Cost-Benefit Analysis methodology

Test Case on the interim Economic Analysis

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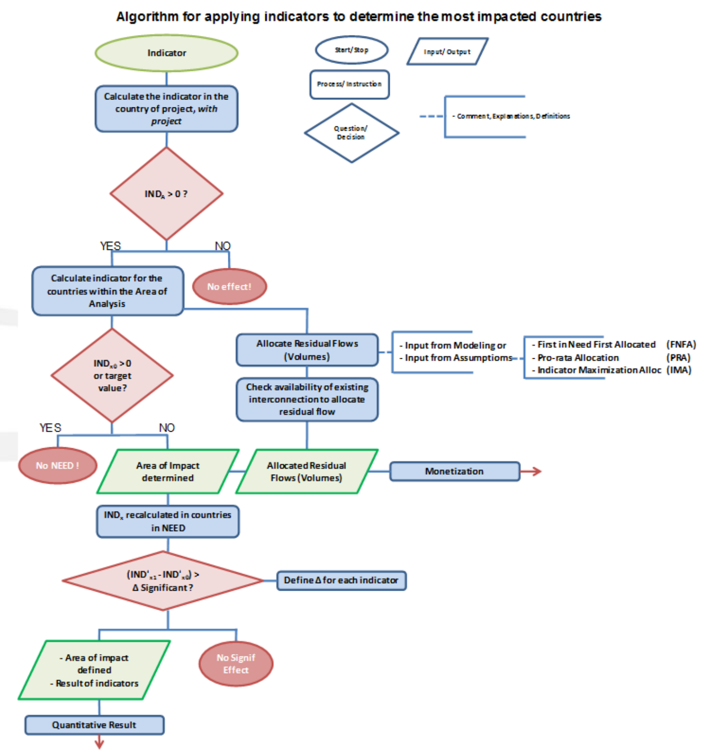
Role of indicators in the CBA methodology

The algorithm for the identification of the available volumes to be distributed, as an alternative solution

> Until the applicability of the targeted approach is fully ensured, the interim Economic Analysis to be used, is based on an Algorithm.

> The Algorithm is built on the following principles:

- Application of the indicators in the country where investment is built
- Application of the indicators in the countries within the area of analysis
- Identification of the most impacted countries considering the availability/need for the incremental volumes of gas released by a new infrastructure
- Distribution of volumes between the most impacted countries based on the results of the indicators (as further input for monetization)



UGS/Pipeline –Case study in steps

I. Assumptions and Identification of the Projects – Identification of the infrastructure scenario

II. Identification of the Area of Analysis

III. Input data for the Quantitative Analysis

IV. The Quantitative Analysis

Step 1. Indicators in country A

Step 2. Identification of the surplus volumes to be distributed from country A to impacted countries

Step 4.Identification of countries “in need “ for additional volumes of gas

Step 5. Distribution of the daily surplus based on Pro-Rata Allocation

Step 6. Calculation of the annual distributed surplus volumes

Step 7. Recalculation of the indicators after distribution of volumes

V. Economic analysis

Calculation of saved costs in impacted countries

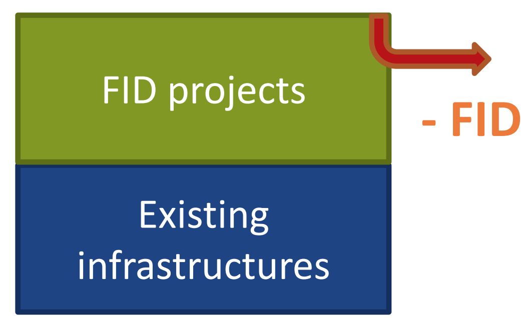
Economic cash flow and economic performance indicators

VI. Qualitative analysis

I. Assumptions and Identification of the Projects – Identification of the infrastructure scenario

Existing infrastructure capacity	UGS	Pipeline
Status	FID	FID
Construction Period	4 years	2 years
CAPEX	600 mEUR	80mEUR
OPEX	3 % of CAPEX	
Commissioning Year (first full year of operation)	2017	2015
Depreciation period	40 years - linear	
Pipeline Project		x
Entry capacity to Country A		100 GWh/day
Exit capacity		N/A
UGS	x	
UGS injection capacity	110 GWh/day	
UGS withdraw capacity	110 GWh/day	

The scenario *"without the project"* is considered by subtracting the project data from the cluster *"Low infrastructure"* which in this case is considered as scenario *"with the project"*



