Work Package 5.6

Assessment of the impact on the European power system of a gas supply shortage in Italy

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SECURE Stakeholders Meeting

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Summary

- Objective of the study
- Gas supply shortage scenario in Italy
- The model of the European power system
- Impact assessment
- Remedies (focus on cross-border transmission capacity)
- Next steps

Objective of the study

- Assess the impact on the European power system of possible **gas supply shortages** in regions highly dependent on gas-fired generation, such as **Italy**
- A cut of gas-fired generation in a country will cause a re-dispatching of the European generation set with different **fuel consumptions**, **CO_2 emissions** and **cross-border flows**

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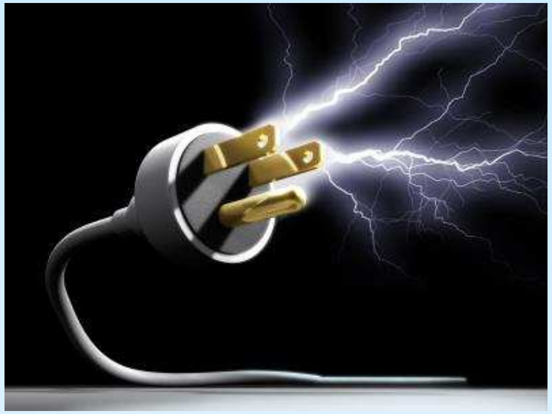
Objective of the study



- The impact assessment has been focused on the three main "pillars" of the EU energy policy:
  - **security of supply** (i.e. Energy Not Supplied)
  - **competitiveness** (i.e. electricity production costs)
  - **sustainability** (i.e. CO_2 emissions)

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Gas supply shortage in Italy

- We assumed an interruption of supply from the **TransMed "Enrico Mattei"** pipeline connecting **Algeria to Italy** via Tunisia, in the reference year **2015**

- The **TransMed** annual maximum capacity is **33.5 bcm** and the interruption is assumed for the **5 months from November to March**, the most critical due to heating demand

- On December 19, 2008, one of the five lines composing TransMed was damaged by the anchor of an oil tanker and in mid-2009 repair operations were still ongoing …

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Gas available for power generation

- In the following, we calculate the **balance** foreseen for 2015 in the five months from November to March between:
  - **gas supply sources**, excluding TransMed
  - **gas demand**, except power generation

in order to determine the monthly amount of **gas available for power generation in the shortage scenario**

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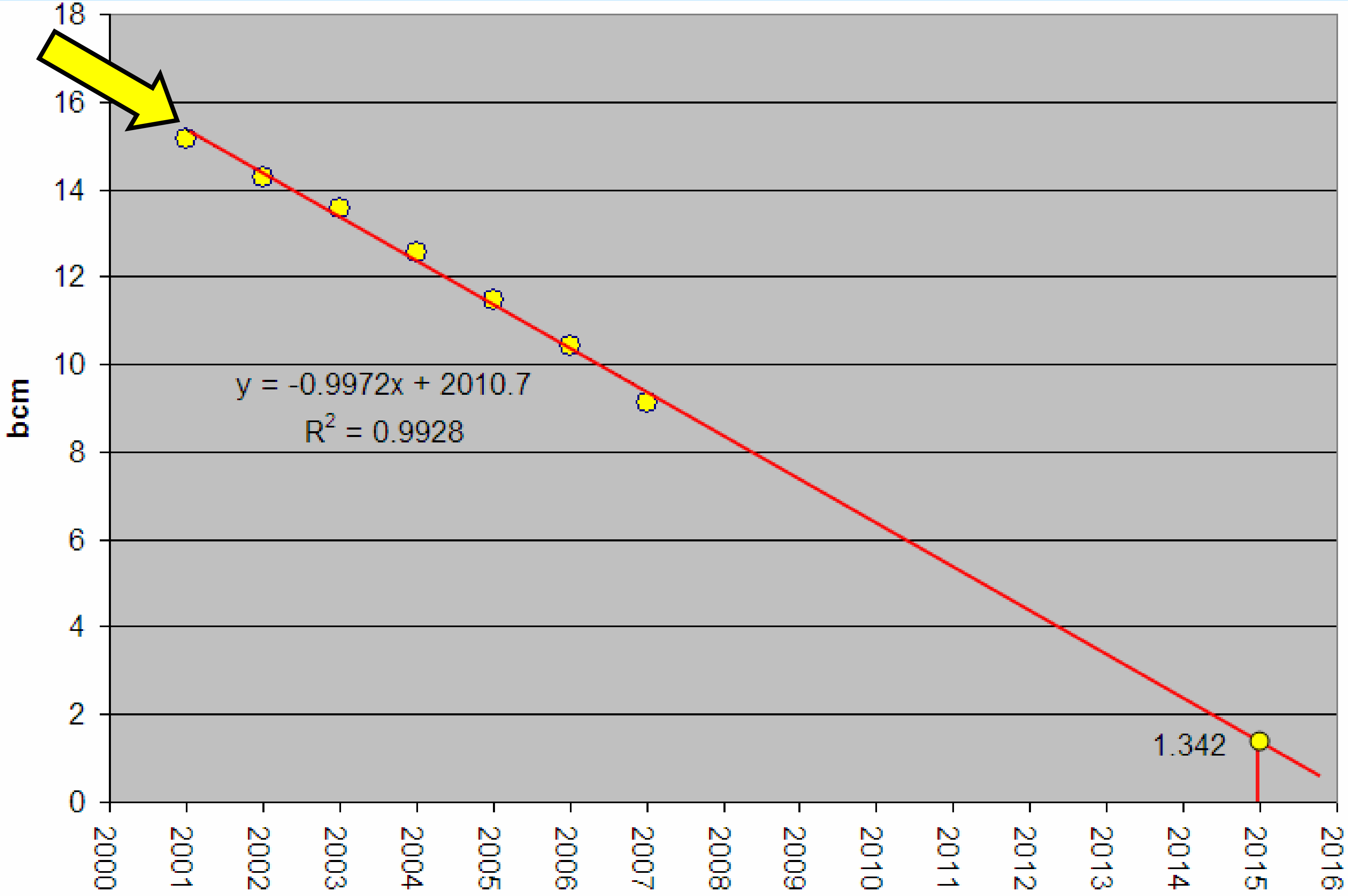
Italian gas balance in 2015: national production



