ENTSOG Cost-Benefit Analysis Methodology

Energy System-Wide CBA Methodology

Executive Summary

This document describes the Energy System-Wide Cost Benefits Analysis (ESW-CBA) methodology developed by ENTSOG to meet Regulation (EC) 347/2013 (the Regulation) requirements. The ESW-CBA, as part of Union-wide TYNDP, will provide both:

> an overall assessment of the infrastructure-related market integration under different scenarios of infrastructure development

> the input to be used by Project Promoters when they will carry out their Project Specific CBA

This ESW-CBA methodology is composed of a set of input data to be used in a combined qualitative, quantitative and monetary analysis and covering a 20-year time horizon. It also describes the network and market modelling approach supporting these analyses.

At this stage the methodology largely derives from ENTSOG TYNDP 2013-2022 and feedback collected until now. As TYNDP, the ESW-CBA is a living organism that will benefit from the consultation process to be run first half of 2014 in addition to ACER, Commission and Member States' opinion.

The document aims at providing a solid basis for discussion and applicability testing in the view of the finalization of the fully-fledged methodology for Summer 2014. Its implementation will then depend on the availability of input data which definitely stand beyond TSOs' remit.

Table of Contents

1. Purpose of the Energy System-Wide CBA (ESW-CBA)

The ESW-CBA builds a bridge between the latest selection of PCIs and upcoming one.

1.1. Assessing the overall impact of the latest selected PCI list

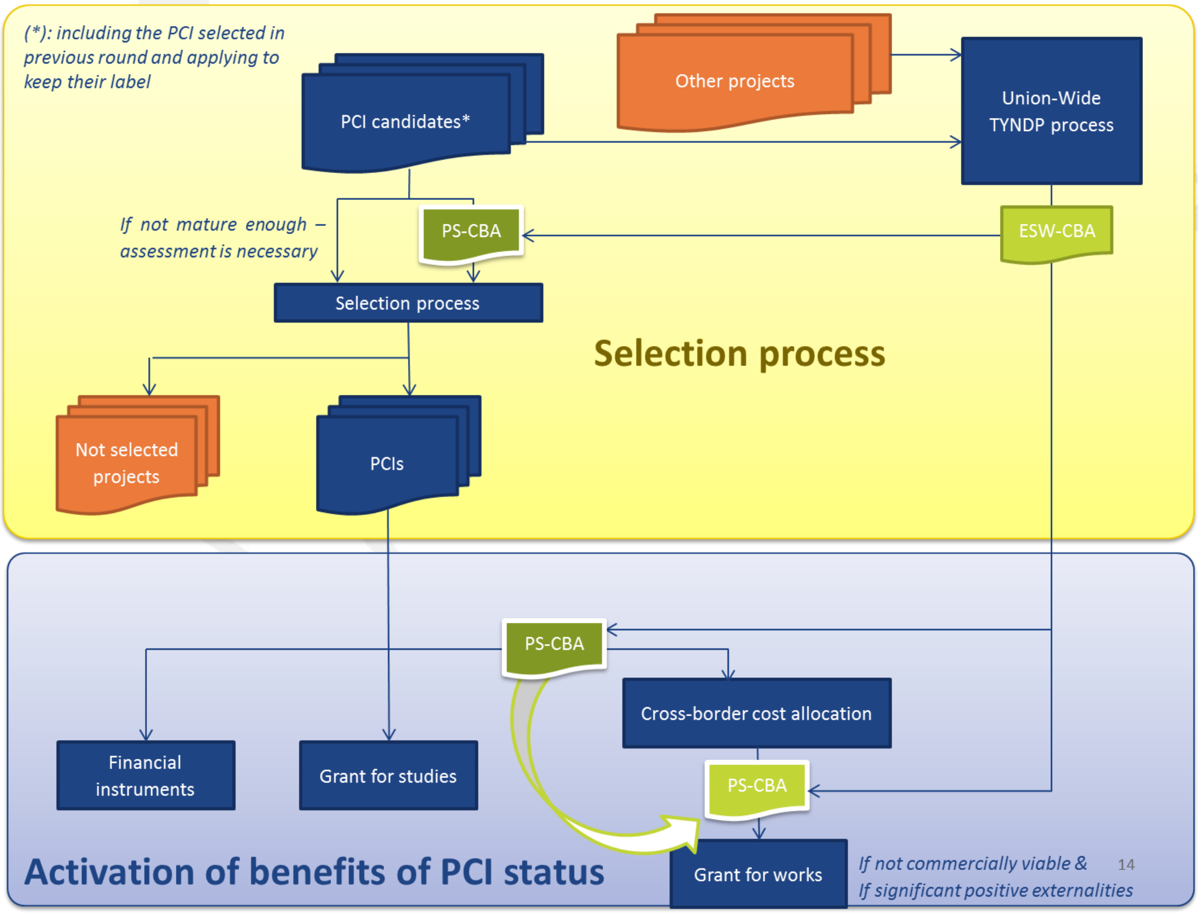
When the PS-CBA measures the marginal impact of a project under a set of infrastructure scenarios, it does not assess the cumulative effect of PCIs. Therefore the ESW-CBA is the instrument assessing the effect of the whole list of PCIs as resulting from the latest selection round.

