TYNDP 2024

The Hydrogen and Natural Gas TYNDP

ANNEX D3

Hydrogen and Natural Gas System Assessment Methodology

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TABLE OF CONTENTS

Picture courtesy of TERRANETS

1 INTRODUCTION

ENTSOG's TYNDP 2024 consists of different deliverables. 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 D1[1]) that contribute to the project-specific cost-benefit analyses (PS-CBA) process and in the TYNDP 2024 Infrastructure Gaps Identification (IGI) methodology (Annex D2[1]) that contributes to the TYNDP 2024 IGI report. The methodologies for any other parts of the TYNDP 2024 are described in this TYNDP 2024 System Assessment methodology (Annex D3). Cross-references to the other documents are used whenever possible. All documents are based on the **TYNDP 2024 scenarios**.

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 TYNDP 2024 IGI report.

1 Available on https://tyndp2024.entsog.eu/

Picture courtesy of GASUM

2 SYSTEM **ASSESSMENT**

The model description contained in section 2 of the 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 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 TYNDP Implementation Guidelines and the TYNDP 2024 IGI methodology, this 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).

As the TYNDP 2024 Implementation Guidelines and the TYNDP 2024 IGI methodology, this TYNDP 2024 System Assessment methodology considers the National Trends+ (NT+) scenarui and 2030 and 2040 as simulation years.

This TYNDP 2024 System Assessment methodology assesses demand curtailments for various stress cases that go beyond those stress cases proposed in the TYNDP 2024 Implementation Guidelines or the TYNDP 2024 IGI methodology. These additional stress cases either apply for a whole year or for less than a year. Curtailment and any results derived from stress cases are 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 (e.g., 1 day for Peak Demand (PD), 2 weeks for Cold Dunkelflaute (CDF), and full year for stressful weather year) 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 assessed:

- Normal (climatic) conditions
- Climatic stress conditions, i.e., 2-week Cold Dunkelflaute (CDF) and Peak Demand (PD)
- Supply stress conditions as import source dependency (S-1) for natural gas sources
  - This case intends to identify dependence on 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. 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 the inputs for supply and demand are sourced from the DHEM simulations as described in sections 2.4.5 and 2.4.6 of the 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 TYNDP 2024 Implementation Guidelines as well as TYNDP 2024 Annex C are also valid in this context for this TYNDP 2024 System Assessment methodology. The remaining parts of section 3, section 4, section 5 and section 6.2 of the TYNDP 2024 Implementation Guidelines are not relevant for this TYNDP 2024 System Assessment methodology as they are related to project-specific assessments.

For the non-yearly DGM simulations, the country-specific values of the final natural gas demand and of the national natural gas production are sourced from the respective values for PD and CDF as stated in the TYNDP 2024 Scenario report. Node-specific values for the natural gas demand for power generation, hydrogen demand, and electrolytic hydrogen production are sourced from the DHEM simulation of the stressful weather year (i.e., 2009) as follows:

- For each time-step of the DHEM (i.e., 1 hour), the natural gas usage for power generation and hydrogen production are aggregated at European level.
- The relevant period (i.e., 1 day for PD and 2 weeks for CDF) when the EU had the highest sum of natural gas usage for power generation and hydrogen production are identified.
- For each node, the natural gas demand for power generation, the hydrogen demand, and the electrolytic hydrogen production values are extracted for the relevant period to be used in the DGM.

For the non-yearly DGM simulations, the demand inputs are directly sourced from the TYNDP 2024 scenarios. 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 entire year. In the second week, additional cargos can arrive allowing supply to reach the daily maximum supply potential of CDF. 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 usage during high demand situations. The actual usage 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 reference weather 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
Reference weather year with no specific stress case	Full year	HDC HCR NGDC NGCR	Node, Country, European Union, or Europe
Stressful weather year			
S-1 for natural gas from Russia for 2030[2]			
PD	1 day		
PD with S-1 for natural gas from Russia for 2030[3]			
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			

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

2 The case can be omitted if no Russian gas is used in the normal year with no specific stress cases.

3 The case can be omitted if no Russian gas is used in the regular PD case.

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, the Supply Adequacy Outlook is a comparison of the annual European natural gas demand versus the annual natural gas supply options. The data for the European natural gas demand as well as the natural gas supply options (i.e., extra-EU natural gas supply potential and different forms of national production like biomethane and synthetic methane) are sourced as described in the previous chapter and based on the respective TYNDP 2024 scenario storyline. Thereby, the TYNDP 2024 scenarios established together with all gas TSOs represent the national supply outlooks that shall feed into the assessment. The comparison allows to identify whether the natural gas supply options are higher than the European natural gas demand. This is a prerequisite for adequate supply of natural gas. Furthermore, the comparison allows to calculate the minimum natural gas imports needed by subtracting the national production from the natural gas demand.

Complementarily, final Supply Mix overviews are produced that are not limited to an annual comparison and that considers infrastructure constraints like transit and underground storage capacities. Therefore, the Supply Mix results are based on the DGM simulations described in the previous sections where, especially under high demand situations, the supply and demand balance is highly dependent on the underground storage utilisation.

