European Union / Instrument for Pre-Accession (IPA) Energy Sector Technical Assistance Project

This project is co-financed by the European Union and the Republic of Turkey

EU IPA13/CS-02.a
2013 ENERGY SECTOR PROGRAM
PHASE-2 PROJECT

Energy Market Development

Network Development Plan Training

6-8 August 2019

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MRC GROUP OF COMPANIES ECCO INTERNATIONAL INC. Energy Consulting eXergia

REPUBLIC OF TURKEY MINISTRY OF ENERGY AND NATURAL RESOURCES

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Network Development Plan Training

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MRC Consultants and Transaction Advisers

Day 2

Module 3. Economic Cost Benefit Analysis in Natural Gas Projects

7 August 2019

Module 3. Economic Cost Benefit Analysis in Natural Gas Projects

Basic principles of economic Cost Benefit Analysis (CBA)

Benefits Analysis in Natural Gas projects

ENTSOG CBA Methodology of Natural Gas Infrastructure Projects

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Basic principles of CBA I

Cost-Benefit Analysis (CBA) is an analytical tool for judging the economic advantages or disadvantages of an investment decision by assessing its costs and benefits in order to assess the welfare change attributable to it.

The analytical framework of CBA refers to a list of underlying concepts:

1. Opportunity cost.
2. Performance indicators expressed in monetary terms.
3. Microeconomic approach.
4. Incremental approach.

Basic principles of CBA II

Opportunity cost: potential gain from the best alternative forgone, when a choice needs to be made between several mutually exclusive alternatives.

- The rationale of CBA lies in the observation that investment decisions taken on the basis of profit motivations and price mechanisms lead, in some circumstances (e.g. market failures such as asymmetry of information, externalities, public goods, etc.), to socially undesirable outcomes.
- On the contrary, if input, output (including intangible ones) and external effects of an investment project are valued at their **social opportunity costs**, the return calculated is a proper measure of the **project's contribution to social welfare**.

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Basic principles of CBA III

Calculation of economic **performance indicators expressed in monetary terms**.

- CBA is based on a set of predetermined project objectives, giving a monetary value to all the positive (benefits) and negative (costs) welfare effects of the intervention.
- These values are discounted and then totalled in order to calculate a net total benefit. The project overall performance is measured by indicators, namely the **Economic Net Present Value (ENPV)**, expressed in monetary values, and the **Economic Rate of Return (ERR),** allowing comparability and ranking for competing projects or alternatives.

Basic principles of CBA IV

Microeconomic approach. CBA is typically a microeconomic approach enabling the assessment of the project's impact on society as a whole via the calculation of economic performance indicators and expected welfare changes.

- Direct employment or external environmental effects realised by the project are reflected in the ENPV, indirect and wider effects (i.e. on public funds, employment, regional growth, etc.) should be excluded because:
  - need to limit the potential for benefits double-counting, most indirect and/or wider effects are usually transformed, redistributed and capitalised forms of direct effects,
  - there remains little practice on how to translate them into robust techniques for project appraisal, thus the need to avoid the analysis relies on assumptions whose reliability is difficult to check.
- It is recommended, however, to provide a qualitative description of these impacts to better explain the contribution of the project to the policy goals.