1.2. Providing a consistent input dataset to support future Project-Specific CBA

The selection of Projects of Common Interest (PCI) by Regional Groups requires the definition of a level playingfield for the comparison of projects. For that purpose the ESW-CBA run by ENTSOG will provide the input data necessary for the Project Specific Cost-Benefit Analysis (PS-CBA) subsenquently carried out by Project Promoters. In order to ease the task of Project Promoters all the input data required for the PS-CBA (including indicators and monetization results per country/zone to be used in the incremental approach) will be gathered in a specific annex of the ESW-CBA.

The PS-CBA methodology is described in a separate document as it is to be applied by Project Promoters when the ESW-CBA is carried out by ENTSOG as part of his TYNDP.

The below pictures shows the role of the ESW-CBA and PS-CBA in each selection round.



2. Energy System-Wide CBA and Union-wide TYNDP

2.1. TYNDP as a pre-requisite for candidates to PCI label

Starting from the second selection round, all projects candidating for a PCI label shall be part of the lastest available Union-wide TYNDP published before the selection. The submission of infrastructure projects to TYNDP will remain under the initiative and responsibility of promoters through an online questionnaire put in place by ENTSOG.
Such process ensures that the list of projects covered by ENTSOG is both transparent and non-discriminatory.

2.2. ESW-CBA as a major section of Union-wide TYNDP

The ESW-CBA methodology is to be used by ENTSOG in the development of its TYNDP. It is in fact a further development of the Supply Adequacy and Assessment chapters of TYNDP 2013-2022. As the Union-wide TYNDP covers more than the ESW-CBA and in order to facilitate the work of Project Promoters carrying out PS-CBA on the basis of ESW-CBA input data and result, a specific sections will identify:

- The input data for the PS-CBA
- The results of the assessment being the basis for the quantification approach of the PS-CBA

3. Data part of the ESW-CBA

This chapter identifies the data to be used in the ESW-CBA on the basis of the developed methodology. The results of the analysis are highly dependent on the input data set which in fact describe a very uncertain environment being the development of the gas market on the long term. It is therefore of crucial importance to build consensus on this dataset and to define the proper sensitivity-analysis.
The definition of exact input data is part of the task laying between the publication of this document on 16 November 2013 and the adapted methodology to be released Summer 2014.

3.1. Time Horizon

Both the set of input data and the assessment carried out within the ESW-CBA covers a 20-year time horizon starting from the year of analysis.

3.2. Demand and supply situation

In order to give the full picture of project potential impacts, the Economic Analysis is carried out under different climatic situations deriving from TSO best estimate. Considered situations are:

- Average Summer day as a proxy for the season
- Average Winter day as a proxy for the season

- High Daily Demand – 1-day Design Case to capture maximum transported quantity
- High Daily Demand – 14-day Uniform Risk to capture the influence of event duration on storages

These situations will ensure that the analysis captures the seasonality of load on gas infrastructures.

