REALISEGRID WP3.5 Cost-benefit analysis and its application to a test bed

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SEVENTH FRAMEWORK PROGRAMME

Presentation outline

- Aims of Cost-Benefit analysis
- Costs and benefits considered for the case study
- The case study
  - test bed
  - scenarios hypotheses
- The tool REMARK
- Results:
  - Benefits of new interconnections
  - Cost-benefit analysis
- Conclusions

Aims of cost benefit analysis

- It provides a criterion to co-evaluate the effects of each benefit weighing them together to provide one single ranking value
- It creates a merit order (ranking) between alternative reinforcements
- It requires a tool able to assess each benefit deriving from transmission grid expansion in the case “with” the new infrastructure respect to the case “without” it
- The chosen tool represents real network features including:
  - reliability of each element in the grid;
  - variability of RES generation.
- Different scenarios analyzed in order to perform the cost-benefit analysis have to be based on a “projection” to the future of the system and must account for its evolution
- Net Present Value (NPV) algorithm has to be applied

Average costs for infrastructure and other elements

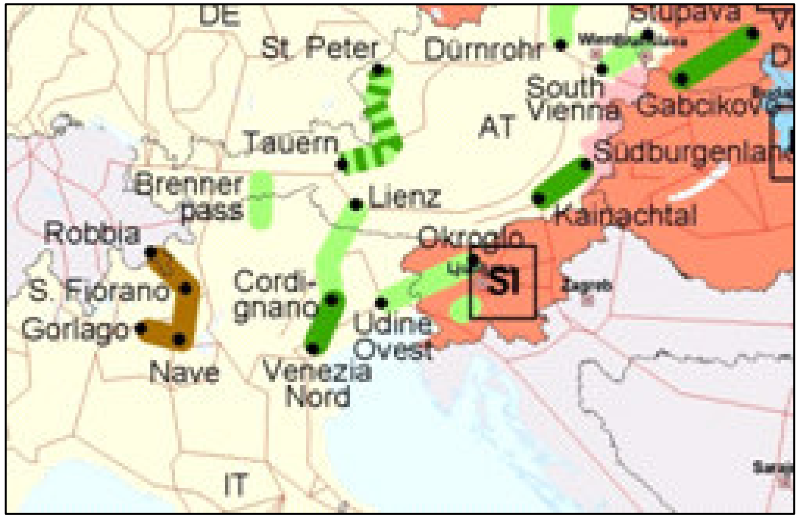
• HVAC OHL, single circuit 400 kV:	600 k€/km
• HVAC OHL, double circuit 400 kV:	1000 k€/km
• HVAC OHL (220>400 kV) uprating:	500 k€/km
• HVDC underground cable pair 1000 MW:	1300 k€/km
• GIL 400 kV:	7000 k€/km
• VSC converter terminal (bipolar) 1000 MW:	100000 k€
• Local compensation:	15% of CAPEX
•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

Benefits considered in the testing bed

1. **Social Welfare Increase** (actually, dispatching cost reduction) – already expressed in money.
2. **Reduction of losses** – monetized by multiplying by an average European market price (in the first analyses, assumed equal to 54 €/MWh, average between annual average figures of IPEX and EEX in 2010).
3. **Reduction of wind overproduction** – monetized by multiplying by a reasonable remuneration factor to wind owners (remunerated at market price, in the first analyses 54 €/MWh).
4. **Reduction of load curtailments** – monetized by multiplying EENS by the VOLL. The latter is assumed equal to 15000 €/MWh, an average value of EENS in European Countries. This value is derived from the results of SECURE project.
5. **CO_2 emission reduction** – for the evaluation of this benefit an average 2010 price on the European ETS market has been used [14 €/tCO_2]. For 2015, 2020 and 2030 the forecast values from the World Energy Outlook report 2009 have been used.
6. **Enhancement of security of supply** - reduction of fuel import from extra EU Countries.

Cost-benefit analysis: test bed/1

REALISEGRID WP3.5 uses the new methodology to carry out a cost/benefits classification 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.

Cost-benefit analysis: test bed/2

Grouping connectors into corridors: hypotheses

- Supposing the region TSOs want to invest in 2015 with a limited amount of available funds.
- The investment is supposed taking place in 2015, by neglecting possible authorization or consensus problems (ideal case). However, needed internal reinforcements have been added to the corridors bundle.
- The NE axis can be improved either by acting on the Brenner corridor, or on the Veneto-Austria corridor or on the Friuli-Slovenia corridor.
- In order to analyze these three choices, the original time sequence of the investment (as given in TYNDP of ENTSO-E) was not taken into account for the three corridors.
- Each corridor has to be autonomous: it has to include all the national and trans-national lines that bring it to function without bottlenecks.