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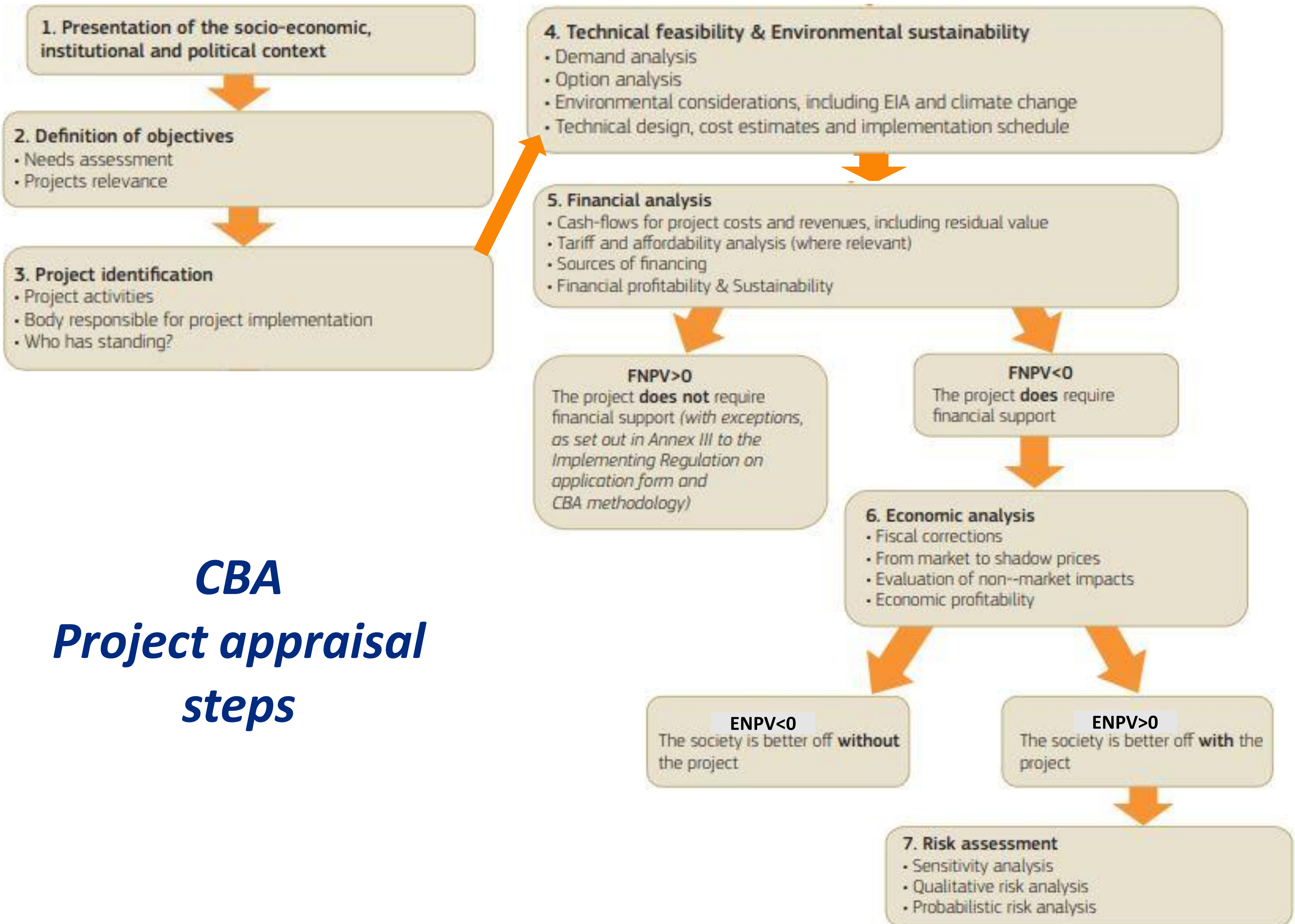
Basic principles of CBA V

Incremental approach: CBA compares a scenario with-the-project with a counterfactual baseline scenario without-the-project. The incremental approach requires that:

- **A counterfactual scenario** is defined as what would happen in the absence of the project. For this scenario, projections are made of all cash flows related to the operations in the project area for each year during the project lifetime.
- Projections of cash-flows are made for the situation with the proposed project.
- CBA considers the difference between the cash flows in the with-the-project and the counterfactual scenarios.

CBA Project appraisal steps



Source: Guide to CBA of Investment Projects, EC (2014)

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Benefits Analysis in NG projects I

Economic Benefit Description	Indicative Outline Approach to Monetization
Supply source diversification A project that enables gas imports from a new supply **source** diminishes the negative impact of a disruption in existing import sources	The benefit can be calculated on the basis of: i. annual probability of a specific source disruption (%) ii. (duration of the disruption (days) iii. the gas volume that is disrupted or the gas volume supplied by the new source (GWh), whichever is lower and iv. the value of gas to the economy (€/ GWh)
Supply route diversification A project that enables gas imports from a new supply **route** (either piped or LNG) diminishes the negative impact of a disruption in existing import routes (NTS entry points)	The benefit can be calculated on the basis of: i. annual probability of a specific route disruption (%) ii. duration of the disruption (days) iii. the gas volume that is disrupted or the gas volume supplied by the new route (GWh), whichever is lower and iv. the value of gas to the economy (€/ GWh)

