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Cost-benefit analysis for gas-infrastructure projects

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Highlights

- To reinvigorate the building of new gas infrastructure in Europe, the European Union has introduced 'projects of common interest' (PCI) in its Energy Infrastructure Package. These PCIs will be evaluated and selected on the basis of systematic cost-benefit analysis (CBA), a method that is novel for the European gas industry. A consistent gas-CBA method has to be designed by ENTSOG, who published a preliminary draft method for public consultation on 25 July 2013, followed by a formal draft CBA method on 15 November 2013.

- This Florence School brief summarizes our findings and recommendations for improvement of the CBA method.

- The time horizon of the CBA can be controversial. Projects can be evaluated against different time horizons and these horizon options affect the relative ranking of the projects. A single reference point for 20-25 years is best practice for the time horizon for infrastructure projects and should be used for gas CBA.

- Project interaction affects the net economic benefits of projects that are complementary or competing with other proposed infrastructure projects. Identification of interaction can be treated within the gas-CBA method, providing important information for ranking individual or clustered projects.

- The monetization model can and must be internally consistent with regard to physical and commercial relations that govern the European gas system. The model output needs to be aligned with a reduced list of significant effects and the model input needs to be monitored.

- Ranking should be primarily based on the monetization with transparent adjustments where justified; ENTSOG should provide guidance to the Regional Groups on how the CBA method has been conceived for selecting projects.

Context of cost-benefit analysis

It is estimated that over 70 billion euro will need to be invested in large-scale gas-infrastructure projects in Europe in the next decade. While an industry-wide consensus on this need exists, the European authorities observe that many projects are at risk of not being realized by the 2020 horizon due to several investment barriers. To help investors overcome these barriers and to reinvigorate the development of trans-European energy networks, the EU adopted – as part of a larger Energy Infrastructure Package – a revised Regulation on trans-European infrastructure.

The Regulation foresees identifying and selecting 'projects of common interest' (PCI) through a multi-stage process as follows. Project promoters nominate a gas-infrastructure project to one of four Regional Groups that reflect the priority corridors established by the European Commission. The nominated projects are subsequently evaluated and selected by the Regional Groups on the basis of a cost-benefit analysis (CBA). In a final step, the regional lists of PCIs are then merged into a union-wide list adopted by the Commission.

The evaluation and selection of PCIs based on a systematic cost-benefit analysis of gas-infrastructure projects is a method that is novel in the European gas industry in terms of its scale and purpose. ENTSOG has made a first effort to design a consistent and comprehensive CBA method. In the following steps of this long design process, ACER, the Commission and the Member States will extensively review the proposed method before it is adopted by the Commission.

This brief is then taking stock of the draft method published by ENTSOG, existing best practices in gas-infrastructure project evaluation and Florence School of Regulation's framework for systematically reviewing CBA methods.[1] It presents recommendations on four areas in the gas-CBA method that are potentially controversial: (1) the time horizon of the CBA, (2) project interaction, (3) monetization models and (4) ranking of the projects.

1. Meeus, L., von der Fehr, N.H., Azevedo, I., He, X., Olmos, L., Glachant, J.M., 2013. Cost Benefit Analysis in the Context of the Energy Infrastructure Package. Florence School of Regulation Policy Brief, Issue 2013/02. ISSN 1977-3919.

Recommendations for cost-benefit analysis for gas-infrastructure projects

We present recommendations to cope with four potentially controversial areas. These areas are: (1) time horizon of the CBA, (2) project interaction, (3) monetization models and (4) ranking of the projects, which are consecutively discussed below.

1. Time horizon

Recommendation 1: Projects can be evaluated against different time horizons and these horizon options affect the relative net present values of projects; A single reference point for 20-25 years is best practice for the time horizon for infrastructure projects and should be used for gas CBA.

It is common for infrastructure projects to have a horizon of 20 to 25 years for the analysis, even if the project will provide benefits for a longer horizon as is the case for pipelines, underground storage and LNG terminals. ENTSOG acknowledges 20 to 25 years to be best practice, but concerns have been expressed that such a horizon would not be able to effectively assess projects with different commissioning dates.

Computing the net present value (NPV) of project benefits is best practice to compare projects with different timings of the costs and benefits. This method has been designed for comparing projects with the same reference point, which refers to the start of the investment, and the same planning horizon, which refers to the lifetime of the investment. To accommodate the comparison of projects effectively having different reference points, there is no perfect adjustment. Multiple options can then be conceived to define a time horizon against which the net present value can be calculated; three of these options are illustrated in Figure 1 and discussed below.

Option 1 consists of modifying the analysis to match the traditional NPV method. To this end, all projects can be presumed to have been commissioned at the same time (N) with the same operational lifetime of e.g. 20 years. The NPV scores then reveal the relative priority of projects with that timing. However, the economic cash-flows might not be a correct representation of the cash-flows when the project is effectively commissioned later.

