THE NORTH-SOUTH CORRIDOR:

NATURAL GAS MARKET DEVELOPMENT & SOCIOECONOMIC VIABILITY

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Brussels, 16th of May 2018

GAZ system

GAZ-SYSTEM – INTRODUCTORY INFORMATION

GAZ-SYSTEM

Certified gas TSO in PL, certified ISO (Yamal-Europe pipeline)

Company with strategic significance for the economy and energy security in PL

Key integrator and facilitator of market development in the CEE and Baltic regions

LNG terminal in Świnoujście operated by its SPV, Polskie LNG

Infrastructure development to enable increased consumption of natural gas as an environmentally-friendly fuel

GAZ-SYSTEM – INTRODUCTORY INFORMATION

11,059 km
LENGTH OF TRANSMISSION NETWORK

100%
SHARES HELD BY STATES TREASURY

903
GAS STATIONS

684 km
LENGHT OF YAMAL-EUROPE PIPELINE

5 bcm/y
REGAS CAPACITY

37
NODES

221.9 TWh
VOLUME OF TRANSPORTED GAS (INC. UGS)

around **200**
SHIPPERS

14
COMPRESSOR STATIONS

GAZ system

GAZ-SYSTEM STRATEGY:
CREATING A REGIONAL AND INTERNAL NATURAL GAS MARKET

NORTH – SOUTH GAS CORRIDOR:

- **Capacity:** up to 10 bmc/y
- **Project role:** creating a large transportation corridor between new supply sources and southern Poland

BALTIC PIPE INTERCONNECTION:

- **Capacity:** NO-DK-PL: 10 bcm/y, PL-DK 3 bcm/y
- **Project role:** diversification of gas supply sources / routes to CEE & CSE markets

LNG TERMINAL ŚWINOUJŚCIE :

- **Capacity:** 7.5 bcm/y
- **Project role:** providing access to the global LNG market

POLAND – LITHUANIA INTERCONNECTION:

- **Capacity:** 2.4 bcm/y towards LT, 1.9 bcm/y towards PL
- **Project role:** integration of isolated gas markets in the East Baltic region, diversification of supply

POLAND – SLOVAKIA INTERCONNECTION:

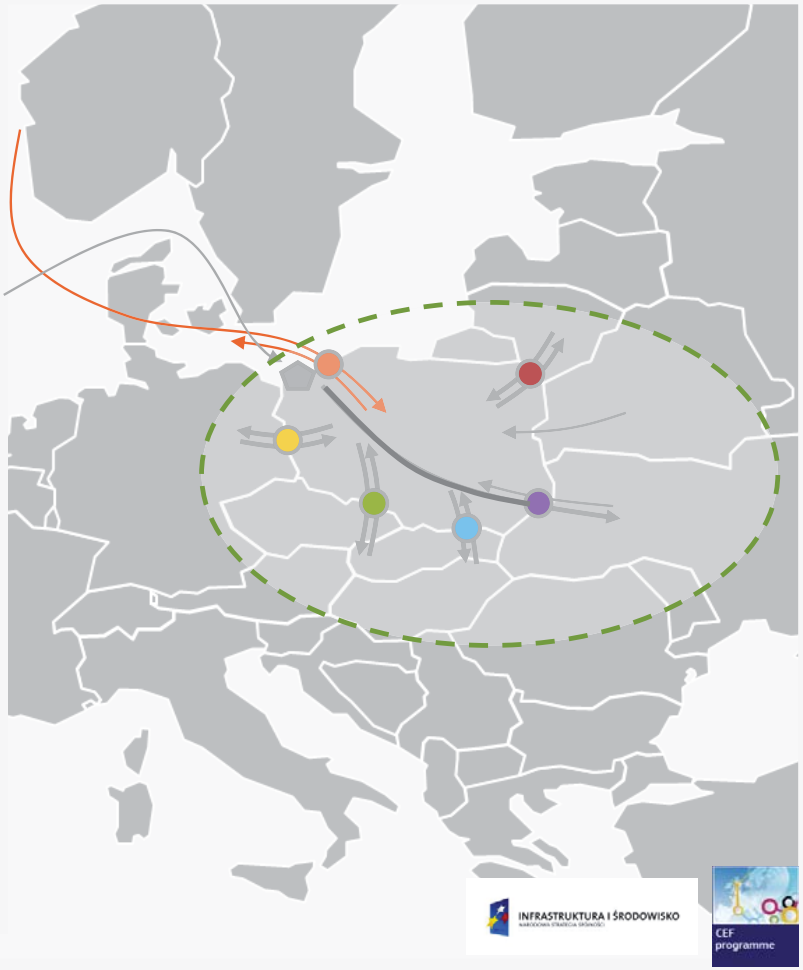
- **Capacity:** 4.7 bcm/y towards SK, 5.7 bcm/y towards PL
- **Project role:** integration of the gas markets by creating a large transportation corridor between both countries

POLAND – UKRAINE INTERCONNECTION:

- **Capacity:** 5 bcm/y towards UA, 5 bcm/y towards PL
- **Project role:** connection of Poland's and Ukraine's systems to diversify gas supplies for Ukraine and further integrate transmission networks and markets in Eastern Europe

POLAND – CZECH REPUBLIC INTERCONNECTION:

- **Capacity:** 5 bcm/y towards CZ, 6.5 bcm/y towards PL
- **Project role:** integration of the gas markets by creating a large transportation corridor between both countries



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THE NORTH-SOUTH GAS CORRIDOR IN POLAND

Related elements of the NSC Program:

- Extension of LNG Terminal (related program)
- Baltic Pipe (related program)
- North – South Gas Corridor
- Connections gas transmission systems in Czech Republic, Slovakia and Ukraine
- System access points from N-S corridor
- XXX thous. m3/h — Maximum technical capacity of system stations

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INVESMENTS INCLUDED IN THE NORTH – SOUTH GAS CORRIDOR

The North – South Gas Corridor is comprised of bi-directional domestic gas pipelines, which are already operational, in design and permitting phase or in construction phase.

