The future of energy in Europe and the climate-security nexus: insights from the SECURE scenarios

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Energy and climate: twin problems

- **Between now and 2050, humanity have to face a twin problem:**
  - The growing scarcity for oil and gas (not for coal !)
  - The acccumulation of GHGs in the atmosphere
- **These « twin problems » cannot be considered independently as:**
  - Hydrocarbon scarcity paves the way to coal
  - Conversely, climate policies open the path to low carbon societies
- **« Smart energy policies » thus have to deal with the two sides of the problem**

SECURE : purpose of the study

- The SECURE project – in FP7 – aims at analysing future energy Security of Supply for Europe
- Research and policy making need to take into account the potential impacts of climate policies on the world energy system
- The POLES long-term world energy model is used to produce a number of framing scenarios, in order to explore the « climate change and energy security nexus »

Scenarios and their policy settings

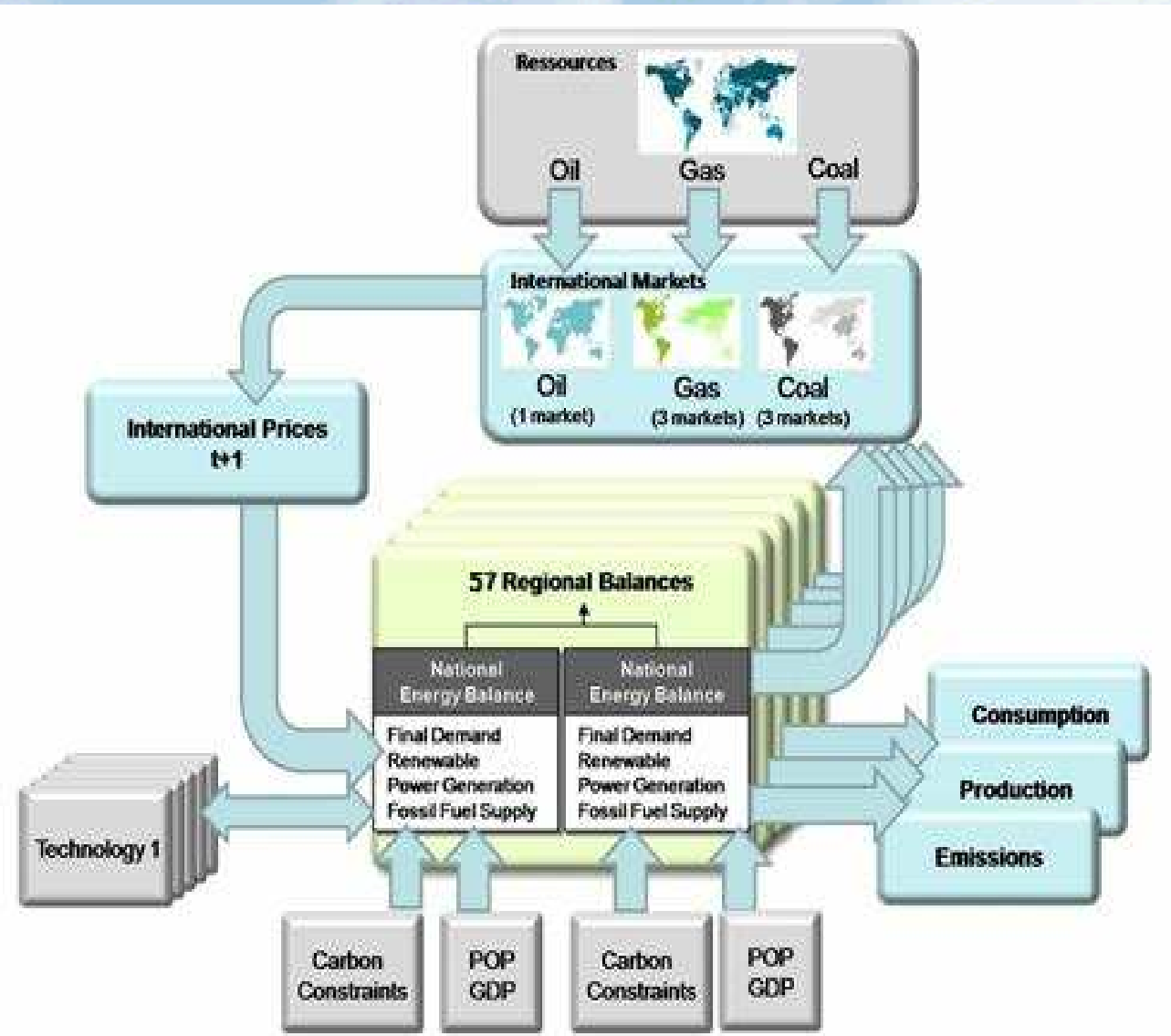
Main results of the SECURE scenarios

Impacts of scenarios on EU and its Southern Neighbours

Main results of the SECURE exercises

Impacts of scenarios on European energy vulnerability

The POLES model year-by-year recursive simulation process



5 scenarios + 3 sensitivity studies with the POLES model

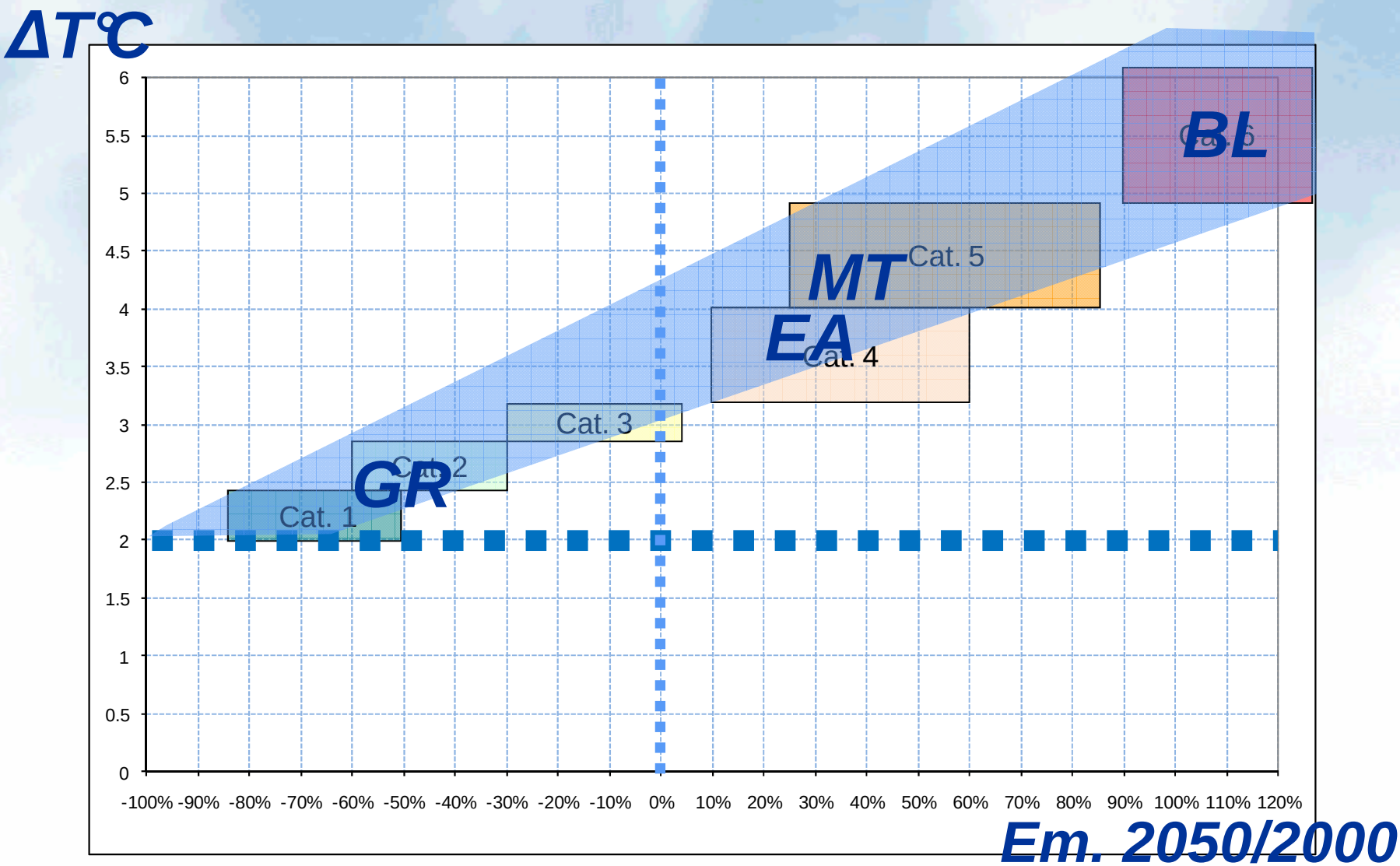
Scenarios

1. The ***BaseLine*** case is a counter-factual, no climate policy scenario, used mostly for benchmarking
2. The ***Muddling Through*** scenario describes the consequences of non-coordinated, low profile climate policies
3. The ***Muddling Through & Europe Plus*** case represents the same settings but with a stronger effort in Europe
4. The ***Europe Alone*** case represents the outcome of a scenario in which only the European Union commits to strong targets (-80%)
5. The ***Global Regime*** explores a new world energy system, under strong emission constraint, consistent with the 2℃ target

Sensitivity studies and shocks

1. Oil and gas shocks
2. Nuclear accident + phase out
3. Problems in the diffusion of the CCS

IPCC AR4 categories and SECURE scenarios



SECURE scenarios, hypotheses and outcomes

	Carbon Price 2050 (€/tCO2)	Emissions 2050 / 1990	AR4 categories
Baseline	0	134%	Type VI (5-6℃) 700 CO2
Muddling Through	40 in Eur 32 in RoW	72% (EU: -21%)	Type IV (3-4℃) 500 CO2
MT E+	89 in Eur 32 in RoW	67% (EU: -40%)	Type IV (3-4℃) 500⁻ CO2
Europe Alone	185 in Eur 32 in RoW	59% (EU: -60%)	Type IV (3-4℃) 500⁻ CO2
Global Regime	392 in A1 257 in NA1	(2050/2000) -50% (Annex 1: -80%)	Type II (2-3℃) 400 CO2

