ENTSOG Cost-Benefit Analysis Methodology

Project Specific CBA Methodology

Executive Summary

This document describes the Project Specific Cost Benefits Analysis (PS-CBA) methodology developed by ENTSOG to meet Regulation (EC) 347/2013 (the Regulation) requirements. The PS-CBA provides a practical "step by step" approach, for the Project Promoters to reflect the contribution of their projects in meeting the criteria requested by the Regulation.

The PS-CBA consists in:

> a financial analysis describing the financial aspects of the project
> an economic analysis describing the socio-economic benefits of the project.

Such benefits reflect the project contribution to competition, market integration, security of supply and sustainability. They are captured through an incremental approach (differential assessment with and without the project).
Those benefits are reflected in a "combined approach" consisting in:

1) The Quantitative Analysis
2) The Monetary Analysis
3) The Qualitative Analysis

These analyses enable the consideration of the widest-range of possible benefits a certain project can generate, and especially their cross-border dimension as a prerequisite for the Project of Common Interest label.
The methodology for the economic analysis is presented in a dual approach:

> The Economic analysis based on network and market modelling
> The Economic analysis based on algorithms as an interim solution until the full development of the modelling tool.

The Methodology describes how to ensure a robust and consistent analysis of all projects. This is achieved through: a common input dataset, reference sources, common indicators, common time horizon, the discount rates to be applied and the way the sensitivity analysis is carried out.

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1. Field of Application

The present methodology has been designed in order to enable Project Promoters (Promoters) to meet the requirements of the Regulation when they have to carry out a PS-CBA. It will enable the Promoters to measure the degree of fulfilment of the general- and specific criteria as defined in the Regulation. This methodology ensures that the below type of infrastructures are treated on a level playing-field:

> transmission pipelines for the transport of natural gas and bio gas that form part of a network which mainly contains high-pressure pipelines, excluding high-pressure pipelines used for upstream or local distribution of natural gas;
> underground storage facilities connected to the above-mentioned high-pressure gas pipelines;
> reception, storage and regasification or decompression facilities for liquefied natural gas (LNG) or compressed natural gas (CNG);
> any equipment or installation essential for the system to operate safely, securely and efficiently or to enable bi- directional capacity, including compressor stations;

1.1. Instances of application

According to the Regulation the PS-CBA shall only be carried out when a project has reached sufficient maturity. Such analysis should enable a relevant reflection of its expected costs and benefits through the PS-CBA.

A Project Promoter shall carry out the PS-CBA in the following instances[1]:

> When submitting the application for selection as a PCI to the Regional Groups, having established the project is mature enough (see 2.2 for pre-conditions) even if the project was already labelled as PCI in the previous selection round
> When submitting the investment request including the cross-border cost allocation request (for non-commercially viable projects)
> When requesting financial assistance for works (for non-commercially viable projects)
> When applying for financial instruments under Connecting Europe Facilities (CEF) (for commercially viable projects)

1.1.1. General Criteria

The general criteria mean that the project shall comply with all the 3 following stipulations of the Regulation:

> the project is necessary for at least one of the energy infrastructure priority corridors and areas;
> the potential overall benefits of the project, assessed according to the respective specific criteria in paragraph 2.1.2, outweigh its costs, including in the longer term; and
> the project meets any of the following criteria:
  - involves at least two Member States by directly crossing the border of two or more

[1] *This is also valid for mature projects selected in the previous round.*

Member States;

- is located on the territory of one Member State and has a significant cross-border impact as set out in Annex IV.1 of the Regulation[2];
- crosses the border of at least one Member State and a European Economic Area country.

1.1.2. Specific Criteria

The Project shall significantly contribute to at least one of the Specific Criteria set by Regulation. These criteria are:

- market integration, inter alia through lifting the isolation of at least one Member State and reducing energy infrastructure bottlenecks; interoperability and system flexibility;
- security of supply, inter alia through appropriate connections and diversification of supply sources, supplying counterparts and routes;
- competition, inter alia through diversification of supply sources, supplying counterparts and routes;
- sustainability, inter alia through reducing emissions, supporting intermittent renewable generation and enhancing deployment of renewable gas;

1.2. Precondition to carry out a PS-CBA

Only the promoters who are capable of providing a value for each project specific data (as defined in the Input Data chapter) shall apply this methodology.

2. Description of the Project

2.1. Identification of the Project and its objectives

For all types of infrastructure, the Promoters shall identify their projects based on the following data:

- Their technical scale and dimension by describing the engineering features of the infrastructures[3]:

Project Types[4]	Data Description
Transmission Projects	Name of the pipeline section

[2] (c) for gas transmission, the project concerns investment in reverse flow capacities or changes the capability to transmit gas across the borders of the Member States concerned by at least 10 % compared to the situation prior to the commissioning of the project;
(d) for gas storage or liquefied/compressed natural gas, the project aims at supplying directly or indirectly at least two Member States or at fulfilling the infrastructure standard (N-1 rule) at regional level in accordance with Article 6(3) of Regulation (EU) No 994/2010 of the European Parliament and of the Council

[3] Please note that Nm^3 refers to m^3 at 0°C and 1.01325 bar (as defined in the EASEEgas CBP 2003-001/01)

[4] As defined under Annex II/2

	Type of pipeline project (Interconnector[5]/Internal Project)
	Length of the pipeline in km
	Diameter (in mm)
	Compressor Power (in MW)
	Interconnected balancing zone and TSOs by the project
	Capacity created by the project per interconnection point and direction
LNG and CNG Terminal	Name of the terminal
	Send out capacity (GWh/d)
	Maximum Size of the ship (m^3 of LNG or CNG)
	Storage capacity (m^3 LNG or CNG)
	Interconnected balancing zone and TSOs by the project
UGS	Name of facility
	Type of storage
	Withdrawal Capacity (GWh/d)
	Injection Capacity (GWh/d)
	Working Volume (GWh)
	Interconnected balancing zone and TSOs by the project

- Provide rational and background of the projects
- Define the objective of the projects, indicating which criteria they comply with, as described in Art.4 of the Regulation.

2.2. Preliminary Identification of the Area of Analysis

The Area of Analysis is an important element of the PS-CBA, on which the cross border effects of the projects shall be assessed, in line with the Regulation.
The Project Promoters should identify the Area of Analysis being as follows:

- Member States and third countries on whose territory the projects shall be built,
- All directly neighbouring member States if directly connected by gas infrastructure
- All other Member states significantly impacted by the Project[6]

3. Input Data

[5] *Bi-directional and mono-directional IPs*
[6] *This will be an output of the Quantitative Analysis*

The quantification and monetization of infrastructure project benefits through the PS-CBA require several input data. The transparency and consistency of such analysis are ensured through the use of a common set of data for all projects. The actual values of the data to be used in this methodology are defined within the ESW-CBA[7].

Considering the uncertainty about many of the input data, a chapter is dedicated to the sensitivity-analysis that the Project Promoters shall carry out in order to illustrate the robustness of the PS-CBA results.

In order to ensure consistency between all PS-CBAs, promoters shall use the data as provided in the ESW-CBA. The sensitivity analysis part of this methodology will support the promoters in the Qualitative Analysis if they want to comment on the effect of their own data assumptions on the PS-CBA results.

3.1. Time Horizon

In order to ensure a consistent basis for project comparison, the Economic Analysis has to be performed on the same number of years of operation. Such common range is defined at 20 years in order to cover a significant part of the long lifetime of gas infrastructures and to meet Regulation requirements on input data[8] and time horizon of the analysis[9].

Considering *n* as the year of analysis and *c* the year of commissioning (the first full year of operation), each project shall apply the PS-CBA on the *n* to *c*+20 time horizon (same number of years of operation).

For each year beyond n+20 and up to *c*+20, the Economic Benefits and Costs used when calculating the Economic Performance Indicators, are considered equal to their average value between the years *n+16* to *n+20* (5 years).

3.2. Input data from Energy System-Wide Analysis

Consistency within the methodology is also ensured by applying the same input data within the PS-CBA of each project. All these input data will be gathered within a specific annex of

7 The numerical value will be part of the Methodology, published by ENTSOG as defined under Art.11/5 of the Regulation.

8 "The methodology shall be based on a common input data set representing the Union's electricity and gas systems in the years n+5, n+10, n+15, and n+20, where n is the year in which the analysis is performed." (Annex V/1)

9 The cost-benefit analysis shall be based on a harmonised evaluation of costs and benefits for the different categories of projects analysed and cover at least the period of time referred to in point (1)" (see above footnote).

the ESW-CBA, to ensure that each Project Promoter utilizes the same figures of the common input dataset.

Input data for the PS-CBA		
Data Item	**Comment / Sources**	**Level of definition**
Existing infrastructure capacity		
Entry capacity	ENTSOG, GSE, GLE database as main sources	per IP and interconnected Zone
Exit capacity		
UGS injection and withdraw capacity		
UGS working gas volume		
LNG sendout capacity		
LNG tank volume		
Identification of the project		
Pipeline	Project Promoters	
IP Name and connected Zones		
Entry capacity		per IP and interconnected Zone
Exit capacity		
UGS		
Injection and withdraw capacity		per IP and interconnected Zone
Working Gas Volume		
LNG		
Send-out capacity		per IP and interconnected Zone
LNG tank volume		
Year of Commissioning		
PCI Status	As resulting from latest selection round	
Demand per situation		per Balancing Zone
High Daily Demand 1-day Design Case	TSOs best estimate	
High Daily Demand 14-day Uniform Risk		
Winter Average Day		
Summer Average Day		
Supply Data		per Balancing Zone
National Production	Deliverability per demand situation	per Balancing Zone
Import sources (Russia, Norway, Algeria, Lybia, LNG, Azeri…)		per source and/or import route
Prices	Well recognized references need to be identified and consensus built around them (e.g. WEO from IEA)	
Natural Gas		per source and/or import route
Coal		per fuel
Lignite		
Oil		
CO_2		for Europe
Physical Constants	Well recognized references need to be identified and consensus built around them (e.g. UN-IPCC)	
• Gross Calorific value of fuels		per Fuel
Natural Gas		
Coking Coal		
Lignite		
Residual Fuel Oil		
• Specific CO_2 emission of fuels/net energy released		
Natural Gas		
Coking Coal		
Lignite		
Residual Fuel Oil		
• Gross/Net Thermal efficiency of power plants		per Balancing Zone
Natural Gas		
Coal		
Lignite		
Fuel Oil		
Electricity Mix of Countries	Coordination with other references such like ENTSOE	per Balancing Zone
Installed Capacity		
Assumed utilization scenarios (for nuclear and renewables)		
Macroeconimic Data		
Currency exchange Rates		
Cost of Disruption per unit of energy		per Balancing Zone
Social discount rate		single figure for Europe
Flow patterns of modelled cases within the ESW-CBA	Table within the ESW-CBA	Modelling
Indicators of the Quantitative Analysis from the ESW-CBA	To be used for the incremental approach in the PS-CBA	per Balancing Zone
Costs from the Monetary Analysis of the ESW-CBA	Data to be used only in modelling solution of PS-CBA	per Balancing Zone
CO2 emission	To be used for the calculation of the saved cost in the PS-CBA	
Power generation		
Gas supply		
Disruption		

For the actual application of the data items please refer to the methodology chapters of this document.