Cost-benefit analysis: test bed/3

CORRIDOR A (Germany – Austria – Italy, Veneto):

4+2 380 kV lines

- ➢ Isar – St. Peter (already included in "without" scenario from 2020) (double line)
- ➢ Salzach – St. Peter (already included in "without" scenario) (double line)
- ➢ Salzach – Tauern (double line)
- ➢ Tauern – Lienz (already included in "without" scenario) (double line)
- ➢ Lienz - Cordignano (single line)
- ➢ Cordignano - Venezia Nord (single line)

CORRIDOR B (Italy, Friuli - Slovenia):

2+1 380 kV lines

- ➢ Bericevo – Okroglo (already included in "without" scenario) (double line)
- ➢ Okroglo – Udine Ovest (+ 2*1500 MVA PST) (double line)
- ➢ Cordignano - Venezia Nord (single line)

CORRIDOR C (Brenner; Germany – Austria – Italy, TAA):

4 380 kV lines

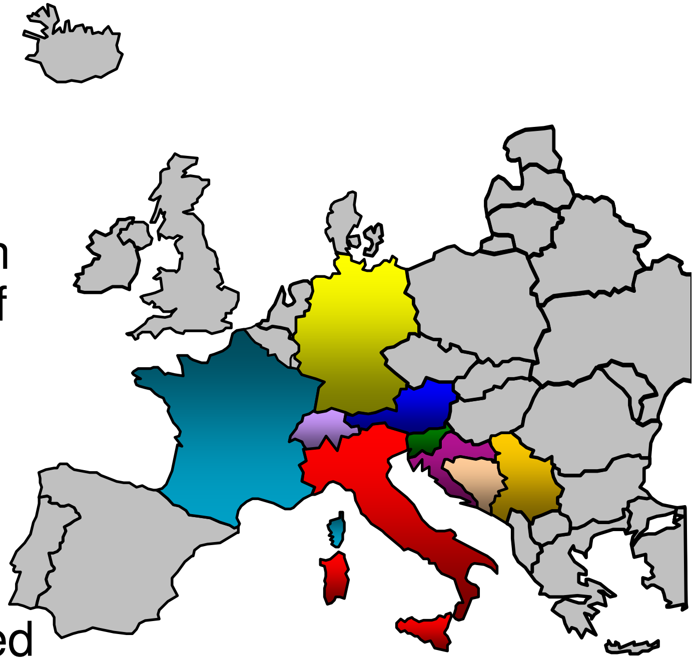
- ➢ Oberbachern - Oberbrunn – Thaur (double line)
- ➢ Thaur – new 380 kV station in TAA (GIL) (double line)
- ➢ new 380 kV station in TAA – new 380 kV station in Lombardia (double line)
- ➢ West Tirol – Thaur – Zell Ziller (double line)

Cost-benefit analysis: test bed/4

- Grid model: ENTSO-E STUM Model winter peak 2008 updated to years 2015, 2020, 2030 with information provided by:
  - ENTSO-E TYNDP
  - TSOs involved in the project

- The transmission network of 10 European Countries is described with a full model of 380 and 220 kV transmission grid (generators, loads, nodes, lines, transformers): AT, BA, CH, DE, FR, HR, IT, ME, RS, SI

- Other European Countries are represented with equivalent network models (i.e. equivalent generators)



Cost-benefit analysis: scenario hypotheses/1

- Two scenarios, optimistic and pessimistic, are considered for three reference years (2015-2020-2030)
- For years 2015 and 2020 information about growth of generation capacity and load are derived from ENTSO-E Report System Adequacy Forecast 2010 – 2025 (SAF)
  - The pessimistic scenario is derived from the SAF conservative scenario (A) that takes into account the commissioning of new power plants considered as certain and the shutdown of power plants expected during the study period.
  - The optimistic scenario is derived from the SAF Best Estimate scenario (B) that takes into account the generation capacity evolution described in scenario A as well as future power plants whose commissioning can be considered as reasonably credible according to the information available to the TSOs.
- Load is assumed to be equal both in the optimistic and in the pessimistic case in the 2015-2020 SAF based scenarios