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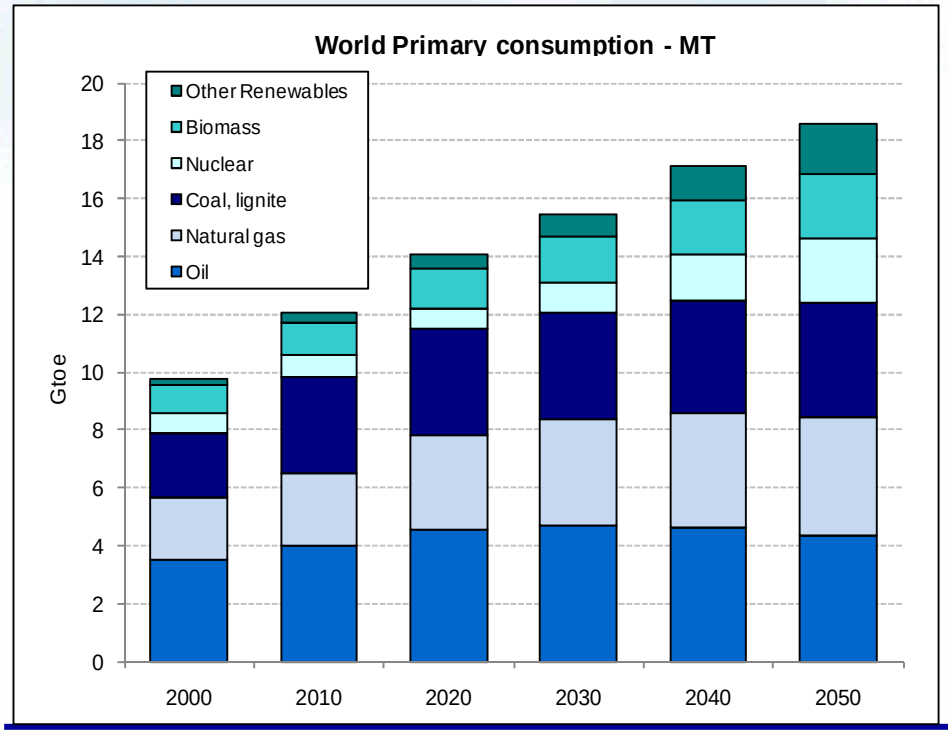
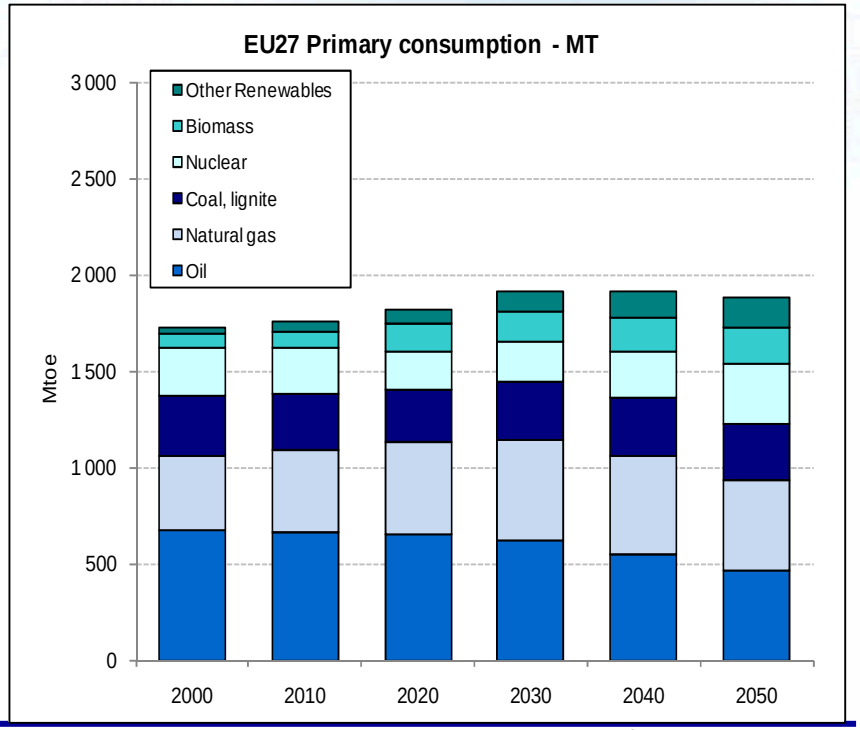
Unsustainability of the Muddling through

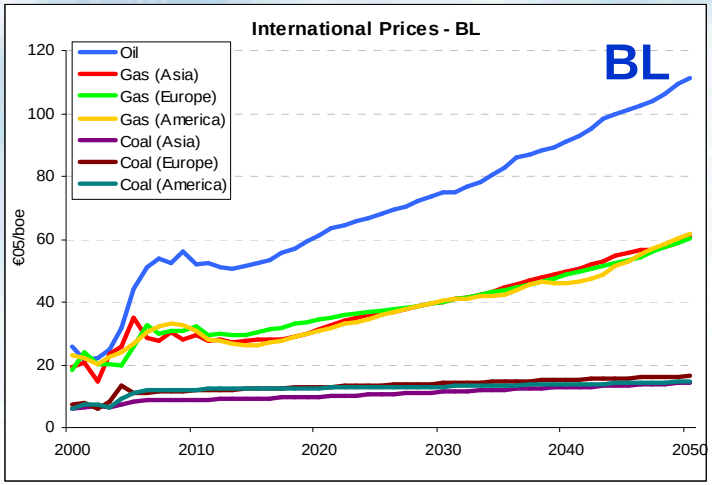
- In the MT case, Oil and Gas first increase but then peak in 2030 and 2040 and thus Coal nearly doubles, to 4 Gtoe in 2050
- For Europe, the dynamics in GIEC is much less pronounced with an increase from 1.7 Gtoe to only 1.9 Gtoe between 2000 and 2050. There again one notes a levelling-off of oil and gas consumption, the progress of renewable and the penetration of coal, although with a more modest magnitude than at world level.

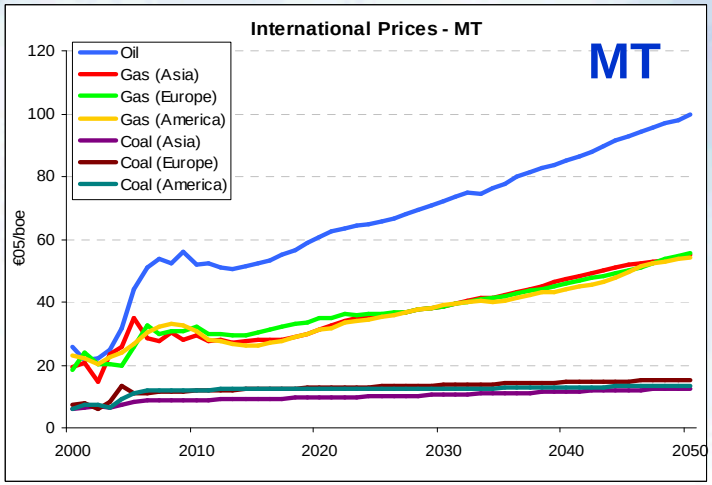


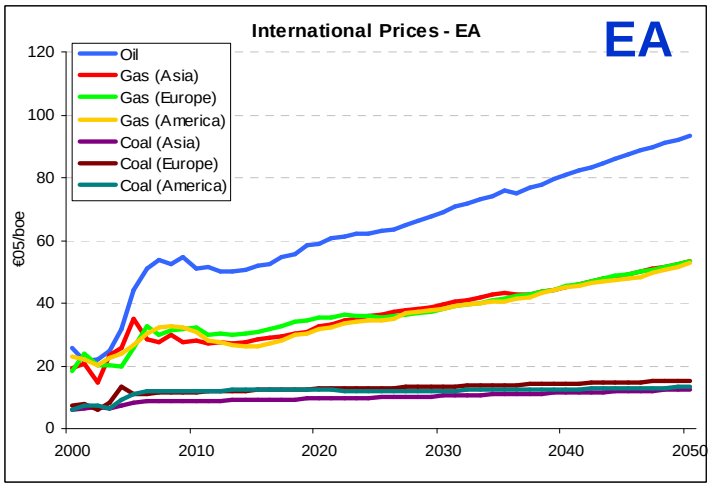


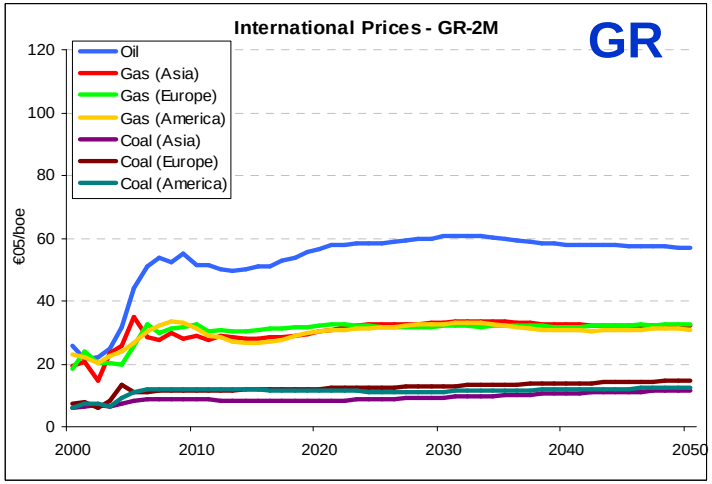
International energy prices

- In 2050, international oil and gas prices are about twice lower in the Global Regime than in the Baseline