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Italian gas balance in 2015: import pipelines

Entry point	Maximum theoretical annual capacity [bcm]	Maximum effective annual capacity [bcm]	Maximum effective monthly capacity [bcm]
Tarvisio (TAG)	40.2	36.7	3.06
Passo Gries (TENP / TRANSITGAS)	23.4	21.3	1.78
Gela (GREENSTREAM)	11	10.0	0.84
Gorizia	0.73	0.67	0.06
Otranto (IGI Poseidon / ITGI)	8	7.3	0.61
SUBTOTAL	83.3	76.1	6.34
Mazara del Vallo (Transmed TTPC / TMPC)	33.5	30.6	2.55
TOTAL	116.8	106.7	8.89

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Italian gas balance in 2015: LNG terminals

Terminal	Maximum theoretical annual capacity [bcm]	Maximum effective annual capacity [bcm]	Maximum effective monthly capacity [bcm]
Panigaglia (ENI)	3.5	3.3	0.28
Porto Levante (Adriatic LNG)	8	7.6	0.63
Livorno (OLT Offshore LNG)	3.75	3.6	0.30
TOTAL	15.25	14.5	1.21

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Italian gas balance in 2015: storage

- **No new storage facilities** assumed

- Capacity: **8.72 bcm** for **modulation** service and **5.17 bcm** for **strategic** storage

- Initial assumption: **preserve the strategic** storage and **use all the modulation** storage between November and March with the following optimal withdrawal profile [bcm]:

Company	November	December	January	February	March
STOGIT	0.92	1.93	2.85	2.26	0.42
EDISON	0.03	0.08	0.09	0.08	0.05
TOTAL	0.95	2.01	2.94	2.34	0.47

Italian gas balance in 2015: demand

- **Industrial sector**'s consumption assumed to recover to the pre-economic crisis levels: about **1.7 bcm/month**

- As for **distribution networks** (mainly heating demand), we estimated the consumption whose probability to occur is **once every 20 years** (reference "cold" winter) [bcm]:

November	December	January	February	March
4.57	6.30	6.68	5.47	4.49

- Network consumptions and losses: **0.125 bcm/month**

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Gas available for power generation

		November	December	January	February	March
SUPPLY	National production	0.11	0.11	0.11	0.11	0.11
	Import pipelines	6.34	6.34	6.34	6.34	6.34
	LNG terminals	1.21	1.21	1.21	1.21	1.21
	Storage	0.95	2.01	2.94	2.34	0.47
	TOTAL	8.61	9.67	10.60	10.00	8.13
DEMAND	Distribution networks	-4.57	-6.30	-6.68	-5.47	-4.49
	Industry	-1.7	-1.7	-1.7	-1.7	-1.7
	Network consumptions and losses	-0.13	-0.13	-0.13	-0.13	-0.13
	TOTAL	-6.40	-8.12	-8.51	-7.29	-6.32
Gas available for power generation		**2.21**	**1.54**	**2.09**	**2.71**	**1.82**