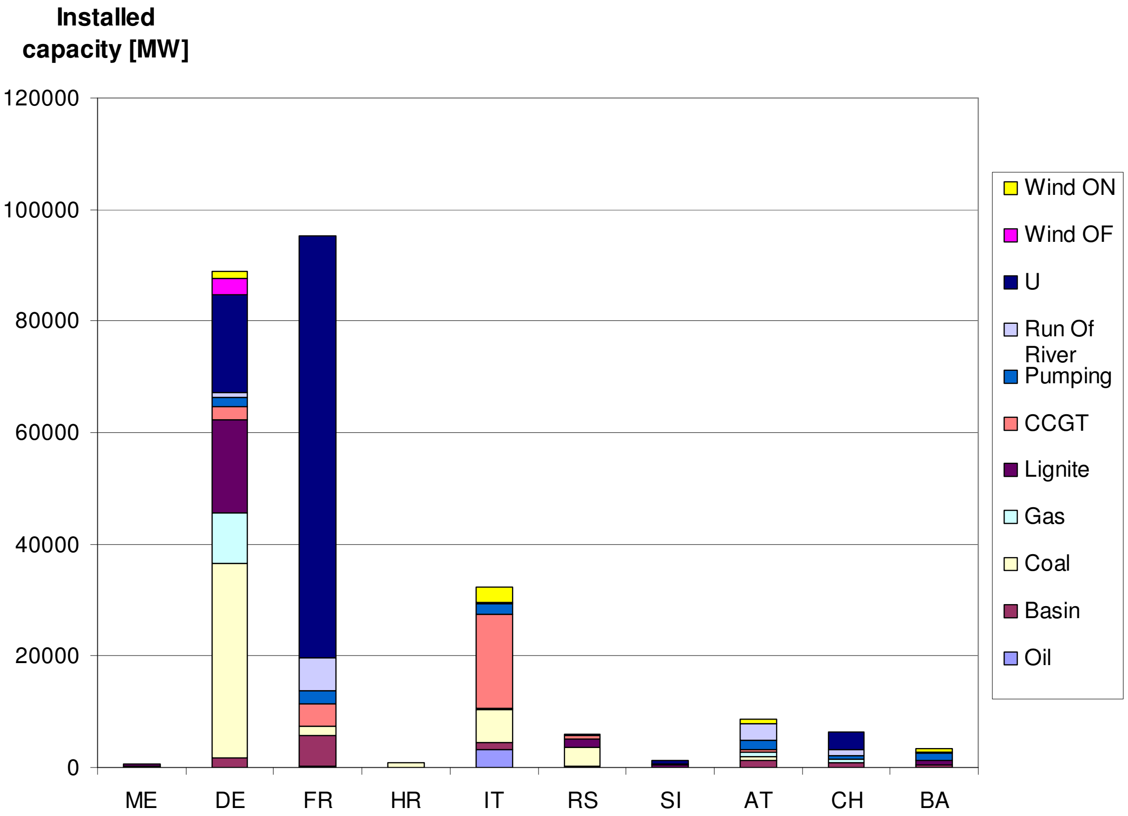
Cost-benefit analysis: scenario hypotheses/2

- For year 2030 information about growth of generation capacity and load are derived from results of optimistic scenario and pessimistic scenario calculated by REALISEGRID WP2
- Fuel prices are derived from World Energy Outlook
- Non dispatchable generators profile and power exchanges from neighboring countries are derived from REALISEGRID WP2 results
- SAF and REALISEGRID WP2 results provided only the overall value of the load fed by the entire transmission network (including lines with voltage < 220kV, not included in our model). For this reason the information provided by the two sources have been used to calculate the annual growth rate of load and generation source in the different countries, starting from the generators and the load present in the ENTSO-E STUM 2008 Model in order to obtain the 2015 - 2020 - 2030 values
- Scenario assumptions have been integrated with more precise information about expected growth of generation where available (i.e. growth of wind generation in Germany)

The tool REMARK: Main features

- Detailed model of the network: nodes, lines, transformers, generators, loads
- Three types of generation: fixed, random variable (wind), dispatchable
- Nodal Loads
- Non-sequential Montecarlo-based combination of:
  - unavailability of lines, transformers, generators [hours/year]
  - maintenance schedules for generators [weeks/year]
  - load and generation forecast profiles
- Statistical profile of wind generation (cumulative probabilistic distribution curve)
- Geographic system/market zones subdivision
- OPF solution of the AC grid is calculated through a simplified DC method