3.3. Additional project specific data

The below table identifies the additional project data that Promoters shall use in addition to those already part of the ESW-CBA.

Project Specific Input data provided by Project Promoters		
Data Item	**Comment**	**Field of Application**
CAPEX	Along time horizon	**Monetary Analysis**
OPEX	Along time horizon	**Monetary Analysis**
Residual Value		**Monetary Analysis**
Financial Discount Rate		**Financial Analysis**

3.3.1. Updating data

Project data may vary between two instances of application of the PS-CBA. In such case the Project Promoters may update part of their project data according to the below table:

	Updatable data items				
Data update after providing data to ESW-CBA to ...	CAPEX	OPEX	Residual Value	Capacity data of the project	Date of Commissioning
Carry out PCI application CBA	YES	YES	YES	NO	NO
Carry out PS-CBA for a CBCA application	YES	YES	YES	YES	YES
Carry out PS-CBA for Financial Assistance	YES	YES	YES	YES	YES

3.3.2. Residual Value of the asset corresponding to the project

Considering that by the end of the time horizon of the analysis, the asset still has potential to deliver further benefits; the Project Promoter shall calculate the residual value as the discounted remaining non -depreciated value of the asset by the end year of the time horizon of the analysis. This discount will occur at the level of the calculation of the economic indicators.

$$\mathbf{Rv} = (\mathbf{A_v} - \mathbf{D})$$

where:

Rv is the Residual value

$\mathbf{A_v}$ is the Initial value of the asset

D is depreciation of the asset during the time horizon of the analysis

The residual value of the asset shall be included in the Financial- and the Economic Analysis for the end year of the time horizon of the analysis as an inflow as following:

- When including the Residual value in the Financial Analysis, the Financial Discount Rate shall be applied.
- When including the Residual Value for the Economic Analysis, the Social Discount Rate

shall be applied.

- The depreciation of the asset during the time horizon of the analysis shall be based on the respective national regulatory framework.

3.4. Prices to be used

When carrying out PS-CBA, Project Promoters shall use constant prices where monetary input data are concerned. The input data shall be used according to input data as reflected in the ESW-CBA, which is to reflect constant prices for the year when the ESW-CBA is published.
Given the use of constant prices, the Project Promoters shall apply real financial discount rate when carrying out a Financial Analysis. The Social Discount Rate defined below is also to be understood as a real value.

3.5. Discount Rates

There are two types of discount rates to be used when applying the methodology:

- Financial Discount Rate - FDR
- Social Discount Rate – SDR

The FDR shall be used when applying a Financial Analysis. The ratio of the financial analysis is a project specific figure, as it reflects the financial environment of the project and the cost of capital. It shall be used when applying discounting within the financial analysis to calculate the Financial Net Present Value of the project for the investor. The FDR shall be applied clean of inflation (real).

The SDR shall be used when applying the Economic Analysis of the CBA methodology for discounting, when generating Economic Net Present Value. For all the projects, one single discount rate shall be used, as the aim of the analysis is not to compare the socio-economic background of the countries, but to analyse and where necessary compare the Projects of Common Interest candidates. It is also advisable to use a single discount rate from an applicability point of view, as the projects do have cross-border impact in countries/regions with heterogeneous social-economical features. Apart from that, the Regional Groups are very heterogeneous themselves, meaning that the use of a country-specific SDR would undermine the basic principle of comparability of projects.
Considering the reduced influence of a uniform SDR and the range of 3.5 and 5.5 per cent as set by the DG Regio[10], and despite the fact that defining a rate is beyond ENTSOG's remit, it is proposed[11] to use a **4.5** per cent rate in order to ensure direct applicability of the methodology. ENTSOG of course welcomes any suggestion in the above matter through Agency, Member States' and Commission opinion on the CBA methodology.

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[10] Guide to Cost Benefit Analysis of Investment Projects – July 2008 – EC, DG Regional Policy

[11] "… The methodology shall give guidance on discount rates to be used for the calculations." (Annex V.5 of Regulation)

4. Financial Analysis

The Financial Analysis shall at least include the following indicators (deriving from the Guide) in addition to potential Promoter-specific approach.

4.1. Financial Performance Indicators

Project Promoters shall calculate the below indicators on the time horizon as explained in the present methodology, using their own financial discount rate, in order to provide a view on the profitability and financial sustainability of their projects:

> **Financial Net Present Value (FNPV)**

The Financial Net Present Value (FNPV) is defined as the sum that results when the expected, discounted investment and operating costs of the project are deducted from the discounted values of the expected revenues (e.g. capacity booking).

The Net Present Value of a project is defined as:

$$FNPV = \sum_{t=0}^{n} a_t S_t = \frac{S_0}{(1+i)^0} + \frac{S_1}{(1+i)^1} + \cdots + \frac{S_n}{(1+i)^n}$$

where

S_t is the balance of cash flow at time t;

i is the discount factor;

a_t is the coefficient for discounting a value at time t.

$$a_t = \frac{1}{(1+i)^t}$$

If FNPV>0 the project generates a net benefit and is desirable in financial terms.

> **Financial Internal Rate of Return (FIRR)**

The Financial Internal Rate of Return (FIRR) is defined as the discount rate that produces a 0 FNPV. The calculation of the FIRR for projects, measures the capacity of the net revenues to remunerate the investment costs. A project is considered financially desirable if the FIRR exceeds the Financial Discount Rate (to be applied on the financial cash flow). The FIRR is an indicator favouring projects generating early revenues.

> **The financial Benefit/Cost ratio (FB/C)**

Cost/benefit ratio is the ration between the discounted revenues and discounted costs. If FB/C exceeds 1, the project is efficient considering that the revenues outweigh costs on the time horizon.

4.2. Identification of the Potential financial gap

To reflect the financial gap, the Promoter should follow the recommendations of the Connecting Europe Facility (CEF) in close relation with Art.14/2/c and Art. 13./2 of the Regulation.

5. Economic Analysis

The Project Specific Cost-Benefit Analysis methodology has been designed to enable Project Promoters to measure in a transparent way the contribution of their project to the criteria set by the Regulation.

To achieve this, the Economic Analysis has been designed in a way to capture the widest-range of possible benefits a certain project can generate, and especially their cross-border dimension as a prerequisite for Projects of Common Interest.

This is achieved, through the use of the so-called *Combined Approach*, which consists of the following parts:

- The Quantitative Analysis
- The Monetary Analysis
- The Qualitative Analysis

The methodology for the economic analysis is presented below in:

- **The Economic Analysis based on modelling solutions**, which is the dynamic, targeted approach based on a network and market modelling tool.
- **The Economic Analysis based on algorithm**, which is an approach to be utilized until the applicability of the modelling approach is fully ensured.

The Economic analysis based on algorithm will be used as an interim approach and is aiming to support the Project Promoters to carry out the PS-CBA until the modelling approach is implemented.

The two Economic Analysis approaches only differ in the definition of input for the monetary analysis:

- In case of the Economic Analysis based on modelling solutions, the main input for saved costs (e.g. the flow patterns, the distribution of flows between impacted countries or the value of some benefits) result from network and market modelling.
- In case of the Economic Analysis based on algorithms, the significantly impacted countries and the distribution of flows, as input for the monetary analysis, are based on the application of an algorithm, applied on capacity-based indicators.

The below figure summarizes the common and different points between the approaches, highlighting that the structure and the logic are the same, but the application of certain steps are different.

CBA input data/sections	Applicability	
	CBA based on modelling approach	CBA based on algorithm
Time horizon	x	x
Input data from ESW	x	x
Updating data	x	x
Project specific data	x	x
Capex	x	x
Opex	x	x
Commissioning date	x	x
Residual value	x	x
Flow pattern allocation	Modelling	Based on algorithm, as an output of the quantitative analysis
Monetization	Input data from modelling	Input data from the quantitative analysis
Sensitivity analysis		
Capex	x	x
Opex	x	x
Commissioning date	Modelling	Based on excel application
Demand	Modelling	Based on excel application
High Infrastructure sensitivity	Modelling	Based on excel calculation

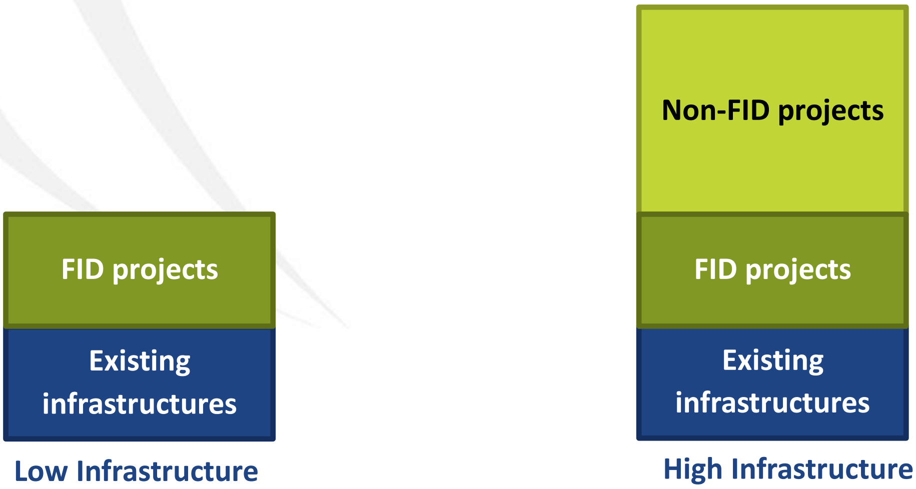
5.1. The infrastructure scenarios as a basis for the incremental approach

The marginal impact of a project is highly dependent on the level of infrastructure development it is compared against.

