REALISEGRID – WP3 Final Workshop

Rome, 31 March 2011

Cost-benefit analysis and its application to the corridor EL2

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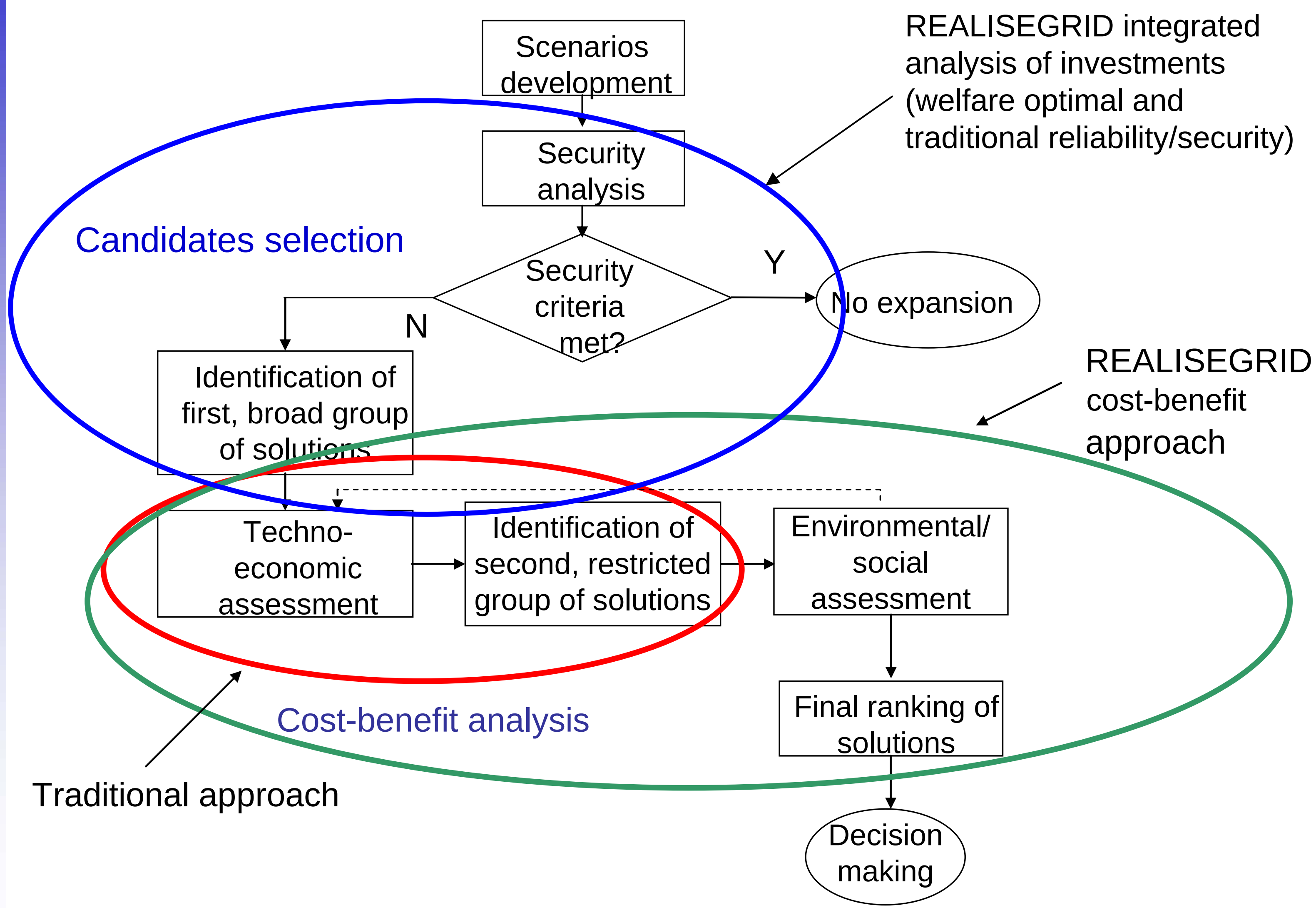
SEVENTH FRAMEWORK PROGRAMME

Presentation outline

- Cost-benefit analysis for prioritizing transmission investments:
  - methodology
  - testing bed results
  - tool

Transmission planning process



Overview of the methodology: what, why, how

WHAT

Cost-benefit assessment for new transmission infrastructure investments

WHY

- Methodology for prioritizing alternative investments both at national and trans-national level (see Infrastructure Package)
- Possible KPI for establishing a dynamic addendum to the ROI of the TSOs
- Information to the public on system advantages from new infrastructure as well as about inaction cost

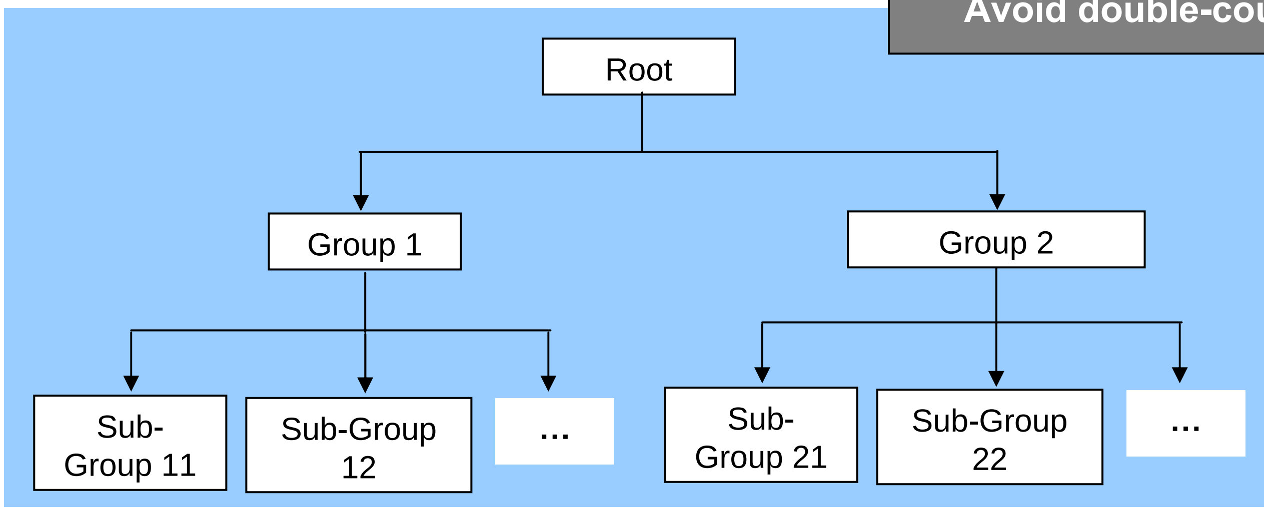
HOW

- OPF analysis with and without the new investment (or series of investments constituting a corridor)
- The tool has to be able to take into account the reliability of both network elements and generators as well as the variable behavior of wind generators
- New elements like PSTs and HVDC lines have to be correctly represented