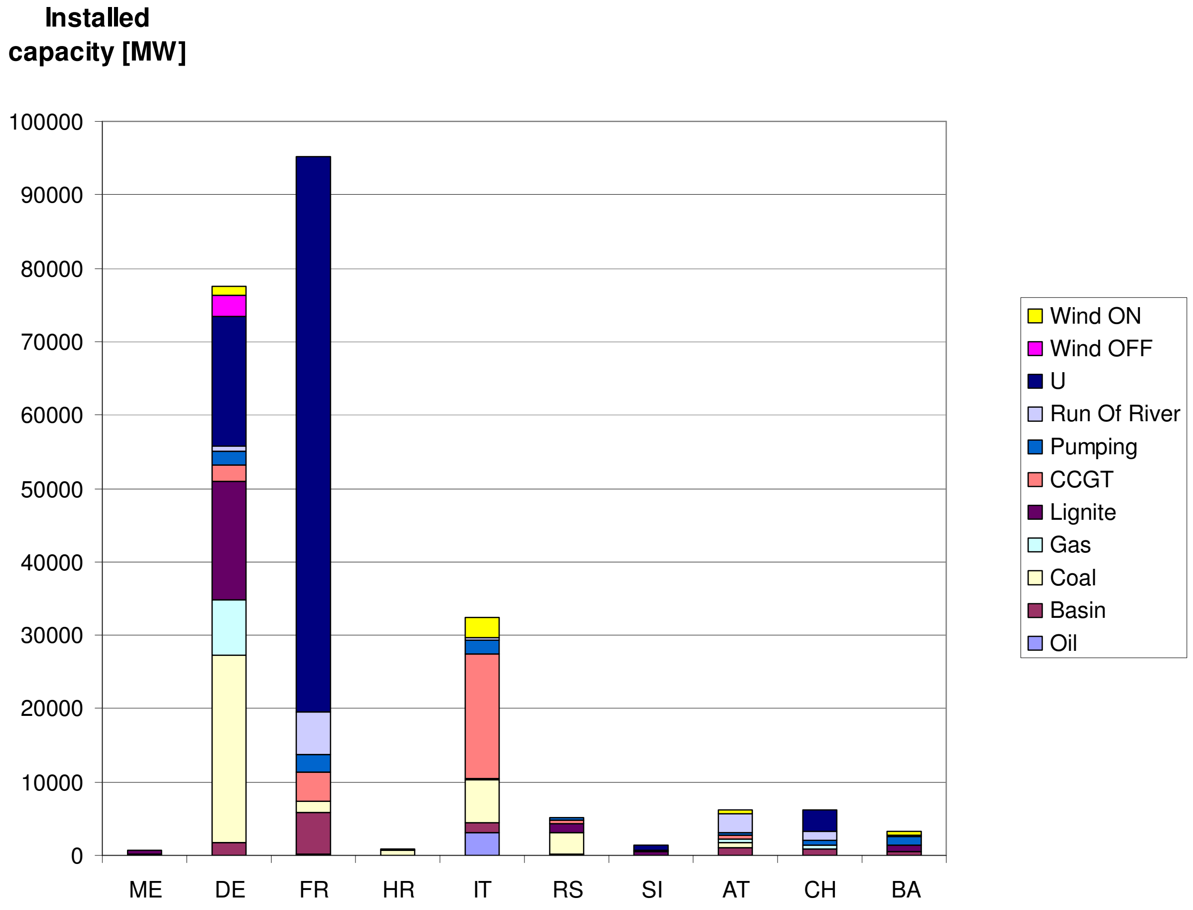
2015 optimistic



Annual load growth rate

	AT	BA	CH	DE	FR	HR	IT	ME	RS	SI	average
%	1.5	3.4	1.4	0.13	1.3	3.7	1.5	3.0	1.1	2.7	1.04

