Study to support the definition of a CBA methodology for gas

A REPORT PREPARED FOR EUROPEAN COMMISSION BY FRONTIER ECONOMICS

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<u>EXECUTIVE SUMMARY</u>

The role of Project of Common interest in European energy policy

The European Commission identified the modernisation and expansion of the European transmission grid across borders as one important step to meet the European Union's core energy policy objectives of competitiveness, sustainability and security of supply. Projects of Common Interest (PCIs) will play a major role in fulfilling these objectives. Hence, for the period up to 2020 and beyond, a limited number of trans-European priority corridors covering, inter alia, electricity and gas infrastructures have been identified.

Regulation No 347/2013 (the Regulation) stipulates that the assessment of the costs and benefits (CBA) of an infrastructure project should be based on a harmonised methodology as far as the process relating to PCIs is concerned. ENTSOG has to develop a methodology for a harmonised energy system-wide cost-benefit analysis at the Union-wide level for the preparation of each ten year network development plan, including projects of common interest.

Relation between Energy System Wide (ESW-CBA) Project Specific (PS-CBA) Cost-benefit Analyses should be clarified

ENTSOG has proposed development of a methodology consisting of an Energy System Wide (ESW-CBA) analysis applied within the TYNDP and a Project Specific Analysis (PS-CBA) to be applied by the project promoter of a PCI.

The ESW-CBA, that is to be applied in the preparation of the 10-year development plan (TYNDP), considers only project benefits, not costs. The cost of a project is only introduced at the PS-CBA level and is then used in the evaluation of the potential PCI status of a project. The lack of cost data as an input to the ESW-CBA is unsatisfactory but stems from the fact that ENTSOG has no ability to compel its members and other project promoters to provide such data.

Our remit is to comment on ENTSOG's PS-CBA but the corner stone of the PS-CBA is a soundly based set of projects in the TYNDP. Without this, there must inevitably be questions about results obtained from ENTSOG's PS-CBA methodology.

Consumer and producer benefits at member states and EEA level are relevant

The November 2013 ENTSOG PS-CBA proposal purports to focus on the benefits of projects to consumers alone. Our interpretation of the Regulation, supported by the view of the Commission, is that both ESW- and PS-CBAs need to consider producer surplus as well as consumer surplus. Furthermore, we raised the issue that, as the Regulation is of EEA relevance, the CBA should consider the welfare of consumers and producers in the EEA and not just in the EU. The EC has confirmed this position. The most important consequence of this is that Norwegian producer surplus should be included in any aggregate cost benefit measure.

While the EC notes that the Regulation does not require the separate computation of a specific projects benefit to the different stakeholder groups (producers, shippers, consumers), it is necessary to identify by how much specific Member States benefit from a particular project as this is a necessary input into any subsequent cross border cost allocation. Hence, we conclude that the ENTSOG model needs to be capable of providing at least information on the benefits per Member States and that this is still a key challenge for ENTSOG's current modelling approach.

ENTSOG's – network modelling approach still needs adjustments

ENTSOG's NeMo model seems to meet at least partially some of the requirements necessary for conducting a cost benefit analysis. However, we note that in several areas further development is desirable, which we discussed extensively with ENTSOG during the project.

- **Differentiated transport costs necessary** – ENTSOG currently applies a uniform structure and set of cost value to all transport costs between nodes. We discussed with ENTSOG that this assumption is not appropriate and needs adjustment. We propose that ENTSOG should use tariff assumptions to model behaviour and, where possible, investment plus short run marginal cost assumptions to model welfare. Where full specification of investment cost implications beyond the horizon of the TYNDP is not possible but congestion is expected, LRMCs of transportation over particular arcs may be used. We understand that ENTSOG intends to stick to its assumptions for transport costs in the gas model.
- **Escalating transport costs not in line with economic theory** – ENTSOG currently uses escalating transport costs with increasing capacity utilisation between market zones. ENTSOG's approach is arbitrary and not grounded in economic theory. We propose that ENTSOG should change its modelling of transport costs to follow the principles outlined above, namely modelling behaviour using estimated use of system tariffs and modelling welfare using the best available proxy for actual costs. We understand that ENTSOG intends to stick to its assumptions for transport costs in the gas model.
- **The importance of marginal cost** – ENTSOG uses a "total system cost approach" to assess the impact of a project on total benefit. We discussed with ENTSOG that this "total system cost approach" has one important disadvantage: it does not allow a differentiation of benefits by region and the appropriate calculation of gas prices per member state, necessary, for example, to assess price convergence. Hence, we proposed that ENTSOG should use the "Marginal cost per node approach" which allows the calculation of:
  - benefits at a country (or node) level; and
  - gas prices on country (or node) level.

  We understand that ENTSOG is currently working on incorporating our suggestions with regard to the "Marginal cost per node approach" into their gas model.
- **Turning daily information into annual welfare** – In its November 2013 proposal, ENTSOG has not given any indication with regard to the aggregation of daily benefits into annual figures. In response to our comment on this issue, ENTSOG indicated that it was working on how to attach weights to different simulations. The proposal they have made in respect of summer/winter/peak days seems appropriate. (There is a separate and still outstanding issue as to what weight to give to other scenarios, e.g. low LNG prices etc.).

ENTSOG – PS-CBA methodology still needs further guidance on the interpretation of results

Based on the November 2013 proposal we identified certain topics where the PS-CBA methodology needs further clarification on the interpretation of the results. This refers mainly to:

- **Infrastructure scenarios** – The next PS-CBA methodology will need to include guidance on how to interpret different outcomes under the High/Low infrastructure scenarios. We understand that ENTSOG is currently working on such guidance.
- **Project definition, complementary and competing projects** – ENTSOG should include more guidance in the PS-CBA methodology in relation to the consideration of "matching", "complementary", and "competing" projects. We understand that ENTSOG is currently working on this.

Saved cost approach – monetising cost of disruption as an open issue

When it comes to assessing security of supply, ENTSOG calculates the physical impact on demand from disruption. ENTSOG notes that the "cost or value for disruption" is a value that would enable the move from quantification to monetisation. However, ENTSOG has noted the absence of a complete set of such cost data for each EU member state.

We discussed three different approaches which have been applied in previous research to derive the economic costs of power and/or gas interruptions:

- some studies have drawn upon historical supply interruptions to infer outage costs from available data;
- surveys have been used to investigate the willingness to pay (WTP) for the avoidance of an interruption among different groups of customers; and
- studies using a macroeconomic approach.

We propose that ENTSOG or another European institution (e.g. ACER) should pursue efforts to monetise the value of lost load for unserved gas, as this is one of the main benefits reported by project promoters.

CBA – further guidance for calculation of and interpretation of economic performance indicators necessary

In the November 2013 methodology ENTSOG proposed that for all the projects, a uniform discount rate of 4.5% (real) should be used. In its opinion ACER recommended the use of 4% as applied in the electricity sector. We note that for pragmatic and political reasons the European wide methodology for the PS-CBA needs a uniform discount rate to be applied. We suggest that ENTSOG uses 4% (real) as the social discount rate to achieve consistency with the ENTSOE and ACER proposal.

The November 2013 methodology does not include any guidance on the economic lifetime of projects. We discussed that assumptions regarding the useful economic life of assets are required. We recommend that ENTSOG uses default lifetimes in line with those used by the European Investment Bank except where there is clear evidence that the project will have shorter economic life.

ENTSOG proposes that project promoters shall calculate and report three different economic performance indicators (EPI) using monetised benefits and costs. We discussed that the EPIs for projects may result in a different "ranking" of the projects as it is possible that one EPI favours one project while the second EPI others. We propose that ENTSOG should consider inclusion of illustrative examples of projects where the rankings based on the economic performance indicators differ and guidance on interpretation of the results in the final PS-CBA.

Sustainability already covered in the ENTSOG gas modelling and improvement should be postponed to next TYNDP process

Gas infrastructure projects may have further positive impacts on sustainability which the Regulation intends should be covered, in particular:

- the support of the integration of intermittent renewable generation or power to gas; and
- transportation of biogas.

With regard to the latter, we note that the impact on the transportation of biogas should be already included in the calculation of the net benefit of a project. In any event, the amount of biogas brought into the system may be reported for information purposes.

The integration of intermittent RES in the electricity market requires flexibility from other power plants. This flexible back-up capacity is mainly provided by gas-fired plants as they are best placed to provide this back-up service. However, a full assessment of the effects of any particular configuration of the gas sector on the economics of gas-fired power plants would involve looking at the effect on flexibility of gas supply and balancing market gas prices and would be extremely complex. Hence, given this and other unresolved issues, e.g. concerning the gas model, being more essential we would propose that ENTSOG postpone the development of further indicators for RES integration to the next TYNDP round.

Taking other environmental issues into account

Investments in gas projects (pipelines, LNG, UGS) may also have an impact on the environment. The PS-CBA from ENTSOG needs to include environmental factors and some further extension of the November 2013 ENTSOG proposal is necessary. We discussed that ENTSOG could follow ENTSOE's approach by making explicit the share of the total investment costs necessary to mitigate the environmental impact from the project. In addition, the residual environmental impact may be reported by non-monetary indicators. However, when defining non-monetary indicators one has to take the following into account:

- *Technology specific indicators* – the impact from a transmission pipeline, a LNG terminal and an UGS facility on the environment differs substantially. For example, if a depleted gas field is used for the UGS facility, the environmental impact will be rather small.
- *Practicability* – project promoters should be able to calculate the indicators without high additional costs. Ideally, the indicators should already be included in documents supporting the internal investment decision by project promoters, e.g. (pre-) feasibility studies.

We understand that ENTSOG is currently investigating the potential application of non-monetary indicators for gas infrastructure projects. One further option to evaluate the environmental impact may be based on "stakeholder involvement". For example, the Commission has mooted that it may be possible to define various decrees of “stakeholder involvement” based on common European standards and use a traffic light system.

Insights from the review of case studies indicate further development points

In consultation with the European Commission, ENTSOG has chosen four PCI-candidates of the TYNDP 2013 to serve as case study projects to illustrate/test the proposed PS-CBA methodology. The candidate projects are:

- the Gas Interconnection Poland-Lithuania – GIPL (TRA-N-212);
- the Underground Gas Storage at South Kavala (UGS-N-076);
- the LNG Regasification Vessel (RV) to Croatia (LNG-N-082); and
- the Montoir LNG Terminal Expansion (LNG-N-225).

Level of benefits depending on gas price scenarios

The results of the case studies show that benefits only occur in the scenarios based on variations of gas source prices, e.g. by making one gas source cheaper or more expensive than others. In the reference case, where all gas sources follow a similar supply cost function, the incremental benefit from the candidate project is always lose to zero. Hence, given the current state of the ENTSOG NeMo model, the assessment of whether benefits exceed costs depends on the chosen price scenario. Further guidance on this will be necessary.

Importance of analysing gas flows

The incremental impact of a project can be determined by the congestion that is outside of the projects influence. Therefore, the incidence and extent of congestion in the European gas grid can provide valuable information that is necessary to understand the impact and benefits from gas infrastructure projects. Hence, we propose that the presentation of results should also include a full picture of the European gas flows and the congested pipelines.

Need for information on competing and complementary projects supported by case studies’ results

Our analysis shows that for all case studies competing and/or complementary projects are relevant. For almost all modelled case studies, the results are lower in the high-infrastructure scenario, indicating the existence of competing projects. This emphasises the value of ENTSOG providing further guidance on competing and complementary projects, which would allow the Regional Groups to assess specific candidate projects more appropriately.

Case studies show no impact on disrupted demand and security of supply

The results for all four case studies from the ENTSOG NeMo gas model do not increase security of supply, as there is no impact on disrupted demand (measured in GWh) from any of the four gas infrastructure projects. These results are rather surprising and we would propose that ENTSOG should investigate further whether:

- the way that disrupted demand is calculated in the NeMo model is appropriate; and
- the gas disruption scenarios are appropriate.

ENTSOG NeMo gas model is not able to capture benefit from reduction of market power

The ENTSOG NeMo model assumes perfect competition. However, an important benefit of a project may also be an increase in competition, i.e. a reduction in market power, in one of the concerned member states.

Analysing the effect on competition of a project would in principle require calculation of the difference in the deadweight loss with/without the project. Two features which would be required for a model to analyse this are not part of ENTSOG's model:

- Elastic demand – A firm with market power would set an infinitely high price if it does not have to fear a decline in demand. Elastic demand modelling would hence be needed to look at market power. The current ENTSOG approach assumes an inelastic demand.
- Modelling market behaviour – The approach analysing market power would need to reflect the fact that suppliers may set their price higher than marginal cost if competition does not constrain them in doing so. That allows firms with market power to earn additional profits. ENTSOG's current model minimises costs, which is equal to maximising welfare in circumstances of perfect competition. ENTSOG's model assumes competitive behaviour. Hence it cannot possibly capture the difference.

While it might be feasible to introduce an assumption about price elasticity, into the model, market behaviour cannot be so readily incorporated: ENTSOG's cost minimisation model does not support a credible way to capture the value of increased competition. Theoretically there are two options to do this:

- **Game-theoretical tools** – Some market models allow the simulation of strategic market behaviour by market participants. These models could be used to assess the mark-up on competitive prices due arising from market power;
- **Empirical models** – These can be used to calculate typical mark-ups on competitive prices under certain market conditions, e.g. market concentration ratios. These mark-ups may be used as a proxy for the competitive effect from different market conditions.

Both approaches would be very assumption driven. This will increase the uncertainty of benefit estimates which may not be robust to small changes in the underlying assumptions.

We conclude that, while a potential reduction in market power or the dependence on single suppliers may be an essential benefit of some projects, these cannot be assessed credibly in the detailed modelling framework ENTSOG is required to apply.

In summary, once transport costs have been adjusted, candidate projects are unlikely to make very much difference to the total short run marginal costs of transportation. The only other benefits that can arise are a reduction in unserved gas and an improvement in the competitive structure of the market. For very understandable reasons, ENTSOG's model is not at all well suited to capturing either of these.

1. INTRODUCTION

1.1. Genesis of the study

The European Commission identified the modernisation and expansion of the European transmission grid across borders as one important step to meet the European Union's core energy policy objectives of competitiveness, sustainability and security of supply.

The Regulation[1] lays down rules for the timely development and interoperability of trans-European energy infrastructure in order to achieve the energy policy objectives of the European Union to ensure the functioning of the internal energy market, to ensure security of supply in the Union, and to promote the interconnection of energy networks.

The European infrastructure package is anchored in the Europe 2020 Strategy for smart, sustainable and inclusive growth, which underlines the importance of upgrading Europe's infrastructure. It is also a vital contribution to the cost-effective achievement of the two binding targets of 20% of primary energy from renewables and 20% of greenhouse gas emission reductions by 2020.

1.2. Scope of the report

Projects of common interest (PCIs) will play a major role in fulfilling these objectives. Hence, for the period up to 2020 and beyond, a limited number of trans-European priority corridors covering, inter alia, electricity and gas infrastructures have been identified. The Regulation aims to facilitate investments in line with these priorities by establishing a list of projects of common interest.

The Regulation stipulates that the assessment of the costs and benefits (CBA) of an infrastructure project should be based on a harmonized methodology as far as the process relating to Projects of Common Interest (PCI) is concerned. In addition the Regulation determines the framework for the CBA methodology development in that it defines the key elements of the methodology as well as the criteria and indicators to be used for project assessment.

According to Article 11 (1) ENTSOG has to develop a methodology for a harmonised energy system-wide cost-benefit analysis at the Union-wide level for the preparation of each ten year network development plan, including projects of common interest. Hence, the cost-benefit analysis will be used to calculate if "benefits outweigh costs" as part of the process of identifying projects of common interest.

ENTSOG has proposed development of a methodology consisting of an Energy System Wide (ESW-CBA)[2] analysis applied within the TYNDP and a Project Specific

[1] REGULATION (EU) No 347/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 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.

[2] ENTSOG (2013a), *Cost-Benefit Analysis Methodology – Energy System Wide CBA Methodology*, November 2013.

Analysis (PS-CBA)[3] to be applied by the project promoter. The CBA methodology should:

- enable an efficient assessment of the European wide impact of the PCIs as a whole, in line with the relevant objectives of the Regulation, and
- provide a consistent, methodological basis for project promoters to undertake their own project analysis in support of their submissions to the relevant authorities for PCI selection and any funding request for cross-border cost allocation and/or EU financial support.

The **general objective** of this study is to support and improve the Project Specific part of the CBA methodology as developed by ENTSOG. We are required by our terms of reference to build on and stay essentially consistent with the concept of the methodology developed by ENTSOG. The EC also set a number of **specific objectives** for the study. The specific objectives - focus on the critical areas identified by ENTSOG for the development of the PS-CBA methodology.

During the project we had on-going discussions with ENTSOG and EC on various topics related to the CBA methodology. The outcomes from these discussions are included in this report.

1.3. Organisation of our report

The report is organised as follows:

- **Section 2** describes the way in which the Regulation addresses PCI selection and provides insight into the challenges this poses with regard to assessing the consistent application of the selection criteria;
- **Section 3** discusses ENTSOG's proposal for the PS-CBA and possible adjustments;
- **Section 4** will discuss the case studies;

[3] ENTSOG (2013b), *Cost-Benefit Analysis Methodology – Project Specific CBA Methodology*, November 2013.

2. ENERGY INFRASTRUCTURE PACKAGE

In this section we discuss the Energy Infrastructure Package Regulation and comment on its implications for the project specific cost-benefit analysis.

2.1. Objective of the Energy infrastructure package

The European Commission identified the modernisation and expansion of the European transmission grid across borders as one important step to meet the European Union's core energy policy objectives of competitiveness, sustainability and security of supply.

On 17 April 2013 the European Commission issued the Regulation on guidelines for trans-European energy infrastructure[4], which would repeal Decision No. 1364/2006/EC laying down guidelines for trans-European energy infrastructures. The Regulation lays down rules for the timely development and interoperability of trans-European energy infrastructures in order to achieve the energy policy objectives of the European Union which are to:

- ensure affordability through the functioning of the internal energy market;
- ensure security of supply in the Union; and
- promote sustainability through energy efficiency and the development of new and renewable forms of energy.

Interconnection of energy infrastructures has a role to play in meeting all three objectives.