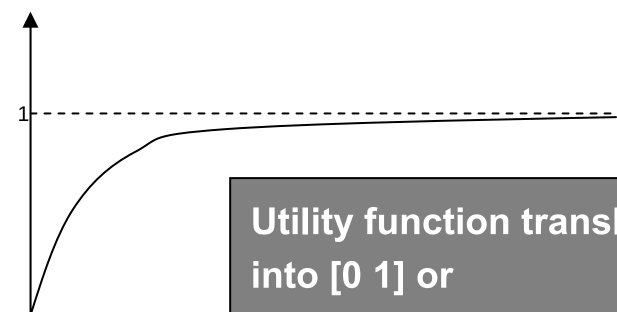
Multi-criteria analysis: general theory

- Top-down criteria tree, evaluation matrix, utility functions, weights

Avoid double-counting!

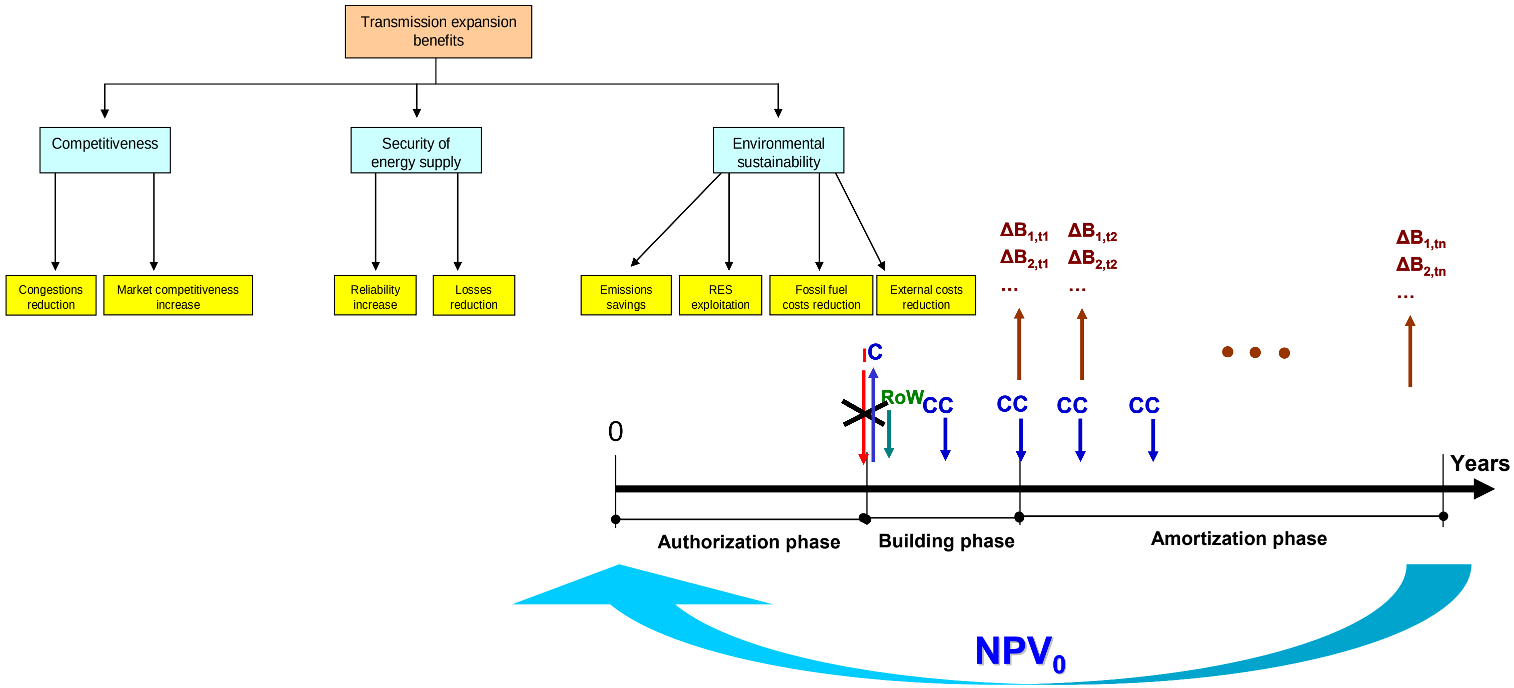


	Alternative 1	Alternative 2	…
Criterion 1			
Criterion 2			
…			



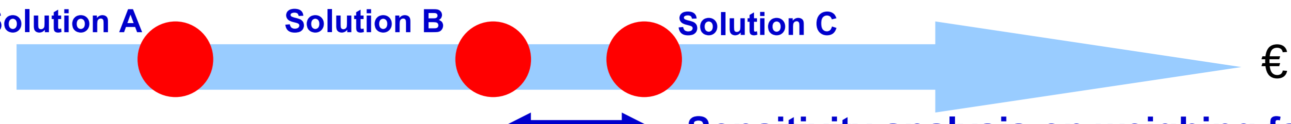
Utility function translates:
into [0 1] or
into monetary terms (better)

The adopted methodology



Utility function → translation into monetary terms

Weighted sum → translation a mono-dimensional ranking



Sensitivity analysis on weighing factors needed

The tool: REMARK

Main features:

- **Detailed** model of the **network**: nodes, lines, transformers, generators, loads
- **Three types of generation**: fixed, random variable (wind), dispatchable
- **Fixed hourly nodal load**
- **Non-sequential Montecarlo**-based combination of:

  unavailability of lines, transformers, generators [hours/year]

  maintenance schedules for generators [weeks/year]

  statistical profile of wind generation (cumulative prob. distribution curve)

  Each run corresponds to a random extraction of one hour
- **Geographic** system/market zones **subdivision**
- **OPF solution** of the mixed AC/DC grid is calculated through a **simplified DC method**

Optimisation objective:

  - **Maximisation of Social Welfare** (if bid-ups are available) or
  - **Minimisation of variable operating costs** (sum of production costs and load shedding costs)

Cost-benefit analysis: test bed

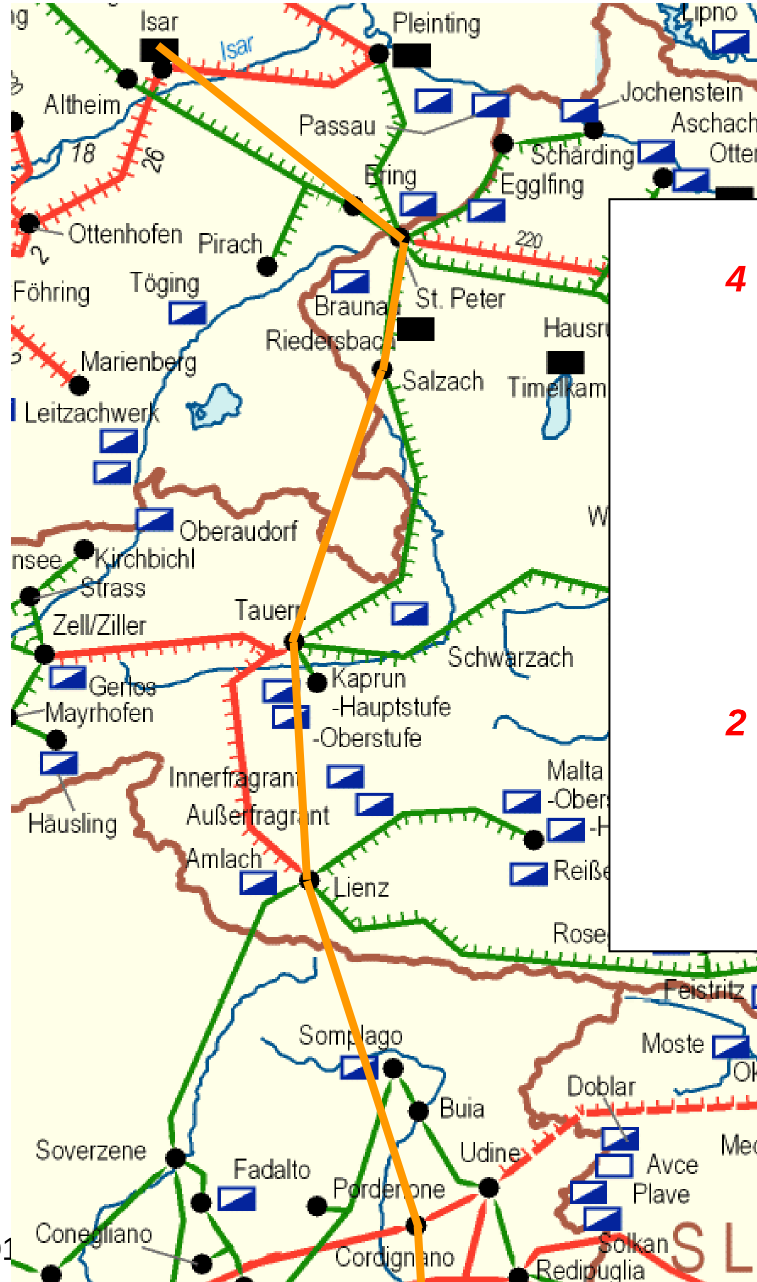
REALISEGRID is going to use the new methodology to carry out a <u>cost/benefits classification</u> of the most important projects belonging to Trans European Network priority axis "*EL.2. Borders of Italy with France, Austria, Slovenia and Switzerland: increasing electricity interconnection capacities*". This region is one of the most interesting ones to assess the impact and the benefits of future cross-border transmission projects.

- Lienz (AT) - Cordignano (IT)
- New interconnection between Italy and Slovenia
- Udine Ovest (IT) - Okroglo (SI)
- S. Fiorano (IT) - Nave (IT) - Gorlago (IT) [completed]
- S. Fiorano (IT) - Robbia (CH) [completed]
- Venezia Nord (IT) - Cordignano (IT)
- St. Peter (AT) - Tauern (AT)
- Südburgenland (AT) - Kainachtal (AT) [completed]
- Austria - Italy (Thaur-Brixen) interconnection through the Brenner rail tunnel.

Basic hypotheses of the testing bed

- Three “tab” years 2015, 2020 and 2030, for which relevant simulation scenarios, “with” and “without” the new infrastructure are created
- The EL2 reinforcements were grouped into three distinct non-interacting corridors. Internal reinforcements necessary in order to de-bottleneck and obtain a real increase of transit capability have been added to the corridors bundle too.
- Build-up time indications of the TYNDP 2010 are disregarded for the lines of the three corridors.
- Investments for the new infrastructures of the three corridors are supposed to be carried out in 2008. They become operative in 2015.
- A priority order is determined on the basis of a cost-benefit ranking. The benefits are actualized to the investment time (NPV). The amortization phase issupposed 20 years long with an actualization rate equal to 8%.