For that purpose, the incremental approach shall be carried out measuring project benefits under each of the two below scenarios for which assessment results are provided in the ESW-CBA:

> A low level of development of infrastructures (Low Interaction)

> A high level of development of infrastructures (High Interaction)



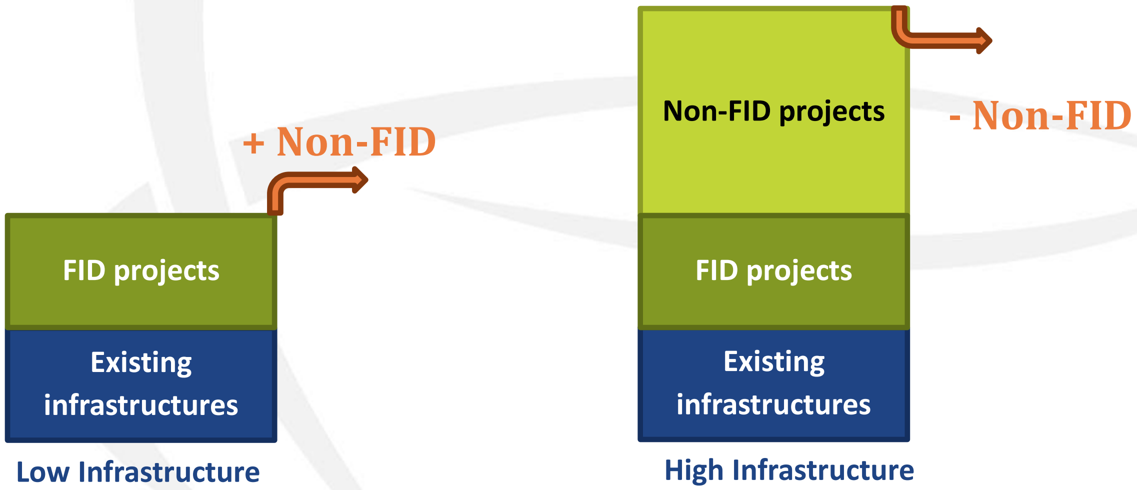
This means that for each of the infrastructure scenarios there will be two sets of analysis performed; one with the project data included in the scenario (**Including Project Data [IPD]**) and one with the project data excluded from the scenario (**Excluding Project Data [EPD]**).

The following table summarizes the number of cases to consider:

	Scenario	Project Data
LI-IPD	Low Infrastructure (LI)	Including Project Data (IPD)
LI-EPD	Low Infrastructure (LI)	Excluding Project Data (EPD)
HI-IPD	High Infrastructure (HI)	Including Project Data (IPD)
HI-EPD	High Infrastructure (HI)	Excluding Project Data (EPD)

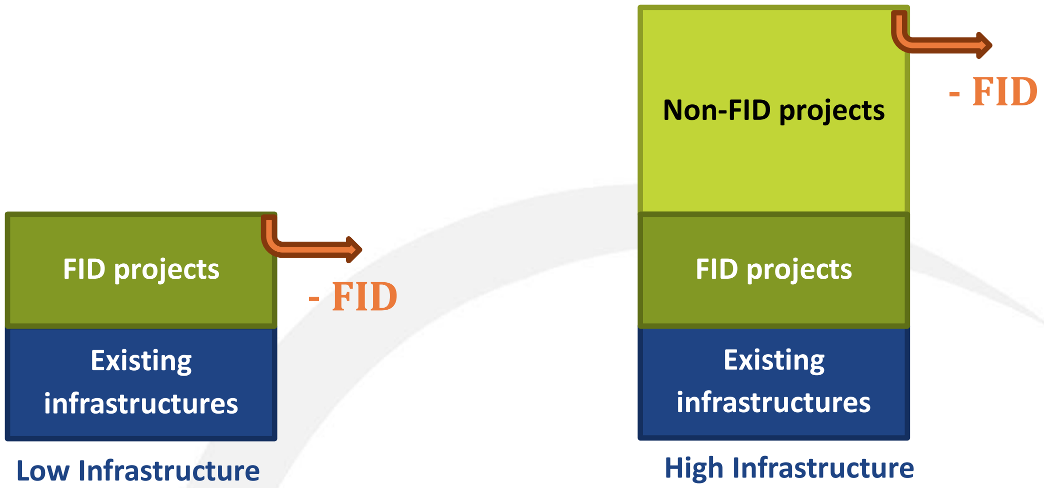
Given the structure of the combination of clusters, the incremental approach is to be applied differently depending on the Final Investment Decision (FID) status of the Project.

In case the project is ***Non-FID;*** the project data will not be included in the Low Infrastructure (LI) scenario but will be included in the High Infrastructure (HI) one. The analysis should therefore be carried out as follows:



Case	Data for Non-FID projects
LI-IPD	Project Data must be **added** to the cluster data *(with project)*
LI-EPD	No data to be added
HI-IPD	No data to be subtracted
HI-EPD	Project Data must be **subtracted from** the cluster data *(w/o project)*

In case the project is ***FID;*** then the project data will be included in the Low Infrastructure (LI) scenario and will also be included in the High Infrastructure (HI) one. The analysis should therefore be carried out as follows:



Case	Data for FID projects
LI-IPD	No data to be added
LI-EPD	Project Data must be **subtracted from** the cluster data *(with project)*
HI-IPD	No data to be subtracted
HI-EPD	Project Data must be **subtracted from** the cluster data *(w/o project)*

When applying the Economic Analysis using modelling, the full analysis (including the sensitivity-analysis) shall be carried out for both Infrastructure Scenarios.
When applying the Economic Analysis based on the algorithm, the full analysis (including the sensitivity-analysis) shall be carried out under the Low Infrastructure Scenario. The Economic Analysis shall be then applied under the High Infrastructure Scenario for which the execution of the sensitivity analysis is not compulsory.

5.2. The Economic Analysis using modelling solutions

This chapter describes the targeted approach based on network and market modelling tool to be elaborated by the deadline set by Art.11. 4 of the Regulation. Until the applicability of the targeted approach is fully ensured, this document describes the interim Economic Analysis to be used, under the chapter Economic Analysis based on Algorithm. The structures of both methodologies are similar; the first one better captures the network dimension of the European gas system.

As part of the requirement set by the Regulation (Art.11 para 1), ENTSOG has delivered within the ESW-CBA the basic description of its network- and market modelling methodology.

The role of modelling within the PS-CBA is to measure the impact of the Project commissioning on the flow patterns through the incremental approach. The calculation of indicators and monetary values based on the flow patterns with and without the project enables the identification of the project impact. The effect of the Project is then described both in terms of magnitude and significantly impacted countries.

5.2.1. List of cases to be modelled

In order to produce a comprehensive assessment of project benefits, the cases to be modelled have to cover a wide range of demand and supply situations. These cases are modelled as part of the ESW-CBA for the Low and High Infrastructure scenarios to serve as a basis to the incremental approach to be applied by the Project Promoter within the PS-CBA.

The following table defines the cases to be modelled as part of the PS-CBA using the incremental approach. Depending on the FID status of the Project, modelling results are to be found in the ESW-CBA or will require additional modelling (Refer to The Infrastructure Scenarios as a basis for the incremental approach chapter of the present methodology).

Demand situation	Supply mix	Supply stress
Average Summer day	Reference	No
		Disruption d1, d2…
	LNG price > Pipe gas price	No
	Pipe gas price > LNG price	No
	Targeted maximization of each source	No
	Full minimization of each source	No
Average Winter day	Reference	No
		Disruption d1, d2…
	LNG price > Pipe gas price	No
	Pipe gas price > LNG price	No
	Targeted maximization of each source	No
	Full minimization of each source	No
14-day Uniform Risk in March	Reference	No
		Disruption d1, d2…
	LNG price > Pipe gas price	No
	Pipe gas price > LNG price	No
1-day Design Case	Reference	No
		Disruption d1, d2…
	LNG price > Pipe gas price	No
	Pipe gas price > LNG price	No

Definitions of supply features (volumes, prices and stress) as well as targeted maximization and full minimization are provided within the ESW-CBA.

5.2.2. Quantitative Analysis – Indicators

This part of the combined approach consists in the calculation of numerical indicators capturing the impact of the projects through the incremental approach.
All indicators are calculated for:

- each Zone (country for the N-1 indicator)
- each year of the time horizon
- each Infrastructure Scenario
- *with*- and *without* the project for the LI and HI infrastructure scenario (depending on their FID status, part of the results are already provided by the ESW-CBA)
- from the commissioning until *n+20* (for remaining years of the time horizon of the analysis not covered by input data, refer to the Time Horizon chapter of the present methodology).

The difference between the two values (with and without the project) shall also be reported in the PS-CBA output table of indicators.
The process between November 2013 and the publication in Summer 2014 will provide the opportunity to fine-tune the formula of these indicators based on formal opinion process and feedback from stakeholders.

5.2.2.1. Capacity Based Indicators

The below indicators use only capacity and demand figures and therefore do not require the definition of flow patterns through modelling.

- **Bi-directional project indicator**

The indicator shall be calculated both at Interconnection Point (IP) and cross-zone levels (where applicable) for projects creating or enhancing bi-directional capacities. As the formula of the indicator already reflects the project increment, it does not need separate calculation *with* and *without* the project.

$$\boldsymbol{Min\left(1;\frac{Added\ Capacity\ at\ IP\ to\ other\ direction}{Existing\ Pipeline\ capacity\ in\ prevailing\ direction}\right)}$$

Where:
Added Capacity at IP to other direction (GWh/day)**:** firm technical capacity of the investment against the prevailing flow direction
Existing Pipeline capacity in prevailing direction (GWh/day)**:** already existing capacity in the prevailing direction.

In case of a new bi-directional IP, the numerator shall be the smaller added capacity. In case the investment changes the prevailing flow, the new prevailing flow shall be the denominator.

$$\boldsymbol{Min}\left(\mathbf{1};\frac{\boldsymbol{Added\ Capacity\ at\ Cross{-}Zone\ level}}{\boldsymbol{Sum\ of\ Existing\ Pipeline\ capacities\ in\ prevailing\ direction\ of\ the\ Cross{-}Zone\ level}}\right)$$

Where:

Added Capacity at cross-zone level to other direction (GWh/day)**:** firm technical capacity of the investment against the prevailing flow direction

Sum of Existing Pipeline capacities in prevailing direction at Cross-Zone level (GWh/day)**:** already existing capacity in the prevailing direction.

In case of a new bi-directional Cross-zone capacity, the numerator shall be the smaller added capacity. In case the investment changes the prevailing flow, the new prevailing flow shall be the denominator.

The maximum value of the Indicator is one; in case the project is a Reverse Flow, it will score above zero.

> **Import Route Diversification index**

This indicator captures the diversification of physical paths that gas can flow through, to reach a zone.

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

Where the below shares are calculated in comparison with the total entry firm technical capacity into the zone from each adjacent EU zone, import source and LNG terminal:

IP_k $Xborder_l$: the share of the firm technical capacity of the interconnection point IP_k belonging to the cross border with the zone l

IP_i from $source_j$: the share of the firm technical capacity of the import point IP_i coming from the non-EU source *j*

LNG $terminal_m$: the share of the firm technical send-out capacity of the LNG terminal m

For Interconnection Points between European Zones, capacity is first aggregated at zone level as those physical points are likely to largely depend on common infrastructure. Import points for non-EU gas and LNG terminals are considered as completely independent infrastructures

The lower the value, the better the diversification is.

