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A modelling-based assessment of EU supported natural gas projects of common interest

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ABSTRACT

Between 2013 and 2020 the EU set up a complex institutional system to select and support the implementation of energy infrastructure projects that are of European interest (PCIs). EUR 1.4 billion EU support was awarded to 16 natural gas projects between 2014 and 2019, most of them are still under construction. With the decarbonization agenda emerging, fossil investments have a limited lifetime to recover their investment. To assess the net socio-economic benefits of the gas PCI projects a modelling-based cost benefit analysis was applied. Results revealed that the cross-border projects that were implemented so far have a joint socio-economic benefit/cost ratio (B/C) above 1 even in the most conservative scenario setups. The ones with a final investment decision would need to face a high gas price environment in the future to push the B/C above 1, which is the reality since 2021. The other projects on the full EU list of PCIs are not beneficial as a single group, as they serve similar needs. Some individual non-FID projects are though promising.

1. Introduction

As a part of the wider EU policy framework, Regulation 347/2013 on the guidelines for trans-European energy infrastructure (hereinafter referred to as "TEN-E Regulation") was designed to address several barriers to the development of energy networks in order to create a more interconnected natural gas markets via source and route diversification (Regulation (EU), 2013). Based on a procedure outlined by the TEN-E Regulation the European Commission approves key energy infrastructure projects called projects of common interest (PCIs) that are essential for reaching policy objectives. Along with a fast-tracked regulatory process of accelerated planning, permitting and approvals, PCIs qualify for significant EU funding. Up to now there have been four selection rounds beginning with the first list adopted in 2013 up to the last in October 2019. Out of the EUR 5.35 billion energy budget of the Connecting Europe Facility (CEF) between 2014 and 2020 about EUR 1.5 billion were allocated to gas infrastructure projects.

Since the implementation of the TEN-E Regulation, a new policy framework has emerged prioritizing climate objectives and decarbonization. In December 2019, the European Commission published the European Green Deal (European Commission, 2019) to chart the course for reaching 2050 carbon neutrality proposed in the European Climate Law.[1] This communication explicitly refers to the need for a review of the TEN-E Regulation to ensure consistency with climate neutrality objectives which requires an evaluation of the current form of the Regulation.

This paper intends to contribute to this process by providing an evaluation metric for the contribution of TEN-E Regulation to European gas markets based on modelled quantification of socio-economic benefits from all completed PCIs and projections from the 4th PCI list. It will apply REKK's competitive short-run equilibrium European Gas Market Model (EGMM), and in doing so contribute to the extensive literature on the numerical modelling of natural gas markets.

The paper begins with a short summary of the gas related TEN-E infrastructure development in the EU followed by a literature review of infrastructure assessment methodologies and market modelling studies. Then the REKK methodological approach is laid out before the modelling results and evaluation of TEN-E Regulation are presented. It concludes with a discussion of general lessons from this modelling exercise.

2. Background

The key objective of the TEN-E Regulation is the development and interoperability of trans-European energy networks to be connected by timely implementation of PCIs. The PCIs should allow for the better

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[1] European Commission (2020), Proposal for a Regulation of the European Parliament and of the Council establishing the framework for achieving climate neutrality and amending Regulation (EU) 2018/1999 (European Climate Law). Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1588581905912&uri=CELEX:52020PC0080.

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integration of renewable energy sources, improved security of supply and more competition leading to lower prices.

In 2013, when the TEN-E Regulation came into force, natural gas security of supply concerns over repeated supply disruptions from Russia, the most severe in January 2009, were setting the agenda.

The fragmented structure of the gas network left certain member states isolated from the interconnected EU transmission system, such as the Baltics and Finland.

The limited interconnectivity between member states also created large wholesale price differentials, with CEE member states typically depending on a single source paying more.

Before the TEN-E Regulation, network investments were predominantly related to new import pipelines from non-EU member states (Russia, Libya, Norway and Algeria) and LNG terminals, mostly exempted from third party access rules. New interconnectors between member states were rare, but typically also exempted (e.g. OPAL, BBL).[2] Therefore, the need for interconnections contributing to market integration was crucial.

To implement the TEN-E Regulation, a methodology and selection process were developed, whereby every two years a so-called list of PCIs was established and published as an Annex to the regulation. Different roles were assigned to different institutions in the process: The European Network of Transmission System Operators for Gas (ENTSOG) assisted the Regional Groups (consisted of representatives of member state's ministries and energy regulators) with data gathering and developing and applying a methodology to assess the proposed PCI projects. Regional Groups proposed the list of PCIs that was finally approved by the European Commission. The Agency for Cooperation of Energy Regulators (ACER) monitors the implementation of PCIs and provides opinion on the selection methodology of ENTSOG. Furthermore, the Innovation and Networks Executive Agency (INEA) is responsible to oversee the CEF funds allocated to PCIs.

Table 1 summarizes the four PCI lists by infrastructure category. The number and the share of gas projects on the PCI lists declines over time mainly because projects were withdrawn or clustered together to reduce the number of projects on the list. Slow progress and delays are a common characteristic of electricity and gas PCI projects, for electricity transmission lines mostly due to permitting issues while for gas it is related to project financing (ACER, 2021a,b). It is well illustrated by the fact that out of the 32 gas projects included in the 4th PCI list, 17 survive from the first list, most of which remain under non-FID status despite regulatory push and EU financial support.

According to the INEA's PCI Interactive map in Fig. 1, 12 gas PCI projects have been commissioned by 2020 out of which 9 are included into this analysis.[3]

ACER reports that about EUR 8 billion or 30% of the total estimated investment costs (EUR 26.6 billion) for gas projects has materialized by January 2021 (ACER, 2021a, p.24).

Most of the newly built gas interconnectors from 2010 were PCIs supported by CEF or by other EU grants. Based on the CEF decisions between 2014 and 2020, EUR 1.4 billion work grants[4] were awarded to 16 projects, mainly between 2014 and 2018, the majority of which have not been commissioned yet (see Table 8 in Annex).

One can speculate as to how many of these projects would have been built or revised without the PCI status and the CEF support effectively intervening in the market, but the question that must be asked with support of EU taxpayer money is whether these investments were worth it from socio economic point of view.

The ACER reports (ACER, 2021a) leave some uncertainty over PCI costs and even more over the credibility of planned commission date of projects. However, the biggest missing piece from ACER's perspective is reliable data on the benefits of the individual and combined PCIs. This article aims to fill this gap and provides a modelling-based quantification of the socio-economic benefits attributable to the selected and supported PCIs.

3. Literature review

The impact of new gas infrastructures on different outcomes was rarely analysed using market modelling tools in past literature. There is only a very small number of models that have been used in the past years for topical analyses. Moreover, many features of natural gas markets are not yet sufficiently well covered in existing numerical models (e.g., entry-exit tariffs, intra-day pricing, wholesale markets and hubs). Compared to electricity market modelling the gas market modelling literature is minuscule.

Prominent modelling tools and applications focusing on the European gas consumer market include GASTALE (Boots et al. (2004); Egging and Gabriel (2006)), NATGAS (Zwart, 2009), TIGER (Lochner and Bothe (2007); Lochner (2011); Dieckhöner et al. (2013)), GASMOD in Holz et al. (2008), the World Gas Model in Egging et al. (2010), the Global Gas Model (Holz et al. (2016) (Richter and Holz, 2015),), the GaMMES in Abada et al. (2013), the EPRG-Gas Market Model (Chyong and Hobbs, 2014) and the RAMONA model (Fodstad et al. (2016)). Multiple papers assessed the impact of Russia's gas pipeline strategy. Mitrova et al. (2016), Paltsev (2014), Hecking and Weiser (2017) Abrell et al. (2016) and Vatansever (2017) examined several gas import and infrastructure scenarios including disruption of Ukrainian transit and the commissioning of the Nord Stream 2, South Stream and TurkStream 2 projects. They concluded that the European gas mix is fairly robust and will maintain a significant share of natural gas from Russia in all scenarios even if the Ukrainian system is not used. Henderson and Sharples (2018) argue that Europe's growing need for gas imports due to decreasing inland production cannot be satisfied without the Ukrainian system even if Nord Stream 2 and TurkStream are built. Modelling studies also point to the increased resilience of the EU gas network to supply and demand shock (ENTSOG (2017) and (2020); Takácsné Tóth et al. (2017)) when compared to previous situation modelled in 2014 (European Commission, 2014a,b). The Quo vadis study by EY & REKK (2018) concluded that the European gas markets are much more resilient to supply shocks and the markets are much better integrated than they used to be a decade ago due to infrastructure investments and regulatory convergence. Takácsné Tóth et al. (2020) model the welfare gains of different pipeline routes and pricing strategies of Russia showing that the current European gas infrastructure allows for flexibility in hosting supplies from different sources and from different routes thereby provide a safety against pricing strategies of the main supplier Russia with or without using the Ukrainian transit route. The improved resilience is partly attributable to better interconnectivity provided by PCIs. More recently (Egging-Bratseth et al., 2021) use the Gas Market Model to assess the impact of geopolitical interventions on the inflow of US LNG to Europe, translating the goals of policy makers in China, Russia, US and Germany into regulatory and infrastructure constraints on the gas market. They find that geopolitical pressure (eg. sanctions on Nord Stream 2) combined with change of global markets supply demand balance can result in very different inflows of US LNG to Europe.