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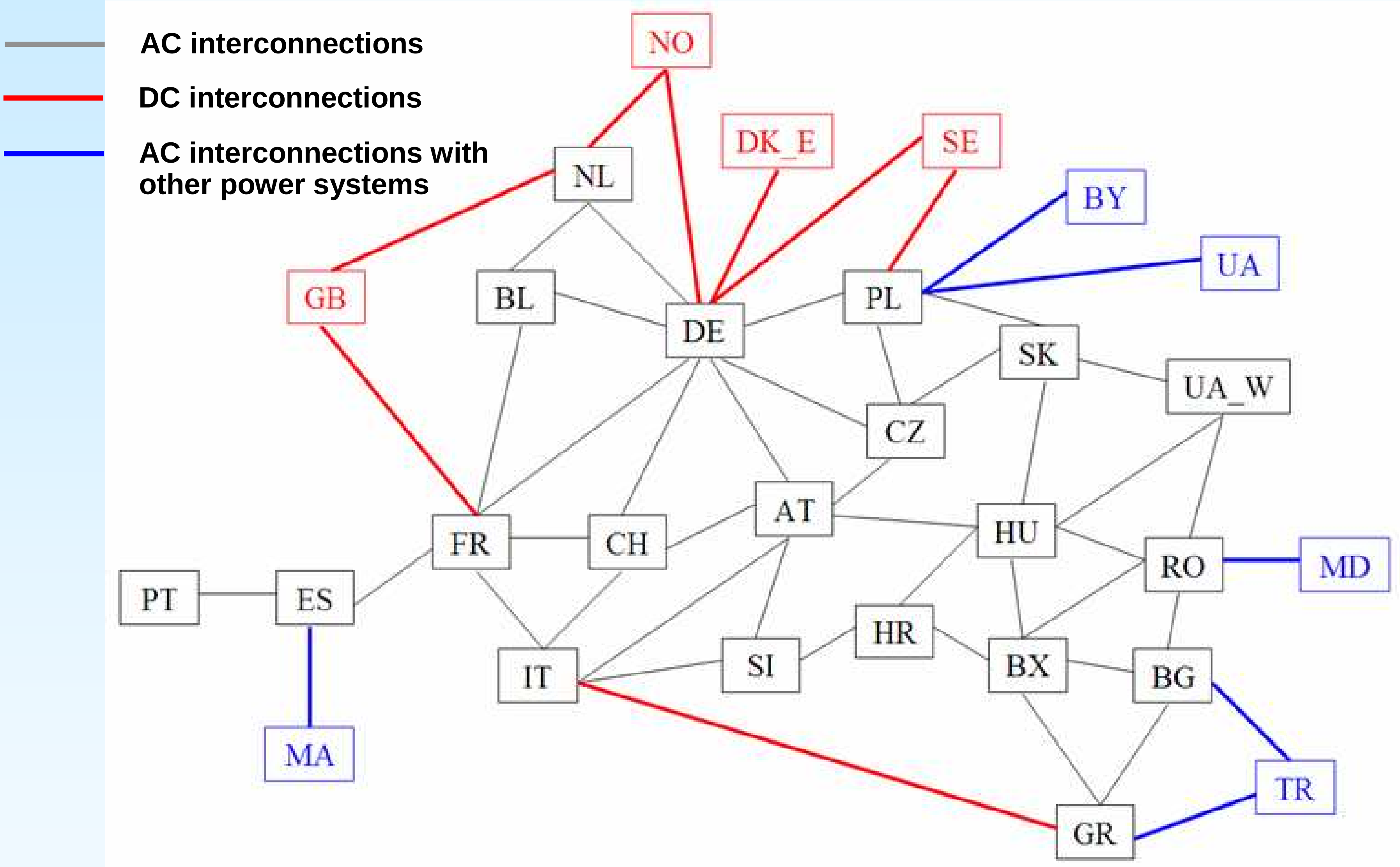
Model based analysis

- The assessment has been carried out by means of a **model of the European power system**, interconnected with neighbouring areas

- The power system has been modeled as a set of **nodes** (composed of one or, in few cases, more countries), interconnected by **cross-border transmission lines** with defined capacities (source: ENTSO-E)

- The equivalent cross-border AC transmission network has been represented using *Power Transfer Distribution Factors* (**PTDF**s) calculated using a detailed model of the European AC network (about 4000 nodes)

The model of the European power system



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The model of the European power system

- As for **DC** interconnections and for **AC** interconnections **with other power systems**, we imposed the latest available power transfer profiles
- As for the **generation set**, each node (country) of the modeled AC network has been characterized by an **"equivalent" power plant for each main dispatchable generation technology / fuel**
- As for **hydro, pumped storage and other RES** power plants, appropriate **generation profiles** for each node (country) and for each technology have been defined and imposed
- Main data source: **ENTSO-E** System Adequacy Forecast (**SAF**) 2009-2020 and **Statistical Database**