Low Infrastructure

II. Identification of the Area of Analysis

Based on the definition of the Area of Analysis in the Regulation

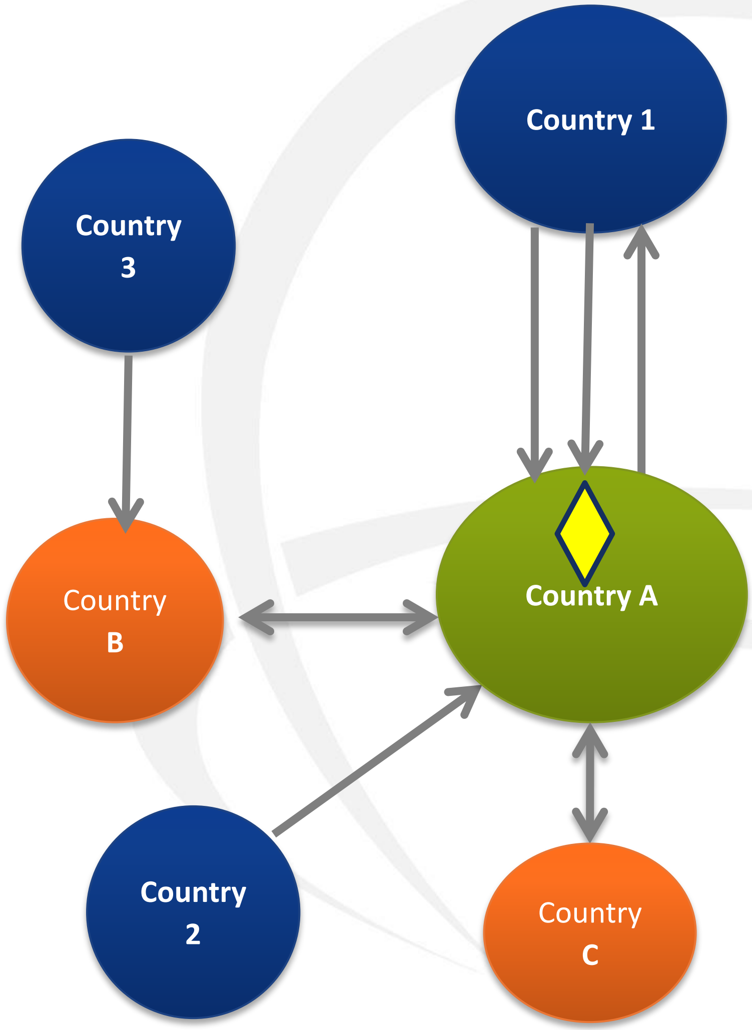
> The country where the project is built

> The neighbouring (directly connected) countries

> ***All others Member States significantly impacted by the project*** *– can only be defined based on the results the Quantitative Analysis*

UGS Example

Area of analysis



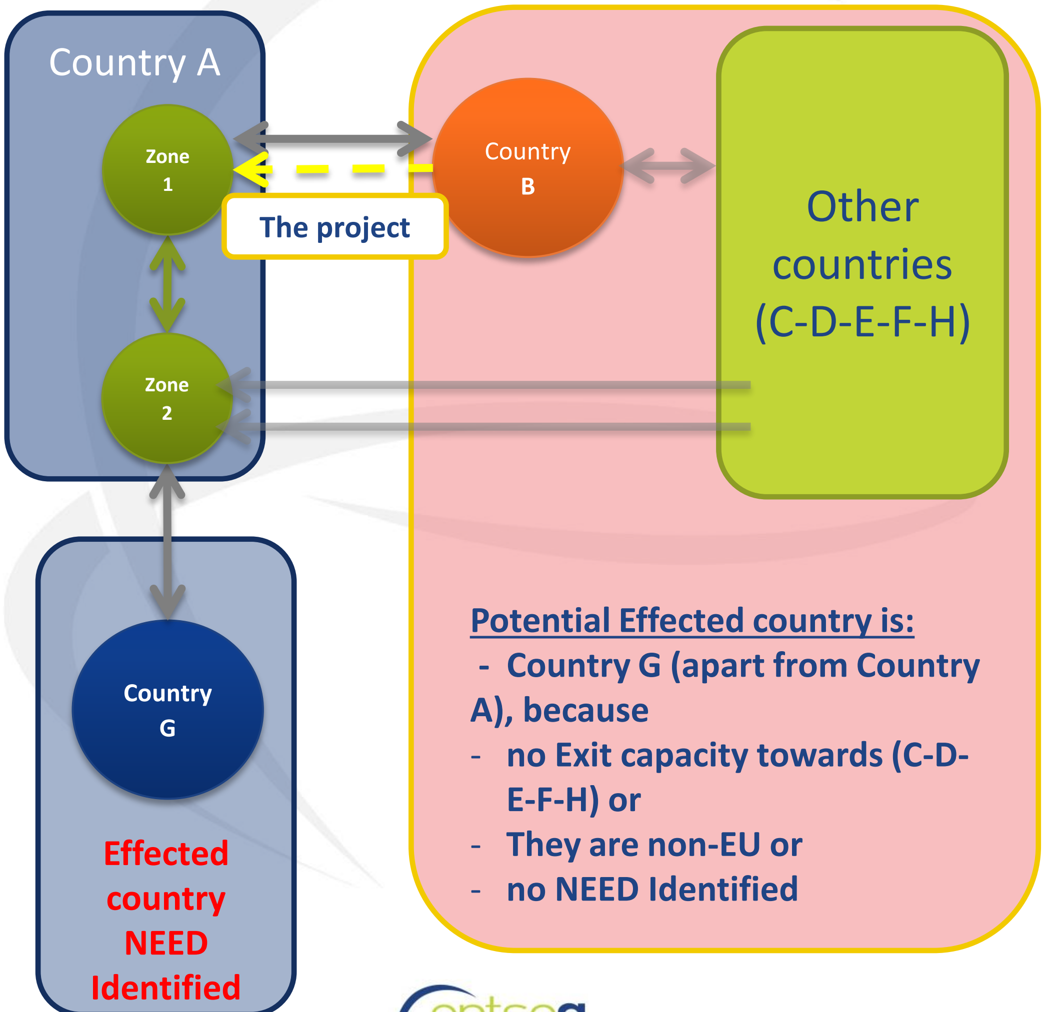
<u>Potential Impacted countries are:</u>

- **Country C and Country B**

- **<u>The other countries not impacted</u>**
- **No « NEED » Identified for Country 1**
- **No Exit points for Country 2**
- **No Exit points from Country B to Country 3**

Pipeline Example

Area of analysis



III. Input data for the Quantitative Analysis

The input data as a key to a PS-CBA...