Corridor 1: Germany – Austria – Italy, Veneto



4 double circuit lines 380 kV

- *Isar – St. Peter*
  (already in "without" scenario from 2020)
- *Salzach – St. Peter*
  (already in "without" scenario)
- *Salzach - Tauern*
- *Tauern – Lienz*
  (already in "without" scenario)

2 single circuit lines 380 kV

- *Lienz-Cordignano*
- *Cordignano-Venezia Nord*
  (already in "without" scenario)

Corridor 2: Friuli - Slovenia

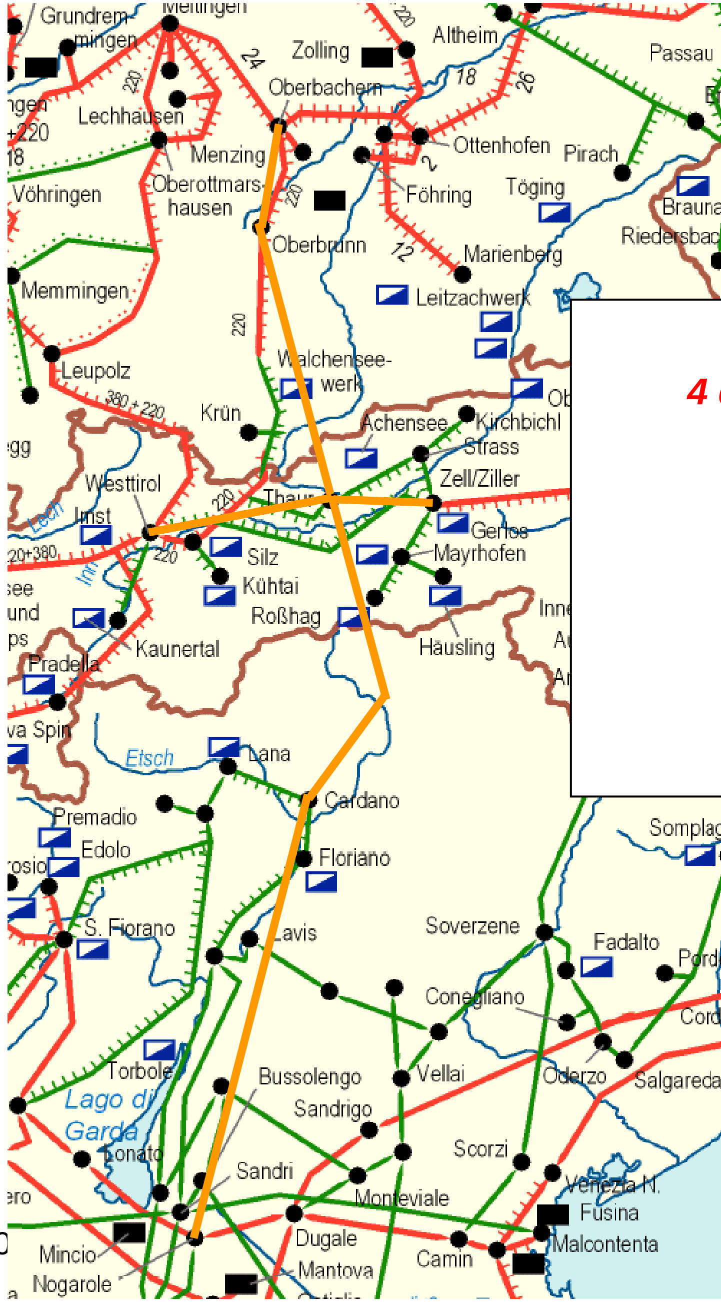
2 double circuit lines 380 kV

- *Bericevo – Okroglo*
  *(**already in "without" scenario**)*
- *Okroglo – Udine Ovest*

1 single circuit line 380 kV

- *Cordignano-Venezia Nord*

Corridor 3: Brenner; Germany – Austria – Italy



4 double circuit lines 380 kV

- *Oberbachern – Oberbrunn - Thaur*
- *Thaur – new 380 kV station in TAA (GIL)*
- *new 380 kV station in TAA – new 380 kV station in Lombardia*
- *West Tirol – Thaur – Zell Ziller*

*(**already in "without" scenario**)*

Infrastructure and additional costs

- **HVAC OHL, single circuit 400 kV: 600 k€/km**
- **HVAC OHL, double circuit 400 kV: 1000 k€/km**
- **HVAC OHL (220>400 kV) uprating: 500 k€/km**
- **HVDC underground cable pair 1000 MW: 1300 k€/km**
- **GIL 400 kV: 7000 k€/km**
- **VSC converter terminal (bipolar) 1000 MW: 100000 k€**
- **Local compensation : 15% of CAPEX**
- **Yearly O&M: 5% of CAPEX**

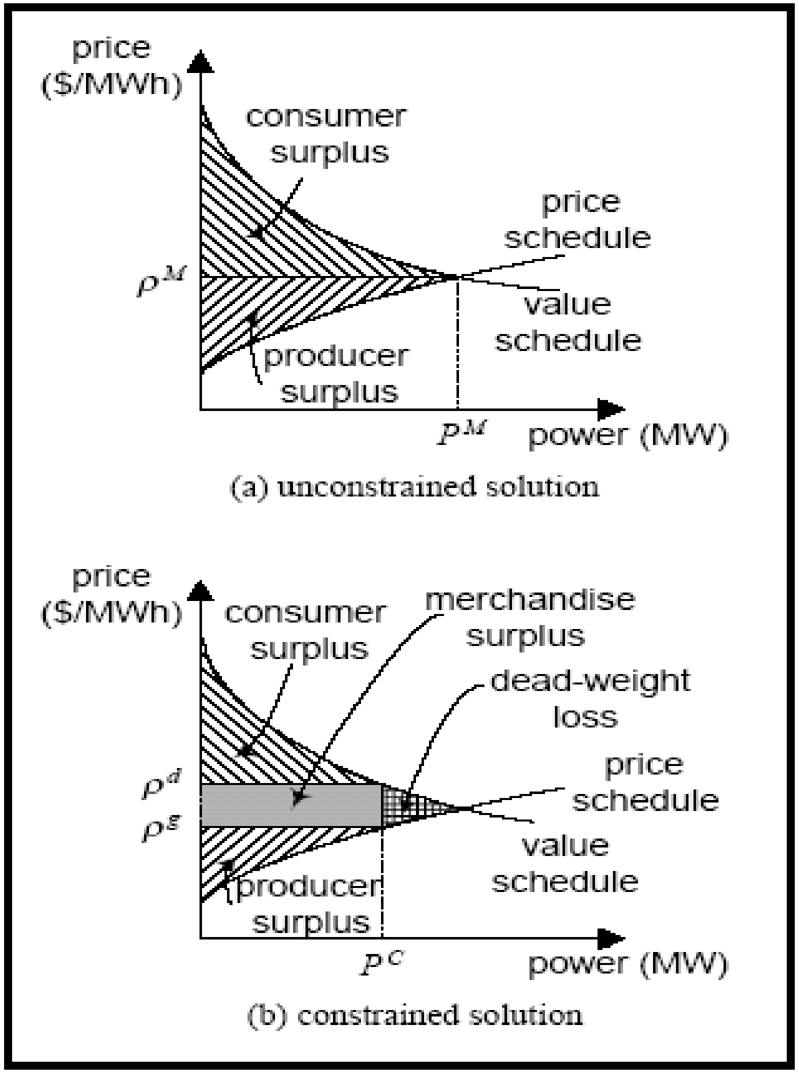
Benefits (1): social welfare [€]