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Benefits Analysis in NG projects II

Economic Benefit Description	Indicative Outline Approach to Monetization
Improved security of supply A gas project in the NTS (pipeline replacement/ new pipeline/ storage etc.) that diminishes the probability of a disruption in the transportation of gas through NTS	The benefit can be calculated on the basis of: i. reduction in annual probability of NTS disruption (%) ii. duration of the disruption (days) iii. the gas volume that is disrupted (GWh) iv. the value of gas to the economy (€/ GWh
Reduction in gas supply costs A project that enables gas-to- gas competition i.e. gas supply at lower cost (purchase price, transit costs, etc.)	The benefit can be calculated on the basis of: i. gas supply through the new project (GWh) ii. difference in gas costs for accommodated demand, before and after the project (€/ GWh)

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Benefits Analysis in NG projects III

Economic Benefit Description	Indicative Outline Approach to Monetization
Reduction in energy costs A project that enables gas to substitute other energy sources (coal, oil, etc.)	The benefit can be calculated on the basis of: i. fuel supply substituted by gas as a result of the project (GWh) ii. difference in unit costs between gas and the substituted fuel (€/ GWh)
Improved energy efficiency A gas project that reduces system losses	The benefit can be calculated on the basis of: i. efficiency gain (%) ii. system losses (GWh) iii. the price of gas (€/ GWh)
Reduction in GHG emissions project that enables substitution of other energy sources (coal, oil, etc.) by gas	The benefit can be calculated on the basis of: i. fuel supply substituted by gas as a result of the project (GWh) ii. difference in GHG emissions between gas and the substituted fuel (tons/ GWh) iii. shadow/ target price of GHG emissions reflecting economic cost of emissions (€/ GWh)

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Benefits Analysis in NG projects IV

- Supply Source Diversification.
- Supply Route Diversification.
- Improved security of supply.
- Reduction in gas supply costs.
- Reduction in energy costs.
- Improved energy efficiency.
- Reduction in GHG emissions.

Modules 4 and 5 explain how to monetize these benefits and related indicators
Simulation Exercises will be focused on the quantification of these benefits

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ENTSOG CBA Methodology

- According to the Regulation (EU) No. 347/2013 ENTSOG has the task to develop a CBA methodology for Energy System wide analysis to support the PCI selection process.
- The first Cost-Benefit Analysis methodology, approved by the European Commission in February 2015, has been applied to the TYNDP 2015 and 2017 and the subsequent 2nd and 3rd Project of Common Interest (PCI) selection processes.
- Based on this experience, and taking into consideration the feedback received from stakeholders, ENTSOG has updated and improved the Cost-Benefit Analysis methodology.
- The 2nd CBA methodology takes into account related opinions from ACER and the EC as well as the findings of the gas CBA study mandated by the EC.

The objective of ENTSOG CBA methodology is to provide guidelines to be applied for the analysis of projects and more generally of the overall gas infrastructure

ENTSOG CBA Methodology

Key elements of ENTSOG CBA methodology are:

- Assessment Framework: Scenarios, Network and Market Modell Assumptions and Inputs.
- System assessment and identification of infrastructure gaps.
- Project specific assessment: benefits, costs, indicators…

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ENTSOG CBA Methodology: assessment framework I

Scenarios

The assessment framework must be in line with the provision of Annex V(1) of the Regulation, which requires that the input data set represents years "n+5, n+10, n+15, and n+20 where n is the year in which the analysis is performed".

ENTSOG TYNDP 2018 scenarios

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Source: ENTSOG TYDNP Methodology (2018)

ENTSOG CBA Methodology: assessment framework II

Network and Market Modelling Assumptions

Network and market modelling are necessary for system and project assessment. This can be performed with different modelling tools (software). Additionally, network modelling and market modelling may be performed with either the same tool, or possibly with different tools. The modelling tool must allow for the calculation of the different CBA indicators. Specific information on modelling used for developing TYNDP must be made publicly available as part of the TYNDP development process.