The welfare effect of PCI projects has received less attention in past

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[2] SEC (2011) 1233 final COMMISSION STAFF WORKING PAPER Impact assessment Accompanying the document Proposal for a Regulation of the European Parliament and of the Council on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC.

[3] At the time of the analysis LNG in Croatia was not yet in operation, and the evacuation pipeline of the Lithuanian LNG terminal, furthermore the internal projects in France (5.7.2 and 5.14) were excluded as they had no direct cross border impact.

[4] CEF work grants directly finance PCI construction that demonstrate (i) socio-economic benefits outweigh their costs and (ii) financing would not be feasible on a market basis and/or the inclusion of the total cost of the project into the regulatory asset base would put an unacceptably high burden on the users. This is for projects in a later stage that need a last bit of financing to arrive at a final investment decision. CEF also supports early stage feasibility studies which are a small fraction of the overall cost and therefore are not considered for this study.

Table 1
PCI projects 2013–2020.

	Date of adoption	Total nr of PCIs	Electricity PCIs	Gas PCIs	Oil PCIs	CO2 PCIs	Smart grid PCIs
1st PCI list	October 2013	248	131	109	6	0	2
2nd PCI list	November 2015	195	108	77	7	0	3
3rd PCI list	November 2017	173	102	53	6	4	4
4th PCI list	October 2019	149	100	32	6	5	6

Source: Akkermans et al. (2020) p. 58

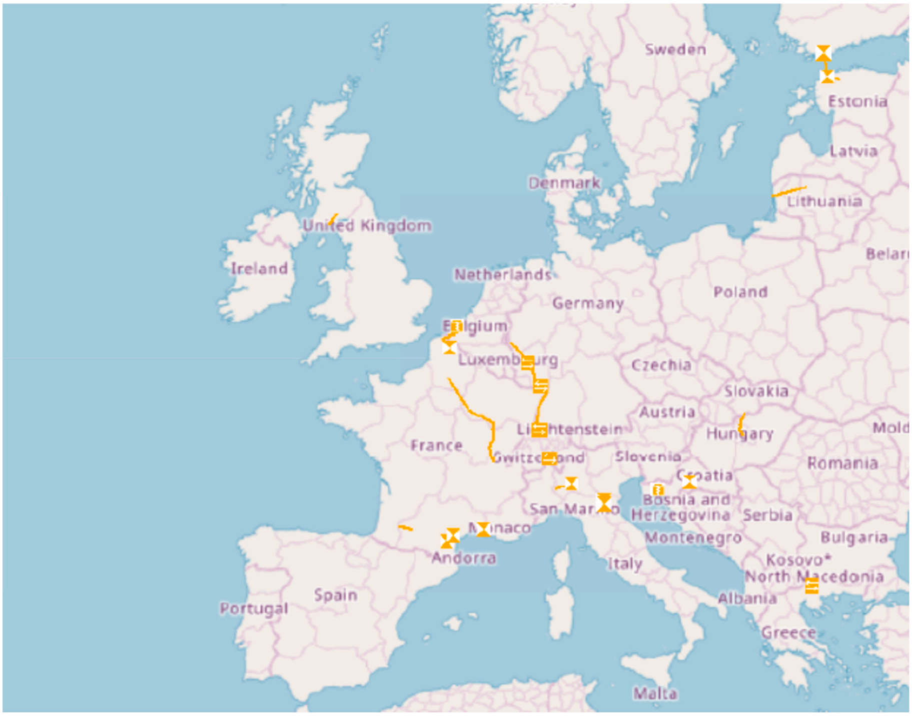

Fig. 1. Completed gas PCI projects. Source: PCI Interactive map, July 07, 2021.

gas market modelling literature. Kiss et al. (2016) analysed the welfare effect of a set of shortlisted gas PCIs from the second PCI list in Central and South-Eastern Europe (CSEE) and identified the groupings resulting in the highest net benefit. Kotek et al. (2019) assessed the socio-economic benefits from the 3rd PCI list using three models with different spatial-temporal resolutions and information structures. The results show that the decarbonization objectives lead to less gas demand and less investment in PCI gas infrastructure. Holz and Kemfert (2020) goes further, suggesting there is no need for more gas pipelines or LNG terminals in Europe owing to the decarbonization agenda. von Hirschhausen et al. (2021) show the massive risks to gas infrastructure becoming stranded assets under an accelerated phase out of natural gas by 2040.

ENTSOG publishes multi-criteria analysis (MCA) in Ten-Year Network Development Plans (TYNDPs) but the monetary CBA indicators are not published, which is heavily criticized by ACER in its opinions (ACER, 2021b) (ACER, 2019).

As put forth by the European Commission in its "Guide to Cost-Benefit Analysis of investment projects" (European Commission, 2014a,b), the cost-benefit analysis (CBA) is the analytical tool that must be used appraise an investment decision according to welfare change. The CBA methodology used during the PCI selection process has been developed by European Network of Transmission System Operators for Gas (ENTSO-G) as required in Article 11 of the TEN-E Regulation. It takes into consideration system needs articulated in TYNDPs before making an incremental PCI selection process. As part of the CBA analysis, network and market modelling are necessary for system and project assessment. This method is based on the MCA that includes monetised and non-monetised CBA measurements. These indicators are used by the Regional Groups to propose candidate projects to the draft PCI list. Although this methodology is subject to continuous fine tuning based on input from the European Commission and other stakeholdersKeyaerts and Glachant (2014), there are still shortcomings to be resolved. Schittekatte et al. (2020) for example, point at the lack of full monetization of the CBA indicators as a major shortcoming of the current methodology, which makes the assessment process less transparent and objective. Another important drawback is that projects are dissected separately, omitting factors of competitiveness or complementarity between projects. A recent study by Trinomics and Artelys (2020) asserts that capacity rather than flow-based sustainability indicators used by ENTSOG are oversimplified and don't capture CO$_2$ emission savings from third countries. Based on ENTSOG methodology for single project assessments the Energy Community has evaluated its PECI (projects of Energy Community Interest) in 2016, (REKK & DNV GL, 2016) 2018 (REKK & DNV GL, 2018) and 2020 (REKK & DNV GL, 2020). For the PECI/PMI evaluations a CBA and MCA methodology has been used based on REKK modelling for electricity and for gas projects using the MCA framework developed by DNV. De Nooit (2011) argues that while the MCA allows for subjectivity over trade-offs, a CBA applies weights to indicators making these trade-offs through monetization. Based on a critical assessment of three electricity transmission line CBAs, the author attempts to show that a CBA addresses social welfare better than the MCA.

The methodology of this study differs from that used in the previous literature in three fundamental ways. First, it assesses the social welfare effect of all commissioned PCIs rather than one by one. Second, the overall welfare effect of the future PCI projects is estimated in group and individually as well in order to capture the complementarity and competing effects between projects. Third, it follows the logic of De Nooit and only applies a CBA using flow-based CO_2 emission calculations (Van Nuffel et al. (2020)).

4. Methodological approach

The welfare effect of gas PCI projects was quantified based on market modelling using the European Gas Market Model (EGMM). The EGMM is a competitive, multi-market equilibrium model that simulates the operation of the wholesale natural gas market across the whole of Europe. It includes a supply-demand representation of 35 European countries, including gas storage and transportation linkages. Large external markets, including Russia, Turkey, Libya, Algeria and LNG exporters are represented exogenously with market prices, long-term supply contracts and physical connections to Europe. The timeframe of the model covers 12 consecutive months, starting in April. Market participants have perfect foresight over this period and dynamic connections between months are introduced by the operation of gas storages and take-or-pay constraints of long-term contracts.

Given the input data, the model calculates a competitive market equilibrium for the modelled countries, where all arbitrage opportunities across time and space are therefore exhausted to the extent that storage facilities, transportation, infrastructure, and contractual conditions permit. As a result, the competitive equilibrium yields an efficient outcome and can equivalently be computed as the solution to a constrained welfare maximization problem. We find this equilibrium by solving the first-order linear complementarity conditions using an MLCP solution algorithm. A detailed description of the model can be found in Kiss et al. (2016).

