# 2nd ENTSOG methodology for cost-benefit analysis of gas infrastructure projects

Draft for ACER and Commission opinions
24 July 2017

**Disclaimer**

The present document constitutes the draft version of ENTSOG 2nd CBA Methodology submitted to ACER and the European Commission for their opinions *i.e.* the draft update of the current ENTSOG CBA Methodology in accordance with article 11 of Regulation (EU) 347/2013[1].

This document has been developed by ENTSOG, with the support of its members, in compliance with Regulation (EU) 347/2013. It considers the feedback received from stakeholders, ACER, NRAs and the European Commission together with experience based on TYNDP 2015 and 2017.

Some elements are meant to be further investigated in the coming months in close cooperation with ACER and EC for possible inclusion in the adapted version.

The 2nd CBA Methodology is developed by ENTSOG in a timeline aiming at its application from TYNDP 2018 onwards. In this view, the final version approved by the European Commission is expected in the second quarter of 2018.

[1] Regulation (EU) No 347/2013 of 17th April 2013 of the European Parliament and of the Council on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009, hereinafter referred to as Regulation (EU) 347/2013.

## Foreword

The first Cost-Benefit Analysis methodology was approved by the European Commission (hereafter EC) in February 2015. This methodology has been applied for the preparation of the Ten Year Network Development Plan 2015 (TYNDP 2015) as well as TYNDP 2017. For this latest TYNDP edition, ENTSOG has complemented the assessment with additional elements on a voluntary basis.

Based on the experience of TYNDP 2015 and 2017 and the 2nd and 3rd PCI selection processes, including the feedback received from stakeholders, ENTSOG has engaged in updating and improving the Cost-Benefit Analysis methodology (hereafter referred to as CBA methodology). The updated CBA methodology takes also into account related opinions from ACER, as well as the recent findings of the study mandated by the EC, whose draft recommendations were released in March 2017[2].

Regulation (EU) 347/2013 defines the different steps to be followed by ENTSOG in the process of updating the CBA methodology, including a consultation process on the possible paths to update the CBA methodology approved in 2015. From early 2017, ENTSOG set up a specific "Prime Movers" group of stakeholders which was consulted to identify what were the most expected improvements in the CBA methodology. ENTSOG has taken these proposals into consideration in the preparation of the public consultation held in May-June 2017[3].

Therefore, the proposed 2nd CBA methodology has been developed by ENTSOG with the support of its members and reflects the input from "Prime Movers" and the feedback received from stakeholders in the public consultation.

The 2nd CBA methodology is being prepared in a timeline to allow its application for the 2018 edition of the TYNDP and for the 4th PCI selection process. Some elements of this draft version are meant to be further investigated in the coming months in close cooperation with ACER and EC for possible inclusion in the adapted version. They are identified in the document (red text).

[2] The draft recommendations are available here: http://fsr.eui.eu/event/gas-cba-2-0-online-consultation/

[3] Material of ENTSOG CBA update public consultation is available here: https://www.entsog.eu/publications/cba-methodology#2ND-CBA-METHODOLOGY

# Contents

## A. Introduction

The European gas infrastructure supports the completion of the Internal Energy Market and contributes to the achievement of the European climate and energy policies, where sustainability represents one of the major pillars together with security of supply, competition and market integration.
Thanks to the projects developed in the last decades, the existing infrastructure already ensures a high level of market integration across most of Europe. Yet, in specific areas, further development of the infrastructure is still required.
TYNDP identifies the investment gaps that prevent the achievement of the pillars of the internal energy market. Where infrastructure gaps are identified, the CBA methodology provides guidelines to support the assessment of projects able to fulfil these gaps.
This assessment consists of a multi-criteria analysis to measure the level of completion of the pillars of the EU Energy Policy from an infrastructure perspective.

### 1. Regulatory background

The present methodology has been developed under Regulation (EU) 347/2013 (the Regulation) supporting the selection of Projects of Common Interest (PCIs) and further steps of the process. The Regulation sets the process for the development and update of the CBA methodology, and indicates the different fields of application.

As defined in art. 11 of the Regulation, ENTSOG has the role to develop the CBA methodology.

> *"[…] the European Network of Transmission System Operators (ENTSO) for Electricity and the ENTSO for Gas shall publish […] their respective methodologies, including on network and market modelling, for a harmonised energy system-wide cost-benefit analysis at **Union level for projects of common interest** […].*

The TYNDP represents the main field of application for the CBA methodology.

> *[The] methodolog[y] shall be applied for the preparation of each subsequent **10-year network development plan** developed by […] the ENTSO for Gas […]".*

In addition Annex III.2 (4) states that all projects that want to apply in the PCI selection process *"shall be part of the latest available 10-year network development plan".*

At the same time the Regulation indicates other areas where CBA methodology has to be used as a basis, such as PCI selection, investment requests (including cross-border cost allocation) and financial assistance.

- Annex III.2 (1): *"Promoters of a project […]* ***wanting to obtain the status of projects of common interest*** *shall submit an application for selection […] that includes: […] for projects having reached a sufficient degree of maturity, a* ***project-specific cost-benefit analysis*** *[…] based on the methodologies developed by the […] ENTSO for gas […]";*
- Art. 12.3, in the context of investment request and cross-border cost allocation (CBCA), "*[…] project promoters […] shall submit an* ***investment request****. That investment request shall include a request for a cross-border cost allocation […] accompanied by […] a* ***project-specific cost-benefit analysis*** *consistent with the methodology drawn up pursuant to Article 11 […]*";
- Art. 14.2: for projects having received a cross-border cost allocation "*[…] projects of common interest are also eligible for Union financial assistance in the form of* ***grants for works*** *if they fulfil all of the following criteria […] : (a) the* ***project specific cost-benefit analysis*** *[…that] provides evidence concerning the existence of significant positive externalities, such as security of supply, solidarity or innovation";*

Finally, Art. 11.6 of Regulation (EU) 347/2013 states that "*The [CBA] methodologies shall be updated and improved regularly in accordance with paragraphs 1 to 5 […]".*

According to the above provisions of the Regulation, the role of CBA Methodology and its field of application can be illustrated as follows.

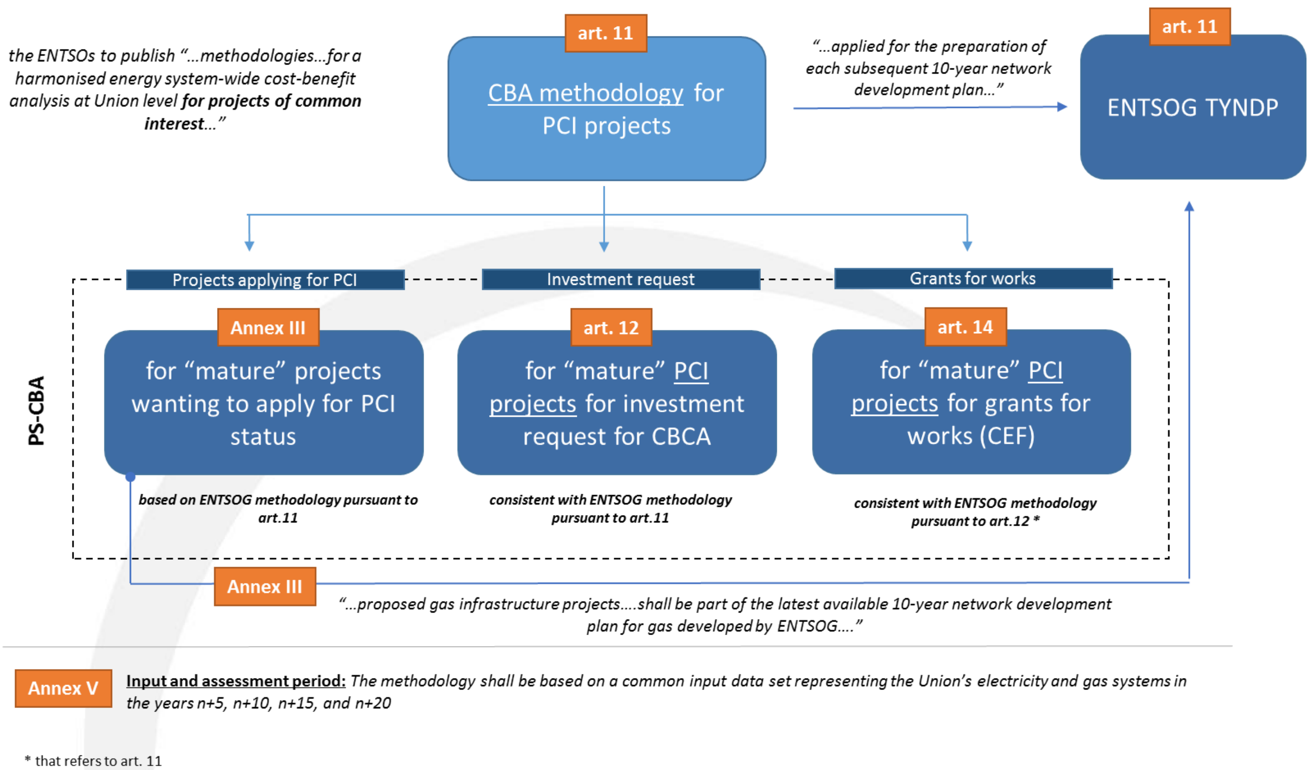



**Figure 1 – Graphical representation of CBA methodology role and fields of application according to the Regulation**

## 2. CBA Methodology objective

The objective of this CBA methodology is to provide **guidelines to be applied for the cost-benefit analysis of projects and more generally of the overall gas infrastructure**. This methodology reflects the specific provisions from the Regulation.

The CBA methodology is subsequently divided in three main sections

- general guidelines on cost-benefit analysis for gas infrastructure projects, which provides the theoretical perspective
- how those guidelines are applied to TYNDP, including in terms of performing project-specific CBA
- recommendations on the application of these guidelines in the context of project-specific CBA for PCI selection and CBCA purposes

The proposed structure can be graphically represented as follows.

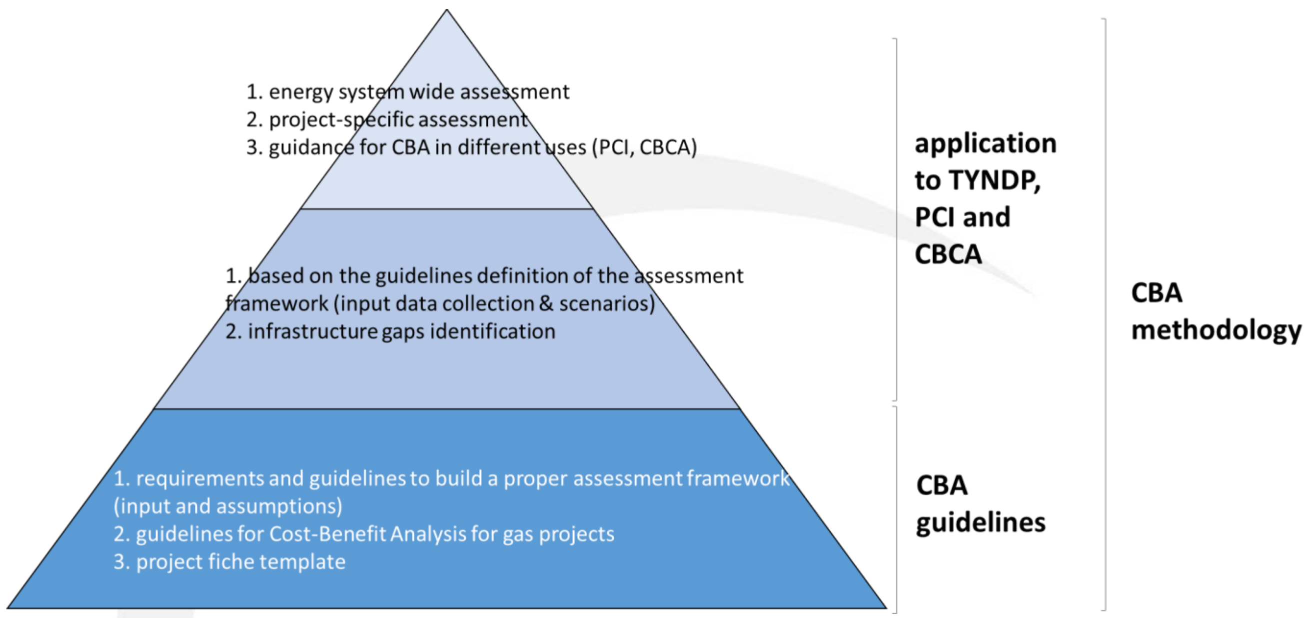



**Figure 2 – Graphical representation of the CBA methodology**

Although the development of the CBA methodology is a task for ENTSOG the individual tasks defined within this methodology also lie within the responsibility of other parties.

## 3. The ENTSOs consistent and interlinked model

The ENTSOs have developed their "*consistent and interlinked model*" in line with Article 11 (8) of Regulation 347/2013. It has been submitted as a draft version to ACER and the Commission for their opinion in December 2016. Once adapted and approved by the Commission, it will be included in the present CBA Methodology.

A fundamental element of the ENTSOs consistent and interlinked model[4] is the joint scenario development process that the ENTSOs will have as part of their TYNDP process. The ENTSOs have committed to implement this joint process from TYNDP 2018 onwards.

[4] The link to the draft of the ENTSOs consistent and interlinked model submitted for ACER and EC Opinions is available in Annex 3 of this methodology,

## B. General guidelines for gas infrastructures cost-benefit analysis

According to the definition provided by EC in its "Guide to Cost-Benefit Analysis of investment projects" (December 2014)[5], hereafter "EC CBA guide", "*CBA is an analytical tool to be used to appraise an investment decision in order to assess the welfare change attributable to it. The purpose of CBA is to facilitate a more efficient allocation of resources, demonstrating the convenience for society of a particular intervention rather than possible alternatives*".

Generally, the cost-benefit analysis of projects should follow the steps below

- analysis of the context and of the assessment framework
- definition and identification of projects and their objectives
- principle for the incremental approach
- cost benefit analysis

This Chapter therefore follows the above mentioned structure.

### 1. Assessment Framework

It is the role of system operators to be prepared for operating the gas system and delivering gas to customers, in a secure and competitive way, whatever the future circumstances may be.

This is the background for the identification of infrastructure gaps that prevent the achievement of the Union energy policies, as performed as part of the TYNDP process. It is also the background for the assessment of projects that may allow the mitigation those infrastructure gaps, in accordance with the present CBA methodology.

Over the last years, gas consumption and supply patterns have shown some volatility subject to different and, sometimes unexpected, events. Over the coming years and decades, the European commitment to move towards a decarbonised energy system could materialise in different ways.

In this context, it is fundamental to consider **contrasted possible futures** when performing the identification of the infrastructure gaps and project assessment. These contrasted futures

[5] The "Guide to Cost-Benefit Analysis of Investment Projects" is available here: http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdf

represent possible alternatives for which none has more or less chance to materialise than the other. While decision-makers might want to favour some of the scenarios, it should not be the role of the CBA methodology to attach any probability to these futures.

For the assessment of gas infrastructure projects, the context to be considered corresponds to possible evolutions in terms of demand, supply patterns and development of the overall gas infrastructure. In this respect, Annex V (1) of Regulation (EU) 347/2013 states the input data set should represent the years *"n+5, n+10, n+15, and n+20"* and that it *"shall comprise at least, in gas, scenarios for demand, imports, fuel prices (including coal, gas and oil), carbon dioxide prices, composition of the transmission network and its evolution*". Additional parameters can be considered.

These contextual elements are developed in the Chapter below from a general perspective.

In practice, the actual context is evolving fast, which requires a regular update of the contextual elements. Both ENTSOs perform an in-depth update of such elements every other year as part of their TYNDP development process. As part of the ENTSOs "*consistent and interlinked model*" foreseen under Article 11.8 of Regulation (EU) 347/2013, and from TYNDP 2018 onwards, both ENTSOs will have a joint scenario development process for their TYNDPs. This process will account for both sectors' expertise and ensure a thorough engagement from stakeholders, institutions and member states in scenario development.

As an outcome of the TYNDP process, the ENTSOs will issue a joint Scenario Report for public consultation, and will make the complete scenario data set used for developing the TYNDPs transparent and publicly available.

This TYNDP input data set, which is used when applying the CBA Methodology to the TYNDP, also constitutes a robust input data source for other fields of application of the CBA Methodology. It is therefore recommended to use the latest available TYNDP input data set whenever performing cost-benefit analysis of projects. Users may consider to use alternative existing sources for part of their input data set (or develop some parts of the input data on their own), if duly reasoned, in line with the general guidelines provided in this Chapter and the ENTSOs consistent interlinked model and, in regards to ensuring the consistency and interlinkage of the scenario elements.