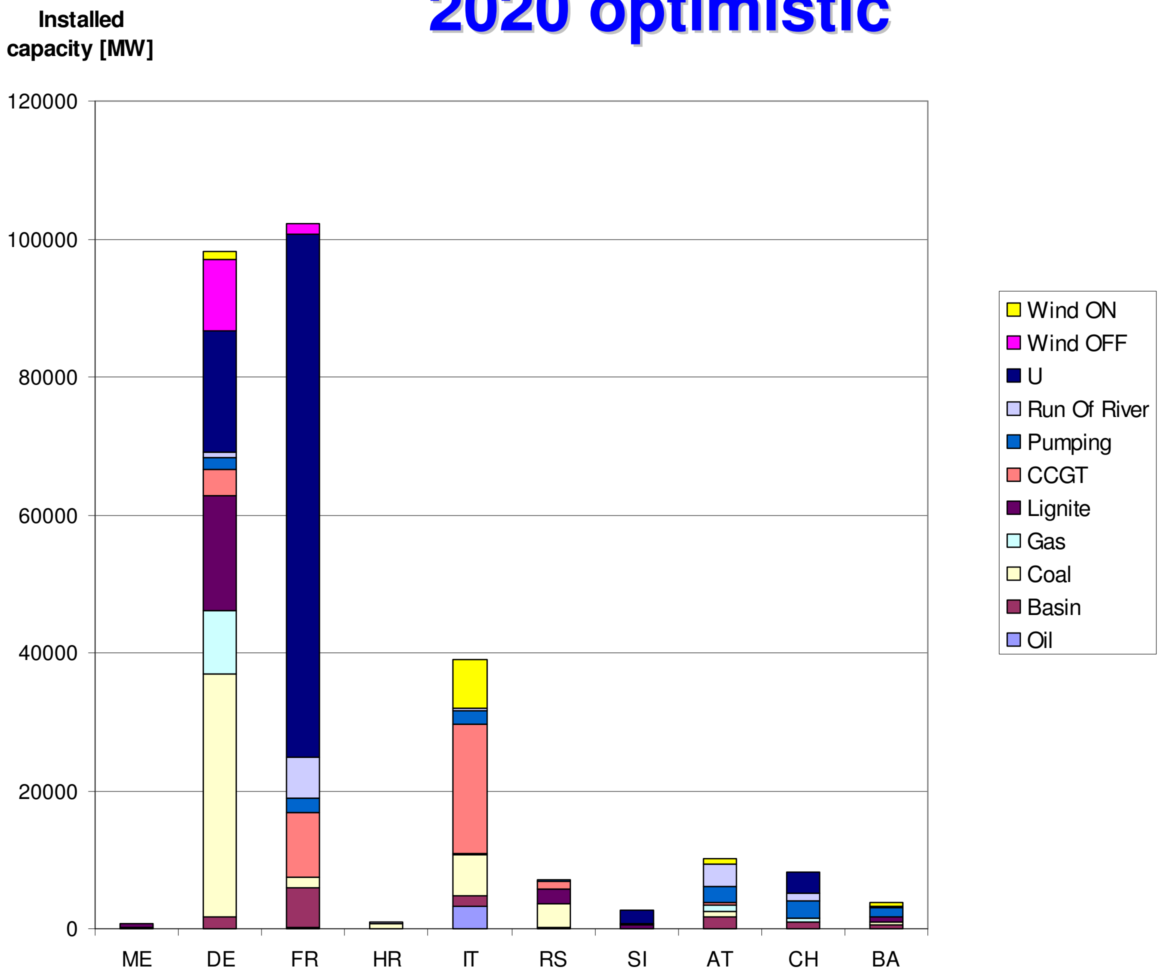
2015 pessimistic



Annual load growth rate

	AT	BA	CH	DE	FR	HR	IT	ME	RS	SI	average
%	1.5	3.4	1.4	0.13	1.3	3.7	1.5	3.0	1.1	2.7	1.04

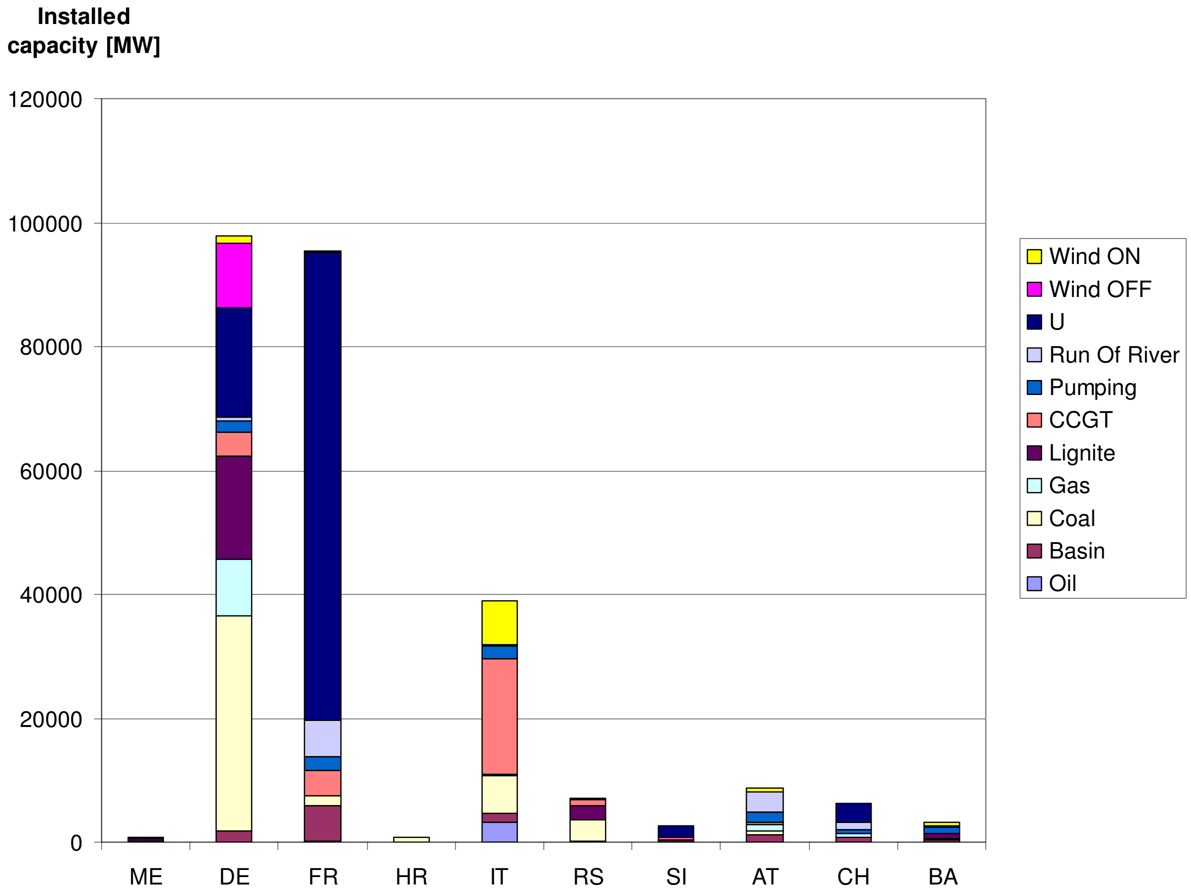
2020 optimistic



Annual load growth rate

	AT	BA	CH	DE	FR	HR	IT	ME	RS	SI	average
%	1.5	2.9	1.5	0.49	0.5	1.6	3.3	5.6	1.5	2.2	1.29