- A robust assessment framework must have a sufficient accurate representation of the gas infrastructure, both in regard to the existing infrastructure and to its possible evolution. **Topology of the gas infrastructure:** existing and projects
- **Market assumptions:** Infrastructure tariffs, gas supply prices, Long-term supply contract

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ENTSOG CBA Methodology: system assessment I

The analysis at system level allows to verify whether the system is already able to cope with the future challenges, or whether further development of the infrastructure is still required to support the completion of the internal energy market and to achieve the climate and energy policies.

To identify the infrastructure gaps is important to define before:

- The **threshold value** beyond which an infrastructure gap does not exist or is less relevant;

  As an example, in case of an indicator measuring how projects solve or mitigate demand curtailment, the minimum threshold to be considered is 100%. In this case, below this threshold the demand cannot be fully satisfied, resulting in an infrastructure gap that can be solved or mitigated by the realisation of one or more projects.

- The level of the grid in place (**infrastructure level**) to be considered as a reasonable counterfactual situation on which to assess the system and identify possible infrastructure gaps.

  An infrastructure level is defined as the potential level of development of the gas network system. It represents the level of infrastructure assumed being in place along the considered analysis time horizon. Therefore, the identification of infrastructure gaps and the need for further development are strictly dependent on the definition of the infrastructure level.

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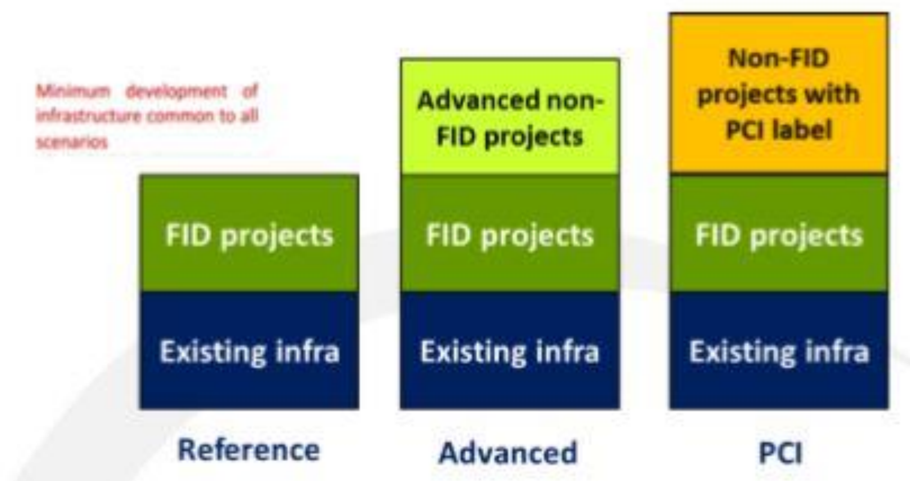
ENTSOG CBA Methodology: system assessment II

When applying the CBA methodology, additional infrastructure levels may be considered for the analysis of the European system and of the projects' impact and to ensure adequate comparison.

- It is recommended to perform a system assessment with the Advanced infrastructure level (including existing infrastructure and project with FID and Advanced status). This should be compared to the one based on the reference grid, ensuring an incremental approach for the overall cluster of projects with Advanced status;

  This may be complemented by the assessment of the European gas system under a PCI infrastructure level gathering all the projects of the prevailing PCI list, although it includes projects of very different maturity.



The reference grid and the Advanced infrastructure level should be used as common basis for all project-specific CBAs.

Source: ENTSOG 2nd CBA Methodology (2018)