## 1.1. Time horizon

As for the time horizon, CBA methodology refers to 20 years, in line with the prescription of Annex V (1) of the Regulation, requiring that the input data set represents years *"n+5, n+10, n+15, and n+20 where n is the year in which the analysis is performed"*.

Furthermore, the EC CBA Guide provides a table showing the durations it uses as a reference period for various economic sectors. The EC refers to 15-25 years for the energy sector.

Table 2.1 European Commission's reference periods by sector

| Sector | Reference period (years) |
|---|---|
| Railways | 30 |
| Roads | 25-30 |
| Ports and airports | 25 |
| Urban transport | 25-30 |
| Water supply/sanitation | 30 |
| Waste management | 25-30 |
| Energy | 15-25 |
| Broadband | 15-20 |
| Research and Innovation | 15-25 |
| Business infrastructure | 10-15 |
| Other sectors | 10-15 |

*Source: ANNEX I to Commission Delegated Regulation (EU) No 480/2014.*

**Table 1 – Reference assessment period by sector (Guide to Cost-Benefit Analysis of Investment Projects – December 2014)**

In line with the provision on the time horizon to be considered for the input data, the assessment of projects should consider both a medium-term and a long-term perspectives.
In addition, in order to be able to evaluate projects impact against the targets set by the European policies while keeping the number of results reasonable, it is recommended that projects cost-benefit analysis (and scenario development) should be conducted for 5-year-rounded years (e.g. 2020, 2025, 2030, etc.). The remaining time horizon should then be covered through interpolation techniques that will be explained later in the document.

## 1.2. Commodity and CO2 prices

Commodity and CO2 prices are important contextual elements to be considered when developing possible future demand scenarios, as both may trigger different situations in terms of energy mix and may impact on gas demand. Additionally, in regards to commodities, it is important to set a reference gas price, to be used as an input when setting the supply price(s) for the different gas supply sources.

In terms of CO2, market prices and Social Cost of Carbon (SCC) represent two different approaches to CO2 prices. The SCC includes the full social cost of emitting one further ton of CO2, once external effects are also integrated. CO2 market prices will be the ones driving market behaviour (in particular in regards to electricity production). In this regard, CO2 market prices appear to be more accurate as a parameter influencing on demand.

The IEA World Energy Outlook is considered one relevant source of information for possible future commodity prices and CO2 market prices.

Yet, there are a number of indications in the literature that the currently foreseen future CO2 market prices may be far below the actual SCC. Therefore, SCC may be seen as a more appropriate basis when assessing the monetary value attached to a reduction of the CO2 emissions in the CBA assessment. This would call for using such cost as a possible alternative to CO2 market prices. The difficulty stems from lack of clear indications in the literature on how to value SCC.

More information may be included in regard to Social Cost of Carbon in the adapted version of this CBA Methodology in case further investigation would allow to provide additional background on the value to be considered.

### 1.3. Demand scenarios

As mentioned in the introduction to this Chapter, the accurate identification of remaining infrastructure gaps and assessment of projects requires the consideration of **contrasted possible futures**. This implies considering demand scenarios that reflect the possible range in terms of the evolution of the future energy mix and gas demand. Each scenario covers a different situation reflecting how uncertain aspects of the future could materialise. The practice of considering different energy scenarios supports decision makers' strategies and policies in an uncertain world, with scenarios describing how alternative energy conditions could develop in the future.

Scenarios can be described based on a number of parameters such as demography, macroeconomic trends, energy prices and emission prices. Energy and environmental policies defined at the national or European level, and related targets, also have an influence on scenarios.

Contrasted yet consistent assumptions can be retained for these different parameters, each set of assumptions corresponding to a scenario story line. Defining different story lines and the related set of assumptions allows for developing different energy and gas demand scenarios.

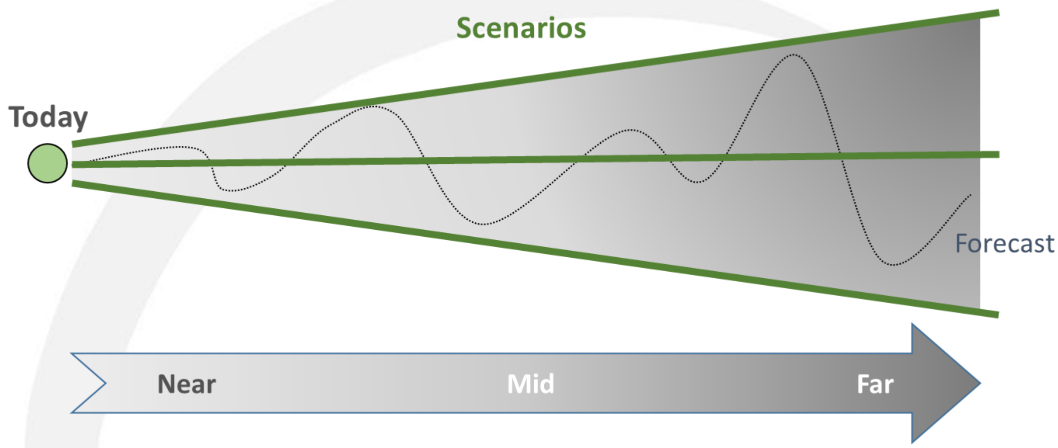



Figure 3 – Scenarios to set the range of possible futures

It is fundamental for a meaningful assessment of the gas infrastructure and projects that demand scenarios are reflected not only from a yearly volumetric perspective but also from a **peak demand** and **seasonal profile** perspectives.

Indeed, the gas demand presents a highly seasonal pattern, particularly in relation to the role that gas plays in the heating and power sector. Therefore peak demand situations are a key parameter for the network design and operation. **Peak demand cases**, on a single day or over a sustained period, are to be considered to reflect the capacity that the gas infrastructure must be able to provide. Consideration of the gas demand **seasonal profile** is also key for an accurate assessment of the gas infrastructure.

This information is vital to assess the role transmission systems, underground storages UGS or LNG terminals play as part of the overall gas system, in providing flexibility and ensuring a safe, secure and sustainable operation of the system. High demand situations in particular, although their occurrence may be low, are critical in assessing security of supply.

For a comprehensive assessment of projects at the European and national level, demand data should be defined at least with a **country level granularity**. As gas demand may evolve in a different way for the different demand sector (residential, transport, industrial and commercial, power), development of demand scenarios should also aim at a sufficiently detailed sectorial breakdown to capture the different sectorial trends.

## 1.4. Supply potentials

Compared to electricity, gas usually travels long distances between production and consumption areas. A large share of the gas supply come from non-EU countries. Indigenous production of conventional gas is also very significant on the continent. Additionally, despite the decrease in current conventional gas production, there are new supply sources in Europe, including renewable gases such as biomethane and synthetic gases (e.g. from power-to-gas technologies).

Demand is to be balanced by supplies. Yet, supply patterns may evolve significantly over the coming decades. When assessing the European gas market it is therefore a basic necessity to capture the uncertainty in the development of supply, by defining a minimum and maximum level of **supply potential** per supply source. The notion of import routes is also closely related to the one of supply sources, and “potentials” have to realistically reflect what could be the potential of supplies in the next years. These assumed minimum and maximum potentials for each source are used as lower and upper limits for supply imports.

In addition to the annual volumes it is recommended to define assumptions for the flexibility of the supply within the seasons of the year and for high demand situations. These assumptions can be updated reflecting recent development.

Gas supply assessment is key to measure by how much a gas infrastructure project yields a positive contribution to the European gas system.

Supplies, within the min/max range, should be attached to supply prices that will drive the supply mix. Whilst the projection of gas price, as referred to in the commodity price section, provides a reference supply price, this does not preclude price variations around this reference.

## 1.5. Network assumptions

A robust assessment framework requires an accurate representation of the gas infrastructure, both in regards to the existing infrastructure and to its possible evolution. This representation of the gas infrastructure will be an input to the network and market modelling exercise underpinning the determination of projects' benefits.

The geographical perimeter should be clearly defined. In line with the Regulation it should cover at least Europe. In instances where connections with other countries exist, these countries may be incorporated or represented with adequate assumptions. The level of detail in which the gas infrastructure is represented should strike a balance between the accuracy of the modelling and the availability and complexity of the underlying network information.

It terms of granularity, it is recommended that the gas infrastructure should be described with a level of detail corresponding at least to a country level granularity. In instances where countries form a market area together this market area granularity can be applied.

The infrastructures to be considered, both in terms of existing or projected infrastructures, should be in line with Annex II of the Regulation and encompass:

- transmission infrastructure contributing to cross-border capacities between countries
- underground storage facilities;
- reception, storage and regasification or decompression facilities for liquefied natural gas (LNG) or compressed natural gas (CNG);

For LNG infrastructures, available volumes in the tanks should be considered to reflect the flexibility it can provide to the system, in particular in case of high demand situations.

For storage facilities, in addition to the working gas volumes and the withdrawal and injection capacities, withdrawal and injection curves function of the inventory level should also be considered.

## 1.6. Market assumptions

When performing project assessment, it is recommended to consider the below assumption in term of functioning of the gas market:

- **Perfect market functioning**: the assumption of perfect competition (allowing arbitrage opportunities) and perfect market functioning (considering the implementation of the network codes and the interconnected network operating under optimal system conditions in terms of flexibility and different market situations) is a prerequisite for the identification of physical bottlenecks. The intent is to focus on infrastructure gaps that market or regulatory rules cannot address. CBA assessment should therefore always consider a perfect market functioning hypothesis[6].

This section of the methodology describes further assumptions that may be considered.

- **Additional market elements**: at the same time, especially when observing the short and medium term, it is probably possible to refine the assumptions on the way markets operate. Assumptions on market can possibly be built based on current knowledge and observation of reality, with the risk that the same assumptions will not be accurate anymore in the future. This may provide a more realistic approach to the actual functioning of gas markets. The following elements could be considered:
  - current and potential market behaviour and trends (for example in case of monopolistic situations or to reflect other actual market situations);
  - infrastructure tariffs: gas infrastructures users pay not only TSO tariffs, LSO and SSO tariffs, which implies significant complexity in terms of data collection, completeness, timing and accuracy. Tariffs can in general correspond either to capacity or commodity charges, which needs to be accounted in view of flow modelling perspective. It should be kept in mind that the impact of actual tariffs on the use of capacity will also depend on the share of capacity booked on short-term basis rather than booked upfront on medium to long-term basis, and that tariffs will evolve over time, e.g. from one regulatory period to the next. More generally, regulated tariffs will influence bookings, which will also in turn require tariff adjustments. In regards to projects, any estimation of the related infrastructure tariffs should be considered carefully in order to avoid possible double counting in addition to project costs;
  - in depth information on gas supply prices in particular in regards to variability among supply sources or import routes, provided data is available.

[6] This assumption also applies as part of the ENTSO-E CBA Methodology for electricity projects.

### 1.7. Infrastructure levels

Project assessment requires to take into account the overall context in terms of development of the gas infrastructure. An **infrastructure level** is defined as the potential level of development of the European gas network system. The selection of the proper infrastructure level is therefore vital for a reliable assessment framework and a proper project assessment.

The "reference grid", should at least consider all the existing infrastructures. The **FID status** is defined according to Regulation (EC) 256/2014[7]; Art.2.3 as follows: '*final investment decision' means the decision taken at the level of an undertaking to definitively earmark funds for the investment phase of a project […]*'. Also Annex V of the Regulation, when describing the input data on which the CBA methodology should be based, invites to take into account "*all new projects for which a final investment decision has been taken*" when defining the composition of the transmission network.
An infrastructure level formed by **existing infrastructure and projects with FID status** represents therefore a **credible minimum set of infrastructure** to be considered for the identification of remaining investment gaps and for the assessment of projects. In regards of study years, it is recommended that FID projects are considered from their first full year of operation, meaning the calendar year following their commissioning date.

When applying the CBA methodology, additional infrastructure levels may be considered for the analysis to provide a complementary perspective in the analysis of the European energy market and of the projects impact and ensure adequate comparison.

## 2. Definition and identification of projects

A proper description of projects and a definition of their objectives are essential for accurate project assessment. Correct information is required for projects technical features, costs and schedules.

[7] Regulation (EU) 256/2014 of the European Parliament and of the Council of 26 February 2014 concerning the notification to the Commission of investment projects in energy infrastructure within the European Union, replacing Council Regulation (EU, Euratom) 617/2010 and repealing Council Regulation (EC) 736/96.

## 2.1. Identification of projects

Identification of projects requires reliable and detailed information.
Below is a list of the information that should be available in view of gas projects assessment:

- project description
- project objectives and benefit expected from the project
- MS(s) or non-EU countries hosting the project
- schedule and current implementation status (stage of development), such as pre-feasibility and feasibility, FEED, market test, permitting, FID, construction and commissioning
- expected commissioning year (for each phase in case of multi-phase projects)
- main technical information (e.g. length, diameter, pressure levels for pipelines)
- new or additional capacity from the implementation of the project, at new or existing points
- indication by promoters of the expected infrastructure gap and regulatory criteria addressed by the project
- location (and route) of the project (depending also on its maturity)
- potential complementary[8] or competing projects
- information on previously acquired PCI label, CBCA decision and CEF funding
- …other additional information

## 2.2. Project costs

Costs represent one of the main elements of a CBA analysis. According to Annex V (5) of the Regulation, costs shall at least consider capital expenditure, operational and maintenance expenditure over the technical lifecycle of the project and decommissioning and waste management costs, where relevant.
Investment costs are therefore classified[9] by:

- **capital expenditure** (CAPEX)
  - **initial investment cost**, the initial investment cost corresponds to the cost effectively incurred by the promoter to build and start operations of the gas infrastructure. CAPEX

[8] Based on the definition used for the EC 3rd PCI process data collection complementarity shall be understood where the commissioning of a project would increase the benefits/effects of another project or enable another project.
[9] This classification is in line with the EC CBA Guide.

  - should consider the costs of obtaining permits, feasibility studies, obtaining rights-of-way, ground, preparatory work, designing, dismantling, equipment purchase and installation[10]
  - **replacement costs**, are the costs borne to ensure that the infrastructure remains operational by changing specific parts of it
- **residual value**, represents the ability of an infrastructure to generate future costs and revenues beyond the assessed period of operation and until the end of its technical life
- **operating expenditure** (OPEX), corresponds to costs that are incurred after the – at least – commissioning of an asset and which are not of an investment nature, such as: direct production/operating costs, administrative and general expenditures, sales and distribution expenditures, etc.

As part of the project's Economic analysis (Chapter 4 of this section) the Residual Value should be calculated according to the following formula and reflected applying a social discount rate:

$$R_v = A_v - D$$

Where:

- $R_v$ is the Residual value
- $A_v$ is the initial value of the asset[11] plus the replacement costs[12], if any, incurred in the time horizon considered
- $D$ is the depreciation of the asset during the considered time horizon of operation (or less for multi-phase projects)

The Residual Value of the asset shall be included in the analysis for the end year of the time horizon of the analysis as an inflow but with negative sign. This will be discounted according to the selected discount rate. In order to depreciate the residual value, different approaches may be adopted[13]. This CBA methodology suggests using by default a **linear depreciation method**. If reasonably justified, a depreciation method based on the respective national regulatory framework could also be applied by promoters.

[10] Costs already incurred at the time of running the project cost-benefit analysis should be generally considered in the assessment while in case of expansion projects only the costs related to the expansion should be taken into account since the costs incurred before already allowed the project to be functional.

[11] As the sum of the initial investment costs until the commissioning of the project.

[12] As per EC CBA Guide.

[13] A variety of depreciation methods exist. The easiest and probably most used one is the straight-line depreciation method. Alternative methods are, among others, the sum of the years' digits method, the double declining balance method, the annuity depreciation method, and composite depreciation methods.

## 2.3. Project grouping

Often, a number of functionally-related project items need to be implemented for their benefit(s) to materialise. The cost-benefit analysis should in this case be performed jointly for these strictly functionally-related project items, ensuring consistency between the considered benefits and costs.

For example in case of an interconnector connecting two countries, two different promoters are usually involved. Similarly a new LNG terminal or storage may need a new evacuation pipeline to connect them to the gas network. There are then cases where projects connecting the EU to new supply sources are actually composed by different projects whose full realisation is a prerequisite to connect the new source.

In such cases those projects need therefore to be **grouped together** to perform their cost-benefit analysis.