No.	Pipeline	Length	Phase
1	DN 1000 Goleniów – Lwówek	188 km	design and permitting
2	DN 1000 Lwówek - Odolanów	168 km	construction
3	DN 1000 Wierzchowice - Czeszów	14 km	operational
4	DN 1000 Czeszów - Kiełczów	33 km	construction
5	DN 1000 Wrocław (Kiełczów) – Zdzieszowice	130 km	construction
6	DN 1000 Zdzieszowice – Kędzierzyn	19 km	construction
7	DN 1000 Kędzierzyn – Tworóg	43 km	construction
8	DN 1000 Tworóg – Tworzeń	56 km	construction
9	DN 1000 Tworzeń – Pogórska Wola	168 km	tender for construction
10	DN 1000 Pogórska Wola – Strachocina	97 km	construction

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THE NORTH –SOUTH GAS CORRIDOR IN POLAND - BENEFITS

I. Increase in the integration of regional gas markets.

II. Increase in security of supply.

III. Possible access to new sources of supply (LNG, Norway) for Eastern Europe.

IV. Reduction of GHG emissions and air pollution.

V. Coordination of large regional infrastructure projects.

VI. Harmonisation/unification of principles that are valid and binding on the market.

VII. Enabling the implementation of regional prevention and emergency procedures in crises situations.

JASPERS ROLE AND INPUT

JASPERS advised on five major projects included in NSC Program

Scope of JASPERS advisory:

- CBA analysis
- Financial analysis
- Risk assessment
- Enviroment sustainability
- Impact of the climat changes
- Demand and option analysis

Effects of cooperation:

- So far, three projects consulted with JASPERS were fully accepted by European Commission
- One project is currently being assessed by the European Commission
- One project is currently being assessed by JASPERS experts

CONSTRUCTION OF CZESZÓW – KIEŁCZÓW PIPELINE

CONSTRUCTION OF LWÓWEK – ODOLANÓW PIPELINE

THANK YOU FOR YOUR ATTENTION

GAZ system

Advisory

Approach to CBA for North-South Corridor

Brussels,
16 May 2018

Presentation prepared for
DG Regio JASPERS CBA Forum meeting on energy

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pwc

Agenda

1) Introduction

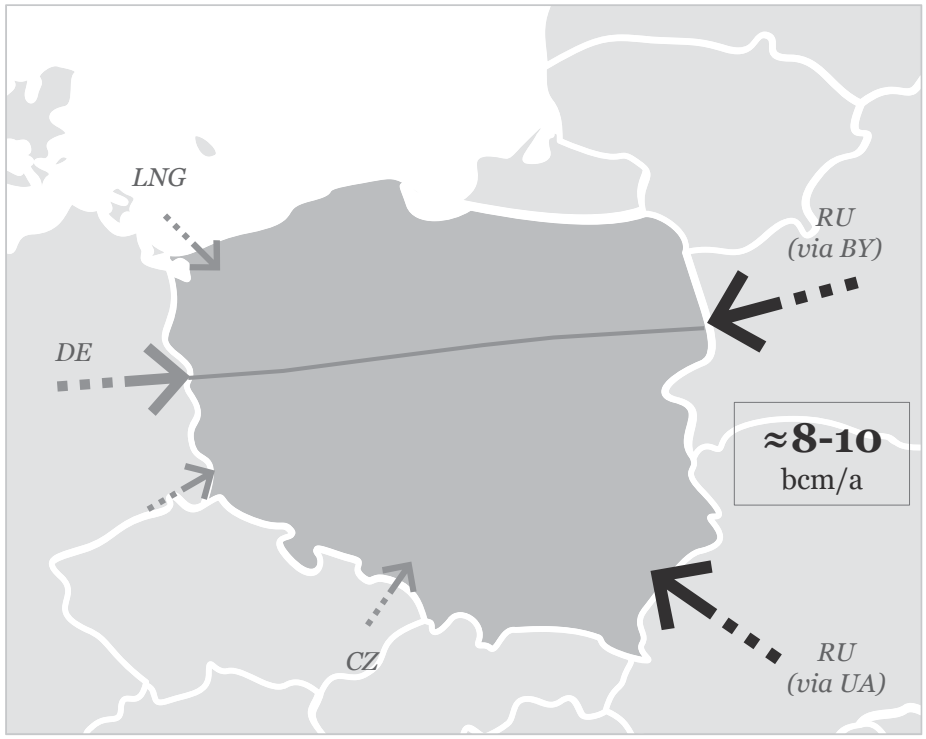
2) Approach to GHG, AP and SC monetisation

3) Approach to SoS monetisation

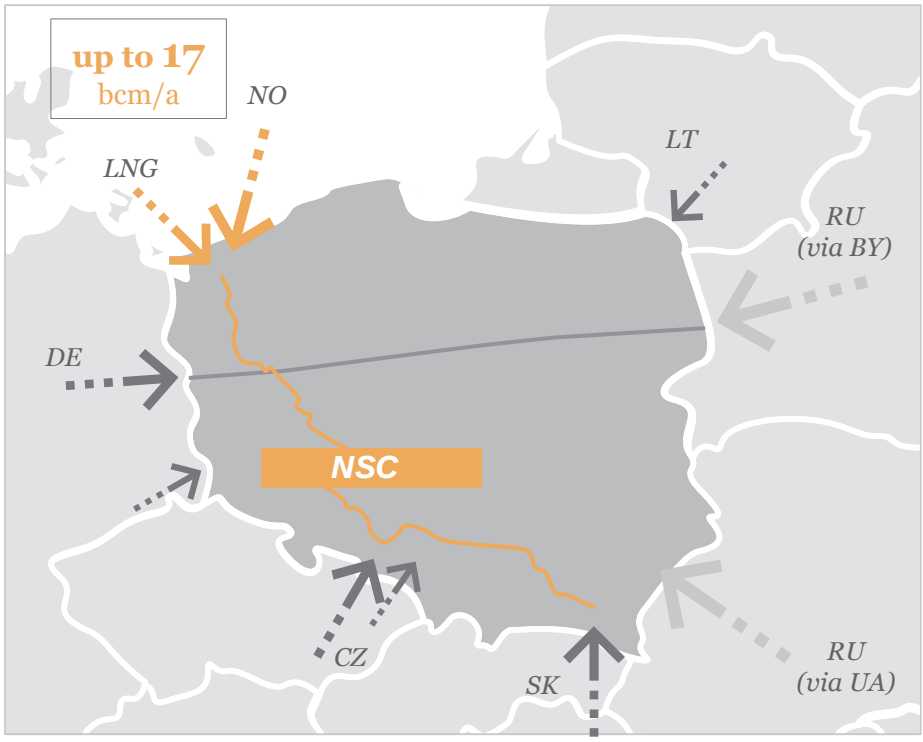
4) Results and conclusions

Currently, most of the gas imports for Poland come from East, and are assessed as being at risk. The NS Corridor will allow to mitigate this by rerouting supplies to Poland through the 'Northern Gate'

'Current' situation (2018)



'With NSC and Northern Gate' situation (2023)



Benefits related to the Security of Supply should be calculated for all three complementary investments: Baltic Pipe, LNG Terminal development and North-South Corridor