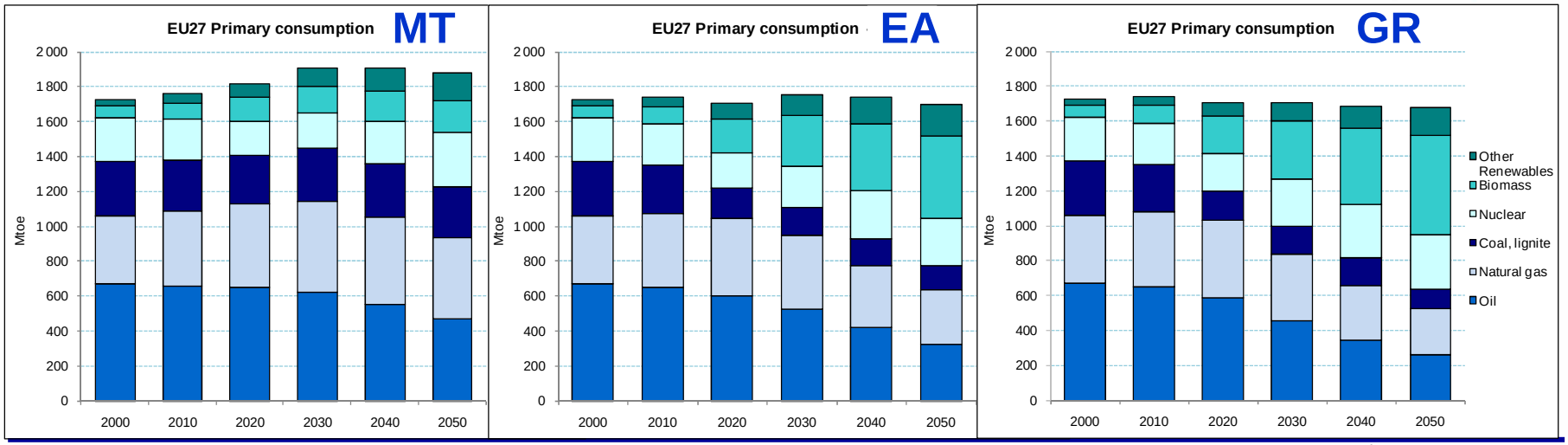


Global outcomes of the SECURE scenarios

- **The *Muddling Through* is not sustainable as it implies:**
  - a doubling of emissions in 2050 (5-6℃ profile)
  - extremely high production levels for oil and gas with risks of crises
- **The *Europe Alone* case somehow alleviate tensions, but it don't solve the twin energy and environment problems**
- **Only the *Global Regime* case can bring a sustainable energy system to 2050:**
  - an emission profile that is (almost) compatible with the 2℃ target
  - lower energy prices (60 €/bl, instead of more than 100)

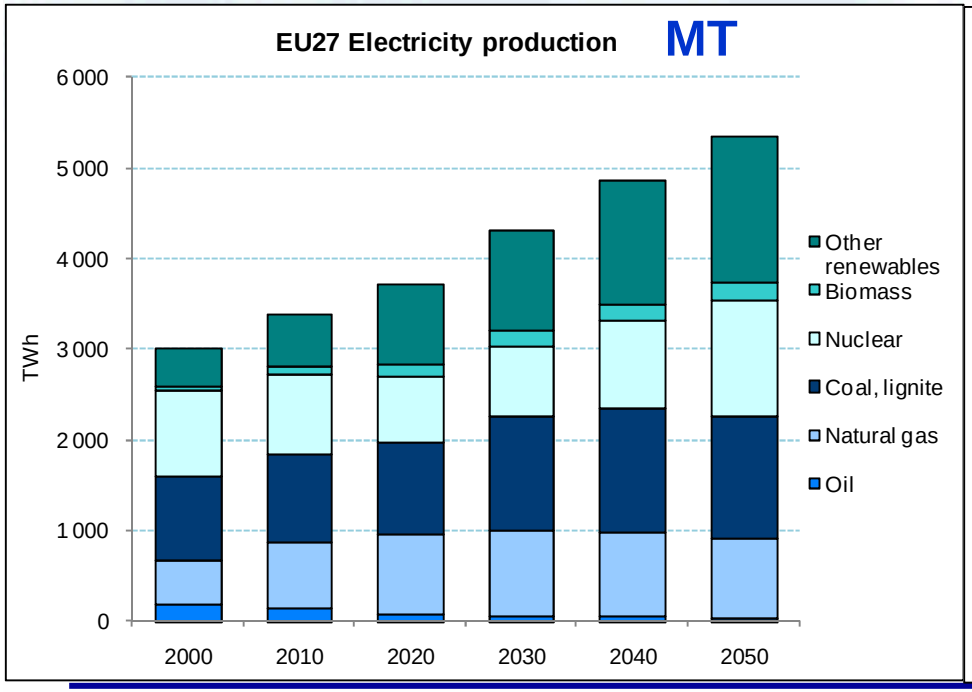
European primary mix by scenario

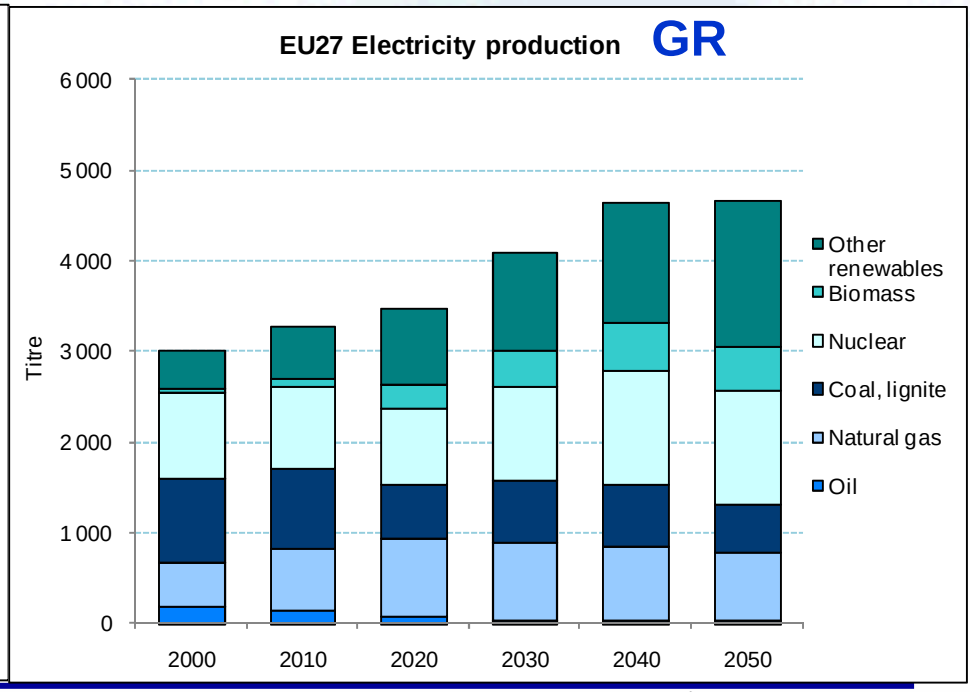
- In the Global Regime total demand is 11% lower in 2050 than in MT
- Non fossil sources represent almost two thirds of supply, compared to only one third in the MT
- Renewables double their their role in 2050 in GR compared to MT
- In terms of Primary consumption there are no very big differences between EA and GR



European electricity production by source

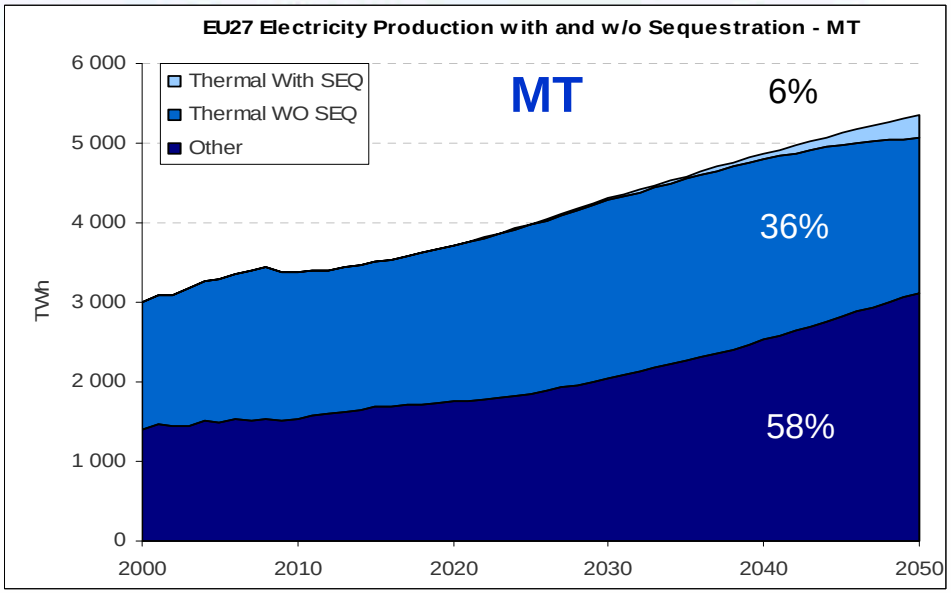
- A strong carbon constraint induces more nuclear and renewables and triggers a substitution of coal-based by biomass-based generation while CCS develops
- Natural gas power generation is hardly impacted too