ENTSOG CBA Methodology: Project-Specific Assessment I

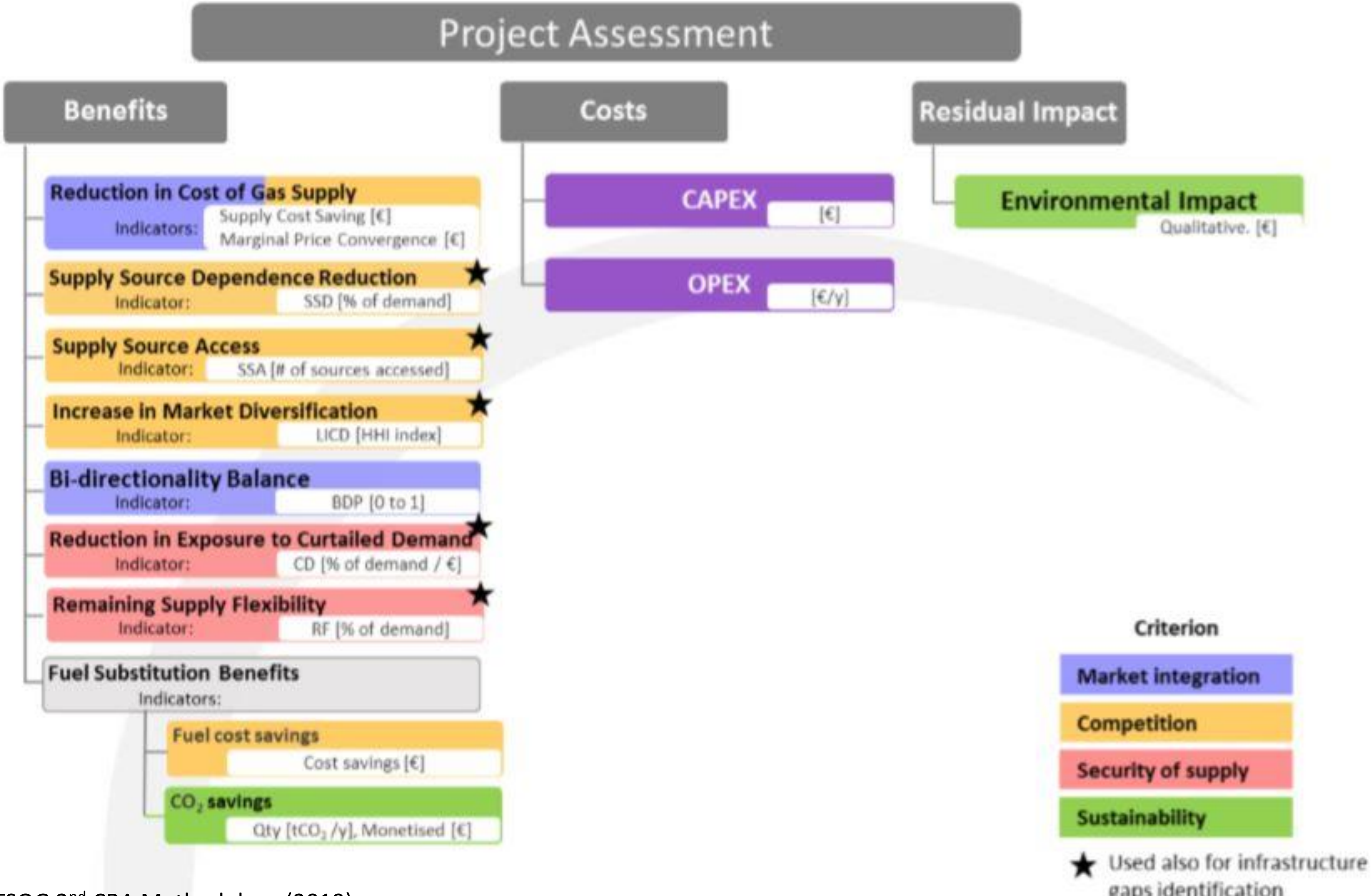
The ENTSO-G CBA methodology combines monetary elements pertaining to the CBA approach, as well as non-monetary and/or qualitative elements referring to the Multi-Criteria Analysis (MCA) approach.

Project-specific assessment is performed as part of the TYNDP process, as this allows for:

- The assessment of projects on a comparable basis;
- Consistent results to be provided to promoters;
- High transparency towards stakeholders on the projects assessment.

ENTSOG CBA Methodology: Project-Specific Assessment II

Projects Benefits: 4 main criteria (**Market integration, security of supply, competition and sustainability).** All projects should be assessed against these criteria.