In order to reflect supply uncertainty, 3 Supply Potential scenarios are defined by source.
For each of the above demand situation and Supply Potential scenario a supply value will be defined at import route level.

3.3. List of input data

The below table gathers the definition of data on which the present ESW-CBA methodology is based. The process between the publication of this methodology and the final version of Summer 2014 may have some impact on the methodolody and the input data as a consequence. The absence of some of data identified in the following table may also result in the impossibility to apply part of the methodology.

Input data for the ESW-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		for Europe

4. Clustering of infrastructure

4.1. Definition of individual clusters

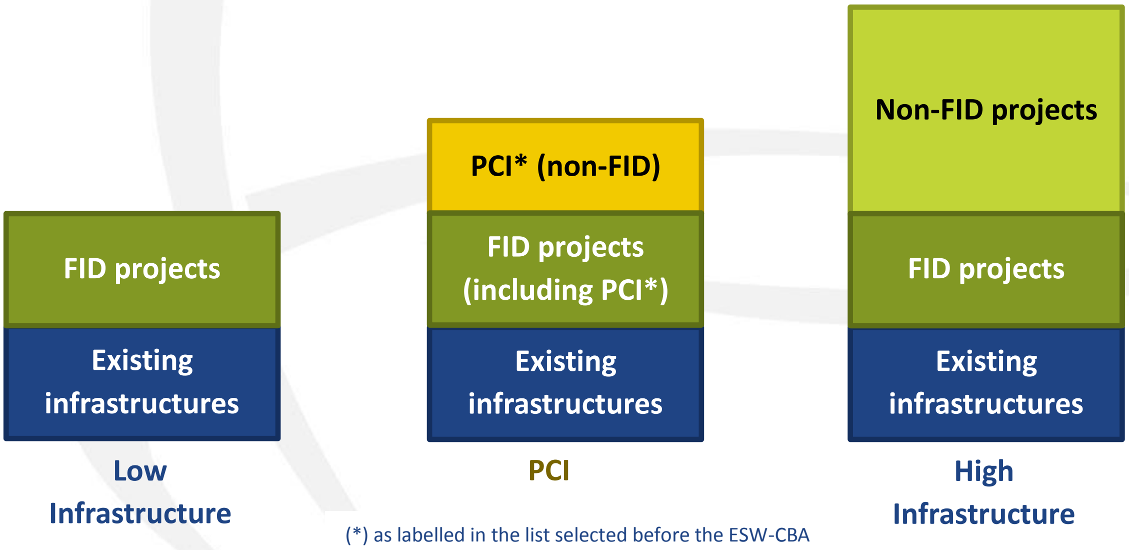
The FID status has been identified as the most robust parameter for clustering planned infrastructure projects within TYNDP. The implementation of Regulation introduces an additional transparent parameter being the granting of PCI label even if this criteria can only be defined after the selection.

4.2. Infrastructure scenarios

Based on the clusters defined above, the ESW-CBA is carried out on 3 infrastructure scenarios representing different level of project implementation being:

> Low Infrastructure Scenario: Existing Infrastructures + Infrastructure projects having a FID status (whatever their PCI status is)
> PCI Infrastructure Scenario (not used in the PS-CBA but used for feedback on previous selection): Existing Infrastructures + Infrastructure projects having a FID status (whatever their PCI status is) + label PCI according latest selection (not having their FID taken)
> High Infrastructure Scenario: Existing Infrastructures + Infrastructure projects having a FID status (whatever their PCI status is) + Infrastructure projects not having a FID status (whatever their PCI status is)

The following graphs illustrate the difference in the level of infrastructure development of each scenario:



The assessment of the European gas system under Low and High Infrastructure Scenarios will show different level of project interaction under high and low infrastructure development scenarios. These assessments shall be used by the Project Promoters as the basis of their incremental approach within the PS-CBA, capturing the marginal benefits of their projects under different assumptions in term of project commissioning.

The assessment of the European gas system under the PCI Infrastructure Scenario is used separately to measure the benefit that would result from a full implementation of the PCI list

resulting from the latest selection on top of FID projects. Its role is to provide a feedback loop to Regional Groups.
This assessment is not to be used by Project Promoters as part of their PS-CBA.