$$SW = \sum_{i=1}^{NC} Q_{Ci} P_{offCi} - \sum_{j=1}^{NG} Q_{Gj} P_{offGj}$$

Load offer prices are indicative
of the value of the goods produced

Generators bid prices should be indicative
of the costs for producing energy

- **The merchandise surplus corresponds to the congestion rent.**
- **The dead-weight loss is an indicator of efficiency loss due to congestion.**
- **If demand is inelastic, a SW increase corresponds to a dispatching cost reduction**



Congestion means lower market efficiency:

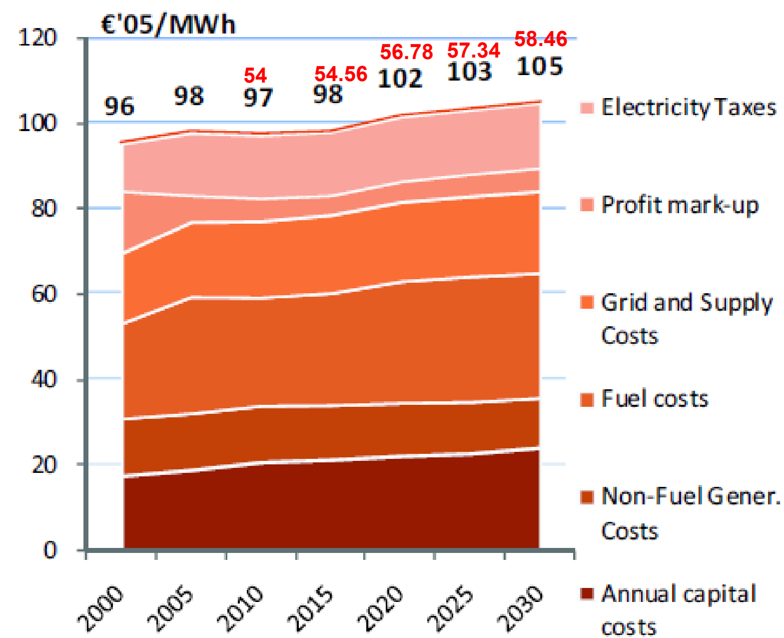
- **Substitution effect:** more efficient generators replace less efficient
- **Strategic effect:** more difficult to exercise market power

Benefits (2): reduction of losses [MWh]

- New corridors usually reduce losses if the transit doesn’t change. However, new corridors increase the overall transit and losses usually grow (negative benefit)
- Losses are translated into money by valorizing them at market price (opportunity cost)
- Market price in 2010 was assumed equal to 54€/MWh (average between annual average figures of IPEX and EEX in 2010), then, price trends were taken from the document “Trends to 2030-Update 2007” edited by EC DG-TREN .

	Quotazioni annuali (€/MWh)				
POWER price	Area	2010	Diff Y-1(%)	Ultima quot. future	Calendar 2011
IPEX	Italia	64,12	*+0,6%*	64,50	68,50
Powernext	Francia	47,50	*+10,4%*	47,85	53,65
EEX	Germania	44,49	*+14,5%*	44,55	51,15
EEX-CH	Svizzera	51,02	*+6,5%*	-	-
EXAA	Austria	44,81	*+15,1%*	-	-
Omel	Spagna	37,01	*+0,1%*	39,70	47,00
UK-APX	Regno Unito	44,72	*+17,3%*	-	-
NordPool	Scandinavia	53,06	*+51,5%*	39,85	58,60

Source: GME Newsletter January 2010



Source: EC DG-TREN

Benefits (3): reduction of wind overproduction [MWh]

- **New corridors can be useful to enlarge the area to which it is possible to export wind peak production. Enlarging the geographical area, reduces the impact on the system of local peaks.**

- **It was translated into money by multiplying by a reasonable remuneration factor to wind owners (typically: market price, the sameas for losses)**

Benefits (4): reduction of load shedding

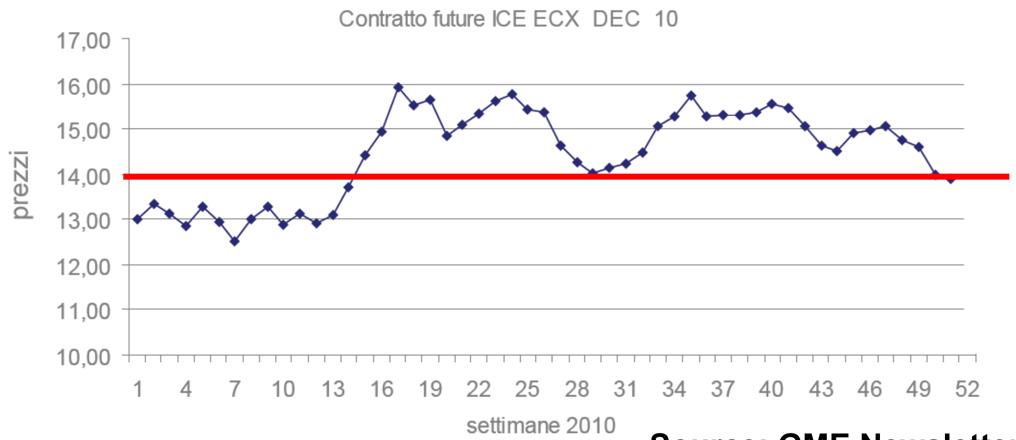
- Usually, the highly meshed European system has a very high security of supply and load shedding stays very low. This can however be more important for less meshed peripheric areas
- It was monetized by multiplying EENS by the VOLL. The latter is assumed equal to 15000 €/MWh, figure estimated for Italy by the report: Cost of Electricity Interruptions – Deliverable 5.6.3 produced by RSE for the project SECURE