Source: ENTSOG 2nd CBA Methodology (2019)

ENTSOG CBA Methodology: Quantification and monetisation of benefits

- The definition of a common set of project assessment metrics ensures the comparability between projects and reflects in an aggregated form their impact along the different policy criteria identified by the Regulation.
- These metrics should be analysed altogether not giving undue priority to one of them.
- When it comes to monetisation, attention should be paid to potential double counting of benefits.
- **Monetisation should only be performed when reliable monetisation is ensured, to avoid nonrobust conclusions when comparing monetised benefits to project costs**

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ENTSOG CBA Methodology: Indicators I

Supply cost savings. This indicator is meant at capturing the benefits stemming from projects reducing the overall cost of gas supply. The monetary analysis of the cost of gas supply is based on the calculation of the gas bill in the situation with and without the project. The benefits are calculated according to the following formula.

$$\text{supply cost saving} = \sum_{1}^{n} (S_1^n * C_1^n) \text{ with project} - \sum_{1}^{n} (S_1^n * C_1^n) \text{ without project}$$

Where:

- S_1^n represents the supply
- C_1^n represents the cost of the gas supply[19], including the price of the gas delivered at the Europe borders and the tariffs (the latter when considered in the assessment)

Supply Source Dependence (SSD). The SSD indicator aims at identifying countries showing a strong dependence to a specific supply source and allows to identify cases where this dependence is related to an infrastructure bottleneck (physical dependence).

$$SSD_{Z,S} = \frac{DC_{Z,S}}{Demand_Z}$$

Where:

- $DC_{Z,S}$ is the demand curtailment (in GWh) in Z when S is not available
- $Demand_Z$ is the demand of Z (in GWh)

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ENTSOG CBA Methodology: Indicators II

The Supply Source Access indicator (SSA) measures the number of supply sources an area can access. The ability of an area to access a given source is measured through a supply source diversification metric. SSA provides the aggregate view across all supply sources.

LNG and Interconnection Capacity Diversification (LICD) This indicator intends to look at the diversification from the perspective of market integration. It measures the diversification of paths that gas can flow through to reach a market area. The LICD is an HHI indicator and ranges from 0 to 10.000. The lower the value, the better the diversification is. Where a market would have two borders the LICD cannot be lower than 5000. For a market having three borders the LICD cannot be lower than 3333.

$$\text{LICD} = \left(\frac{\text{LNG border}}{\text{Total Capa border}} * 100\right)^2 + \sum_{1}^{\text{N borders}} \left(\frac{\text{Capa border}_1}{\text{Total Capa border}} * 100\right)^2$$

Bi-Directionality Measuring the bi-directionality of capacities is an indication of the physical integration of markets. The indicator is only to be calculated as part of project assessment and can by nature only be calculated for transmission projects. It is calculated as the ratio between Added capacity at IP to other direction and Existing capacity in prevailing direction

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ENTSOG CBA Methodology: Indicators III

Single Largest Infrastructure Disruption (SLID) or N-1 Indicator. describes the ability of the gas system to meet the daily peak demand in case of interruption of the main import infrastructure.

$$N-1 = \frac{IP + NP + UGS + LNG - I}{D_{max}} \times 100$$

IP: Sum of Entry interconnections capacity.
NP: National production
UGS: Underground Storage withdrawal capacity
LNG: regasification capacity
I: Single Largest Infrastructure Entry capacity

Remaining Flexibility (RF) The remaining flexibility aims at capturing the extra supply flexibility a country can access through its infrastructure.
A zero value would indicate that the country is not able to fulfil any additional demand and a 100% value would indicate that it is possible to supply twice the level of the demand.

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ENTSOG CBA Methodology: Curtailment Demand

Curtailment Demand (CD) The analysis should allow to identify where projects provide benefits coming from mitigating possible demand curtailment. Identification of demand curtailment risk should be performed individually for:

- Normal (climatic) conditions
- Climatic stress conditions, in case of extreme temperatures with lower probability of occurrence than normal conditions (e.g. occurring with a statistical probability of once in 20 years, 1/20);
- Supply stress conditions, in case of supply stress due to specific route disruptions (e.g. Russian transit trough Ukraine);
- Infrastructure stress conditions, in case of disruption of the single largest infrastructure of a country.

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ENTSOG CBA Methodology: Monetisation of the avoided demand curtailment

The benefit of avoided demand curtailment should be monetized as follows.