W1 and W0 scenarios differ with realisation of NS Corridor in Poland. Investment enables full utilisation of Northern Gate as well as full coverage of increasing demand for energy in the investment area

	W0 Without the investment			**W1** With the investment		
	Baltic Pipe	*LNG Terminal development*	*North-South Corridor*	*Baltic Pipe*	*LNG Terminal development*	*North-South Corridor*
Infrastructure *(key investments)*	✓	✓	✗	✓	✓	✓
Utilisation of 'Northern Gate' capacity	✓	***Highly limited.*** *Keeping* ***high exposure*** *to gas supplies from* ***eastern direction***		✓	***Possible full utilisation***	*Key issue for SoS*
Coverage of increasing demand in the investment area	✗	***Not possible***		✓	***Full coverage***	*Key issue for GHG, AP and SC*

Five indicators were included and monetised in the cost-benefit analysis. Three of them refer to emissions, one refers to fuel costs and the last one to the Security of Supply

Indicators included in the analysis





Greenhouse gases (GHG)	***Greenhouse gases (GHG)***	***Air Pollution (AP)***	***Substitution cost (SC)***	***Security of Supply (SoS)***
Emission change resulting from ***fuel consumption structure***	*Emission in* ***construction period*** *and during further* ***pipeline operations***	*Change in* ***air pollution emission*** *resulting from* ***fuel consumption structure***	*Costs directly related to* ***fuel consumption structure*** *and resulting change in* ***fuel purchase costs***	*Avoided social and economic costs related to the* ***energy that would not be delivered*** *in crisis situation*

1) Introduction

2) Approach to GHG, AP and SC monetisation

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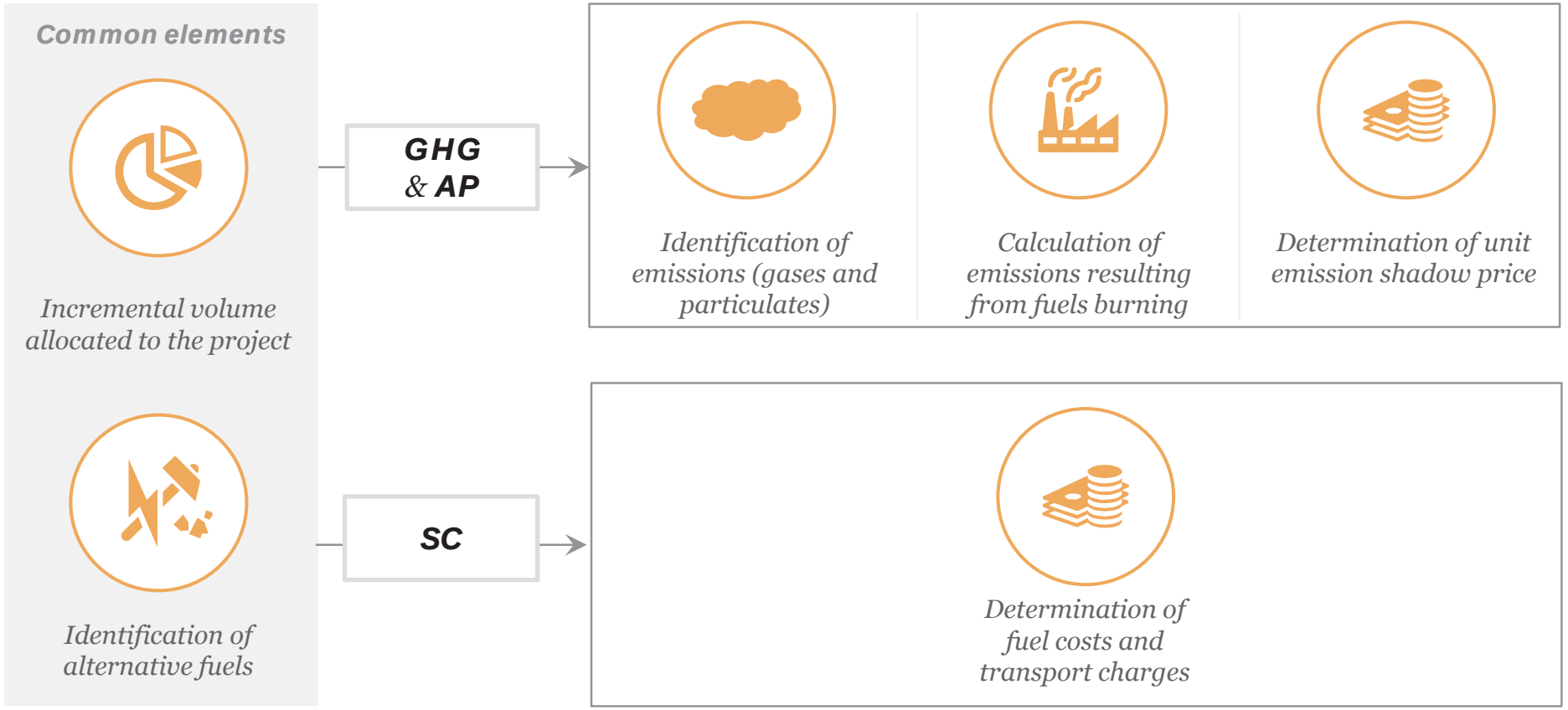
For purpose of GHG, AP and SC monetisation it was required to determine base project assumptions and gather input data from several reference sources

Elements necessary for monetisation of costs and benefits resulting from changed emission of Greenhouse gases (GHG) and Air Pollution (AP) and Substitution Cost of fuels (SC)



Incremental volume assigned to the project was determined based on results from Feasibility Study. Only demand change in the investment area was considered