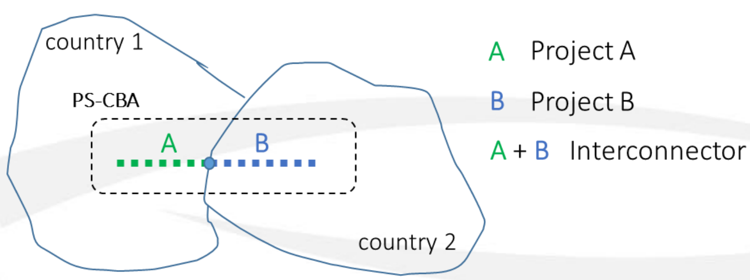



**Figure 4 – Example of project grouping in case of an interconnection formed by two projects**

The impact of some projects may also depend on other infrastructure projects to be implemented. It is important to understand which other projects need to be in place in order to enable other ones or in order to capture the full potential (intended as the possibility to use the maximum capacity for which it has been planned). In some cases groups may correspond to a single project.

The guidelines for project grouping are provided in Annex 1. Any update of those guidelines in the future will be developed in consultation with EC and ACER.

## 3. Incremental approach

Estimating socio-economic benefits and costs associated with the proposed project requires establishing the "with project" and "without project" situations and comparing the two. The incremental approach constitutes the way to assess the impact of a project, by comparing the situation "with the project" and a counterfactual baseline situation "without the project". The level of development of the gas infrastructure against which the project is assessed (the "infrastructure level" as described in Chapter 1.7) will play on the value given to the project.
This is why the benefits of an infrastructure project may be assessed against different infrastructure levels in order to get a correct view of what could be the impact of a project, and the infrastructure level(s) should be clearly identified.

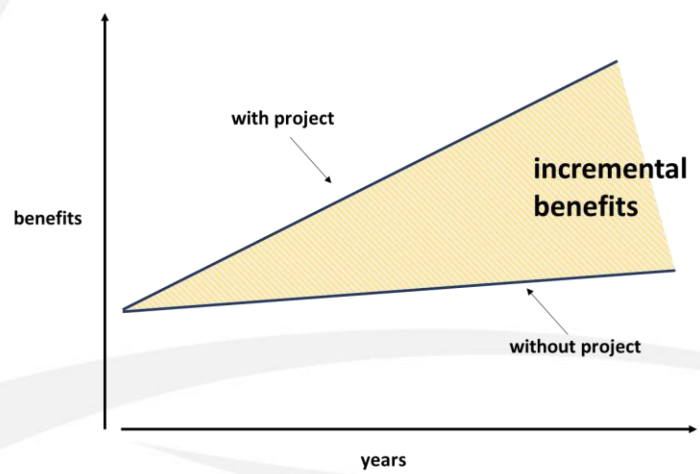



Figure 5 – Incremental approach (adapted from Belli (ed.) et al. – Economic Analysis of investment operations - 2001)

The incremental approach is at the core of the analysis. It is based on the differences of indicators and monetary values between the scenario "with the project" and the scenario "without the project".
The available literature proposes two methods for the application of the incremental approach:

- **Put IN one at a time** (PINT), implies that the incremental benefit is calculated by adding one project[14] compared to the considered infrastructure level, in order to measure the impact of implementing projects compared to the corresponding infrastructure situation. Following this approach each project is assessed as if it was the very next one to be commissioned.

[14] In line with the content of Chapter 2.3 of section B the term project generally refers to group of projects. In some cases the group may coincide with a single project.

> **Take OUT one at a time** (TOOT) implies that the incremental benefit is calculated by removing one project compared to the infrastructure level, in order to measure the impact of implementing projects compared to the corresponding infrastructure situation Compared to the PINT approach, the application of TOOT considers as if the project is the very last one to be implemented.

As showed in the example below, depending on the composition of the considered infrastructure level as reference grid and the status of the assessed project, it is possible to apply **either one or the other** of two approaches.

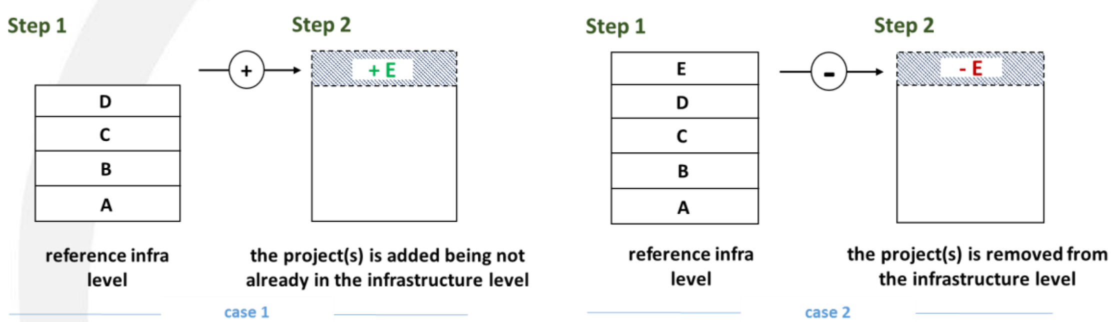



**Figure 6 – Incremental approach with PINT (case 1) and TOOT (case 2)**

# 4. Socio-economic benefits analysis

The analysis of the socio-economic benefits of gas infrastructure projects is based on an assessment of their impact on welfare. A project will imply changes on the gas sector through evolutions in prices and flows. The economic approach insists on the notion of externalities[15], and the need for estimating also non-market effects of a new project (in terms of reduced CO2 emissions for example).

## 4.1. Combined multi-criteria and cost-benefit analysis

This CBA methodology combines monetary elements pertaining to the CBA approach, as well as non-monetary and/or qualitative elements referring to the **Multi-Criteria Analysis (MCA)** approach.

The CBA methodology aims at assessing projects submitted to TYNDP and applying for the Projects of Common Interest (PCI) list. Its perimeter is therefore wider than the pure monetary assessment. Quantitative indicators can provide detailed, understandable and comparable information independently of their potential monetary value. The reality of the gas market and its effect for European economy and society generally require that non-monetary effects are also taken into account.

## 4.2. Benefits from gas infrastructures

The Regulation has identified four main criteria: market integration, security of supply, competition and sustainability. A project should significantly contribute to at least one of them as a pre-requisite to be considered as a project of common interest[16]. In line with those criteria gas infrastructure projects potential benefits to Europe and MSs are listed below as incremental project impact:

- reduction of the cost of gas supply;
- contribution to security of supply, for example mitigating the risk of demand curtailment;
- increase of the number of supply sources that a country has access to, improving security of supply and competition

[15] Theoretically externalities can be both positive and negative.
[16] Art. 4 of Regulation (EU) 347/2013.

- covering incremental demand in existing or new markets to replace more polluting or expensive fuels;
- reduction of CO2 related to the integration of renewable energy (including biomethane and other synthetic gases), substitution by gas of higher-carbon energy sources (like coal in power generation), and improved flexibility between the interlinked electricity and gas systems (e.g. power-to-gas, hereafter P2G);
- price convergence

As already explained not all those benefits can be monetised but still are taken into account in this methodology.

### 4.3. Calculation of the Social Welfare

The change in the social welfare compares the full cost of the project with the full benefits expected from the project, once all externalities are taken into account on both costs and benefits side. The theoretical approach to social welfare is detailed in Annex 2.

C**hange in the total Social Welfare** can be induced by projects driving change in the gas supply due to projects

- bringing more gas to the hub
- connecting EU to new sources or new national production
- connecting existing sources or national production to previously not connected MSs, or lifting an infrastructure bottleneck limiting the access to a given supply source

Additionally to the change in the social welfare benefits can also stem from **change in the externalities** due to projects

- mitigating the risk of demand curtailment
- avoiding the cost of alternative fuels, due to a substitution effect, both in terms of cheaper fuel and reduced CO2 emissions

Focusing on the evolution of social welfare for each specific stakeholder is less relevant than focusing on the evolution of total social welfare. The individual social welfare may evolve even without any change in the total social welfare because of some redistribution between stakeholders.

**Indirect effects** (or secondary market effects), such as projects impact on employment, should be excluded by the assessment in order to avoid double counting or evaluating benefits by default difficult to estimate though reliable techniques.

## 4.4. Social discount rate

The notion of 'social discount rate' (SDR) corresponds to the rate which equalises the discounted sum of benefits and the discounted sum of costs.
It is the discount rate applied to economic benefits and costs of the project (both CAPEX and OPEX). It allows to take into account the time value of money.

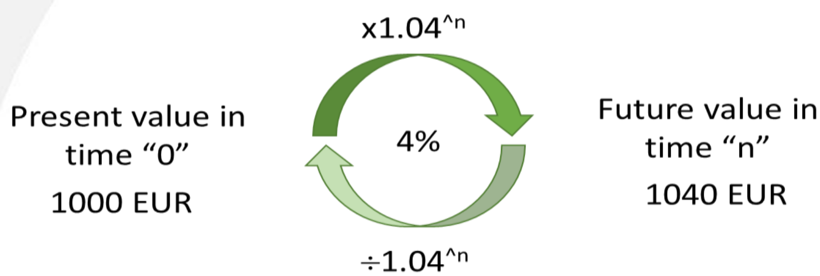



**Figure 7 – Example of how the social discount rate works.**

It can be interpreted as the minimum profitability that should be reached by a gas infrastructure project for it to bring net economic benefits. It can also be interpreted as economic interest rate provided by the best alternative project, following the principle of opportunity costs.

The same SDR for all projects and equal to 4% should be used for the cost-benefit analysis of projects. It corresponds to the middle-ground solution between EC recommendations to use a SDR of 5% for major projects in Cohesion countries and 3% for the other countries. It therefore provides a fair basis for the comparison of projects, unbiased by the location of the projects.

In line with Chapter 4.5 the SDR should be considered in real terms. Vice versa, when the analysis is executed at current (nominal) prices, a nominal SDR should be used.

## 4.5. Constant (real) prices

The socio-economic benefits analysis should be carried out at **constant (real) prices**, i.e. considering fixed prices at a base-year. In order to ensure consistency throughout the time horizon, the already incurred costs (investment) shall be considered as constant prices for the year of occurrence. By doing so, one neutralises the effect of inflation.

## 4.6. Indicators and monetisation

The definition of a common set of indicators ensures the comparability between projects and reflects in an aggregated form their impact along the different policy criteria identified by the Regulation. They should be analysed altogether not giving undue priority to one of them. When it comes to monetisation attention should be paid to potential double counting of benefits.

### 4.6.1. Indicators

The below set of indicators is defined in order to identify the potential infrastructure gaps as part of the TYNDP process and to perform project assessment along the policy criteria.

All the described indicators are used in an incremental approach in order to evaluate the contribution of an infrastructure project along the specific indicator and criteria set by the Regulation.

Taking into account the Annex IV of the Regulation and the possible benefits stemming from the implementation of gas infrastructure projects described in Chapter 4.2, below a minimum set of indicators that should be considered when assessing projects impact.
Based also on the table of "infrastructure needs" identified by the Regional Groups[17] during the 3rd PCI selection process[18], those indicators shall generally measure:

- market integration, in terms of

[17] According to the Regulation the gas Regional Groups are "*established for the purpose of proposing and reviewing projects of common interest*" and, as indicated in Annex III.1 (1) of the same Regulation, "*shall be composed of representatives of the Member States, national regulatory authorities, TSOs, as well as the Commission, the Agency and the ENTSO for Gas*".
[18] The tables are available on https://circabc.europa.eu/.

  - **market access diversification** in terms of diversification of paths that gas can flow through countries, as a proxy for counterparty diversification and market integration. The indicator should be calculated as a capacity-based Herfindahl-Hirschman Index at country level (or balancing zone level where relevant). It should consider the technical entry capacity of the interconnection points (IPs) for a given border and the aggregated entry capacity from LNG terminals to the considered country. The calculation should focus only on IPs within EU or between EU and non-EU and disregard import points. In order to properly account for the impact of transit capacity on the considered country, the entry capacity should be capped by the country demand[19];
  - **balance in bi-directional capacity**, as the technical capacity offered in both direction of an interconnection.
- security of supply, in terms of
  - in line with currently revised Regulation (EU) 994/2010, **resilience** of a country in case of **disruption of the main infrastructure** under high demand condition, taking into account the technical capacity of all other entry points, the maximum technical production capability, the maximal storage technical deliverability and the maximal technical LNG facility capacity;
  - the level of **disrupted demand** in case of high demand condition and/or for relevant major infrastructure or supply disruption cases;
  - **remaining flexibility**, i.e. the resilience at country-level calculated as the possible increase in demand before an infrastructure or supply limitation is reached somewhere in the European gas system.
- competition (and possibly security of supply), in terms of
  - **number of sources** a country can access to, including indigenous production;
  - physical **dependence** on a single supply source. Related price exposure may constitute an additional information.
- competition (and market integration), in terms of
  - **gas supply costs**, as basis for the calculation of the change in socio-economic welfare;
  - **marginal prices** as basis for price convergence among countries (including as a result of mitigating monopolistic supplier behaviour).
- sustainability, in terms of
  - **$CO_2$ emissions**.

[19] This is based on the feedback received from Regional Groups discussion during the 3rd PCI process on the IRD indicator from the previous CBA methodology.

This can be summarised in the table below.

| | Market Integration | Security of supply | Competition | Sustainability |
|---|---|---|---|---|
| **Market access diversification** | X | | | |
| **Balance in bi-directional capacity** | X | | | |
| **Resilience in case of main infrastructure disruption** | | X | | |
| **Disrupted demand** | | X | | |
| **Remaining flexibility** | | X | | |
| **Number of sources** | | X | X | |
| **Physical dependence** | | X | X | |
| **Gas supply costs** | X | | X | |
| **Marginal prices** | X | | X | |
| **CO2 emissions** | | | | X |

**Table 2 – Indicators and Regulation criteria**

An example of the possible indicators is provided in Annex 5.

### 4.6.2. Monetisation

Over time, specific investigations may allow to identify meaningful and reliable ways to monetise an increased number of quantitative indicators. Until such reliable monetisation is ensured, non-monetised quantitative indicators should be maintained.

As explained in Chapter 4.1 the accurate assessment of gas infrastructures requires to combine monetary as well as non-monetary and qualitative elements a part of a multi-criteria analysis.

While this subchapter focuses on monetization, this only part of the procedure to assess a gas infrastructure project.

#### 4.6.2.1. Reduced cost of supply (change in socio-economic welfare)

The monetary analysis of the cost of gas supply is based on the calculation of the gas bill in the situation with and without the project. Benefits at EU level could be generally observed in case of projects connecting EU to a new supply source or to national production.

#### 4.6.2.2. Improvement in security of supply

Analysis should allow to identify where projects provide benefits coming from mitigating possible demand curtailment or increasing the N-1 of a country in a quantitative manner. Such benefit may be monetised using the Value of Lost Load (VoLL).
Based on the avoided quantity of curtailed demand and the VoLL, the avoided disrupted demand can be monetized as follows.

Monetisation of Disruption:

(Disrupted demand with the project [volume] – Disrupted demand without the project [volume]) * VoLL [EUR/volume]

The same approach is used for monetisation of demand curtailment mitigation both in case of no route disruption and under the case of route disruption.

The improvement under a situation of disruption of the main infrastructure thanks to the implementation of a new project can also be monetized using the VoLL.

While a standardized EU-level VoLL ensures comparability and harmonised assessment of projects, some feedbacks suggest that different values on a country/consumer basis could be considered for the VoLL. ENTSOG has not received any specific suggestion on the handling of VoLL as part of the public consultation.
Depending of possible further investigation, this topic may be further developed as part of the adapted version of the CBA methodology.

#### 4.6.2.3. Change in CO2 emissions

The benefits stem from the implementation of a project enabling the substitution of higher carbon content fuels with gas (also renewable gas). This benefit can be monetised as follows

Benefit from replacement of higher carbon content fuels

$$= (Q_{fuel1}*factor_{fuel1} +....+ Q_{fuel n}*factor_{fuel n} - Q_{gas}*factor_{gas}) * CO2\ value$$

where

- Q is the quantity of $fuel_i$ in energy terms (all quantities need to be expressed in the same units)
- fuel $_{i=1 \text{ to } n}$ is any alternative fuel replaced by the increased gas driven by the new project
- $factor_{fuel}$ is the CO2 emission factor of the specific replaced fuel
- $factor_{gas}$ is the CO2 emission factor of gas
- CO2 value consistently with subchapter 1.2

Additionally, benefits can come also in terms of replacement with gas of more expensive alternative fuels, supporting in this way market competition.