> Building the input data for the examined zones (countries) as provided in PS-CBA
> The correct identification of the input data is of crucial importance for the PS-CBA

> All the input data shall be considered from the ESW-CBA

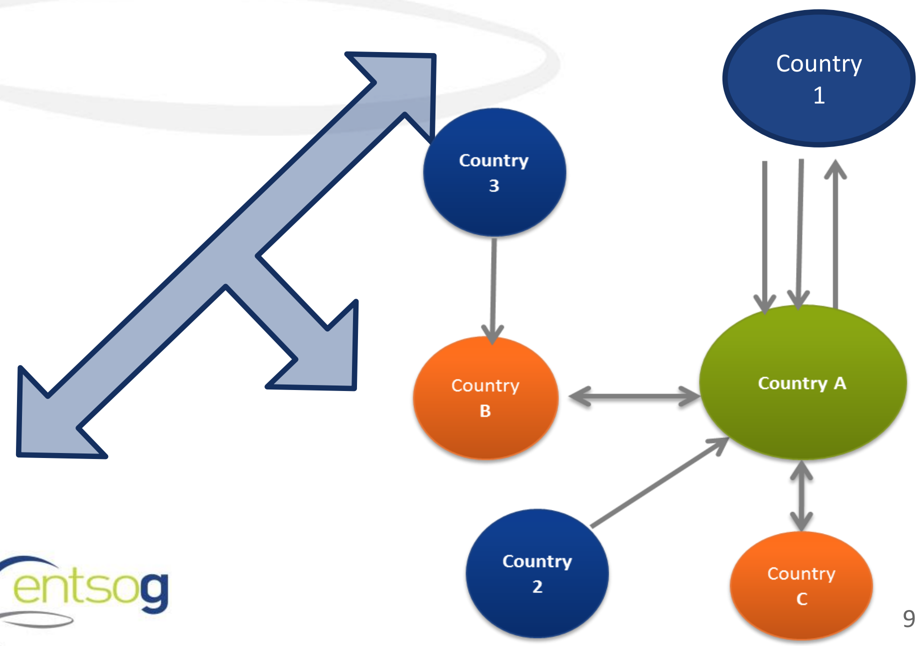
> Data tables are created based on the above presented analyzed countries – examples follow

UGS Example

The input data for the analysis based on the identified area...

GWh/d			Year	
Country	**Input data**	**No**	**2013**	**2017**
A	National Production		8	40
	LNG		0	0
	INJ (w/o)		40	40
	WITH (w/o)		40	40
	WITH max (w/o)		40	40
	INJ (w)		40	150
	WITH (w)		40	150
	WITH max (w)		40	150
	Dsa		50	75
	Dwa		93	147
	Dh		178	224
	IP	**5**	920	920
	EX		680	680
B	National Production		0	0
	LNG		0	0
	INJ		24	24
	WITH		24	24
	WITH max (w)		24	24
	Dsa		57	77
	Dwa		106	140
	Dh		140	140
	IP	**2**	190	190
	EX		70	70

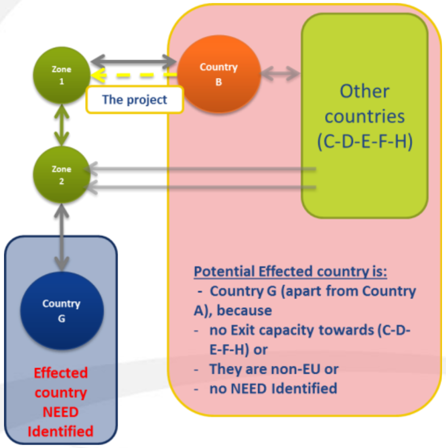
C	National Production		0	0
	LNG		110	110
	INJ		0	0
	WITH		0	0
	WITH max		0	0
	Dsa		120	150
	Dwa		160	210
	Dh		240	310
	IP	2	190	190
	EX		100	100

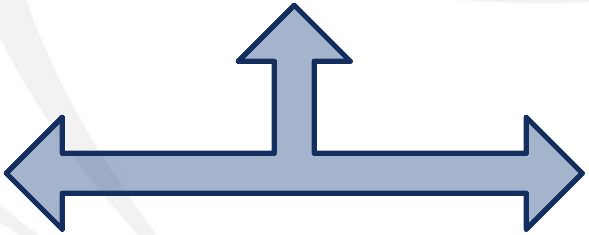


Pipeline Example

The input data for the analysis based on the identified area…

		2013	2015
Country A Zone 1			
	NP - Annua	550,0	500,0
	NP - Daily	1,5	1,4
	Dh - Design	2800,0	2850,0
	Dwa	1350,0	1350,0
	Dsa	500,0	500,0
	UGS	48500,0	48500,0
	UGS/day	132,9	132,9
	Injection	600,0	600,0
	Withdrawa	900,0	900,0
	LNG	400,0	400,0
	# of Ips w/o	4,0	4,0
	# of Ips w	4,0	5,0
	Border B		
EN	**IP1**	600,0	600,0
EN	**IP2**	250,0	250,0
EN	**IP3**	0,0	100,0
EX	**IP4**	0,0	0,0
	Border C		
		N/A	N/A
	Border D		
EN	**IP5**	800,0	800,0
	Border E		
EX	**IP6**	700,0	700,0
	Border F		
		N/A	N/A
	Border Zone 1-2		
EN	**IP7**	250,0	250,0
EX	**IP8**	1000,0	1000,0
	Border Zone 2-G		
EN	**IP8**	200,0	200,0
EX	**IP9**	800,0	800,0
	Direct Supply 1		
EN	**IP10**	600,0	600,0
	Direct Supply LNG		
LNG	**LNG1**	400,0	400,0
LNG	**LNG2**	0,0	0,0
SEM EN w/o		2700,0	2700,0
SUM EN w		2700,0	2800,0
SUM EX		1700,0	1700,0
SUM LNG		400,0	400,0