2.2. The role of Projects of common interest (PCI)

Projects of common interest (PCIs) will play a major role in fulfilling these objectives. Hence, for the period up to 2020 and beyond, a limited number of trans-European priority corridors covering, inter alia, electricity and gas networks have been identified. The aim of the Regulation is to facilitate implementation of investments in line with these priorities by establishing a list of projects of common interest (PCIs), which will benefit from one or more of the following:

- streamlining of permit granting procedures to reduce significantly the lead time for projects and increase public participation in, and acceptance of, the implementation of such projects;
- facilitation of the regulatory treatment of PCIs in electricity and gas by allowing the allocation of costs to match the distribution of benefits and ensuring allowed returns are in line with the risks incurred; and
- ensuring implementation of projects by providing where necessary direct EU financial support to complement market-based funding.

[4] Regulation (EU) No. 347/2013.

2.3. Identifying PCIs

Article 3 of the Regulation sets out the procedure for identifying PCIs, the parties to be involved and the process to be followed. The process follows a multi-step approach:

- Regional Groups (Member states, NRAs, project promoters, ACER, ENTSOs, and other members agreed by the Regional Group) propose the lists by priority corridor; and
- Decision making bodies (Member states and European Commission) finalizes the list of PCIs;

According to Article 3 (5) of the Regulation, the European Commission (when adopting the final list) has to:

- "ensure that only those projects that fulfil the criteria in Article 4 are included;
- ensure cross-regional consistency, taking into account the opinion of the Agency for the Cooperation of Energy Regulators ("the Agency") as referred to in Annex III.2 (12);
- take into account any opinions of Member States as referred to in Annex III.2 (9); and
- aim for a manageable total number of projects of common interest on the Union list."

The Regulation does not foresee any ranking of projects[5]. There are two exemptions from this general rule:

- Regional group level (Art 4.4) – the assessment of projects on Regional Group level shall lead to a ranking of projects but only for "internal use of the group".
- EU level (Art 4.4. and Annex III.2(14)) – If the total number of proposed projects of common interest on the Union list would exceed a manageable number, the Commission shall consider not including in the Union list projects that were ranked lowest in the internal ranking of the Regional Groups.

2.4. Defining Projects of common interest

According to the Regulation, for a project to become a PCI it has to meet both:

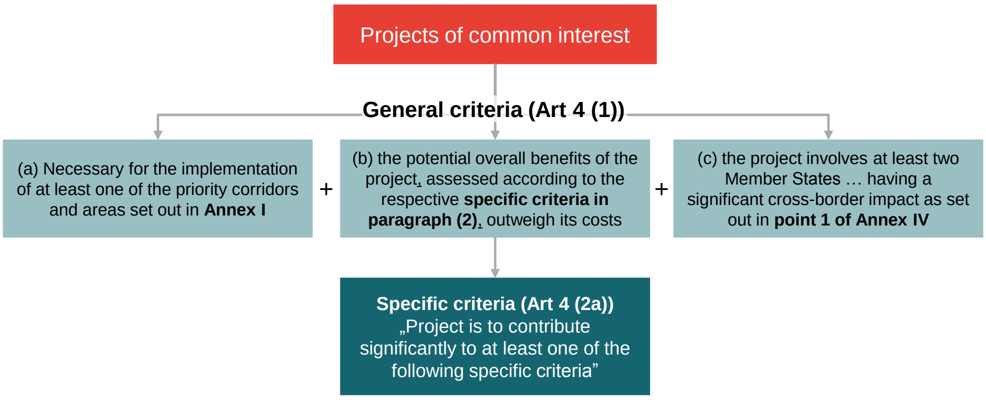
- **general criteria**, applying to any potential project; and
- **specific criteria** which vary according to the industry 'sector' (gas, electricity, oil, carbon dioxide).

These criteria can be categorised in one of two ways:

- criteria that involve a pass/fail test; and
- criteria that describe objectives where the aim is in some sense to maximise attainment.

[5] Regulation Art 4.4: "Neither the regional list nor the Union list shall contain any ranking, nor shall the ranking be used for any subsequent purpose except as described in Annex III.2(14)."

Figure 1. Criteria for projects of common interest



Source: Frontier

2.4.1 General criteria (Article 4 (1))

Article 4 (1) of the draft Regulation defines three general criteria that PCIs must meet cumulatively, namely:

> "(a) the project is necessary for the implementation of at least one of the priority corridors and areas set out in Annex I;
> (b) the potential overall benefits of the project, assessed according to the respective specific criteria in paragraph (2), outweigh its costs; and
> (c) the project involves at least two Member States, either by directly crossing the border of one or more Member States or by being located on the territory of one Member State and having a significant cross-border impact as set out in point 1 of Annex IV"

Criterion (c) is a discrete pass/fail test, where the project passes the test if at least two member states are involved. A gas project is deemed to have a significant cross-border impact if:

- 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; and
- 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 (1).

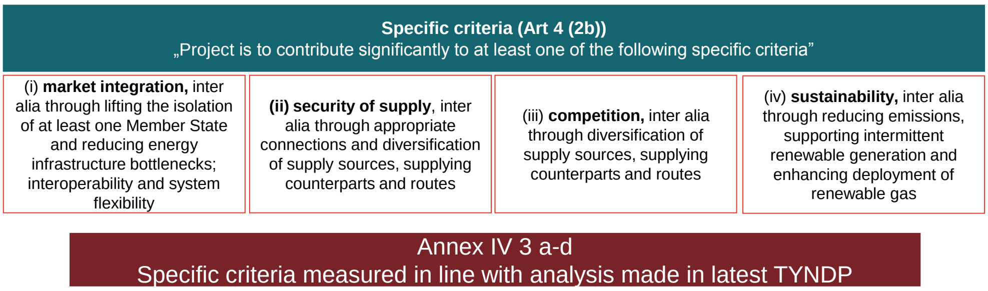
Criteria (a) and (b) describe objectives which the project has to fulfil. In relation to criterion (a) the Regulation asks the promoter of a project to prove its necessity for the implementation of one of the priority corridors or areas.

According to general criterion (b), the overall benefits of the project have to outweigh its costs and the benefits have to be assessed according to the specific criteria in Article 4(2).

2.4.2 *Specific criteria (Article 4 (2))*

Article 4(2b) refers to four criteria for gas projects (**Figure 2**).

Figure 2. Specific criteria for gas projects



Source: Frontier based on EIP Regulation.

Article 4 (2b) itself defines these objectives in general terms, e.g. market integration or sustainability, and does not specify how benefits in relation to these specific criteria should be measured. However, Article 4(3) does require these benefits to be measured according to criteria set out in Annex IV 2 to 5 and relates the approach to measurement to the respective methods applied in the latest available ENTSOG Ten-Year Network Development Plan (TYNDP). In the following we quote from the Regulation.

- "**Market integration and interoperability** – shall be measured by calculating the additional value of the project to
  - the integration of market areas and price convergence; and
  - the overall flexibility of the system, including the capacity level offered for reverse flows under various scenarios.
- **Competition** – shall be measured on the basis of diversification, including the facilitation of access to indigenous sources of supply, taking into account, successively:
  - diversification of sources;
  - diversification of counterparties;
  - diversification of routes;
  - the impact of new capacity on the Herfindahl-Hirschmann index (HHI) calculated at capacity level for the area of analysis.
- **Security of gas supply** – shall be measured by
  - calculating the additional value of the project to the short and long-term resilience of the Union's gas system and to enhancing the remaining flexibility of the system to cope with supply disruptions to Member States under various scenarios; as well as
  - the additional capacity provided by the project measured in relation to the infrastructure standard (N-1 rule) at regional level in accordance with Article 6(3) of Regulation (EU) No 994/2010.
- **Sustainability** – shall be measured as the contribution of a project to
  - Reduce emissions;
  - Support the back-up of renewable electricity generation or power-to-gas and biogas transportation, taking into account expected changes in climatic conditions."

2.5. Project specific cost-benefit analysis

According to the Regulation, promoters of a project wanting it to obtain the status of a PCI shall submit an application for selection as a PCI that includes

- an assessment of their projects with regard to the contribution to implementing the priority gas corridors;
- an analysis of the fulfilment of the general and specific criteria defined in Article 4;
- for projects that have reached a sufficient degree of maturity, a project-specific cost-benefit analysis based on the methodologies developed by ENTSOG pursuant to Article 11; and
- any other relevant information for the evaluation of the project.

The PS-CBA will be circumscribed by Article 11 on the "energy-system wide cost-benefit analysis". According to Article 11 (1) ENTSOG has to develop a methodology for a harmonised energy system-wide cost-benefit analysis at the Union-wide level for the preparation of each ten year network development plan, including PCIs. Annex V of the draft Regulation sets out the principles that the cost-benefit analysis has to fulfil. Furthermore, the methodology must be consistent with the indicators set out in Annex IV and described above.

3. PROJECT SPECIFIC COST-BENEFIT ANALYSIS

In this section we discuss ENTSOG's proposal for the project specific cost-benefit analysis (PS-CBA), make proposals for adjustments and raise some further points for discussion. Our analysis refers to the methodology proposed by ENTSOG in November 2013. We note where ENTSOG has updated its methodology in the meantime and highlight remaining points for development.

The section is organised as follows:

- EC-framework (Section 3.1);
- Overview of ENTSOG's PS-CBA methodology (Section3.2);
- Specific topics related to ENTSOG's proposal (Section 3.3); and
- Additional topics raised by the EC (Section 3.4).

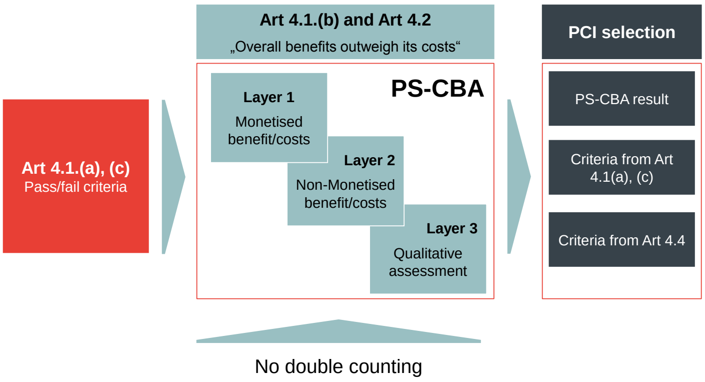
3.1. EC – framework

The EC has set the framework for the role of the PS-CBA in accordance with the Regulation as follows:

- **Main objective of the PS-CBA methodology is to support the PCI evaluation process.** In addition, the PS-CBA also serves as an input to help NRAs allocate costs cross-border where that is requested by the promoters later in a project's life cycle (after it has become a PCI and reached sufficient maturity).
- **PS-CBA methodology is not intended to provide a quantification of the financial gap.** The financial gap for a project is determined at a later stage after the PCI selection process is completed (and after account has been taken of (the part of) the investment costs covered by national tariffs, regulatory incentives, cross-border cost allocation if applicable). The main focus of the PS-CBA is on the economic analysis. If its outcome is positive, the financial analysis would indicate whether the project is also financially viable or not (in the Regulation this is referred to as the business plan). This information may also be an important input for the cross-border cost allocation.
- **The EC supports the "layered" approach of identifying benefits**. This means that benefits related to EU policy objectives are monetised as a first layer, to which additional layers of quantitative indicators and qualitative assessments are added in order to assist interpretation of the results of monetisation. This information will, inter alia, inform the Regional Groups' discussion and ranking of projects. The PS-CBA methodology is neither expected to, nor should provide any ranking of projects. That is the task of the Regional Groups The CBA itself does not need to include the "business plan". However, the promoters need to present both the CBA and a business plan when submitting a so called investment request to the Regulatory Authority

Hence, the general criteria Article 4.1(a), (c) and the additional assessment criteria from Article 3.5 and Article 4.4 the PS-CBA may be embedded in the PCI selection process as illustrated in **Figure 3**.

Figure 3. Role of CBA in PCI selection process



Source: Frontier

3.2. ENTSOG's PS-CBA – overview

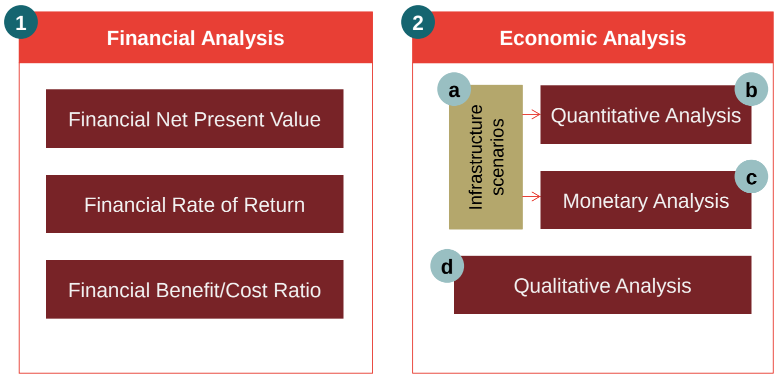
In the following we give a short overview of:

- the relationship between ESW-CBA and the PS-CBA; and
- the structure of the PS-CBA proposed by ENTSOG.

We understand that the ESW-CBA, that is to be applied in the preparation of the 10-year development plan (TYNDP), considers only project benefits not costs. ENTSOG's position is that the ESW-CBA is not meant to filter projects entering the TYNDP. Hence, it views the objective of the ESW-CBA as being to collate a set of input data to be used in a combined qualitative, quantitative and monetary analysis and to describe the network and market modelling approach supporting these analyses.

The cost of a project is only introduced at the PS-CBA level and is then used in the evaluation of the potential PCI status of a project. ENTSOG differentiates between the financial and the economic analysis (**Figure 4**). The principle structure of the ENTSOG proposal follows closely the European Commission's guide to CBA (European Commission, 2008[6]).

Figure 4. ENTSOG PS-CBA



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[6] European Commission, *Guide to the cost-benefit analysis of investment projects – Structural Funds, Cohesion Fund and Instrument for Pre-Accession*, 2008.

Source: Frontier based on ENTSOG

- **Financial analysis** – takes place on behalf of just the owners of the project and only takes into account the revenues collected directly by the owner of the project. We understand that ENTSOG does not aim to develop any new evaluation techniques in terms of financial analysis. As a consequence ENTSOG provides only a recommendation for the project promoters to use the European Commission's guide (2008) when carrying out a financial analysis. ENTSOG states that the financial analysis in the PS-CBA is not meant to identify the financial gap. However, its purpose remains unclear.
- **Economic analysis** – The economic analysis appraises the project's contribution to the economic welfare of a specific region or country. Hence, it is made on behalf of the whole of society, not just the owners of the infrastructure. This is the part of the ENTSOG's proposal that the EC sees as the relevant PS-CBA.

We understand from discussions with the EC that the EC recommends a better integration of the energy system wide and project specific CBA. As the energy system wide CBA does not include any cost data the EC highlights the importance, that the two CBAs are better integrated in order to make sure that overall the methodology covers all the requirements of the Regulation and thus can be considered as an energy system-wide cost-benefit analysis. Hence, the EC recommends ENTSOG to clarify how the analysis from the project-specific CBA methodology will be included in the TYNDP 2015.

We support this recommendation from the EC.

3.3. ENTSOG topics

In the following, we discuss topics from the November 2013 ENTSOG PS-CBA methodology, which ENTSOG should in our view clarify or amend. We note that our discussion is intended to build on and stay broadly consistent with the methodology proposed by ENTSOG.

3.3.1 Financial analysis

The November 2013ENTSOG PS-CBA proposal includes financial analysis. We understand that ENTSOG provides only a recommendation for the project promoters to use the guide in European Commission (2008) when carrying out a financial analysis. According to ENTSOG's understanding, the EC has been in favour of such inclusion since early development of the PS-CBA methodology. As noted above, ENTSOG states that the financial analysis is not meant to determine the financial gap.

We understand from the EC that, while the economic analysis is the main part of the PS-CBA, it should also include some guidance on the financial analysis ("business plan"). In addition, the EC states that the financial indicators that ENTSOG proposes (financial net present value (FNPV), financial internal rate of return (FIRR) and benefit/cost (B/C) ratio) are regarded sufficient at this time.

Hence, our report does not comment further on the financial analysis included in the ENTSOG PS-CBA.

3.3.2 Cost benefit analysis – whose benefit should be relevant?

The November 2013 ENTSOG PS-CBA proposal professes to focus on the benefits of projects to consumers:

> "Beneficiary means **gas consumers** who 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."[7] (emphasis added)

However, the approach is not precisely consistent with the stated intention. We discuss first the reasons why a broader perspective is required. We then discuss what ENTSOG's modelling actually does.

Which stakeholders?

There are a number of reasons why focussing solely on consumers may have shortcomings:

- **Welfare effects may relate to both consumers and producers** – When comparing the costs and benefits of a project, the impact on all relevant stakeholders should be taken into account. If only considering the effect on one group of stakeholders, one might declare an inefficient project efficient, or an efficient project inefficient. This can happen, for example, if:
  - a project does not pass the consumer-focused PS-CBA because of limited positive impacts on customers – despite having large benefits to gas producers who could bring low cost supplies to the market (replacing more expensive sources of production and thereby creating profits, dividends, taxes and so forth); or
  - a project passes the PS-CBA as it brings large benefits to consumers, but the negative impact on existing EU suppliers is not taken into account.

  Hence, based on economic principles, effects both on producers and consumers should be taken into account when assessing the benefits of a project.
- **Consistency with ENTSOE approach** – As ENTSOE's PS-CBA for PCIs in the electricity transmission takes into account both producer and consumer surplus. Not doing so in the gas CBA would give rise to an inconsistent evaluation of energy projects.

We understand from discussions with the EC that the EC interprets the Regulation as requiring both producer and consumer benefits to be taken into account. Furthermore, the Regulation is of EEA relevance. The most important consequence of this is that Norwegian producer surplus should be included in any aggregate cost benefit measure.

The EC has indicated that the effects on producers in third countries, i.e. outside the EEA, should not be included in measures of aggregate benefit.

3.3.3 Cost benefit analysis – where do the benefits appear?

The EC notes that the Regulation does not require the separate computation of a specific projects benefit to the different stakeholder groups (producers, shippers,

[7] ENTSOG (2013b: 38)

consumers). Only the total benefits the project brings to each member state is relevant. We understand based on discussions with ENTSOG during the project that ENTSOG has the same understanding of the Regulation.

However, it is necessary to identify by how much specific Member States benefit from a particular project as this is a necessary input into any subsequent cross border cost allocation. Hence, we conclude that the ENTSOG model needs to be capable of providing at least information on the benefits per Member States.