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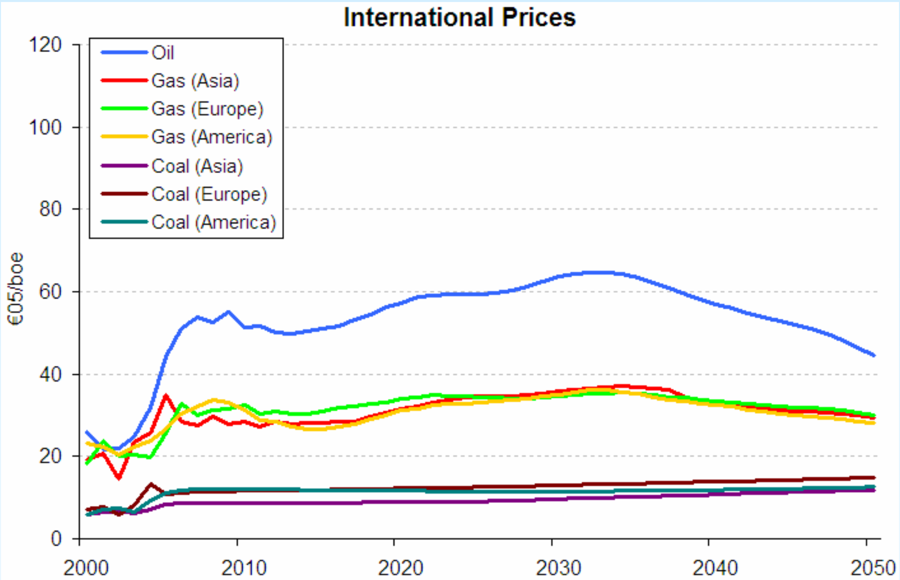
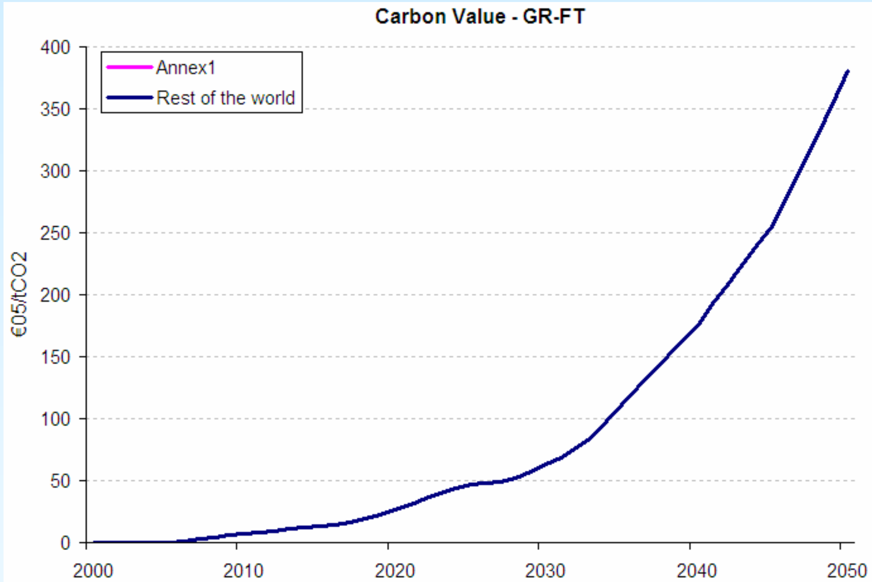
Other scenario assumptions

- **Fuel prices**, **CO_2 emissions value** and annual **electrical load** of each country for year 2015 taken from the POLES scenario **"GR-FT Global Regime with Full Trade"**





- The 2015 **hourly** load profile of each country has been defined by **scaling** the 2008 one and **adjusting** it for 2015 holidays (source: ENTSO-E Statistical Database)

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The power system simulator

- We used **MTSIM**, a zonal electricity market simulator developed by ERSE, able to carry out:
  - an **optimal hourly dispatching** over a **one-year** time horizon
  - a **minimization of the overall operating costs** (fuel costs, CO_2 emissions costs, costs related to Energy Not Supplied)
- No market power exercise has been simulated, in order to focus on the **“natural” best response** of the modeled power system to the considered shortage
- Gas supply shortage has been modeled by using **constraints on fuel consumption** implemented by the MTSIM simulator

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Results of the simulations

- Comparison between the **"base case"** (normal operation with no shortage) and the **"shortage case"**

	[bcm]	November	December	January	February	March	Nov÷Mar
shortage	Gas available for power generation	2.21	1.54	2.09	2.71	1.82	10.37
base case	Consumption of CHP power plants	-1.58	-1.63	-1.63	-1.48	-1.60	-7.92
base case	Consumption of non-CHP power plants	-1.04	-1.13	-1.58	-1.83	-1.17	-6.75
	Balance	-0.41	-1.22	-1.12	-0.6	-0.95	-4.3

- To keep a **normal operation** of the Italian generation set in case of shortage it would be necessary to use **4.3 bcm** out of 5.17 bcm of **strategic storage**

Results of the simulations

- In the **"shortage case"**, if we assume:
  - to let CHP plants to use strategic storage (only 92 Mcm in December) in order not to cut their heat demand
  - to prevent non-CHP plants from using strategic storage
  - to maximize electricity imports through the DC interconnector with Greece

the simulator redispatches the European power system, in particular operating **fuel oil-fired power plants** in Italy and **increasing imports** from neighboring countries

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Results of the simulations

- In such a case, **gas consumption of non-CHP power plants** in Italy in the five months **decreases** from **6.75 bcm** to **2.55 bcm** (that is **-62%**) …

- … nevertheless it is not possible to avoid **349.5 GWh of energy not supplied in Italy in December**, that is the most critical month

- Using a modern CCGT power plant, to avoid such unserved energy only **66 Mcm** of gas withdrawn from **strategic storage** would be necessary