EGMM pipeline, storage and LNG infrastructure inputs are based on the Gas Infrastructure Europe capacity[5] and GIIGNL data (GIIGNL, 2020). Infrastructure tariffs on the terminals and cross border entry and exit points are collected from the national regulatory authorities and from the terminal websites. Long term contracts[6] used in the model are based on Cedigas, GIIGNL and own collection from public sources. Demand and production volumes are based on the PRIMES EUCO 3232.5 scenario.[7]

Data for the analysed infrastructure projects is taken from the PCI transparency platform,[8] ACER monitoring reports and the selection decisions[9] of CEF financial supports from the Commission.

4.1. Methodology for welfare analysis

The TEN-E Regulation aims to carry out a methodologically sound socio-economic CBA based on monetization of market integration, security of supply and sustainability impacts. Our methodological approach is in line with this concept (illustrated in Fig. 2.)

The modelling follows the total welfare approach, which means that welfare is quantified for all stakeholder groups including consumers, producers, traders and infrastructure operators.

Total socio-economic welfare for a modelled period (year) is calculated as the sum of the welfare change of all market participants[10]:

- Consumer surplus [to consumers]
- Producer surplus (or short-run profit, excluding fixed costs) [to producers]
- Profit on long-term take-or-pay contracts [to importers]
- Congestion revenue on cross-border spot trading [to TSOs]
- Cross-border transportation profit (excluding fixed costs) [to TSOs]
- Storage operation profit (excluding fixed costs) [to Storage System Operators]
- Congestion revenue due to constrained storage capacities [to storage operators]
- Profit on inter-temporal arbitrage via gas storage [to traders]
- Congestion revenue due to constrained regasification capacities [to LNG operators]
- Profit of LNG operators [to LNG operators]

Modelling also applies an incremental approach, meaning that total welfare change is measured by modelling “the with” and “the without the PCIs”.

Changes across all welfare components due to price and flow changes between “the with” and the without the PCIs” capture the market integration benefits and some of the competition related benefits.

The security of supply (SOS) benefits are calculated by the change in welfare in the case of a gas supply disruption modelled as a 100% cut to the riskiest Russian long-term contract delivery route in January for a full month (on the Ukrainian route in 2020 and on the Turkish route in 2030). The difference in welfare between supply shock scenarios with and without the projects represent the SOS benefit of the evaluated PCIs.

To measure the aggregate change in socio-economic welfare due to the evaluated PCIs in one year, the weighted sum of project related welfare changes under normal and SOS conditions are calculated. Weights are the assumed probabilities for normal and SOS scenarios to occur: 95% normal and 5% supply disruption assuming a 1 in 20 probability of disruption.

Sustainability benefits are estimated by the impact of projects in changing greenhouse gas emissions. The project related environmental benefit is estimated by multiplying the corresponding change in the EU countries’ CO2 emissions with an exogenous carbon value.[11] For the calculation a simplified assumption is used in that the modelled change in gas demand changes the average primary energy mix but not the total energy consumption of the respective countries and without crowding out renewables.

These annual benefits are then compared to the yearly investment cost of the evaluated projects, providing a net benefit and benefit/cost ratio. Investment costs are annualized assuming a 25-year period with a 4% social discount rate.

Net benefit due to the TEN-E Regulation is calculated using the following formula:

$$NB = 0.95 \cdot \Delta SW_{normal} + 0.05 \cdot \Delta SW_{SOS} + \Delta CO_2 - C$$

where

NB is the total net benefit of the Regulation,
ΔSW_{normal} is the change of total social welfare due to the analysed projects in normal scenario,

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[5] www.gie.eu.

[6] Long term contracts are defined by their annual contract quantity and their route. This means that capacities are reserved for these flows. The downward flexibility of the Russian and Norwegian long-term contracts have been however set high, therefore in case spot deliveries are more beneficial, the contract is not necessarily delivered. In this case the pipeline capacities can be used for spot trade, as it is regulated in the EU system by use-it or lose it principle and/or short-term auctioning.

[7] EUCO3232.5 is a policy scenario using the PRIMES model designed to achieve a 32% share of renewable energy in gross final energy consumption and a 32.5% energy efficiency target in the EU up to 2030.

[8] https://cinea.ec.europa.eu/connecting-europe-facility/energy-infrastructure-connecting-europe-facility/pci-transparency_en.

[9] https://ec.europa.eu/inea/connecting-europe-facility/cef-energy/calls.

[10] welfare changes of stakeholders are equally weighed.

[11] CO2 emission factors used, kg/GJ: Hard coal 93.65 Lignite 112.07 Gas 55.82.

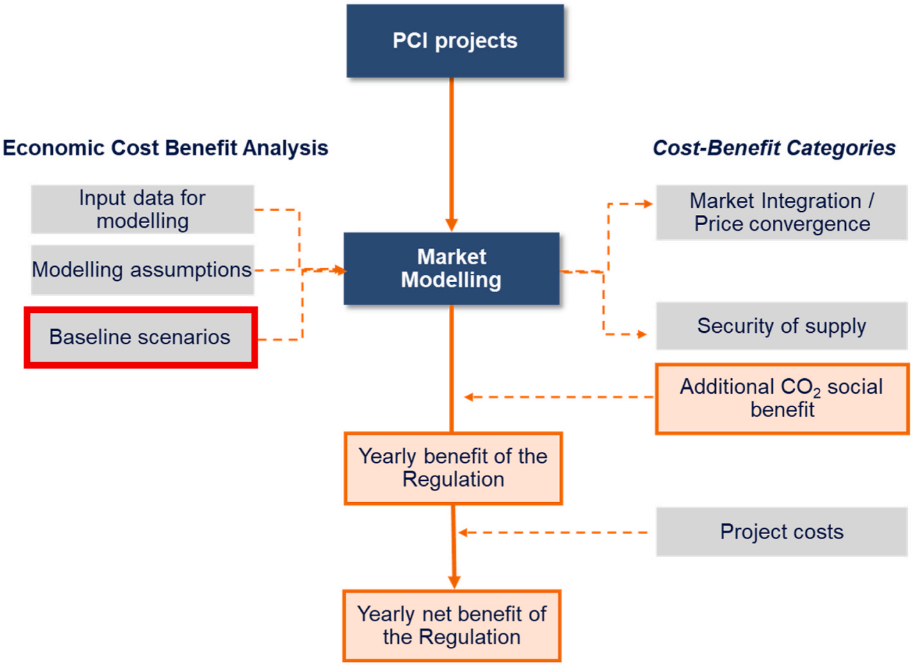

Fig. 2. Conceptual framework of gas market modelling.

ΔSW_{SOS} is the change of total social welfare due to the analysed projects in security of supply scenario,
ΔCO_2 is the value of the change of CO2 emission due to the analysed projects,
C is total investment cost of the analysed projects.

It must be noted that this modelling approach is conservative and might underestimate the benefits for the following reasons:

- Calibration to 2020 prices underestimate benefits for PCIs commissioned earlier in a higher price environment.
- Exporter price discounts arising from competition opened by the new capacities cannot be captured by static modelling.
- Security of supply benefits may be also underestimated since only a reduction on one supply route is taken into account and other supply risks or demand shocks are not modelled.
- EGMM can only capture benefits of projects that have a direct cross border impact, and therefore the effect of those PCIs that target internal bottlenecks or interoperability cannot be captured.
- Not all gas infrastructure built in Europe is a result of the TEN-E Regulation but some of the non-PCIs could have benefitted from commissioned PCIs, a positive impact that cannot be captured by modelling. For example, the Klaipeda LNG terminal was not a PCI project but the pipeline connection to the network was. This conservative approach includes the terminal in the baseline without assigning any benefits to the connecting pipeline.
- Not all projects have been commissioned at the same time so including them as a cluster is a simplification allowing the combined impact to be included.

5. Infrastructure baselines and analysed scenarios

Modelling was carried out for 2020 and 2030, with 2020 representing the current gas markets and 2030 a projection of the future market.

The following infrastructure scenarios were developed to estimate the monetised benefit of the TEN-E Regulation (PCI projects) according to socio-economic welfare change (summarized in Fig. 3):

- **Baseline (without TEN-Regulation) scenarios** are defined as a basis of comparison.
  - **Baseline 2020** includes current infrastructure based on the latest (2019) ENTSOG capacity maps. Additionally, FID projects from TYNDP 2018 that were planned to be commissioned by 2020 are included with infrastructure commissioned in 2019–2020 that are not part of the TYNDP (e.g. Turkish Stream 1). On the other hand, PCI projects that were already commissioned are excluded except for those that already had an FID in 2013 and hence their realization is not attributable to the TEN-E Regulation, meaning the Southern Corridor Projects[12] are included in the baseline.
  - For **Baseline 2030** 2020 infrastructure is supplemented with the already commissioned PCIs, FID projects from TYNPD 2018 to be commissioned between 2020 and 2030 and those projects that are under construction but are not part of the TYNDP (e.g. Nord Stream 2, Turkish Stream 2)
- The **'TEN-E scenarios'** are compared to these baseline scenarios in order to capture the effect of the TEN-E Regulation.
  - The **TEN-E 2020** scenario models a market scenario with infrastructure from the Baseline 2020 scenario plus the already commissioned PCIs.
  - The **TEN-E 2030 FID scenario** models a market situation with infrastructure from the Baseline 2030 scenario plus FID PCIs from the 4th list.
- The **TEN-E 2030 4th PCI scenario** is more forward-looking and incorporates the overall effect of all PCIs from the 4th list compared to Baseline 2030.