Benefit from replacement of more expensive fuels

$$= Q_{fuel1}*P_{fuel1} +...+ Q_{fuel n}*P_{fuel n} - Q_{gas}*P_{gas}$$

where

- Q is the quantity of $fuel_i$ in energy terms (all quantities need to be expressed in the same units)
- fuel $_{i=1 \text{ to } n}$ is any alternative fuel replaced by the increased gas driven by the new project
- $P_{fuel}$ is the price of the specific replaced fuel

Benefits related to change in CO2 emissions might in particular result from:

> a project allowing the gasification of areas not previously connected to gas, or allowing further gasification

> a project allowing a switch from coal (or oil) to gas for power generation

### 4.6.3. Economic Performance indicators

The following Economic Performance Indicators should be considered

- **Economic Net Present Value (ENPV)**: The ENPV is the difference between the discounted benefits and the discounted costs expressed in real terms for the basis year of the analysis (discounted economic cash-flow of the project). If the ENPV is positive the project generates a net benefit and it is desirable from a socio-economic perspective. The ENPV reflects the performance of a project in absolute values and it is considered the main performance indicator. As not all benefits are monetised, project may be desirable even if ENPV is not positive.

- **Economic Internal Rate of Return (EIRR)**: The indicator is defined as the discount rate that produces a zero ENPV. A project is considered economically desirable if the EIRR exceeds its Social Discount Rate.

- **The Economic Benefit/Cost ratio (EB/C)**: it represents the ratio between the discounted benefits and the discounted costs. If EB/C exceeds 1, the project is considered as economically efficient as the benefits outweigh the costs on the time horizon. This performance indicators should be seen as complementary to ENPV and as a way to assess projects of different sizes (different level of costs and benefits). This performance indicator still allow to compare projects even in case of EB/C lower than 1.

Detailed calculation is available as part of Chapter 3 of section D.
Economic performance indicators are sensitive to the time horizon, the Social Discount Rate applied and therefore to the distribution of revenues and costs within the time horizon of the analysis.

## 5. Qualitative elements

Qualitative elements can be added by the project promoter in order to

- comment the results from the monetized and non-monetized indicators
- provide possible additional information regarding the project
- justify potential additional benefits of the project that may not have been sufficiently captured by the analysis

## 6. Project fiche

It is recommended that the cost-benefit analysis of a project would be presented along a project fiche using a standardised template. Such presentation allows for a harmonised approach in providing relevant information and the results of the conducted PS-CBAs in a synthetic and comparable manner. The project fiche also simplifies the assessment and evaluation of projects by institutions and provides a uniform template that can be used to compare projects as part of the PCI selection process and more generally for all PS-CBA purposes identified in Regulation (EU) 347/2013.

The Project Fiche is at project group level and cover the following elements:

- technical information about the group of projects and all the individual projects composing the group
- the benefits arising from the PS-CBA, including an indication of Members States and third countries impacted by the project
- qualitative elements (as per Chapter 5)
- the cost information

It is recommended to use the Project Fiche template provided in Annex 4. The template may be modified over time, in consultation between ENTSOG, EC and ACER.

## 7. Sensitivity analysis

Sensitivity analysis enables the identification of those elements affecting most the social economic performance of a project. Critical factors can be divided in the following categories

- **gas market factors**, the concerned elements are
  - demand evolutions
  - renewables penetration
  - commodity and CO2 prices
  - supply potentials

  Those elements are already captured by the different demand scenarios and supply potentials considered (see subchapters 1.3 and 1.4).

  It is recommended to have a scenario-based approach for such sensitivity analysis, as some of the elements (such as gas demand and prices) are interdependent over time, and to keep CBA results to a manageable level.
- **project-specific data**, to be instead reflected directly in the project-specific assessment:

  - commissioning year (this is especially important when assessing multi-phase projects or group of projects composed by projects that may have different commissioning years, where economic performance indicators could be calculated alternatively based on soonest or latest commissioning)
  - investment and operating expenditures costs
- **financial data** directly impacting the calculation of the social economic performance of the project:
  - social discount rate
  - VoLL level
  - sensitivity on price supply associated to minimization and maximization of the considered supply sources intended to measure potential temporary price situations of one supply source and evaluate the impact of a project allowing this benefit to spread over Europe

## C. CBA Methodology guidelines applied to TYNDP

The primary field of application of this CBA methodology is within the TYNDP process, in line with Regulation (EU) 347/2013 statement that *"[The] methodolog[y]* ***shall be applied for the preparation of each subsequent 10-year network development plan*** *developed by […] the ENTSO for Gas* […]*".*

As described in section B ("Guidelines for gas infrastructure cost-benefit analysis") the CBA methodology aims at providing common guidelines for the definition of inputs and assumptions required to build an assessment framework as uniform basis for the assessment of projects.

The TYNDP process allows for the development of the complete input data set required to build the assessment framework, as well as for collecting the necessary information on the existing infrastructure and on projects. In particular, the TYNDP represents the entry door for projects intending to apply in the PCI selection process. This is covered in the following Chapter 1 (Assessment Framework).

TYNDP also has the important role of identifying the future remaining infrastructure gaps. This defines the basis against which project impact should be assessed. This is covered in Chapter 4.

Project-specific CBA should be performed in the TYNDP, allowing to provide all the necessary modelling results to promoters. This is covered in Chapter 5 of this section. Results should also be published in the TYNDP in the form of a "Project Fiche" (see subchapter 5.3 of this section). This will allow to provide technical support to promoters while ensuring a level-playing field and a transparent assessment towards all stakeholders.

### 1. Assessment framework

As explained in Chapter 1 of section B, the accurate identification of remaining infrastructure gaps and the assessment of projects require to consider contrasted possible futures.

Input data set requires regular update. The dataset of all input necessary for the implementation of a proper CBA assessment at EU and project-specific level are built through the TYNDP every two years.
The TYNDP, in line with the ENTSOs consistent and interlinked model, provides the process for this regular update. The process includes stakeholder engagement (in form of workshops, webinars and Stakeholder Joint Working Sessions), and publication of data for consultation.

The CBA methodology, including the ENTSOs consistent and interlinked model, describes principle-wise which input have to be considered for the CBA assessment framework (see Chapter 1 of section B). The TYNDP process further develops and specifies those input content-wise, taking into account their possible change overtime.

### 1.1. Time horizon

In Chapter 1.1 the time horizon for input data is defined accordingly to the Regulation as "n+5, n+10, n+15, and n+20".
In order to comply with the provision of the Regulation while keeping the assessment focused on significant years from the EU targets perspective, the assessment will be carried out **for 5-year-rounded years.**
This approach will also ease the follow-up form one TYNDP edition to the next.

### 1.2. Commodity and CO2 prices

Commodity and CO2 prices are important contextual elements to be considered when developing possible future demand scenarios, as both may trigger different situations in terms of energy mix and may impact on gas demand. In regards to gas price, such input is used to set a reference gas price, serving as an input when setting the supply price(s) for the different gas supply sources.

### 1.3. Demand scenarios

The uncertainty related to the evolution, in the next decades, of the energy mix and of gas demand need to be captured through different and reasonable demand scenarios able to cover volumetric, seasonal and peak[20] situations. Those scenarios, describing the possible futures, are the basis for the identification of possible infrastructure gaps and for the assessment of the projects` impact at European and Member States level. Those demand scenarios should be kept to a manageable number.

The following elements should be considered when building the storylines for demand scenarios

> **energy policies and regulation**: the demand scenarios should be realistically defined, which notably implies to reflect actual energy policies/regulations set by public decision-makers. For example, any energy and environmental regulations at Member State level or at the EU level should be taken into account;
> **economic conditions**: current economic trends as well as future evolutions should be carefully considered in order to define demand scenarios. In case economic scenarios expect a global recession, the demand scenario covering the upcoming years should not be similar to the one implied by a global economic boom. Therefore, it is a major need to have contrasted views on what may be the economic context in the next decades before preparing scenarios for demand;
> **commodity and CO2 prices evolution**: the same logic applies as the one for the economic conditions. As already mentioned above commodity and CO2 prices may have a direct influence on energy demand;
> **green ambition and renewables development**: demand scenarios also have to be consistent with the development path of renewables. MSs have commitments in terms of renewables, and their ability or not to achieve results should be reflected in demand scenarios. Demand scenarios may integrate optimistic or pessimistic evolutions in order to cover possible futures and will be defined in regards to the targets set by MSs and European Union;
> **energy efficiency**: different assumptions regarding the capacity of stakeholders to achieve goals on energy efficiency are taken into consideration for gas demand scenarios. Being the combination of policy-driven measures and individual behaviour, energy efficiency trend is captured by scenarios in different ways, along more optimistic or more pessimistic lines;
> **drivers of demand evolution** in the different sectors: demand evolution in the different sectors may be impacted by different parameters such as heating technologies and transport modes.

The ENTSOs consistent and interlinked model (see Chapter 3 of section A) defines the ENTSOs joint scenario development process that should be applied for each TYNDP edition, allowing for

[20] In particular in regards to design case as may be defined at national level.

the update of demand scenarios as well as the assumptions behind. This process consist in particular of:

- consultation with stakeholders, including national regulators and member state representatives, on scenario story lines
- collection and/or elaboration of scenario data
- publication of a joint Scenario Development Report for public consultation

The scenario data stemming from the scenario development process shall be published, as part of each new TYNDP development process.

## 1.4. Supply potentials

As a reminder, as part of TYNDP, possible evolution of the supply mix is handled independently from the possible evolution of the gas demand.
For each TYNDP, in a process that involves all interested stakeholders, the potential of each of gas supply sources is defined. As described in subchapter 1.4 of section B, minimum and maximum potentials are identified for each import source in order to capture the uncertainty in the development of supply.

New discoveries that will bring new supply to Europe or that will increase the potential of the existing ones may be made/connected in the future. The related assumptions on their potentials need therefore to be constantly investigated and updated in each TYNDP and in line with the interlinked model provisions.

Renewable sources of gas such as biomethane, synthetic gas and power-to-gas, are meant to develop significantly over the next decades on the path to decarbonize the European energy mix. Those sources should be considered as part of the indigenous production and in accordance with scenario storylines.

The process for the development of supply potentials can be described as follows:

- ENTSOG proposes the supply potential for each considered source based on
  - publicly available information
  - discussion with specific stakeholders (e.g. producers)

- the proposed supply potentials are consulted with all stakeholders as part of the Scenario Development Report consultation and, where relevant, during the TYNDP Stakeholders Joint Working Session (SJWS) to receive feedback
- the proposal for the supply potentials will be part of the final Scenario Development Report

For modelling purposes the supply potentials and supply prices should be reflected into supply curves. Reference prices for each supply sources are used to derive actual supply curves for the TYNDP.

Regarding the granularity of the supply sources at least the following sources should be reflected: National production[21] (per EU country), Russian pipe gas, Norwegian pipe gas, Algerian pipe gas, Libyan pipe gas, Azeri pipe gas, and LNG. A higher granularity within the sources can be developed within the TYNDP process.
Currently it is investigated whether LNG can be reflected as several basins**.**

## 1.5. Infrastructures

### 1.5.1. Existing infrastructures

An accurate definition of the current infrastructure endowment represents one of the first step to build a reliable assessment framework.
The existing infrastructures are defined as the available technical capacity at least for

- interconnection point between two countries (or balancing zones) on both entry and exit direction
- regasification capacity of the LNG terminals
- working gas volume, withdrawal and injection capacities for UGS facilities

The figures on existing capacity are collected by ENTSOG:

- from TSOs for transmission capacities , based on commercialised capacities as reported on ENTSOG Transparency Platform
- from the competent associations of SSOs and LSOs (GSE and GLE) for UGS and LNG capacities
- from other competent stakeholders and public sources when the information above are not available or regard capacities for non-EU countries

[21] As explained, national production includes both conventional production and renewable gases.

The regasification capacity of LNG infrastructures may differ between average and high demand situations. The LNG tank volumes have characteristics that can provide flexibility to the system in case of high demand situations. A flexibility factor that defines the share of the tank volume that can be expected to be available during high demand situations should therefore be considered[22]. In order to take into account the ability of storages to withdraw or inject gas depending on the inventory level, in addition to the working gas volumes and the withdrawal and injection capacities, withdrawal and injection curves should be considered[23].

The above considerations on LNG terminals and underground storages refer both to existing infrastructures and to projects.

### 1.5.2. Projects

The role of TYNDP is to collect all projects of EU relevance. In particular, the Regulation defines that all projects intending to apply for the PCI label must be part of the latest available Ten-Year Network Development Plan. **The role of the TYNDP is therefore also to collect all relevant projects' information** for the CBA assessment.

In line with Chapter 2 of section B, the following information should be collected through TYNDPs:

- description and objective of the project: clear indication of project description and definition of the objectives (in terms of infrastructure needs expected to be met by the project implementation), help the identification of the project and its impact analysis;
- new capacity at the entry/exit points to be associated to a specific project is important for the application of the incremental approach (see Chapter 3 of section B). For transmission projects, such capacity is recommended to be determined based on detailed country-level network modelling, such as hydraulic simulations
- technical information regarding the investment items within the project
- intention to apply to PCI selection when it will be launched by EC
- cost information: costs are a key element for the CBA assessment and promoters are expected to provide, at least for projects for which the Cost-Benefit analysis is expected/ requested, an estimation of their projects costs. For both mature and non-mature projects, promoters can always decide, providing a justification, to indicate a cost estimate based on publicly available

[22] For each TYNDP ENTSOG revises those curves in cooperation with GLE.
[23] For each TYNDP ENTSOG revises those curves in cooperation with GIE.

sources such as the ACER Unit Investment Costs Report[24] or other alternative sources. Promoters should also provide lower and upper ranges for the provided costs information

- information allowing a clear traceability of projects, such as indication if the project is part of a National Development Plan, and the related project code, and if the project is part of the last available PCI List, and the related PCI label
- a TYNDP code will be automatically affected by ENTSOG

A clear definition of the projects' objective and their technical and economic features is essential for the CBA implementation.
Data submission is a critical prerequisite of the infrastructure analysis.

The project data collection process is managed by ENTSOG through its Project Data Portal and can be generally described as follows:

- ENTSOG publicly announces upfront when TYNDP project data collection opens in order to ensure all project promoters are adequately informed about the timeline and the steps for data collection;
- ENTSOG provides all the necessary material to support all promoters submission;
- project submission by promoters, including all information relevant for TYNDP and for the CBA assessment, during which both projects already part of the previous TYNDP should be confirmed and updated and new projects can be submitted
- promoters' data consistency check phase

### 1.5.3. Project status

Depending on their level of maturity projects are categorized along different status. Those status are a pre-requisite for the definition of the infrastructure levels.
Each project status is directly derived from the information provided by its promoter in the process described above.

In line with the guidelines defined in subchapter 1.7 of section B the **FID status** corresponds to those projects that have taken the final investment decision ahead of TYNDP project collection.

---

[24] The ACER Report "On Unit Investment cost indicators and corresponding reference values for electricity and gas infrastructure" can be downloaded here:
http://www.acer.europa.eu/official_documents/acts_of_the_agency/publication/uic report - gas infrastructure.pdf

In addition, in order to better reflect the different level of maturity among non-FID project, the **Advanced status** is applied to all projects that, based on the information submitted, have:

- commissioning year expected at the latest by 31st December of the year of the TYNDP project data collection + 6 (e.g. 2022 in case of TYNDP 2017, for which projects were collected in 2016)
- and
  - whose permitting phase has started ahead of the TYNDP project data collection
    OR
  - FEED has started (or the project has been selected for receiving CEF[25] grants for FEED[26]) ahead of the TYNDP project data collection

In concertation ENTSOG/EC/ACER may decide to review the criteria for the definition of the Advanced status. In this case, it will be discussed with stakeholders as part of the stakeholder engagement process.

If modified, criteria for the definition of project status shall be provided before the relevant project data collection.

### 1.5.4. Project data reliability

It is project promoters' responsibility to provide projects information. However in order to ensure as much as possible the reliability of those information, a check phase in the data collection may be conducted by ENTSOG possibly using publicly available information, such as the ACER PCI Monitoring exercise.

## 1.6. Network assumptions

The **topology of the gas infrastructure** used in the TYNDP process, as developed and regularly updated by ENTSOG, is intended to reflect the following existing and planned European gas infrastructure:

- Transmission infrastructure
  - cross-border capacities between countries (including complex interconnections between more than two TSOs)
  - intra-country capacities between balancing zones

[25] Connecting Europe Facility.
[26] Front End Engineering Design.

  - and meaningful intra-balancing zone constraints, where relevant
  - transit capacities
- LNG terminals infrastructure
  - regasification capacities both along the year and during high demand situations
  - the tank volumes characteristics including a flexibility factor defining the share of the tank volume expected to be available during high demand situations
- Underground storage infrastructure
  - connection to the gas grid
  - the working gas volume
  - the withdrawal and injection capacities
  - the withdrawal and injection curves which define their ability to withdraw or inject gas depending on the filling level
- connection to indigenous production infrastructure
- the gas infrastructure in countries adjacent to the EU as much as the infrastructure in these countries contributes to imports to or exports from Europe.

The topology refers both to the existing and planned infrastructure

Network capacities for the TYNDP time horizon will be made publicly available as part of the TYNDP development process.