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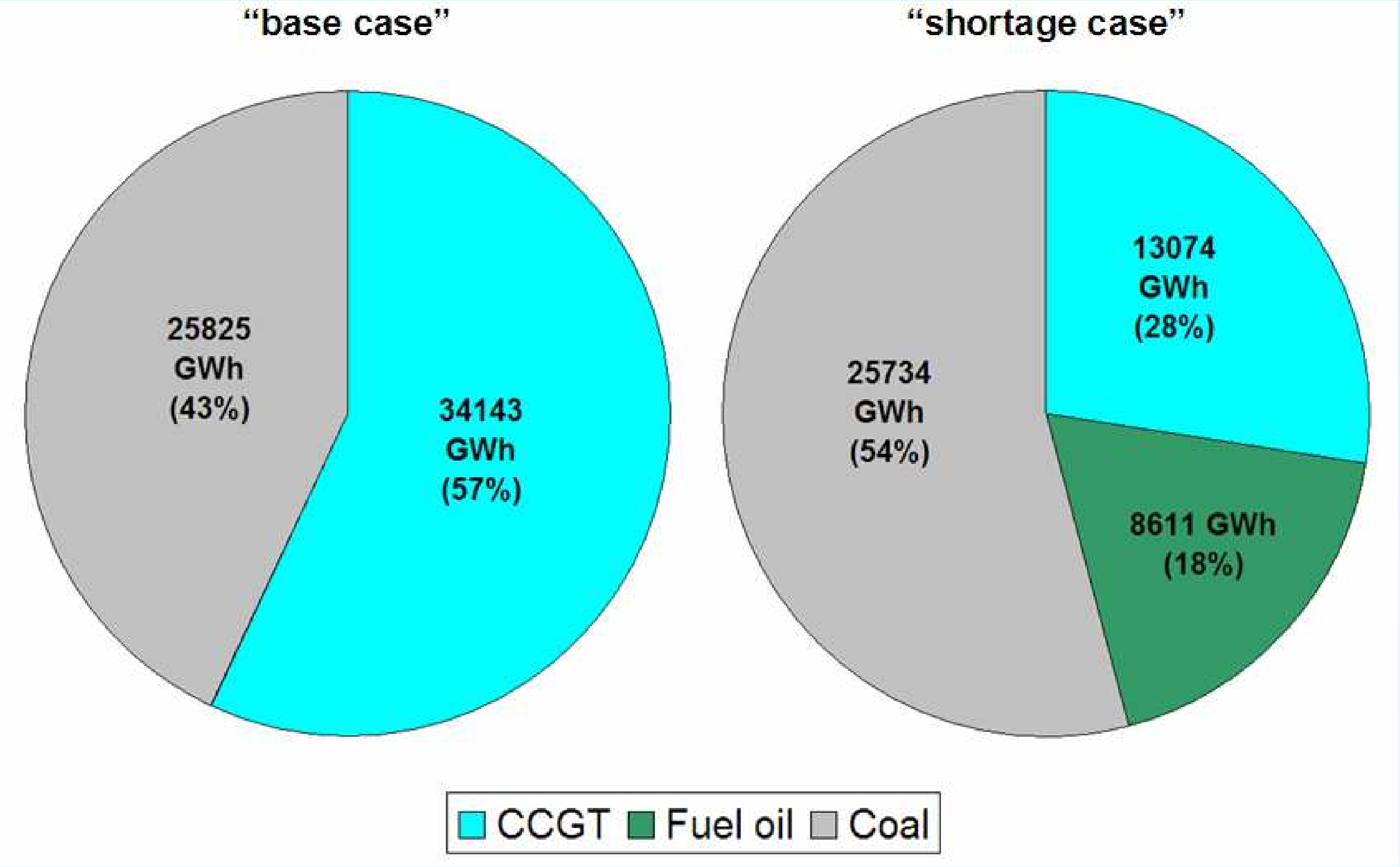