Option 2 consists of creating a separate time horizon for each project based on its expected commissioning date (C) and operational lifetime. The NPV is first calculated for the horizon running from C to C+20 and subsequently discounted to the common time reference N. This option takes into account the expected economic cash-flows. However, it disregards the later cash-flows of projects commissioned earlier while the implicit

Figure 1.
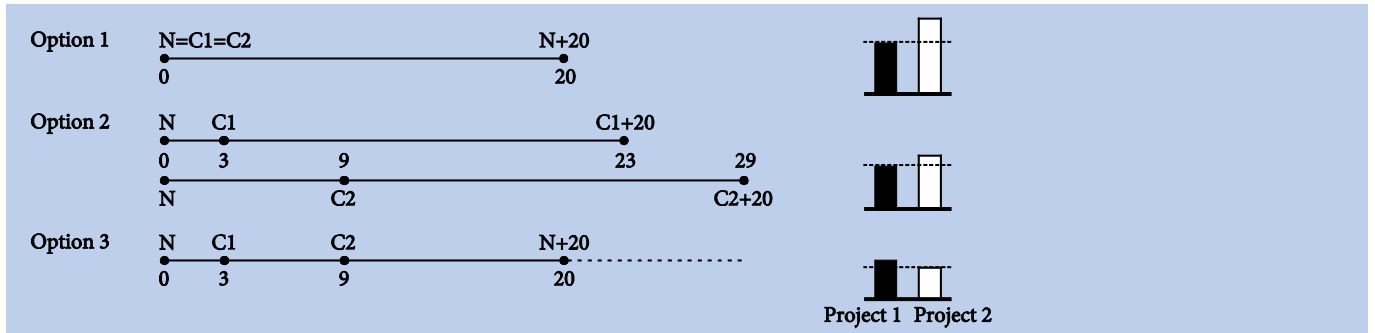
Net present value for two projects against three possible horizons: (1) single reference point N (presumed commissioning dates C1=C2=N) and 20 years of operation (N>N+20), (2) two reference points (C1=3 and C2=9) and 20 years of operation discounted to common time reference (N>C1+20 and N>C2+20), and (3) single reference point N and 20 years horizon (N>N+20) with projects commissioned at C1=3 and C2=9, respectively (own depiction).

horizon of analysis extends to 20 years after the last commissioned project.

Option 3 consists of having a horizon of analysis that extends from the common reference point N up to a certain number of years after N, e.g. 20 years or longer and considers the projects' cash-flows that fall within that horizon. This option implies that there is a cut-off point for the calculation of benefits which affects distant-future projects more than earlier projects. Because of the discounting, the net present value of very distant-future benefits is small; disregarding these benefits thus does not affect the results significantly for most projects.

Whatever the option chosen, it is important to be aware that the selected method affects the relative NPV scores of projects as illustrated in Figure 1. In this particular example, project 1 is the better project according to options 1 and 2, whereas option 3 favors project 2. We highlight that the Regional Groups should put emphasis on correctly evaluating earlier projects because distant-future projects can and must be re-evaluated with every PCI list revision when their benefits become more certain. We recommend the use of a single reference point with a 20-25-year horizon (option 1 above) as it allows identifying priority projects on an equal footing.

2. Project interaction

Recommendation 2: Project interaction is important and can be treated within the cost-benefit analysis; the Regional-Group level is better suited to carry out cost-benefit analysis that accounts for project interaction.

The PCI candidate projects are added to, and interact with, an existing gas system. Moreover, the gas system evolves over the horizon of analysis because other infrastructure, PCI and non-PCI, is commissioned. Complementary projects then generate higher benefits if built together; competing projects, on the other hand, reduce each other's individual value when built together. Project interaction is important information for the Regional Groups and project promoters and it is possible to treat it in the baseline definition and in the project definition of the CBA method.

Within the baseline definition of the CBA method, two approaches can be used to track down competing and complementary projects. First, each project can be assessed against two baselines, one without any of the PCI candidates and one with all of them or a specific subset of proposed PCI projects. A significantly diverging value then indicates interaction without identifying the projects involved. A second approach consists of systematically having pairwise comparison of projects' combined and individual values against either of the two baselines. Such an approach would allow identification of the interacting projects, but would be time and resource consuming. Whatever approach is chosen, the Regional Group level is better suited to carry out CBA accounting for project interaction. Indeed, such analysis requires information from all projects whereas project promoters only have access to their own projects. The regional groups are also better placed to define subsets of projects to create the double infrastructure baseline.