5. Approach of network/market modelling

5.1. Infrastructure-related market integration

Within TYNDP 2013-2022, ENTSOG has defined the infrastructure-related market integration as a physical situation of the interconnected network which, under optimum operation of the system, provides sufficient flexibility to accommodate variable flow patterns that result from varying market situations. In addition to its embedded value, market integration sustains the pillars of the European energy policy (Security of Supply, Competition and Sustainability). These four aspects define the specific criteria under this Regulation.
A thorough assessment of this infrastructure component of market integration shall be based on modelling in order to capture the network and market dimensions of the European gas system. These dimensions are not limited to capacity and demand but are strongly influenced by supply availability, source and price.

5.2. Rationales for the perfect market approach

When assessing the physical layer of market integration it is important to assume a well functioning commercial layer (e.g. full implementation of Network Codes). The consideration of market constraints (e.g. a minimum flow between 2 zones deriving from commercial arrangements) within the EU could lead to weak investment signals that bear the risk of future stranded assets.

5.3. Topology

ENTSOG has developed since 2010 a modelling approach based on a specific structure facing the need to consider simultaneously network and market dimensions.

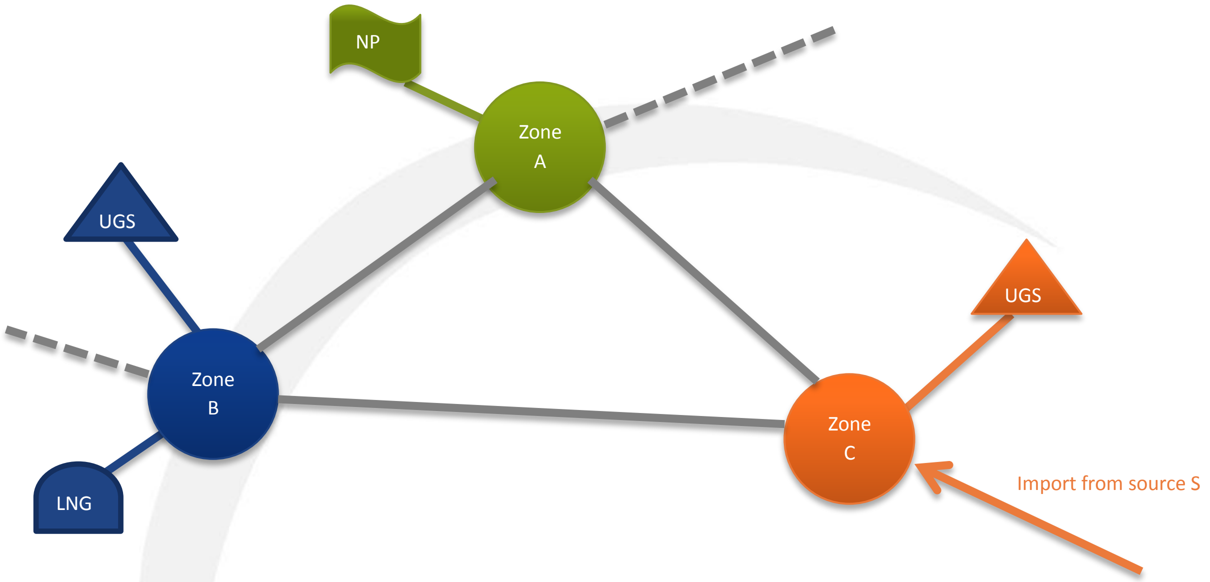
ENTSOG builds its model on the results of hydraulic simulations performed by TSOs using the methodology of the "Network Flow Programming[1]". The ENTSOG tool for simulating the European Gas Network combines the capacity figures obtained through hydraulic simulations with a common approach to the assessment of European supply and demand balance. When assessing the resilience of the European gas system, ENTSOG uses linear modelling of the market (based on energy) with:

- nodes representing Zones. Nodes are the points characterized by a certain demand, representing an off-take that the model tries to balance with supply
- arcs representing cross-border or hub-to-hub[2] capacity between nodes. Arcs are the

[1] Network Flow Programming is a methodology used in the Operational Research (study of logistic networks to provide for decision support at all levels). The term network flow program includes such problems as the transportation problem, the assignment problem, the shortest path problem, the maximum flow problem.
[2] In an entry/exit model, capacity of Interconnection Points between two same zones can be represented by a single hub-to-hub capacity without loss of physical information

paths carrying the gas from one node to another, characterized by a lower and an upper flow limit, defining the possible range for the calculated flows. The upper limit may represent a Supply Potential of a given source or the capacity of infrastructures.