To summarize, the welfare effect of commissioned PCIs is calculated relative to the 2020 market situation, while the expected future welfare effect of the 4th PCI list is modelled compared to the 2030 baseline scenario. The difference in total social welfare between the respective TEN-E and Baseline scenarios yields the annual benefit of the TEN-

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[12] The Southern Corridor projects are the projects that enable shipping of Azeri gas from the Shah Deniz fields via Georgia, Turkey, Greece, Albania to Italy. Here we refer to the Trans Adriatic Pipeline (TAP), the Trans Anatolian Pipeline (TANAP) and the extension of the Southern Caucasus Pipeline (SCPX).

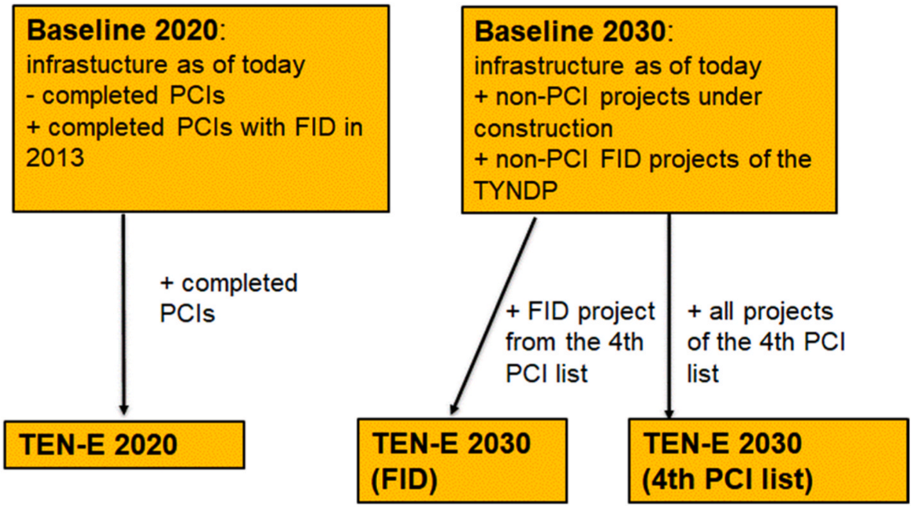

Fig. 3. Summary of the analysed scenarios.

Regulation (brought by commissioning of PCIs) in defined 2020 and 2030 market conditions.

The set of analysed projects are summarized in Table 2 with detailed project data in the Annex. Here we do not use the full name of the projects but refer to the projects by their location using country abbreviations.[13]

6. Modelling results

6.1. *Evaluation of commissioned PCIs compared to 2020 baseline scenario*

Fig. 4 shows the yearly average price effect of commissioned PCIs. There is a significant price decline in the Central-Southern-Eastern Europe due to the SK-HU interconnector and price convergence in the Baltic Region due to Balticconnector.

Table 3 shows that the market integration benefits in the normal scenario are the highest, security of supply benefit is also significant, and CO_2 emission reduction benefits are marginal. As CO_2 benefits are calculated assuming that the additional gas consumed in the EU crowds out other fossil fuels, the results show, that there is limited room for enabling (by these projects) a coal to gas switching.

The overall social welfare benefit of the commissioned PCIs in 2020 is EUR 132.5 million per year, mainly due to the significant price decline in CSEE and the price convergence in the Baltic Region. The highest welfare gains are realized by the Finnish and Hungarian consumers, while the Lithuanian LNG operator and Latvian and German TSOs also gain significantly.

Table 2
Analysed project groups.

Completed PCI projects as of 2020	LNG extension BE; Reverse flows CH-DE IT-CH, and interconnectors between UK-IE, FR-BE, FI-EE, HU-SK, HR-HU, BG-RO
FID projects as of 2020	LNG HR, Interconnectors: PL-SK, GR-BG, BG-RS, RO-HU, RO-BG, LT-PL, Reverse flow: HR-HU, Storage: HR-HU
All projects of the 4th PCI list	LNG: IE, GR, PL, CY Interconnectors: IT-MT, HU-SK, SI-HU, RO-HU, SI-HR, AT-SI, CY-GR, LV-LT, DK-PL Storages: BG, GR, RO, SK

The net benefit (modelled yearly benefits decreased by annualized investment costs) of these projects calculated for 2020 is positive (EUR 23.5 million per year) with a B/C ratio above 1 (1.2), even in the low-price environment. Hence, it can be concluded that the overall benefits of the commissioned PCIs outweigh the cost in the long-term, meeting the TEN-E Regulation requirements (Article 4 1(b) paragraph).

The majority of socio-economic benefits are attributable to market integration. Security of supply benefits of the PCIs are low in 2020 as the disruption scenario assumed the one-month supply cut on the largest Russian supply route (Ukraine). This risk has been addressed by some PCIs (e.g. the Southern Corridor provides new source to Italy form Azerbaijan, Hungary-Slovakia interconnector allows for more inflow to Hungary from the West) but also by Russia, that implemented consequently a route diversification strategy by investing into Turk Stream and Nord Stream as well. [14] The SOS modelling – not deferring much from a normal scenario confirms that the resilience of the natural gas network has improved substantially.

The utilization of the infrastructure (Fig. 5) follows the price changes shown above. The SK-HU interconnector and the Balticconnector are used both in the normal and the SOS scenarios when other PCIs are not. Reverse flow projects and certain internal pipelines are not used by the model, partly because non-PCI projects have been implemented parallel and they became obsolete. This is the case for the BG-RO pipeline, where the Turk Stream and Balkan Stream pipeline changed the market and the commercial flows substantially.

6.2. *Modelling results for 2030 - forward looking analysis*

Even if the positive impact of the commissioned PCIs is significant, there are remaining infrastructure needs identified by the Regional Groups and some remaining bottlenecks that still need to be addressed. [15]

In order to quantify additional benefits from the 4th PCI list, they are included in the 2030 Baseline scenario. Beyond calculating the overall

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[13] AT: Austria; BE: Belgium, BG: Bulgaria, CH: Switzerland, CY: Cyprus, DE: Germany, DK: Denmark, EE: Estonia, FI: Finland, FR: France, GR: Greece, HR: Croatia, HU: Hungary, IE: Ireland, IT: Italy, LT: Latvia, LV: Lithuania, MT:Malta, PL: Poland, RO: Romania, RS: Serbia, SI: Slovenia, SK: Slovakia.

[14] In the light of the 2022 Russian Ukrainian war considering a full Russian supply cut could have been tested as well. An excuse to not doing so is that none of the methodologies considered war scenarios in 2020. It is for another article to assess war and sanction readiness of the European gas system.

[15] Methodology for assessing the gas candidate PCI projects PCI 2018–2019 exercise 17 June 2019 Draft for Regional Groups comments.