We still note that while a full computation of total consumer and producer surplus may not be feasible in the context of the ENTSOG modelling approach, the ENTSOG model should be capable of estimating the **change in** producer and consumer surplus as a consequence of a potential PCI (which is sufficient for the incremental approach comparing the change in welfare with/without the project) for each Member State. For that purpose, it is not necessary to assess the full willingness to pay of consumers or the production costs of different producers – it would be sufficient to understand the expected price changes in different market areas and the corresponding consequences on producer and consumer surplus.

One of the main challenges facing ENTSOG is the development of a modelling approach that will allocate total European-system wide benefits to the affected Member States.

3.3.4 ENTSOG – Network Modelling approach

Any gas model for conducting PS-CBAs should:

- be able to model realistically gas flows between European market zones based on the actual physical capability of the system;
- account for sources (production and imports from outside the EEA) and sinks (demand for gas) at the system entry and exit points, respectively;
- be based on assumptions with regard to supply volumes and costs, transport and storage costs, and demand (volumes and demand elasticity) which are as realistic as possible; and
- assume an efficient operation of the system[8].

ENTSOG's NeMo model seems to meet at least partially some of these requirements. However, we note that in several areas further development is desirable. We discuss these below.

Input parameters

With respect to input parameters, we conclude that the following areas may in any case need further consideration:

Transport costs are depicted identically at all virtual interconnection points in the model. Virtual interconnection points represent the sum of all physical interconnections between two market zones. ENTSOG uses the word 'arc' to describe the virtual interconnection of two zones. On each of these arcs, transport costs increase with the utilisation of capacity (see next paragraph). However, for a

[8] Strictly speaking, this requirement should be expressed as a requirement that the model should assume efficient use of the system by market participants, given the transportation tariffs that they face, and efficient operation of the system by TSOs, given the demands of market participants.

given utilisation, transport costs are currently set to a uniform value by ENTSOG, which means that transport of the same volume between any two market areas incurs the same cost.

ENTSOG's reasoning behind this is that any assumptions on transport costs are bound to differ from actual costs, so a uniform structure of costs is the "best guess". In addition, costs associated with specific transmission arcs in the ENTSOG model are meant to shape flow patterns and not to reflect actual transmission costs. The use of differentiated transport costs might result in dominant routes, leaving other routes nearly empty. This could have a strong impact on the evaluation of projects, while the reality of the priority given to certain routes is very difficult to assess and is likely to change along the time horizon. Hence, at this stage ENTSOG does not favour using differentiated transport costs.

While we accept that assumptions on transport costs may be difficult to determine, a uniform structure of transport costs applied to each arc is, of course, itself an assumption – and certainly not the best available estimate, given that the geographic granularity of the model varies across regions. The more nodes any given geographic region is broken into for the model, the higher are the transport costs to transit this region (because more arcs have to be traversed, each involving similar costs).

The distorting effect of the assumption becomes clear in an example. Transport cost across France differs by 100% depending on whether one considers a (Nord-Sud) market zone merger to be likely (in a future scenario) or not.

The correct treatment of transport costs is quite complicated to define. We discuss below the elements that we believe are key.

In essence transport costs need to be considered from two quite different perspectives:

- The first is that transportation tariffs (and congestion charges) determine how market participants will use the system; and
- Real transportation costs are an important input into the determination of the welfare differences between simulations with and without the candidate project.

With respect to the first perspective, there is no point modelling the use of the European gas network on the assumption that transportation tariffs and congestion premia do not matter. The aim should be to model how shippers will use the system, with and without the project, and tariffs have a role to play in determining how they will use the system. We accept that future tariffs may be difficult to model accurately but even use of existing reference prices would be a helpful change in the right direction. Welfare differences between these two patterns of use then need to be estimated.

However, tariffs (and congestion charges) do not represent real elements of welfare comparisons with and without a candidate project. The correct identification of welfare changes requires consideration of true costs (and not just transfer payments)

Provided all changes in investment plans into the future consequent of particular project are taken into account, the model should reflect the short run marginal costs of the systems operations. The modelling approach looks at a number of snapshots and models costs associated with those snapshots. However, it is important that the later snapshots are based on sensible assumptions about what capital investments will be in place in the year to which the snapshot refers. Doing this properly would require consideration to be given to projects that would be commissioned beyond the TYNDP planning horizon. Currently, it would seem likely that ENTSOG is not in a position to add in such background investment when modelling a specific project.

If inclusion of specific investment is not feasible in later years, it is possible that certain elements of the system may then be modelled better by applying long run marginal cost (LRMC) values for later snapshots. However, this would be quite difficult to apply in practice as, with the possibility of declining gas demand, a number of routes may never need investment and may therefore continue be appropriately modelled using short run marginal costs. Hence only some might require use of LRMC as a proxy to capture unspecified investment effects.

Transport costs – Proposal

We propose that ENTSOG should use tariff assumptions to model behaviour and, where possible, investment plus short run marginal cost assumptions to model welfare. Where the latter is not possible but congestion - and hence some investment - is expected, LRMCs of transportation over particular arcs may be used.

The second comment arises as a direct result of our first. It concerns the implementation of **escalating transport costs** with increasing capacity utilisation between market zones. The transport costs between market areas increase with the capacity utilisation. ENTSOG endeavours in this way to mirror a (perceived) observation by shippers that the value of transport capacity increases with capacity utilisation. In reality the value should only rise when congestion occurs, or in the purchase of future capacity through the CAM auctions, has a nonzero probability of occurrence.

This aspect of ENTSOG’s approach is not consistent with the rest of the methodology of the NeMo model (which we think is generally appropriate). The model takes a social welfare perspective and, at least in principle, looks at actual costs (for e.g. gas production). With increasing pipeline utilisation the value of transport capacity to shippers might increase but should only do so when the pipeline is congested. The increase in the value of capacity is merely a rent for the capacity holder – which accrues to that holder as a “windfall gain”. This may be manifest as redistribution to the capacity holder (or TSO) from producers or consumers, but which is not an actual cost to the system as a whole.

Hence, in welfare terms transport costs between two market areas should only increase in line with actual costs, for instance for enhanced compression requirements if system load is high, but not because of congestion rents. Congestion rents can be the outcome of the model but should not be included as an input cost.

ENTSOG notes in discussions during the project that they understand Frontier’s position that relatively even flow patterns may not be more useful in modelling benefits than flow patterns where some routes are highly used and others nearly empty.

We remain of the opinion that escalating transport tariffs are contrary to economic theory and not consistent with the rest of the methodology of the NeMo model.

Escalating transport tariffs – Proposal

We propose that ENTSOG should change the representation of transport costs in the NeMo model.

Our final issue with ENTSOG’s proposed approach concerns the relativity of transport and production costs. For a comprehensive evaluation of a project, changes in total system costs – including the costs of transport as well as the cost of gas – are relevant. However, in order to produce meaningful results in this respect, the model needs to be able to capture the trade-offs between transport and production costs. This requires the relative magnitude of cost parameters for transport and production in the model to be realistic. ENTSOG's present approach assigns an arbitrary cost to transportation and its relativity with gas production costs (or EU border costs) is not grounded in fact. The changes to the treatment of transportation costs that we have proposed above would address this deficiency.

ENTSOG defines the gas supply cost for the various gas supply sources as follows. Under the reference case the average price/cost of all sources corresponds to the average supply price/cost for Europe. However, the price at each source depends on the volume supplied from that source. ENTSOG applies minimum and maximum volumes to each source, based on observed historic flows. The minimum volume is assumed to correspond with a price that is 90% of the average price for Europe, while the maximum winter volume corresponds with 110% of the average gas price/cost for Europe. The relation between minimum and maximum winter volume determines the slope of the gas supply price/cost for each individual gas source. The relationship is assumed to be linear between these two extremes.

The main drawback of the ENTSOG approach is that it treats as the supply curves at each entry point into the EEA (imports from third countries or production in the EEA) as exogenous.[9] However, in principle the gas supply curves ta each source will be endogenous. Gas producers will wish to maximise the present value of what is earned from their gas reserves. Producing and selling gas today has an opportunity because it is gas that cannot then be sold at a later date. Hence projections of future market prices affect the willingness of producers to supply today. The exercise of market power may also introduce a further element of endogeneity. However, we note that modelling endogenous gas supply costs is a complex task, which should be considered as a potential future development of the current ENTSOG approach, albeit an important one.

Ratio between supply and transportation costs – proposal

ENTSOG should address the relativity of transport and gas production/supply costs by making the changes set out above.

The importance of marginal cost

There are two ways to determine the economic benefits of an investment in the modelling environment proposed by ENTSOG:

- **Evaluation of total system costs** – If total system cost declines with the inclusion of a potential PCI, and if the present value of the cost saving exceeds the present value of investment costs of the PCI, the project is beneficial in the scenario modelled. (In the following we refer to this as the "total system cost approach".)
- **Evaluation based on changes in market prices** – If, for example, an LNG terminal is found to reduce the market price of gas in a given market area

[9] Strictly they are modelled as exogenous. However, the default of putting in place similar supply curves at each source reflects an implicit acknowledgement of the linkage.

(referred to as a "node" in the model context) by X€, the project would be beneficial if its incremental cost (of construction and operation) was less than X€ multiplied by the demand in the market area minus X€ multiplied by production of indigenous producers in the market area. In the framework of the model, the market price in a zone would be estimated by the marginal supply cost at the respective node. This is consistent with economic theory which says that the most expensive unit sold determines the price.[10] (In the following we refer to this approach as "marginal cost by node approach".)

In economic theory, both approaches yield the same result (under perfect competition).

Based on the way that ENTSOG described its CBA methodology, we understood initially that the ENTSOG's modelling was aimed at determining the economic benefits based on changes in average costs at every node (=market area) – an approach which would not have been suitable to determine the economic efficiency of an investment. However, further discussions with ENTSOG have revealed that ENTSOG actually envisages looking at the average cost of all supplies to Europe in total. While computing that "average" may be an unnecessary complexity, it does involve looking at the total system cost of gas supplies (and dividing by volume) – and the change in total system cost is one of the suitable approaches through which to assess the overall benefits of an investment (see "total cost approach"), if assumptions on production and transport costs are set appropriately (see previous remarks on transport cost assumptions).

However, this "total system cost approach" also has one important disadvantage; it does not allow a differentiation of benefits by region or type of stakeholder (producer or consumer). The former is required by the Regulation[11]. In **Table 1**, we compare the advantages and disadvantages of the two approaches.

Table 1. Identifying the benefits of a project in the modelling framework

	"Total system costs approach"	"Marginal cost per node approach"
Pros	Clear indication of total system costs saved due to a PCI (which can be compared with project costs)	Nodal price approach provides information on regional effects (market zones) and distribution of benefits among stakeholders (producers, consumers, TSOs)
Cons	No differentiation is possible between benefits to different regions/market areas or types of stakeholder	

Source: Frontier

While the total system cost approach (or ENTSOG's implementation of it) may be suitable to determine the overall EU-wide benefits of a project – an assessment of

[10] This is not inconsistent with long-term contracts: In the short term, the price levels in those contracts do not set the wholesale price as they come into the market on a take-or-pay basis, i.e. their price does not affect the marginal supply price. In the medium term, regular price revisions imply that they should adjust to the market price based on supply and demand.

[11] EIP Reg Annex V (11): "The analysis shall identify Member States on which the project has net positive impacts (beneficiaries) and those Member States on which the project has negative impact (cost bearers)"

benefits between Member states (and consumers, EU producers, and non-EU producers) as required by the Regulation would also require looking at marginal costs per node.

Complementing ENTSOG's existing model evaluation, which reflects the total cost approach, to develop marginal nodal prices should be feasible. ENTSOG's model is a linear program (LP) optimisation model using a public domain solver. Without having experience with that specific solver, we would expect all LP solvers to be capable of reporting the so-called "dual value" on any constraint in the model. Hence, the ENTSOG model should have an equation stating that at each node (=market area), demand has to be met by all supply options, comprising:

- gas produced locally,
- gas transported via interconnection points to that market areas,
- gas demand "avoided" in power generation (which is an implicit form of supply for other users),
- withdrawal from storage etc.

Consequently, ENTSOG's model solver should be capable of simply reporting the "marginal value" related to that equation which would indicate the change in total system costs if demand were to increase by one marginal unit. Under the assumption of perfect competition, this value would be equivalent to the price in that market area – and can be interpreted by ENTSOG as such.

Hence, ENTSOG's model should have all the capabilities needed in that respect and the results would just need to be reported. Changes in producers and consumer surplus could then be approximated at each node:

- A fall in price implies an increase in consumer surplus for all demand at that node (Change in price * market area demand). In accordance with ENTSOG's assumption, this formulation implies zero price elasticity of demand[12]; and
- A fall in price implies a corresponding decrease in producer surplus for all gas "produced" at the respective node, i.e. domestic production (Change in price * market area domestic production).
- The sum of the change in consumer and producer surplus for each market area indicates the change in the total benefits for the respective market area.

This approach can be repeated for all nodes. As ENTSOG assigns individual nodes also to upstream producers in- and outside the EEA (e.g. Russia vs. Norway vs. LNG producers vs. Netherlands … and so on), the approach can also distinguish between EEA and non-EEA producers. Hence, while the ENTSOG NeMo model may in theory (depending on model assumptions, scenarios and so on) already be able to determine the benefits of an investment, limited additional analysis (as opposed to changes in the model logic itself) will also make estimation of the benefits to market areas and stakeholder types feasible. However, without this extension, ENTSOG's current approach based on the "total system cost approach" does not support the distribution of benefits to member states.

The "Marginal cost at each node approach" would allow calculation of the price per node. However, in order to arrive at sensible prices at each node, adjustments with regard to the assumptions for transportation costs are necessary (see discussion above).

[12] Note that ENTSOG assumes a non zero short term price elasticity of demand exists only for the power sector, when calculating the impact on CO_2 emissions

In addition, calculating prices per node (Member States) using the "Marginal cost per node approach" is necessary to quantify the modelled indicator "price convergence".

Evaluation based on changes in market prices – Proposal

ENTSOG should add additional functionality to implement the "Marginal cost at each node approach". This would allow the calculation of benefits at each node (and hence Member States). However, in order to arrive at relevant prices, ENTSOG needs to take account of the costs as perceived by market participants who set prices.

Incorporation of storage

In most of ENTSOG's scenarios, we understand that ENTSOG looks at only the peak demand. There is one scenario which looks at both the average summer and average winter day in the same scenario (to accommodate inter-temporal optimisation).

This has the following implications:

- **Scenarios only looking at peak demand do not allow conclusions to be drawn on value of storage (and potentially distorts the value of non-storage PCIs)** – As the value added by storage is the inter-temporal movement of gas from periods of low prices (typically summer) to periods of high prices (typically winter), a scenario only looking at a particular time of the year cannot provide information on the value of storage. Analysis of a peak demand period would presumably make the simple assumption that storage was full – although there would be no indication as to whether there would have been gas available in low demand periods to fill the storage, or what its price would have been in those low demand periods – two important pieces of information for determining monetary benefits. As the operation of storage has an impact on the value of other infrastructure assets, there are also potentially distortionary effects on the value of other projects (e.g. an LNG terminal has a higher value in winter if the storage is not filled with gas in summer or can only be filled with costly gas).
- **Focus on average demand underestimates the value of storage.** Only a scenario in which both periods (of high and low prices) are modelled can provide a value of storage from a theoretical perspective. However, that scenario only considers "average" circumstances and is, therefore, likely to underestimate the benefits of storage which might be especially relevant in non-average circumstances (e.g. the 2009 Ukraine crisis, winter demand peaks as observed in February 2012 or March 2013 in some central European countries) – these would not be captured in ENTSOGs average scenarios. Less dramatically, storage may be filled in a much shorter period than the full summer season and emptied in much less than a full winter season, thus exploiting better price differentials.

Hence, it is unlikely that ENTSOG's approach will capture the value of storage correctly. One pragmatic approach in the evaluation of PCIs could be to:

- First, perform the simulation which considers average summer and winter day at the same time (inter-temporal optimisation) to (i) check that there is sufficient capacity in the network to fill the storage in summer and (ii) determine the marginal cost of filling storage in summer (using the same marginal cost per node approach described above – putting more gas in a storage in summer is also a form of "demand" in summer and is therefore associated with the same costs) – this should be done for all storage in the model, not just if the storage is a PCI; and

- Secondly, using the marginal cost of filling storage in summer (plus cost of capital employed etc.), i.e. the output of that first simulation, as an input assumption for the other simulations reflecting the cost for withdrawals of gas from storage in winter (again, all storages are relevant, not just the potential storage PCI).

Note that this approach should be applied in all PCI candidate project analysis, not just when the concerned PCI is a storage project, as the correct modelling of storage also affects the benefits of other potential PCI projects. Storage is in essence a substitute for winter transportation capacity.

ENTSOG notes that, at this stage, its proposed approach measuring the storage effect on the seasonal spread (average winter/average summer price) represents a compromise between complexity and accuracy. ENTSOG considers that further refinements could be introduced into a future version of the methodology.

Turning daily information into annual welfare

ENTSOG plans to use the results from modelling changes to welfare, under different scenarios, to calculate economic performance indicators which are based on a discounted cash flow approach. According to the Regulation the relevant time horizon has to be at least 20 years. Hence, this means that an aggregation to annual benefits is necessary to undertake the discounted cash flow calculations.

In its November 2013 proposal, ENTSOG has not given an indication with regard to the aggregation of benefits. We understand that in the course of the case study process, ENTSOG has decided to accumulate daily benefits according to the "algorithm approach" (see Section 4.2) including also the two-week-peak day. Hence, ENTSOG calculates the annual surplus value by:

Annual surplus = (Surplus "average summer day" * 183) + (Surplus "average winter day * 168) + (Surplus "Two-week peak day"* 14) + (Surplus "1-day Design Case" * 1)

In addition, ENTSOG also considered including results from stress scenarios, which cover partly the (monetised) effect from gas disruption. However, we are not aware on the progress with respect to this.

Turning daily benefits into annual benefits

ENTSOG's nascent methodology for combining daily results seems to us to be appropriate. For the reasons we have explained it will value storage imperfectly and this may have a spill over effect on the valuation of other infrastructure. However, given the scale and complexity of the task, we feel that this is quite acceptable for the methodology at this stage.