Country G			
	NP - Annua	0	0
	NP- Daily	-	-
	Dh - Design	2050	2150
	Dwa	1450	1550
	Dsa	950	1050
	UGS	43600	43600
	UGS/day	119,5	119,5
	Injection	250	250
	Withdrawa	300	300
	LNG	1425	1425
	# of IPs	3	3
	Border A Zone2		
EN	**IP9**	200	200
EX	**IP8**	400	400
	Border Other		
EN	**IP41**	80	80
EX	**IP42**	350	350
	Direct Supply 3		
EN	**IP43**	600	600
	Direct Supply LNG		
EN	**LNG1**	500	500
EN	**LNG2**	300	300
EN	**LNG3**	400	400
EN	**LNG4**	400	400
EN	**LNG5**	100	100
EN	**LNG6**	200	200
SUM EN		880	880
SUM EX		750	750
SUM LNG		1425	1425

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IV. Quantitative Analysis – The algorithm

1) Indicators in Country A – with and without the project

$$SACB = \frac{Min(EX \; ; NP + \frac{N-1}{N} * IMP + LNG - INJ - Dsa)}{\mathbf{Dsa}}$$

$$WACB = \frac{Min(EX \; ; NP + \frac{N-1}{N} * IMP + LNG + \mathbf{WITH} - \mathbf{Dwa})}{\mathbf{Dwa}}$$

$$DCB = \frac{Min(EX \; ; NP + \frac{N-1}{N} * IMP + LNG + WITH_{max} - Dh)}{Dh}$$

Where:

EX: Exit capacity after application of the lesser rule (to other EU and third countries) (GWh/day)

NP : Daily national production deliverability (GWh/day)

N: Number of entry IPs

IMP : Daily capacity of entry IP (from other EU and third countries) (GWh/day)

LNG : Daily send-out of LNG Terminal (GWh/day)

On the two sides of the border concerned

INJ: min(Injection capacity ;Working Gas Volume /183) (GWh/day)

WITH: The minimum between the daily Withdrawal capacity and daily average Working Gas Volume (GWh/day)

$WITH_{max}$: Withdrawal capacity (GWh/day)

Dh: High daily demand under Design Case (GWh/day)

Dsa: average summer demand (GWh/day)

Dwa: average winter demand (GWh/day)

As the steps for calculating the indicators (N-1; bi-directionality...) are the same, only the above three indicators which can be applied for the algorithm have been considered as example

UGS Example

The result of indicators in the first full year of operation <u>with</u> ana <u>w/o</u> <u>the project in Country A</u>

GWh/d			Year	
Country	Input data	No	2013	2017
A	National Production		8	40
	LNG		0	0
	INJ (w/o)		40	40
	WITH (w/o)		40	40
	WITH max (w/o)		40	40
	INJ (w)		40	150
	WITH (w)		40	150
	WITH max (w)		40	150
	Dsa		50	75
	Dwa		93	147
	Dh		178	224
	IP	5	920	920
	EX		680	680

$$SACB = \frac{Min(EX \;;\; NP + \frac{N-1}{N} * IMP + LNG - INJ - Dsa)}{Dsa}$$

$$WACB = \frac{Min(EX \;;\; NP + \frac{N-1}{N} * IMP + LNG + WITH - Dwa)}{Dwa}$$

$$DCB = \frac{Min(EX \;;\; NP + \frac{N-1}{N} * IMP + LNG + WITH_{max} - Dh)}{Dh}$$

Input data	2017
Indicators (w/o)	
SACB	8,81
WACB	4,55
DCB	2,64
Indicators (w1)	
SACB	7,35
WACP	4,63
DCB	3,04
SACB Δ= (w-w/o)	-1,47
WACPΔ = (w-w/o)	0,07
DCB Δ= (w-w/o)	0,39

As reflected within the example, only the SACB does not bring improvement for the indicator, therefore cannot be considered for defining the volumes to be distributed

Pipeline Example

The result of indicators in the first full year of operation <u>with</u> and <u>w/o</u> <u>the project in Country A</u>

$$SACB = \frac{Min(EX \;\; ; NP \;\; + \frac{N-1}{N} * IMP \;\; + LNG \;\; - INJ - Dsa\,)}{\mathrm{Dsa}}$$

$$WACB = \frac{Min(EX \;\; ; NP \;\; + \frac{N-1}{N} * IMP \;\; + LNG \;\; + \mathrm{WITH} - \mathrm{Dwa})}{\mathrm{Dwa}}$$

$$DCB = \frac{Min(EX \;\; ; NP \;\; + \frac{N-1}{N} * IMP \;\; + LNG \;\; + WITH_{max} - Dh)}{Dh}$$