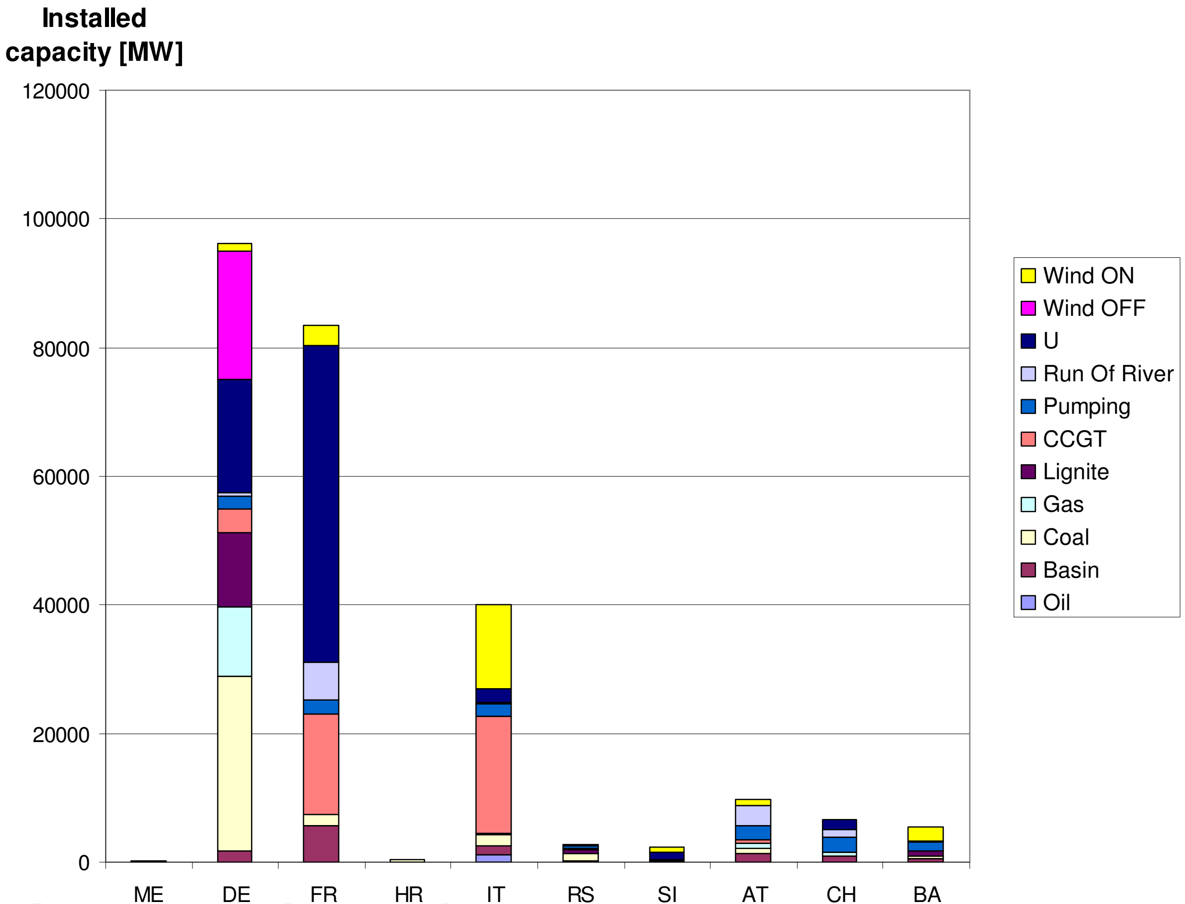
2020 pessimistic



Annual load growth rate

	AT	BA	CH	DE	FR	HR	IT	ME	RS	SI	average
%	1.5	3.4	1.5	0.49	0.5	1.6	3.3	5.6	1.5	2.2	1.29