> **N-1 Infrastructure Standard Indicator on regional level**[12]

The value of the indicator will be provided within the ESW-CBA for each country, in case it has been calculated by the Competent Authority of Member States. Where not provided by the Competent Authority the indicator shall be calculated by the Project Promoter on the significantly impacted countries (as defined within the *Quantitative Analysis*).

When calculating the indicator, Project Promoters shall utilize the input data as provided within the ESW-CBA and shall select the single largest infrastructure along the time horizon according to their knowledge until guidance is provided by Competent Authority. This selection shall be justified.

According Regulation (EC) 994/2010, the formula is:

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

where

The optimal value of such an indicator should be N-1 ≥ 100%

IP: technical capacity of entry points (GWh/d), other than production, storage and LNG facilities covered by NP_m, UGS_m and LNG_m, means the sum of technical capacity of all border entry points capable of supplying gas to the calculated region, taking into account the contractual restrictions of the border entry points to the calculated region.

Contractual restrictions are included in the border entry points that connect third countries with the calculated region. The border entry points take into consideration only the entry points from the adjacent region.

NP: maximal technical production capability (in mcm/d) means the sum of the maximal technical daily production capability of all gas production facilities which can be delivered to the entry points in the calculated area; taking into account their respective physical characteristics (e.g. lower production capability of gas production facilities during high demand period).

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

I_m means the technical capacity of the single largest gas infrastructure (GWh/d) of common interest. The single largest gas infrastructure of common interest to a region is the largest gas infrastructure in the calculated region that directly or indirectly contributes to the supply of gas to the Member States of that region and shall be defined in the joint Preventive

[12] This indicator is not applicable to the algorithm based on static indicators

Action Plan, according to Regulation 994/2010 concerning the measures to safeguard security of supply.

***D*$_{max}$** means the total daily gas demand (GWh/d) of the calculated area during a day of exceptionally high gas demand occurring with a statistical probability of once in 20 years.

> **Seasonal capacity balance indicators**

These indicators capture the potential capacity balance *surplus* or *need* lack of gas under different climatic situations. This balance results from both the technical ability to export gas (see the first part of the formula) and the availability of gas above the national demand (see the second part of the formula). A value greater than 0, indicates a potential gas capacity surplus, resulting in possible volume surplus to be allocated across borders[13]. The Project Promoters shall utilize the algorithm described under *Quantification of the cross-border impact* chapter in order to identify the significantly impacted countries. The resulting flow patterns (one per seasonal situation) shall then be used in the Monetization part of the Economic Analysis.

- Summer Average Capacity Balance

$$SACB = \frac{\boldsymbol{Min(EX\ \ ;\ NP\ \ + \frac{N-1}{N} * IMP\ \ + LNG\ \ - INJ - Dsa\,)}}{\mathbf{Dsa}}$$

- Winter average Capacity balance

$$WACB = \frac{\boldsymbol{Min(EX\ \ ;\ NP\ \ + \frac{N-1}{N} * IMP\ \ + LNG\ \ + \mathbf{WITH} - \mathbf{Dwa})}}{\mathbf{Dwa}}$$

- Design (case) Capacity Balance

$$DCB = \frac{\boldsymbol{Min(EX\ \ ;\ NP\ \ + \frac{N-1}{N} * IMP\ \ + LNG\ \ + WITH_{max} - Dh)}}{\boldsymbol{Dh}}$$

Where:

EX: Exit capacity after application of the lesser rule[14] (to other EU and third countries) (GWh/day)

NP : Daily national production deliverability (GWh/day)

N: Number of entry IPs

IMP : Daily capacity of entry IP (from other EU and third countries) (GWh/day)

LNG : Daily send-out of LNG Terminal (GWh/day)

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[13] *Assuming a load factor of 100%*

[14] *On the two sides of the border concerned*

INJ: min(Injection capacity ;Working Gas Volume /183) (GWh/day)
WITH: The minimum between the daily Withdrawal capacity and daily average Working Gas Volume (GWh/day)
$\mathbf{WITH_{max}}$: Withdrawal capacity (GWh/day)
Dh: High daily demand under Design Case (GWh/day)
Dsa: average summer demand (GWh/day)
Dwa: average winter demand (GWh/day)

5.2.2.2. Modelled Indicators

The calculation of the dynamic indicators is based on flows resulting from modelling. Therefore these indicators consider supply data, both in terms of availability and source.

> **Remaining Flexibility at Zone level**

Indicator is used to assess the impact of the project on infrastructure resilience, which looks at the ability of the infrastructure to transport large quantities of gas under high daily conditions (supply stress). This indicator will be calculated under 1-day Design Case and 14-day Uniform Risk situations according the below formula:

$$RF = 1 - \frac{\sum Entering\ Flow}{\sum Entry\ Firm\ Technical\ Capacity}$$

Where **Entering flow** and **Entry Capacity** (GWh/day) cover interconnection with other zones, direct import from non-EU sources, national production, withdrawal and LNG terminal send-out.
The indicator at zone level considers both the gas staying in the zone to face demand and the gas exiting to adjacent systems
The higher the value, the better the resilience is (in TYNDP, differences above 20% are disregarded).

> **Supply Source Dependence assessment (SSDEP)**

Supply Source Dependence assessment aims at the identification of Zones whose balance depends strongly on a single supply source. This indicator is calculated at zone level minimizing each import source one-by-one. This indicator will be calculated under Average Winter and Summer days according the below formula:

$$SSDEP = \frac{Flow\ from\ minimized\ supply\ source}{\sum Entering\ Flow}$$

Where
The lower the value of SSDEP is, the lower the dependence (in TYNDP, dependence below 20% are disregarded).

> Supply Source Diversification assessment (SSDIV)

The assessment of the Supply Source Diversification at Zone level aims at determining the ability of each Zone to access alternatively each supply source. This indicator is calculated at zone level, maximizing the share of each import source one-by-one. This indicator will be calculated under Average Winter and Summer days according the below formula:

$$SSDIV = \sum_{i}^{maximized\ source} if(x_i > 5\%; 1)$$

Where

x_i is the share of the source *i* when maximized, in the total flow entering the zone.

As an example if country C may have alternative access to four different sources, with each one covering at least 5% of C's need, then the indicator will score 4.

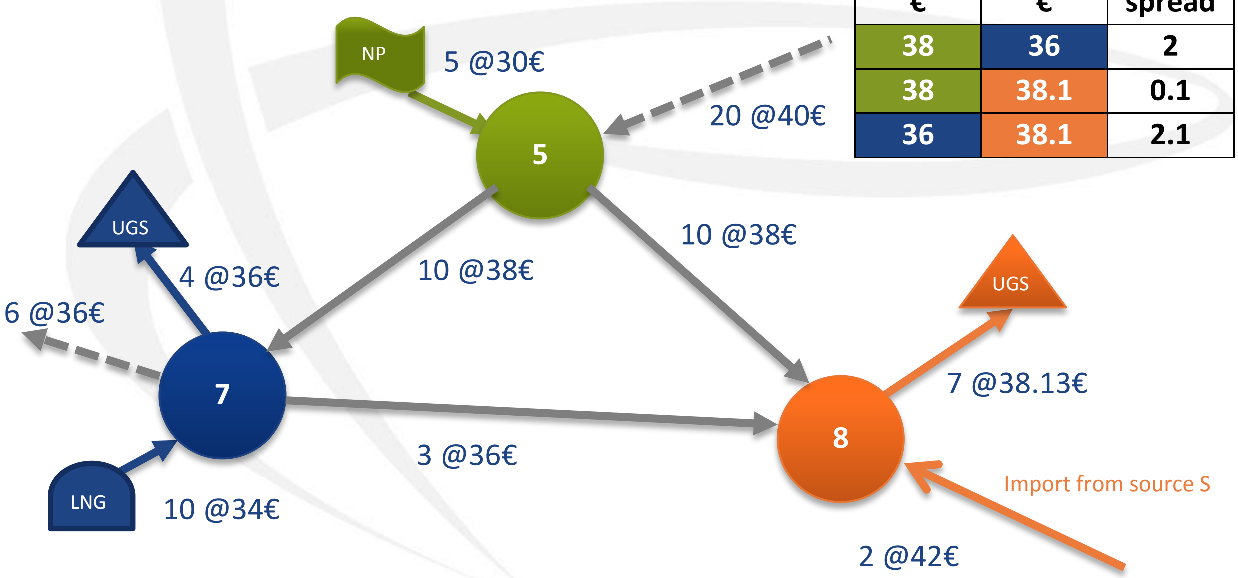
> Price Convergence

Price convergence represents the evolution of the spread of prices of supply, between two countries which are output of the modelling. This approach requires prices per source and/or per import route which are still to be defined based on recognized references and sensitivity-analysis (e.g. WEO of IEA).

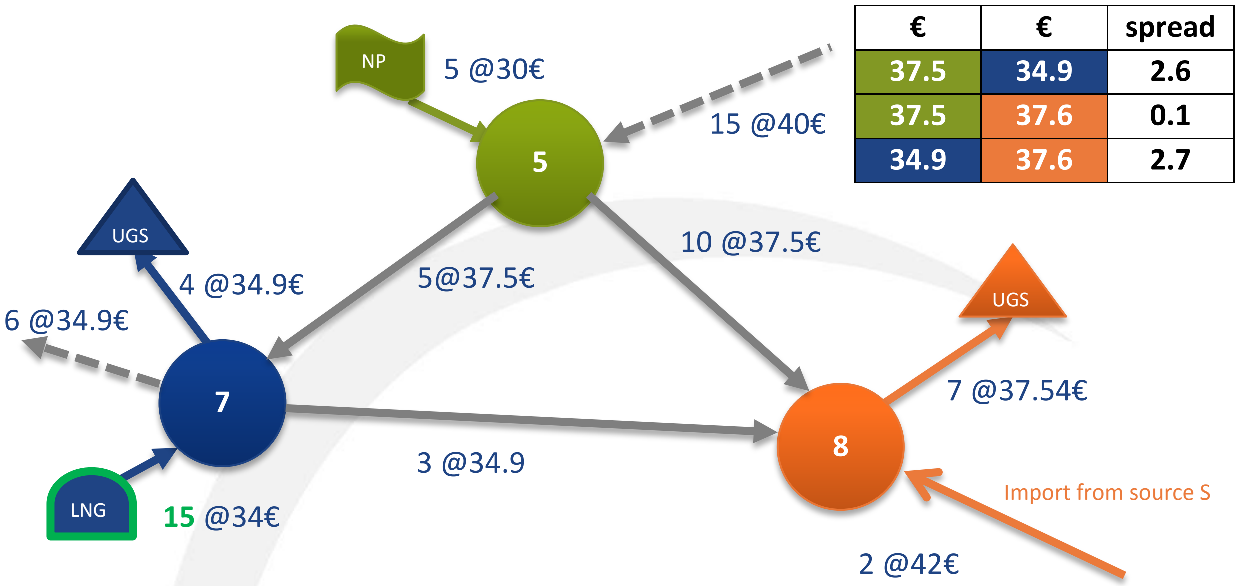
This convergence will be measured as the price spread between each adjacent zone as below:

Before the Project

€	€	spread
38	36	2
38	38.1	0.1
36	38.1	2.1



After the Project



€	€	spread
37.5	34.9	2.6
37.5	37.6	0.1
34.9	37.6	2.7

Resulting supply cost and price convergence

Spread between zones		Convergence
(green)	(blue)	+0.6
(green)	(orange)	0
(blue)	(orange)	+0.6

Supply cost	Evolution
(green)	-0.5
(blue)	-1.1
(orange)	-0.5

This example illustrates that price convergence may evolve in an opposite direction compared to supply cost.