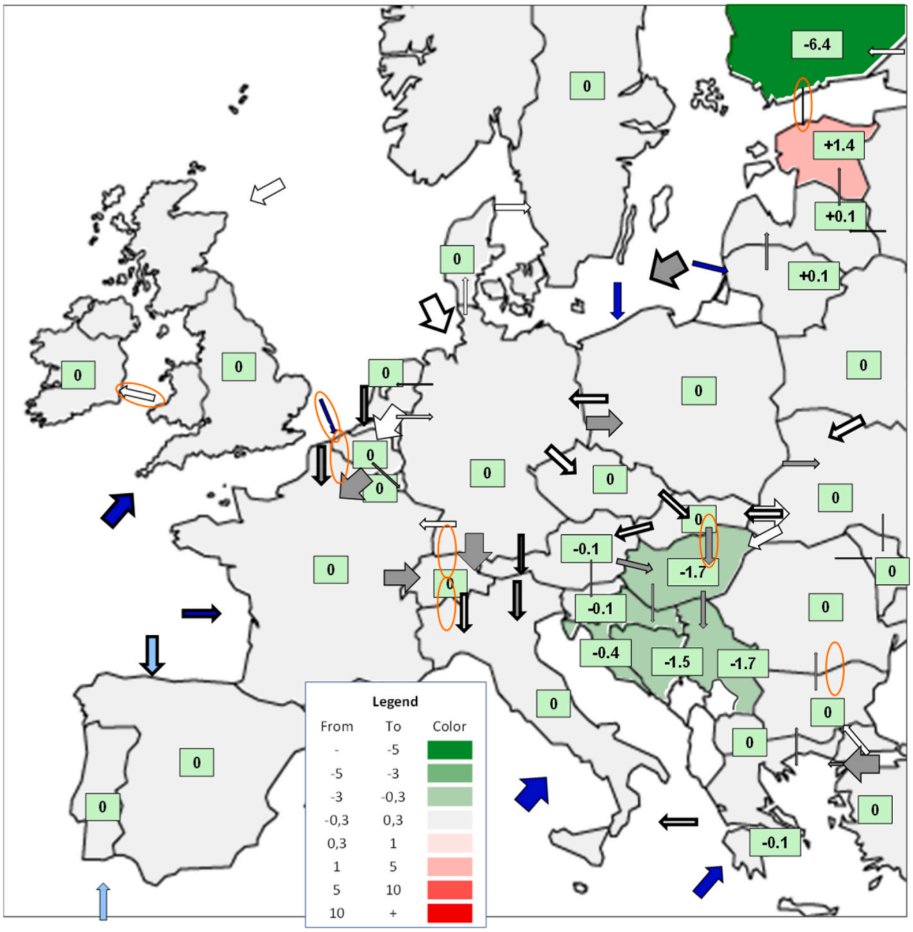

Fig. 4. Price effect of commissioned PCIs in normal scenario: price change in €/MWh. The green boxes represent the €/MWh price change attributable to PCIs, the blue arrows show LNG flows, the white arrows modelled gas flows on pipelines. Size of the arrows indicate the volume of gas delivered. Dark grey and dark blue arrows indicate that there is congestion on the pipeline interconnections or at respective LNG regasification terminals at least in one month. New projects are circled. Empty circles indicate new project without utilization. Source: REKK modelling. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 3
Welfare effect of commissioned PCIs compared to the 2020 baseline.

	Weighted average price change (€/MWh)	−0.03
II.	Normal Welfare (m€/year)	127.6
III.	SOS Welfare (m€/year)	117.6
IV.	Total Welfare (m€/year) (0.95*II.+0,05*III.)	127.1
V.	CO2 benefit (m€/year)	5.4
VI.	Total yearly benefit (m€/year) IV.+V.	132.5
VII.	Annualized investment cost (m€)	109
VIII.	Yearly net benefit (m€/year) VI.-VII.	23.5
IX.	Benefit/Cost ratio VI./VII.	1.2

Source: REKK modelling

welfare effect of all projects from the 4th PCI list, first only those with an FID were included. As a first step, Fig. 6 illustrates the price effect of the modelled projects.

With FID projects from the 4th PCI list, the situation in the CSEE region changes compared to 2020, as there is lower flow on the Slovakian-Hungarian interconnector and the Romanian-Hungarian interconnector is used instead (Fig. 7). Increased Romanian production also leads to higher flows on the Romanian-Bulgarian interconnector in the security of supply scenario. Croatian LNG has significant impact in Croatia but it does not affect other markets. GIPL is also highly used to deliver gas from Lithuania to Poland raising prices in Poland and lowering them in Baltic countries.

Beyond the effect of FID projects, prices fall in some additional countries mainly due to the high utilization of new LNG capacities in Greece, Poland and Ireland (Fig. 8) (see Fig. 9).

The welfare outcomes show that although the additional benefits of the FID PCI projects are significant (EUR 74.3 million per year in 2030), they do not outweigh the costs, yielding negative net benefit (EUR -44.7 million per year) compared to the 2030 Baseline scenario. The overall Benefit/Cost Ratio of these projects is 0.62 with most FID PCI benefits realized by Romanian producers (Table 4).

Gas imports in 2030 are about the same as for 2020 based on stagnant projected EU gas demand and only a small decline in EU production (based on EUCO 3232.5 scenario). Furthermore, there is a convergence of gas markets and high competition among external suppliers (pipeline and LNG) leading to a drop in overall gas prices. These effects together reduce the need for new EU gas infrastructure.

Consequently, although FID PCIs would bring significant additional benefits, they are considerably lower in 2030 than it was expected when they were decided to be implemented because:

(i) Forecasts for future gas demand have been substantially lowered in the last decade by all institutions.
(ii) Due to the construction of competing (partly non-PCI) projects some PCI projects may remain unused.

The clear message is that any delay in implementation of FID PCIs diminishes benefits and increases the risk of building stranded assets.

Comparing the overall welfare effect of all projects from the 4th PCI list to the Baseline 2030, it can be observed that despite significant benefits from the 4th PCI list, the net benefit is still negative (EUR -228 million per year) due to some enormous project costs, and the Benefit/Cost Ratio is 0.66. The most significant welfare gains here go to new LNG

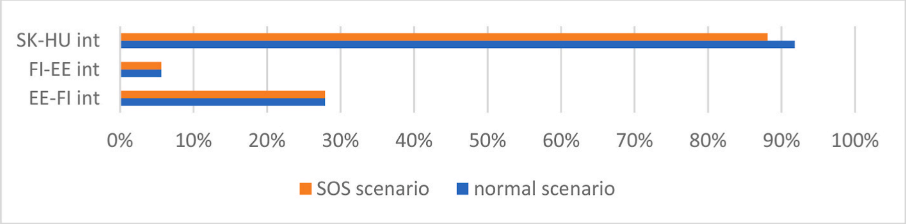

Fig. 5. Utilization of commissioned projects in 2020. Source: REKK modelling* only projects with utilization rates above zero.

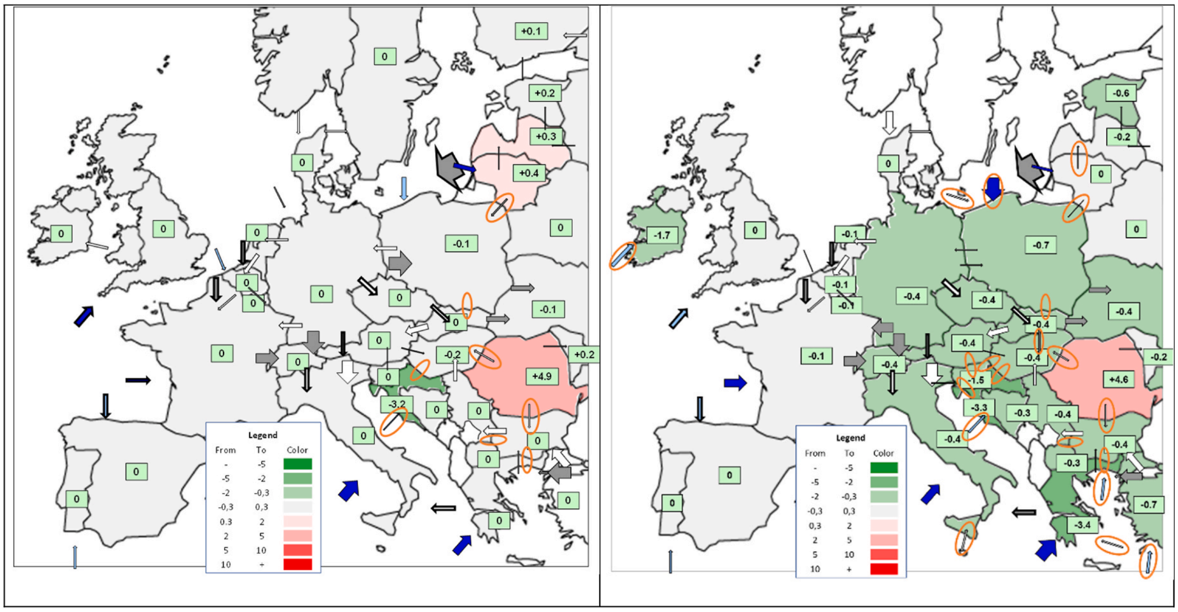

Fig. 6. Price effect of PCIs with FID (left) and all projects from the 4th PCI list (right) in normal scenario (€/MWh). The green boxes represent the €/MWh price change attributable to PCIs, the blue arrows show LNG flows, the white arrows modelled gas flows on pipelines. Size of the arrows indicate the volume of gas delivered. Dark grey and dark blue arrows indicate that there is congestion on the pipeline interconnections or at respective LNG regasification terminals at least in one month. New projects are circled. Empty circles indicate new project without utilization. Source: REKK modelling. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

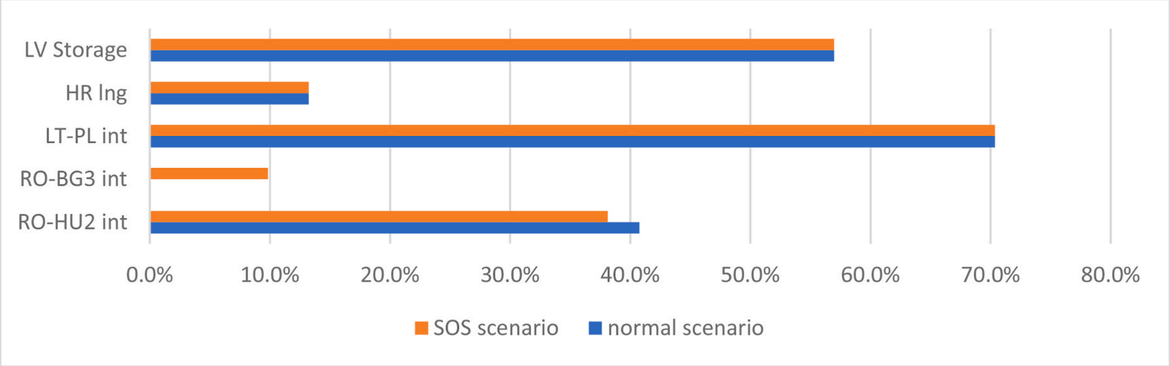

Fig. 7. Utilization of FID PCI projects* only projects with utilization rates above zero. Source: REKK modelling.

terminals (Table 4).