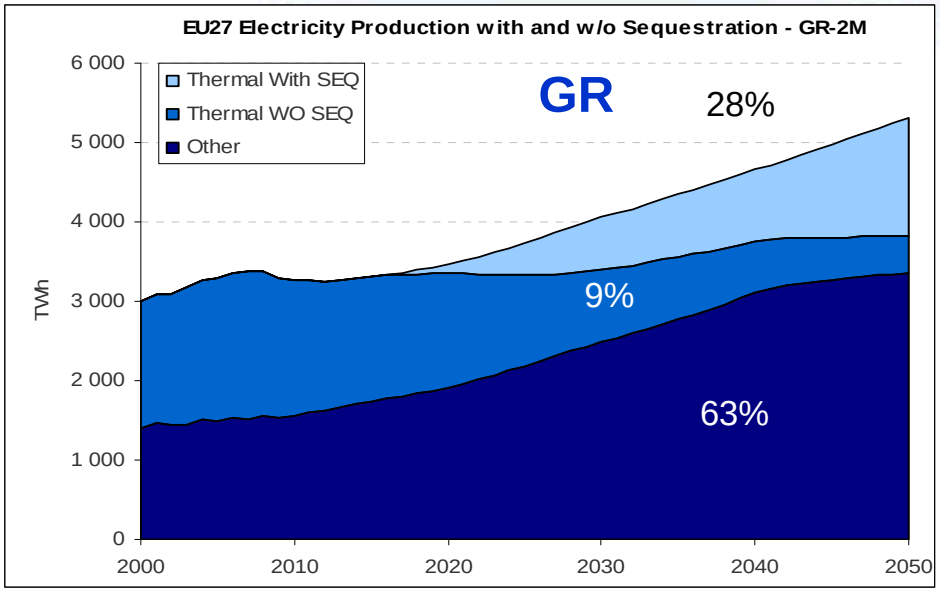




European electricity production: CCS

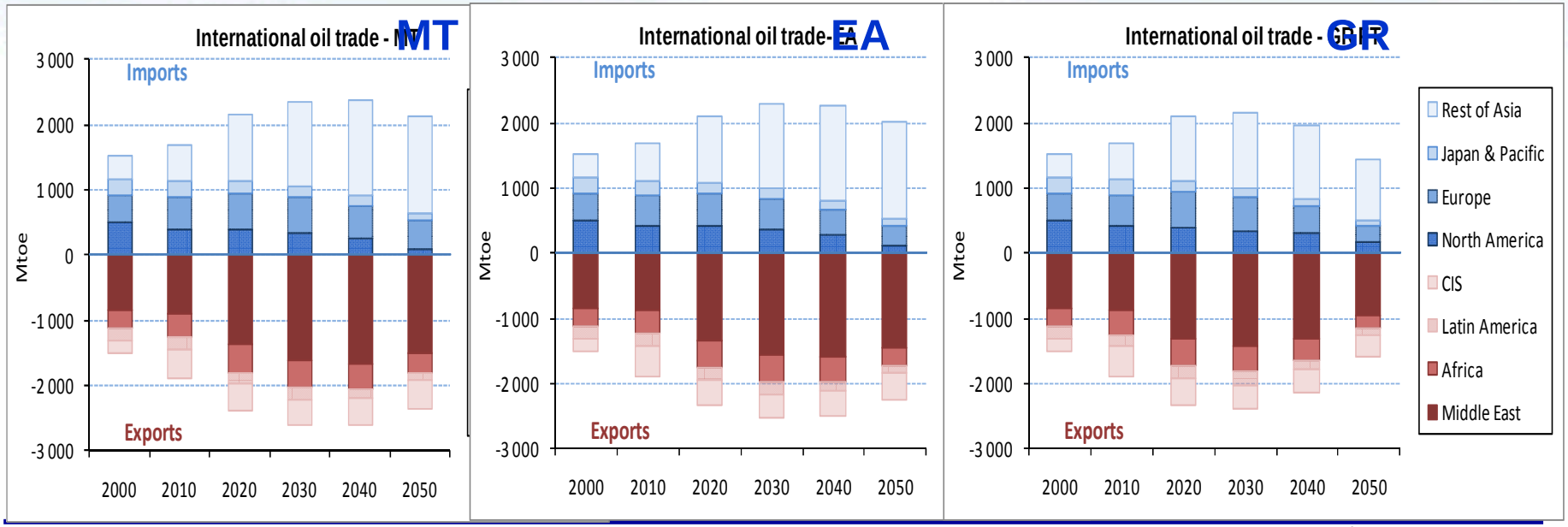
- The share of non fossil production increases sooner in the global regime case
- … and thermal production with CCS increases dramatically just after 2020, when the emission constraint is reinforced
- This poses the problem of the industrial capability of industry to bring in CCS at such a high speed





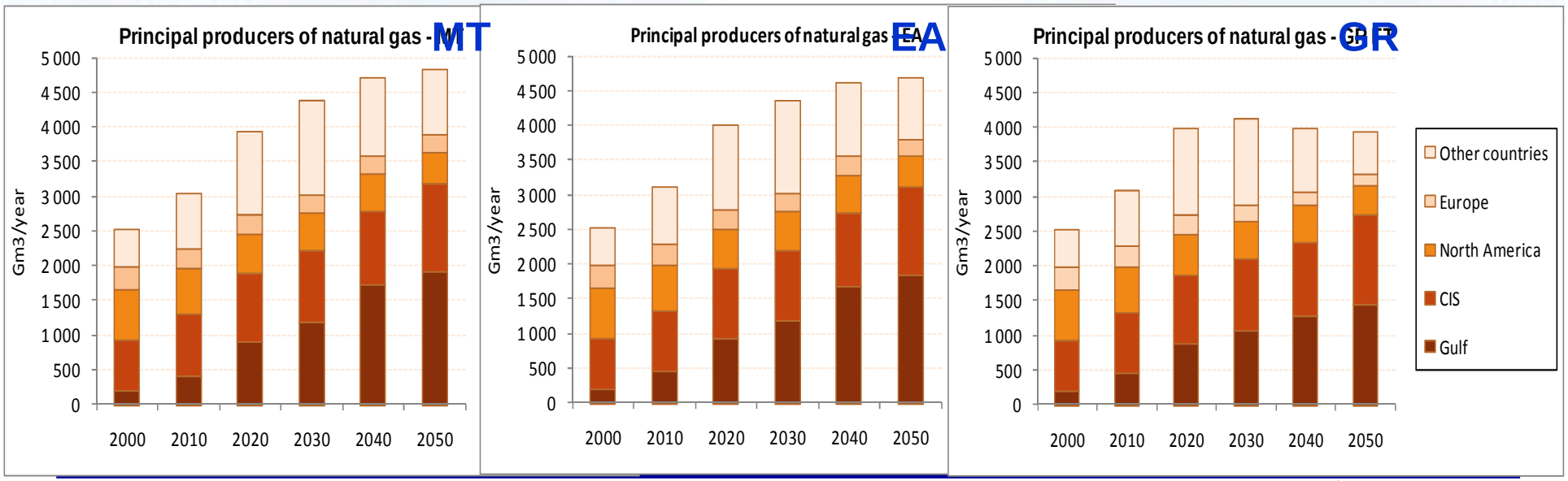
International oil trade

- *Oil exports of the four structurally exporting regions are doubled in 2030 compared to 2000,*
- *The situation in 2050 is to a large extent a return to 2000 situation, with almost unchanged market shares a maintained dominance of the Middle East in total exports*



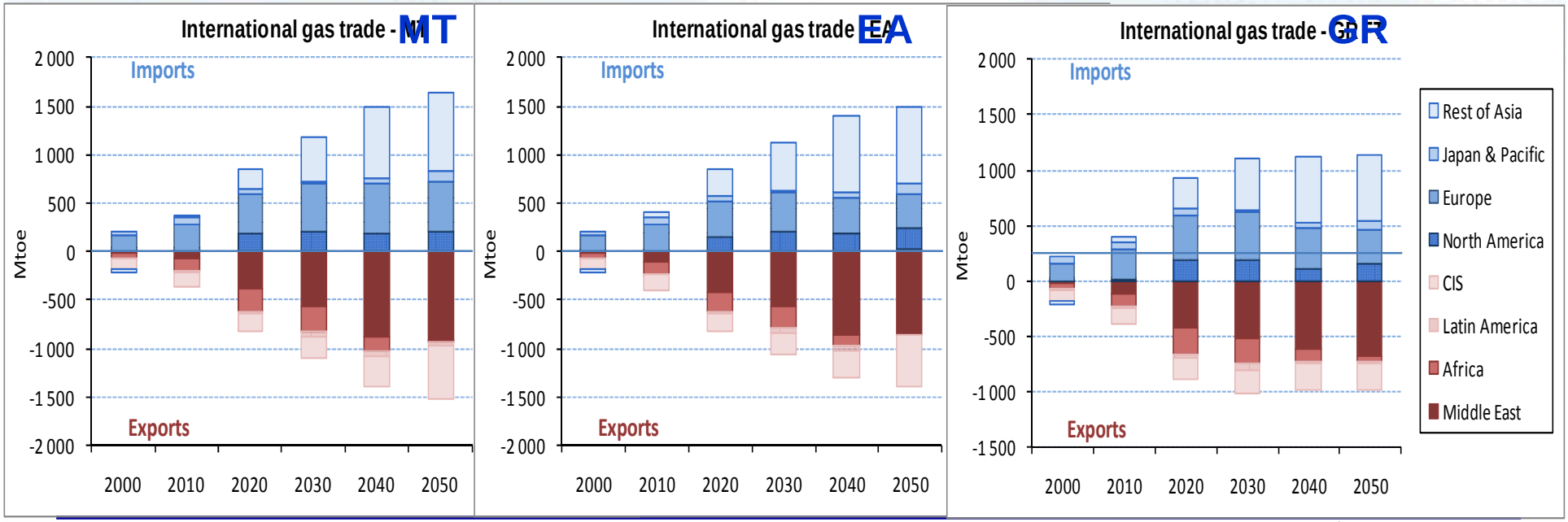
Principal producers of natural gas

- *In the MT case, contrarily to the oil situation, there is no peak gas before 2050, and by that date world gas production is about twice that of 2000, with 4.8 Bcm.*
- *The Gulf and CIS regions represent an increasing share of world production in the future, as European and North American production decrease in absolute terms.*
  - *In particular, gas production in the Gulf region increases from 0.4 Bcm in 2010, to 1.9 Bcm in 2050.*
- *Again, the EA case doesn't introduce noticeable changes at world level.*
- *Only in the GR case is world gas production significantly impacted: a significant increase in world gas production, from 3 Bcm in 2010 to 4 Bcm in 2050.*
- *The Gulf region and CIS are the main world suppliers, with each 35 % of total world gas production.*