		2013	2014	2015	2016	2017	2018
Country A Zone 1							
	NP - Annua	550,0	0,0	500,0	8000,0	16000,0	23000,0
	NP - Daily	1,5	0,0	1,4	21,9	43,8	63,0
	Dh - Design	2800,0	2850,0	2850,0	2900,0	2900,0	2950,0
	Dwa	1350,0	1350,0	1350,0	1400,0	1400,0	1400,0
	Dsa	500,0	500,0	500,0	500,0	500,0	500,0
	UGS	48500,0	48500,0	48500,0	48500,0	48500,0	48500,0
	UGS/day	132,9	132,9	132,9	132,9	132,9	132,9
	Injection	600,0	600,0	600,0	600,0	600,0	600,0
	Withdrawa	900,0	900,0	900,0	900,0	900,0	900,0
	LNG	400,0	400,0	400,0	900,0	900,0	900,0
	# of Ips w/o	4,0	4,0	4,0	4,0	4,0	4,0
	# of Ips w	4,0	4,0	5,0	5,0	5,0	5,0
	Border B						
EN	**IP1**	600,0	600,0	600,0	600,0	600,0	600,0
EN	**IP2**	250,0	250,0	250,0	250,0	250,0	250,0
EN	**IP3**	0,0	0,0	100,0	100,0	100,0	100,0
EX	**IP4**	0,0	0,0	0,0	0,0	200,0	200,0
	Border C						
		N/A	N/A	N/A	N/A	N/A	N/A
	Border D						
EN	**IP5**	800,0	800,0	800,0	800,0	800,0	800,0
	Border E						
EX	**IP6**	700,0	700,0	700,0	700,0	700,0	700,0
	Border F						
		N/A	N/A	N/A	N/A	N/A	N/A
	Border Zone 1-2						
EN	**IP7**	250,0	250,0	250,0	250,0	250,0	250,0
EX	**IP8**	1000,0	1000,0	1000,0	1000,0	1000,0	1000,0
	Border Zone 2-G						
EN	**IP8**	200,0	200,0	200,0	200,0	200,0	200,0
EX	**IP9**	800,0	800,0	800,0	800,0	800,0	800,0
	Direct Supply 1						
EN	**IP10**	600,0	600,0	600,0	600,0	600,0	600,0
	Direct Supply LNG						
LNG	**LNG1**	400,0	400,0	400,0	400,0	400,0	400,0
LNG	**LNG2**	0,0	0,0	0,0	500,0	500,0	500,0
SEM EN w/o		2700,0	2700,0	2700,0	2700,0	2700,0	2700,0
SUM EN w		2700,0	2700,0	2800,0	2800,0	2800,0	2800,0
SUM EX		1700,0	1700,0	1700,0	1700,0	1900,0	1900,0
SUM LNG		400,0	400,0	400,0	900,0	900,0	900,0

Indic.	Yr.	Value		
		w/o	*w*	*Δ*
SACB	3.	3,3198	3,4000	**0,0802**
WACB	3.	0,9936	1,1529	**0,1593**
DCB	3.	0,1671	0,2426	**0,0754**

In the third year (2015), the project is improving the result of the indicator in Country A in each season, therefore it can be considered for defining the volumes to be distributed

IV Quantitative Analysis – The algorithm

2) Indicators within the Area of Analysis – without the project – identifying potential NEED for additional volumes of gas

> The indicators have to be calculated for all potentially impacted countries within the Area of Analysis. (scenario *without the project*)

> The identification of the countries in NEED is based on the value of these indicators.

> In case the value of the indicator in these countries is lower than the value of the indicator in Country A, a NEED is identified.

> The countries in NEED are considered as the **Significantly Impacted Countries** by the project.

UGS Example

The result of indicators in the countries within the Area of Analysis

SURPLUS

A higher value in Country A, than w/o the project

NEED

A lower value in Country B and Country C, than in Country A, where the project is built

Input data	2017
Indicators (w/o)	
SACB	8,81
WACB	**4,55**
DCB	**2,64**
Indicators (w1)	
SACB	7,35
WACP	**4,63**
DCB	**3,04**
SACB Δ= (w-w/o)	-1,47
WACPΔ = (w-w/o)	0,07
DCB Δ= (w-w/o)	0,39

&

Indicators (w/o) B	
SACB	-0,08
WACB	-0,58
DCB	-0,15

e.g.:
4,63 > -0,02

Indicators (w/o) C	
SACB	0,37
WACB	-0,02
DCB	-0,34

The values of the SURPLUS and the NEED vary from one year to another one.

Each indicator for each season (summer, winter, design case) can reflect different situations

Pipeline Example

The result of indicators in the countries within the Area of Analysis

SURPLUS

A higher value in Country A, than w/o the project

Indic.	Yr.	Value			Alloc. Test
		w/o	w	Δ	
SACB	3.	3,3198	3,4000	**0,0802**	**Alloc Possible**
WACB	3.	0,9936	1,1529	**0,1593**	**Alloc Possible**
DCB	3.	0,1671	0,2426	**0,0754**	**Alloc Possible**

&

e.g.:
3,4 > 0,6877

NEED

A lower value in Country G, than in Country A, where the project is built

Value			Need
w/o	w	Δ	
0,7895		2,5306	**NEED**
0,7500		2,5670	**NEED**
0,6877		2,7123	**NEED**
0,6110		2,7890	**NEED**
0,6110		3,1890	**NEED**
0,5410		3,2590	**NEED**
0,5172		0,4765	**NEED**
0,4999		0,4927	**NEED**
0,4516		0,7013	**NEED**
0,4516		0,7627	**NEED**
0,4062		0,9509	**NEED**
0,3636		0,9936	**NEED**
0,1276		0,0604	**NEED**
0,1008		0,0659	**NEED**
0,0752		0,1674	**NEED**
0,0508		0,3499	**NEED**
0,0274		0,3808	**NEED**
0,0051		0,3858	**NEED**

The values of the SURPLUS and the NEED vary from one year to another one.