Incremental volume

Increased demand for energy in the region

Incremental gas demand determined in ***Feasibility Study for Project***

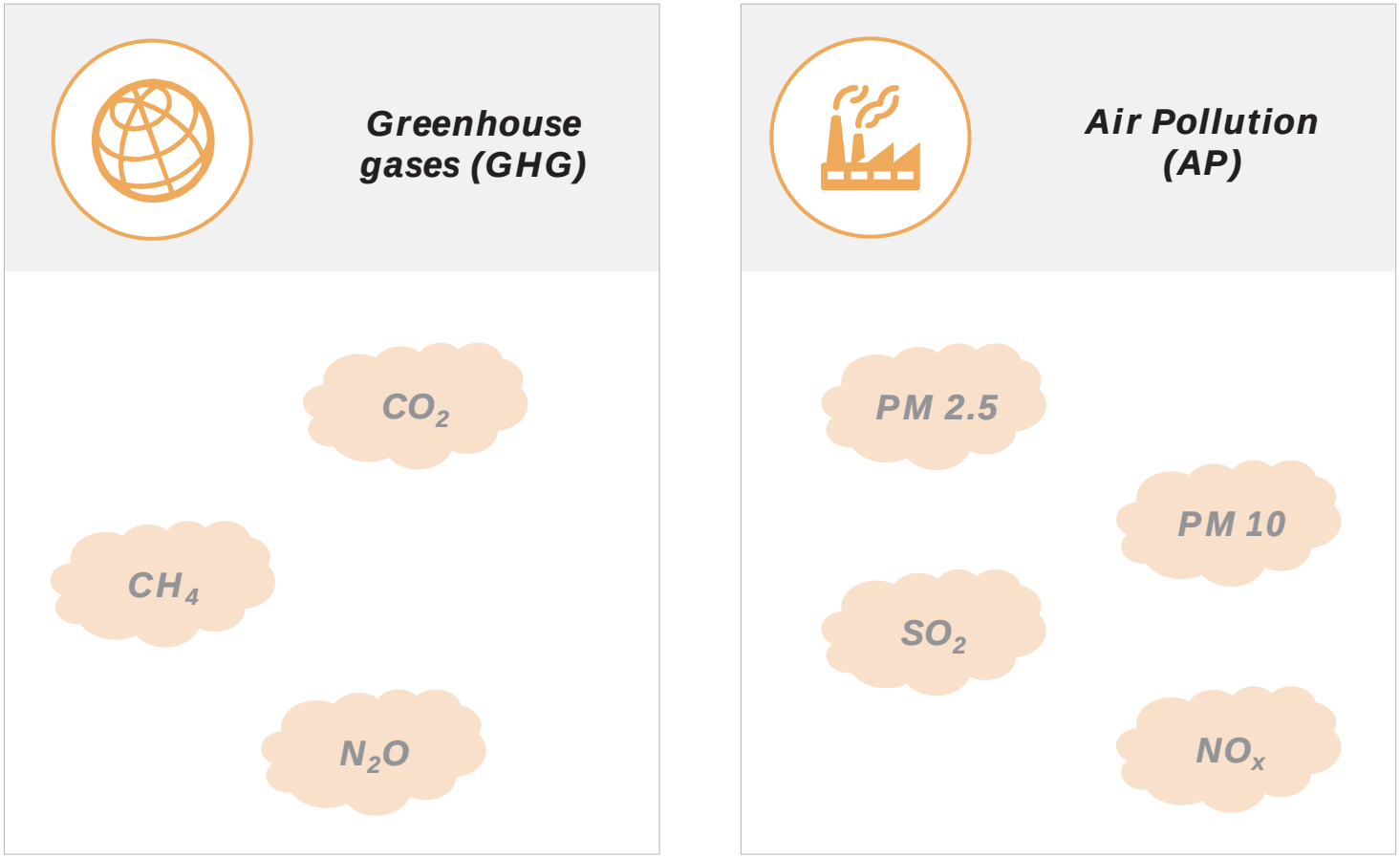
W0	***W1***
• ***Hard coal***	• *Hard coal*
• ***Heating oil***	• *Heating oil*
• ***LPG***	• *LPG*
	• ***Natural gas***

Volumes, prices, and boiler/furnace efficiencies and emission factors were differentiated for three main consumer groups separately

Households *Commercial* *Industrial*

In the analysis three main greenhouse gases were included. In the air pollution group two gases and two particulates were included

Environmental externalities (emissions) resulting from fossil fuels burning – included gases and particulates



Data required for emissions calculation and unit shadow cost determination were taken from reference sources

Calculation of emissions resulting from fuel burning

Use of several sources in order to determine emissions from fuel burning, i.a.:

- *CBA Guide (2014)*
- *Guide to IPCC Guidelines for National Greenhouse Gas Inventories (2006)*
- *National Fund for Environmental Protection and Water Management*
- *The National Centre for Emissions Management*

Determination of unit emission shadow prices

- *Inclusion of shadow prices for emissions*
- *Use of two main data sources for purpose of emissions cost determination:*
  - *For GHG: DG Clima's Climate Change and Major Projects (central estimate)*
  - *For Air Pollution: Energy Economics and the Rational Use of Energy, University of Stuttgart - data provided thanks to JASPERS' support*

Final fuels prices were determined with regards to guidelines included in CBA Guide. Therefore, border or hub prices increased with the transportation cost to final consumers were applied

Approach to the total fuel prices determination

<table>
<tr><th></th><th>Guidelines from CBA Guide</th><th>Natural gas</th><th>Hard coal</th><th>Heating oil</th><th>LPG</th></tr>
<tr><td> 
Fuels prices</td><td>„As fuels are traded internationally, the use of border prices instead of national market prices allows excluding taxation and other market distortions so as to better reflect the opportunity cost of these resources in the economic analysis”</td><td>Average German import price (BAFA)</td><td>ARA area</td><td>ARA area</td><td>ARA area</td></tr>
<tr><td></td><td></td><td colspan="4">Indexation with commodities price forecasts from reference sources</td></tr>
<tr><td> 
Transpor-tation cost</td><td>Fuel prices should include „cost of transportation to the relevant market”, in this case the final consumers burner-tip</td><td>• Transmission from Germany to Poland
• Distribution to final consumers</td><td colspan="3">• Ship freight to Poland
• Deliveries to the main distribution point where final consumers purchase fuels</td></tr>
</table>

For purpose of monetisation of GHG emissions during investment and operational period five main areas where emissions may occur were included in the analysis

Emissions related to the construction period and during further pipeline operations

CO_2	CO & CO_2	CH_4	CH_4	CH_4
Car traffic, work of construction machines, power generators, pumps etc.	*Welding process*	*Methane emission from operational vents*	*Methane emission caused by leaks*	*Methane emission as a result of failure*

Emissions observed in the investment period

Emissions observed in the operational period

- *Emissions identified in each area*
- *Adopted emissions costs*
- *Probability (where applicable)*

→ ***Total costs to the society***

Approach and data for this indicator were provided to PwC by GAZ-SYSTEM. PwC's role was to perform monetization of quantified emissions only

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Three main areas necessary for SoS monetisation were identified as: definition of supply disruption scenarios, their duration and occurrence probability and CoDU evaluation

Elements necessary for monetisation of benefits resulting from increase of Security of Supply in Saved Cost Approach

Supply disruption scenarios *(and the Disrupted Demand which can be covered by new infrastructure)*

Disruption duration and occurrence probability

Cost of Disrupted Unit (CoDU)

Framework for SoS assumptions was established in the Polish Preventive Action Plan