## 1.7. Market assumptions

As indicated in subchapter 1.6 of section B CBA assessment should be performed using a perfect market functioning assumption, to assess projects in terms of their contribution to addressing infrastructure gaps that market or regulatory rules cannot address.

In theory, modelling as part of the TYNDP exercise could be perform **with or without additional market assumptions**.

**Transmission tariffs have been raised by a number of stakeholders as a meaningful market element that should be reflected in the modelling to ensure a realistic approach to gas flows. Transmission tariffs would need to be considered as part of a comprehensive frame, also accounting for realistic tariffs for the storages and LNG terminals, and for realistic supply prices. In regards to projects, any estimation of the related infrastructure tariffs should be considered carefully in order to avoid possible double counting in addition to project costs.**

**ENTSOG will further investigate the relevance and feasibility of considering such additional market assumptions. One of the difficulty will be the ability to access, on a regular basis, to comprehensive enough, up-to-date and reliable market data, at EU-wide level.**

**Depending on the outcomes of the investigation, additional market assumptions may be integrated in the Adapted CBA methodology after ACER and EC opinion.**

## 2. Approach to modelling

The modelling should allow for network and market modelling. The use of linear flow programming, based on a flow optimisation algorithm, have shown relevant.

Supply flows, marginal prices and curtailed demand if any (as a virtual last resource supply) are outputs from the modelling. These outputs are used to derive the CBA indicators.,

More detailed and updated information on modelling will be made publicly available as part of the TYNDP development process.

## 3. CBA indicators in TYNDP

TYNDP has key regulatory roles:

- as per Regulation 715/2009 the role to identify the remaining infrastructure gaps, through the assessment of the overall gas infrastructure (as further detailed in the following Chapter).
- as per Regulation 347/2013 to be developed applying the CBA Methodology.

CBA indicators should be used for both those roles of performing the assessment of the gas infrastructure at Union-wide level and performing project-specific assessment.
The analysis of projects' impact in terms of socio-economic benefits require to reflect on their impact in regards to security of supply, market integration, competition and sustainability. This is handled through indicators that have been described in general terms as part of Chapter 4 of section B. These indicators can either be capacity-based (i.e. calculated solely based on inputs) or modelling-based (i.e. calculated as an outcome of the modelling exercise).

The below list provides as an example the CBA indicators that have proved relevant for the TYNDP 2017 and 3rd PCI selection process exercises:

- Import Route Diversification, to evaluate impact of projects enabling reverse flow or increasing diversification of entry points
- Cooperative Supply Source Dependence, to measure the benefit stemming from a project able to mitigate the physical dependence on a source
- Access to supply sources, to measure the impact of projects allowing access to additional supply sources
- Disrupted Demand, to measure the impact of projects in terms of mitigation of demand curtailment, including under import route disruption cases
- Resilience of a country and the impact of projects in terms of mitigation demand curtailment in case of disruption of the main infrastructure
- Marginal price, to measure the impact of projects in terms of reduction of price spreads

The detail on how these indicators are calculated should be part of an Annex to the TYNDP report. Annex 5 gives an example how such TYNDP Annex would look like. Where ENTSOG identifies that some indicators would benefit from being amended, these amendments should be discussed with the Commission and ACER and be presented as part of the TYNDP stakeholder engagement process.

## 4. Identification of infrastructure gaps and assessment of the overall gas infrastructure

Art. 8 (10) of Regulation (EU) 715/2009 defines that gas TYNDP "*shall, in particular […] identify investment gaps, notably with respect to cross-border capacities*".
On this respect, TYNDP has a role in the identification of infrastructure gaps and areas where additional infrastructure may still be needed.

### 4.1. Infrastructure levels for the identification of infrastructure gaps and Energy System Wide assessment

Based on the existing infrastructure and the advancement status of the proposed projects, the infrastructure levels correspond to different potential levels of development of the European gas network system. The TYNDP will consider three infrastructure levels: **Low**, **Advanced** and **PCI**.

- Low Infrastructure Level: existing Infrastructures + Infrastructure projects having a FID status (whatever their PCI status is), in line with subchapter 1.7 of section B;
- Advanced Infrastructure Level: existing infrastructures + Infrastructure projects having a FID status + Advanced non-FID projects;
- PCI Infrastructure Level: existing Infrastructures + Infrastructure projects having a FID status (whatever their PCI status is) + Infrastructure projects labelled PCIs according to the previous selection (not having their FID taken).

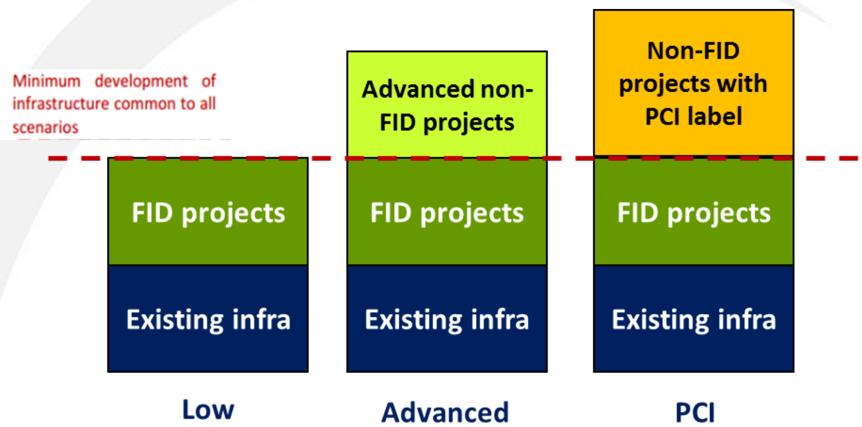



Figure 8 – Infrastructure levels

### 4.1.1. Identification of infrastructure gaps

For the identification of the **remaining infrastructure gaps** the Low infrastructure level is used. This represents the minimum level of infrastructure common to all assessments.

The assessment of the Low infrastructure level provides the analysis of what the current infrastructure, complemented with FID projects, already achieves and which are the remaining gaps that may trigger additional investment.

Identification of the infrastructure gaps will be performed along the different CBA indicators. For a given indicator, and for the different countries, the existence of an infrastructure gap relates to a target value which if not achieved signal an infrastructure gap.

For some indicators, this target value is straightforward. For example, a positive demand curtailment under a disruption event indicates a security of supply concern. As the approach may not be as straightforward for all indicators, target values – if any - as defined by Regional Groups as part of the latest PCI selection process should be considered as a guidance in the identification of infrastructure gaps.

The identified infrastructure gaps should be reported as a specific section of the TYNDP report.

The TYNDP infrastructure gaps assessment represents a key input in the context of the selection process for Projects of Common Interest (PCI), as a basis for the discussion among the Regional Groups on each gas corridor's problems and related infrastructure needs.

Let's take an example:
In the example below, based on the Low infrastructure level an infrastructure gap is identified for country 2: with the infrastructure endowment considered in the Low infrastructure level country 2 is in fact not able to entirely cover its gas demand even in case of infinite availability of gas from the supply source. One or more projects may therefore help to mitigate or entirely solve the situation.

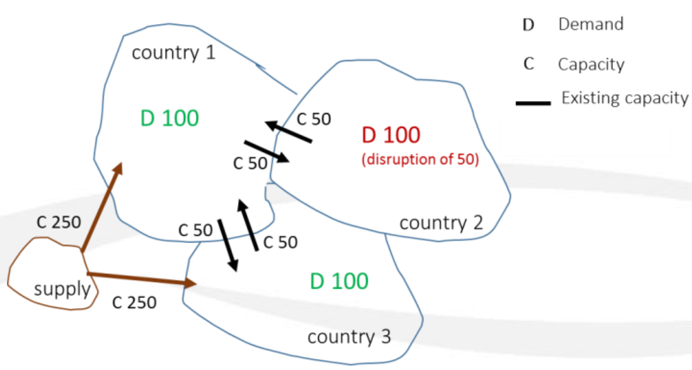



**Figure 9 – Role of LOW infrastructure level in the identification of infrastructure gaps**

### 4.1.2. Assessment of the overall gas infrastructure

Once the infrastructure gaps are identified, the **assessment of the European gas system** may be complemented by assessing the overall further impact of the projects having an advanced status. The results of the Advanced infrastructure level should be compared to those of the Low infrastructure level, ensuring an incremental approach for the overall cluster of projects with Advances status. The Advanced infrastructure level allows to take into account project interaction occurring under such level of development of the infrastructure.

The assessment of the European gas system under the PCI infrastructure level can be used as an assessment of the **prevailing PCI list**. The PCI List infrastructure level includes projects of very different maturity.

## 4.2. Infrastructure gaps as basis for project specific assessment

Identification of infrastructure gaps, as analysed and reported in the TYNDP, should be used to frame project-specific assessment, allowing for a focused and level-playing field cost benefit analysis of projects.

Or said differently:

- in cases where TYNDP identifies a remaining infrastructure gap, project-specific assessment should show if and to which extend the project allow to mitigate this infrastructure gap;
- in cases where TYNDP identifies that gas infrastructure is already sufficiently developed to prevent the apparition of an infrastructure gap, there is no need for related project-specific assessment.

For example, TYNDP may indicate that some countries show irreducible dependence to Russian gas or LNG, but no irreducible dependence to other supply sources. As a consequence projects should only be assessed against the need to reduce the dependence to Russian gas or LNG. In this respect the TYNDP analysis will set the frame for the application of the CBA methodology at project level (the PS-CBA).

As another example, let’s imagine that the TYNDP identification of infrastructure gaps concludes that:

- the European gas infrastructure is resilient to the disruption of Import Route A
- some areas of the gas infrastructure is not resilient to the disruption of Import Route B, that is such disruption would lead to demand curtailment in some countries

In such case, there is no need to assess specific projects against a disruption of Import Route A. Disruption of Import Route A will not be part of the project-specific assessment framework.
But there is a need to assess specific projects against a disruption of Import Route B. Different kind of projects may allow to mitigate the situation: a cross-border interconnection, or alternatively an LNG terminal or a storage. The solution is not unique. In this perspective, when assessing projects` impact against the identified infrastructure gap, the assessment should go

beyond the sole cross-border capacity perspective, in order to properly inform on possible investment solutions.

This approach ensures a comparable basis for the assessment of projects since all projects will be assessed against the same identified infrastructure needs as defined by the TYNDP. In addition, in order to cover any specific project impact beyond what is captured by the CBA methodology indicators, the project valuation will be always complemented by promoters` qualitative assessment, as indicated in Chapter 5 of section B.

Prerequisite for the assessment of projects against the identified infrastructure gaps is the identification for each indicator of an adequate target values beyond which the impact of a project can be considered less relevant. As indicated in Chapter 4.1.1 of this section, the target values – if any - as defined by Regional Groups as part of the latest PCI selection process should be considered as a guidance in the identification of infrastructure gaps.

## 5. Project-specific assessment within the TYNDP

Performance of project-specific CBA as part of the TYNDP process allows for:

- using the TYNDP platform to assess all concerned projects on a comparable basis
- providing transparency on CBA of projects

Performance on project-specific CBAs should be handled as part of the TYNDP process:

- for project groups formed in line with the **project grouping guidelines**.
- **for those groups where projects having signalled their intention to participate in the PCI selection process**, or where at least one project has signalled such intention, as part of the TYNDP project collection
- on the basis of **TYNDP input** (in regards to commodity and CO2 prices, demand, supplies and project data)
- against the **identified infrastructure gaps**

The intention to apply for PCI is independent from the actual PCI application which follows the call launched by Commission, and does not engage projects.
ENTSOG will not perform PS-CBA for those projects not having signalled intention, neither as part of the TYNDP, nor at a later stage of the related PCI selection process.

These elements will be covered in more detail below.

The overall process can be described as follows.

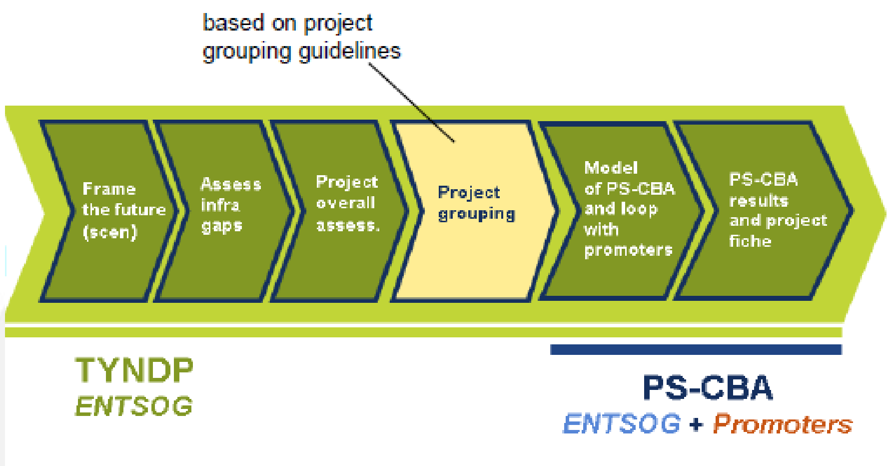



Figure 10 – Overview of the assessment process inside TYNDP

## 5.1. Infrastructure levels for the PS-CBA basis

**The Low and the Advanced infrastructure levels should be used as common basis for the project-specific CBA.**

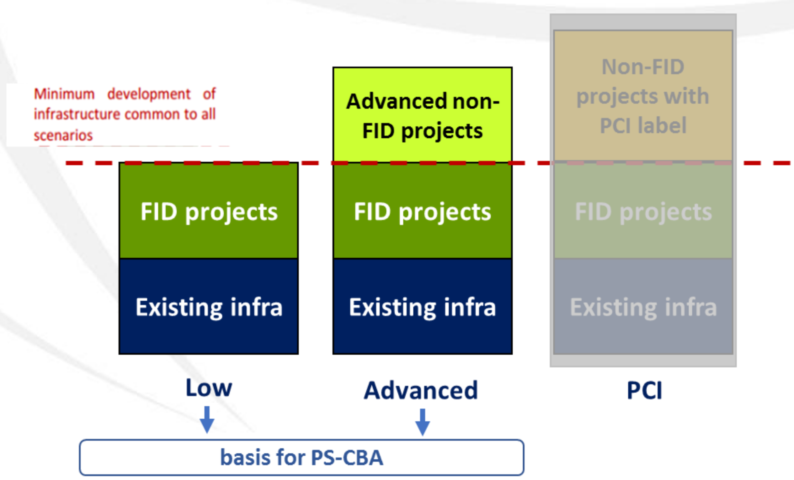



Figure 11 – Infrastructure levels for PS-CBA

Assessing the benefits of projects under different infrastructure levels allows to reflect on different kind of interaction among projects when calculating the differences between the situation with the project and the situation without the project ("incremental approach" as described in Chapter 3 of section B).

Depending on the status of the assessed projects, the incremental approach will be applied to the infrastructure level following the PINT/TOOT "methodology" as follows:

- Low infrastructure level: removing projects with FID status while adding project non-FID (being both Advanced or non-Advanced)
- Advanced infrastructure level: removing projects with FID status or non-FID but Advanced status while adding project non-FID non-Advanced

By comparing the situation "with" and "without" the project it will be possible to identify the impact of the project in mitigating or solving the identified infrastructure gap.

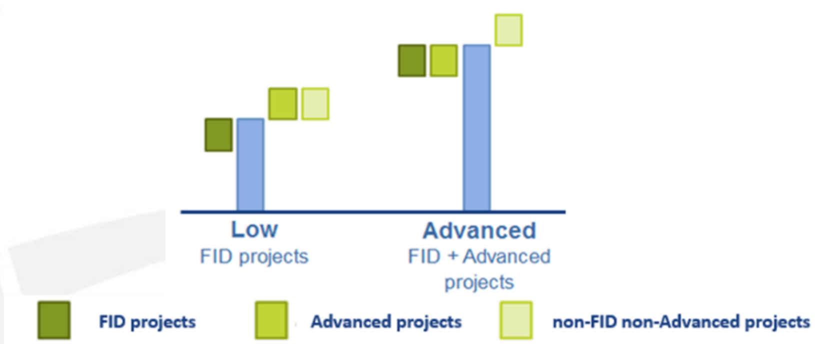



**Figure 12 – Incremental approach for PS-CBA depending on project status**

In line with chapter 1.7 of section B the LOW infrastructure level should be used as basis for PS-CBA.

In addition, considering as basis for PS-CBA an infrastructure level that also includes non-FID but advanced projects represents a more conservative approach since all project benefits are calculated under the assumption that the evaluated project is the last **marginal project** to be implemented. In fact, the higher the number of projects included in the infrastructure level and the lower will be the marginal impact brought by the assessed project when applying the incremental approach. This approach may also allow to identify synergies between projects.