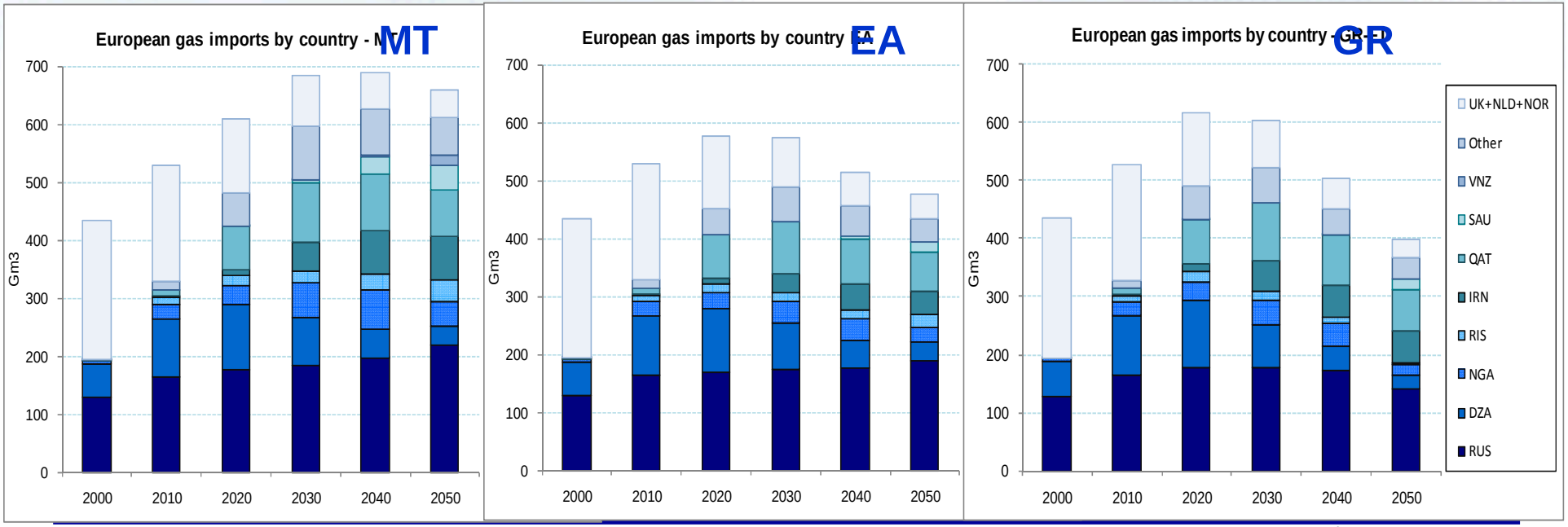
International gas trade

- *Inter-regional trade in gas increases considerably in the Muddling Through scenario from 0.2 Gtoe today to 1.5 Gtoe in 2050 (These figures exclude intra-regional trade).*
  - *The Middle East and the CIS are by far the largest exporters in 2050.*
  - *The principal importing regions in 2050 are Asia, Europe and to a lesser extent North America;*
  - *Africa is self-sufficient for its gas supply.*
- *The decrease of the gas demand in other scenarios is accompanied by reduction of the imports to 1 Gtoe in 2050 in Global Regime.*



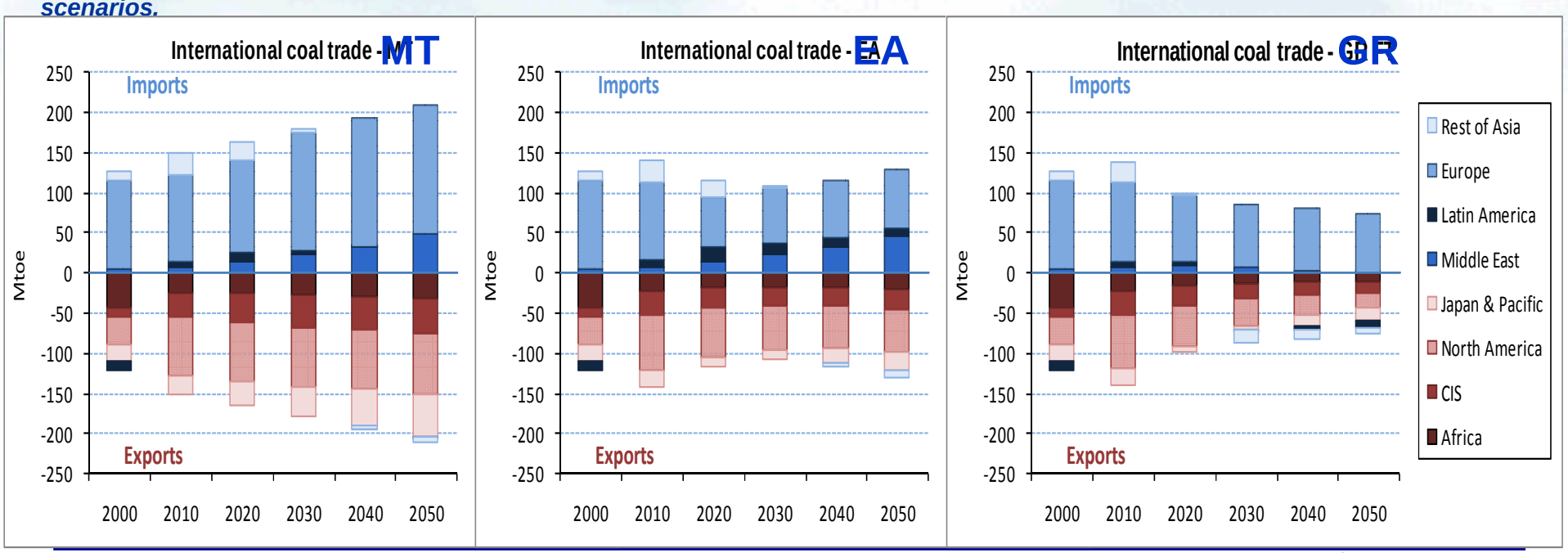
Europe's natural gas supplies

- *Domestic production drops over time and as imports stabilize after 2040 at a level triple of today MT.*
- *They peak in 2020 and then decrease in the EA and GR cases*
- *In the MT sc, total Western Europe gas imports are expected to increase dramatically over the next decades, from 200 to 650 Bcm in 2050.*
- *This happens, in spite of a total demand that is levelling-off at about 700 Bcm between 2030 and 2040, but this is due to the reduction in regional domestic production from Norway, UK and Netherland, which are divided by a factor of almost four between 2000 and 2050, from 240 to 50 Bcm.*
- *While supply from Russia increases from 130 Bcm to 219-226 Bcm in these two scenarios, European gas supply also increasingly depends from new supplies from Nigeria, the Community of Independent States (mostly Kazakhstan) and Iran.*



International coal trade

- *International coal trade doubles over the projection period in the MT. The high volume of trade reflects the strong comeback of coal in a double context of relative scarcity and high prices of oil and gas, accompanied by only moderate GHG emission constraints.*
- *The situation changes in the EA and GR scenarios. Coal trade remains almost stable during the period in the Europe Alone scenario and it even decreases compared to current levels in the Global Regime scenario.*
- *Europe remains the major importer, representing more than 80% of net imports during the whole period in all scenarios, but the Europe Alone case in which other world region continue to intensively use coal.*
- *However, European coal imports shrink from MT scenario to the others, due to changes in the structure of the electricity generation and final consumption in favour of decarbonised energies and cleaner technologies.*
- *The four main exporting regions are North America, the Pacific, Africa and the CIS. Because of the rapid growth in consumption, Asia becomes a net importer late in the period. Their share remains nearly stable, while the volume diminishes in the EA and GR scenarios.*



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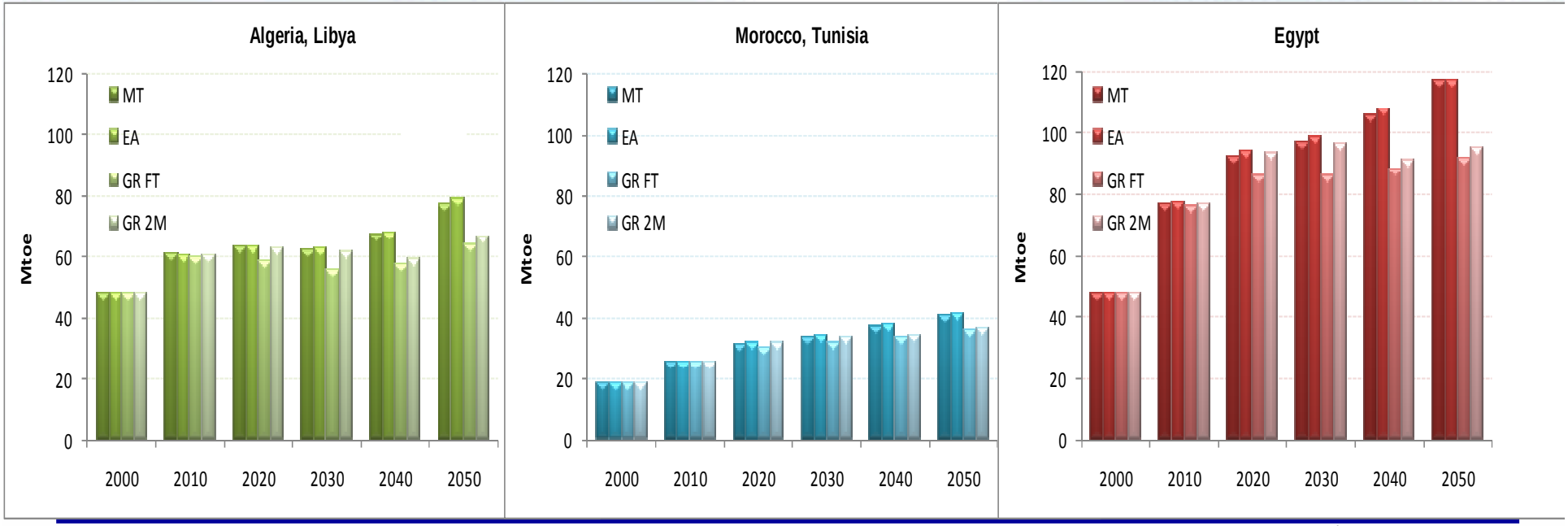
Impacts of scenarios on European imports