Example of topology:



5.4. Functioning of the tool

The primary objective of the tool is to find a feasible flow pattern to balance supply and demand defined for the considered case whilst using the available system capacities defined by the arcs. Under a given set of assumptions (includingprices for each supply source), the tool supports the monetization of benefits resulting from the implementation of a project using the incremental approach.

The linear approach enables the NeMo tool to compute a great number of cases in a short time. This is a key advantage when considering that a robust assessment of Regulation criteria requires a consequent sensitivity-analysis in order to encompass the uncertainty of gas market development.

6. Economic Analysis

The analysis described in this chapter is carried out on the 3 Infrastructure Scenarios in order to assess the level of infrastructure-related market integration under different assumption of project commissioning. Results for the FID and Non-FID Scenarios also serve as a basis for the incremental approach to be applied by Project Promoters when carrying out their PS-CBA.

The Economic Analysis consists in the assessement of the Regulation criteria based on a combined approach:

> Quantitative Analysis through a list of indicators

> Monetary Analysis of project benefits

The matrix below illustrates the link between the Economic Analysis described in the present methodology and the specific criteria set by the Regulation (EC) 347/2013:

	Market integration	Security of supply*	Competition*	Sustainability*
Quantitative Analysis				
N-1 indicator from REG-994		X		
Import Route Diversification	X	X	X	
Potential Seasonal Balance	X	X		
Remaining Flexibility	X	X		
Supply Source Dependance		X	X	
Supply Source Diversification	X	X	X	
Price Convergence	X		X	
Monetary Analysis				
CO2 emission				X
Power generation				X
Disruption		X		
Gas supply cost	X		X	

(*): as part of the pillars of the European Energy Policy

6.1. Definition of flow patterns

The ESW-CBA will use modelling to define flow patterns under various cases in order to enable both the calculation of some indicators and the monetization of some benefits.
For each Infrastructure Scenario and each year of the time horizon, a flow pattern will be defined for each of the below cases:

Demand situation	Supply mix	Supply stress
Average Summer day	Reference	No
		Disruptions
	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
		Disruptions
	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
		Disruptions
	LNG price > Pipe gas price	No
	Pipe gas price > LNG price	No
1-day Design Case	Reference	No
		Disruptions
	LNG price > Pipe gas price	No
	Pipe gas price > LNG price	No

> Supply mixes:

- Reference: zero spread between LNG and gas pipe sources, each supply source share is defined according the 3 years situation before the year of analysis (each supply source is limited by its Intermediate Potential Scenario)
- LNG price > Pipe gas price: spread to be defined with stakeholders during the TYNDP consultation process first half of 2014 (LNG is limited by its Minimum Potential Scenario and pipe gas sources are limited by their Maximum Potential Scenarios)
- Pipe gas price > LNG price: spread to be defined with stakeholders during the TYNDP consultation process first half of 2014 (LNG is limited by its Maximum Potential Scenario and pipe gas sources are limited by their Minimum Potential Scenarios)
- Targeted Maximization: each source is pushed one-by-one up to its Maximum Potential Scenario in order to maximize its share in each Zone one-by-one
- Full Minimization: each source is reduced to the minimum necessary to balance all Zones

The modelling approach is able to consider more detailled differences in the price of sources and/or entry point into EUin order to better capture the economical aspect of supply. This is possible if such price data are available and a consensus exists on their use.