3.3.5 Infrastructure scenario and incremental approach

In order to illustrate the uncertainty of the future infrastructure development ENTSOG uses two infrastructure scenarios when assessing the incremental impact from a project:

- **Low infrastructure scenario** – Existing infrastructure plus FID projects; and
- **High infrastructure scenario** – Existing infrastructure plus FID and non-FID projects.

This allows it to illustrate different project interactions under the two scenarios. For example, a specific project may show:

  – a low net benefit in the low infrastructure scenario, and
  – a high net benefit in the high infrastructure scenario.

This would indicate the existence of complementarity between the project being analysed and one or more non-FID projects. The reverse would indicate the project being analysed is competing with one or more non-FID projects. The project promoter and/or the Regional Groups may face substantial challenges in assessing the qualification of a project as a PCI when confronted with different outcomes from the two infrastructure scenarios. Hence, at least some guidance in the PS-CBA on how to interpret disparate outcomes may be helpful.

The EC agrees that guidance on how to interpret the results would be important, especially to help the Regional Groups identify competing and complementary projects for further evaluation.

We understand that ENTSOG is currently working on the development of such guidance for inclusion in the next iteration of the PS-CBA methodology.

Infrastructure scenarios – Proposal

The next PS-CBA methodology will include guidance on how to interpret different outcomes under the High/Low infrastructure scenarios. ENTSOG is currently working on such guidance.

ENTSOG has noted, in its comments on our initial analysis, further critical areas it intends to investigate in.

One such issue was the definition of dependent projects at the time of submission to PCI selection. ENTSOG notes that inadequate definition may lead to problems with the PS-CBA methodology, in particular if the statuses of "matching projects", e.g. both sides of a flange, differ.

In the following, we summarise some principles from the EC and the Energy Community on this topic.

- **"Major projects" in the context of the Structural and Cohesion Funds** – we note that the EC defines as a "major project", inter alia, a group of projects that indicatively:
  – are located in the same area or along the same transport corridor
  – achieve a common measurable goal
  – belong to a general plan for that area[13].

  ENTSOE uses these principles when defining the clustering of investments[14] for the purposes of evaluating potential electricity PCIs. However, the EC notes that clustering in gas will be more limited and will be proposed by the Regional Groups based on the outcome of the CBA.

[13] European Commission, *Guide to the cost-benefit analysis of investment projects – Structural Funds*, Cohesion Fund and Instrument for Pre-Accession, p. 20, 2008.

[14] ENTSOE, *ENTSOE Guideline for Cost Benefit Analysis of Grid Development Projects*, p.19-20, Nov 2013.

- **Energy Community "matching projects"** – are defined as "projects that share the same transmission routes/branches/pipelines/facilities or at least a part of it. These are essentially the same projects, but proposed by different project promoters."[15] Hence, such projects should be evaluated jointly as a single project.
- **Energy Community "complementary projects"** – are defined as "potential relations between projects which require the development of a specific project for the implementation of another (dependent) project."[16] In addition a further distinction is made between "strongly complementary" projects and projects which can be developed on a standalone basis, but their benefits can be enhanced by other specific projects. The Energy Community decided to cluster complementary projects into a single project, if:
  - a strong technical dependency of the projects, e.g. LNG terminal and the link to the network was observed; and
  - the treatment as a single project was agreed by the project promoters.

When it comes to "mirror projects" the EC notes that it is important to consider them as one project (ENTSOG follows this line of argument). In terms of the FID/non-FID status, the EC prefers to assume both are non-FID until both are FID. While there is a merit in giving both the same designation, it is not clear to us that non-FID is the preferable one. Normally we would expect the final investment decision one to be taken only when it is essentially certain that the other will get FID.

ENTSOG notes that, with regard to "mirror" projects, the data collection process for TYNDP/ESW-CBA will include some tests in order to detect possible inconsistencies.

When it comes to "complementary projects" the EC notes that if all projects are necessary to bring about the benefit than they should be evaluated as one project, even if from a legal point of view, they may have to be disaggregated into sections once they become a PCI. Hence, the EC takes the strong technical dependency of the projects as a key criterion for treating them as complementary. However, the EC raises a disclaimer in this context, e.g. if commissioning dates are very different, evaluating complementary projects as one project should not be allowed. ENTSOE, for example, does not allow clustering of projects with commissioning dates more than 5 years apart.[17]

In addition we understand that the EC asked ENTSOG to provide detailed description on how project interactions (likely competing and complementary projects) can be determined using the methodology. This description should also cover further steps or decisions that need to be taken by the Regional Groups in order to allow the identification of the project clusters that are likely to be complementary or competing.

We understand that ENTSOG will pay special attention to the issue of "complementary" and "competing" projects when redrafting the PS-CBA

[15] DNV KEMA/REKK/EIHP, *Development and Application of a Methodology to Identify Projects of Energy Community Interest*, Report for Energy Community, p. 14, 2013.

[16] DNV KEMA/REKK/EIHP, *Development and Application of a Methodology to Identify Projects of Energy Community Interest*, Report for Energy Community, p. 16, 2013.

[17] ENTSOE (2013: 21)

methodology. The aim is to ensure that Regional Groups understand when possible interactions would be indicated and how they could be further investigated.

Project definition, complementary and competing projects– Proposal

ENTSOG should include more guidance in the PS-CBA in relation to the consideration of "matching", "complementary", and "competing" projects. We understand that ENTSOG is currently working on this.

3.3.6 Quantitative indicators

In this section we provide an overview of the quantitative indicators that are included in the PS-CBA as well as a first assessment of these indicators. Within the Economic Analysis of a project, the indicators are assessed under the *incremental approach* calculated for each zone, each year and each infrastructure Scenario – once including and once excluding the project data.

The November 2013 ENTSOG PS-CBA proposal includes two categories of indicators:

- **Capacity based indicators** – Capacity based indicators are calculated based on capacity and demand data. They include
  - the Bi-directional project indicator;
  - the Import Route Diversification Index;
  - the N-1 Infrastructure Standard Indicator (on regional level); and
  - Seasonal capacity indicators.
- **Modelled indicators** – Modelled indicators are calculated based on the flows resulting from the model. They include
  - the Remaining Flexibility at Zone level;
  - the Supply Source Dependence assessment;
  - the Supply Source Diversification assessment; as well as
  - price convergence.

Capacity based indicators

- **Bi-directional project indicator** – This indicator identifies whether an interconnector project enhances bi-directional capacity, i.e. is a reverse flow project. It assesses the general criterion of "significant cross border impact" according to Art. 4 I c (ii) and Annex IV (1c) of Regulation 347/2013.
  This indicator is required explicitly by Regulation 347/2013. Therefore, no adjustment is suggested.
- **Import Route Diversification Index** – This indicator assesses the possible diversification of supply sources within a zone. Being based on the sum of squared shares of technical firm capacity (at zone level) of the respective supply sources, it resembles the Herfindahl-Hirschman Index (HHI) as described in the Regulation.
  The aggregation of capacity at zone level is adequate in this context. The lower the indicator level, the higher is the diversification of import routes.
  However, there might be apparently adverse outcomes of this indicator, where an increase in IP capacity increases the indicator value, as the example in **Figure 5** illustrates. Assume that Zone A imports gas from Zone 1 and Zone 2. When shares of technical firm capacity are evenly distributed, an increase of IP4 from 3 to 5 decreases the Import Route Diversification Index

by 1% (Case 1) for Zone A. If, however, there is a single IP that has a high share of technical firm capacity (in this case IP4), an increase of this IP's share increases the Import Route Diversification Index, indicating an inferior resilience of the system (Case 2) for Zone A.

Figure 5. Import Route Diversification Index

Case 1: Evenly distributed share

Zone 1	capacity LI	share LI	capacity HI	share HI
IP1	3	33%	3	27%
IP2	2	22%	2	18%
(SUM %IPXBorder1)^2		*31%*		*21%*
Zone 2	**capacity LI**	**share LI**	**capacity HI**	**share HI**
IP3	1	11%	1	9%
IP4	**3**	33%	**5**	45%
(SUM %IPXBorder2)^2		*20%*		*30%*
Import Route Diversification Index		**51%**		**50%**

Case 2: Dominant supply source

Zone 1	capacity LI	share LI	capacity HI	share HI
IP1	3	19%	3	14%
IP2	2	13%	2	10%
(SUM %IPXBorder1)^2		*10%*		*6%*
Zone 2	**capacity LI**	**share LI**	**capacity HI**	**share HI**
IP3	1	6%	1	5%
IP4	**10**	63%	**15**	71%
(SUM %IPXBorder2)^2		*47%*		*58%*
Import Route Diversification Index		**57%**		**64%**

Source: Frontier Economics

Currently, the indicator includes the capacity of interconnectors, non-EU supply sources as well as LNG send-out capacity. Consideration could be given to including send-out capacity from national production (or UGS), which could also be enhanced by a PCI candidate project.

Hence, based on the terminology of Annex IV (3b) of Regulation 347/2013, the Import Route Diversification may provide some information germane to the specific criterion of competition, as it illustrates the diversification of sources.[18] However, the general caveat remains that without information on the capacity positions, e.g. capacity rights of shippers, a reasonable assessment of competition is not really feasible.

[18] "Competition shall be measured on the basis of diversification … taking into account … diversification of sources." (Annex IV (3b) of Regulation 347/2013)

We understand based on discussions during the project that the EC is not in favour of extending the index to include national production and UGS, as the index should be about diversification of imports and national production and UGS does not provide relevant information on this. This is a tenable position but ignores the advantage that UGS bestows. UGS allows more imported gas to provide supply at peak times than pipeline import capacity would suggest. However, we agree that there is no obviously better way to construct this index.

- **N-1 Infrastructure Standard Index** – The definition of this indicator is given by Regulation (EC) 994/2010. It assesses the resilience of a system, by analysing peak situations, without the largest supply source. This indicator is calculated by either the Competent Authority of the Member State or the Project Promoter. In accordance with Annex IV (3c) of Regulation 347/2013, it evaluates the specific criterion of security of supply.
  This indicator is defined by Regulation 994/2010. Therefore, no adjustments are proposed.
- **Seasonal capacity indicators** – These indicators assess the capacity balance within a zone under different supply and demand conditions. They aim at identifying affected countries under the interim approach. In accordance with Annex IV (3c) of Regulation 347/2013, the indicators evaluate the specific criterion of security of supply.
  The seasonal capacity indicators are mainly used to identify flows within the interim approach. After finalisation of the modelling approach, the necessity to keep these indicators should be assessed, as gas flows are a main output of the model. ENTSOG is currently assessing the need of this indicator.

Modelled indicators

- **Remaining Flexibility at Zone level** – This indicator assesses the infrastructure resilience of zone under supply stress. It is calculated under different supply situations and refers to the ratio of the sum of entering flows to total firm technical entry capacity. Therefore, total entry capacity has to be aggregated. In doing so, one has to make assumptions about the technical availability of capacity. In accordance with Annex IV (3c) of Regulation 347/2013, it evaluates the specific criterion of security of supply.
  We think that in principle ENTSOG's approach is appropriate. Notwithstanding this, ENTSOG has announced its intention to revise this indicator, although we are not clear on the motivation for this.
- **Supply Source Dependence assessment (SSDEP)** – This indicator assesses the dependence of zones on specific supply sources. Each supply source is minimized, one-by-one, until the remaining sources can no longer meet demand in the balancing zones. If a zone requires at least 20% supply from the minimised source, it is identified as dependent on that source. We note that this threshold differs from the Gas Target Model (GTM1) criteria which seek a residual supply index (RSI) of at least 110%. We are not aware why ENTSOG has chosen the threshold that it has. The indicator is calculated under average winter and summer conditions.
  Based on the terminology of Annex IV (3b) of Regulation 347/2013, the **SSDEP** may provide information on the specific criterion of competition. However, the general caveat remains that without information on the owners of the gas source, a proper assessment of competition is not really feasible.
  Currently, this indicator does not take into account contractual congestions which arise through long-term capacity contracts not being fully utilised (and

not subject to effective long-term UIOLI) or taking inefficient routes through the system. This seems appropriate as an investment decision for new capacity should not be based on the potential existence of contractual congestion which could also be removed through other measures (i.e. without investment). The implementation of CMP and the ENTSOG network codes should already contribute to removing such inefficiencies in the medium term, making ENTSOG's assumption sensible.

- **Supply Source Diversification assessment (SSDIV)** – This indicator assesses the ability of each zone to access different supply sources under average summer and winter day conditions. The indicator attributes one point to every supply source that can supply at least 5% of demand of the respective zone. Each supply source is maximised in the direction of the respective zone. In order to obtain an aggregated index number, results of several simulations have to be combined. Based on the terminology of Annex IV (3b) of Regulation 347/2013, the SSDIV may provide information on the specific criterion of competition. However, once again, the general caveat remains that without information on the owners of the gas source a proper assessment of competition is not feasible.
  ENTSOG has already announced its intention to revise this indicator, as it presents modelling challenges. Currently, this indicator does not take into account contractual congestions which arise through long-term capacity contracts not being fully utilised (and not yet subject to effective long-term UIOLI) or gas flows taking inefficient routes through the system. This seems appropriate as an investment decision for new capacity should not be based on the potential existence of contractual congestion which could also be removed through over measures (i.e. without investment). The implementation of CMP and the ENTSOG network codes should already contribute to removing such inefficiencies in the medium term, making ENTSOG's assumption sensible.
- **Price convergence** – The indicator of price convergence captures the evolution of supply prices. In accordance with Annex IV (3a) of Regulation 347/2013, it evaluates the specific criterion of market integration and interoperability.
  ENTSOG has already announced its intention to revise this indicator. However, we note that the information on price convergence will be a direct output of the gas model, when using the "marginal cost at each node approach" discussed in section 3.3.

Additional topics on indicators – Compliance with Regulation 347/2013

According to Annex IV (3) Regulation 347/2013, PCI-candidates should be evaluated in terms of their enhancement of:

- market integration and interoperability;
- competition;
- security of supply; and
- sustainability.

The assessment of the enhancement of competition should take into account the diversification of sources, counterparts – meaning the number of suppliers available to supply through a particular route – and routes as well as the impact on the Herfindahl-Hirschman Index (HHI) calculated at capacity level for the area of analysis.

- **Diversification counterparties** – A project's impact on diversification of sources and routes is currently captured by the Import Route Diversification Index and the Supply Source Diversification Index. Diversification of counterparties is currently not assessed explicitly within ENTSOG PS-CBA methodology. However, it is not clear that the project promoter is in a position to provide information on the diversification of counterparties. This is not information that a TSO should be expected to hold.
  Notwithstanding this, the EC notes that at least for some projects this information may be available, e.g. the project promoter of an LNG terminal may already has information who booked capacities and based on this information may make a guess where the supply comes from. While accepting that this information may not be available for most projects, the EC still sees some value in including diversification of counterparties, if it is available, at least as additional information for a qualitative assessment.
- **Herfindahl-Hirschman Index (HHI)** – we discussed above that the Import Route Diversification Index follows the structure of an HHI index and that this index might be accepted as the HHI as set out in the Regulation. The EC confirms that the Import Route Diversification Index as described in the draft can be accepted as also covering the HHI index on capacity level.

Table 2 gives an overview of the different indicators and the specific and general criteria defined by Regulation 347/2013. As shown in the table, almost all criteria set out by Regulation 347/2013 are met by ENTSOG's indicators. Currently, the exceptions are:

- overall flexibility (including reverse flow) as part of the specific criterion of market integration and interoperability;
- the support of biogas; and
- the back-up of RES generation.

Table 2. Criteria set out by Regulation 347/2013 and ENTSOG indicators

	Criterion Regulation 347/2013	ENTSOG indicator
General criteria Art. 4 I c (ii) and Annex IV	Involvement of at least two MS	Assessed through general description of the project
	Located on the territory of one MS	Assessed through general description of the project
	Crosses border of one MS and EEA -state	Assessed through general description of the project
	Significant cross border impact	Bi-directional project indicator (other criteria to define significant cross border impact follow directly from the Regulation)
Specific criterion **Market integration and interoperability**	Integration of market areas	intended to be derived from model outcome
	Price convergence	intended to be derived from model outcome
	Overall flexibility (incl. reverse flow)	
Specific criterion **Competition**	Diversification of sources	Import Route Diversification Index Supply Source Dependence assessment
	Diversification of counterparts	Supply Source Diversification assessment

	Herfidahl-Hirschmann-Index (HHI)	Import Route Diversification Index
Specific criterion **Security of supply**	Short- and long-term resilience of the system	N-1 Infrastructure Standard Index
	Remaining flexibility	Remaining Flexibility at Zone level
Specific criterion **Sustainability**	Reduction of CO2-emission	Model outcome
	Back-up of RES generation	
	Support of power-to-gas	
	Support of biogas transportation	Model outcome

Source: Frontier Economics

3.3.7 Saved cost approach – monetising cost of disruption

ENTSOG calculates the physical impact on demand from disruption as follows. The gas flows and disrupted demand[19] are calculated, first with the relevant project and then without it. The difference provides a measure of the extent to which the project increases supply security.

ENTSOG notes that the "cost of value for disruption" is a value that would enable the move from quantification to monetization. However, ENTSOG has drawn attention to the absence of a complete set of such cost data for each EU member state. Even for a single member state it is very difficult to assess as the cost is not linear with the loss of load served. Any physical interruption with gas supplies to consumers leads to the costly exercise of system flushing and relighting of pilot lights etc.

Determining the appropriate value of lost load for gas is a challenging task. Methodologically, three different approaches have been applied in previous research to derive the economic costs of power and/or gas interruptions (i.e. VOLL):

- some studies have drawn upon historical supply interruptions to infer outage costs from available data;
- surveys were used to investigate the willingness to pay (WTP) for the avoidance of an interruption among different groups of customers[20]; and
- studies using the macroeconomic approach[21]. Within this framework, electricity and gas is interpreted as an input factor for both firms and

[19] ENTSOG calculates the disrupted demand by so-called "disruption arcs". These are fake arcs that link the origin with each node with a cost of 100.000 €/GWh. As the cost of using these arcs is very high, they are only used in the case in which the network is not able to provide an alternative path. These "disruption arcs", therefore, measure disrupted demand, because they would not be used if there was an alternative way to cover this demand. Hence, "disruption arcs" are only used if all other arcs into a node are congested. In addition, ENTSOG also includes "fake gas source". In the case that there is a supply disruption, which cannot be compensated by alternative sources because they already reached their maximum scenario, the node is supplied with the "fake gas source" via the "disruption arcs".