Looking into the future : EU and its Southern Neighbours

1. "Muddling Through" sc. maybe the most probable, but not the most desirable scenario from the climate perspective
2. Major uncertainties remain on European supply: after 2030, this scenario supposes 400 Bcm from other regions (mostly Iran and Middle-East); other hypotheses may raise dependence problems
3. "Europe Alone" sc is plausible if Europe sticks to its climate policy while the RoW doesn't follow.
4. "Global Regime" is a desirable for climate but low probability scenario
5. As for the other world regions this scenario supposes a « paradigm shift » in the energy system, with low consumption and low fossil production

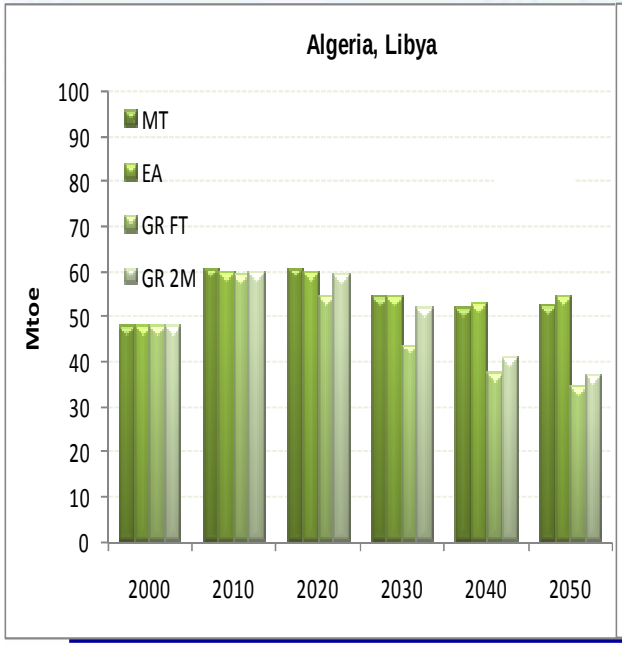
South Mediterranean primary consumption by scenario

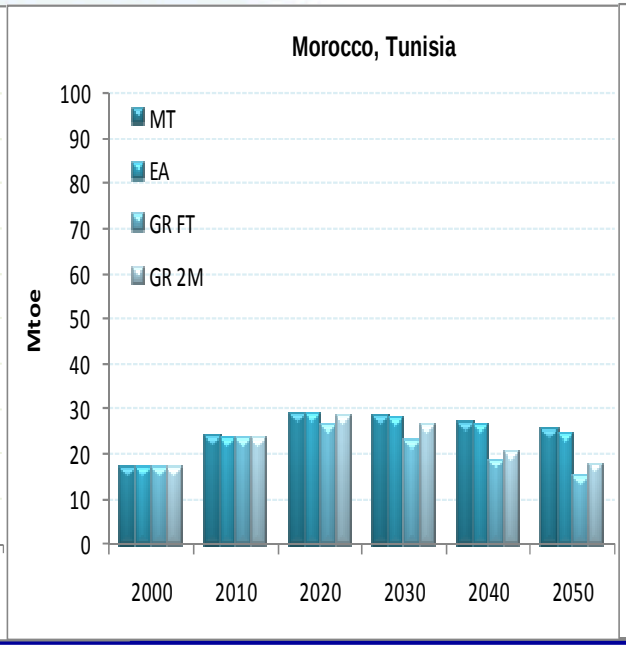
- Egypt, Tunisia and Morocco more than doubles their primary consumption by 2050 in MT and EA sc., while Algeria and Libya increase more slowly.
- In the Global Regime total demand is -22 (-19)% , -12 (-11%) and -14% (-14%) lower in 2050 than in MT
- In terms of Primary consumption there are no very big differences between EA and GR

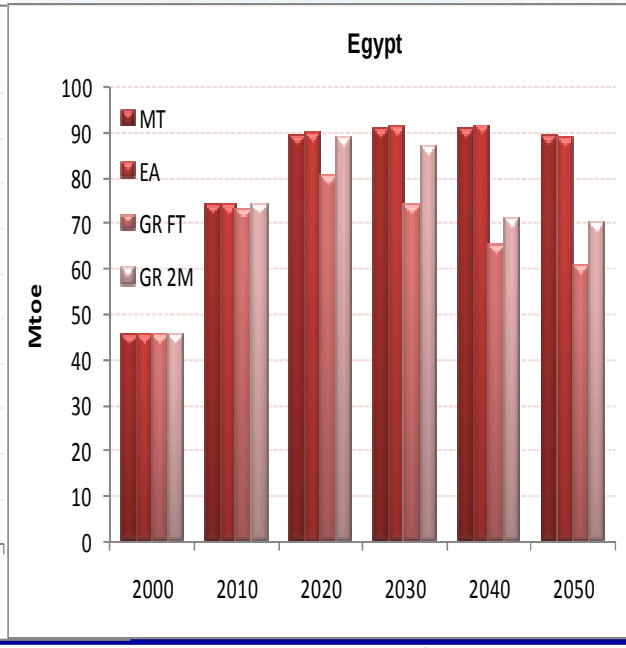


South Mediterranean primary fossil consumption by scenario

- Fossil fuels represent more than 92% of primary consumption for these countries
- Fossil fuels remain relatively stable during the period in the sc. MT and EA.
- In the Global Regime fossil demand decrease by more than 25% in the end of the period.

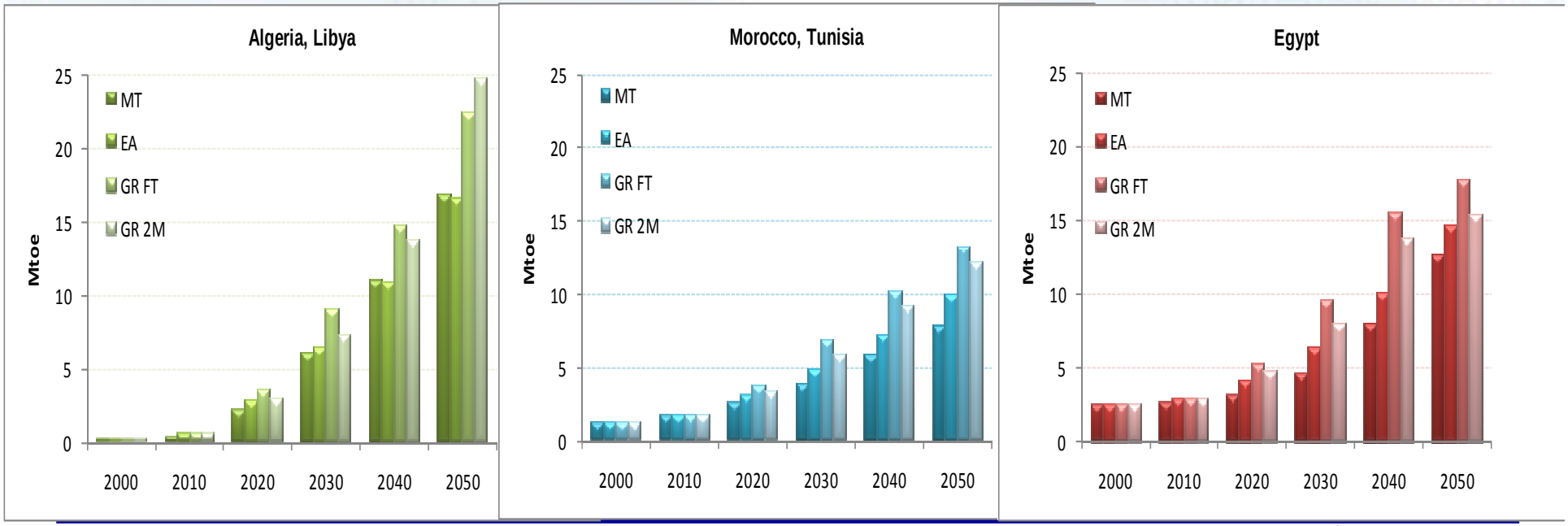






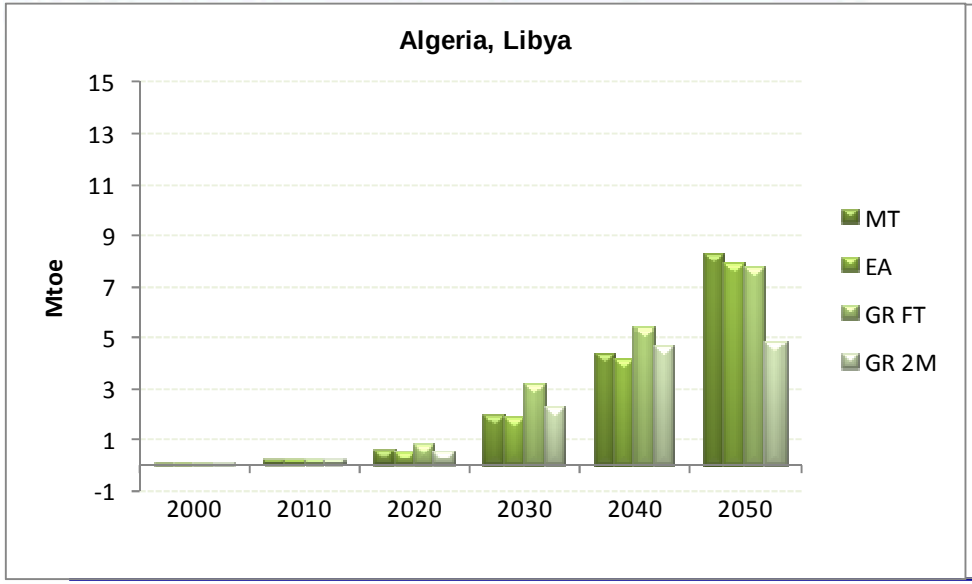
Renewables in South Mediterranean countries by scenario