2016 Risk assessment – risk matrix from the Preventive Action Plan prepared by Ministry of Energy

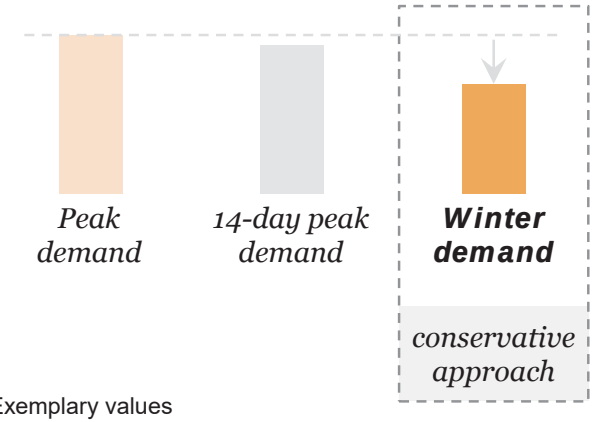
Consequences \ Probability	Low	Medium	High
Severe	• **Eastern variant** – no supplies from eastern direction, sustained gas transmission via Yamal pipeline; • **Eastern variant** – no supplies from eastern direction, stopped gas transmission via Yamal pipeline; • **Gas nodes malfunction**		
Noticeable			
Insignificant	• **No supplies from the Mogilno UGS** facility; • Malfunction at the **Jarosław CS**; • Malfunction at the **LNG Terminal** in Świnoujście	• **Belarusian variant** (without Wysokoje)	• **Ukrainian variant**

Three main scenarios assuming range of supplies disruption from eastern direction were considered, based on preventive action plan, historical observations and TSOs expert knowledge

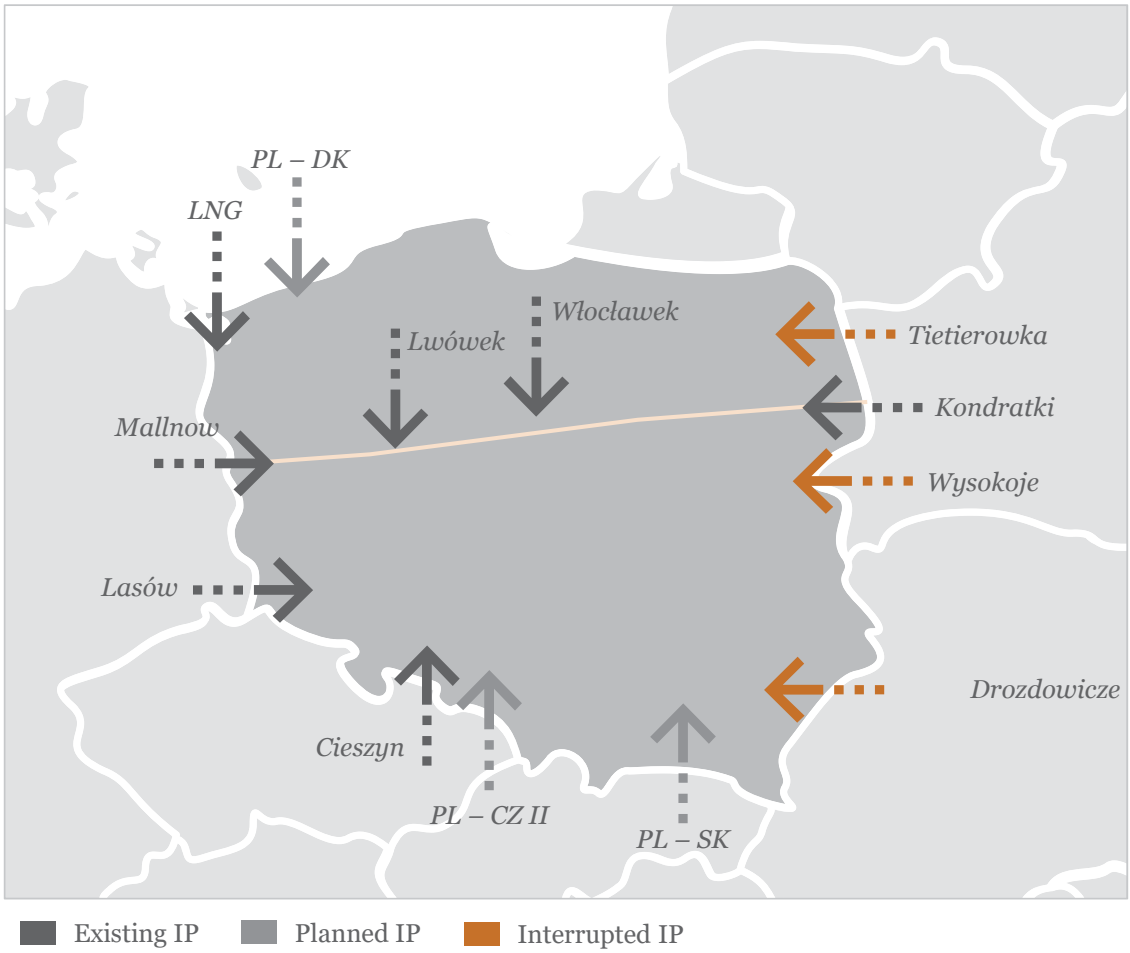
Analysed scenarios

#a	*Limited natural gas deliveries via Ukraine*
#b	*Suspended gas deliveries from Russia, <u>sustained</u> deliveries via Yamal Pipeline*
#c	*Suspended gas deliveries from Russia, <u>suspended</u> deliveries via Yamal Pipeline*

Applied gas demand



Exemplary disruption scenario (#b)



Exemplary values

Scenarios were analysed under two disruption durations, where main difference resulted from UGS withdrawal rates. Occurrence probability was assessed with use of qualitative analysis

Disruption duration

#1 30-day crisis	#2 180-day crisis
Low *stock level in UGS at the beginning of crisis*	***High*** *stock level at the beginning of crisis*
No gas injection during crisis	
Effectively ***intermediate average*** *withdrawal rate*	*Effectively* ***low average*** *withdrawal rate – high impact*

Crisis durations were applied with regards to approach proposed by European Commission when analysing short term resilience of the European gas system ('stress test') in year 2014