[20] See a study for gas: London Economics, *Estimating Value of Lost Load (VoLL)*, Report for OFGEM, 2011.

[21] See for example: London Economics, *Estimating the Value of Lost Load*, Report for Electric Reliability Council of Texas, 2013; OXERA, *An assessment of the potential measures to improve gas security of*

private households. The approach seeks to derive economic costs of electricity and gas outages from the loss in 'output' generated by these two groups. 'Output' for private households is defined by the utility people gain from leisure activities. However, the relation between availability of gas and leisure is not straightforward. There may be arguments that the correlation of leisure-induced welfare and gas consumption are close to zero.

We are unaware of any European surveys on WTP to avoid gas interruption. We understand from ACER that NRAs do not generally have estimates of value of lost load. Hence, for the short term the WTP approach is not available for the PS-CBA.

In a recent report for the EC, Booz & Company(2013)[22] used a macroeconomic approach to quantify the benefits of gas infrastructure investments on security of supply. The report calculates the reduction of "GDP at risk" as a reduction in the probability of occurrence of outages in the gas supply for a given country. It estimates the impact of a 1% point reduction in the probability of the occurrence of a supply disruption on GDP. The results indicate a wide range of "daily GDP at risk" from 0.1 €mn.(2005) for Latvia, Bulgaria and Slovenia to 19.4 €mn.(2005) in the United Kingdom. The methodology only captures the effect on a daily basis with no reference to € per MWh gas not served.[23] In our view this approach, applied in this way, is not useful.

In a recent report for the Energy Community DNV KEMA/REEK/EIHP (2013)[24] used another approach to estimate the benefit of a gas investment on the security of supply. They used a three step procedure:

- The benefits are measured by the change in economic welfare due to the implementation of the project in the case of a gas supply disturbance.
- The gas supply disturbance is assumed to be a 30% reduction of gas deliveries on the interconnectors from Russia/Ukraine to the region in January for a given year.
- The economic welfare change due to the realization of the proposed infrastructure is calculated as the difference between the welfare under disturbance conditions with and without this project.

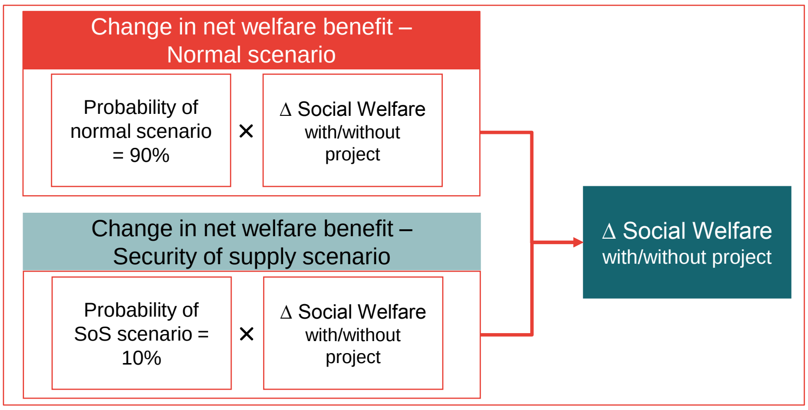
Figure 6. Calculation method of project related aggregated economic welfare change (including security of supply)

supply, Report prepared for the Department of Trade and Industry, 2007; EWI, *The Costs of Power Interruptions in Germany – an Assessment in the Light of the Energiewende*, EWI Working Paper No 13/07, April 2013.

[22] Booz & Company, *Benefits of an integrated European energy market*, in association with LeighFisher, Professor David Newbery (University of Cambridge), Professor Goran Štrbac and Danny Pudjianto (Imperial College, London), and Professor Pierre Noël (IISS, Singapore), Report prepared for European Commission – DG Energy, 2013.

[23] However, instead of dividing the "total share of GDP at risk" by 365 day, one can divide the "total share of GDP at risk" by the total gas consumption to get to an indication of the €/MWh figure.

[24] DNV KEMA/REKK/EIHP, *Development and Application of a Methodology to Identify Projects of Energy Community Interest*, Report for Energy Community, 2013.



Source: DNV KEMA/REEK/EIHP

In order to calculate the project related aggregate change in socio-economic welfare for a given year, DNV KEMA/REEK/EIHP (2013) calculates the weighted average of project related welfare changes under normal and disturbance conditions. Weights are the assumed probabilities for normal and disturbance scenarios to occur (90% versus 10%). The report does not justify why the weights 90%/10% were chosen, nor why a representative disturbance was one month in duration

However, we note that this approach does not calculate the monetary value of loss load, but only the additional costs necessary to substitute the source that is interrupted. It does not consider circumstances in which load will actually be cut off.

We understand from discussions with ENTSOG during the project that ENTSOG is currently evaluating monetising the cost of disruption for two different scenarios:

- **A scenario where part of gas demand cannot be covered** – ENTSOG is analysing the possibility of using rough estimates for VOLL.
- **A scenario where gas demand can be covered but at higher cost** – ENTSOG is currently analysing the definition of different stress situations together with the issue of the probability of their occurrence.

We think that ENTSOG is pursuing two sensible ways to try to monetise the cost of disruption.

Monetising cost of disruption – Proposal

ENTSOG should continue to pursue the approach as described to us, namely attempting to monetise the cost of disruption for two different scenarios.

3.3.8 Saved cost approach – power generation and CO2-emissions

As part of the monetary analysis, ENTSOG evaluates a project's impact on the cost of power generation and CO2-emissions. The impact of a project on the costs of power generation is given by the cost reduction in power generation achieved through a cheaper supply of gas.

A reduction of CO2-emissions is obtained by the amount of power generation from coal-fired plants that is replaced by generation from gas-fired plants. A substitution of coal-fired generation is achieved, if the short-run marginal costs of gas-fired generation are lower than the short-run marginal costs of coal-fired generation.

ENTSOG proposes to define **for each node**

- the part of power generation produced by thermal production, including gas- and coal-fired power generation;
- the thermal efficiency of power plants;
- a lower limit for the power produced from each fuel, derived from historical load factors provided by ENTSOE; and
- an upper limit of production is given by the installed production capacity.

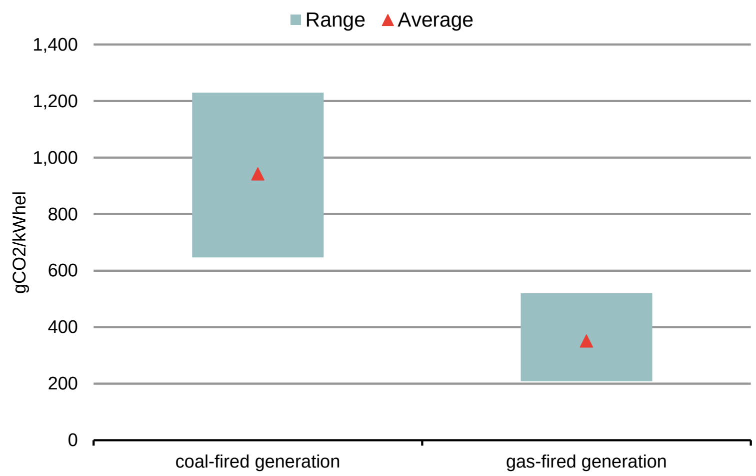
In addition, ENTSOG proposes to define **for all nodes** uniform

- fuel costs of coal; and
- emission factors for gas and coal.

We note that defining uniform fuel costs for coal and emission factors for power generation rather than for each individual node may result in an over-/underestimation of potential benefits for different projects, as, for example, the substitution of coal in one region may be "more valuable" than in another region. This may be the case as CO2-emission factors of coal-fired plants vary between regions.

In order to incorporate regional differences in the evaluation of CO2-emissions reduction, one could assume differentiated emission factors for power production from gas and coal for each node. Such emission factors are for example provided by IEA (2012).[25] IEA (2012) indicates a wide range of emission factor for EU-Countries ranging from 647 gCO2/kWhel in Denmark to 1.230 gCO2/kWhel in Belgium (**Figure 7**). The difference in emission factors can be caused by different CO2-intensity of the fuel used in combustion and/or different efficiency rates.

Figure 7. Range of CO2-emissions from power generation in EU countries (2010)



Source: IEA (2012)

A further refinement through differentiation of coal prices could be used in the calculation of price spreads between gas and coal. This could be done by adding a

[25] IEA (2012) CO_2-Emissions from fuel combustion – Highlights, pp. 114: *CO2 emissions from coal and peat/gas consumed for electricity generation, in both electricity-only and combined heat and power (CHP) plants, divided by output of electricity generated from coal/gas. Both main activity producers and autoproducers have been included in the calculation. This indicator is not available when electricity output is very small or where inputs to electricity generation do not match electricity output.*

component of transportation cost to the coal price. This component should reflect the cost of transporting coal from the point of the price benchmark to the relevant balancing zone.

3.3.9 Social discount rate

ENTSOG proposes that for all the projects, a uniform discount rate of 4.5% (real) shall be used, which lies in the range of 3.5% to 5.5% set by European Commission (2008).

In its opinion ACER recommends the use of 4% as applied in the electricity sector. ACER refers to Frontier (2012)[26], which noted that using 4% pa (real) as a discount rate in accordance to the European Commission's advice in "Commission Impact assessment guidelines", 15 January 2009 (Annex 11.6 on discounting) would not be unreasonable. Cost-benefit analysis involves comparing projects with different flows of financial or economic costs and benefits occurring in different time periods. Discounting recognises that the use of money has a value. A euro today is worth more than a euro in five years even after allowing for inflation. This is known as the time value of money. There is a huge literature on how to set the discount rate for cost benefit analysis. However, there is little consistency in the literature.

We note that for pragmatic and political reasons the European wide methodology for the PS-CBA needs a uniform discount rate to be applied. The rate proposed by ENTSOG lying in the range of the European Commission (2008) rate, seems to be one candidate. Another one would be the 4% proposed by ENTSOE and ACER, lying in the range of rates proposed by the European Commission (2008). We understand from discussions with ENTSOG during the project that ENTSOG is currently analysing a potential change to 4%. As there is a broad consensus that economic growth prospects are now lower than in 2008 when the Commission arrived at its estimated range, adoption of a 4% real rate of return would seem the best way to achieve consistency.

Social discount rate – proposal

We suggest that ENTSOG uses 4% (real) as the social discount rate to achieve consistency with the ENTSOE and ACER proposal.

3.3.10 Economic lifetime of projects

Assumptions regarding the useful economic life of assets are also required.

We understand that ENTSOG currently considers that for regulated assets the national regulatory depreciation periods should be used as the economic lifetime. For non-regulated assets we assume that the depreciation periods from the project promoters' business plan should be used.

We note that regulatory depreciation periods differ around European member states, which may reduce the comparability of different projects. Similar problems may also arise in relation to non-regulated assets.

[26] Frontier Economics, Project of common interest – Selection process, Report for NRAs, 2012.

As with the social discount rate, there is huge literature on how to set the economic lifetime for cost benefit analysis. However, we note that for pragmatic reasons the economic lifetimes used by the European Investment Bank in their economic appraisal of investment projects could be used as default parameters. The EIB[27] uses:

- **Gas network (including pipes and compressor stations)** – 25 years;
- **LNG/UGS** – 20 years.

These economic lifetimes are similar to the time horizon which the Regulation foresees for the snapshot years in the energy system wide cost benefit analysis (n+5, n+10, n+15, and n+20), although terminal values may still be needed.

Circumstances can arise when such default lives would not be appropriate. There may be cases where patterns of capacity use are changing and capacity on a particular route may only be required for a limited period, in which case it would be important to reduce the assumed economic life. However, this may be unlikely to occur in relation to potential PCI projects related to priority corridors

Economic lifetime – proposal

We recommend that ENTSOG uses default lives in line with those used by EIB except where there is clear evidence that the project will have shorter economic life.

3.3.11 Economic performance indicators

ENTSOG (2013b: 25) proposes that project promoters shall calculate and report three different economic performance indicators (EPI) using monetised benefits and costs:

- *Economic Net Present Value (ENPV)* – calculated by the aggregated discounted value of all monetary cash flows generated by the project considering "benefits" from saved cost approach and total costs of project. The unit of the ENPV is €;
- *Economic Internal Rate of Return (EIRR)* – calculated by the discount rate that produces a zero ENPV. The unit of the EIRR is %; and
- *Economic Benefit / Cost ratio (EB/C)* – calculated by the present value of the present value of economic benefits divided by the present value of economic costs. The EB/C is a ratio.

We note that the EPIs for project A and project B may result in a different "ranking" of the projects as it is possible that

- ENPV: A > B; and
- EIRR: A < B.

Hence, in order to assess the project based on the economic performance indicators some further thought on the interpretation of the indictors may be necessary when it comes to PCI assessment (and internal ranking at Regional Group level). The European Commission (2008: 211ff) states the following with regard to the relation between the three EPIs:

[27] European Investment Bank, *The Economic Appraisal of Investment Projects at the EIB*, p. 120, March 2013.

- "The **Internal Rate of Return** is an indicator of the relative efficiency of an investment, and should be **used with caution** … If the sign of the net benefits, benefits minus costs, changes in the different years of the project's lifespan there may be multiple IRRs for a single project. In these cases the IRR decision rule is impossible to implement. Examples of this type of project are mines and nuclear power plants, where there is usually a **large cash outflow at the end of the project because of decommissioning costs**." (emphasis added)
- "There are many reasons in favour of the NPV decision rule. The **IRR contains no useful information** about the **overall economic value** of a project. …**Welfare depends on NPV** not IRR." (emphasis added)
- "Being a ratio, the indicator (**benefit-cost ratio, BCR**) does **not consider the total amount of net benefits** and therefore the ranking can reward more projects that contribute less to the overall increase in public welfare. The **appropriate case for using the BCR is under capital budget constraints**." (emphasis added)

We agree with this position. It implies that total welfare (in € terms) matters in the PCI selection process. Furthermore, the most plausible interpretation of the binding constraint is the number of manageable projects and not the capital budget. Therefore special attention should be placed on the economic performance indicator ENPV (as opposed to EIRR and EB/C) in the PCI assessment process.

The EC notes that ENPV indeed provides information on a project's overall value which could be one of the main inputs for the Regional Groups on each project and could be the starting point for a first ranking. However, IRR and B/C ration could provide additional information, as well. ENTSOG notes that the PS-CBA methodology need not include any guidance favouring one indicator.

We agree with ENTSOG that, formally, the PS-CBA need not include any guidance favouring one indicator. The Regulation does not require the PS-CBA methodology to specify what weighting should be given to each indicator and this could in theory be left to the Regional Groups and the EC. This seems also be in line with the EC position. However, we note that some illustrative examples and interpretations of results in the case where, e.g.

- ENPV: A > B; and
- EIRR: A < B

may be helpful for Regional Groups in their assessment process. ENTSOG may consider including such examples in the PS-CBA methodology.

Economic performance indicators – Proposal

ENTSOG should consider inclusion of illustrative examples of projects where the rankings based on the economic performance indicators differ and guidance on interpretation of the results in the final PS-CBA.

3.4. European Commission – Topics

The EC raised some specific questions. Some of these have already been addressed in our discussion of ENTSOG topics. However, some remain. We discuss these below.

3.4.1 Sustainability: Intermittency, RES generation, innovative use of gas infrastructure – valuing the benefits of natural gas infrastructure

Gas infrastructure projects may have further positive impacts on sustainability which the Regulation intends should be covered, in particular:

- the support of the integration of intermittent renewable generation or power to gas; and
- transportation of biogas.

With regard to the latter, we note that the impact on the transportation of biogas should be already included in the calculation of the net benefit of a project. For example, if a project allows the infeed of biogas this will be included as additional national production at each node. Hence, a separate indicator seems unnecessary unless a higher weight is to be given to new biogas than new conventional gas.[28] In any event, the amount of biogas brought into the system may be reported for information purposes.

The integration of intermittent RES in the electricity market requires flexibility from other power plants. This flexible back-up capacity is mainly provided by gas-fired plants as they are best placed to provide this back-up service. Hence, improving the economic framework for gas-fired plants may facilitate increasing the share of RES from volatile production in the system. Gas infrastructure investments may improve the economic environment for gas-fired power plants in various ways. However, in order to assess fully the economics of gas-fired power plants a complex separate assessment including modelling of the electricity market is necessary. This is essentially out of scope of the PS-CBA for gas infrastructure. We note that the change in CO2 emission by increasing power production from gas-fired power plants already captures (part of) the value of gas substituting for coal but does not capture any additional benefit derived from the fact that flexible gas plant may improve the economics of, and hence encourage investment in, intermittent RES.

We understand that the EC is concerned that a gas infrastructure project's effect on intermittent RES is only partially included in the change of CO2 emissions by more power production from gas-fired power plants. The EC notes, for example, additional effects arise if:

- electricity production from gas replaces RES – we note that in general the short run marginal cost of RES, e.g. wind, PV, is lower than the short run marginal cost of gas-fired plants. (Only RES from biomass would be a possible exception.) Hence, gas-fired power plants tend generally not to replace RES generation;
- gas-fired-power plants are built instead of RES – we note that the investment drivers for RES and gas-fired plants are different. While RES is mainly driven by subsidies the latter is driven by the market. Hence, it is not likely that gas-fired plants are built instead of RES.

The EC also expressed concerns that ENTSOG's approach does not cover the case of a country which does not have a strong RES strategy. However, if we assume that a country follows no RES strategy at all, resulting in no RES capacities for power generation, then the value of gas infrastructure for the support of integration of (non-existing) intermittent RES would by definition be zero.

ENTSOG notes that the potential support of an infrastructure project to RES integration through the increase of flexibility for gas-fired power generation is currently under investigation. We have not received any further information from ENTSOG. However, given the complexity of this topic and other still unresolved

[28] This has parallels with issues related to RES support. If biogas is supported explicitly it is not necessarily logical to consider transport of biogas as any more valuable than transport of other gas.

issues (e.g. material changes to the gas modelling) being more pressing, we would propose that ENTSOG postpone the development of a more sophisticated indicator for RES integration to the next TYNDP round.

With regard to power-to-gas, we note that power-to-gas is still in the early development phase and the inclusion in the current PS-CBA may be too early. We understand that the EC agrees with this.