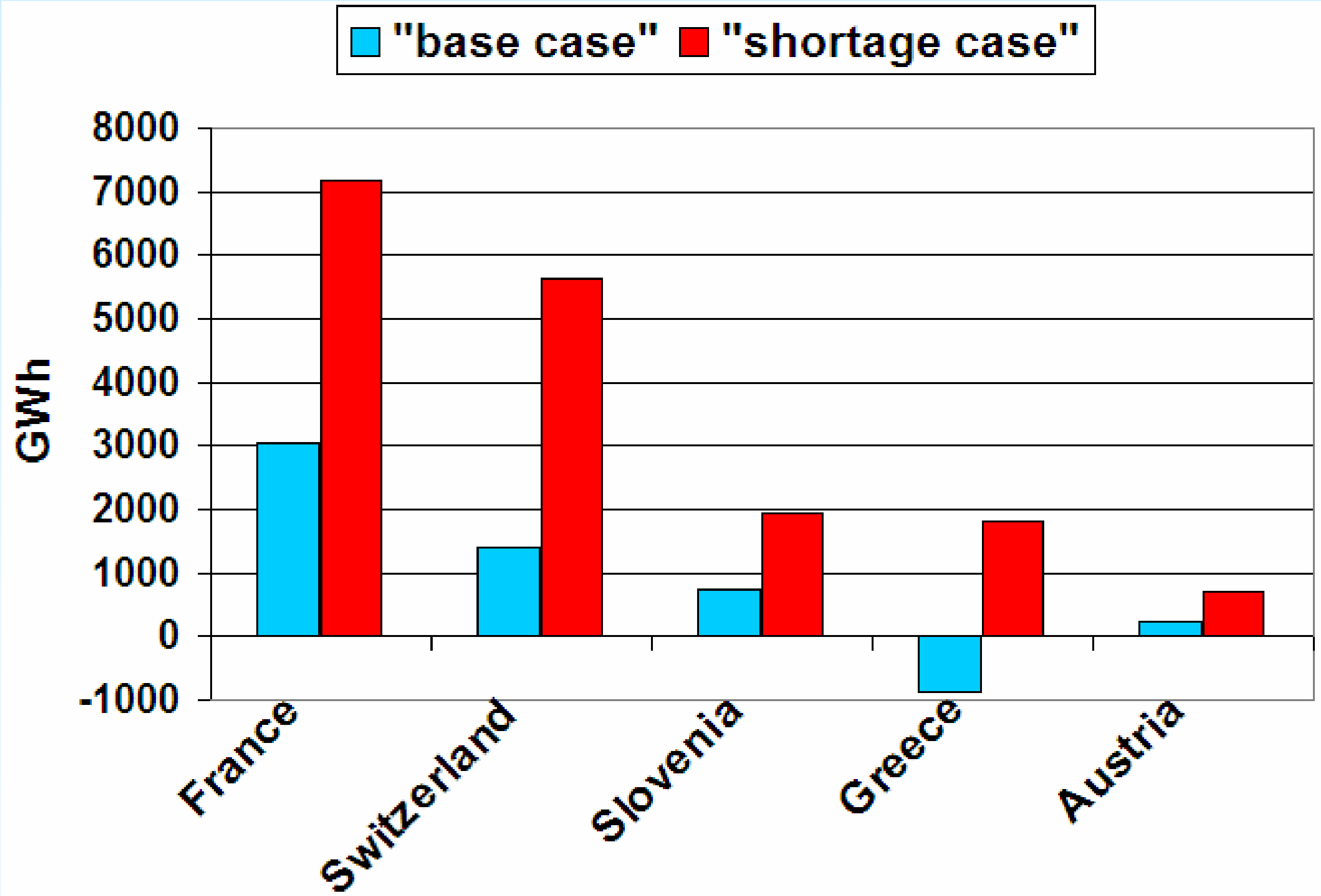
Non-CHP thermal generation in Italy