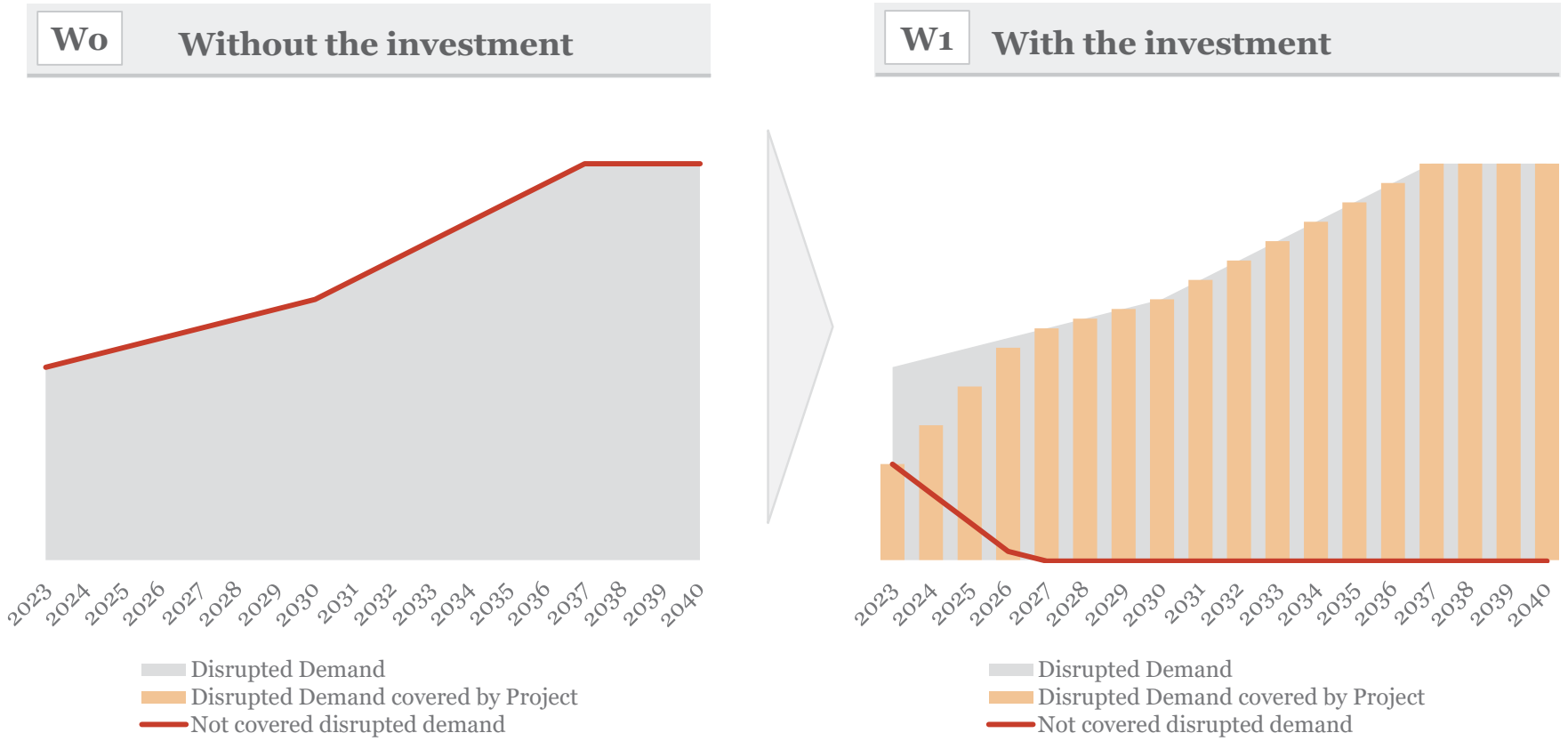
Disruption occurrence probability

Probability was determined with inclusion of several issues:

- ***Historical data*** *about supply interruptions (where applicable)*
- *Current* ***political situation development***
- *Information provided in* ***reports prepared by National Authorities***
- ***Expert knowledge*** *of the transmission system operator*

For each analysed scenario Disrupted Demand estimation was executed

Exemplary estimation of Disrupted Demand with assessment of its part to be covered by Project



Not actual values – exemplary results are shown for presentation purposes

Four CoDU calculation approaches were identified. For purpose of analysis Macroeconomic (GDP) approach supported with Historical approach were applied

How to calculate CoDU for Poland ?

Historical approach

Use of historical data regarding supply interruptions to estimate outage costs

Willingness to Pay ('WTP') approach

Use of surveys to investigate willingness to pay for an avoidance of an interruption

Macroeconomic ('Welfare') approach

*The approach seeks to derive economic costs of outages from the loss in 'welfare output' generated by firms and private households**

