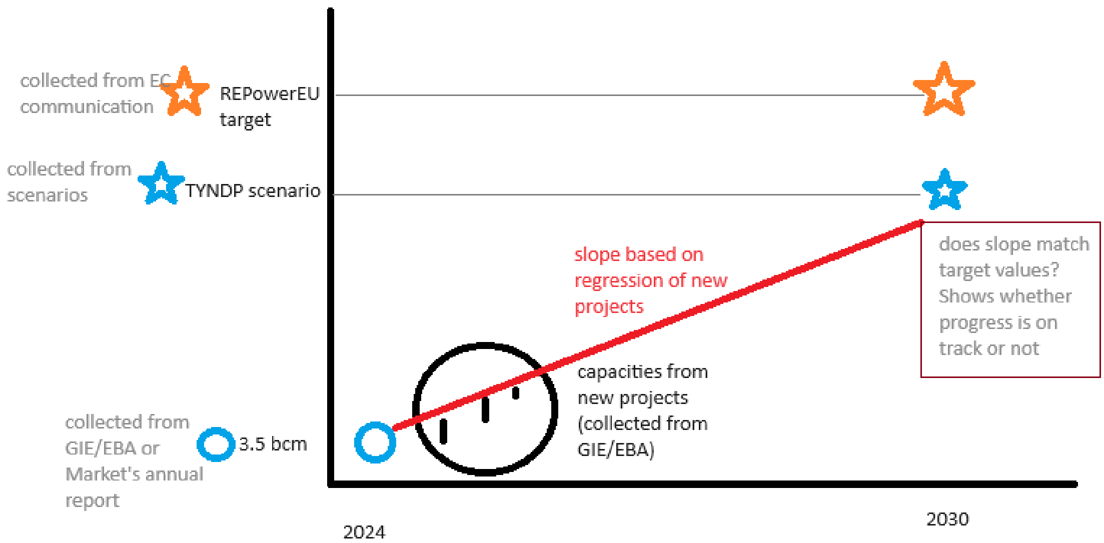

Figure 1: Methodology for the analysis of progress of the European Biomethane production.

[12] Link to the REPowerEU plan of 18 May 2022: https://eur-lex.europa.eu/resource.html?uri=cellar:fc930f14-d7ae-11ec-a95f-01aa75ed71a1.0001.02/DOC_1&format=PDF

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