> Supply stress:

The different situations will have to be defined during the TYNDP consultation process first half of 2014. The basis for discussion is the list of disruptions as defined in TYNDP 2013-2022:

- Disruption of Russian transit through Ukraine
- Disruption of Russian transit through Belarus
- Disruption of Langeled between Norway and UK
- Disruption of Franpipe between Norway and France
- Disruption of Transmed between Algeria and Italy
- Disruption of MEG between Algeria and Spain

- Disruption of Azeri gas supply

The supply stress for LNG is covered by the “full minimization of LNG supply” and the “LNG prices above Pipe gas prices”.

6.2. Quantitative Analysis

This part of the analysis aims at providing a view of the level of infrastructure-related market integration through the calculation of numerical indicators. All indicators are calculated for:

> each Zone (country for the N-1 indicator)
> each year of the time horizon
> each Infrastructure Scenario

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.

6.2.1. Capacity Based Indicators

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

6.2.1.1. Import Route Diversification index

This indicator captures the diversification of 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.

6.2.1.2. N-1 Infrastructure Standard Indicator on regional level

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

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

where

- The optimal value of such an indicator should be N-1 ≥ 100%
- ***IP:*** technical capacity of entry points (in mcm/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 (in mcm/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 (in mcm/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 (in mcm/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 Action Plan, according to Regulation 994/2010 concerning the measures to safeguard security of supply.
- D_{max} means the total daily gas demand (in mcm/d) of the calculated area during a day of exceptionally high gas demand occurring with a statistical probability of once in 20 years.

6.2.1.3. Seasonal capacity balance indicators

These indicators capture the potential excess or 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 capacity surplus, resulting in possible volume surplus to be allocated across borders[3].

a) Summer Average Capacity Balance

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

b) Winter average Capacity balance

$$\frac{Min(EX \quad ; NP \quad + \frac{N-1}{N} * IMP \quad + LNG \quad + \text{WITH} - \text{Dwa})}{\text{Dwa}}$$

c) Design (case) Capacity Balance

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

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

6.2.2. 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.

6.2.2.1. 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

[3] Assuming a load factor of 100%

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).

6.2.2.2. 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).

6.2.2.3. 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:

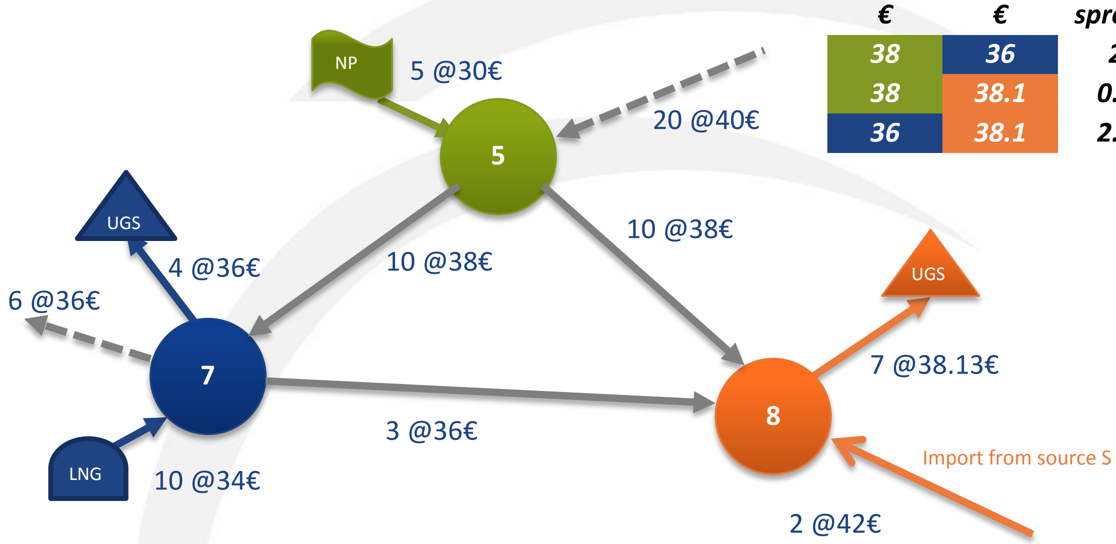
$$SSDIV = \sum_{i}^{maximized\ source} if(x_i > 5\%; 1)$$

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.

6.2.2.4. 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.

