THE NORTH-SOUTH CORRIDOR:
NATURAL GAS MARKET DEVELOPMENT & SOCIOECONOMIC VIABILITY

Adam Strzymiński, Head of Public Aid Unit
Brussels, 16th of May 2018
GAZ-SYSTEM – INTRODUCTORY INFORMATION

- 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 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 ŚWINOUJSIE:
► 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
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

Maximum technical capacity of system stations:

- LNG terminal
- Baltic Pipe
- 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
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.

<table>
<thead>
<tr>
<th>No.</th>
<th>Pipeline</th>
<th>Length</th>
<th>Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DN 1000 Goleniów – Lwówek</td>
<td>188 km</td>
<td>design and permitting</td>
</tr>
<tr>
<td>2</td>
<td>DN 1000 Lwówek - Odolanów</td>
<td>168 km</td>
<td>construction</td>
</tr>
<tr>
<td>3</td>
<td>DN 1000 Wierzchowice - Czeszów</td>
<td>14 km</td>
<td>operational</td>
</tr>
<tr>
<td>4</td>
<td>DN 1000 Czeszów - Kiełczów</td>
<td>33 km</td>
<td>construction</td>
</tr>
<tr>
<td>5</td>
<td>DN 1000 Wrocław (Kiełczów) – Zdziechosowice</td>
<td>130 km</td>
<td>construction</td>
</tr>
<tr>
<td>6</td>
<td>DN 1000 Zdziechosowice – Kędzierzyn</td>
<td>19 km</td>
<td>construction</td>
</tr>
<tr>
<td>7</td>
<td>DN 1000 Kędzierzyn – Tworóg</td>
<td>43 km</td>
<td>construction</td>
</tr>
<tr>
<td>8</td>
<td>DN 1000 Tworóg – Tworzeź</td>
<td>56 km</td>
<td>construction</td>
</tr>
<tr>
<td>9</td>
<td>DN 1000 Tworzeź – Pogórska Wola</td>
<td>168 km</td>
<td>tender for construction</td>
</tr>
<tr>
<td>10</td>
<td>DN 1000 Pogórska Wola – Strachocina</td>
<td>97 km</td>
<td>construction</td>
</tr>
</tbody>
</table>
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
- Environment sustainability
- Impact of the climate 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
Advisory

**Approach to CBA for North-South Corridor**

*Presentation prepared for DG Regio JASPERS CBA Forum meeting on energy*

Mateusz Konieczny
*Vice Director*
*Oil, Gas & Chemicals, PwC Polska*
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**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 Wo 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**

<table>
<thead>
<tr>
<th></th>
<th>Without the investment</th>
<th>With the investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltic Pipe</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>LNG Terminal development</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>North-South Corridor</td>
<td>✗</td>
<td>✓</td>
</tr>
</tbody>
</table>

**Wo Without the investment**

- **Highly limited.**
- Keeping high exposure to gas supplies from eastern direction

- **Not possible**

**W1 With the investment**

- **Possible full utilisation**

- **Full coverage**

**Key issue for SoS**

**Key issue for GHG, AP and SC**

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Approach to CBA for North-South Corridor • DG Regio JASPERS CBA Forum

PwC 16 May 2018
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

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenhouse gases (GHG)</td>
<td>Emission change resulting from fuel consumption structure</td>
</tr>
<tr>
<td>Greenhouse gases (GHG)</td>
<td>Emission in construction period and during further pipeline operations</td>
</tr>
<tr>
<td>Air Pollution (AP)</td>
<td>Change in air pollution emission resulting from fuel consumption structure</td>
</tr>
<tr>
<td>Substitution cost (SC)</td>
<td>Costs directly related to fuel consumption structure and resulting change in fuel purchase costs</td>
</tr>
<tr>
<td>Security of Supply (SoS)</td>
<td>Avoided social and economic costs related to the energy that would not be delivered in crisis situation</td>
</tr>
</tbody>
</table>
1) Introduction

2) Approach to GHG, AP and SC monetisation

3) Approach to SoS monetisation

4) Results and conclusions
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)

- Identification of emissions (gases and particulates)
- Calculation of emissions resulting from fuels burning
- Determination of unit emission shadow price
- Identification of alternative fuels
- Determination of fuel costs and transport charges
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