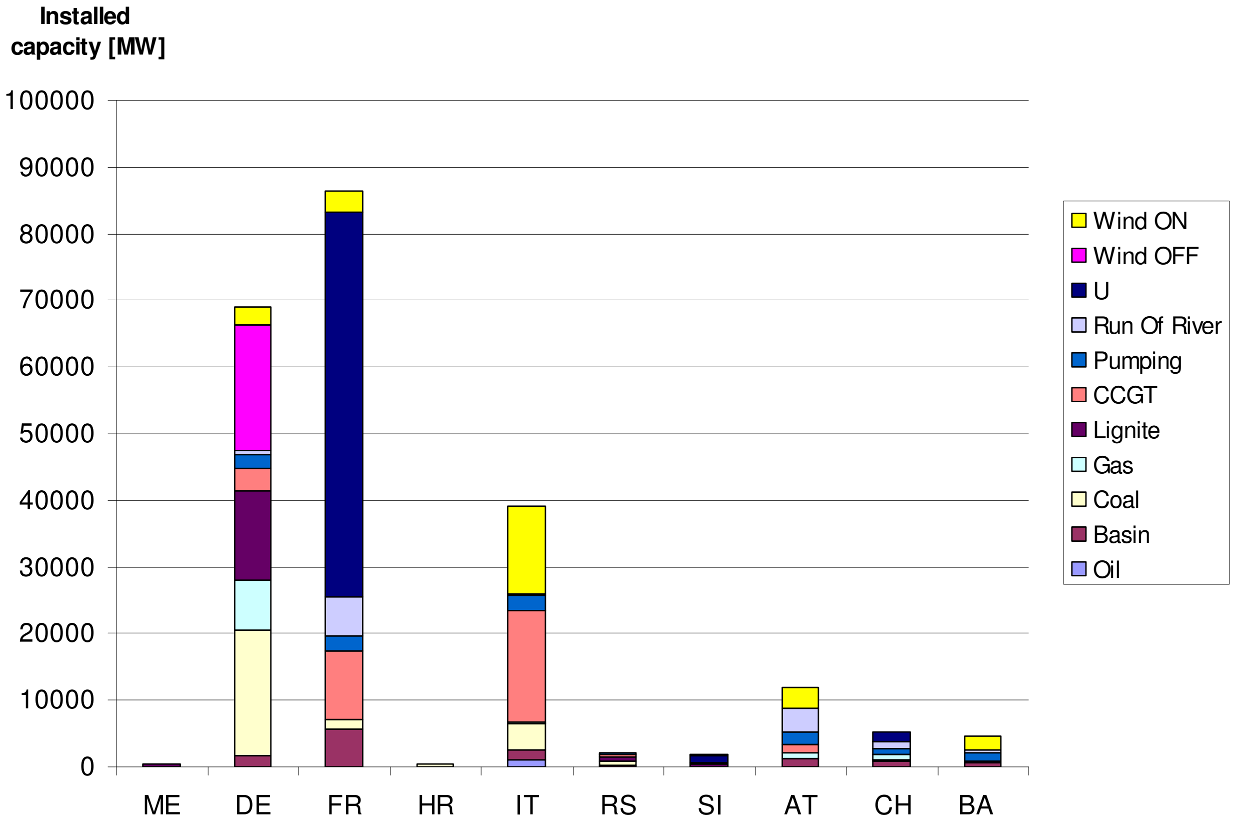
2030 optimistic



Annual load growth rate

	AT	BA	CH	DE	FR	HR	IT	ME	RS	SI	average
%	2.3	2.2	2.2	1.2	1.2	2.2	2.1	5.3	3.8	2.0	1.6

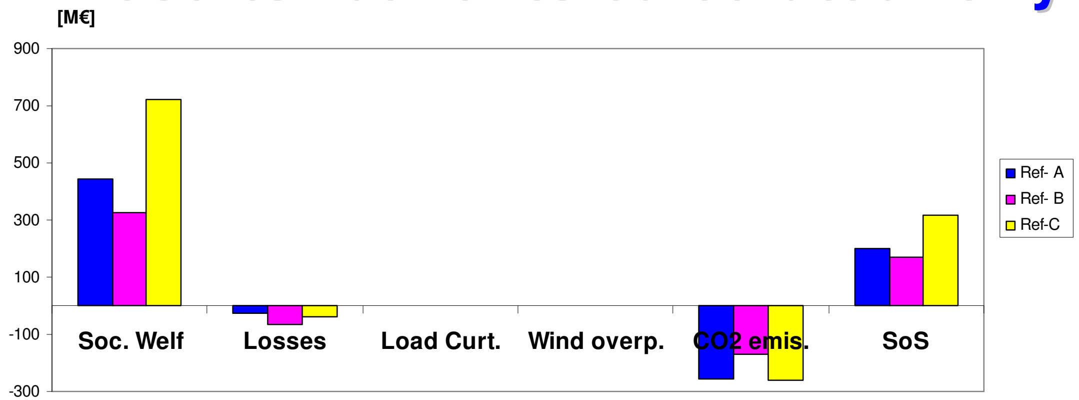
2030 pessimistic



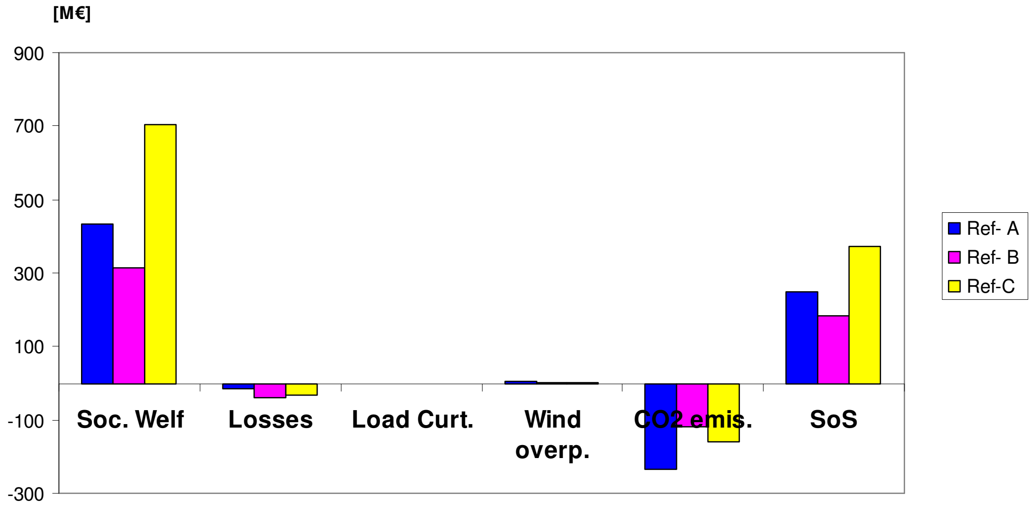
Annual load growth rate

	AT	BA	CH	DE	FR	HR	IT	ME	RS	SI	average
%	0.8	1.1	0.6	-0.2	-0.1	1.3	-0.5	2.9	1.1	1.1	-0.04