The CBA method's project definition should facilitate the tracking down of project interaction in two ways. First, sufficiently detailed project information is needed in terms of technology type, geography and engineering features to allow the proper delineation of individual de-clustered projects. This information can assist in the tracking down of the particular projects that are interacting. In fact, it is best practice in gas-infrastructure studies on the project-promoter level to compare competing project alternatives on the aforementioned terms. Second, project promoters should be stimulated to bring their

complementary projects into a single project cluster, providing evidence of the complementarities. It is already an industry practice to cluster several projects that belong together, such as many pipeline sections of a long-distance pipeline.

3. Monetization models

Recommendation 3: Monetization models consist of input, output and an algorithm.

The addition of a new piece of infrastructure has several effects. The monetization of these effects requires models to be internally consistent with regard to the physical and commercial relations that govern the gas system. Due to the novelty of CBA for evaluating and selecting gas-infrastructure projects on a European or regional scale, there is limited experience with the application of such models. Yet many models exist or can be conceived to capture specific benefits. In this brief, we thus limit our study to the minimum requirements of such models to ensure internal consistency, characterizing a model by (1) its output, (2) its input and (3) the algorithm that links the two.

Output

Recommendation 3a: The monetization-model output needs to be aligned with a reduced list of significant effects.

The output requirements of the model should be aligned with the effects to be monetized. Some effects are significant for all projects, making up the reduced list of effects to be monetized. Some effects can be significant for specific projects, in which case additional analysis should be carried out. Finally, some effects can be dismissed from the monetization for the reasons explained below.

The reduced list of significant effects starts from a comprehensive effect mapping that includes three levels: (1) the gas system, (2) the externalities and (3) the macro-economic level (Figure 2).

(1) Gas-system effects can be further categorized as infrastructure costs, supply-cost savings, gross-consumer surplus, security benefits and other market benefits. *Infrastructure costs* are a significant effect for all projects. They are obtained as part of the financial analysis for the project and no further monetization is needed. *Supply-cost savings* refer to all supply-side effects of a project. They are significant for all projects and should be monetized. *Gross-consumer surplus* encompasses all demand-side savings as well as changes in the capacity rents. This effect should also be monetized. Note that in this effect mapping, inter-temporal arbitrage profits through storage and trading are included in the demand-side and supply-side effects. *Security benefits* refer to the impact of a project in case

Figure 2.
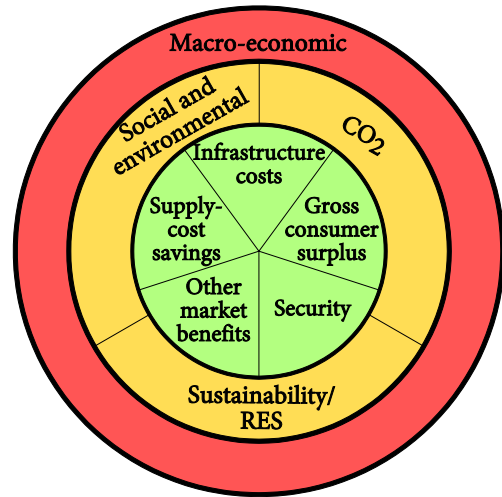
Comprehensive effect mapping; the inner ring represent effects in the gas system, the middle ring are externalities and the outer ring the macro-economic effects (own depiction).

of a disruption for whatever reason. These benefits can be significant for some projects, but they can and should be monetized via the supply-side and demand-side savings, applying dedicated probability-weighted gas-disruption scenarios in the input of the monetization model. *Other market benefits* such as increased competition or liquidity can be significant, but are likely to be similar within a region. They can thus be dismissed for most projects. Indicators can signal cases for which this presumption is not correct in which cases supplementary analysis is justified.

(2) Externalities comprise increased sustainability and integration of renewable energy, CO_2 costs and other environmental costs. *Sustainability and renewable energy improvements* should be internalized in the demand and supply assumptions in the input of the monetization model. *CO_2 costs* should be internalized in the demand assumptions for gas through the European carbon price. Other *social and environmental costs* such as landscape costs should be integrated into infrastructure costs as they are linked to construction and other requirements that have to be met by the project. Separately monetizing these externalities could lead to double counting of the same benefit.

Finally, (3) *Macro-economic effects* of infrastructure investments can be significant, but are likely to be of the same order of magnitude in the defined Regional Groups and thus their dismissal from the monetization will not significantly affect the relative values of projects.

Supply- and demand-side savings are then the two retained effects for the monetization, noting that infrastructure costs

are already monetized. While it is possible to monetize some of the other benefits that can be significant for some projects, severely more complex algorithms would be needed. To calculate the supply-side and demand-side savings, the output of the monetization model should then at least include price levels, consumption levels, and supplied quantities from domestic production, spot trade and long-term contracts.