Similar to the 2020 results the sustainability benefit of the 4th PCI projects is limited, and in case of the FID projects the positive CO_2 benefits are offset by the Romanian result, where due to price increase the consumption of gas is decreasing. Due to the simplicity of our methodology for sustainability this results in estimating an increased CO2 emission.

The comparison of modelled benefits with the total investment cost can be misleading, not only because the benefits may be underestimated but mostly because there are several competing projects on the list with the same goals and it is unlikely that all of them will be realized.

ENTSOG's corridor approach used in a project-based evaluation can leave projects on the list that are about to solve the same regional need. In previous lists, about 40% of the proposed PCIs have been withdrawn or not resubmitted. The PCI selection process evaluates each project on an equal basis and does not select from two that might be competing.

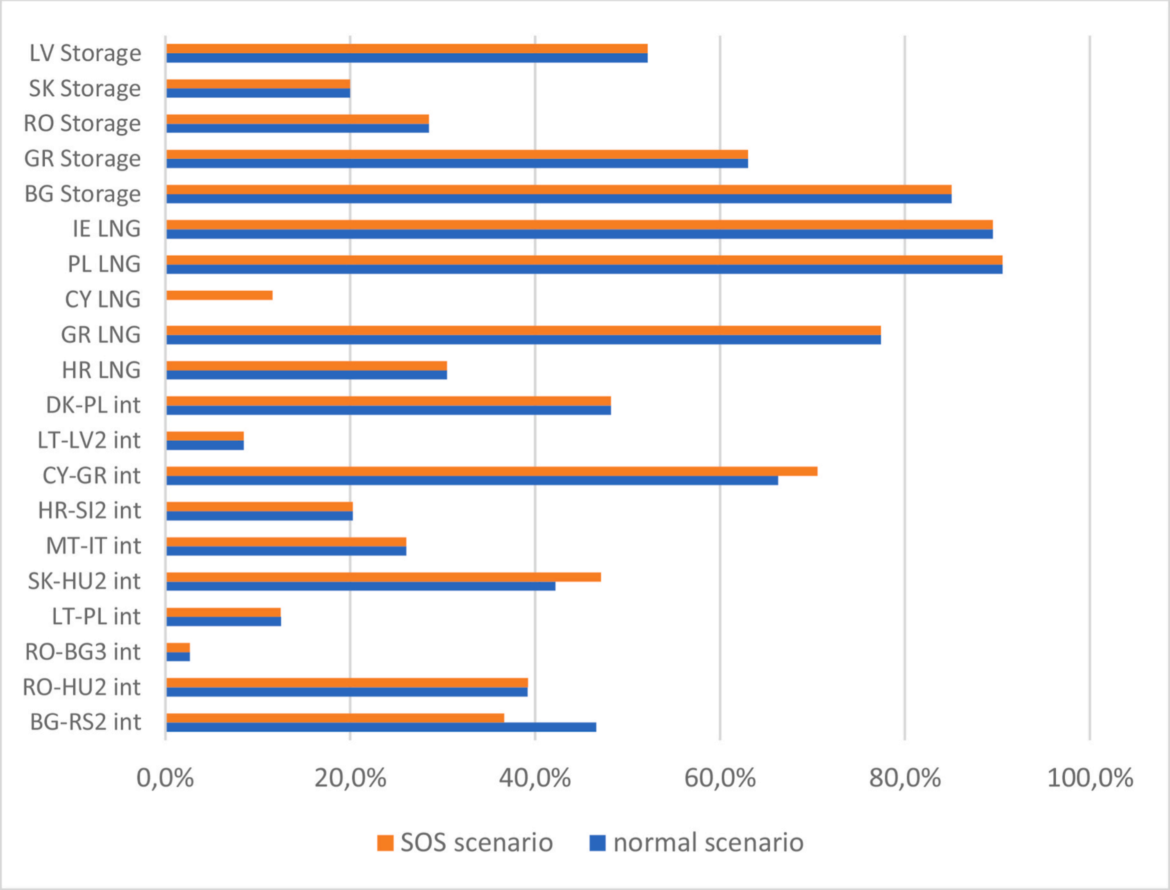

Fig. 8. Utilization of all projects from the 4th PCI list. Source: REKK modelling* only projects with utilization rates above zero.

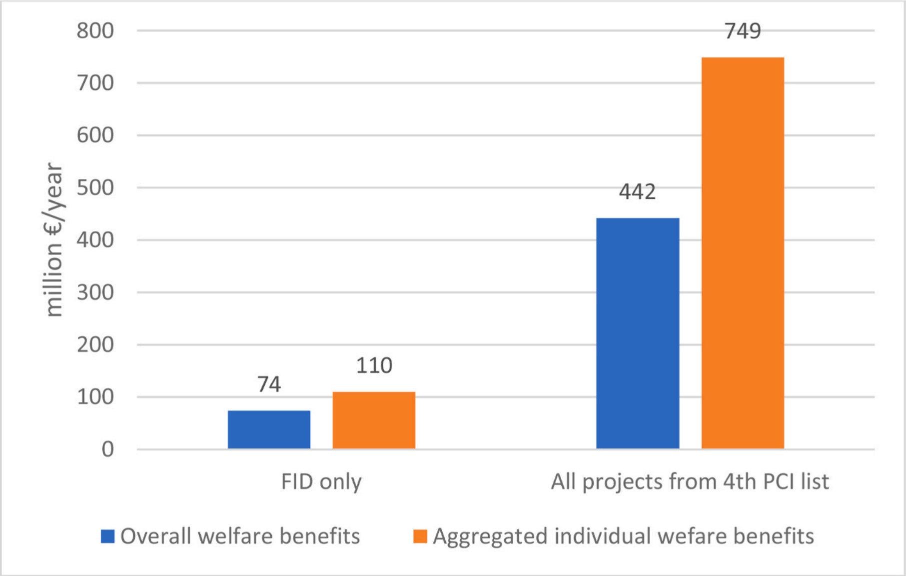

Fig. 9. Clustered vs. aggregated individual PINT benefits.

Rather, the goal is only to select the project that contributes most to the listed needs. Therefore, although remaining bottlenecks still need to be addressed, not all listed projects are necessary, otherwise some of them may result in financing stranded assets.

In order to better illustrate the competitive impact between projects and corridors in the PCI list, a PINT (put one in at a time) analysis is used to quantify the benefit of the individual projects. Fig. 9Fig. 9 shows the sum of individual benefits of the projects using the PINT methodology compared to the clustered benefits (when we include them into the model together) which are significantly higher (by 50% in case of FID projects and 70% in case of the whole PCI list) than in the clustered welfare effect. These results support our previous statement that the PCI

Table 4
Welfare effect of FID PCIs and PCIs of 4th list compared to the 2030 baseline.

		Only FID projects	All projects from the 4th PCI list
I.	Weighted average price change (€/MWh)	−0.01	−0.19
II.	Normal Welfare (m€/year)	83.2	428.4
III.	SOS Welfare (m€/year)	68.5	432.4
IV.	Total Welfare (m€/year) (0.95*II.+0,05*III.)	82.5	428.6
V.	CO2 benefit (m€/year)	−8.2	13.4
VI.	Total yearly benefit (m€/year) IV.+V.	74.3	442
VII.	Annualized investment cost (m€)	119	670
VIII.	Yearly net benefit (m€/year) VI.-VII.	−44.7	−228
IX.	Benefit/Cost ratio VI./VII.	0.62	0.66

Source: REKK modelling

list include several projects aiming the same goals.

Fig. 10 illustrates that using the PINT B/C ratio less than half of the projects have quantifiable benefits and only six projects have benefit/cost ratio larger than one: three LNG terminals, the BRUA corridor, the Poland-Lithuania interconnector and the Baltic Pipe (DK-PL).