The underground storage utilisation is only visible in Supply Mix overviews for non-yearly DGM simulations. In yearly simulations, storage filling levels start and end at the same value. Therefore, for the annual Supply Adequacy Outlook as well as for the Supply Mix overviews that are based on yearly DGM simulations, storages are not displayed.

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[4] for 2030, and iii) other benchmarks for 2030 are evaluated against the expected new biomethane production capacities to be commissioned before 2030. Information about such capacities will be collected by Gas Infrastructure Europe (GIE) and/or the European Biogas Association (EBA) and provided to ENTSOG. The information may be complemented by insights provided by ENTSOG's annual report on the quantity of renewable gas and low-carbon gas injected into the natural gas network on the basis of Article 26.3(i) of the GHR. The progress report will allow to estimate whether the European Union is on track to reach the listed targets (see Figure 1).

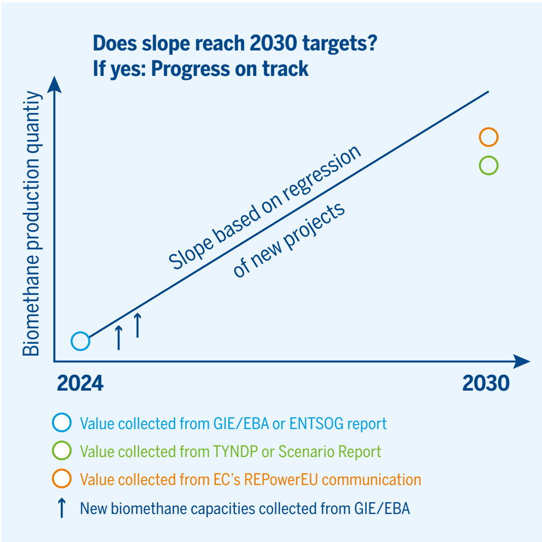

Figure 1: Methodology for the analysis of progress of the European Biomethane production.

4 REPowerEU plan of 18 May 2022

LIST OF **ABBREVIATIONS**

The lists of abbreviations of the TYNDP 2024 Implementation Guidelines (Annex D1[5]) and the TYNDP 2024 Infrastructure Gaps Identification (IGI) methodology (Annex D2[5]) are also valid for this document. Additionally, the following abbreviations apply:

CDF	2-week Cold Dunkelflaute
CR	Curtailment Rate
DC	Demand Curtailment
DGM	Dual Hydrogen/Natural Gas Model or Dual Gas Model
DHEM	Dual Hydrogen/Electricity Model
EBA	European Biogas Association
ENTSOG	European Network of Transmission System Operators for Gas
EU	European Union
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
HCR	Hydrogen Demand Curtailment Rate
HDC	Hydrogen Demand Curtailment
IGI	Hydrogen Infrastructure Gaps Identification
LNG	Liquefied Natural Gas
MWh	Megawatt Hour
N-1	Unavailability of a certain infrastructure element
NGCR	Natural Gas Demand Curtailment Rate
NGDC	Natural Gas Demand Curtailment
PD	Peak Demand (Design Case)
PCI	Project of Common Interest
PMI	Project of Mutual Interest
PS-CBA	Project-Specific Cost-Benefit Analysis
S-1	Unavailability of a certain supply source
SLID	Single Largest Infrastructure Disruption for Natural Gas
TYNDP	Ten-Year Network Development Plan

5 Available on https://tyndp2024.entsog.eu/

COUNTRY CODES (ISO)

AL	Albania	**LU**	Luxembourg
AT	Austria	**LV**	Latvia
AZ	Azerbaijan	**LY**	Libya
BA	Bosnia and Herzegovina	**MA**	Morocco
BE	Belgium	**MD**	Moldova
BG	Bulgaria	**ME**	Montenegro
BY	Belarus	**MK**	North Macedonia
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EE	Estonia	**RS**	Serbia
ES	Spain	**RU**	Russia
FI	Finland	**SE**	Sweden
FR	France	**SI**	Slovenia
GR	Greece	**SK**	Slovakia
HR	Croatia	**TM**	Turkmenistan
HU	Hungary	**TN**	Tunisia
IE	Ireland	**TR**	Turkey
IT	Italy	**UA**	Ukraine
LT	Lithuania	**UK**	United Kingdom

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The TYNDP was prepared by ENTSOG on the basis of information collected and compiled by ENTSOG from its members and from stakeholders, and on the basis of the methodology developed with the support of the stakeholders via public consultation. The TYNDP contains ENTSOG own assumptions and analysis based upon this information.

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Avenue de Cortenbergh 100
1000 Brussels, Belgium

Co-Authors Mads Boesen, Maria Castro, Arturo de Onis Romero-Requejo, Axelle de Cadier de Veauce, Diana Fathelbajanova, Joan Frezouls, Alexander Kättlitz, Isabell Kolonko, Pierre Marani, Simona Marcu, Dante Powell, Rafail Tsalikoglou, Thilo von der Grün, Aisling Wall, Arnaud Weissrock, Kacper Zeromski, NeMo KG, INV WG, SCN WG

Design DreiDreizehn GmbH, Berlin | www.313.de

european network
of transmission system operators
for gas

ENTSOG AISBL
Avenue de Cortenbergh 100 | 1000 Brussels, Belgium
Tel. +32 2 894 51 00

info@entsog.eu | www.entsog.eu