Each indicator for each season (summer, winter, design case) can reflect different situations

IV. Quantitative Analysis – The algorithm

*3) Identifying the daily/annual surplus volumes to be allocated**

> Based on the improvement of the indicators in Country A, volumes can be calculated, and surplus volumes can be distributed to countries in NEED.

> The increase of the value of each indicator in Country A, reflects potential surplus volumes, which can be allocated to countries in NEED.

> When calculating the surplus volumes, the value of the indicator in Country A *with the project* should not become lower than the value of the same indicator *w/o the project*. The difference between the two indicator results (*with and w/o the project*), defines the surplus volume, as shown in the examples on the following slides.

> Annual allocated volumes are to be generated based on the following formula, deriving from the daily volumes:

$$\boldsymbol{V_y = (CB_s * 183) + CB_w * (182 - 14) + (CB_h * 14)}$$

Where:

CB_s is the allocated surplus under the Average Summer day

CB_W is the allocated surplus under the Average Winter day

CB_h is the allocated surplus under the High Daily Demand day

Daily capacity, assuming 100% Load Factor (potential benefit) resultsing in daily volume

UGS Example

Identifying the surplus volumes to be allocated

No distribution for summer, as UGS decreses the result of the SACB indicator

		2017
Country A	Volume distribution DCB per day (GWh/d)	109,8
	Volume distribution WACB per day (GWh/d)	110,0

$$(CB_h * 14)$$

$$CB_w * (182 - 14)$$

	2017
Volume distribution DCB per year (GWh/d)	1.537,8
Volume distribution WACB per year (GWh/d)	18.598,1

Technically done, with an Excel function (Goal Seek).

Generate a value for the daily volume, that brings the value of the indicator (*with the project*) to the initial value (*w/o the project*)

20.135,9 GWh distributed volumes for 2017

Pro Rate Allocation utilized, which is defined by the ratio between the NEEDs in the effected countries.

	2017
Total volumes distributed to country B per year (GWh/year)	10.574,44
Total volumes distributed to country C per year (GWh/y)	9.561,45

Pipeline Example

Identifying the surplus volumes to be allocated

Indic.	Yr.	Value			Alloc. Test	Avail. Volume/day (GWh)	
		w/o	*w*	*Δ*			
SACB	3.	3,3198	3,4000	**0,0802**	**Alloc Possible**	100,0000	3,3198
WACB	3.	0,9936	1,1529	**0,1593**	**Alloc Possible**	100,0000	0,9936
DCB	3.	0,1671	0,2426	**0,0754**	**Alloc Possible**	100,0000	0,167149

Technically done, with an Excel function (Goal Seek).

Generate a value for the daily volume, that brings the value of the indicator (*with the project*) to the initial value (*w/o the project*)

$$V_y = (CB_s * 183) + CB_w * (182 - 14) + (CB_h * 14)$$

$$36.500_{year\ 3} = (100_{CBs} * 182) + [100_{CBw} * (183 - 14)] + (100_{CBh} * 14)$$

36.500 GWh distributed volumes for the third year

As only one country is impacted, all the volumes go to country G, thus no distribution pattern had to be considered (no difference)

UGS Example

Output of the quantitative analysis

4) ***Recalculation of indicators after distribution***

Country	Input data	2017
A	Indicators after distribution	
	SACB	7,35
	WACP	4,55
	DCB	2,64
B	**Indicators after distribution**	
	SACB	n.a
	WACB	-0,16
	DCB	0,23
C	**Indicators (w after distribution)**	
	SACB	n.a
	WACB	0,22
	DCB	-0,16

Indicators	Value of Indicator			Available volumes/day	Distribution of volumes/year	Value of the indicator after distribution
	Values for 2017					
	w/o	w	↗	GWh/d	GWh/y	
Country A						
SACB	8,81	7,35	-1,46	na	na	n.a
WACB	4,55	4,63	0,08	110,05	18589,13	4,55
DCB	2,64	3,04	0,40	109,84	1537,76	2,64
Country B						
SACB	-0,08		na	n.a	n.a	n.a
WACB	-0,58		0,42	58,17	9830,69	-0,16
DCB	-0,15		0,38	53,13	743,75	0,23
Country C			0,00			
SACB	0,37		n.a	n.a	n.a	n.a
WACB	-0,02		0,25	51,88	8767,44	0,22
DCB	-0,34		0,18	56,71	794,01	-0,16

The value of indicators after distribution, in country A remains as initially (w/o); for country B and C the value of indicators after distribution has been improved

V. Economic Analysis

1) Input data for the Economic Analysis

- The purpose of the Economic Analysis is to calculate economic performance indicators to reflect the societal value of a project in monetary terms.
- This reflection is done by calculating different ”layers” of saved costs for each impacted country, as described in the PS-CBA document.
- The calculated potential saved costs:
  - from CO2 emissions
  - of fuel after switching to gas within the electricity mix
  - swing value as difference of gas price between two periods: injection and withdrawal – UGS specific
  - from avoiding disruption – no cost of disruption/unit of energy available