6.3. *Sensitivity results*

Since modelled benefits for 2030 are highly dependent on the assumptions applied in the EUCO3232.5 scenario, additional sensitivity scenarios are executed. The first sensitivity scenario uses a lower level of Romanian production.[16] A crucial assumption is high Romanian production, which significantly affects benefits associated with CSEE gas infrastructure projects, and in reality is uncertain in 2020 market conditions. British Petroleum estimates a 10.6 reserves per production ratio for the Romanian gas in 2019, meaning, that the resources are very limited (BP, 2020). The second sensitivity assumes less LNG arrives to Europe (50% of current 2020 LNG import, around 600 TWh) The volume of LNG inflows to Europe can change along Asian appetite for gas but also along geopolitics as discussed also Egging-Bratseth, Holz & Czempinski (2021). The low LNG scenario estimates the benefits of the PCIs in a less oversupplied market with higher prices.

Table 5 shows that the modelled benefits vary significantly across the sensitivity scenarios. For one, lower Romanian production yields significantly lower benefits for the assessed projects, especially those that were planned to transmit partly this new Romanian source. For two, lower LNG imports yield much higher benefits for the assessed projects which perform better when gas prices are higher (both market integration and SOS). In this sensitivity scenario the B/C ratio for FID PCIs is 1.4 and for the 4th list is 1. Alternatively proposed LNG terminals produce more benefits when European LNG imports are higher.

Even though FID PCIs and the 4th list did not perform well in the Baseline Scenario, the social net benefits of these projects were positive or at least close to zero in the low LNG sensitivity scenario. It is evident that the B/C Ratio of future PCI projects highly depends on market expectations.

7. Conclusions and policy implications

This paper evaluated the success of the EU's selection and support for natural gas interconnection, LNG and storage projects that foster market integration, contribute to security of supply and help the EU reaching its sustainability goals.

There are numerous factors that make it difficult for EU decision makers to reach this goal. First, the aim is not to select projects that are economical but those that are not financially feasible or do not result in direct benefits for host member states but for wider European welfare, especially consumers. Therefore, it is suggested that the CBA is applied to candidate PCIs focusing on exclusion of unrealistic project proposals and flagging competing alternatives.

Second, the EU cannot force promoters to proceed with their projects. The long delays in project implementation due to lack of commitment, conflicting interests of promoters or political gamesmanship behind the scenes resulted sometimes allowing competing alternative projects to overtake PCIs. Following ACER recommendations, projects with overoptimistic commissioning dates, repeated delays, rescheduling or without serious progress should be put under increased scrutiny.

Third, large Russian infrastructure projects (Nord Stream 1, Turk Stream 1 and 2) have a huge impact on EU flows redirected away from Ukraine to Central and Eastern Europe. Thus, the scenario design should take into account the strategic behaviour of key suppliers to the EU and more geopolitically framed sensitivity scenarios needs to be designed to estimate the effect of the PCI projects.

Fourth, there is a certain time requirement for large investment projects to materialize. Market circumstances have changed dramatically in only a few years' time, markedly impacting the benefits from these projects. ACER reports confirm that delays to gas PCI implementation are due to uncertainty over future supply and demand.

Despite all these factors, it can be firmly concluded that even with substantial modelling simplifications and a conservative approach underestimating benefits, the natural gas PCI projects implemented up to now were beneficial from a European perspective, contributing to the internal gas market and resulting in a robust and resilient gas network that ensures security of supply. The commissioned PCIs have lowered prices considerably in more isolated member states. The underutilization of certain projects is a result of changing market circumstances and the redirection of Russian flows. The combined effect of these lead to a reduction of SOS benefits.

The FID PCIs are mostly supported by CEF funds awarded between 2014 and 2016 but according to the modelled outcomes the net benefits of these investments are less than the costs in the Baseline scenario. The results, however, depend on market circumstances. The low-price environment characterizing 2020 does not support the projects, but any scarcity in LNG supply that would increase the European prices (as experienced in 2021) would reverse this. The non-FID projects do not perform well as a package under any conditions because of competing projects that will not happen together.

Furthermore, in a decarbonized future the need for gas will be limited and any further investments should be made future proof

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[16] We used the assumption of 52.3 TWh/yr (in line with the ENTSOG TYNDP), as opposed to the 123 TWh/year in the Baseline scenarios.

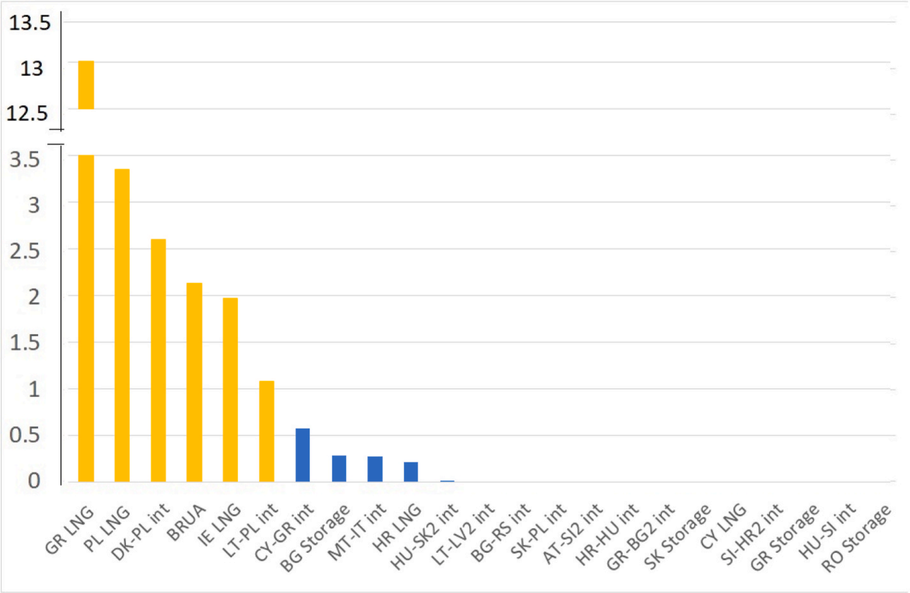

Fig. 10. PINT B/C Ratio in the reference scenario.

Table 5
Modelling results in the sensitivity scenarios, EU27.

		Total yearly benefit	Annualized investment cost	Net benefit	B/C
2030 Baseline	FID only	74	119	−45	0.6
	All projects from 4th PCI list	442	670	−228	0.7
2030 low RO production	FID only	17	119	−102	0.1
	All projects from 4th PCI list	355	670	−315	0.5
2030 low LNG (high price environment)	FID only	171	119	52	1.4
	All projects from 4th PCI list	664	670	−6	1.0

Source: REKK modelling

allowing for alternative use, especially hydrogen transport. Any delay in implementation reduces the effective years of the projects when they can generate income and increases the risk of stranded assets. Though according to the new TEN-E proposal the EU will not financially support natural gas projects going forward, those funds already allocated to FID projects that will materialize in coming years will contribute to keeping EU natural gas prices competitive.

CRediT authorship contribution statement

Adrienn Selei: Methodology, Formal analysis, modell run, Writing – original draft, Writing – review & editing, Software. **Borbála Takácsné Tóth:** Conceptualization, Methodology, Validation, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Annex. Detailed data of the analysed projects

Tables below summarize the PCI projects which were analysed in the different scenarios. It must be noted that only projects with cross-border effect can be evaluated.

Table
The already commissioned PCIs included into the evaluation

List of completed PCIs						
PCI number	Pipeline	From market	To market	Maximum flow (GWh/day)	Year	Cost (m€)
5.2	PCI Twinning of Southwest Scotland onshore system between Cluden and Brighouse Bay (United Kingdom)	UK	IE	12.1	2016	93
5.16	PCI Extension of the Zeebrugge LNG terminal	LNG	BE	472	2020	208
5.13	PCI New interconnection between Pitgam (France) and Maldegem (Belgium)	FR	BE	270	2016	186

(continued on next page)

Table (*continued*)

List of completed PCIs						
PCI number	Pipeline	From market	To market	Maximum flow (GWh/day)	Year	Cost (m€)
5.11	Reverse flow interconnection between Italy and Switzerland at Passo Gries interconnection point	IT	CH	429	2018	738
8.1.1	Interconnection Estonia - Finland [currently known as “Balticconnector"]	EE	FI	48	2020	250
8.1.1	Interconnection Estonia - Finland [currently known as “Balticconnector"]	FI	EE	48	2020	
6.3	PCI Slovakia – Hungary Gas Interconnection between Vel’ké Zlievce (SK) – Balassagyarmat border (SK/HU) - Vecsés (HU)	HU	SK	52	2015	170
6.3	PCI Slovakia – Hungary Gas Interconnection between Vel’ké Zlievce (SK) – Balassagyarmat border (SK/HU) - Vecsés (HU)	SK	HU	127	2015	
6.5.5	Compressor station 1 at the Croatian gas transmission system	HR	HU	13.6	2019	25
6.24.1	Pipeline Ruse (BG)-Giurgiu (RO)	RO	BG	1.8	2019	21
	Pipeline Ruse (BG)-Giurgiu (RO)	BG	RO	7.9	2019	
5.10	Reverse flow on TENP	CH	DE	172.8	2018	17.3
Total investment cost (m€, non-discounted):						**1708**
Total annualized investment cost* (m€):						**109**

*Cost values are first discounted to 2020 than annualized.