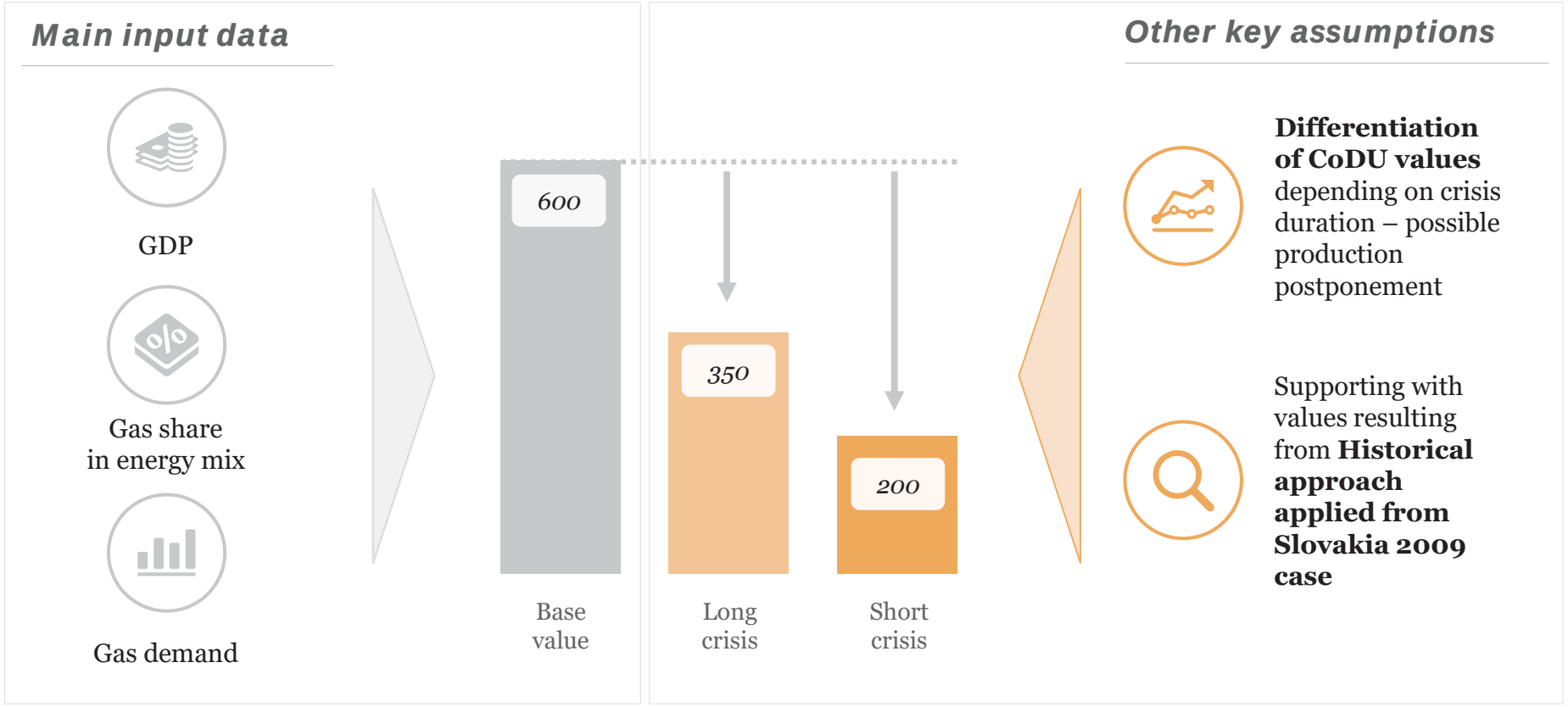
Macroeconomic (GDP) approach

Approach based on GDP and gas share in the fuel mix and resulting production value dependent on natural gas supplies

* Where 'Welfare Output' for private households is defined by the utility people gain from leisure activities

Resulting base CoDU value is similar to the one used by ENTSOG. However, finally applied values were differentiated for long- and short crisis and are lower than the base value

CoDU values resulting from adopted approach [EUR/MWh]



In TYNDP 2017 ENTSOG used a Value of Lost Load equal to 600 EUR/MWh

Values do not include probability of each disruption
Not actual values – rough approximation of analysis results is shown

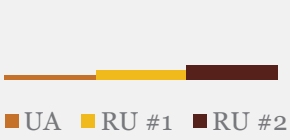
Benefits from increased Security of Supply were induced by all three investments. Benefit for North South Corridor project was accounted pro-rata with CAPEX allocation key

Summary of SoS calculation steps and scenarios

30-day crisis

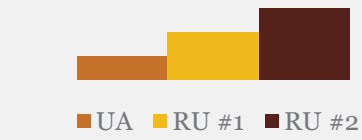
CoDU
200
EUR/MWh

Disrupted Demand



180-day crisis

CoDU
350
EUR/MWh



Probability of each analysed case

Statistically, only one weighted average 'Russian' crisis was included in the period of analysis