Sustainability – Proposal

The EC notes that a useful and informative indicator for the support of intermittent RES still needs to be developed. We understand that ENTSOG is currently investigating such an indicator. Frontier has not received any proposal from ENTSOG on this topic. However, given the complexity of this topic and other still unresolved issues (e.g. material changes to the gas modelling) being more pressing, we propose that ENTSOG postpone the development of a more sophisticated indicator for RES integration to the next TYNDP round.

3.4.2 Environmental and social impact

Investments in gas projects (pipelines, LNG, UGS) may also have an impact on the environment. This may result in possible public resistance against the project, which has to be taken into account by the project promoter and/or by Regional Groups when assessing PCIs. The EC notes that the cost of any more local environmental impact needs to be included in some form in the CBA methodology. Any mitigation measures taken by the project promoters should be internalised within the project cost. To the extent that unmitigated adverse impacts remain, they need to be captured, at least within a qualitative report.

The current ENTSOE guide for CBA[29] takes into account the environmental and social impact of a project in two ways:

- *Part of total project expenditures* – the costs of measures taken to mitigate the impacts are included in the total investment costs as monetary values[30];
- *Non-monetary indicators*[31] – some of the impacts may not be reflected by monetary costs. ENTSOE includes them in two further indicators:
  - *Environmental impact* – characterises the local impact of the project on nature and biodiversity and is expressed in terms of the number of kilometres an overhead line or underground/submarine cable runs through environmentally sensitive[32] areas. With regard to power storage projects ENTSOE notes that the impact is different from a transmission line and highly dependent on technology.

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[29] ENTSOE, *Guideline for Cost Benefit Analysis of Grid Development Projects*, 14 November 2013.

[30] ENTSOE (2013: 25): "Expected environmental and consenting costs (such as environmental costs avoided, mitigated or compensated under existing legal provisions, cost of planning procedures, and dismantling costs at the end of the life time)."

[31] ENTSOE (2013: 26)

[32] The sensitivity with regard to biodiversity is relevant. ENTSOE (2013: 65) defines these areas inter alia by „Land with national parks and areas of outstanding national beauty" and „Land with cultural significance".

- *Social impact* – characterises the project impact on the (local) population and is expressed in terms of the number of kilometres an overhead line or underground/submarine cable run through socially sensitive[33] areas. With regard to power storage projects ENTSOE notes that the impact is different from a transmission line and highly dependent on technology.

The PS-CBA from ENTSOG needs to include environmental and social measures and some further extension of the ENTSOG proposal is necessary. ENTSOG could follow ENTSOE's approach with:

- **Inclusion in total investment costs** – the investment costs for the project should explicitly include and report the cost of measures taken to mitigate the impacts on the environment and achieve social acceptance of the project. ENTSOG should consider providing respective guidance on the types of measures a project promoter may report in the PS-CBA. Guidance from ENTSOG (and the member TSOs) has the advantage of including "industry best-practice".
- **Non-monetary indicators** – in addition the residual environmental and social impact may be reported by non-monetary indictors.

However, when defining non-monetary indicators one has to take the following into account:

- *Technology specific indicators* – the impact from a transmission pipeline, a LNG terminal and an UGS facility on the environment differ substantially. For example, if a depleted gas field is used for the UGS facility, the environmental and social impact will be rather small, while the impact from a new LNG terminal on the environment can be substantial. We also note that a gas pipeline may have an impact on the environment while under construction but not have an impact through its operational life, which is quite different from the case of overhead power lines.
- *Practicability* – project promoters should be able to calculate the indicators without high additional costs. Ideally, the indicators should already be included in documents supporting the internal investment decision by project promoters, e.g. (pre-)feasibility studies.

We understand that the EC agrees with the approach of making the (expected or planned) costs for mitigating the impacts on the environment explicit in the investment costs. This will ease the communication with the public and environmental stakeholders. In addition, the EC notes that a closer look on projects, where environmental issues were important, may possibly lead to the identification of additional indicators.

We understand that ENTSOG is currently investigating the applicability of a quantitative approach for gas infrastructure projects modelled broadly on the ENTSOE approach.

The EC has mooted a further option to evaluate the environmental and social impact may be based on "stakeholder involvement". For example it may be possible to define various degrees of "stakeholder involvement" based on common European standards and use a traffic light system:

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[33] The sensitivity with regard to population density and landscape is relevant. ENTSOE (2013: 65) defines these areas inter alia by „ Land that is close to densely populated areas (as defined by national legislation)" and Land protected by directives or international law.

- *Green* – stakeholder involvement above European standard;
- *Orange* – stakeholder involvement according to European standard;
- *Red* – stakeholder involvement below European standard.
- We agree that this could be helpful in the evaluation of projects but it can only be made operational if it is possible to characterise what the 'European standard' is.

Environmental and social impact – Proposal

We recommend that ENTSOG continue its efforts to develop a scoring system fashioned after that of ENTSOE. We are of the view that any further assessment of other environmental factors would be too difficult to include in the current PS-CBA and should only be addressed when the next refinement is undertaken.

4. CASE STUDY REVIEW

In the following we discuss and review case studies provided by ENTSOG. This part of the report aims to provide an external review of the functioning of the PS-CBA methodology with an explicit focus on the modelling tool developed by ENTSOG. We note that ENTSOG is still working on the finalisation of the modelling tool, which means that a full review, e.g. analysis of benefits per country, indicators based on modelling, of the case studies was not possible.

The process of case study review has been characterised by close interaction between ENTSOG and Frontier Economics. Questions with regard to the results from different modelling rounds have been discussed through the forum of a weekly 'Jour Fixe'. ENTSOG has indicated that the results of the case studies, which we have analysed in this section, need to be considered as preliminary results.[34]

The analysis is structured as follows:

- Description of the candidate projects analysed in the case studies (**Section 4.1**);
- Definition of the modelled scenarios and analysed benefits (**Section 4.2**);
- Hypotheses regarding the expected outcome of the modelling (**Section 4.3**);
- Description and analysis of the gas model results (**Section 4.4**); and
- Summary of the case study review (**Section 4.5**).

4.1. Description of case studies

In close interaction with the European Commission, ENTSOG has chosen four PCI-candidates from the TYNDP 2013 to serve as case study projects to test the proposed PS-CBA methodology. The candidate projects are:

- the Gas Interconnection Poland-Lithuania – GIPL (TRA-N-212);
- the Underground Gas Storage at South Kavala (UGS-N-076);
- the LNG Regasification Vessel (RV) to Croatia (LNG-N-082); and
- the Montoir LNG Terminal Expansion (LNG-N-225).

In the following, we describe the main characteristics of each project.

4.1.1 Gas Interconnection Poland-Lithuania – GIPL (Poland/Lithuania)

The Gas Interconnector Poland-Lithuania (GIPL) is a pipeline project located in the north-east of Poland connecting the gas transmission systems of Poland and Lithuania. It aims to integrate the Baltic States into the EU gas grid in order to enhance competition and security of supply in these areas. GIPL would allow the Baltic States to have access to the global LNG-market through the Polish LNG-terminal Świnoujście. The expected commissioning date of GIPL is 2017. Therefore the capacity increase of 29 GWh/d in the direction of Lithuania to Poland and of 68 GWh/d from Poland to Lithuania is modelled as of 2018.

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[34] Provided by ENTSOG on 07 May 2014.

Figure 8. Profile - Gas Interconnector Poland-Lithuania (GIPL)

Gas Interconnection Poland-Lithuania (GIPL)

Source:ENTSOG

- **Technical information**
  - Pipeline Length 562 km
  - Compressor Power 2.1 MW
  - Maximum Capacity 68 (exit); 29 (entry) GWh/d
- **Project information**
  - Commissioning 2017
  - FID (Y/N) (N) 2013 Q4
  - TPA Regulated
  - Financing EU fund expected
- **Expected benefits** (extract, according to ENTSOG)
  - Increased market integration and SoS in Baltic states and CEE
  - Connection isolated Baltic states into EU gas grid and LNG supply (including alternative supply route to Baltic states)
  - Longterm perspective: Import shale gas from Poland
  - Access to Latvian Incukalns UGS
  - Supply non gasified areas in LT and PL

Source: Frontier based on ENTSOG TYNDP 2013

4.1.2 Underground Gas Storage at South Kavala (Greece)

South Kavala is an almost depleted offshore natural gas reservoir in the North-East of Greece, exploitation rights are held privately until 2014. The projected conversion into an UGS facility could increase the EU's ability to make use of transportation capacity from the East into Europe and help to integrate the East Med pipeline and TAP (Trans Adriatic Pipeline) into the EU gas infrastructure.

Figure 9. Profile - Underground Gas Storage at South Kavala

Underground Gas Storage at South Kavala

Source:ENTSOG

- **Technical information**
  - WGV 360 mcm
  - Max. Injection 55 GWh/d
  - Max. Withdrawal 44 GWh/d
- **Project information**
  - Commissioning 2018
  - FID (Y/N) (N) 2013 Q4
  - TPA Regulated
  - Financing Multilateral financing
- **Expected benefits** (extract, according to ENTSOG)
  - Increases security of supply in the area of South East Europe / Balkan States
  - Diversification of sources
  - Back-up for renewables
  - Increased integration of East Med / TAP in EU gas infrastructure

Source: Frontier based on ENTSOG TYNDP 2013

4.1.3 LNG Regasification Vessel (Croatia)

The LNG Regasification Vessel (RV) situated at the city of Omišalj on the Croatian Island, KRK, is part of the NSI East gas corridor. Working in conjunction with the development of connected projects, its objective is to diversify supply sources for the CEE/SEE,.

Figure 10. Profile - LNG RV (Croatia)

LNG Regasification Vessel (Croatia)

Source:ENTSOG

- **Technical information**
  - Volume: 2 bcm/y
  - Send-out: 60.5 GWh/d
  - Max. Withdrawal: 44 GWh/d
- **Project information**
  - Commissioning: 2015
  - FID (Y/N): (N) 2013
  - TPA: -
  - Financing: -
- **Expected benefits** (extract, according to ENTSOG)
  - Security of supply
  - Back-up for renewables
  - Increased gasification of the entire region
  - Market integration with CWE and CEE
  - Increased security of supply

Source: Frontier based on ENTSOG TYNDP 2013

4.1.4 Montoir LNG Terminal Expansion

The LNG Terminal Montoir-de-Bretagne is located in the north-west of France, in the balancing zone PEG-Nord. The current regasification capacity at Montoir amounts to 10 bcm/year. The planned expansion, the construction of storage tanks and regasification units, will increase this capacity to 16.5 bcm/year. The project is well located to receive LNG from Northern America and is therefore likely to increase source diversity and security of supply in France and Central-Western Europe.

Figure 11. Profile - Montoir LNG Terminal Expansion

Montoir LNG Terminal Expansion

Source:ENTSOG

- **Technical information**
  - Volume: +6.5 bcm/y
  - Send-out: +55 GWh/d
- **Project information**
  - Commissioning: 2018 Q4
  - FID (Y/N): (N) 2015
  - TPA: No
  - Financing: -
- **Expected benefits** (extract, according to ENTSOG)
  - Security of supply / N-1 France and Regional
  - Market integration
  - Reverse Flow
  - Diversification of sources and routes
  - LNG from North America
  - Linking of Northern and Southern European Markets

Source: Frontier based on ENTSOG TYNDP 2013

4.2. Description of scenarios and benefits

ENTSOG calculates benefits for different scenarios, which we describe below.

4.2.1 Modelled scenarios

The methodology as currently developed includes a wide range of different scenarios which can be distinguished by the following dimensions:

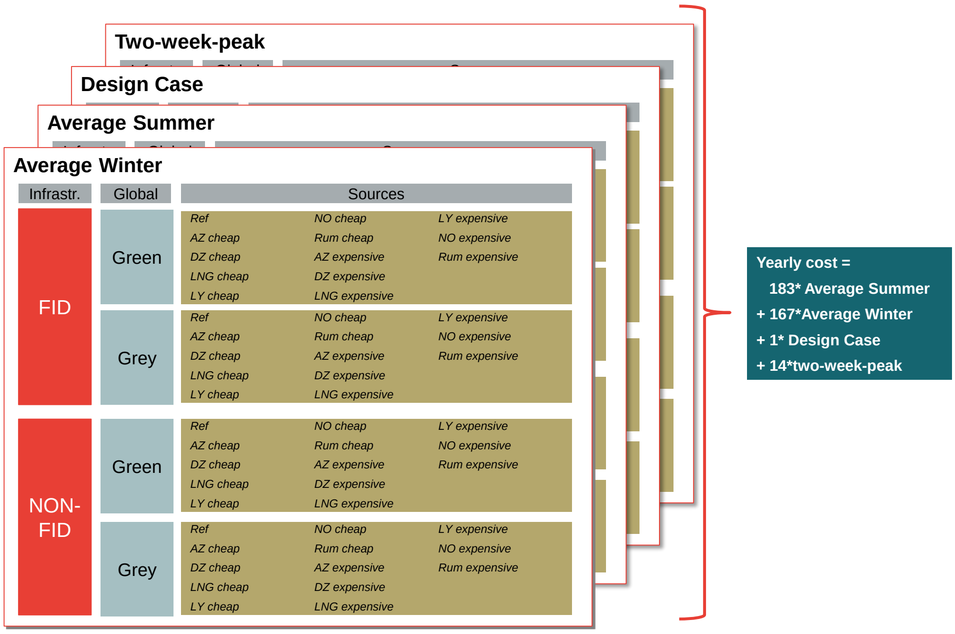
- **Infrastructure scenario**: FID or FID+NON-FID projects;
- **Global Scenario**: "Green" or "Grey" which differ with regard to fuel prices, demand etc.; and
- **Gas source prices**: 13 price scenarios defining a price per gas source based on an increase or decrease of supply from individual sources, while keeping all other sources constant, e.g. decreasing supply cost ("price") of Russian gas, while keeping all other sources constant.

The 52 possible scenarios derived from combinations of these parameters are subsequently analysed for four different climatic conditions and aggregated to yearly average values per day using the weights:

- Average Winter (weight 167/365 = 46%)
- Average Summer (weight 183/365= 51%);
- Design-Case (weight 1/365=0.3%); and
- Two-week-peak (weight 14/365= 4%).

In order to obtain the incremental effect of a project, one has to calculate every scenario once including and once excluding the project. **Figure 12** summarises the modelled scenarios.

Figure 12. Modelled scenarios



Source: Frontier

The number of different scenarios places a challenge on reporting the results. In theory one has to show the results for the 52 possible combination scenarios, which may not allow a clear view of the final results for gas infrastructure projects. One option may be to reduce the number of possible combinations. However, the main drawback is that by restricting the number of scenarios information may get lost.

Another option may be to undertake the calculations for all 52 combinations of scenarios but only report the results for those scenarios where the total benefit exceeds a certain threshold value. Hence, no material information is lost but the drivers of the results become clearer. In our discussion of the case studies we follow this second approach.

4.2.2 Total costs benefits (EU-level)

ENTSOG calculates the benefits of a gas infrastructure project by the incremental effect of the project on total system costs in the EU. The incremental effect is captured by the incremental approach described in **Section 3.3.5**, i.e. the difference in costs including and excluding a project in a certain scenario.

The benefits on the EU-level are defined as a decrease in the value of the objective function of the ENTSOG gas model, i.e. the total system costs. Elements of the objective function are:

- Gas supply costs;
- Costs of national production;
- Costs of coal;
- Transportation cost;
- Storage costs for injection and withdrawal;
- LNG infrastructure costs; and
- CO2-costs.

In addition, ENTSOG reports costs of disrupted demand. However, ENTSOG stresses that it only uses a dummy figure for the value of lost load.

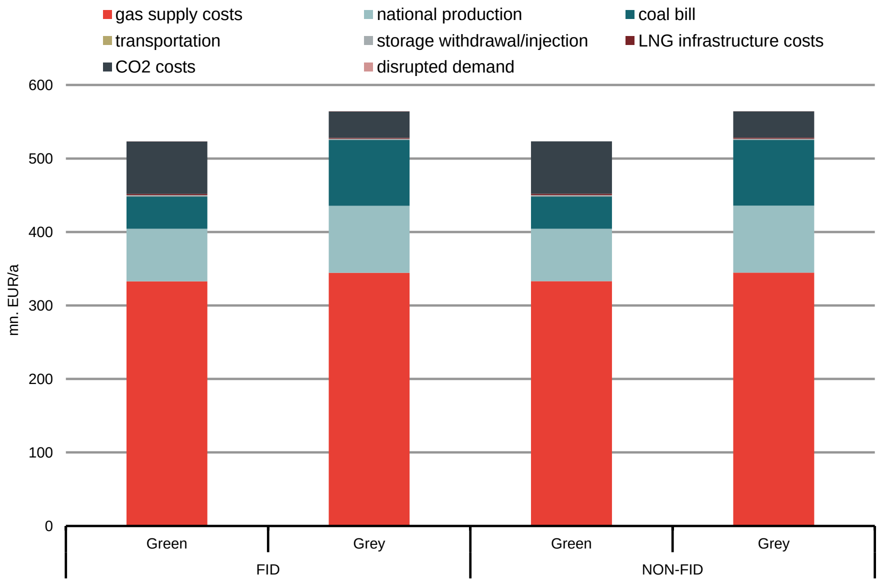
In order to evaluate the importance of the different elements of total costs, we have analysed the share of each element in the four reference cases of the

- FID and NON-FID[35] infrastructure scenarios;
- "Green" and "Grey" scenarios for fuel prices, etc.

Figure 13 illustrates the distribution of total costs in mn.EUR/year across the different cost elements. It can be observed that gas supply costs have the highest share of total costs in all reference cases. Further, gas supply costs and costs of national production are higher under the assumption of the "Grey" framework. The "Green" scenarios are characterised by, *inter alia*, higher CO2 prices. Therefore, CO2 costs increase compared to the "Grey" scenario. There is only a minor difference in total costs between FID and NON-FID scenarios in the reference cases.

[35] The NON-FID scenario includes FID and NON-FID projects.

Figure 13. Elements of total costs (reference case)



Source: Frontier

The share of the other cost elements is negligible, in particular transportation costs and the cost of disrupted demand.

4.2.3 Benefits on country level

ENTSOG intends to calculate benefits per country based on the changes in value of flows reaching the respective balancing zones. A change in value can be induced by the extent to which it is possible to make use of cheaper gas sources and reduce the extent of more expensive gas.