- **Wo**
  - Hard coal
  - Heating oil
  - LPG

- **W1**
  - Hard coal
  - Heating oil
  - LPG
  - Natural gas

Volumes, prices, and boiler/furnace efficiencies and emission factors were differentiated for three main consumer groups separately.
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)
• 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>
<thead>
<tr>
<th>Fuels prices</th>
<th>Guidelines from CBA Guide</th>
</tr>
</thead>
<tbody>
<tr>
<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></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transportation cost</th>
<th>Natural gas</th>
<th>Hard coal</th>
<th>Heating oil</th>
<th>LPG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel prices should include „cost of transportation to the relevant market”, in this case the final consumers burner-tip</td>
<td>Average German import price (BAFA)</td>
<td>ARA area</td>
<td>ARA area</td>
<td>ARA area</td>
</tr>
</tbody>
</table>
| Indexation with commodities price forecasts from reference sources | • Transmission from Germany to Poland  
• Distribution to final consumers | • Ship freight to Poland  
• Deliveries to the main distribution point where final consumers purchase fuels |
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

<table>
<thead>
<tr>
<th>CO$_2$</th>
<th>CO &amp; CO$_2$</th>
<th>CH$_4$</th>
<th>CH$_4$</th>
<th>CH$_4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car traffic, work of construction machines, power generators, pumps etc.</td>
<td>Welding process</td>
<td>Methane emission from operational vents</td>
<td>Methane emission caused by leaks</td>
<td>Methane emission as a result of failure</td>
</tr>
</tbody>
</table>

Emissions observed in the investment period

- Emissions identified in each area
- Adopted emissions costs

Emissions observed in the operational period

- Probability (where applicable)

Total costs to the society
3) **Approach to SoS monetisation**
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

<table>
<thead>
<tr>
<th>Consequences</th>
<th>Probability</th>
<th>Eastern variant – no supplies from eastern direction, sustained gas transmission via Yamal pipeline;</th>
<th>Eastern variant – no supplies from eastern direction, stopped gas transmission via Yamal pipeline;</th>
<th>Gas nodes malfunction</th>
<th>Belarusian variant (without Wysokoje)</th>
<th>Ukrainian variant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe</td>
<td>Low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noticeable</td>
<td>Medium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insignificant</td>
<td>High</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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, **suspended** deliveries via Yamal Pipeline
- **#c** Suspended gas deliveries from Russia, **sustained** deliveries via Yamal Pipeline

### Applied gas demand

- **Peak demand**
- **14-day peak demand**
- **Winter demand**

### Exemplary disruption scenario (#b)

Exemplary values

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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

<table>
<thead>
<tr>
<th>30-day crisis</th>
<th>180-day crisis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low stock level in UGS at the beginning of crisis</td>
<td>High stock level at the beginning of crisis</td>
</tr>
</tbody>
</table>

No gas injection during crisis

Effectively intermediate average withdrawal rate

Effectively low average withdrawal rate – high impact

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

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.
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.
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]**

<table>
<thead>
<tr>
<th>Main input data</th>
<th>Other key assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>Differentiation of CoDU values depending on crisis duration – possible production postponement</td>
</tr>
<tr>
<td>Gas share in energy mix</td>
<td>Supporting with values resulting from Historical approach applied from Slovakia 2009 case</td>
</tr>
<tr>
<td>Gas demand</td>
<td></td>
</tr>
</tbody>
</table>

**Section 3 – Approach to SoS monetisation**

Values do not include probability of each disruption

Not actual values – rough approximation of analysis results is shown

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

<table>
<thead>
<tr>
<th>30-day crisis</th>
<th>180-day crisis</th>
</tr>
</thead>
<tbody>
<tr>
<td>CoDU</td>
<td>CoDU</td>
</tr>
<tr>
<td>200 EUR/MWh</td>
<td>350 EUR/MWh</td>
</tr>
</tbody>
</table>

**Disrupted Demand**

<table>
<thead>
<tr>
<th>Probability of each analysed case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistically, only one weighted average 'Russian' crisis was included in the period of analysis</td>
</tr>
</tbody>
</table>

### SoS results allocation to NSC project

<table>
<thead>
<tr>
<th>Baltic Pipe</th>
<th>LNG Terminal development</th>
<th>North-South Corridor</th>
</tr>
</thead>
</table>

**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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4) Results and conclusions
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

- Air Pollution (AP) emission change resulting from fuel consumption structure
  - 50%
- Greenhouse gases (GHG) emission change resulting from fuel consumption structure
  - 25%
- Security of Supply (SoS) (part allocated to NSC)
  - 25%
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

<table>
<thead>
<tr>
<th>Guideline in the methodology</th>
<th>Greenhouse gases (GHG)</th>
<th>Air Pollution (AP)</th>
<th>Substitution cost (SC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data availability (reference sources)</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

General conclusion:
- Well established calculation methodology
- Vital for natural gas projects (in the Polish context)
- Well established calculation methodology
- Some limitations to data sources
- Some limitations to data sources
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)

Guidelines in the methodology

Data availability (reference sources)

Other specific indicators

- 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.