- **Non-CHP thermal generation in Italy decreases by 12.5 TWh (-21%) and the fuel mix changes**



Italian imports

- Italian imports **increase by 12.5 TWh** (almost **triplicate**)



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Overall modeled non-CHP generation set

Fuel	"base case" [GWh]	"shortage case" [GWh]	Δ%
Nuclear	317341	317177	-0.1
Hard coal	189231	185315	-2.1
Lignite	111115	110744	-0.3
Natural gas	138275	132080	-4.5
Fuel oil	218	10510	4722.6

- **At the overall system level, there is a somewhat unexpected decrease of hard coal production, that the simulator performs to accommodate the greater electricity flows towards Italy, taking into account the constraints of the meshed cross-border transmission network**

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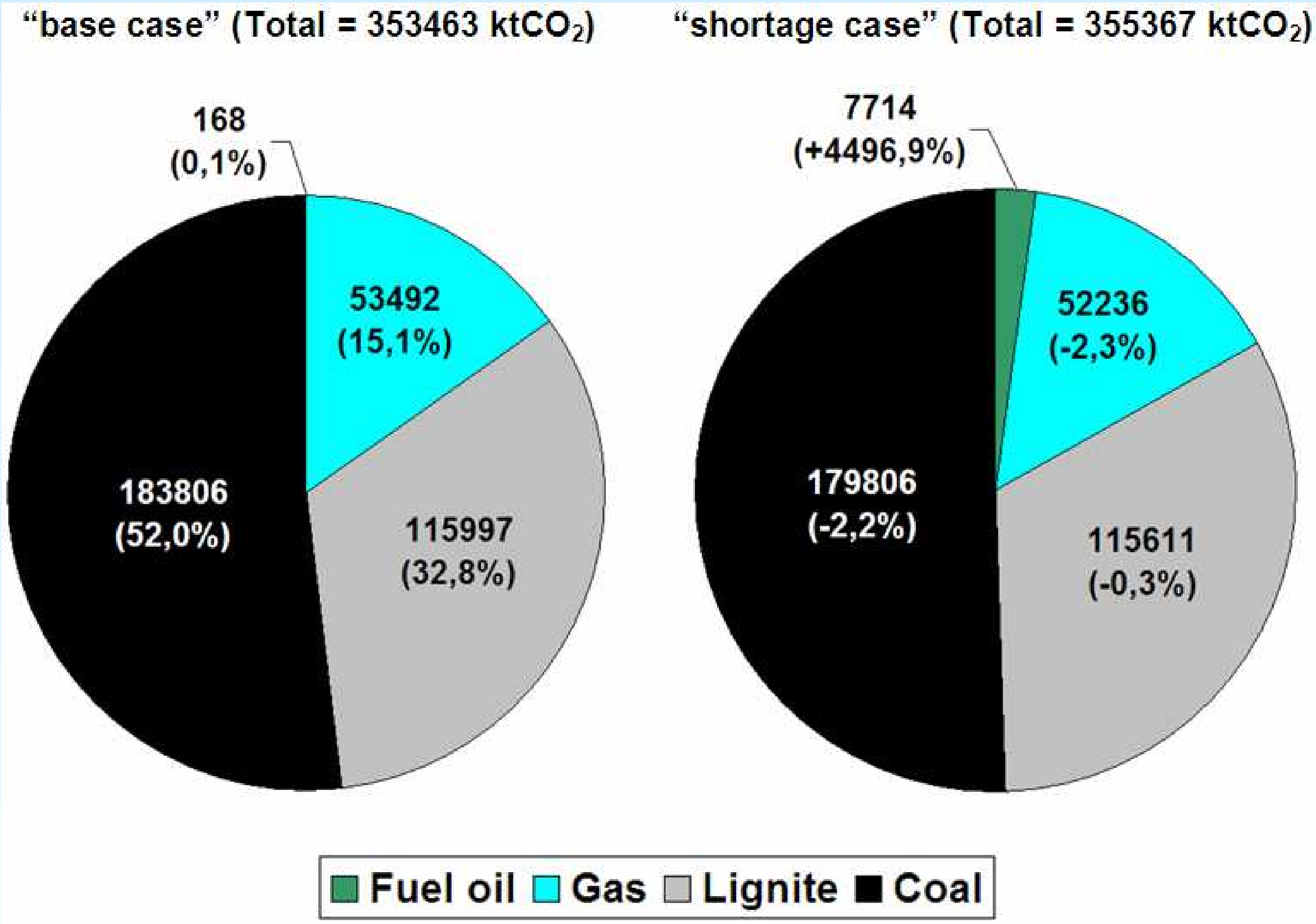
Overall non-CHP CO_2 emissions

- CO_2 emissions **increase by 1904 ktCO_2**



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Overall extra-costs

- Assuming to avoid energy not supplied by using a small amount of strategic gas storage, the **extra-costs** of the **"shortage case"** are due to:
  - **change of fuel mix** (more expensive fuels and less efficient power plants in operation)
  - **increase of CO_2 emissions** and of the related need for allowances

	Extra-costs [M€]
Change of fuel mix	619
Increased CO_2 emissions	27
Total	**646**

Short-term remedies

- Short-term remedies in the gas sector:
  - Maximize gas imports from the remaining supply sources
  - Use gas storage
  - Reduce demand
- Short-term remedies in the electricity sector:
  - Increase electricity imports
  - Perform fuel switching
  - Reduce demand

Long-term remedies

- **Long-term remedies in the gas sector:**
  - **Diversify supply sources (both suppliers and supply infrastructures)**
  - **Increase gas storage capacity**
  - **Increase energy efficiency in gas consumption**
  - **Develop Renewable Energy Sources for heating**

- **Long-term remedies in the electricity sector:**
  - **Diversify generation sources**
  - **Increase cross-border transmission capacity**
  - **Increase energy efficiency in electricity consumption**

“Unconstrained” shortage case

- We compared the results of the “shortage case” with an **ideal** scenario (**“unconstrained”** shortage case) where all **cross-border AC transmission capacity constraints are removed**
- In this way, we can assess the strength of **network bottlenecks** in constraining the system
- By removing network constraints, what happens to Italian imports and to hard coal and fuel oil production?