Results: benefits calculated for year 2015

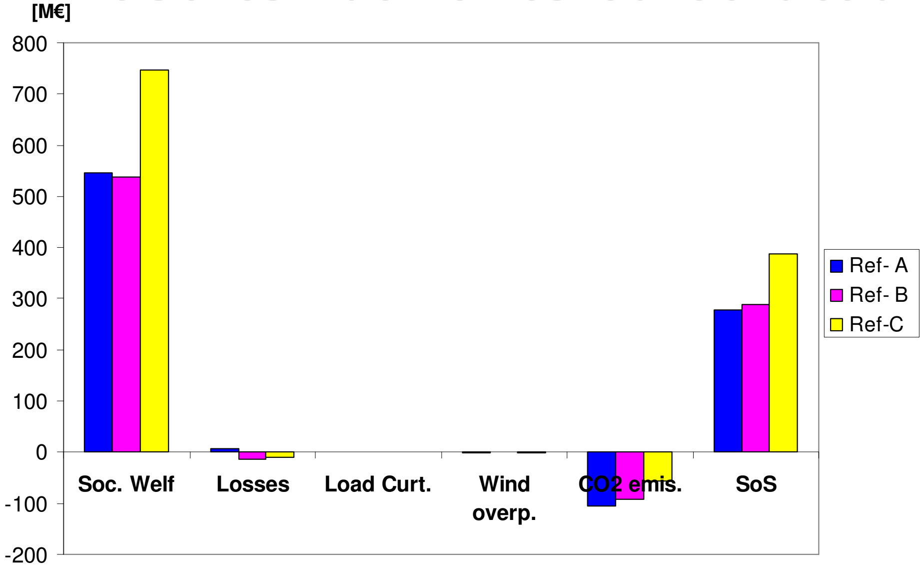


Optimistic scenario

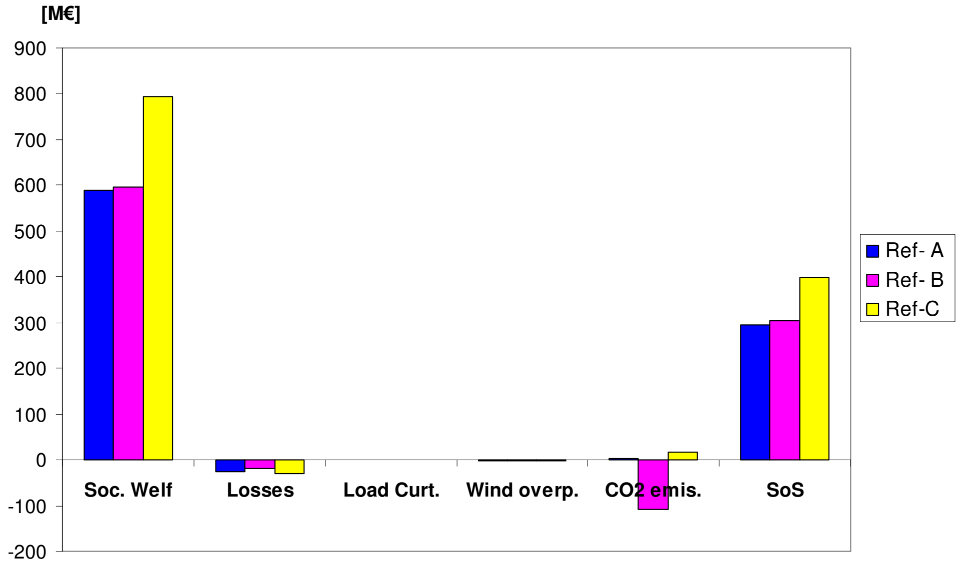


Pessimistic scenario

Results: benefits calculated for year 2020



Optimistic scenario



Pessimistic scenario

Results: Cost-Benefit analysis

Optimistic scenario

BENEFITS B1-B6	Corr. A	Corr. B	Corr. C
NPV [M€]	3217	1918	5486
NPV/IC	15	9	6

BENEFITS B1-B5	Corr. A	Corr. B	Corr. C
NPV [M€]	1728	728	3012
NPV/IC	8	3	3

Pessimistic scenario

BENEFITS B1-B6	Corr. A	Corr. B	Corr. C
NPV [M€]	3649	2809	6956
NPV/IC	17	13	8

BENEFITS B1-B5	Corr. A	Corr. B	Corr. C
NPV [M€]	2096	1397	4170
NPV/IC	10	7	5

Conclusions

- 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 CO_2 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, do not 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.

Thank you for your attention...

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