Country	Sector	€/kWh not supplied	€/kW interrupted	NOTES
Great Britain	All sectors Transmission	4.18 52.9		Distribution Transmission
Italy	All sectors	15.0		Transmission
Sweden	Urban Suburban Rural	12.0 8.8 7.4	2.5 1.9 1.6	Distribution
Norway	Residential Commercial Industrial	0.96 11.8 7.9		Distribution
Ireland	All sectors	7.2		Distribution
Portugal	All sectors	1.5		Distribution

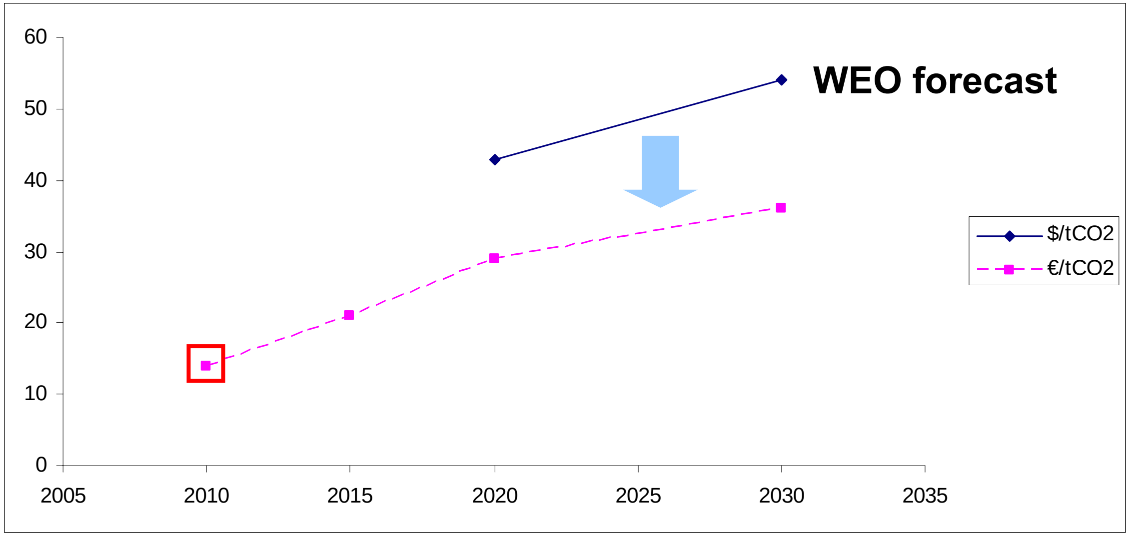
Source: SECURE Deliverable 5.6.3

Benefits (5): reduction of CO_2 emissions

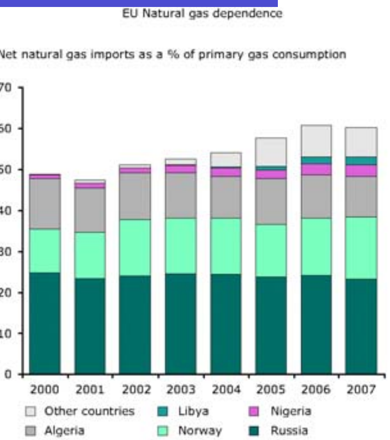
- **New corridors allow cheaper but not necessarily "greener" generation to be dispatched (e.g. German coal replaces Italian gas): the benefit may be negative**
- **It was translated into money assuming an average 2010 price on the European ET market: 14 €/tCO2 and taking the forecast values at 2015, 2020 and 2030 from the World Energy Outlook report 2009**

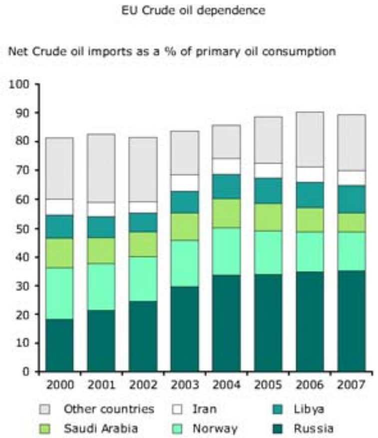


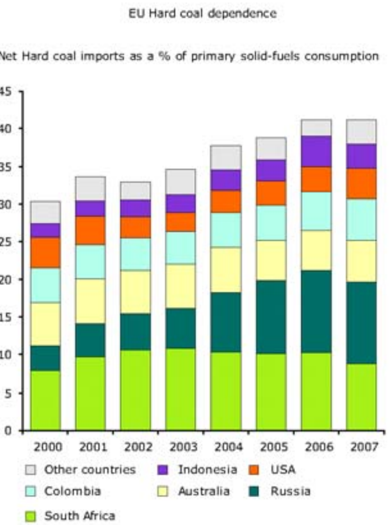
Source: GME Newsletter January 2010

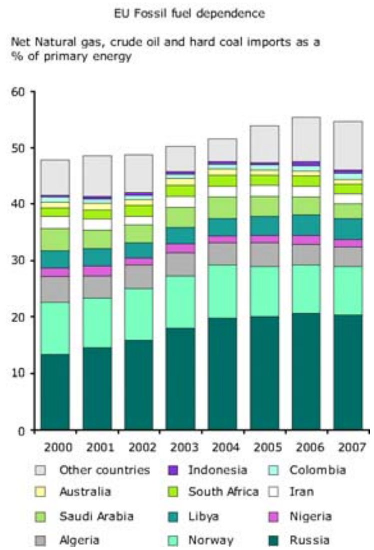


Benefits (6): reduction of cost for extra-EU fuel









- **Reducing the amount of money spent to import fuel from extra-EU countries means:**
  - **Increasing the reliability of supply**
  - **Having a positive effect on the European trading balance**
  - **Reduce the incumbence of fuel monopolists**
- **The benefit can be monetized as:**

$$B_6 = -\Delta GAS_{with-without} * \%GAS_{extra-EU} * P_{GAS} + \\ -\Delta COAL_{with-without} * \%COAL_{extra-EU} * P_{COAL} + \\ -\Delta OIL_{with-without} * \%OIL_{extra-EU} * P_{OIL}$$