5.2.3. Monetary Analysis with modelling

This part of the combined approach consists in the monetization of the impact of the projects through the incremental approach. The flow patterns supporting this analysis result from modelling.

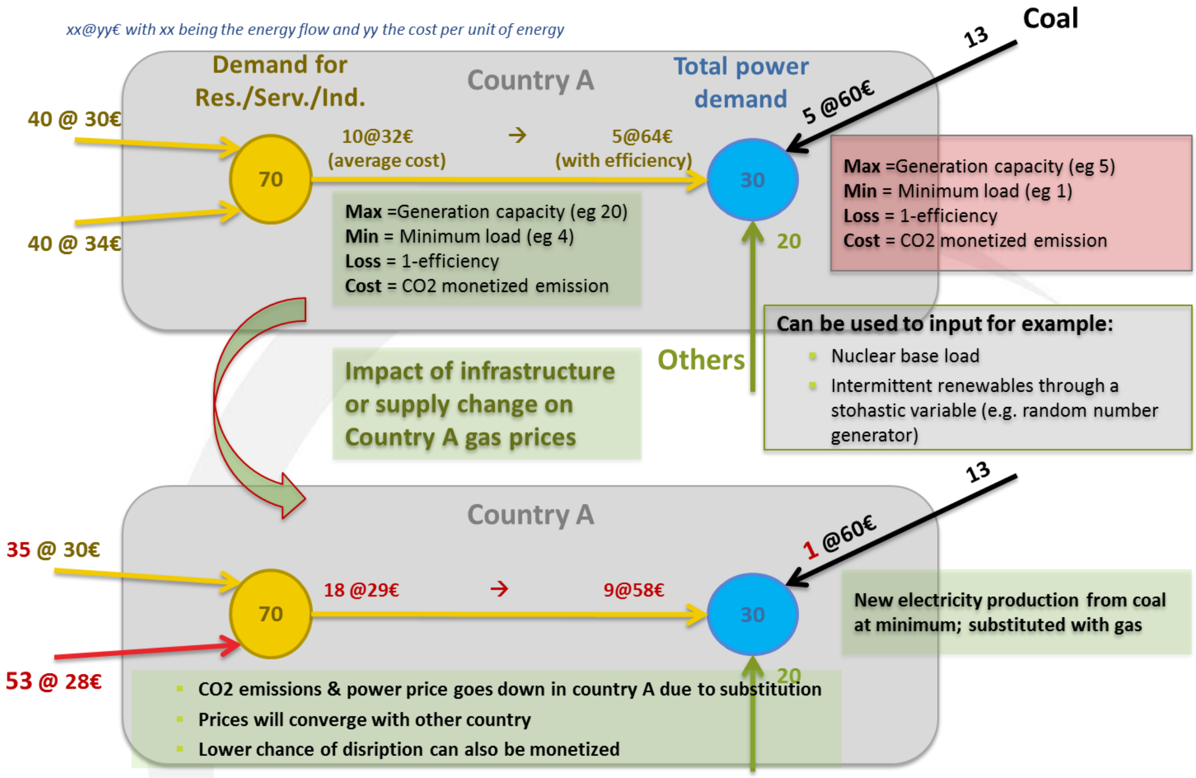
5.2.3.1. The saved cost approach and the cost types

The following saved cost *types* are to be monetized by the modelling tool along the time horizon, based on the generated flows:

- CO2 emission and power generation
- Disruption
- Gas supply

- **Monetization of CO2 emission and power generation cost**

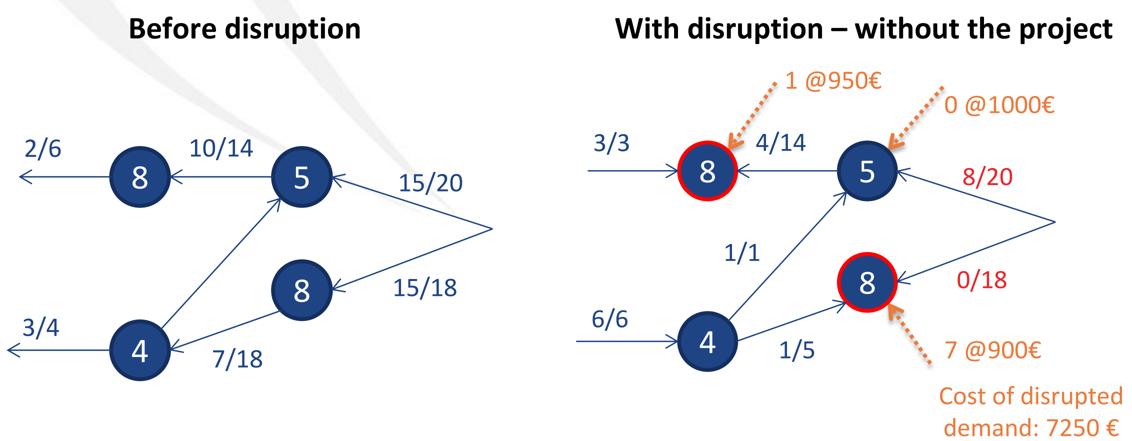
Power generation and CO2 emission costs are to be calculated according to the ESW-CBA methodology once with and once without the Project. The below picture illustrates this incremental approach:



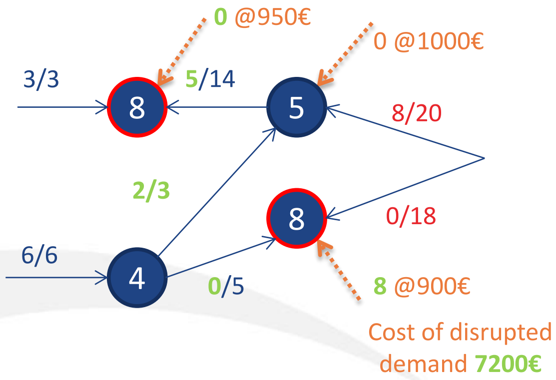
The difference between the two values represents the saved costs, resulting from the project commissioning. This value shall be reported in the PS-CBA output table and used as an input when creating the Economic Cash Flow.

Cost of disruption

Disruption costs are to be calculated according to the ESW-CBA methodology once with and once without the Project. The below picture illustrates this incremental approach:



With disruption With project



The difference between the two values (with disruption with and without the project) represents the saved costs resulting from the project commissioning. This value shall be reported in the PS-CBA output table and used as an input when creating the Economic Cash Flow.

> **Cost of gas supply**

Using TYNDP 2013 topology, the introduction of a cost of gas for each supply source (potentially different for each import route), the tool will define a supply cost for each country and each modelled case. The evolution of this cost then feed the PS-CBA incremental approach.
Applying the incremental approach, a new cost of supply for each country will be calculated on the basis of the new flow pattern generated by the modelling tool compared to the ESW-CBA results.
An illustration of the approach can be found under the Price Convergence indicator definition.

5.2.3.2. Economic Performance Indicators

Project Promoters shall calculate the below indicators on the time horizon using the SDR. The table in 8.3 indicates the structure of the economic cash flow based on the saved-cost approach. The economic cash flow represents the difference between the economic benefits and the economic costs of the project.

> **Economic Net Present Value**

The Economic Net Present Value is the aggregated discounted value of all the cash flow generated by the project considering the saved costs described above and the total cost of the project. The Economic Net Present Value of a project is defined as:

$$ENPV = \sum_{t=a}^{c+20} \frac{B_t - C_t}{(1+i)^{t-a}}$$

where
B_t is the monetization of the above saved cost layers for year t (including the Residual Value as an inflow for the year c+20)
C_t is the total economic cost of the project for the year t
t is the time starting from the year of analysis
i is the Social Discount Rate
c is the year of commissioning
a is the year of analysis

> **Economic Internal Rate of Return (EIRR)**

The Economic Internal Rate of Return (EIRR) is defined as the discount rate that produces a zero ENPV. The calculation of the EIRR on investment, measures the capacity of the net revenues to remunerate investment costs. A project is considered economically desirable if the EIRR exceeds the Social Discount Rate. The EIRR is an indicator with high sensitivity to the time horizon and the moment in time, when the incomes are generated.

> **The Economic Benefit/Cost ratio (EB/C)**

Cost/benefit ratio is the present value of the present value of economic benefits divided by the present value of the economic costs of the project. If B/C>1, the project is suitable considering that the benefits, measured by the present value of total cash inflows are bigger than the costs.

$$EB/C = \frac{\sum_{t=a}^{c+20} \frac{B_t}{(1+i)^{t-a}}}{\sum_{t=a}^{c+20} \frac{C_t}{(1+i)^{t-a}}}$$

where
B_t is the monetization of the above saved cost layers for the year t (including the Residual Value as an inflow for the year c+20)
C_t is the total economic cost of the project for the year t
t is the time starting from the year of analysis
i is the Social Discount Rate
c is the year of commissioning
a is the year of analysis

5.2.4. Qualitative Analysis

The qualitative analysis shall complement the results of the quantitative and monetary analyses. The Project Promoter has the possibility to add description on potential benefits, considering the specificities of each type of project, not already reflected.
The Project Promoter shall describe these potential benefits, by linking the explanation with the results of the assessment done in the ESW-CBA -on the impact of the PCIs

implementation over the European infrastructure-. On top of the above described potential benefits, the Project Promoter will assess qualitatively the benefits of the project by giving due consideration to:

- Complementarity with other projects
- Commercial aspects (eg: diversification of supply counterparts)
- Lifting Isolation

The wording of the Qualitative Analysis shall be concise and each time justified, easing the assessment of the Regional Groups, NRAs and all Financial Institutions involved in this process.