Input

Recommendation 3b: The monetization-model input should be monitored for the explicitness and transparency of its assumptions and for the validity and accuracy of its data.

The input side of the model is most critical as it determines the quality of the output. Therefore, assumptions must be transparent and well documented, and data must be validated or benchmarked and it must be accurate e.g. in terms of time and space. Furthermore, the model must be flexible enough to accommodate multiple input scenarios, e.g. normal operation and dedicated security scenarios.

Assumptions are needed with regard to the *demand for gas*, which can be an explicit or implicit function of relative fuel prices and of externalities that have been internalized as explained in the previous section. In general, a simple, yet validated, 'engineered' demand function will be sufficient. On the *supply* side, cost and other contract parameters such as minimum and maximum levels need to be defined for long-term contracts, for local production capabilities, for LNG supplies, which can also be long-term contracts, and for underground storage, which has both demand and supply characteristics. Finally, assumptions are needed with regard to the physical and commercial network capacities. Note that the physical transport capacity of a gas system is determined dynamically by its configuration and operation, and that the addition of new infrastructure can lead to significant changes thereof; improperly using technical capacities results in overestimation of the feasible gas flows and their related benefits.

Algorithm

Recommendation 3c: The monetization-model algorithm needs to ensure internal consistency of physical and commercial relations while making trade-offs between higher accuracy of the monetization model and increased computational complexity.

The algorithm forms the backbone of the model and is subject to a number trade-offs. First, the time must be defined in terms of the time horizon (e.g. 1 week, 20 years…) and the time step (e.g. hourly, summer/winter…) of the model. Second, space must be defined in terms of the area considered by the model and the granularity of the model. The area considered by the model can start from the 'region of analysis' that is defined in the Regulation. The spatial granularity can range from domestic networks to market zones and their interconnectors, which can be modeled individually or as aggregated border capacity. There is no right or wrong in specifying time and space; there is, however, a trade-off between higher accuracy (smaller time step, more granularity), on the one hand, and finer data requirements and more computational complexity, on the other hand. Finally, the algorithm needs internally consistent constraints that prescribe the relations between the input and the output. In the case of a gas system, network constraints ensure the physical balance of the system, whereas commercial constraints define balance between import, production, (virtual) trade, storage and consumption. This consistency also includes the specification of appropriate boundary conditions that link model outcomes if sequential monetization models or model runs are used.

Gas-dispatch models can be made compliant with the aforementioned input, output and algorithm requirements and can be used to monetize those effects that have been identified as significant for all projects. The monetization of other effects that are very significant for specific projects requires monetization models with much more complex algorithms that can capture strategic behavior. Finally, if several monetization models are used to capture the different effects, it is important that the output is aggregated in a consistent way to allow a correct comparison between projects.

4. Ranking of the projects

Recommendation 4: Ranking should be primarily based on the monetization with transparent adjustments where justified; ENTSOG should provide guidance to the Regional Groups on how the CBA method has been conceived for selecting projects.

ENTSOG does not address ranking in its draft method because the ranking and selection of projects is the exclusive competence of the Regional Groups. Nevertheless, ENTSOG's conception of the CBA method predetermines how its output can be used for selection of PCI projects, essential information the Regional Groups should be aware of.

Ranking should be primarily based on the monetization. However, transparent adjustments might be justified to accommodate certain considerations. In this brief, we discuss five such potential concerns: double counting, project interaction, uncertainty, regional specificity and project-type specificity; all these concerns can be treated within the CBA method.

First, *double counting* of an effect distorts the ranking of projects. This distortion can be avoided by having a proper reduced list of significant effects. Second, the Regional Groups must

be informed about how *project interaction* has been dealt with in the CBA method and how the ranking should be adjusted. Third, the benefits of some project might be more *uncertain* than those of other projects. The Regional Groups need information on the robustness of the benefits. This information can be provided by means of a sensitivity analysis to the major determinants of the costs and benefits. It is also important that the outcome of such sensitivity analysis is reported in a clear and informative way. Fourth, the method of ranking can differ according to *regional specificity*. ENTSOG should provide guidance on how the CBA method can reflect this specificity e.g. through the adjustment of the monetization model to capture strategic behavior for projects in a region with less mature markets. Fifth, and final, we did not find evidence suggesting that *project-type specificity* requires significantly different CBA

methods. The Regional Groups should be aware that all project types can and should be evaluated with the same CBA method.

Conclusion

The conception of a method for cost-benefit analysis for gas-infrastructure projects is a challenging task. It requires making choices on potentially controversial issues. The reviewing process, to which this brief contributes with its four structural recommendations, will help improve the method to become a robust tool for evaluating and selecting gas-infrastructure projects of European interest.

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The Florence School of Regulation

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