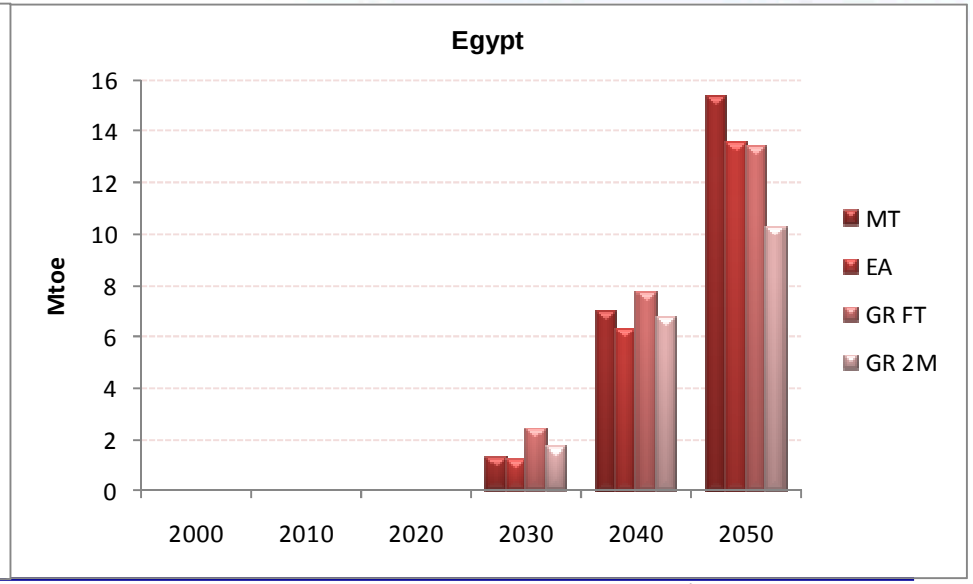
- Renewables increase considerably in all scenarios and all countries
- At the end of the period renewables represent 21-37% of TPC in Algeria, Lybia according the scenarios; 19-37% in Morocco, Tunisia ; and 11-19%



Nuclear in South Mediterranean countries by scenario

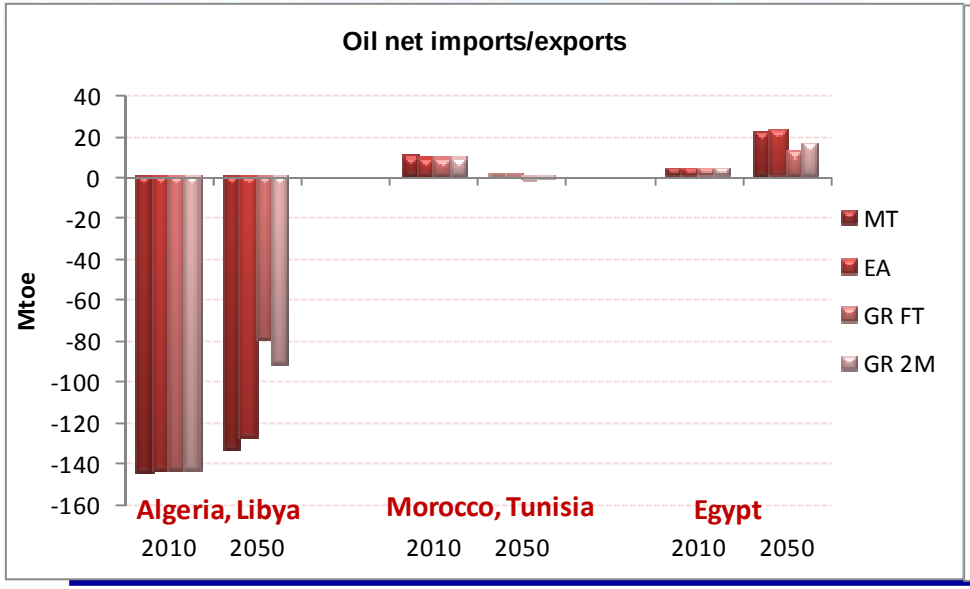
- Nuclear energy is prospected to appear after 2020 in Egypt, Algeria&Libya
- In MT the increase seems more important than in other scenarios.
- The share of the nuclear in TPC is prospected to represent respectively 11 and 13% in MT sc.and 7 and 11% in GR 2M

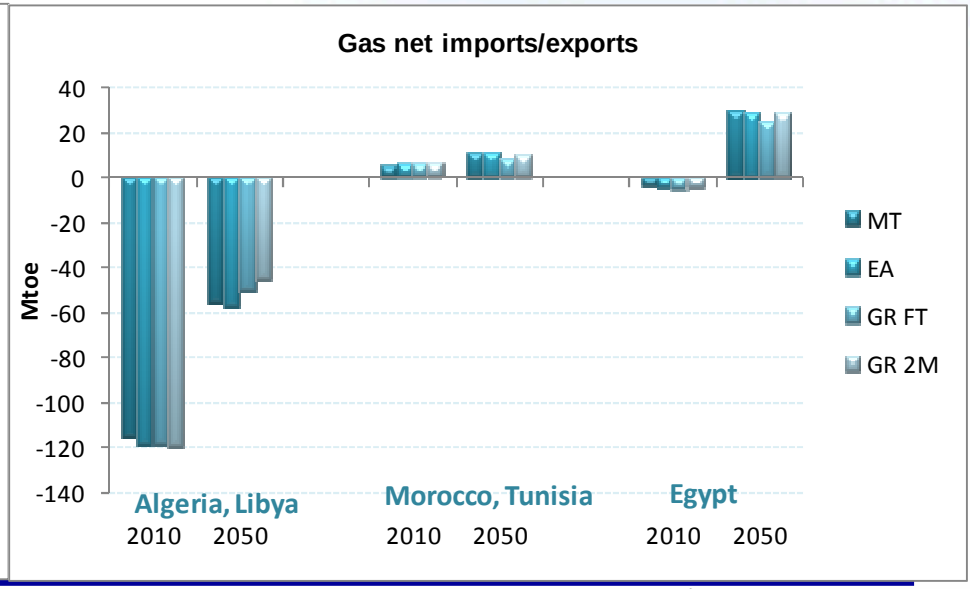




Oil and gas net imports/exports in South Mediterranean countries by scenario

- Algeria&Libya remains net exportes of oil and gas during the whole period whith decreasing amounts according the scenarios
- Egypt remains net exporter of natural gas up to 2035.





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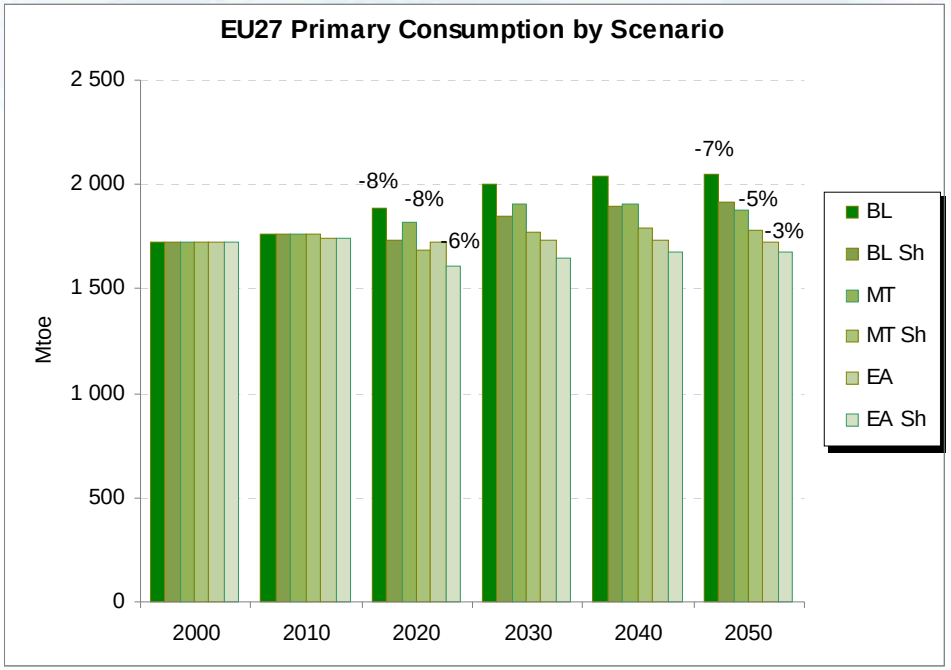
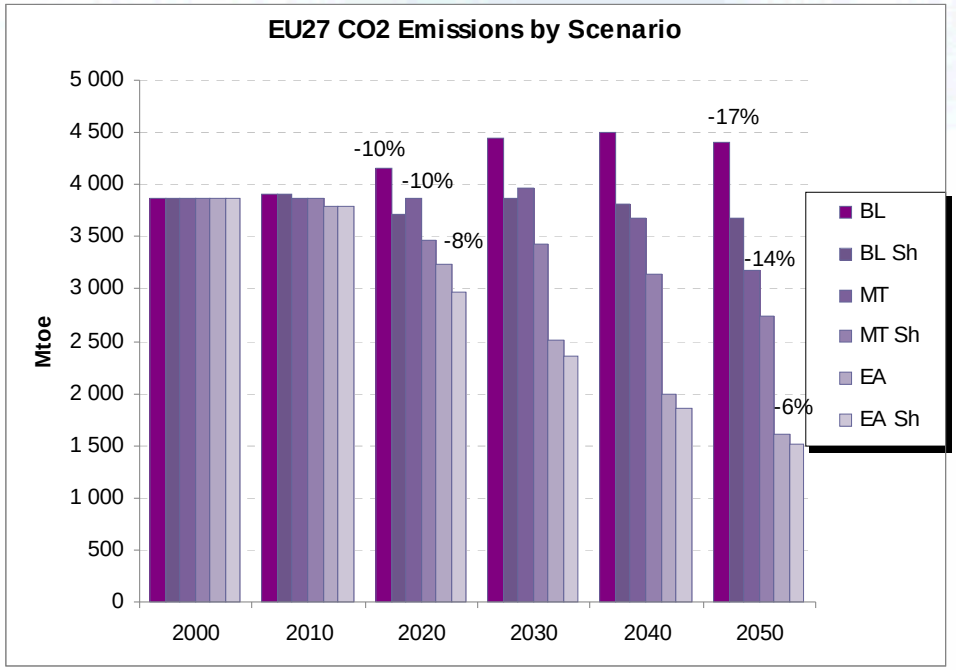
Impact of Oil&Gas shock