Data source European Environment Agency
http://www.eea.europa.eu/data-and-maps/figures/eu27-net-imports-of-natural

Type	Actual	(EC) PRIMES 2008 Baseline	
	2007	2020	2030
Coal and lignite	41,2%	58,5%	62,5%
Oil	89,6%	101,0%	103,0%
Gas	60,3%	77,0%	84,0%

Scenario hypotheses (1/2)

- Three reference years: 2015, 2020, 2030
- Two only scenarios among the four of the WP2
  - Optimistic: emission target reached in 2020
  - Pessimistic: emission target reached in 2030

Drivers	Optimistic	Pessimistic
Population	HIGH	LOW
Welfare	HIGH	LOW
Climate Change Mitigation	STRONG	WEAK
Technological Improvement	HIGH	LOW
Oil and gas supply	HIGH	LOW
Electric interties	BOUNDED	BOUNDED

Source: REALISEGRID D2.2

- Fuel prices: from WEO 2009

"450" ($2008)	2008	2015	2020	2025	2030
IEA crude oil imports (€/kWh)	0.0371	0.0331	0.0343	0.0343	0.0343
Natural gas imports (€/kWh)	0.0313	0.0318	0.0335	0.0335	0.0335
OECD steam coal imports (€/kWh)	0.0132	0.0093	0.0087	0.0079	0.0071
LIGNITE (€/kWh)	0.0059	0.0042	0.0039	0.0036	0.0032
Nuclear (€/kWh)	0.0029	0.0029	0.0029	0.0029	0.0029

reference	2008	2015	2020	2025	2030
IEA crude oil imports (€/kWh)	0.0371	0.0331	0.0381	0.0410	0.0439
Natural gas imports (€/kWh)	0.0313	0.0318	0.0367	0.0397	0.0426
OECD steam coal imports (€/kWh)	0.0132	0.0099	0.0114	0.0117	0.0119
LIGNITE (€/kWh)	0.0059	0.0045	0.0051	0.0053	0.0054
Nuclear (€/kWh)	0.0029	0.0029	0.0029	0.0029	0.0029

Scenario hypotheses (2/2)

Assumptions on the network data:

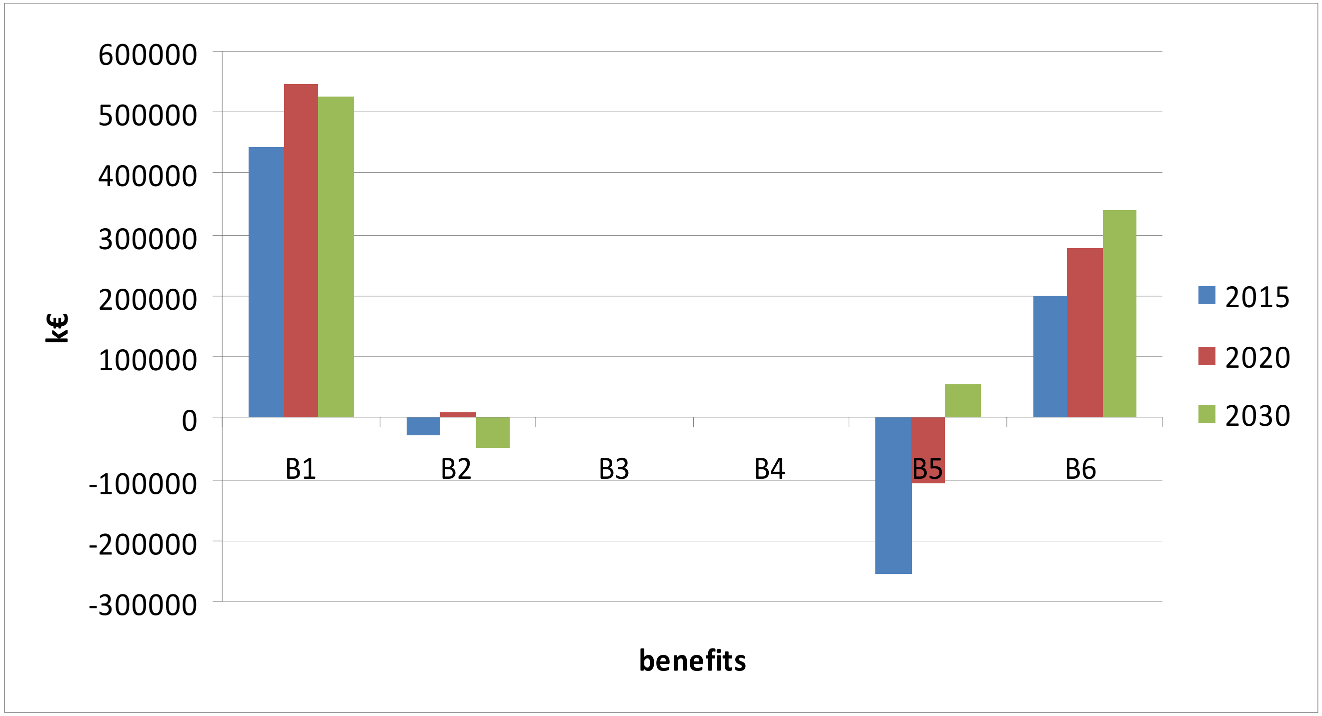
- The perimeter of the test-bed model includes: France, Germany, Switzerland, Austria, Italy, Slovenia and Croatia and western Balkans.
- Basic model: UCTE 2008 Winter Peak STUM (for grid, load and generation)
- 2015, 2020, 2030 grid updates: ENTSO-E TYNDP 2010 + info by Terna/APG