SoS results allocation to NSC project

Total benefits related to the Security of Supply

Baltic Pipe	*LNG Terminal development*	*North-South Corridor*

CAPEX Allocation key

NSC pipelines CAPEX share in the total CAPEX of Northern Gate

Not actual values – exemplary results are shown for presentation purposes

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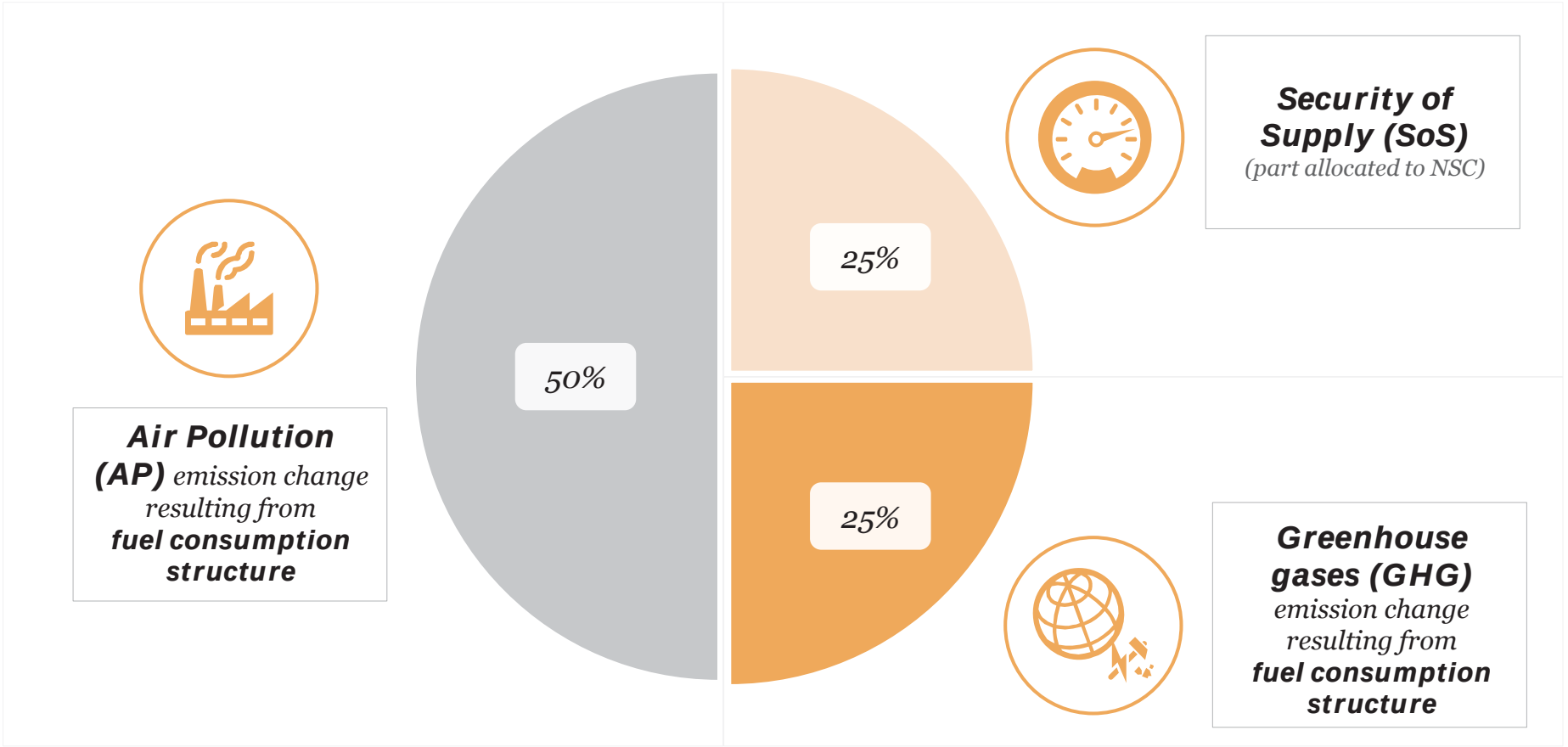
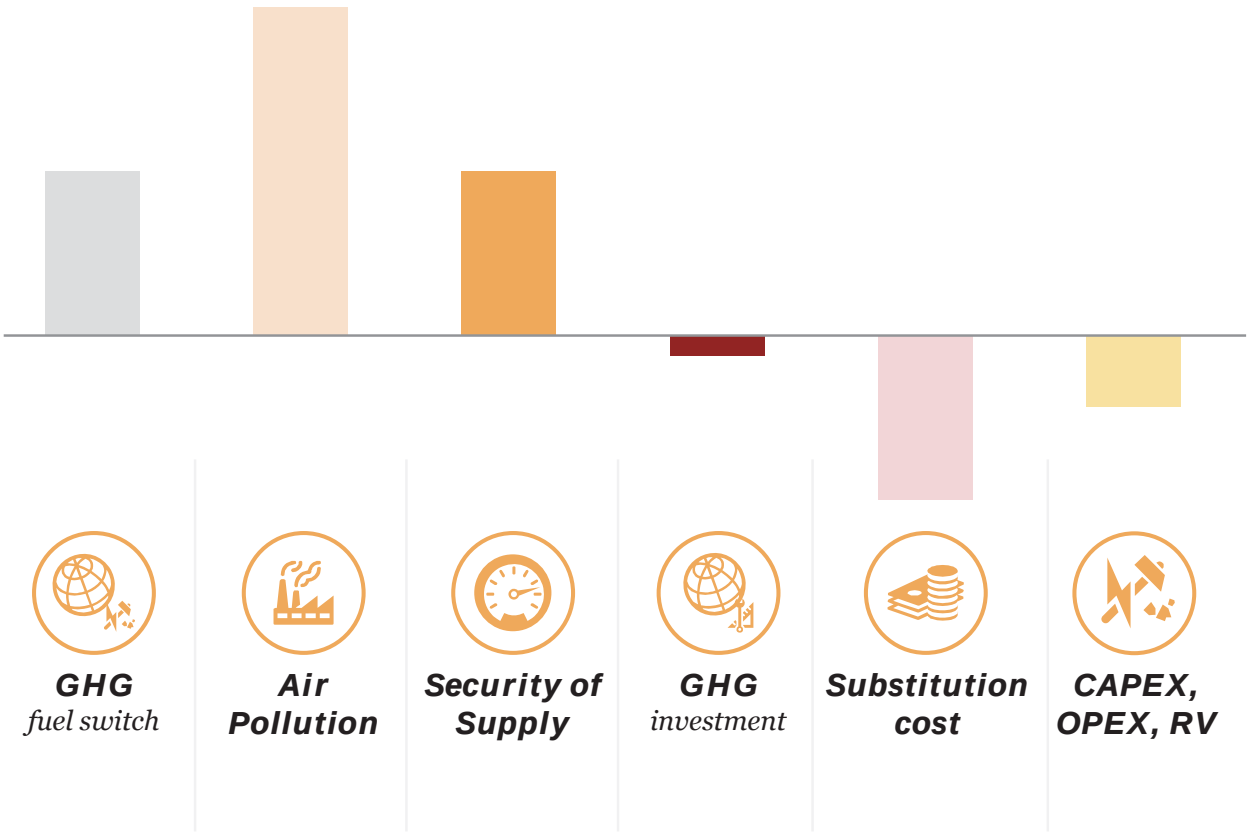
Circa half of the total benefits were monetised in the area of Air Pollution. The remaining half is a result of Greenhouse Gases emission reduction and increase of Security of Supply

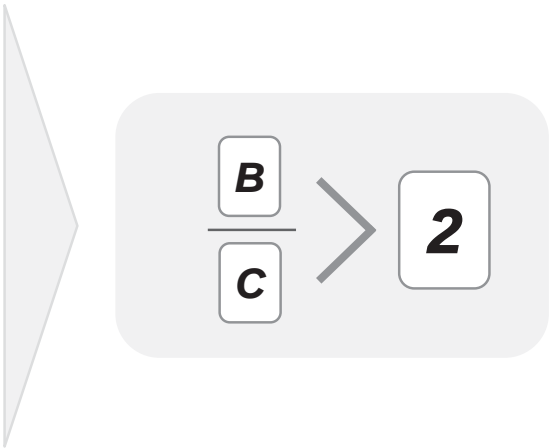
Benefits – distribution of results by monetary value



Finally, when including all benefits and costs, project reached the B/C ratio exceeding value of 2

Benefits and costs – results





Magnitude shown for illustration purpose only. It is not an actual result of analysis

The calculation methodology for emissions is very well established. Diligent and justified estimation of incremental demand for analysis is crucial for a reliable Cost Benefit Analysis

Our conclusions

Greenhouse gases (GHG)

Air Pollution (AP)

Substitution cost (SC)

	Greenhouse gases (GHG)	Air Pollution (AP)	Substitution cost (SC)
Guidelines in the methodology	✓	✓	✓
Data availability (reference sources)	▬▬▬	▬▬▭	▬▬▭
General conclusion	• *Well established calculation methodology* • *Well structured data sources*	• *Vital for natural gas projects (in the Polish context)* • *Well established calculation methodology* • *Some limitations to data sources*	• *Well established calculation methodology* • *Some limitations to data sources*

Availability: ▬▬▬ *Full* ▬▬▭ *Limited* ▬▭▭ *Very limited*

A general framework for Security of Supply (and other non-emission indicators) is established. This gives project promoters some flexibility but may lead to discrepancies between different projects

Our conclusions

Security of Supply (SoS)

Other specific indicators

	Security of Supply (SoS)	Other specific indicators
Guidelines in the methodology	✓	✓
Data availability (reference sources)	▬▭▭	?
General conclusion	• *SoS was crucial in context of this particular project. However, other projects related to UGS, Interconnection points, LNG Terminals may have a very different impact on economies and societies. Exemplary other indicators that may be crucial are for instance: Price convergence; Market integration; Support to RES intermittency; Summer winter gas price spread.* • *General framework on these indicators is included in the CBA Guide, but the methodology is not as well established as for emissions or fuel costs impact calculation.* • *This makes the analysis of this specific indicators very challenging and may lead to discrepancies in approaches adopted for different projects by different project promoters.* • *At the same time this leaves some flexibility for project promoters to reflect local or specific implications of their projects in the analysis.*	

Availability: ▬▬▬ *Full* ▬▬▭ *Limited* ▬▭▭ *Very limited*