One difficulty in this respect is to determine the correct price for each node. We understand that ENTSOG has chosen to use marginal (or dual) prices to calculate benefits per member state. We note that ENTSOG is currently still working on this issue and results have not been finalised at this stage. Hence, our discussion of the case studies cannot include any comments on the distribution of benefits by Member State.

4.3. Hypotheses – case study results from gas model

In this section we describe our expectation for the results of the ENTSOG NeMo model for the case studies. We note that we have not assessed the correctness of the coding used in the ENTSOG's NeMo model, i.e. if the minimisation problem is defined and programmed correctly. This was not the scope of our assignment. However, our analysis of the results from the NeMo model allows provides some cross-check on the integrity of the model. Taking into account the characteristics of each project individually[36] as well as ENTSOG's expectations of benefits, we can

[36] Expectations on the outcome are based on the isolated evaluation of these projects. They do not take into account potential synergies or interdependencies with other projects, but which amy affect the results when the two infrastructure scenarios FID and NON_FID are modelled.

derive the following hypotheses with regard to what the outcomes of the case studies should be.

4.3.1 Gas Interconnection Poland-Lithuania

- **H1: Increased security of supply and market integration in the Baltic States** – GIPL serves as additional capacity connecting the Baltic States to Western Europe's gas markets. An increased security of supply and market integration with Western Europe might manifest itself through:
  - Lower gas supply costs in most cases, as higher diversification of sources for the Baltic States is possible.
  - A higher substitution of Russian gas by other sources in the scenarios with expensive Russian gas (representing the effect of possible supply disruptions).
- **H2: Reduced costs due to higher share of LNG** – GIPL allows the Baltic States to have access to Polish LNG terminal Świnoujście, therefore we would expect lower gas supply costs in the case of cheap LNG.

4.3.2 Underground Gas Storage at South Kavala

- **H1: Increased security of supply in South East Europe / Balkans** – The UGS South Kavala is located in a geographical area which is highly dependent on Russian gas. Additional storage capacity could decrease this dependency by puffering Russian gas. We would expect a decrease in the supply from Russia in the case of expensive Russian gas (representing the effect of possible supply disruptions).
- **H2: Increased transport capacity of Russian gas to the west** – The additional storage capacity offered by South Kavala may facilitate increased imports from Russia. This should be observed in the case of cheap Russian gas.

4.3.3 LNG Regasification Vessel (Croatia)

- **H1: Increase security of supply in South East Europe / Balkans** – Similar to the UGS in South Kavala, the LNG RV is located in a geographical area which is highly dependent on Russian gas. Additional LNG supply could decrease this dependence by offering an alternative source of supply. We would expect a decrease in the supply from Russia in the case of expensive Russian gas (representing the effect of possible supply disruptions)
- **H2: Increased diversification of sources** – Additional LNG capacity should have a substantial effect on the total cost of gas, if the LNG price is below the average of other sources. Therefore we would expect a benefit in the case of LNG cheap.

4.3.4 Montoir LNG Terminal Expansion

- **H1: Increased diversification of sources** – Additional LNG capacity should have a substantial effect on the total cost of gas, if the LNG price is below the average of other sources. Therefore we would expect a benefit in the case of LNG cheap.

4.4. Description and analysis of the gas model results

In this section we describe the case study results for the individual projects. In particular, we

- analyse the project's incremental effect on total costs;
- analyse the project's effect on gas supply by supply sources in order to explain the observed welfare effects; and
- draw conclusions based on the hypothesis formulated above.

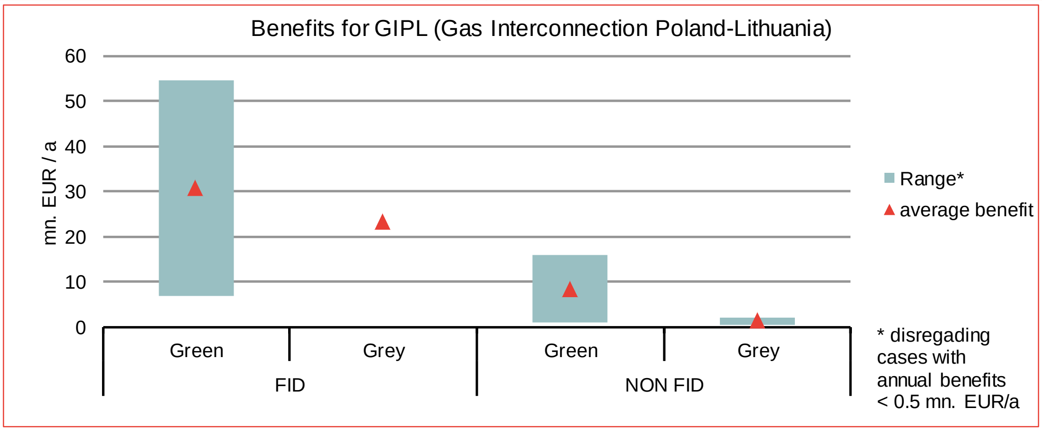
Below we only describe scenarios resulting in positive benefits identified by the ENTSOG NeMo model. Hence, we disregard scenarios which result in increasing total costs[37] caused by the gas infrastructure project.

4.4.1 Gas Interconnection Poland-Lithuania – GIPL (Poland/Lithuania)

Figure 14 summarises the annual gross benefits for the different scenarios. In order to assess if benefits exceed the investment and operating costs of the project additional information of the costs will be necessary. We note that ENTSOG did not provide us with information on the investment costs and operational costs for the projects.

Figure 14. Annual (gross) Benefits GIPL

Infra.	Global	average benefit	maximum benefit	minimum benefit	Range*	# of cases	case with max. benefit
FID	Green	31	55	7	48	2	FID - Green - Rum cheap
	Grey	23	23	23	0	1	FID - Grey - Rum cheap
NON FID	Green	9	16	1	15	2	NON FID - Green - Rum cheap
	Grey	1	2	1	1	2	NON FID - Grey - Rum expensive



Note: RUm cheap (expensive) = price scenario with cheap (expensive) Russian gas; NON FID = infrastructure scenario including FID and NON_FID projects; average benefit = simple average of scenarios with benefits > 0.5 mn. EUR/a without weights (probabilities) assigned to scenarios; #of cases: number of scenarios with benefits > 0.5 mn. EUR/a
Source: ENTSOG

The modelling results for GIPL are as follows:

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[37] Total costs include the above mentioned costs: gas supply costs; costs of national production; costs of coal; transportation cost; storage costs for injection and withdrawal; LNG infrastructure costs; and CO_2-costs. Project costs (investment costs and opex) are not included in these total costs.

- **Highest benefit from cheap Russian gas** – In almost every scenario, the highest annual benefits can be observed in the case of cheap Russian gas, indicating that GIPL allows for more imports from Russia, if ceteris paribus, all other sources are relatively more expensive. The highest benefit is observed in the case "FID-Green – RUm_cheap" with 55 mn. EUR/a.
- **Increased use of LNG only in some cases** – In the case of increased supply cost from Norway, GIPL allows for more LNG to enter the system, substituting expensive Norwegian gas. There are no substantial benefits of GIPL in the cases of cheap LNG supply. An increase of LNG supply can only be observed in combination with the high infrastructure scenario (Non-FID) and "grey" global assumptions, resulting in a benefit of 1 mn. EUR/year.
- **Likelihood of competing project** – Generally, benefits are higher in scenarios with low infrastructure (FID projects only). This indicates the existence of competing projects that reduce the incremental benefit of GIPL.
- **Security of supply** – including GIPL does not have an impact on disrupted demand[38] measured in GWh based on the NeMo gas modelling results provided from ENTSOG, hence, GIPL does not increase security of supply given this information. ENTSOG did not provide a full set of capacity indicators, including indicators reflecting security of supply. Hence we are unable to assess the impact from GIPL on security of supply.
- **Range of NPV for gross benefits** – Although no cost information is available, the range of the net present value[39] of gross benefits makes it possible to get an indication of whether the net benefit of the project may be positive for certain scenarios. We estimate a range for the NPV for gross benefits of 13 mn. to 741 mn. EUR for GIPL. The average benefit reported in **Figure 14** is calculated using only scenarios with benefits > 0.5 mn. EUR/a. All other scenarios are disregarded when calculating the average benefit.

Our conclusions with regard to the extent that the hypotheses described above are met are as follows:

- **H1: Increased security of supply and market integration in the Baltic States** – We observe a substantial decrease in total costs only in scenarios, where Russian gas is cheaper than other sources. There is only one combination in which expensive Russian gas leads to a decrease in supply from Russia (Non-FID-Green) and higher supply from Azerbaijan. Hence, the market integration effect (as distinct from any competition effect), which may allow access to other gas sources except Russian gas, is low. In addition, there is no impact on security of supply measured by the change in disrupted demand from GIPL.
  Hence, we conclude that possible benefits from GIPL in terms of increasing the diversification of sources to the Baltic States are currently not reflected by the modelling results. A possible reason may be congested capacity at the border between Germany to Poland so that additional capacity from Poland to Lithuania does not yield any additional benefit.
- **H2: Reduced costs due to higher share of LNG** – The outcome of the modelling does not support the hypothesis of a higher share of LNG due to

[38] We note that the data provided by ENTSOG did not include an explicit description of the basis of the gas disruption scenario.

[39] We calculate the NPV of gross benefits by summing up the discounted annual figures over 20 years. We use the social discount rate of 4% for discounting.

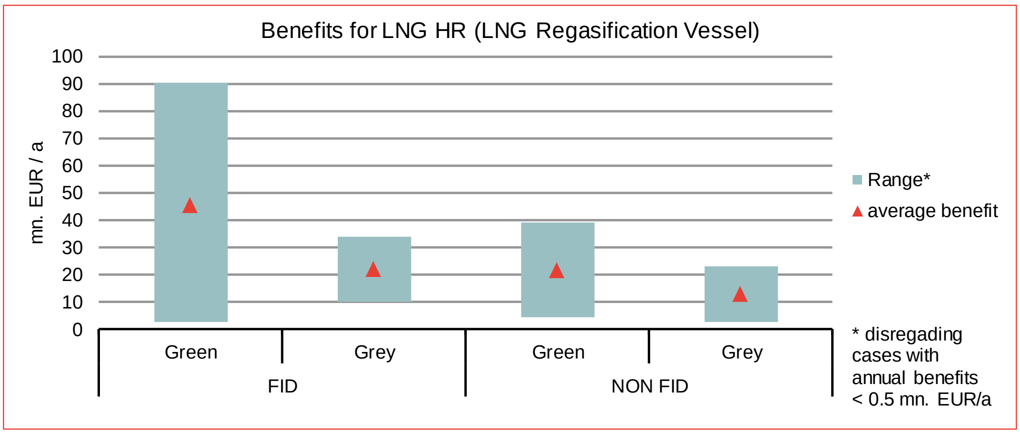
the implementation of GIPL. We observe an increased use of LNG in some cases. Of those cases, only the above mentioned combination of expensive Norwegian gas leads to benefits higher than 1 mn. EUR/year.
Hence, we conclude that modelling result do not confirm the expected increase in the share LNG due to GIPL. A possible reason for this may be the Lithuanian LNG terminal of Klapedia which is included in the calculations as off 2015 and reduces the possible benefit of GIPL. This means that the benefit from access to LNG from GIPL is largely already captured by the LNG terminal of Klapedia.

4.4.2 Underground Gas Storage at South Kavala (Greece)

Figure 15 summarises the annual gross benefits for the different scenarios. In order to assess if benefits exceed the investment and operating costs of the project additional information on the costs will be necessary. Once again, we note that ENTSOG was unable to provide us with information on the costs of these projects.

Figure 15. Annual gross benefits UGS GR

Infra.	Global	average benefit	maximum benefit	minimum benefit	Range	# of cases	case with max. benefit
FID	Green	46	91	3	88	3	FID - Green - LNG cheap
	Grey	22	34	10	24	2	FID - Grey - Rum expensive
NON FID	Green	22	39	4	35	2	NON FID - Green - LNG cheap
	Grey	13	23	3	20	2	NON FID - Grey - Rum expensive



Note: RUm cheap (expensive) = price scenario with cheap (expensive) Russian gas; NON FID = infrastructure scenario including FID and NON_FID projects; average benefit = simple average of scenarios with benefits > 0.5 mn. EUR/a without weights (probabilities) assigned to scenarios; #of cases: number of scenarios with benefits > 0.5 mn. EUR/a
Source: ENTSOG

The modelling results for UGS GR are as follows:

- **Highest benefit from cheap Russian gas** – The highest benefit is observed in the case "FID-Grey-RUm_cheap" with 16 mn. EUR/a. In this case, the additional UGS capacity increases the supply from the relatively cheaper source, Russia, substituting LNG.
- **Increased use of UGS** – The additional capacity offered by UGS South Kavala is used in almost every scenario.
- **High likelihood of competing project** – For UGS GR we observe no benefits if all other NON-FID projects are included. This is an indication that

competing NON-FID projects decrease the incremental benefit of additional UGS GR capacity.

- **Security of supply** – including UGS GR does not have an impact on disrupted demand measured in GWh based on the NeMo gas modelling results provided from ENTSOG, hence, UGS GR does not increase security of supply given this information. ENTSOG did not provide a full set of capacity indicators, including those reflecting security of supply. Hence we are not able to assess the impact from UGS GR on security of supply.
- **Range of NPV for gross benefits** –We estimate a range for the NPV of gross benefits of 7 mn. to 224 mn. EUR. The average benefit reported in **Figure 15** is calculated using only scenarios with benefits > 0.5 mn. EUR/a. All other scenarios are disregarded when calculating the average benefit.

Our conclusions with regard to the extent that the hypotheses described above are met are as follows:

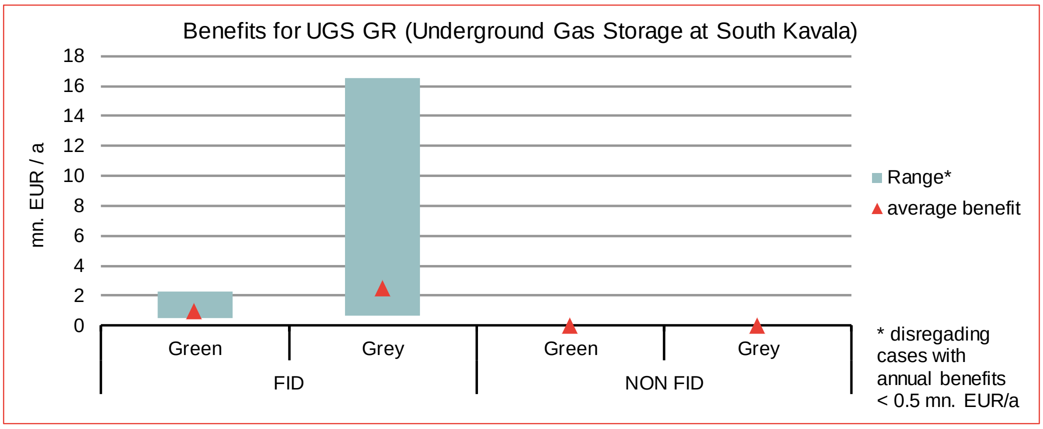
- **H1: Increased security of supply in South East Europe / Balkans** – The modelling results partly confirm increased security of supply (indirectly) measured as possible substitution of Russian gas in the cases where Russian gas is more expensive than other sources. However, the impact is rather low. In addition, this is only the case in the low-infrastructure scenarios. There are no additional benefits in the case of the high-infrastructure scenario. There is no impact on security of supply measured directly by the change in disrupted demand from UGS GR.
  We conclude that in the context of low infrastructure levels, UGS GR can decrease the dependence of Russian gas imports.
- **H2: Increased transport capacity of Russian gas to the west** – The modelling results partly support the hypothesis that UGS South Kavala increases the transport capacity of Russian gas to the west. As mentioned above, the use of relatively cheaper Russian gas increases in the case FID-Grey.
  Therefore, we conclude that in the context of low infrastructure scenario, UGS GR can increase the transport capacity for Russian gas.

4.4.3 LNG Regasification Vessel (Croatia)

Figure 16 summarises the annual gross benefits for the different scenarios. In order to assess if benefits exceed the investment and operating costs of the project additional information of the costs will be necessary.

Figure 16. Annual gross benefits LNG HR

Infra.	Global	average benefit	maximum benefit	minimum benefit	Range	# of cases	case with max. benefit
FID	Green	1	2	1	2	5	FID - Green - Rum expensive
	Grey	2	16	1	16	12	FID - Grey - Rum cheap
NON FID	Green	0	0	0	0	0	
	Grey	0	0	0	0	0	



Note: RUm cheap (expensive) = price scenario with cheap (expensive) Russian gas; NON FID = infrastructure scenario including FID and NON_FID projects; average benefit = simple average of scenarios with benefits > 0.5 mn. EUR/a without weights (probabilities) assigned to scenarios; #of cases: number of scenarios with benefits > 0.5 mn. EUR/a
Source: ENTSOG

The modelling results for LNG HR are as follows:

- **Increased supply from LNG** – We observe a decrease in total costs in every case that includes LNG being cheaper than other sources. The highest benefit of 91 mn. EUR/year is observed in the combination of low infrastructure and "Green" global assumptions. In that case, LNG substitutes primarily imports from Algeria and Norway.
- **Higher diversification of sources** – As mentioned above, the LNG RV is located in an area that is highly dependent on Russian gas. In scenarios where Russian gas is relatively more expensive than other sources, increased supply from LNG displaces Russian gas.
- **Influence of competing project(s)** – Including all other Non-FID projects in the assessment of LNG HR decreases the potential benefits but to a smaller extent than for the two projects analysed above. For example, the benefits of additional LNG capacity in the Non-FID/Green scenario decreases from 91 mn. EUR/year to 39 mn. EUR/year.
- **Minimum load constraints increase costs** – LNG supply is characterised by a minimum load constraint that is partly explained by technical reasons. This constraint forces LNG into the system even in cases where LNG supply is relatively more expensive than other source. This effect can be observed in scenarios under the "grey" and expensive LNG scenarios. We understand that ENTSOG is currently investigating reducing the minimum send out rate, which need be no more than the boil off.
- **Security of supply** – including LNG HR does not have an impact on disrupted demand as measured in GWh based on the NeMo gas modelling results provided from ENTSOG, hence, LNG HR does not increase security of

supply given this information. As noted ENTSOG did not provide a full set of capacity indicators.