5.3. The Economic Analysis based on indicators

The below method shall be used by Project Promoter until the modelling tool is able to support the targeted Economic Analysis based on modelling.

5.3.1. Quantitative Analysis

Through the Quantitative Analysis, the Project Promoter shall calculate the capacity-based indicators as described under the Economic Analysis based on modelling chapter.

5.3.1.1. Quantification of the cross-border impact

In a view of identifying the most significantly impacted countries and the distribution of the flow between these countries, the Project Promoter shall apply the below algorithm to the 3 Seasonal Balance indicators.

The following steps are leading the Promoter through the algorithm to identify the cross-border impacts for each of the three indicators.

Step1- Identification of the area of analysis which is composed of:

- the Member States and third countries where the project is built
- all directly interconnected neighbouring Member States

Step 2- Calculate the value of the indicator and the improvement in country where the project is built

Calculate the *seasonal capacity balance indicators* starting with the country where the project is built. The difference $\Delta_1$between the indicators(I_{w1}) for scenarios with the project and (I_{w0}) for the scenario without the project, reflects that there are surplus volumes of gas which could be distributed to the adjacent countries. The value of the indicator (I_{w1}) will reduce due to the distribution of volumes towards the adjacent countries.

Step 3 – Identification of the surplus volumes to be distributed from the country where the project is built to the adjacent countries.

Identification of the volumes of gas to be distributed to the adjacent countries considering the value of the indicator I_{w1} and the difference(Δ_1) reflecting the improvement in the country where the project is built.
The distribution of surplus volumes to the adjacent countries cannot decrease the value of the indicator of the country where the project is built below the maximum between:

> zero
> I_{w0}

The resulting level is reflected by the new value of the indicator after distribution(I_{w2}).

Step 4 – Identification of countries "in need" for additional volumes of gas
The countries "in need" for such a distribution of volumes are identified within the Area of Analysis based on the value of the indicator in the infrastructure scenario without the project. Those countries are the ones for which the result of the indicator is belowI_{w1}.
The next steps will only consider these countries in need.

Step 5 – The distribution of the daily surplus volumes between country where the project is built and countries "in need" (CB_i)
Distribution of the surplus volumes from the country where the project is built to the countries "in need" of the Area of Analysis, could be done using different ways of allocation (patterns). The "reference" pattern is the Pro Rata Allocation (explained below) as being the one producing the most balanced flow pattern. The other patterns identified below should only be used for sensitivity analysis.

- **Pro-Rata Allocation (PRA):** the volumes of gas will be allocated pro-rata between the impacted countries based on the identified volumes needed in these countries and the amount of surplus volumes to be allocated. The value of the indicator where the project is built shall not go below the value of the indicator in the countries in need.
- **First in Need First allocated (FNFA):** applicable for those countries with value of indicators below zero. The distribution of volumes starts with the country with the lowest value of the indicator and further on by allocating the remaining surplus volumes, if available, to other countries "in need". Following the distribution of volumes to the countries in need, the value of indicator in these countries, after distribution will increase up toward a safety level. The value of the indicator where the project is built shall not go below the value of the indicator in the countries in need.
- **Indicator Maximization Allocation (IMA):** the flow will be allocated in order to maximize alternatively the value of the indicator in each country "in need". This allocation will then lead to several flow patterns, one by country "in need".

Each pattern will provide a different distribution of surplus volumes between countries. The volumes to be distributed between impacted countries will served as input data for monetization.

Step 6- Calculation of the annual distributed surplus volume

For each allocation pattern, the Promoter shall build a yearly flow pattern as resulting from the weighted sum of the 3 indicators and consider the resulting flow as input for the monetization. For each year 'y' of the time horizon and each country "in need" the following formula gives the allocated surplus volume:

$$V_y = (CB_s * 183) + CB_w * (182 - 14) + (CB_h * 14)$$

Where:
CB_s is the allocated surplus according to step 5 under the Average Summer day
CB_W is the allocated surplus according to step 5 under the Average Winter day
CB_h is the allocated surplus according to step 5 under the High Daily Demand day

Step 7 – Recalculation of the indicators after the distribution of volumes
After the distribution, the new indicators (I_{w2}) will be calculated per day:

- For country distributing (country where the project is built) the surplus volumes by deducting CB_i from the numerator of each formula
- For countries receiving the surplus volumes of gas**,** by adding the distributed volumes CB_i to the numerator of each formula.

Example: Considering country A where the project is built and two other countries (B and C) identified as "in need", based on the algorithm, the calculation of the (I_{w2}) *for each country (for the Average Summer Day) is as follow:*

- *Country A - Summer Average Capacity balance*

$$\frac{Min(EX \; ; NP + \frac{N-1}{N} * IMP + LNG - INJ - Dsa - \text{CBi})}{Dsa}$$

- *Country B Summer Average Capacity balance*

$$\frac{Min(EX \; ; NP + \frac{N-1}{N} * IMP + LNG - INJ - Dsa + \text{CBi})}{Dsa}$$

- *Country C Summer Average Capacity balance*

$$\frac{Min(EX \; ; NP + \frac{N-1}{N} * IMP + LNG - INJ - Dsa + \text{CBi})}{Dsa}$$

The same method to recalculate the value of the indicator will be considered for each Seasonal Capacity Balance indicator on which the algorithm can be applied.

5.3.2. Monetary analysis

The monetary analysis is the part of the Economic Analysis consisting in the projection of the discounted economic cash flow, reflecting in this way the societal value of a project in monetary units (as reflected by the Economic Net present Value – ENPV) easing the comparison between projects.

5.3.2.1. The Saved Cost Approach and its layers

After having identified the impacted countries and the volumes to be distributed toward each country, the project promoter will start monetizing the possible net benefits per impacted country, based on the reference flow pattern (PRA) as described in the chapter "Quantification of the cross-border impact".

All the other input data necessary to be considered to support the reflection of these benefits in monetary units, are reflected in the Input Data chapter of the current methodology.

In the chapter introducing the saved cost approach for modelling, it has been explained that the following benefits can be monetized, building on a modelling tool.

- Gas supply
- CO2 emission and power generation
- Disruption

Not applying the modelling tool, however not all of them can be monetized. In the following, the benefits are reviewed and where possible, a step-by-step methodology is provided, to calculate the monetary flow attributed to each benefit.

Type of saved costs	Explanation
Gas supply	Without applying the modelling and using source-, season- and market-specific price data, this benefit cannot be monetized in a static approach. This benefit includes:
	- Price Convergence
	- Cheaper supply of gas
	- Seasonal swing of gas price – a possible benefit for UGS projects
Power generation and CO2 emission	Although slightly differently than in case of modelling, this benefit can be captured in a static approach as well. The following saved-cost types are to be monetized:
	- Saving in CO_2 emission
	- Increase in power generation efficiency

	- Change in the fuel cost for generation
Disruption	The methodology as explained at the modelling solution cannot be applied in a static approach. In case a cost of disruption data is provided by the Members States, the below explained methodology is applicable and can be used to monetize the possible benefit due to decrease in the cost of Disruption

In the following, the calculation of the possible saved costs as defined above table will be presented.

> **Supply of Gas**

The possible benefit of a new supply of gas includes three sub-categories:

- Developments in Price Convergence
- Cheaper supply of gas
- Seasonal swing of gas price

In absence of market and network modelling tool only the seasonal swing may be monetized provided that seasonal price data are available as follow:
The value of swing seen as a difference (Δ) in the average prices of gas between two different periods shall be multiplied by the working volumes of the UGS, along each year of the time horizon of the analysis. The SDR should be applied accordingly on these annual values. After discounting, this result can be used for the aggregated cash flow within the monetary analysis.
This benefit particularly reflects the potential benefits of storages.

> **Power generation and CO2 emission**

The possible substitution of more polluting fuels within the electricity fuel mix represents three possible changes of costs:

- **Change in CO_2 emission** – the emission factor of the fuel/energy released changes
- **Change in fuel costs** – the fuel cost of the electricity production changes
- **Change in the thermal efficiency of power generation** – the technology of the generation changes

The below step-by-step guide explains how to calculate the above possible benefits along the time horizon per country and how to generate a cash flow from these possible benefits.

- **Change in CO2 emission**

The considered criterion to measure pollution is the *Specific CO2 emission of fuels/net energy released*.

The necessary input data for this calculation are:

- Distributed volume as output of the Quantitative Analysis per year, per impacted country
- Electricity Mix of respective countries
- Net Calorific Value of Fuels
- Specific CO_2 Emission of Fuels
- Thermal Efficiency of Power Plants
- Price of Fuels (Natural gas and the substituted fuels)
- Price of CO_2

For each year of the time horizon, the change in CO2 emission is monetized as below (see also subsequent example):

1) Take the *gross electricity generation (C2)* in the examined country from the data provided within the ESW-CBA[15] and calculate the electricity produced by the more polluting fuels than natural gas. To know which fuels are more polluting, refer to the *Physical Constants*.

   This calculation can be done by multiplying the *gross electricity generation (C2)* by the share of each more polluting fuel within the *gross electricity generation* of the examined year. The amount of *original gross electricity generation per fuel (E3)* is available now.
2) Take this value and divide it by the *net thermal efficiency of generation (C7)* by source. It will define the *original fuel mix (C12)*. Multiply this value with the s*pecific CO2 emission of fuels (C16)* for each source, which will define the o*riginal emission of the fuel mix (C21)*.
3) Calculate the a*mount of natural gas required to generate the same amount of electricity (C26)* for each fuel by dividing the *original gross electricity generation per fuel (E3)* by the *net thermal efficiency of generation (C11)* from natural gas.

   Then calculate how much of the generation from more polluting fuels is *possibly substituted (C31)*, by considering that from each fuel only 2/3 of the production can be substituted; so at least 1/3 of the production has to remain.

   Then take the value of the *allocated natural gas (C30)* amount for the country being examined and calculate how much of the generation from more polluting fuels is *to be substituted (C35).*

   The possible outcomes are:
   - Some of the most polluting fuel can be substituted
   - All of the most polluting fuel can be substituted and also some of the second most polluting fuel can be substituted … etc.
   - All of the more polluting fuels then natural gas can be substituted and some excess natural gas remains. Do not consider this excess gas hereafter.
4) After identifying in step 3 the amount of the more polluting generation which is actually

[15] Gross electricity production scenario and the share of each fuel in generating this electricity.

to be substituted (C35), the *emission of the new fuel mix (C44)* (with substitution of the polluting fuels) has to be calculated. To do it, calculate the *emission of the new fuel mix (C44)* and add to it the emission generated by the natural gas quantity *(C48)*, which is substituting fuels from the original electricity mix.