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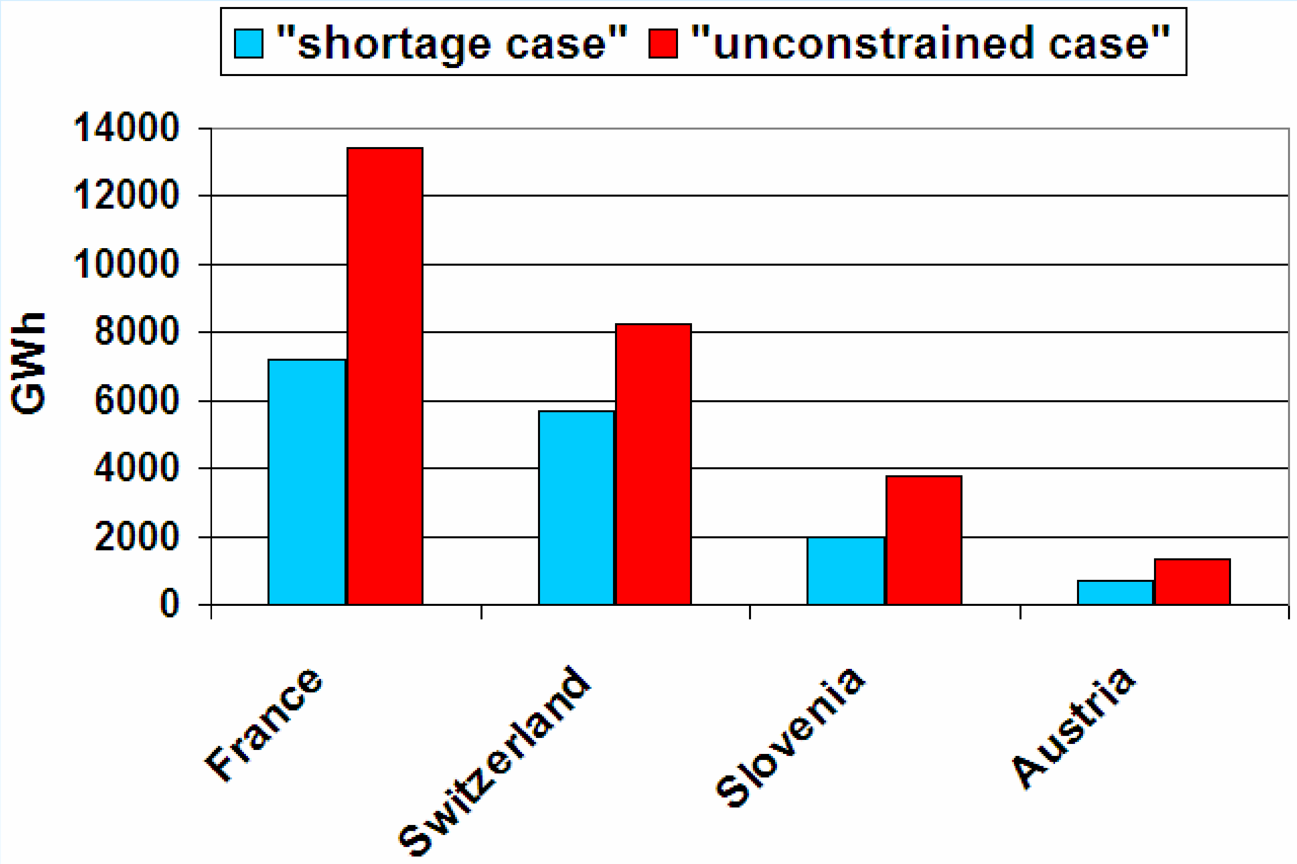
Results of the "unconstrained" case

- Italian **imports** from the northern frontier **increase by 11.2 TWh** (**+72%**) and no energy not supplied occurs in December



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Results of the "unconstrained" case

- The greater availability of "foreign" energy allows **not to dispatch Italian fuel oil-fired power plants**

- A significant **increase at the European level of cheaper coal production** substitutes not only **fuel oil-fired**, but also **gas-fired** generation

Fuel	"shortage case" [GWh]	"unconstrained" [GWh]	Δ%
Nuclear	317177	317395	0.1
Hard coal	185315	199865	7.9
Lignite	110744	111577	0.8
Natural gas	132080	127345	-3.6
Fuel oil	10510	0	-100

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Results of the "unconstrained" case

- The increased **coal** production causes an **increase of CO_2 emissions** of about **3584 ktCO_2**

- Due to a strong **reduction of fuel costs**, the "unconstrained" case is about **900 M€ cheaper than the "shortage case"**, that is **254 M€ cheaper** even **than the "base case"**, where no gas shortage occurs

	∆ costs [M€]
Change of fuel mix	-946
Increased CO_2 emissions	46
Total	**-900**

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Next Steps

- This quite rough and simple analysis of the **strength of network bottlenecks** is just the starting point of future work concluding this work package
- The objective is the impact assessment of a **non-optimal cross-border transmission infrastructure development**
- To this aim, we will use the model to analyze the criticality of constraints on the different frontiers and to determine the **optimal expansion of cross-border lines** to relieve such constraints in a **cost-effective** way

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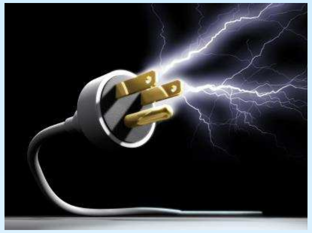
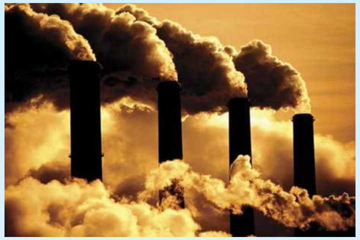
Next Steps

- A **cost-benefit analysis** will be carried out on the determined optimal expansions, again in terms of:
  - security of supply
  - competitiveness
  - sustainability



- The assessment will be focused on the reference years **2015** and, especially, **2030**, when **POLES scenarios** (used as common framework) are significantly differentiated

- The study will be carried out sharing input data and information with the FP7 **REALISEGRID** project, coordinated by ERSE

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Thank you for your attention !!!

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