Avoided Curtailed Demand [volume] * CoDG [EUR/volume]

- Avoided Curtailed Demand is the difference (in GWh) between the curtailed demand without the project and the resulting curtailed demand (if still any) after the project implementation;
- CoDG is the "Cost of Disruption of Gas Supply" (EUR/GWh).

The CoDG value cannot be observed on a market and needs to be calculated. Different approaches can be considered in view of calculating CoDG:

- Standardized EU-level CoDG, this ensures comparability and harmonised assessment of projects. For TYNDP 2017 ENTSOG used **600 EUR/MWh**
- Differentiated CoDG values, that may take into consideration elements such as country, type of users/consumers and duration of the curtailment. Macroeconomic approach that consists in calculating the social cost of avoided unserved energy by dividing the annual gross value added (GVA) by the annual volume of energy

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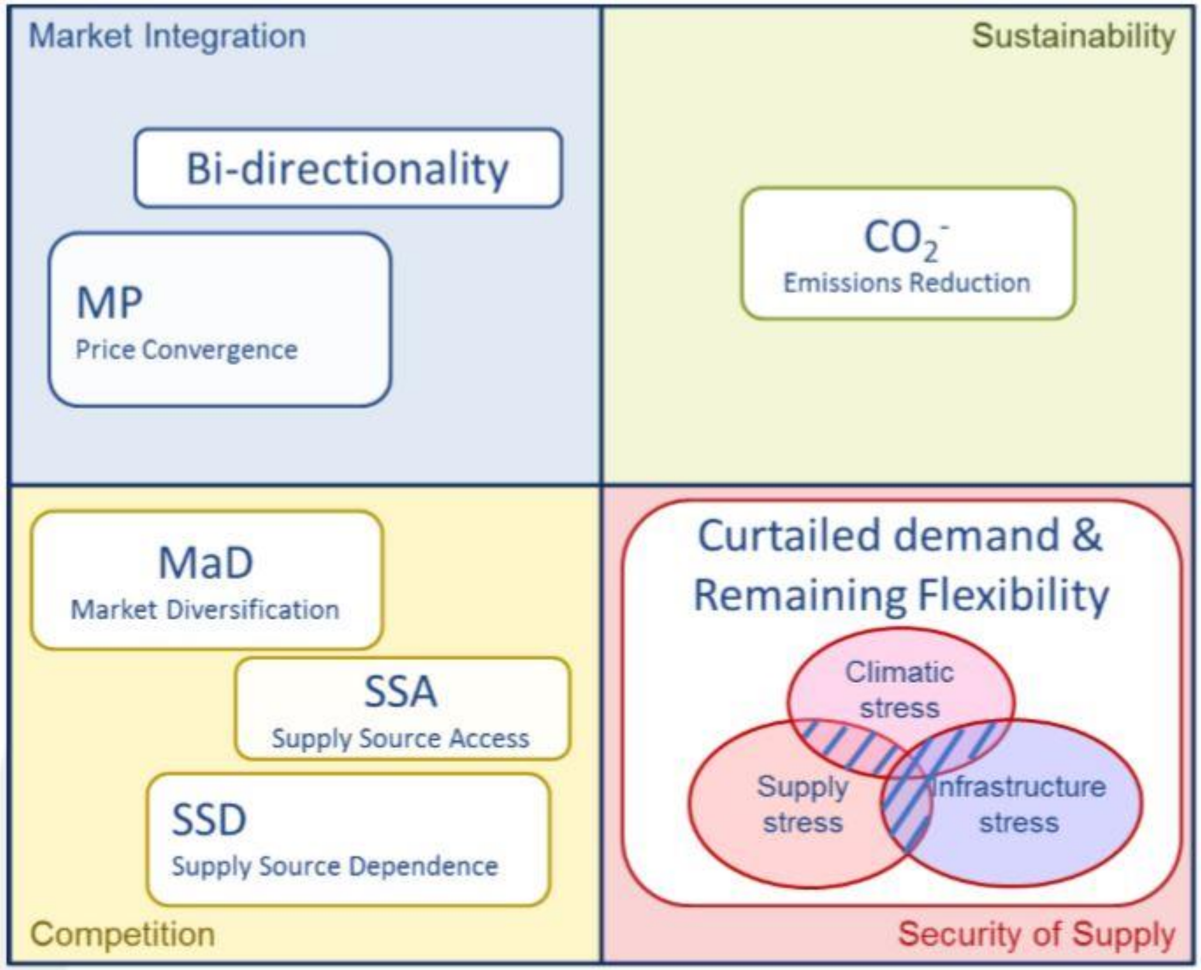
ENTSOG CBA Methodology: Substitution effect