5) Since in Step 2 the emission of the original electricity mix has been calculated, the amount of the *saved CO_2 emission (C50)* can be calculated by calculating the difference between the cumulated emissions of the old and new electricity mixes *(C25-C49)*.
6) In order to assign monetary value to the saved CO_2, the calculated *saved CO_2 emission (C50)* has to be multiplied with the *CO_2 price (C51)*, as available from the referenced sources for each year of the analysis. On this value, the *SDR (C55)* has to be applied to discount it to the constant price of the year of analysis. Finally for each year, the value of the saved CO_2 emission cost is calculated and can be used for the aggregated cash flow within the monetary analysis.

Example of monetization of fuel substitution:

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
2			Y					Y+1		Y+2		...	Y+c		
3		**Gross electricity generation in year *Y* (GWh)**	100.000					105.000		107.000			140.000		
4	STEP 1	**Original electricity generation mix (% and GWh)**		Orig. G^0 elec. gen./fuel					Orig. G^0 elec. gen./fuel		Orig. G^0 elec. gen./fuel			Orig. G^0 elec. gen./fu	
5		Coal	25%	**25.000,0**				26%	**27.300,0**	23%	**24.150,0**		19%	**19.950,0**	
6		Oil	5%	**5.000,0**				5%	**5.250,0**	6%	**6.300,0**		4%	**4.200,0**	
7		Lignite	10%	**10.000,0**				10%	**10.500,0**	11%	**11.550,0**		2%	**2.100,0**	
8		**Net Thermal Efficiency of generation (including PP own consumption) (%)**													
9		Coal	35%					35%		35%			38%		
10		Oil	40%					40%		40%			42%		
11		Lignite	35%					35%		35%			38%		
12		Natural Gas	50%					50%		50%			55%		
13		**Original Fuel mix (GWh)** to generate given electricity amount													
14		Coal	71.428,6					78.000,0		69.000,0			52.500,0		
15		Oil	12.500,0					13.125,0		15.750,0			10.000,0		
16	STEP 2	Lignite	28.571,4					30.000,0		33.000,0			5.526,3		
17		**Physical Constant - Specific CO2 emission of fuels/net energy released**	*kg/TJ*	*kg/GWh*	*1TJ =*	*0,2778*	*GWh*								
18		Gas	56.100,0	15.583											
19		Coal	94.600,0	26.278											
20		Oil	77.400,0	21.500											
21		Lignite	101.000,0	28.056											
22		**Original emission of the fuel mix (t)**													
23		Coal	1.876.985,6					2.049.668,3		1.813.168,1			1.379.584,4		
24		Oil	268.750,2					282.187,7		338.625,3			215.000,2		
25		Lignite	801.587,9					841.667,3		925.834,1			155.044,0		
26		**Cummulated original emission**	**2.947.323,8**					**3.173.523,4**		**3.077.627,5**			**1.749.628,6**		
27		**Amount of natural gas required to generate same amount of electricity (GWh)**													
28		Coal	50.000,0					54.600,0		48.300,0			36.272,7		
29		Oil	10.000,0					10.500,0		12.600,0			7.636,4		
30		Lignite	20.000,0					21.000,0		23.100,0			3.818,2		
31		**Allocated natural gas for the country per year (GWh)**	8.000,0					8.000,0		8.000,0			8.000,0		
32		**Possibly Substituted - 66,6% of the production**													
33	STEP 3	Coal	33.333,3					36.400,0		32.200,0			24.181,8		
34		Oil	6.666,7					7.000,0		8.400,0			5.090,9		
35		Lignite	13.333,3					14.000,0		15.400,0			2.545,5		
36		**To be substitued -** in the order of pollution													
37		Coal	-					-		-			5.454,5		
38		Oil	-					-		-			-		
39		Lingnite	8.000,0					8.000,0		8.000,0			2.545,5		
40		**New fuel mix, including gas for substitution (GWh)** to generate given electricity amount													
41		Coal	71.428,6					78.000,0		69.000,0			44.605,3		
42		Oil	12.500,0					13.125,0		15.750,0			10.000,0		
43		Lignite	17.142,9					18.571,4		21.571,4			1.842,0		
44	STEP 4	Natural Gas	8.000,0	OK				8.000,0	OK	8.000,0	OK		8.000,0	OK	
45		**Emission of the new fuel mix (t)** after substitution													
46		Coal	1.876.985,63					2.049.668,31		1.813.168,12			1.172.128,13		
47		Oil	268.750,22					282.187,73		338.625,27			215.000,17		
48		Lignite	480.952,77					521.032,16		605.198,90			51.679,48		
49		Natural Gas	124.666,77					124.666,77		124.666,77			124.667,47		
50		**Cummulated new emission**	**2.751.355,4**					**2.977.555,0**		**2.881.659,1**			**1.563.475,3**		
51	S 5	**Saved CO2 emission (t)**	**195.968,4**					**195.968,4**		**195.968,4**			**186.153,3**		
52		CO2 price (EUR/t)	7					7,5		7,2			25		
53		**Saved CO2 emission cost (EUR/yr)**	**1.371.778,9**					**1.469.763,1**		**1.410.972,6**			**4.653.833,3**		
54		- out of which attributable to efficiency gain													
55	STEP 6	- out of which attributable to emission of the fuel													
56		**SDR**	0,06%					0,04%		0,04%			0,04%		
57		**Discounted cash flow**	**1.370.956,30**					**1.468.587,98**		**1.409.280,74**			**4.609.379,14**		
58		**NPV**	**8.858.204,16**												

- **Change in generation fuel cost for power generation**

Another cost change to be used for the aggregated cash flow within the monetary analysis is the fuel price difference between the old and the new energy mix.

1) To calculate it, the *amount of energy required from the original fuel* has to be multiplied by the price of each fuel and summed for each year. (Note the unit when multiplying)! This will result in the cost of the original electricity mix.
2) Then, the *new electricity mix in the energy required from the original fuel with substitution* also has to be multiplied by the price of each fuel and summed for each year. This will result in the cost of the new electricity mix.
3) The cost of the second electricity mix has to be deducted from the cost of the original electricity mix for each year and the *SDR* has to be applied. Finally, for each year and each country the cost/benefit of switching fuel is calculated and can be used as for the aggregated cash flow for the Monetary Analysis.

- Change in the thermal efficiency of power generation

This benefit is included when calculating the avoided CO_2 emission cost and the change in generation fuel cost, as the new fuel mix (after substitution) already considers the increased thermal efficiency, due to the fact that the generation from natural gas takes place at the thermal efficiency of gas power plants *(C12)*.

> **Saved Cost of Disruption**

The Saved Cost of Disruption can be calculated, only in case the country-specific data of cost of disruption becomes available.

The affected countries by a disruption are identified under the ESW-CBA.

1) Take the minimum between incremental entry volume resulting from the Quantitative Analysis per day and the amount of non-supplied demand from the ESW-CBA per effected country.
2) This flow value shall be multiplied by the cost of disruption per unit of energy. This will result in an avoided cost of gas, not being supplied for each country for one day if the disruption happened.
3) In order to generate an annual value, that reflects the avoided cost of disruption if it happens, assume a 14 days disruption scenario[16]. Multiply the result of the first step with 14.
4) In order to generate a long term cost of disruption, the occurrence (x%) of such event shall be defined[17]. Multiply the result of the previous step by x%. This will result in a long term, annual saved cost of disruption.

[16] As used in TYNDP Infrastructure Resilience assessment

[17] It means 100% risk for disruption once every 20 years.

5) Apply the SDR on each year accordingly and use the cash flow received when aggregating the results of the Monetary Analysis.

5.3.2.2. Economic Performance Indicators

Based on the aggregation of the monetization of each layer of saved cost, the Promoter shall calculate the Economic Performance Indicators as defined within the Economic Analysis based on modelling chapter.

5.3.3. Qualitative Analysis

For description of the Qualitative Analysis within the Economic Analysis, please refer to the already described Qualitative Analysis chapter within the Economic Analysis based on modelling chapter.

6. Sensitivity Analysis

The results of the Economic Analysis may give the impression of a very deterministic assessment of project benefits if attention is not paid to the full picture and the link to the input dataset.

The Project Promoters shall carry out a sensitivity-analysis on key input data in order to inform on the robustness project benefits. In order to limit the complexity of this analysis both in term of number of cases and interpretability of results, key input data shall be tested one-by-one.

The following table defines the data to be analysed and the variation to be considered:

Type of sensitivity		Range of variables or scenarios to be considered	Applicability			
			Financial analysis		Economic analysis	
			Financial cash flow and performance indicators	Financial sustainability	Quantitative analysis	Monetary analysis
No.	**Data Item**	**Units**	**Impact**			
I.	**Project Specific variables**					
1.1	Capex	(+/-) 1-10-20 %	x	x		x
1.2	Opex	(+/-) 1-10-20%	x	x		x
1.3	Commissioning Date	1-3 years	x	x	x	
II.	**Supply and Demand**				**x**	
2.1	Demand				x	
2.1.1.	*High daily demand*	(+/-) 5 %			x	
2.1.2.	*Winter average demand*	(+/-) 5 %			x	
2.1.3.	*Summer average demand*	(+/-) 5 %			x	
2.2.	National Production	(+/-) 5 %			x	
III.	**Prices**					
3.1	Fuel prices	IEA (current policy- & 450ppm Scenario)				
3.2	CO2 prices	IEA (current policy- & 450ppm Scenario)				
IV.	**Volume Allocation Patterns**				**x**	
4.1	FNFA (First in Need First Allocated)				x	
4.1	IMA (Indicator Maximization Allocation)				x	
V.	**Infrastructure scenarios**				**x**	
5.1	High Infrastructure				x	

Above values are given as a basis for the sensitivity range, it could be further elaborated.

As for the Quantitative and Monetary Analysis, and depending on the FID status of the projects, part of the sensitivity-analysis can be found in the ESW-CBA.

7. Summary of the PS-CBA Results

Based on the results of the PS-CBA, the project promoter shall check, if the project fulfils all the general criteria and at least one of the specific criteria requested by the Regulation.

8. Appendix

8.1. Definition of terms

Beneficiary means gas consumers having a benefit from a gas infrastructure project, particularly gas consumers that are located in a Member State different from the location of the gas infrastructure project

Business plan means a financial analysis evaluating the financial sustainability of a project, including the chosen financing solution.

Capacity-based Indicator: category of indicators not using modelling output in their formula, however their value change with time, depending on the change of the input data.