## 5.2. PS-CBA in TYNDP

The PS-CBA should be performed as part of the TYNDP process for those projects having signalled during the related TYNDP project data collection, their **intention to participate in the upcoming PCI selection process**, and grouped in accordance with the project grouping guidelines.

While Regulation 347 does not include any explicit requirement that project-specific CBA could be performed as part of applying the CBA methodology to TYNDP, such assessment delivers in terms of ensuring a level-playing field and providing transparency in regards to project assessment.

The project scope for project specific assessment in TYNDP goes beyond the actual regulatory requirements in regards to PS-CBA as part of the PCI selection process, which refers to sufficiently mature projects. It is intended to provide a relevant contribution to the PCI process, for all projects able to provide the necessary project data, in line with the practice of the 2nd and 3rd PCI processes.

The project-specific (PS) assessment is carried out by ENTSOG and promoters **at project group level** and builds on the **TYNDP input** and the identified **infrastructure gaps**.

Consistently with the provision of Regulation (EU) 347/2013, the focus of the PS-CBA run by ENTSOG is to evaluate the **change in the social welfare** from a group of projects. Projects should be assessed against all CBA indicators as long as the infrastructure gaps are identified.

The process will be performed as follows:

- when submitting a project to the TYNDP, promoters will be asked if they intend to apply in the next PCI selection process;
- for these projects modelling of the project-specific CBA will be handled as part of the TYNDP
- ENTSOG will provide PS-CBA results to promoters before publication of PS-CBA in TYNDP. On this basis promoters will be asked:
  - to confirm to ENTSOG if they still intend to apply in the next PCI selection process
  - to provide to ENTSOG a qualitative analysis for the concerned project group
- for those projects confirming their intention to apply, the PS-CBA for each group of projects should be presented **in line with the project fiche template** (as defined in chapter 6 of section B).

Below the graphical description of the different steps of the PS-CBA assessment directly included in the TYNDP process.

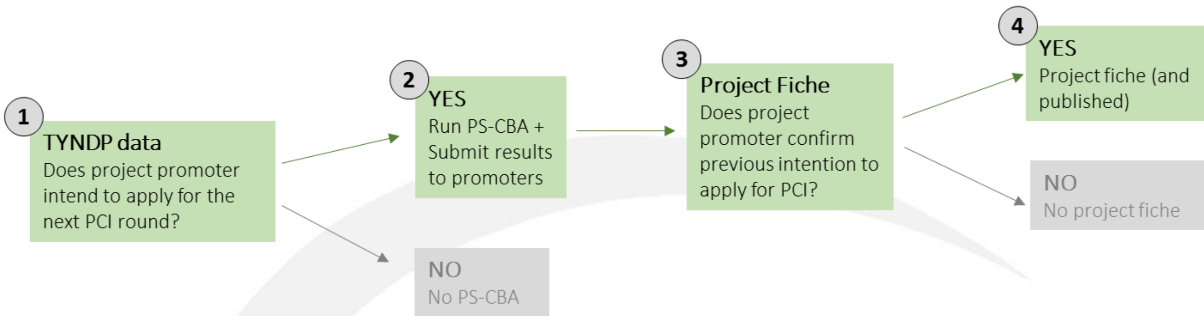



**Figure 13 – Representation of the CBA process in TYNDP**

## 5.3. Project Fiche publication

For those promoters which, after having received the PS-CBA results, confirm their previous intention to apply for PCI, ENTSOG will publish the Project Fiche as part of the TYDNP.

The publication of a Project Fiche represents a useful tool for promoters applying for the PCI label. It also guarantees transparency to stakeholders and towards all purposes where PS-CBA can be used (including CBCA). It ensures a uniform standardized approach that will simplify the assessment and the evaluation of projects by the involved institutions.

The Project Fiche presents together the benefits and costs of projects. Yet in some instances promoters may consider their project costs as a commercially sensitive information for which confidentiality should be preserved. For this reason, **cost information will be published in the project fiche unless marked as confidential by promoters**.

## D. CBA Methodology guidelines applied to PCI process and investment requests

### 1. CBA Methodology in the PCI process

Project cost-benefit analysis represents one of the main input for the PCI selection process.

Annex III (2) of Regulation (EU) 347/2013 states that *"Promoters of a project […]* ***wanting to obtain the status of projects of common interest*** *shall submit an application for selection […] that includes […] for projects having reached a sufficient degree of maturity, a project-specific cost-benefit analysis […] based on the methodologies developed by the ENTSO for electricity or the ENTSO for gas […]"*.

In respect to the PCI selection process, the application of the CBA methodology to the TYNDP provides, as part of the TYNDP process, for:

- the identification of the remaining future infrastructure gaps at European and country level, which can be used as an input by Regional Groups for a discussion on infrastructure needs[27];
- for the projects intending to apply in the PCI selection process, the assessment of the socio-economic impact against the identified infrastructure gaps, established on a level level-playing field among all projects
- the possibility for promoters to complement their analysis with further qualitative assessment.

Application of the CBA methodology to TYNDP also allows, as part of the PCI selection process:

- to provide promoters intending to apply in the PCI process with a readily available PS-CBA developed within the TYNDP shortly ahead of the process
- to provide transparency towards all stakeholders on PCI applicants
- to support the task of Regional Groups by providing a summarised overview of each PS-CBA through the Project Fiche, enabling the assessment of PCI candidates on a fully comparable basis, and possibly allowing for the identification of potentially competing projects

[27] This approach was implemented for the first time during the 3rd PCI selection process where Regional Groups has used the TYNDP as one of the basis for the identification of relevant regional infrastructure needs.

As part of the PCI process, project promoters will have to calculate the Economic Performance Indicators for their projects in line with Chapter 3 of section C. This may be based on a standardised Economic Template that ENTSOG will prepare to consolidate project assessment results and support promoters and Regional Group members.

## 2. CBA Methodology in investment requests and CBCA

Art. 12 of Regulation (EU) 347/2013 states that project promoters whose PCI projects have reached sufficient maturity may submit an investment request including a request for cross-border cost allocation (CBCA) alongside a **PS-CBA consistent with the methodology developed** by ENTSOG.

Art. 12 states that, apart from the PS-CBA, promoters shall also provide a business plan evaluating the financial viability of the project (including the result of market testing) and a proposal for a cross-border cost allocation (if all project promoters agree).

CBCA deals with distribution of costs among all the countries which are affected positively and/or negatively by a gas infrastructure project having cross-border impact. CBCA involves redistributive effects among a limited number of member states affected by a project and is dependent on regulatory decisions by the NRAs of concerned member states.

Project-specific CBA allows to assess the socio-benefit impact of projects at country-level. As such it supports the identification a countries that are positively or negatively affected by a project (see also the example at the end of this section).

The CBA methodology, and its application in the TYNDP, will support projects selected as PCI and intending to perform a CBA for investment request:

- by providing a **publicly available input data set** (in terms of demand scenarios, supply potentials, infrastructure data, etc.) that should be used as basis, and could be completed with additional data if duly reasoned;
- by providing, as part of TYNDP, a PS-CBA with **country-level outputs** focusing on the social economic assessment and indicating the possible cross-border impact of the projects in terms of benefits.

**The minimum requirements for modelling tools** to be used for running PS-CBAs will be provided as part of the adapted version of the ENTSOs consistent and interlinked model.

As part of their investment request, project promoters will have to calculate the Economic Performance Indicators for their projects in line with Chapter 3 of section C.

Additionally, it is recommended that the standard **Project Fiche template** proposed as part of the current CBA Methodology would be used by promoters when developing their own CBA, ensuring consistency in the presentation of results and improving their readability.

The purpose of the Cost-Benefit Analysis used for CBCA differs from the PCI selection process where a comparable basis is essential for the assessment of projects and the subsequent ranking by Regional Groups. When preparing their CBA for CBCA, promoters, following the guidelines provided in Chapter 5 of section B, should be able to handle some sensitivity analysis based on CBA outputs, such as in term of the monetary value attached to certain benefits (e.g. VoLL), the social discount rate, the commissioning year of the project, etc.

This will overall ensure a high usability of CBA methodology for investment requests.

In line with the provision of art. 12 of Regulation (EU) 347/2013, the CBA outputs available to promoters focus on the social economic assessment. Promoters can always complement their CBAs with an assessment of the financial viability of their project (as described in Chapter 4 of this section).

In line with Regulation (EU) 347/2013 the Cross-Border Cost Allocation part of the investment requests remains a separate process from the project-specific assessment described in the CBA methodology, which is out of the remit of ENTSOG.

Example of cross-border socio-economic impact:
The example below considers the dependence to a given supply source. In the initial situation without the project, country 1 and country 3 are quite well diversified in terms of access to supply sources, being directly, or indirectly, connected to two supply sources and also to the rest of Europe. Those countries present a maximum dependence to the considered supply source not higher than 16%. On the other hand, country 2 is connected only to country 1 and directly to one of the available supply sources, this situation make the country more dependent to one or more

supply sources and the unreducible share gas coming from a source is 30%. Assuming a threshold of supply dependence of 25%[28], country 2 shows an "infrastructure problem".

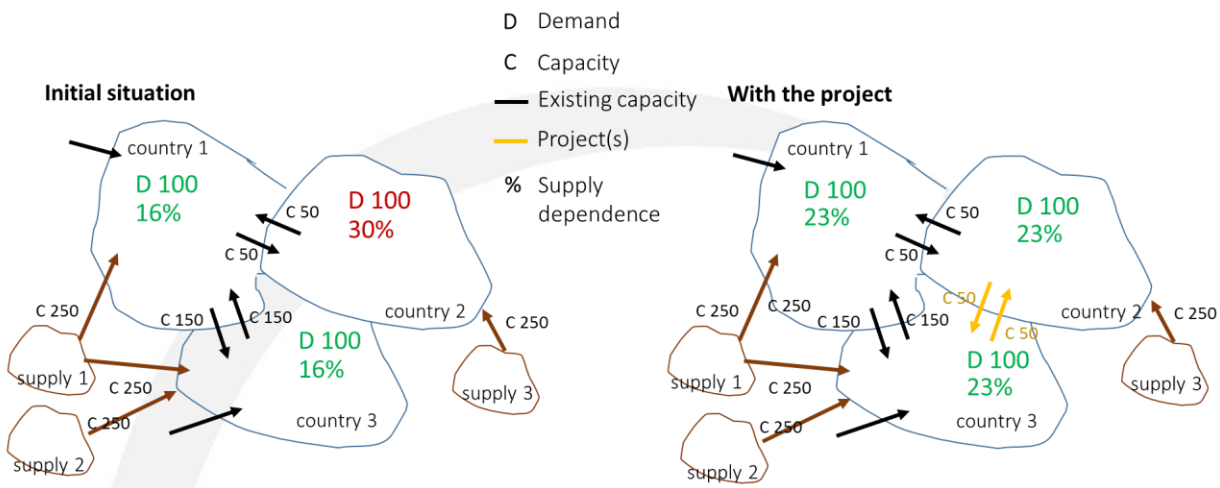



**Figure 14 – Representation of a possible cross-border socio-economic impact**

With the realisation of new capacity between country 2 and country 3 (project initiated by country 2 being the one with the worse starting situation), country 2 has now access to a higher number of sources allowing to reduce the share of dependence to 23% and also to reduce the overall Europe dependence. According to the communicating vessels theory, country 1 and country 3, without bottlenecks, see their situation worsening and the source dependence increasing since now they are fully interconnected with country 2.
Therefore, even in case of an overall improvement of the dependence in Europe, country 3 would have a net negative impact in case of realisation of this project, which should be accounted for in deciding for cross-border cost allocation.

The situation described in the example above may happen with marginal prices. In this case we would observe an alignment in marginal prices with the cost of gas in country 2 decreasing while increasing in the remaining countries. Still, for Europe we would observe a decrease in the cost of gas.

[28] This was the threshold approved by Regional Groups during the 3rd PCI selection process.

## 3. Economic Performance indicators

The below Chapter provides guidance for the calculation of Economic Performance indicators.

Economic performance indicators are sensitive to the time horizon, the Social Discount Rate applied and therefore to the distribution of revenues and costs within the time horizon of the analysis. Economic Performance Indicator shall be calculated on a 20-year time horizon.

In order to ensure transparency and comparability, costs and monetized benefits shall be expressed in EUR and reported at the price level of a single base year.

> **Economic Net Present Value (ENPV)**: it represents the discounted economic cash-flow of the project. It shall be calculated according to the following formula

$$ENPV = \sum_{t=f}^{c+19} \frac{R_t - C_t}{(1+i)^{t-n}}$$

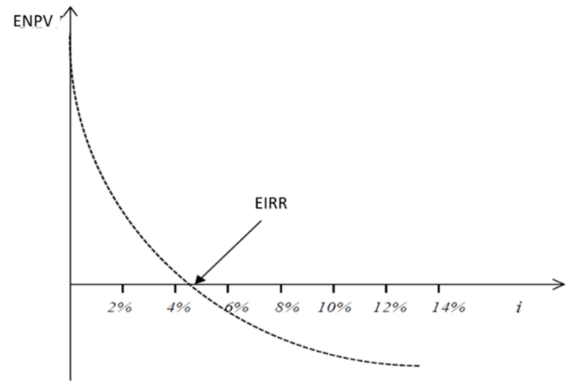
Where:

- $c$ is the first full year of operation
- $R_t$ is the European Social Welfare induced by the project ( $\Delta SW_{EU}$ ) on year $t$ (on year c+20 it also includes the Residual Value of the project)
- $C_t$ is the sum of CAPEX and OPEX on the year $t$
- $n$ is the year of analysis
- $i$ is the Social Discount Rate of the project
- $f$ is the first year where costs are incurred

If the ENPV is positive the project generates a net benefit and it is desirable from a socio-economic perspective. As not all benefits are monetised, project may be desirable even if ENPV is not positive.

The ENPV reflects the performance of a project in absolute values and it is considered the main performance indicator.

> **Economic Internal Rate of Return (EIRR)**: The indicator is defined as the discount rate that produces a zero ENPV.




A project is considered economically desirable if the EIRR exceeds its Social Discount Rate. Mathematically, the EIRR is also the value of the discount rate that satisfies the following formula.

$$\mathbf{0} = \sum_{t} \frac{R_t - C_t}{(1 + EIRR)^t}$$

Where:

- $t$ is the year of analysis
- $R_t$ is the European Social Welfare induced by the project ( $\Delta SW_{EU}$ ) on year $t$ (on year c+20 it also includes the Residual Value of the project)
- $C_t$ is the sum of CAPEX and OPEX on the year $t$

> **The Economic Benefit/Cost ratio (EB/C)**: it represents the ratio between the discounted benefits and the discounted costs.

$$EB/C = \frac{\sum_{t=f}^{c+19} \frac{R_t}{(1+i)^{t-n}}}{\sum_{t=f}^{c+19} \frac{C_t}{(1+i)^{t-n}}}$$

Where:

- $c$ is the first full year of operation
- $R_t$ is the European Social Welfare induced by the project ( $\Delta SW_{EU}$ ) on year $t$ (on year c+19 it also includes the Residual Value of the project)
- $C_t$ is the sum of CAPEX and OPEX on the year $t$

- ***n*** is the year of analysis
- ***i*** is the Social Discount Rate of the project
- ***f*** is the first year where costs are incurred

If EB/C exceeds 1, the project is considered as economically efficient as the benefits outweigh the costs on the time horizon. This performance indicators should be seen as complementary to ENPV and as a way to assess projects of different sizes (different level of costs and benefits). This performance indicator still allows to compare projects even in case of EB/C lower than 1.

<u>Recommendations on time horizon for EPI and interpolation</u>

In addition, when assessing cost-benefit analysis at project level, the Economic Performance Indicators shall be implemented in order to identify the social economic impact of each group of projects.