Reduction of CO2 emissions This indicator measures the benefits related to CO2 savings of the following types of projects:

- A project allowing to lift isolation of areas not previously connected to gas, or allowing further use of gas;
- A project allowing a switch from coal (or oil) to gas for power generation;
- A project replacing or modernising an existing infrastructure in order to increase its efficiency.

Fuel cost saving; benefits come from replacement of more expensive alternative fuels with gas, which supports market competition.

ENTSOG CBA Methodology: Recap of indicators



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Source: ENTSOG 2nd CBA Methodology (2019)

ENTSOG CBA Methodology: Project Costs

Investment costs are classified by:

Capital expenditure (CAPEX)

- initial investment cost, that corresponds to the cost effectively incurred by the promoter to build and start operation of the gas infrastructure. CAPEX should consider the costs of obtaining permits, feasibility studies, obtaining rights-of-way, ground work, preparatory work, designing, dismantling, equipment purchase and installation
- replacement costs, are the costs borne to ensure that the infrastructure remains operational by changing specific parts of it.

Operational and maintenance expenditure (OPEX), corresponds to costs that are incurred after the commissioning of an asset and which are not of an investment nature, such as direct operating and maintenance costs, administrative and general expenditures, etc.

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ENTSOG CBA Methodology: Balance between costs and benefits

Economic Performance Indicators are based on project costs as well as the part of the benefits that are monetised. The CBA methodology builds on Multi-Criteria Analysis, on the ground that not all benefits of projects can be monetised. For this reason, Economic performance indicators, and in particular **Economic Net Present Value**, only represent a part of the balance between project costs and benefits.

The ENPV is the difference between the discounted monetised benefits and the discounted costs expressed in real terms for the basis year of the analysis (discounted economic cash-flow of the project). The ENPV reflects the performance of a project in absolute values and it is considered the main performance indicator.

$$\mathrm{ENPV} = \sum_{t=f}^{c+24} \frac{B_t - C_t}{(1+r)^{t-n}}$$

Where:

- ***c*** is the first full year of operation
- B_t is the monetised benefits (SEW) induced by the project on year *t* (this includes the Residual Value at the end of the project economic lifetime, when considered)
- C_t is the sum of CAPEX and OPEX on the year *t*
- ***n*** is the year of analysis (common for all projects)
- ***r*** is the Social Discount Rate of the project
- ***f*** is the first year where costs are incurred

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

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ENTSOG CBA Methodology: Sensitivity analysis

Sensitivity analysis enables the identification of those elements most affecting the performance of projects. Critical factors can be divided in the following categories:

Sensitivity on gas market factors,

- demand evolutions
- renewables penetration
- commodity and CO2 prices
- supply potentials

Sensitivity on project-specific data, that should be reflected in the project-specific assessment:

- commissioning year,
- investment and operating expenditures costs
- tariffs for projects

Sensitivity on monetary parameters directly impacting the calculation of the monetised benefits and Economic performance indicators:

- social discount rate
- value for the cost of disruption of gas supply (CoDG)
- Sensitivity on supply prices, associated to minimization and maximization of the considered supply sources, with the intention to measure potential temporary price situations of one supply source and to evaluate the impact of a project allowing this benefit to spread over Europe

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Module 3. Key Takeaways

- Understanding the general principles of CBA analysis.
- Identification of main benefits related with Gas infrastructure projects.
- Comprehension of ENTSOG CBA methodology as a reference for Network Development planning and projects assessment.
- Main indicators used in CBA of Gas projects.
- Identification of possible sensitive analysis.

To better understand the use of indicators and sensitive analysis in CBA of gas projects

Simulation exercise in Module 4

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Thanks for your attention

Questions & Answers Time

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