- **Range of NPV for gross benefits** –We estimate a range for the NPV for gross benefits of 36 mn. to 1,231 mn.€ for LNG HR. The average benefit reported in **Figure 16** is calculated using only scenarios with benefits > 0.5 mn. EUR/a. All other scenarios are disregarded when calculating the average benefit.

Our conclusions with regard to the extent that the hypotheses described above are met are as follows:

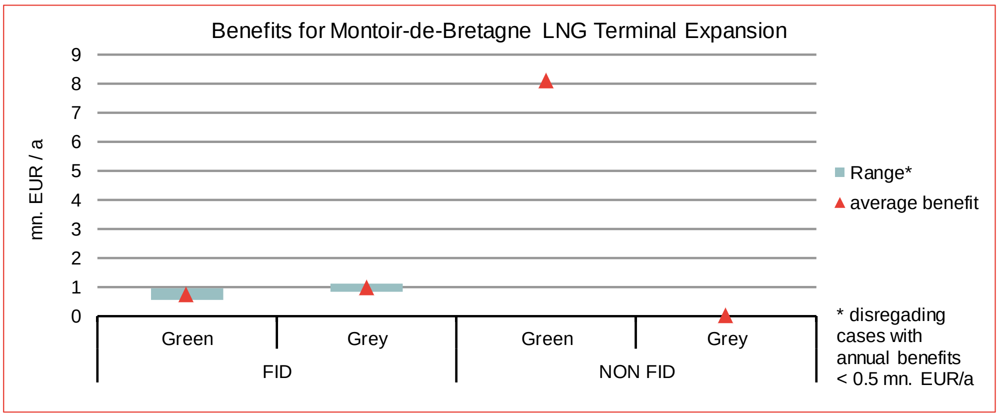
- **H1: Increased security of supply in South East Europe / Balkans** – The modelling results confirm that offering additional LNG capacity in Croatia increases security of supply in this area. LNG serves as substitute for more expensive sources (e.g. Russia). However, there is no impact on security of supply directly measured by the change in disrupted demand from LNG HR.
  Hence, we conclude based on the modelling results that LNG HR decreases the dependency on Russian gas in South East Europe. An explicit effect on security of supply (measured in change of disrupted demand) cannot be observed on the basis of ENTSOG's modelling results.
- **H2: Increased diversification of sources** – Not surprisingly, the scenarios with cheap LNG supply show the highest observed benefits of all scenarios. We observe that LNG substitutes other sources that are assumed to have higher cost (e.g. Norway in the scenario of Norway expensive).
  Hence, we conclude based on the modelling results that LNG HR can increase the diversification of sources in this area.

4.4.4 Montoir LNG Terminal Expansion

Figure 17 summarises the annual gross benefits for the different scenarios. In order to assess if benefits exceed the investment and operating costs of the project additional information of the costs will be necessary. As in the other case studies, ENTSOG was unable to provide us with this information on the costs of the project.

Figure 17. Annual benefits Montoir LNG

Infra.	Global	average benefit	maximum benefit	minimum benefit	Range	# of cases	case with max. benefit
FID	Green	1	1	1	0	2	FID - Green - LNG cheap
	Grey	1	1	1	0	2	FID - Grey - LNG cheap
NON FID	Green	8	8	8	0	1	NON FID - Green - LNG cheap
	Grey	0	0	0	0	0	



Note: LNG cheap = price scenario with cheap LNG gas; NON FID = infrastructure scenario including FID and NON_FID projects; average benefit = simple average of scenarios with benefits > 0.5 mn. EUR/a without weights (probabilities) assigned to scenarios; #of cases: number of scenarios with benefits > 0.5 mn. EUR/a
Source: ENTSOG

The modelling results for Montoir LNG Terminal Expansion are as follows:

- **High likelihood of complementary projects** – Increasing the LNG capacity in Montoir-de-Bretagne shows only minor benefits of a maximum of 1 mn. EUR/year in the case of cheap LNG supply and the low infrastructure level (FID). In the case of high infrastructure (Non-FID) and cheap LNG the benefit increases to 8 mn.EUR/a. LNG substitutes mainly imports from Algeria.
- **Minimum load constraints increase costs** – LNG supply is characterised by a minimum load constraint that is partly explained by technical reasons. These constraints force LNG into the system even in cases where LNG supply is relatively more expensive than other source. This effect can be observed in scenarios under "grey" assumptions and expensive LNG.
- **Security of supply** – including Montoir LNG Terminal Expansion does not have an impact on disrupted demand measured in GWh based on the NeMo gas modelling results provided by ENTSOG, hence, Montoir LNG Terminal Expansion does not increase security of supply given this information. As noted ENTSOG did not provide a full set of capacity indicators.
- **Range of NPV for gross benefits** – Although no cost information is available, the range of the net present value[40] for gross benefits provides a useful input to the assessment of whether the net benefit of the project is positive for certain scenarios. We estimate a range for the NPV for gross

[40] We calculate the NPV of gross benefits by summing up the discounted annual figures over 20 years. We use the social discount rate of 4% for discounting.

benefits of 11mn. to 110 mn. EUR. The average benefit reported in **Figure 17** is calculated using only scenarios with benefits > 0.5 mn. EUR/a. All other scenarios are disregarded when calculating the average benefit.

Our conclusions with regard to the extent that the hypotheses described above are met are as follows:

- **H1: Increased diversification of sources** – We observe that the diversification effect from additional LNG capacity in France has only a minor effect, as the price scenario LNG cheap only results in increased benefit of 1 mn. (8 mn.) EUR in the low (high) infrastructure scenario. Hence, Montoir LNG Terminal does not increase LNG use in Europe.

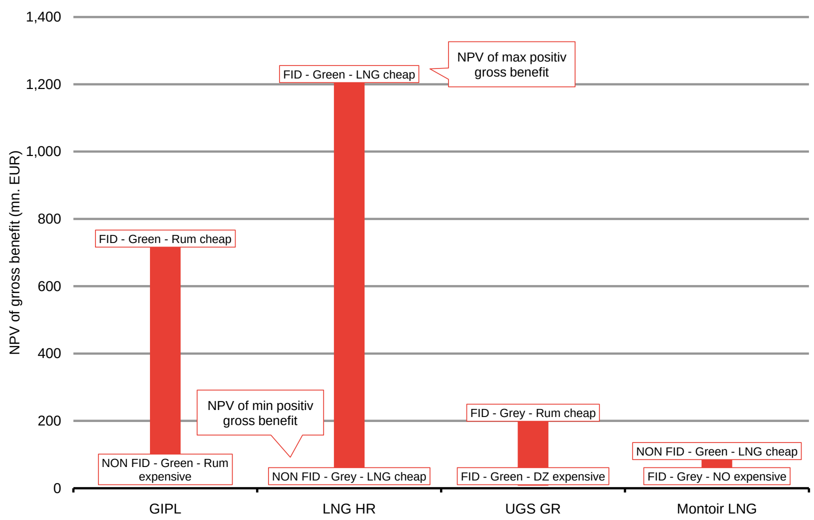
4.5. Conclusions from case study review

In the following we summarise the main conclusions from our review of the case studies.

Level of benefits dependi on gas price scenarios

The results show that benefits only occur in the scenarios exhibiting price variations among gas sources prices, e.g. by making one gas source cheaper or more expensive than others. In the reference case, where all gas sources follow a similar supply cost function the incremental benefit from the investigated project is close to zero.

Figure 18. Range of NPV of projects gross benefit



Source: Frontier

Figure 18 illustrates the range of the net present value of the minimum and maximum positive gross benefit per project. The NPV of the maximum gross benefit can be interpreted as the threshold for the NPV of total costs (investment costs and operating expenses) for a project to have a positive net benefit under at least one scenario. Except for LNG HR, the NPV of the maximum gross benefit is below 1 bn. EUR.

Hence, given the current stage of development of the ENTSOG NeMo model, the assessment of whether benefits exceed costs depends on the chosen price scenario.

Further guidance will be necessary to ensure a transparent selection process for PCIs.

We note that currently the ENTSOG NeMo model includes assumptions on transportation costs, which are not appropriate and need adjustment. We understand that ENTSOG is currently investigating inclusion of more realistic assumptions for transportation costs. These may reflect better the trade-off between transport cost and gas supply costs by either:

- Importing gas from an expensive source closer to demand (low transport costs); or
- Importing gas from a cheaper but more remote source, incurring higher transportation cost.

However, it is not clear if this adjustment will result in incremental benefits for the reference case, where all gas sources follow a similar supply cost function.

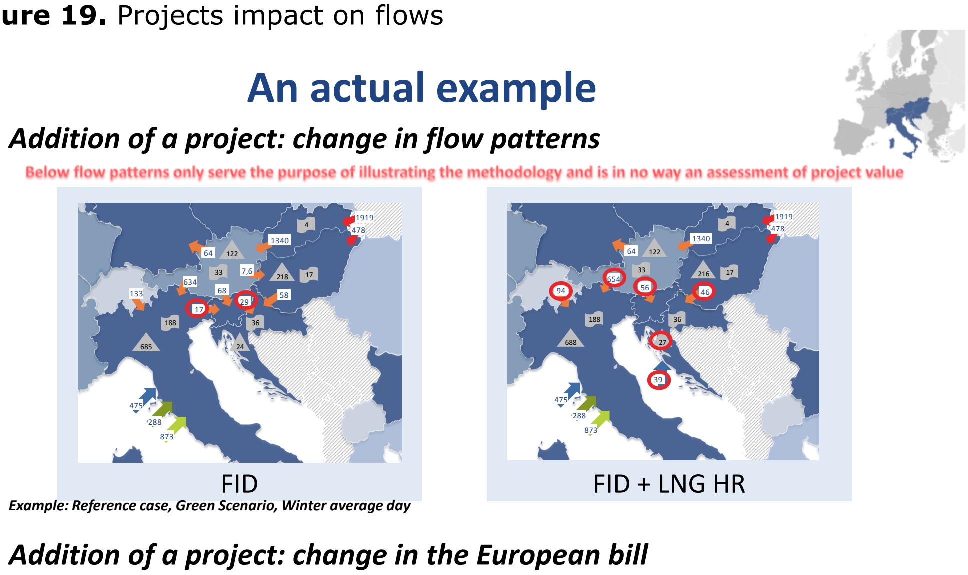
Importance of analysing gas flows

The hypothesis was that GIPL would enable Baltic States to access Western Europe gas markets. This would allow the Baltics States to substitute Russian gas in cases where Russian gas is relatively more expensive than other sources. However, the results from the ENTSOG model do not show this effect. A possible explanation for this counterintuitive result could be congestion to the West of GIPL, e.g. supply routes from West to the East are already at their limits in the case of expensive Russian gas.

The example of GIPL shows that the incremental influence of a project can be determined by the congestion that is outside of the project’s obvious influence. Therefore, information on congestion in the European gas grid is valuable and necessary to understand the impact and benefits from gas infrastructure projects.

A possible form of representation of gas flows in the system has been given by ENTSOG at the 5th Stakeholder Joint Working Session on 15 May 2014 (**Figure 19**).

Figure 19. Projects impact on flows



Source: ENTSOG

Competing and complementary projects

Our analysis shows that for all case studies competition and/or complementarity among projects are relevant. For almost all modelled case studies, the results are lower in the high-infrastructure scenario, indicating the existence of competing projects. On the other hand, the expansion of the Montoir LNG Terminal has a higher benefit in the NON-FID scenario. This indicates the existence of one or more complementary NON-FID projects, which are necessary to supply more European countries with cheap LNG from Montoir LNG Terminal.

In addition, we observed a counterintuitive result in the case of GIPL. We hypothesised that GIPL would allow the Baltic States to get access to LNG from Poland. However, the modelled outcome does not show this effect. The reason for this is the Lithuanian LNG terminal in Klapedia coming into operation in 2015. Hence, the LNG terminal in Klapedia already captures the benefit from access to LNG for the Baltic States.

We would suggest a sensitivity analysis on to test the functioning of the model in this respect by excluding Klapedia LNG terminal.

Disrupted demand and security of supply

An increase in the security of supply represents one of the main benefits argued in relation to each of the case study project. However, the results for all four case studies from the ENTSOG NeMo gas model do not increase security of supply. There is no impact on disrupted demand (measured in GWh) from all four gas infrastructure projects. As noted, ENTSOG did not provide a full set of capacity indicators, including indicators reflecting security of supply. Hence we are unable to assess the impact from the four gas infrastructure projects on security of supply from this perspective.

However, the results on security of supply are rather surprising and we would propose that ENTSOG should investigate further if

- the manner in which disrupted demand is calculated in the NeMo model is appropriate; and
- The gas disruption scenarios are appropriate;

Further sensitivity analysis may be necessary to understand better how the current results can be interpreted.

Reduction of market power

A benefit of a project may also be an increase in competition, i.e. a reduction in market power, in one of the concerned member states. Benefits could manifest themselves as:

- Reduction of a welfare loss – In standard economic theory the welfare loss due to the abuse of market power is defined by the concept of the deadweight loss. Simply speaking, that is the loss in welfare which results from the price being too high and, therefore, demand being too low relative to what demand would be in a fully competitive market.
- From a consumer perspective, a reduction of market power could also lead to a significant shift of welfare from (non-European) producers to consumers.

  Theoretically, however, it does not affect the total welfare effect of a project if all producers and consumers are taken into account. However, with the welfare measure preferred by the Commission, which refers to consumers and producers in the EEA, such changes if they affect non-EEA producers do have a welfare effect.

Analysing the effect on competition of a project would in principle require calculation of the difference in the deadweight loss with/without the project. Two model features which would be required for that analysis are not part of ENTSOG's model:

- Elastic demand – A firm with market power would set an infinitely high price if it does not have to fear a decline in demand (or sanction for breach of competition law). Elastic demand modelling would hence be needed to look at market power. However, this will not be possible in the current ENTSOG approach, which assumes inelastic demand. In case of inelastic demand the size of the total welfare, defined as the sum of producer and consumer surplus, is independent of the exercise of market power. This means that a reduction in prices due to an increase in competition results only in shifting producer surplus to consumer surplus but keeping the sum constant.
- Modelling market behaviour – An approach analysing market power would need to reflect that suppliers may set their price higher than marginal costs if competition does not constrain them in doing so. That allows firms with market power to earn additional profits. ENTSOG's current model minimises costs, which is equivalent to maximising welfare, given its fixed demand assumptions. Welfare is maximised when price equals marginal cost – in this case, the deadweight loss would always be zero. Hence, market power is never exercised in the context of that approach – a project can therefore not be measured as contributing to a reduction in market power.

Market behaviour cannot be incorporated into the model easily. The cost minimisation approach does not facilitate a credible measurement of the value of increased competition. Theoretically there are two options to do this:

- **Game-theoretic models** – Some market model allow the simulation of strategic market behaviour by market participants. These models could be used to assess the mark-up on competitive prices due to abuse of market power; and
- **Empirical models** – These can be used to calculate typical mark-ups on competitive prices under certain market conditions, e.g. market concentration ratios. These mark-ups may be used as a proxy for the competitive effect from different market conditions.

Both approaches will be assumption driven. This will increase the uncertainty of the results, which may not be robust to small changes in the underlying assumptions.

We conclude that, while a potential reduction in market power or the dependence on single suppliers may be an essential benefit of some projects, these cannot be credibly assessed in the modelling framework that ENTSOG has developed.

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6. ANNEXE 1: SUMMARY TABLE OF FINAL CASE STUDY RESULTS

Below we summarise the total cost benefits as provided by ENTSOG for the four case study projects. The candidate projects are:

- the Gas Interconnection Poland-Lithuania – GIPL (TRA-N-212);
- the Underground Gas Storage at South Kavala (UGS-N-076);
- the LNG Regasification Vessel (RV) to Croatia (LNG-N-082); and
- the Montoir LNG Terminal Expansion (LNG-N-225).

Table 3 shows the projects incremental benefit in the analysed scenarios. The benefit is defined as the project's influence on total cost in mn. EUR/a calculated as

- the weighted average daily benefit over the four climatic cases;
- multiplied with 365 in order to obtain yearly results (a positive number indicates a benefit, a negative number additional costs).

Table 3. Summary of total cost benefits (in mn. EUR/a)

Scenario		GIPL	UGS GR	LNG HR	LNG FRN
FID Green	Ref	0	0	0	0
	AZ cheap	0	0	0	0
	DZ cheap	0	0	0	0
	LNG cheap	0	1	91	1
	LY cheap	0	0	0	0
	NO cheap	0	0	0	0
	Rum cheap	55	1	0	0
	AZ expensive	0	0	0	0
	DZ expensive	0	1	0	0
	LNG expensive	0	1	0	0
	LY expensive	0	0	0	0
	NO expensive	7	0	3	1
	Rum expensive	0	2	43	0
Grey	Ref	0	1	0	0
	AZ cheap	0	1	0	0
	DZ cheap	0	1	0	0
	LNG cheap	0	3	10	1
	LY cheap	0	1	0	0
	NO cheap	0	1	0	-2
	Rum cheap	23	16	-8	0
	AZ expensive	0	1	0	0
	DZ expensive	0	1	0	0
	LNG expensive	0	1	-8	-24
	LY expensive	0	1	0	0

	NO expensive	0	0	0	1
	Rum expensive	0	2	34	0
Non-FID Green	Ref	0	0	0	0
	AZ cheap	0	0	0	0
	DZ cheap	0	0	0	0
	LNG cheap	0	0	39	8
	LY cheap	0	0	0	0
	NO cheap	0	0	0	0
	Rum cheap	16	0	0	0
	AZ expensive	0	0	0	0
	DZ expensive	0	0	0	0
	LNG expensive	0	0	0	0
	LY expensive	0	0	0	0
	NO expensive	0	0	0	0
	Rum expensive	1	0	4	0
Grey	Ref	0	0	0	0
	AZ cheap	0	0	0	0
	DZ cheap	0	0	0	0
	LNG cheap	1	0	3	0
	LY cheap	0	0	0	0
	NO cheap	0	0	0	0
	Rum cheap	0	0	-1	-1
	AZ expensive	0	0	0	0
	DZ expensive	0	0	0	0
	LNG expensive	0	0	-8	-23
	LY expensive	0	0	0	0
	NO expensive	0	0	0	0
	Rum expensive	2	0	23	0

Source: Frontier based on ENTSOG data