Considering the long technical life and the possible late date of commissioning of gas infrastructures, the calculation of Economic Performance Indicators is based on an extended time horizon. For the Economic Performance Indicators and based on CBA results for simulated years the economic cash flow for each year should be calculated in the following way:

- from the first full year of operation until the next simulated year the monetised benefits should be considered equal to the monetised benefits of the simulated year
- the monetised results as coming from the simulations and used to build the EPI will be **linearly interpolated** between two simulated years (e.g. n+10 and n+15)
- the monetised benefits will be kept constant until the 20th year of life of the project after the last simulated year

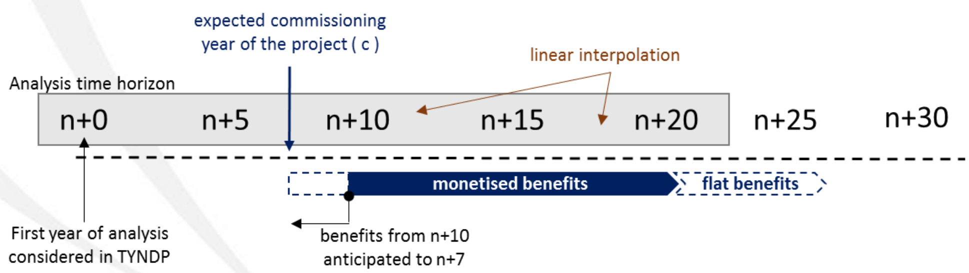



**Figure 15 – Representation of economic cash flow assessment in case of projects to be commissioned between two assessed years**

For multi-phase projects or group of projects the benefits will be counted according to the year of the first phase/project to be commissioned. This allows to take into account projects or group

of projects where the implementation of the first phase/project already bring benefits and contribute as enhancers to the other phases/projects of the group.
Furthermore, in line with the defined time horizon in case of assessment of multi-phase projects or group of projects the residual value of each phase/project should be indicated accordingly to the commissioning year of the considered stage/project.

Below a table representing both the situation of a single phase and a multiphase project.

| TYNDP-horizon | n+0 | … | n+4 | n+5 | n+6 | n+7 | … | n+16 | … | n+20 | *Constant benefit* | | | *Input for residual value (yrs.)* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Economic cash flow | **Single phase project** | | | **c** | c+1 | c+2 | … | c+11 | … | c+15 | c+16 | … | c+19 | **20** |
| | **Multiphase project – Phase 1** | | | **c** | c+1 | c+2 | … | c+11 | … | c+15 | c+16 | … | c+19 | **20** |
| | **Multiphase project – Phase 2** | | | | | **c** | … | C+9 | … | C+13 | C+14 | … | C+17 | **18** |
| | | | | *Common time horizon of 20 years of operation for EPI calculation*<br><br>*For multi-phase projects the Time Horizon for the whole project ends with the 20 years of operation of the first phase* | | | | | | | | | | |

(*) n is the first year of analysis
(**) c is the commissioning year
(***) number of years of operation to be considered for the depreciation of the asset in the calculation of the Residual Value

**Table 3 – Illustration of the economic cash flow assessment**

At the same time, in order to not overestimate the benefits and in line with the guidelines defined in Chapter 7 of section B, a sensitivity analysis on the commissioning year should be considered, starting this time taking into account the benefits from the full operational year of the last phase/project to be commissioned. In this way the total benefits, when discounted, will be lower since happening farther in the future. This allows to take into consideration situation where the first phase/project are enabler of the other phases/project of the group and the benefits do not appear before the full implementation of the project/group of project.
Continuing with the example above this time we start calculating the benefits of the overall project from the commissioning year of the last phase to become operational.

| TYNDP-horizon | n+0 | … | n+4 | n+5 | n+6 | n+7 | … | n+20 | *Constant benefit* | | | | *Input for residual value (yrs.)* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Economic cash flow | **Multiphase project – Phase 1** | | | c | c+1 | c+2 | … | c+15 | … | c+19 | … | C+21 | **22** |
| | **Multiphase project – Phase 2** | | | | | **c** | … | C+13 | … | C+17 | … | C+19 | **20** |

(*) n is the first year of analysis
(**) c is the commissioning year
(***) number of years of operation to be considered for the depreciation of the asset in the calculation of the Residual Value
Table 4 – Illustration of the economic cash flow assessment in case of sensitivity on the commissioning year.

**Table 5 – Illustration of the economic cash flow assessment in case of calculation based on the commissioning year of the last phase to become operational**

## 4. Financial assessment in investment requests

As already mentioned above, in art. 12 of the Regulation it is stated that, apart from the PS-CBA, promoters submitting an investment request shall also provide a business plan evaluating the financial viability of the project. According to the Regulation, the financial viability assessment is out of scope of the PS-CBA to be conducted consistently with the CBA methodology. However, in order to support promoters and stakeholders, this Chapter provides some **indicative** guidelines for the preparation of the financial analysis, based in particular on the EC CBA Guide.

The purpose of the analysis is to provide an assessment of the financial performance of the project.

The analysis should take into account:

- cash inflows (revenues) in terms of tariffs that are paid by users of the project infrastructure for the service of transporting energy[29]
- cash outflows, where all the costs categories from Chapter 2.2 of section B should be considered

[29] In case of financial assessment of group of projects it is recommended to align on load factor assumptions to have consistent revenues assumptions within the group.

- a time horizon consistent with the one considered in this methodology for the social economic analysis
- the analysis should be carried out in constant real prices and the financial discount rate (FDR) expressed in real terms[30]
- the analysis should be net of VAT both on the costs and revenues side, if recoverable by the promoter
- calculations have to be carried out before tax reduction on capital, income, etc.

The following indicators should be computed

- **financial net present values (FNPV)** on investment as the difference between the expected discounted costs (both investment and operating costs) and the discounted value of revenues
-

$$FNPV = \sum_{t=f}^{c+19} \frac{R_t - C_t}{(1+i)^{t-n}}$$

  - ***c*** is the first full year of operation
  - $R_t$ is the promoter revenue generated by the project on year *t* (on year c+19 it also includes the Residual Value of the project)
  - $C_t$ is the sum of CAPEX and OPEX on the year *t*
  - ***n*** is the year of analysis
  - ***i*** is the Financial Discount Rate of the project
  - ***f*** is the first year where costs are incurred

  The FNPV is an indicator reflecting the commercial viability of a project. It is a reflection of the performance of a project in absolute values and it is considered the main performance indicator.

- **financial rate of return (FIRR)** as the discount rate that gives a zero FNPV. A project is considered financially desirable if the FIRR exceeds its financial discount rate.
  Mathematically, the FIRR is also the value of the discount rate that satisfies the following formula

[30] The EC CBA Guide indicates the benchmark of 4%. However, different values may be justified at national level.

$$0 = \sum_{t} \frac{R_t - C_t}{(1 + FIRR)^t}$$

Where:

- $t$ is the year of analysis
- $R_t$ is the promoter revenue generated by the project
- $C_t$ is the sum of CAPEX and OPEX on the year $t$

> **financial benefit/cost ratio (FB/C)** as the ratio between the discounted revenues and the discounted costs.

$$FB/C = \frac{\sum_{t=f}^{c+19} \frac{R_t}{(1+i)^{t-n}}}{\sum_{t=f}^{c+19} \frac{C_t}{(1+i)^{t-n}}}$$

- $c$ is the first full year of operation
- $R_t$ is the promoter revenue generated by the project on year $t$ (on year c+19 it also includes the Residual Value of the project)
- $C_t$ is the sum of CAPEX and OPEX on the year $t$
- $n$ is the year of analysis
- $i$ is the Financial Discount Rate of the project
- $f$ is the first year where costs are incurred

The financial benefit/cost ratio should be higher than 1.

## 5. Environmental Impact

Any gas infrastructure has an impact on its surrounding. This impact is of particular relevance when crossing some environmentally sensitive areas. Mitigation measures are taken by the promoters to reduce this impact and comply with the EU Environmental acquis[31].

[31] Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programs on the environment.

In order to give a comparable measure of project effects, the Table 21 shall be filled in by the promoter.

| Section of the project | Stage of the project | Type of infrastructure | Surface of impact | Environmentally sensitive area | Mitigation measures |
|---|---|---|---|---|---|
| Section 1 | | | | | |
| Section 2 | | | | | |

Table 6 - Environmental impact and Mitigation Measures of a Project

Where:

- The section of the project is used to geographically identify the concerned infrastructure
- Stage of the project identifies the phase of implementation of the project (e.g. FEED, construction…) considering that the accuracy of information provided in the matrix is linked to the progress of the project
- Type of infrastructure identifies the nature of the section (e.g. compressor station, pipes…)
- Surface of impact is the area covered by the section in square meters and in linear meters and nominal diameter for pipe. It is used as a proxy as the actual impact may exceed this surface but its definition is too much dependent from national framework to ensure comparability.
- Environmentally sensitive area is described by the relevant legislation as defined below:
  - EIA Directive (2011/92/EU) Annex 3 and its amendment (2014/52/EU) which is to be transposed in 3-year time horizon by Member States
  - SEA Directive (2001/42/EC)
  - Natura 2000 (Habitats Directive (92/43/EEC) and Birds Directive (2009/147/EC))
  - Water Field Directive
  - RAMSAR Convention
  - IUCN key biodiversity areas
- Mitigation measures are the actions undertaken by the promoter to compensate/minimize the impact of the section (e.g. they can be related to the Environmental impact assessment carried out by the promoter)

# List of figures

## Annex 1 – Project grouping

In order to support the identification of reasonable project groups this CBA methodology proposes as **guidelines** that project groups should be defined based on

- the project grouping identified in the most recent approved PCI List or if more recent as reviewed by Regional Groups
- where amendments are needed for the modelling to properly reflect the benefits of projects, grouping should respect the following functionality criteria
  - Interconnection of two or more countries or connection to an existing or new source
  - LNG terminal (and connecting pipe)
  - Underground storage (and connecting pipe)
  - Supply chain to bring gas to one or more EU Countries from an existing or new source
  - Interconnectors (and internal enablers)
  - Reverse flow + relevant projects (eg. Compressor Stations or internal enabler)

When grouping projects, other elements may be considered as a secondary input to check groups consistency, such as the projects implementation status (e.g. under consideration vs under construction, etc.) and the expected commissioning year. For example, grouping together projects expected to be commissioned far apart in time may introduce the risk that eventually one of more investments are not realised.

## Annex 2 – Theoretical approach to Socio-economic Welfare

Based on the economic theory the European social welfare is defined as the yellow area between the supply and demand curves. The change in social welfare induced by a project is the additional orange area resulting from the change of the supply curve where there is an access to a cheaper source as shown in the Figure 16 and Figure 17 (also defining the marginal price as the price at the intersection of the two curves).

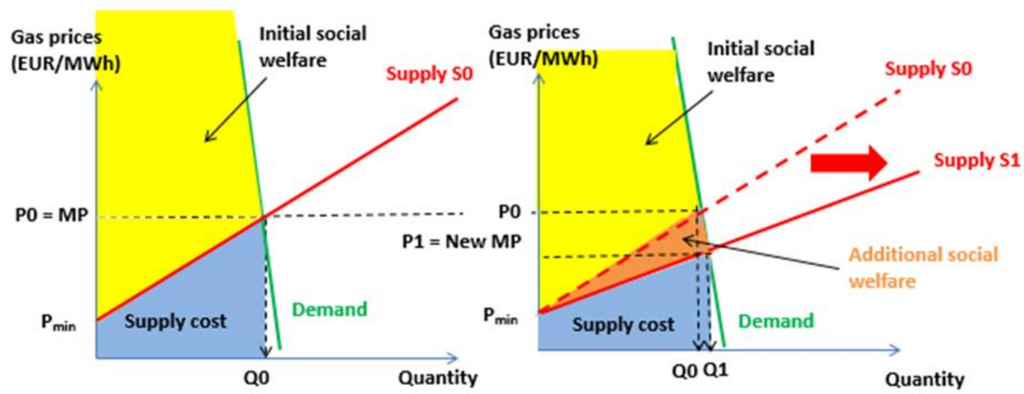



**Figure 16 – Socio-economic Welfare before/after the project in case of a new source not cheaper than the current cheapest one**

The above graph shows that the new infrastructure project, in Figure 8 allows to bring in a new gas supply source, or more gas from the same supply sources, and the supply curve rotates to the right around point (0,Pmin): for a given gas price, gas volumes available on the market are higher. In this case the additional gas – provided from the same or different sources – is never cheaper than the cheapest existing source before the investment (Pmin is still the minimum for which some supply is brought to the market). The equilibrium on the gas market has changed, thanks to the new infrastructure: quantities have increased from Q0 to Q1, and the marginal price has decreased from P0 to P1. The additional socio-economic welfare on the gas market corresponds to the surface in orange, which is comprised between the old and the new supply curve and the unchanged demand curve in Figure 7 above.

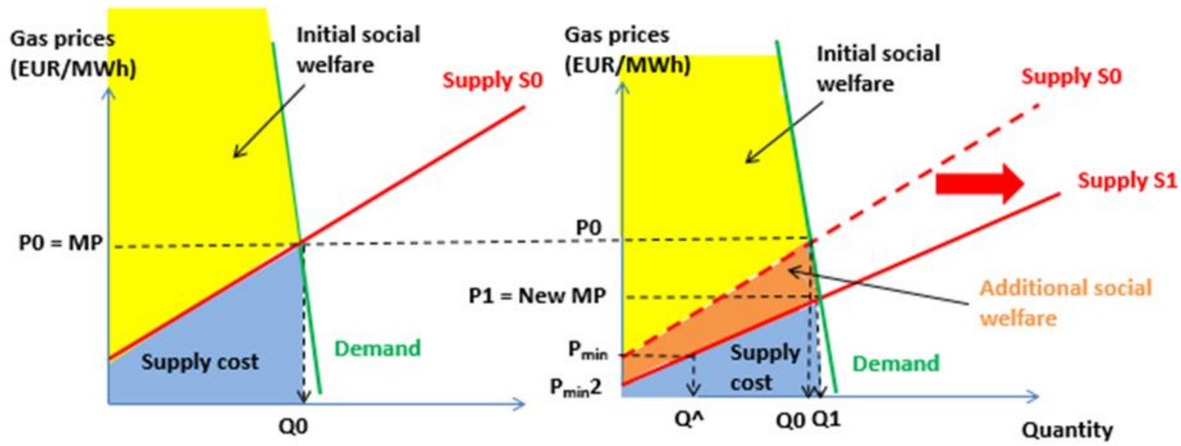



Figure 17 – Socio-economic Welfare before/after the project in case of a new cheaper source

Compared to the previous case, the supply curve is not simply derived by a rotation of the existing curve. The new source is now cheaper than the current cheapest source, until quantity level Q^. Therefore, volumes up to Q^ will be made possible by the new infrastructure allowing the new gas source. Beyond this volume, gas will be supplied by both the new and the incumbent sources. The equilibrium on the gas market has changed, thanks to the new infrastructure: quantities have increased from Q0 to Q1, and the marginal price has decreased from P0 to P1. The additional socio-economic welfare on the gas market corresponds to the surface in orange, which is comprised between the old and the new supply curve and the unchanged demand curve.

It should be noted that in practice, at a given point in time, the **elasticity of gas demand is limited**. For example, in the heating sector, when temperature is cold, consumers are not willing to shift their demand. In the power sector, in theory respective gas and coal (or oil) prices impact on the generation mix. Yet, once gas and coal prices are fixed as part of the CBA assessment frame, there remains little ground for such shift, except if a project would have an impact on a country's gas price sufficient to trigger a change in the generation merit order.

## Annex 3 - ENTSOs consistent and interlinked model

The draft submitted in December 2016 for ACER and EC Opinions of the Consistent and Interlinked Electricity and Gas Model is available on ENSTOG website[32].

Following the opinion to be issued by the Commission, the adaptation of the consistent and interlinked model by the ENTSOs and approval by the European Commission, the consistent and interlinked model will be included, as an annex, in the CBA methodologies developed by each ENTSO and it shall then be applied by each ENTSO as part of applying the CBA methodologies.

32 https://www.entsog.eu/publications/cba-methodology#CONSISTENT-AND-INTERLINKED-ELECTRICITY-AND-GAS-MODEL

## Annex 4 – Project Fiche

It is proposed to use the following Project Fiche template. This proposal may be discussed in view of the adapted version.
Where relevant the Project Fiche may later on be modified following consultation among ENTSOG, ACER and EC.