	2015	2020	2030
Optimistic	Load: trend SAF 2010-2025 optimistic Generation: trend SAF 2010-2025 optimistic	Load: trend SAF 2010-2025 optimistic Generation: SAF 2010-2025 optimistic	Load: trend WP2 optimistic Generation: trend WP2 optimistic
Pessimistic	Load: trend SAF 2010-2025 pessimistic Generation: trend SAF 2010-2025 pessimistic	Load: trend SAF 2010-2025 pessimistic Generation: trend SAF 2010-2025 pessimistic	Load: trend WP2 pessimistic Generation: trend WP2 pessimistic

SAF = ENTSO-E System Adequacy Forecast

Benefits figures in the three tab-years

Corridor 1 (optimistic scenario)



B1	Social welfare
B2	Losses
B3	Load curtailment
B4	Wind overproduction
B5	CO2 emissions
B6	extra-EU fuel import

Synchronic results for the three tab years

WIE IMMER OHNE GEWÄHR

With Benefit B6

2020 [M€]

	Total annuity cost	Benefits	Algebraic sum (unitary weights)
C1 (Veneto- Austria)	30	• Optimistic: 727 • Pessimistic: 857	• Optimistic: 697 • Pessimistic: 827
C2: (Friuli – Slovenia)	32	• Optimistic: 718 • Pessimistic: 774	• Optimistic: 686 • Pessimistic: 742
C3: (Brennerpaß)	129	• Optimistic: 1068 • Pessimistic: 1178	• Optimistic: 939 • Pessimistic: 1049

Without Benefit B6

2020 [M€]

	Total annuity cost	Benefits	Algebraic sum (unitary weights)
C1 (Veneto- Austria)	30	• Optimistic: 450 • Pessimistic: 563	• Optimistic: 420 • Pessimistic: 533
C2: (Friuli – Slovenia)	32	• Optimistic: 430 • Pessimistic: 469	• Optimistic: 398 • Pessimistic: 437
C3: (Brennerpaß)	129	• Optimistic: 681 • Pessimistic: 779	• Optimistic: 552 • Pessimistic: 650

Cost-benefit ranking of the three corridors (NPV)

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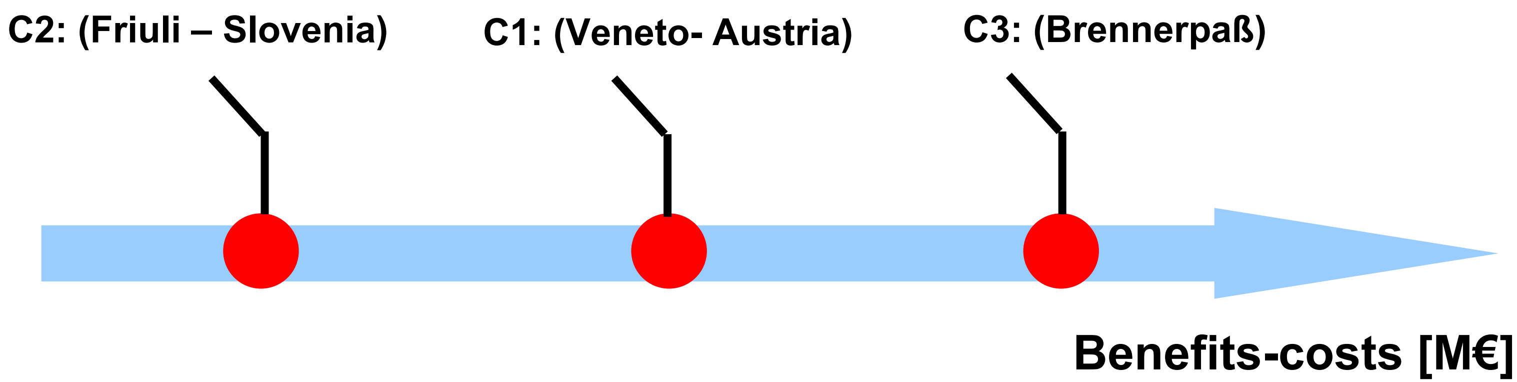

With benefits B1÷B6

Optimistic case

	Corridor A	Corridor B	Corridor C
NPV	3217	1918	5486
NPV/IC	15	9	6

Pessimistic case

	Corridor A	Corridor B	Corridor C
NPV	3649	2809	6956
NPV/IC	17	13	8

With benefits B1÷B5

Optimistic case

	Corridor A	Corridor B	Corridor C
NPV	1728	728	3012
NPV/IC	8	3	3

Pessimistic case

	Corridor A	Corridor B	Corridor C
NPV	2096	1397	4170
NPV/IC	10	7	5

Conclusions of the cost-benefit analysis

- The SW benefit is by far the prevailing one.
- The benefits are usually able to recover the costs just after one or two years of operation.
- Better interconnecting Germany with Italy will produce by sure a decrease of the total dispatching costs by allowing to reduce the differences between the prices on the EEX and IPEX markets.
- However, unless specific regulatory provisions are taken, the CO2 emissions are destined to grow because the Italian gas generation is mostly replaced by German coal generation and does not lead to a significant increase of dispatch of the North Sea RES generation (due to bottlenecks in Germany but also to the insufficiency of the wind production, mostly consumed in Germany).
- Losses are generally increased by opening new corridors.
- The benefit by a load shedding reduction is very small in all cases.
- The reduction of wind overproduction is possible only if the corridors allow to reach the wind area in the North Sea.

- In any case, while some data unavailabilities, concerning the network setup and the generation set, don’t allow to draw from the test case any conclusion on grid investments, the real advance brought by the test case is to show the applicability of the theoretic framework of the multi-criteria cost-benefit analysis elaborated by REALISEGRID to a realistic case encompassing a significant range of European nations.
- The extension of the model to a fully pan-European case seems not to present particular additional criticities, but also in this case the availability of real data would be the key element for drawing reliable evaluations

REALISE GRID

Thank you for your attention...

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