Table
The PCIs from the 4th list with FID included into the evaluation

List of FID PCIs						
PCI number	Project name	From market	To market	Maximum flow (GWh/day)	Year	Cost (m€)
6.2.1	Poland — Slovakia interconnection	SK	PL	175	2021	269
6.2.1	Poland — Slovakia interconnection	PL	SK	144	2021	
6.5.1	Development of a LNG terminal in Krk (HR) up to 2.6 bcm/a– Phase I and connecting pipeline Omišalj – Zlobin (HR)EN 7 EN	LNG	HR	109	2027	220
6.5.1	Development of a LNG terminal in Krk (HR) up to 2.6 bcm/a– Phase I and connecting pipeline Omišalj – Zlobin (HR)EN 7 EN	HR	HU	82	2020	27.3
6.8.1	Interconnection Greece — Bulgaria [currently known as “IGB"] between Komotini (EL) and Stara Zagora (BG) and compressor station at Kipi (EL)	GR	BG	90	2020	240
6.8.1	Interconnection Greece — Bulgaria [currently known as “IGB"] between Komotini (EL) and Stara Zagora (BG) and compressor station at Kipi (EL)	BG	GR	90	2020	
6.8.3	Gas interconnection Bulgaria — Serbia [currently known as “IBS"] (6.10 on the 3rd PCI list)	RS	BG	51	2022	77
6.8.3	Gas interconnection Bulgaria — Serbia [currently known as “IBS"] (6.10 on the 3rd PCI list)	BG	RS	51	2022	
6.24.1	ROHU(AT)/BRUA – 1st phase, including: Development of the transmission capacity in Romani a from Podișor to Recas, including, a new pipeline, metering station andthree new compressor stations in Podisor, Bibesti and Jupa	RO	HU	47	2020	448
6.24.1	ROHU(AT)/BRUA – 1st phase, including: Development of the transmission capacity in Romania from Podișor to Recas, including, a new pipeline, metering station andthree new compressor stations in Podisor, Bibesti and Jupa	RO	BG	43	2020	
8.2.4	Enhancement of Inčukalns Underground Gas Storage (LV)	Storage	LV	84	2019	88.2
8.5	Poland-Lithuania interconnection [currently known as “GIPL”]	LT	PL	58	2021	492
8.5	Poland-Lithuania interconnection [currently known as “GIPL”]	PL	LT	74	2021	
Total investment cost (non-discounted, m€):						**1862**
Total annualized investment cost (m€):						**119**

Table
Other (non-FID) PCIs from the 4th list included into the evaluation

PCI number	Project name	From	To	Capacity (GWh/day)	Year	Investment cost, m€ (TYNDP 2018)
5.3	Shannon LNG Terminal and connecting pipeline (IE)	LNG	IE	86	2022	450
5.19	Connection of Malta to the European gas network — pipeline interconnection with Italy at Gela	IT	MT	56	2024	342
5.19	Connection of Malta to the European gas network — pipeline interconnection with Italy at Gela	MT	IT	56	2024	
6.2.13	Development and enhancement of transmission capacity of Slovak-Hungarian interconnector	HU	SK	102	2022	58
6.2.13	Development and enhancement of transmission capacity of Slovak-Hungarian interconnector	SK	HU	26	2022	
6.9.1	LNG terminal in northern Greece	LNG	GR	253	2020	300
6.20.2	Chiren UGS expansion (BG)	storage	BG	48	2025	226
6.20.3	South Kavala UGS facility and metering and regulating station (EL) and one of the following PCIs:	storage	GR	44	2023	320
6.20.4	Depomures storage in Romania	storage	RO	15	2024	87
6.20.6	Sarmasel underground gas storage in Romania	storage	RO	45	2024	133
6.23	Hungary – Slovenia - Italy interconnection	SI	HU	12	2023	113

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Table (*continued*)

PCI number	Project name	From	To	Capacity (GWh/day)	Year	Investment cost, m€ (TYNDP 2018)
6.23	Hungary – Slovenia - Italy interconnection	HU	SI	12	2023	
6.26.1	Cluster Croatia — Slovenia — Austria at Rogatec	SI	HR	162	2023	76
6.26.1	Cluster Croatia — Slovenia — Austria at Rogatec	HR	SI	121	2023	
6.26.1	Cluster Croatia — Slovenia — Austria at Rogatec	AT	SI	105	2023	100
6.26.1	Cluster Croatia — Slovenia — Austria at Rogatec	SI	AT	167	2023	
6.27	LNG Gdansk (PL)	LNG	PL	138	2025	196
7.3.1	Pipeline from the East Mediterranean gas reserves to Greece mainland via Crete	CY	GR	110	2025	5200
7.3.1	Pipeline from the East Mediterranean gas reserves to Greece mainland via Crete	GR	CY	30	2025	
7.5	Development of gas infrastructure in Cyprus [currently known as “Cyprus Gas2EU"]	LNG	CY	40	2022	261
8.2.1	Enhancement of Latvia — Lithuania interconnection	LV	LT	54	2023	25.4
8.2.1	Enhancement of Latvia — Lithuania interconnection	LT	LV	63	2023	
8.3.2	Poland–Denmark interconnection [currently known as “Baltic Pipe”]	PL	DK	91	2022	716
8.3.2	Poland–Denmark interconnection [currently known as “Baltic Pipe”]	DK	PL	307	2022	
Total investment cost (m€):						**8603**
Total annualized investment cost (m€):						**551**

Table
CEF works support awarded to PCI project 2014–2020

PCI name	Country	Applicant	CEF (M€)	Year	Support share %	CAPEX (M€)	STATUS as of 2020
5.2. PCI Twinning of Southwest Scotland onshore system between Cluden and Brighouse Bay.	UK	Gaslink Independent System Operator Limited	34	2014	33%	102	completed
8.2.3. Capacity enhancement of Klaipeda-Kiemenai pipeline in Lithuania	LT	AB Amber Grid	28	2014	50%	55	completed
8.5. PCI Poland-Lithuania interconnection [“GIPL”]	LT, PL	GAZ-SYSTEM S.A./AB Amber Grid	295	2014	60%	492	FID 4th PCI list
5.10. PCI Reverse flow interconnection on TENP pipeline in Germany	DE	Fluxys TENP GmbH	9	2015	50%	17	completed
7.1.5. Gas pipeline from Bulgaria to Austria via Romania and Hungary	RO	TRANSGAZ S.A.	179	2015	40%	448	FID 4th PCI list
8.1.1. Interconnector between Estonia and Finland “Balticconnector”	FI,EE	Elering AS/Baltic Connector Oy	188	2016	75%	250	completed
8.2.2. Enhancement of Estonia-Latvia interconnection	EE	Elering AS	19	2016	50%	37	non-FID 4th list
6.2.1. Poland – Slovakia interconnection	SK,PL	eustream, a.s./GAZ-SYSTEM S. A.	108	2016	40%	269	FID 4th PCI list
6.5.1. LNG Regasification vessel in Krk	HR	LNG Hrvatska d.o.o.	101	2016	46%	220	FID 4th PCI list
	HR	Plinacro Ltd	16	2017	50%	33	FID 4th PCI list
7.3.2. LNG FSRU and storage located in Cyprus [“Mediterranean Gas Storage”]	CY	Ministry of Energy, Commerce, Industry and Tourism	101	2017	40%	253	not evaluated as not on the 4th PCI list and also not completed
6.8.2 Rehabilitation, modernization and expansion of the Bulgarian transmission system Phase 2	BG	Bulgartransgaz EAD	27	2018	40%	68	not evaluated as no cross border impact
8.2.4 Enhancement of Inčukalns Underground Gas Storage (LV)	LV	Joint Stock Company “Conexus Baltic Grid"	44	2018	50%	88	FID 4th list
8.3.1 Reinforcement of Nybro — Poland/Denmark Interconnection	PL,DK	GAZ-SYSTEM S.A.	215	2018	30%	716	non-FID 4th list
8.2.1 Enhancement of Latvia — Lithuania interconnection	LT,LV	AS Conexus Baltic Grid | AB Amber Grid	5	2019	50%	10	non-FID 4th list
6.8.3 Gas interconnection Bulgaria — Serbia ["IBS"] (6.10 on the 3rd PCI list)	BG	BG	28	2020	36%	77	FID 4th PCI list
TOTAL			1397			3135	

Source: authors based on CEF decisions;

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