## Group Fiche

| Group reference | Group name - To be filled in by promoters |
| --- | --- |
| | CAPEX [Million EUR 2017] |

**Description - To be filled in by promoters**

<please provide the necessary description>
<Should you have any change in the schedule compared to project submission in TYNDP please report it here>

## Projects Constituting the Group

| Project Code | Project Name | Promoter | Applied for 3rd PCI list | 2nd PCI List No. |
| --- | --- | --- | --- | --- |

## Complementarity

| Project Code | Project Name | Promoter | Complementarity | Comments |
| --- | --- | --- | --- | --- |

## Project Overview

Transmission Projects

| Project Code | Country | Operator | Interconnection Point | Entry Capacity Increment | Exit Capacity Increment | Commissioning Year | Diameter (weighted average) [mm] | Length [km] | Compressor Power [MW] | Last Completed Stage | Enabler | Commissioning Year in TYNDP 2015 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

LNG Projects

| Project Code | Country | Operator | Interconnection Point | Increment Capacity [GWh/d] | Commissioning Year | Expected Yearly Volume | Storage Increment | Last Completed Stage | Enabler | Commissioning Year in TYNDP 2015 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

Underground Storage Projects

| Project Code | Country | Operator | Interconnection Point | Injection Capacity Increment [mcm] | Withdrawal Capacity Increment [mcm] | Commissioning Year | WGV Increment [mcm] | Last Completed Stage | Enabler | Commissioning Year in TYNDP 2015 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

## Group Benefits

**Comments on benefits - To be filled in by promoters**

<please provide the necessary information>

## Impacted Countries - Pre-filled by ENTSOG based on Simulation results (below)

## Economic Results in Million EUR/year [2017]

| | LOW | | | ADVANCED | | |
| --- | --- | --- | --- | --- | --- | --- |
| | Blue Transition | Green Evolution | EU Green Revolution | Blue Transition | Green Evolution | EU Green Revolution |
| EU Bill improvement | | | | | | |
| Mitigation in Disrupted Demand | | | | | | |
| Mitigation in N-1 | | | | | | |
| Gasification (by promoter) | | | | | | |

**Simulation Results** *- based on PS-CBA results*

Delta values are the incremental impact of the group up to (resp. down to) the threshold defined by Regional Groups

list of impacted countries per considered indicators

| | LOW<br>2020<br>Green Evolution<br>Value | Delta | 2025<br>Blue Transition<br>Value | Delta | Green Evolution<br>Value | Delta | EU Green Revolution<br>Value | Delta | 2030<br>Blue Transition<br>Value | Delta | Green Evolution<br>Value | Delta | EU Green Revolution<br>Value | Delta |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Access to supply sources (nb of sources) | | | | | | | | | | | | | | |
| - | | | | | | | | | | | | | | |
| Dependence to LNG (%) | | | | | | | | | | | | | | |
| - | | | | | | | | | | | | | | |
| Dependence to Russia (%) | | | | | | | | | | | | | | |
| - | | | | | | | | | | | | | | |
| Disruption Rate (%) - Ukraine route disruption | | | | | | | | | | | | | | |
| - | | | | | | | | | | | | | | |
| Disruption Rate (%) - Belarus route disruption | | | | | | | | | | | | | | |
| - | | | | | | | | | | | | | | |
| Disruption Rate (%) - Without any supply disruption | | | | | | | | | | | | | | |
| - | | | | | | | | | | | | | | |
| IRD | | | | | | | | | | | | | | |
| - | | | | | | | | | | | | | | |
| N-1 for ESW CBA (%) | | | | | | | | | | | | | | |
| - | | | | | | | | | | | | | | |

list of impacted countries per considered indicators

| | ADVANCED<br>2020<br>Green Evolution<br>Value | Delta | 2025<br>Blue Transition<br>Value | Delta | Green Evolution<br>Value | Delta | EU Green Revolution<br>Value | Delta | 2030<br>Blue Transition<br>Value | Delta | Green Evolution<br>Value | Delta | EU Green Revolution<br>Value | Delta |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Access to supply sources (nb of sources) | | | | | | | | | | | | | | |
| - | | | | | | | | | | | | | | |
| Dependence to LNG (%) | | | | | | | | | | | | | | |
| - | | | | | | | | | | | | | | |
| Dependence to Russia (%) | | | | | | | | | | | | | | |
| - | | | | | | | | | | | | | | |
| Disruption Rate (%) - Ukraine route disruption | | | | | | | | | | | | | | |
| - | | | | | | | | | | | | | | |
| Disruption Rate (%) - Belarus route disruption | | | | | | | | | | | | | | |
| - | | | | | | | | | | | | | | |
| Disruption Rate (%) - Without any supply disruption | | | | | | | | | | | | | | |
| - | | | | | | | | | | | | | | |
| IRD | | | | | | | | | | | | | | |
| - | | | | | | | | | | | | | | |
| N-1 for ESW CBA (%) | | | | | | | | | | | | | | |
| - | | | | | | | | | | | | | | |

**Annex 5 – Indicators**

**As described in the methodology indicators may be adapted over time based on experience gained and feedback received as part of each TYNDP edition. This Annex provides as an example the indicators used for TYNDP 2017 (Annex F) and, also for some of them, in the 3rd PCI selection process. This set of indicators covers all specific criteria of the Regulation.**

**ENTSOG has already received from the Regional Group members during the 3rd PCI selection process, and from the CBA public consultation closed on the last 23 June 2017, some indication on possible improvements for the IRD indicator and some suggestions to focus on CSSD in terms of supply dependence.**

### 1. Import Route Diversification (IRD)

This indicator measures the diversification of paths that gas can flow through to reach a Balancing Zone in an EU country, or a non-EU country that is part of the TYNDP perimeter. Together with the Supply Source Price Diversification, it provides a proxy to the assessment of counterparty diversification.

***IRD =***

$$\sum_{l}^{X\,border}\left(\sum_{k}^{IP}\%\,IP_k Xborder_l\right)^2+\sum_{j}^{source}\left(\sum_{i}^{IP}\%\,IP_i from\ source_j\right)^2+\sum_{m}(\%\,LNG\ terminal_m)^2$$

The below shares are calculated in comparison with the total entry technical capacity into the Balancing Zone from each adjacent Balancing Zone or country part of the TYNDP perimeter, from each import source, and from each LNG terminal:

- **$IP_k$ $Xborder_l$**: the share of the technical capacity of the interconnection point $IP_k$ belonging to the border with the Balancing Zone or the non-EU country part of the TYNDP perimeter
- **$IP_i$ from $source_j$**: the share of the technical capacity of the import point $IP_i$ coming directly from the source *j* (e.g. offshore pipeline).
- **LNG $terminal_m$**: the share of the technical send-out capacity of the LNG terminal *m*

For Interconnection Points between Balancing Zones and/or non-EU countries part of the TYNDP perimeter, capacity is first aggregated at Balancing Zone or country level[33], as those physical points are likely to largely depend on common infrastructures. LNG terminals are considered as completely independent infrastructures.

The lower the value, the better the diversification is.

**2. N-1 for ESW-CBA (N-1)**

Under REG (EC) 994/2010, this indicator is calculated by the Competent Authority on a two year range. The use of such an indicator within the ESW-CBA will be based on the same formula, using the ESW-CBA data set:

$$N-1=\frac{IP+NP+UGS+LNG-I_m}{Dmax}*100$$

The indicator is calculated for all Infrastructure Levels considered in the respective TYNDP, as well as for a set of Global Scenarios defined within the TYNDP. It is calculated at country level, where:

> **IP:** technical capacity of entry points *(GWh/d)*, other than production, storage and LNG facilities covered by *NP*, *UGS* and *LNG*, means the sum of technical capacity of all entry points capable of supplying gas to the transmission system(s) of the calculated country. The entry points which are considered are :
  - Cross-Border Import Points from non-EU countries to EU countries
  - Cross-Border Export Points from EU countries to non-EU countries part of the TYNDP perimeter
  - Cross-Border Points between non-EU countries and non-EU-countries part of the TYNDP perimeter
  - Cross-Border Points between EU countries
  - In-Country Points between two distinct Balancing Zones

> **NP:** maximal technical production capability (GWh/d) means the sum of the maximal technical daily production capability of all gas production facilities which can be delivered to the entry points of the transmission system(s) in the calculated country; taking into account their respective physical characteristics.

> **UGS:** maximal storage technical deliverability *(GWh/d)* means the sum of the maximal technical daily withdrawal capacity of all storage facilities which can be delivered to the entry points of the transmission system(s) in the calculated country, taking into account

[33] In France, FRs and FRt are treated as one zone (TRS). The results for this zone are relevant for both FRs and FRt.

their respective physical characteristics.

- **LNG:** maximal technical LNG facility capacity *(GWh/d)* means the sum of the maximal technical send-out capacities at all LNG facilities in the calculated country, taking into account critical elements like offloading, ancillary services, temporary storage and re-gasification of LNG as well as technical send-out capacity to the system.
- $\mathbf{I_m}$ is the technical capacity of the single largest gas infrastructure *(GWh/d)*. The single largest gas infrastructure is the largest gas import infrastructure covered either by *IP* or by *LNG* that directly or indirectly contributes to the supply of gas to the transmission system(s) of the calculated country. The application of the "lesser of" rule and the analysis on a 20-year time horizon may result in a different infrastructure than the one identified by Competent Authorities as part of the Risk Assessment under Regulation (EC) 994/2010.
- $\mathbf{D_{max}}$ is the total daily gas demand *(GWh/d)* of the calculated area during a day of exceptionally high gas demand, as defined by the 1-day Design Case (DC, Peak) high demand situation.

Only in case that a regional formula has been defined and agreed by the Competent Authorities of the corresponding region, the calculation shall be adjusted using the same ESW-CBA data set. The higher the indicator is, the better the resilience.

**3. Remaining Flexibility (RF)**

This indicator measures the resilience of a Zone as the additional share of demand each country is able to cover before no longer being able to fulfil its demand without creating new demand curtailment in other Zones. The value of the indicator is set as the possible increase in demand of the Zone before an infrastructure or supply limitation is reached somewhere in the European gas system.
This indicator will be calculated under 1-day Design Case and 14-day Uniform Risk situations with and without supply stress.

The Remaining Flexibility of the Zone Z is calculated as follows (steps 2 and 3 are repeated independently for each Zone):

1. Modelling of the European gas system under a given climatic case
2. Increase demand of Zone Z by 100%
3. Modelling of the European gas system in this new case

The Remaining Flexibility of the considered Zone is defined as 100% minus the percentage of disruption of the additional demand.

The higher the value, the better the resilience is. A zero value would indicate that the Zone is not able to fulfil its additional demand and a 100% value would indicate that it is possible to supply a demand multiplied by a factor two.

**4. Disrupted Demand (DD) and Disrupted Rate (DR)**

The amount of disrupted demand for a given Zone is provided:

- In energy (DD)
- As relative share /percentage (DR)

This amount is calculated in a Cooperative mode, that is, under the flow pattern maximising the spreading of the disrupted demand (in order to reduce the relative impact on each Zone). This means that, if possible, all the Zones will share the same disrupted rate.

**5. Uncooperative Supply Source Dependence (USSD)**

This indicator identifies Zones whose physical supply and demand balance depends strongly on a single supply source when each Zone tries to minimise its own dependence (the Zones closest to the considered source are likely to be the more dependent).

It is calculated for each Zone vis-à-vis each source under a whole year as the succession of an Average Summer and an Average Winter.

The Supply Source Dependence of all Zones to source S is calculated as follows (steps 1 to 4 are repeated for each source):

1. The availability of source S is set down to zero
2. The availability of the other sources is not changed
3. The cost of disruption is set flat and at the same level for each Zone
4. Modelling of the European gas system under the whole year

The Uncooperative Supply Source Dependence of the Zone Z to the source S is defined as:

$$USSD = \frac{DD^Z}{Demand^Z}$$

Where:

- $DD^Z$ is the disrupted total gas demand
- $Demand^Z$ is the total gas demand

The lower the value of USSD, the lower the dependence.

**6. Cooperative Supply Source Dependence (CSSD)**

This indicator identifies Zones where the physical supply and demand balance depends strongly on a single supply source, when all Zones together try to minimise the shared relative impact (the flow pattern resulting from modelling will spread the dependence as wide as possible in order to mitigate as far as possible the dependence of the most dependent Zones).

It is calculated for each Zone vis-à-vis each source under a whole year as the succession of an Average Summer and an Average Winter.

The Supply Source Dependence of all Zones to source S is calculated as follow (steps 1 to 4 are repeated for each source):

1. The availability of source S is set down to zero
2. The availability of the other sources is not changed
3. The cost of disruption is escalating by step of 10% of demand with the same price steps for each Zone. This ensures a cooperative behaviour.
4. Modelling of the European gas system under the whole year

The Cooperative Supply Source Dependence of the Zone Z to the source S is defined as:

$$CSSD^Z = \frac{DD^Z}{Demand^Z}$$

Where:

- $DD^Z$ is the disrupted total gas demand
- $Demand^Z$ is the total gas demand

The lower the value of CSSD, the lower the dependence.

### 7. Supply Source Price Diversification (SSPDi)

This indicator measures the ability of each Zone to take benefits from an alternative decrease of the price of each supply source (such ability does not always mean that the Zone has a physical access to the source).

For the calculation of this indicator:

- the minimum supply constraint is removed for each supply source
- the maximum supply constraint is removed for the studied supply source

It is calculated for each Zone under a whole year as the succession of an Average Summer and Average Winter.

The Supply Source Price Diversification of all Zones to source S is calculated as follows:

Step 1: The maximum supply constraint for source S is removed.

Step 2: All sources have their price curves set flat at the same price (including national production).

Step 3: The price level of source S is decreased by 20% ensuring that source S is maximised.

Step 4: The marginal price curves are computed for each Zone (see description below).

Step 5: The price level of source S is further decreased by 10% (from 80% to 72%).

Step 6: The marginal price curves are computed again for each Zone (see description below).

Marginal price curve

For a given Zone, the marginal price curve mentioned in step 4 and step 6 is a set of marginal prices ($\boldsymbol{MP_k}$) that are determined for successive simulations with different percentage of demands.
The process for the $k^{th}$ simulation is the following:

- Consider the original demand for the given scenario
- For each Zone, take $\boldsymbol{x_k}$ % of the demand, where the $\boldsymbol{x_k}$ values are ranging from 0.1% to 99.9%.
- Reduce the lower constraints (minimum supply constraints) to $\boldsymbol{x_k}$ **%** of their original values.
- Run a simulation, and for each Zone retrieve the resulting marginal price $\boldsymbol{MP_k}$ .

SSPDi formula

For each demand range [k,k+1], an average drop of marginal price is computed (except for the two extreme ranges, the first and last 0.1%, where only one marginal price is used):

- $\text{MP change}_{[k,k+1]} = \frac{1}{2} * [\text{Abs}\left(\frac{\text{MP}_{k+1\ \text{Step6}}}{\text{MP}_{k+1\ \text{Step4}}} - 1\right) + \text{Abs}\left(\frac{\text{MP}_{k\ \text{Step6}}}{\text{MP}_{k\ \text{Step4}}} - 1\right)]$

- $Demand\ range\ percentage_{\ [k,k+1]} = x_{\ k+1} - x_{\ k}$

$$\boldsymbol{SSPDi = \frac{1}{10\%} * \sum_{k} \left(MP\ change_{\ [k,k+1]}\right) * \left(Demand\ range\ percentage_{\ [k,k+1]}\right)}$$

The bigger the SSPDi, the better the access from a price perspective.

Finally the diversification of a Zone is characterised by both:

- the number of sources for which the SSPDi is high
- the magnitude of a given SSPDi.

**8. Supply Source Price Dependence (SSPDe)**

This indicator measures the price exposure of each Zone to the alternative increase of the price of each supply source.

The process is exactly the same as for the SSPDi. The only difference is that, instead of decreasing the flat price by 20% and 10% in step 3 and 5, it is rather increased by 20% and 10%.

The bigger the SSPDe, the higher the exposure from a price perspective.

Finally the dependence of a Zone is characterised by both:

- the number of sources for which the SSPDe is high for the considered Zone
- the magnitude of a given SSPDe.

**9. Marginal Price**

For each climatic case, the marginal price of gas supply of a Zone is a direct output of the optimisation.

It is calculated for each Zone under a whole year as the succession of an Average Summer and an Average Winter, resulting potentially in two different marginal prices (one for summer and one for winter).

The lower the difference between the marginal prices of two Zones, the better the Price Convergence.

## 10. Import Price Spread Configuration

Objective

The import price spread configuration investigates the impact of different supply prices for different routes of the same supply. It intends to model projects' impact on monopolistic behaviour and value the associated benefits of increased competition.

Price Spreads input

Based on transparent information, different import price spreads are set per route, at the border of EU. These spreads are measured against a reference Zone, for which the import spread has been set at 0. For the TYNDP 2017, the reference Zone is GASPOOL (noted hereafter DEg).

Initial situation

The configuration starts from an initial situation, where these price spreads inputs are used. The modelling of the initial situation will provide the "initial import flows".

Following years

After the initial year, the situation will evolve depending on demand and infrastructure.
Assumptions retained to model the behaviour of the initially monopolistic supplier:

- The supplier will maintain its import route pricing policy, although losing volumes, up to the point of losing **20%** of the volume delivered to the import point (the "initial import flows").
- Beyond this point, the supplier will align its price to the competing source.
- The supplier adopts a **volume priority strategy.**

In order to avoid impossible constraints, an exception is made for countries where the demand is decreasing below the 80% threshold along the years. For the TYNDP 2017, this threshold is changed to 80% of their lowest import demand, that is, demand minus national production (instead of 80% of the initial import flows). The lower boundary on the threshold is set to 10% of the lowest demand along the years and scenarios.

Price curves

For the TYNDP 2017, a balanced approach has been used where all supply curves (upstream of the import route) are at the same level.