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V. Economic Analysis

1) Input data for the Economic Analysis – saved cost approach

	Year											
Price	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**…**	**2035**	**2036**
CO2 price/tone - EUR	3,7	6,3	9,0	11,6	14,3	16,9	19,6	22,2	23,0		33,3	33,3
Natural Gas - EUR/GWh	25.275,2	26.539,0	27.802,7	28.055,5	28.308,2	28.561,0	28.813,7	29.066,5	29.268,7		31.594,0	31.594,0
Oil - EUR/GWh	43.573,0	47.058,8	50.544,7	50.849,7	51.154,7	51.459,7	51.764,7	52.069,7	52.278,9		54.466,2	54.466,2
Steam Coal - EUR/Gwh	11.346,6	10.802,9	10.259,2	10.325,4	10.391,6	10.457,8	10.524,0	10.590,2	10.609,1		10.873,8	10.873,8
Swing value for the UGS (EU					1.520,0	1.520,0	1.520,0	1.520,0	1.520,0		1.520,0	1.520,0
Disruption cost (EUR/GWh)	500.000,0	500.000,0	500.000,0	500.000,0	500.000,0	500.000,0	500.000,0	500.000,0	500.000,0		500.000,0	500.000,0
Risk of Occurance	5%	5%	5%	5%	5%	5%						

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UGS Example

2) Substitution of Fuels and the Saved Cost "layers" for Country B

Input data	2017	
Allocated natural gas for the country per year (GWh)	10.574,44	
Possibly Substituted - 66,6% of the production		
Coal	5.333,3	
Oil	13.333,3	
Lignite	2.666,7	
To be substitued - in the order of pollution		
Coal	5.333,3	
Oil	5.241,1	
Lingnite		
New fuel mix, including gas for substitution (GWh) to generate given electricity amount		
Coal	3.809,5	
Oil	18.448,6	
Lignite	5.714,3	
Natural Gas	10.574,4	OK
Emission of the new fuel mix (t) after substitution		
Coal	100.105,90	
Oil	396.645,45	
Lignite	160.317,59	
Natural Gas	164.785,23	
Cummulated new emission	821.854,2	
Saved CO2 emission (t)	**176.281,6**	
Saved CO2 emission cost (mEUR/yr)	**2,5**	
Cost of fuels before substitution (mEUR)	1.457	
Cost of fuels after substitution (mEUR)	1.342	
Saved costs of fuels (mEUR)	115	
Saved costs of swing (mEUR)	**16**	
Total saved costs country C (mEUR)	**133,6**	

The total saved costs/year will be considered as input data for the economic cash flow

UGS Example

2) Substitution of Fuels and the Saved Cost "layers" for Country C

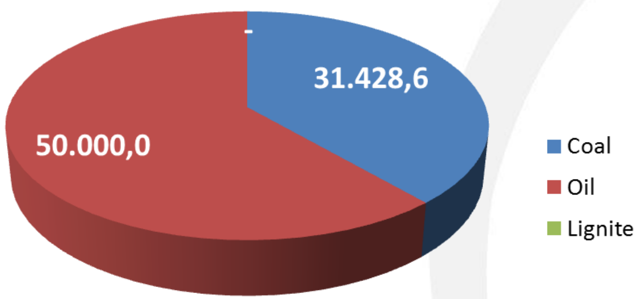
Input data/year	2017	
Allocated natural gas for the country per year (GWh)	9.561,45	
Possibly Substituted - 66,6% of the production		
Coal	6.666,7	
Oil	16.666,7	
Lignite	3.333,33	
To be substitued - in the order of pollution		
Coal	6.666,67	
Oil	2.894,8	
Lignite		
New fuel mix, including gas for substitution (GWh) to generate given electricity amount		
Coal	4.761,9	
Oil	27.631,5	
Lignite	7.142,9	
Natural Gas	9.561,45	**OK**
Emission of the new fuel mix (t) after substitution		
Coal	125.132,38	
Oil	594.078,21	
Lignite	200.396,99	
Natural Gas	148.999,36	
Cummulated new emission	**1.068.606,9**	
Saved CO2 emission (t)	179.062,7	
Saved CO2 emission cost (mEUR/yr)	**2,6**	
Cost of fuels before substitution mEUR	1.821	
Cost of fuels after substitutionEUR	1.808	
Saved costs of fuels (mEUR)	**13**	
Saved costs of swing	**14,53**	
Total saved costs country C (mEUR)	**30,49**	

The total saved costs/year will be considered as input data for the economic cash flow

Pipeline Example

2) Substitution of Fuels and the Saved Cost "layers" for Country G

Electricity generation mix of Country G - more polluting fuels (GWh/y)

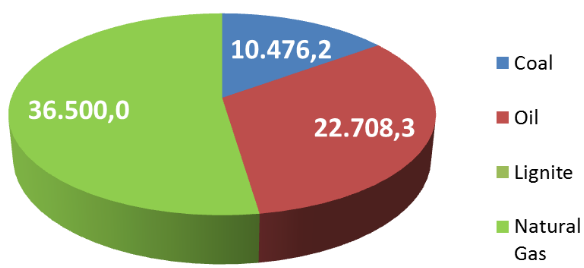


Cummulated emission (t CO2) – 1.900.875

Substitution with the allocated volumes of more polluting fuels is possible, in the order of their pollution/GWh. (36.500 GWh/2015)

Physical Constant	*kg/TJ*	*kg/GWh*
Gas	56.100,0	15.583
Coal	94.600,0	26.278
Oil	77.400,0	21.500
Lignite	101.000,0	28.056

Electricity generation mix of Country G - more polluting fuels (GWh/y)



Cummulated emission (t CO2) – 1.332.313

Saved CO2 cost:
5.114.046 EUR/2015
5.242.336 EUR/2017
Change in fuel costs:
579.603.396 EUR/2015*
-85.987.131 EUR/2017

** Results change each year, as previous steps change – The whole Time Horizon matters*

Pipeline Example Continued

2) Substitution of Fuels and the Saved Cost ”layers” for Country G

- It is of crucial importance to acquire the cost of disruption /unit of energy data
- For the sake of example (without refference to any source), 500.000 EUR/GWh has been considered.
- Cost of disruption /unit of energy and chance of occurance has not been set within the methodology – external data needed!