The below example illustrate such calculation:



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

6.3. Monetary Analysis

This part of the analysis aims at providing a monetization of infrastructure-related market integration under each Infrastructure Scenario. The monetization is done per type of benefit and for each country. This approach requires prices per source and/or per import route which are still to be defined based on recognized references (e.g. WEO of IEA) considering that sensitivity-analysis will be further applied.

The below cost will be calculated under all Reference Cases and LNG vs. pipe gas cases to serve as a basis of the saved cost approach of the PS-CBA:

- CO2 emission and power generation
- Disruption
- Gas supply

6.3.1. Monetization of CO2 emission and power generation cost

Compared to TYNDP 2013 topology, an enhanced topology will enable the reflection of:

- The elasticity of gas demand for power generation
- The use of the different fuel for power generation

> The CO2 emissions

The enhanced topology is based on:

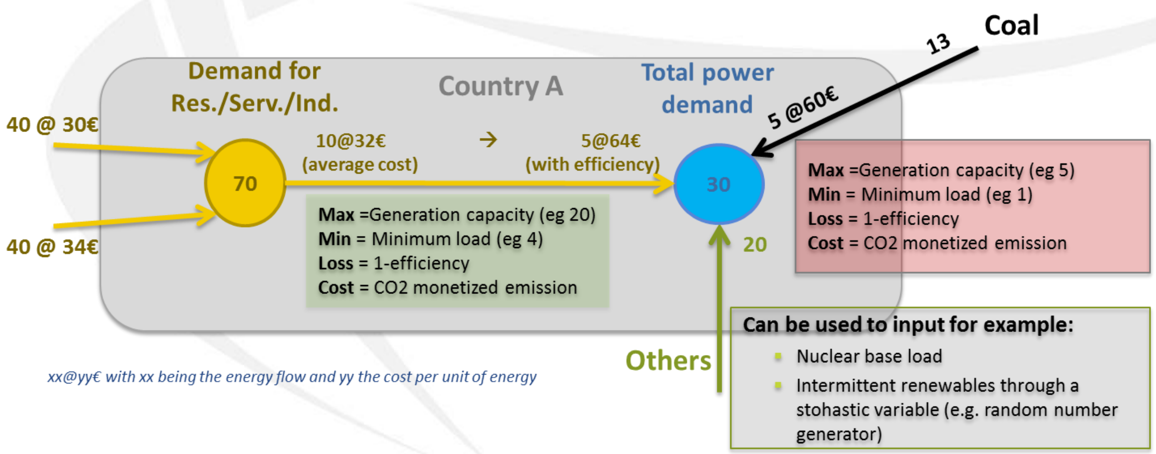
- A node per fuel for power generation other than gas (fuel-node)
- A node per gas balancing zone representing the associated power load (load-node)
- An origin arc entering each fuel-node where the cost per transported unit stands for the price of the fuel
- An arc between each load where:
  - The upper value stands for the generation capacity
  - The lower value stands for the technical minimum use of the generation capacity
  - The loss factor stands for 1 minus the efficiency of the generation capacity

  The cost per transported unit stands for the CO2 emission factor multiply by the cost of one unit of CO2

Therefore the model will define the optimum use of each fuel for power generation taking into account:

- the price of each fuel
- the CO2 price
- the efficiency of each fuel
- the emission factor of each fuel

The below schema illustrate such functioning:

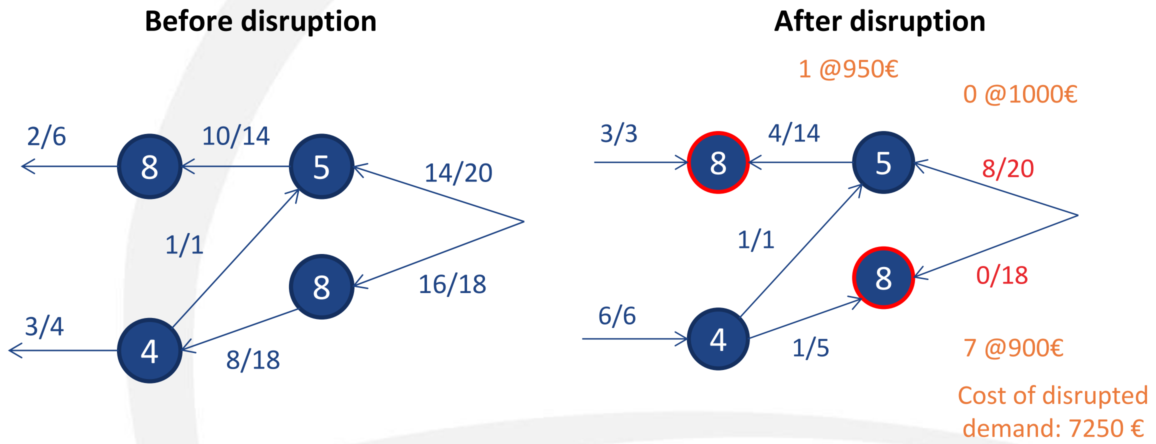


The objective function of the tool will give a monetary value of the CO2 emission and power generation mix for the modelled case. An ex-post calculation will provide these information per country.

6.3.2. Monetization of disruption

The following methodology only applies in case the cost of disruption per unit of energy is provided by each Member State.
Based on such input data and compared to TYNDP 2013 topology, an enhanced topology will enable the monetization of the disruption of a given amount of gas demand. In case the cost of disruption of one unit of demand varies from one country to the other, the tool will also enable the minimization of the total cost of a disruption at European level.

The enhanced topology is based on the introduction of one origin arc per balancing zone. The cost per transported unit through this arc stands for cost of disrupted unit of demand for the given zone.



Therefore the model will define the optimum flow pattern which minimize the cost of disruption for Europe. An ex-post calculation will provide the cost of disruption for each country.

6.3.3. Monetization of gas supply cost

Using TYNDP 2013 topology, the introduction of a cost of gas for each supply source (potentially different for each import route) will enable the tool to define a supply cost for each country and each modelled case. The evolution of this cost than feed the PS-CBA incremental approach.
An illustration of this process is given under the explanation of the Price Convergence indicator.

7. Sensitivity Analysis

The results of the Economic Analysis may give the impression of a very deterministic evolution of the infrastructure-related market integration if attention is not paid to the full picture and the link to the input dataset.

A sensitivity-analysis will be carried out on key input data as a way 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 will be tested one-by-one. The following table defines the data to be analysed and the variation to be considered:

Data	Positive variation	Negative variation
Demand under 1-day Design Case	+5%	-5%
Demand under 14-day Uniform Risk	+5%	-5%
Demand under Average Winter Day	+5%	-5%
Demand under Average Summer Day	+5%	-5%
Fuel and CO2 prices (together)	450 ppm scenario	Current policies scenario

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

Doing this analysis at the ESW-CBA level will facilitate the sensitivity-analysis within the PS-CBA for each Project Promoter.

8. Continuous enhancement process

8.1. Union-wide TYNDP consultation process

The present methodology is based on the experience of TYNDP 2013-2022 and the feedback received on this report and the Cost-Benefit Analysis consultation process. It is consistent with the accompanying PS-CBA methodology to be published on 16 November 2013.
As ESW-CBA and TYNDP are deeply interlinked, the present methodology will evolve based on:

- TYNDP 2015 Stakeholder Joint Working Session process first half of 2014
- Formal opinion of ACER, Commission and Member States on the Cost-Benefit Analysis methodology published by ENTSOG on 16 November 2013.

The resulting methodology will constitute the backbone of TYNDP 2015 and will serve as a basis for the second PCI selection process and associated PS-CBA.
Based on ENTSOG experience of the first 3 TYNDPs, the main challenge of the phase between 16 November 2013 and the release of the adapted CBA methodology in Summer 2014 will be the definition of the input data set. It needs to be comprehensive in order to ensure the applicability of the methodology, to create consensus in order to have an undisputed selection and finally this set should also capture the uncertainty of gas market development.

8.2. Consistence between ESW and PS CBAs

During the above evolution process, the consistence between the two methodologies will be maintained in order to ensure easy application by the Project Promoters and interpretability by Regional Groups.