CBA (Cost-Benefit Analysis) means a conceptual framework applied to any systematic, quantitative appraisal of a public or private project to determine whether, or to what extent, that project is worthwhile from a social perspective; such CBA is carried out according to a CBA methodology

CBA methodology means the Cost-Benefit Analysis methodology developed by ENTSOG on the basis of the Regulation and covering the Energy system-wide analysis and Project-specific analysis

Commercially sensitive information means information of either qualitative or quantitative character whose exposure to non-authorized third parties could incur damage on the party concerned by the information or on its commercial partners; authorized third parties can be either authorities having the right of access to Commercially sensitive information embedded in national or European legislation or third parties, notably consultants, who have signed a confidentiality agreement with the owner of the information.

Competition means rivalry in which every seller tries to get what other sellers are seeking at the same time: sales, profit, and market share by offering the best practicable combination of price, quality, and service. Where the market information flows freely, competition plays a regulatory function in balancing demand and supply.

Composition of the transmission network means the analytical description of the transmission network through structural elements used for the representation of the network in a network model

Constant prices are those prices as expressed in real value, not affected by the inflation rate.

Cross-border cost allocation means a procedure, as well as the results of such procedure, through which concerned National Regulatory Authorities, or ACER where applicable, take a decision on allocating parts or all costs incurred by a (regulated) project promoter in relation to a project in one Member State to an entity, most likely a TSO, in another Member State benefitting from this project. Such cross-border cost allocation may spread across multiple Member States. According to the Regulation, a Cross-border cost allocation should only be launched upon a request by the concerned project promoter(s) and be based, among other things, on the Project-specific analysis; Cross-border cost allocation is not linked to any specific implementation measures for the financial transfers implied by the Cross-border cost allocation

Discount rate means the rate used in discounting future cash flows in order to reflect how the benefits and costs are to be valued against the present ones.

Diversification of supply sources means a process, and the result of such process, whereby the number of different supply sources that can physically, and to a limited extent also only commercially, reach a certain market increases

Diversification of supply counterparts means a process, and the result of such process, whereby the number of different suppliers (producers) that can physically, and to a limited extent also only commercially, reach a certain market increases

Diversification of supply routes means a process, and the result of such process, whereby the number of different routes that a certain supplier (producer) can use to physically deliver its supplies to a certain market.

Economic analysis means the analysis based on and complementary to the financial analysis aiming at assessing a project's externalities and as such its contribution to the economic welfare of a region or country according to specified criteria;

Energy system-wide analysis means an analysis of the European gas infrastructure as a whole aiming at assessing the overall impact of all TYNDP projects along the criteria of market integration, competition, security of supply and sustainability taking into consideration the energy infrastructure priority corridors defined in the Regulation; this analysis is carried out by ENTSOG within the TYNDP once the Regulation has entered into force

Externality means a secondary or unintended consequence of an activity; externality may be either positive or negative; when non-market impacts do not occur in the transactions between the producer and the direct users /beneficiaries of the project services but fall on uncompensated third parties, these impacts are defined as externalities.

Extrapolation means a projection of input data figures for an additional time horizon where either lack of data or uncertainty prevents the use of concrete figures.

Final Investment Decision (FID) means the decision taken at the level of an undertaking to definitively earmark funds towards the investment phase of a project, the investment phase meaning the phase during which construction or decommissioning takes place and capital costs are incurred. The investment phase excludes the planning phase, during which project implementation is prepared and which includes, where appropriate, a feasibility assessment, preparatory and technical studies, obtaining licences and authorisations and incurring capital costs (*definition taken from Council Regulation (EU) 617/2010 concerning the notification to the Commission of investment projects in energy infrastructure within the European*)

Financial sustainability of a project means the ability of a project to prove a cumulated positive net cash flow over all the years considered for the financial analysis (in nominal or real terms)[18]

Financial analysis means the analysis using the cash flow forecasts to calculate net return indicators especially the Financial Net Present and Financial Internal rate of return

Financial Discount Rate which means the appropriate discount rate applied to the financial cash flow in order to calculate the present value of the future cash flows; the financial

[18] We recommend the use of the constant prices and appropriate financial discount rate to be applied

discount rate reflects the opportunity cost of capital, defined as the "expected return forgone by bypassing other potential investment activities for a given capital".

Financial Net Present Value (FNPV)/Economic Net Present Value (ENPV) means the result obtained from the deduction of the expected investment and operating costs of a project (suitably discounted) from the discounted value of the expected revenue from the project

Financial Rate of Return (FRR)/ Economic Rate of Return (ERR) means the discount rate that produces a zero FNPV /ENPV

Incremental approach means the analysis of differences in the costs and benefits between the scenario with the project and the scenario without the project.

Interoperability means the ability of two or more systems operated by different entities to exchange natural gas and operate in a compatible and efficient mode including the seamless and efficient execution of transmission system operations and business transactions between TSOs and network users in a manner of conduct which may reasonably be approximated to the conduct of a transmission system as if operated by a single entity *(taken from Framework Guidelines on Interoperability)*

Investment costs (CAPEX) means all those costs that are incurred in view of the effects that will accrue beyond the period in which the relative disbursements were made.

Liquidity means the ability to quickly buy or sell reasonable volumes of gas without causing a significant change in price and without incurring significant transactions costs. A key feature of a liquid market is that it has a large number of buyers and sellers willing to transact at all times. The assessment of market liquidity usually includes consideration of the volumes traded, churn rates and the number of players on the market.

Main parameters means variables for which an absolute variation of 1% around the best estimate give rise to a corresponding variation of not less than 1% in the NPV

Market integration means a process by which formerly separate markets connect with each other both physically and commercially, the latter enabled especially by compatible regulatory frameworks

Modelled Indicator: Category of indicators using modelling output in their formula and therefore variable according to the output of modelling.

National Production means the energy amount of gas produced from geological formations, delivered by the producer either to the distribution or transmission system.

Network model means an analytical tool for the assessment of the European gas infrastructure along multiple criteria as developed, operated and managed by ENTSOG and used for the production of ENTSOG reports and analysis according to Regulation (EC) 715/2009 or Regulation (EU) 10/994

Option analysis means a process aiming at providing evidence that the project can be implemented as proposed and is the best option among all feasible alternatives

Operating costs (OPEX) means all those costs that are incurred after the 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.

Payer means an entity responsible for the financial transfers implied by a specific Cross-border cost allocation

Project-specific analysis means a cost-benefit analysis of a PCI project included in the TYNDP, aiming at assessing the impact of a specific project on the European gas infrastructure along the criteria of market integration, competition, security of supply and sustainability taking into consideration the energy infrastructure priority corridors defined in the Regulation; this analysis is carried out by the project's promoter, or on their behalf, to the extent necessary and according to requirements of the PCI process

Project of Common Interest (PCI) means a project which meets the general and at least one of the specific criteria defined in Art. 4 of the Regulation and has been granted the label of PCI project according to the provisions of the Regulation

Regulation means the Regulation (EU) No 347/2013 of the European Parliament and of the Council on 17 April 2013 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

Residual value is the discounted remaining non-depreciated value of the asset added as inflow by the end year of the time horizon of the analysis.

Sensitivity analysis means the analysis aiming at determining the critical variables or parameters of the model whose variations, positive or negative, have the greatest impact on a project's financial and/or economic performance.

Social Discount Rate which means the discount rate used for the economic analysis, which reflects the social view on how future benefits and costs are to be valued against present ones and could derive from the predicted long term growth in the economy.

Stakeholders means parties and authorities directly or indirectly affected by the PCI process

Sustainability means the contribution of a project to emissions reduction, back-up of renewable electricity generation or power-to-gas and biogas transportation taking into account expected changes in climatic condition under different scenarios

System flexibility means the technical and physical availability of an infrastructure allowing for different flow patterns.

Ten-Year Network Development Plan (TYNDP) means the Union-wide report on the outlook for the European gas infrastructure development including the assessment of the resilience of the system as well as of market integration under multiple scenarios and respective cases; the TYNDP is developed by ENTSOG using the combination of top-down and bottom-up approaches.

8.2. Output table of the quantitative analysis

> For country "A" where the project is implemented (w/o – "scenario without the project"; w- scenario "with the project")

Indicators	Time horizon	Value of Indicator			Available volumes	Distribution of volumes	Value of the indicator after distribution
	Year of impact (starting with the commissioning year)	w/o	w	Δ	w	w	
I_1	1						
	2						
	3						
	4						
	5						
	6						
	7						
	……						
	20						
I_2	1-20						
I_3	1-20						
I_x	1-20						

> Output table for the impacted countries

Indicators	Time horizon	Value of indicators/y	Distributions of volumes &Value of indicators/y (with the project)									Averaged distribution		
			PRA (reference)	Value of indicator	Δ PRA	FNFA	Value of indicator	Δ FNFA	IMA	Value of indicator	Δ IMA	PRA (reference)	FNFA	IMA
	Year of impact (starting with the commissioning year)	w/o										w	w	w
I_1	1													
	2													
	3													
	4													
	5													
	6													
	7													
	……													
	20													
I_2	1-20													
I_3	1-20													
I_x	1-20													

Where

Δ = (Value of indicator with the project- value of indicator without the project)%

I= value of the indicator under a certain flow pattern

w/o= scenario without the project

w=scenario with the project

8.3. Saved cost approach- Structure of the economic flow

The table below reflect the way in which the benefits calculated per country, shall be reflected in the economic cash flow (considering, as example, that 3 countries are impacted by the project).

Saved cost approach- Structure of the economic flow									
			Time horizon						
No	Explanation	Source of information	Years						
			n*+0	n+1	n+2	n....	c1	c...	c+20
A	Input data								
I=1+2+3	Total costs								
1	Investment costs	Financial analysis	-	-	-	-			
2	Operating costs						-	-	-
3	Other costs (decommissioning)							-	
4	Residual value*								+
II=1+2+3	Total discounted Economic benefits	Quantitative analysis Country specific data							
1	Saved costs in country A						+	+	+
	change in fuel price						+	+	+
	CO_2 emmisssions						+	+	+
	Cost of disruption						+	+	+
2	Saved costs in country B						+	+	+
	change in fuel price						+	+	+
	CO_2 emmisssions						+	+	+
	Cost of disruption						+	+	+
3	Saved costs in country C						+	+	+
	change in fuel price						+	+	+
	CO_2 emmisssions						+	+	+
	Cost of disruption						+	+	+
III	Social discount rate (SDR)	Common Input Data	applied on the Cash flow (starting with (n+0) and ending with year (c+20)						
B	Output data								
(IV =II-I)	Net economic benefits (if ∑Economic benefits>∑Costs)		-	-	-	-	+	+	+
V	Economic performance indicators								
1	ENPV (>0)		calculated based on the Cash flow						
2	EIRR (>SDR)								
3	B/C (>1)								

n* is the year of analysis

Residual value* it is the remaining non depreciated value of the investment, added as an inflow for the lasy year of the time horiz