	2015
Disruption Scenario	14-days Full Supply 1 to A
Unsupplied Gas (GWh/ 14days full disrupt)	8.400,00
Substitutable from new infrastructure (during disruption)	14x100GWh/d=1.400 GWh
Avoided cost if occurs EUR	700.000.000,00
Chance of occurance	5%
Avoided cost EUR/ year	**35.000.000,00**

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UGS Example

3) The Economic Cash Flow and aggregating the results

Input data		2013	2014	2015	2016	2017	2018	2019	20......	2030	2031	2032	2033	2034	2035	2036
		0	1	2	3	4	5	6		17	18	19	20	21	22	23
Investment cost	mEUR	150	150	150	150											
O&M costs	mEUR					18	18	18		18	18	18	18	18	18	18
Replacement costs	mEUR															
Residual value	mEUR															-300
Total costs		**150**	**150**	**150**	**150**	**18**	**18**	**18**		**18**	**18**	**18**	**18**	**18**	**18**	**-282**
Saved costs country B						133,56	135,01	139,10		136,88	136,35	135,83	135,30	134,77	134,24	134,24
Saved costs country C						30,49	38,24	29,41		19,52	18,82	18,12	17,43	16,73	16,03	16,03
Total saved costs						**164,05**	**173,25**	**168,51**		**156,40**	**155,17**	**153,95**	**152,72**	**151,50**	**150,27**	**150,27**
Net benefits		**-150,00**	**-150,00**	**-150,00**	**-150,00**	**146,05**	**155,25**	**150,51**		**138,40**	**137,17**	**135,95**	**134,72**	**133,50**	**132,27**	**432,27**

SDR	**4,50%**
Output data	
ENPV (m EUR)	€ 1.120,72
ERR	18%
B/C ratio	3,31
NPV costs	€ 630,16
NPV benefits	€ 2.087,96

The project has a positive societal value : ENPV>0, ERR>SDR, B/C>1

Note: For simplicity, this table does not reflect the whole time horizon (for the applicability see also see Excel Case study)

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Pipeline Example

3) The Economic Cash Flow and aggregating the results

Results presented throughout the steps on the previous slides

Saved CO2 emission cost (EUR/yr)				5,114,046.43	357,807.46	5,242,336.02	6,532,139.26
Saved fuel cost (EUR/yr)				579,603,395.90	-18,626,854.69	-85,987,130.67	-175,192,240.04
Avoided cost EUR/ year				35,000,000.00	35,000,000.00	35,000,000.00	35,000,000.00
Monetary Analysis							
CAPEX (mEUR)		€ 40,000,000	€ 40,000,000				
OPEX (mEUR)				€ 2,400,000	€ 2,400,000	€ 2,400,000	€ 2,400,000
Residual Value (EUR)							€ -70,000,000
Total Costs (EUR/yr)	€ -	€ 40,000,000	€ 40,000,000	€ 2,400,000	€ 2,400,000	€ 2,400,000	€ -67,600,000
Saved Costs Country G				€ 619,717,442	€ 16,730,953	€ -45,744,795	€ -133,660,101
Saved Costs Country ... - *no other country in this example*							
Total Saved Costs (EUR/yr)	€ -	€ -	€ -	€ 619,717,442	€ 16,730,953	€ -45,744,795	€ -133,660,101
Net Benefits (EUR/yr)	€ -	€ -40,000,000	€ -40,000,000	€ 617,317,442	€ 14,330,953	€ -48,144,795	€ -66,060,101
SDR	4.500%	4.500%	4.500%	4.500%	4.500%	4.500%	4.500%
Discounted Net Benefits	€ -	€ -38,277,512	€ -36,629,198	€ 540,953,178	€ 12,017,383	€ -38,633,841	€ -50,727,270

ENPV	€ 388,702,741
ERR	231%
EB/C ratio	14.4
NPV costs	€ 29,038,500
NPV benefits	€ 417,741,240

Economic Performance Infdicator results not completely meaningful without reflecting the whole time horizon of 20 years of opretaion for the analysis

VI. Qualitative Analysis for UGS

Conclusions

> The UGS project built in country A has impacted countries B and C as follows:

- It has created a new source of supply for country B and enhanced security of supply, considering that country B has access to only two sources and it has not other local facilities as National production or LNG
- Due to the project built in country A, country C has access to a new source and the security of supply is increased due to the fact that this country has access to only one source.
- Both countries has increased the sustainability, considering the saved costs CO2 emissions
- The security of supply considering the cost perspective, is enhanced due to the swing value of the UGS
- By increasing SoS for both countries, the market integration of these countries is increased and also the competition, considering the new sources of supply and the available volumes to cover the winter and peak demand.

The quantitative and monetary analysis have proved the societal value of the project, all the general criteria have been proved and also the specific criteria (SoS, sustainability, market integration, competition)

Thank You for Your Attention

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