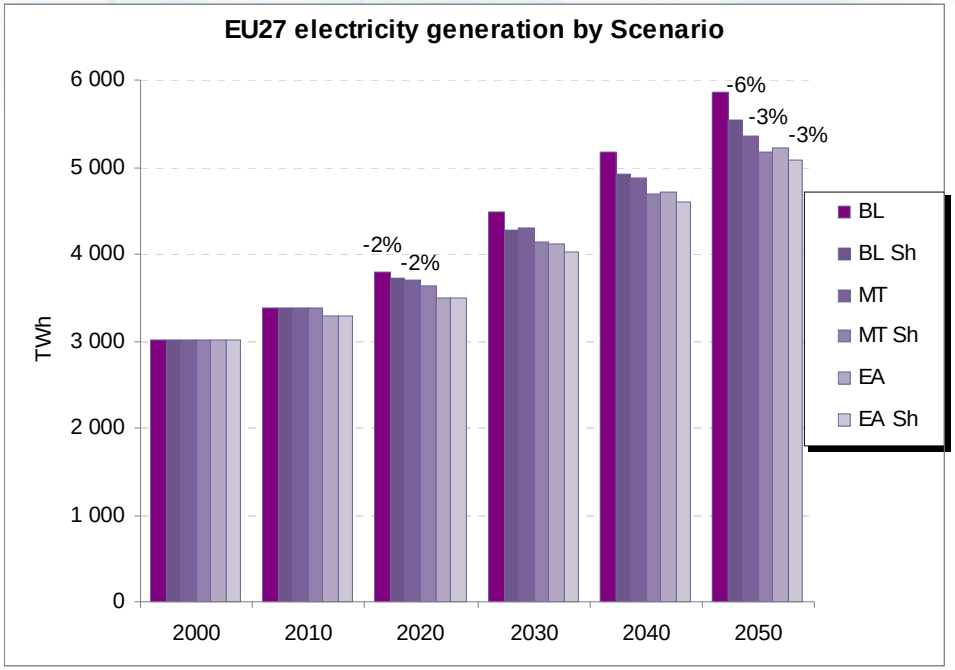
- Assumption : oil & gas price are multiplied by 3 in 2015
- -6% to -8% the impact on primary consumption in Europe in 2020 and from -3% to -7% in 2050
- -8% to -10% for CO2 emissions in 2020 and from -6% to -17% in 2050 for BL sh and EA sh

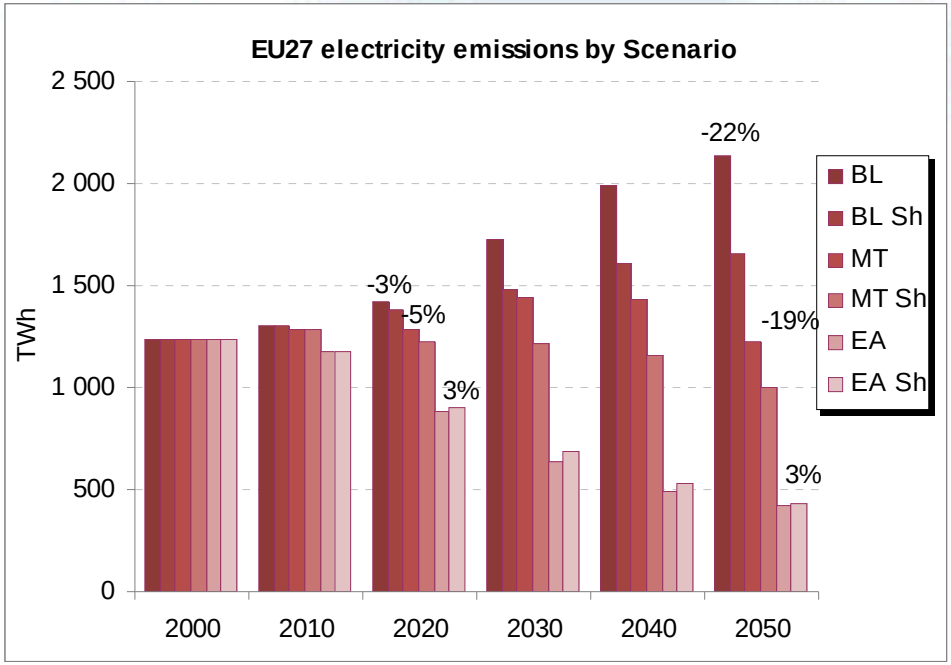




Impact of Oil&Gas shock

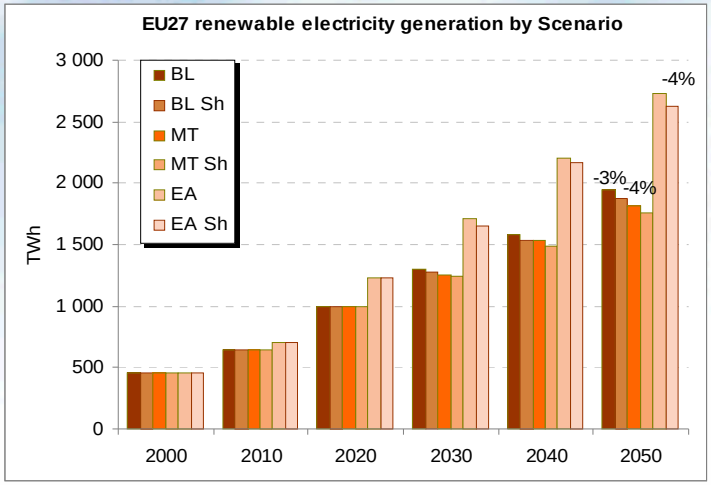
- The impact on total EU electricity generation is weak,-2% in 2020 and from -6% to -3% in 2050
- However the impacts on the electricity emissions are more visible, particularly in 2050.
- This situation results from important impacts on electricity mix.

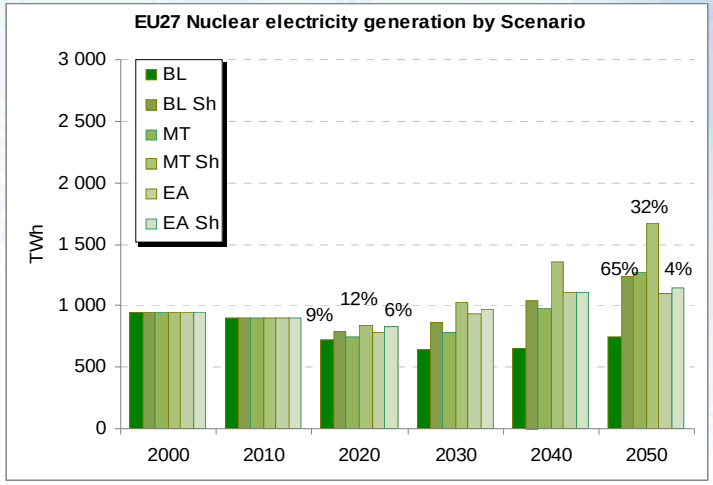


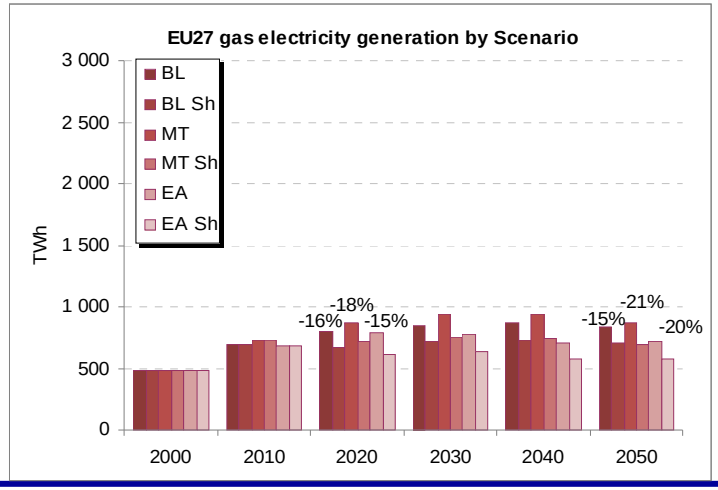


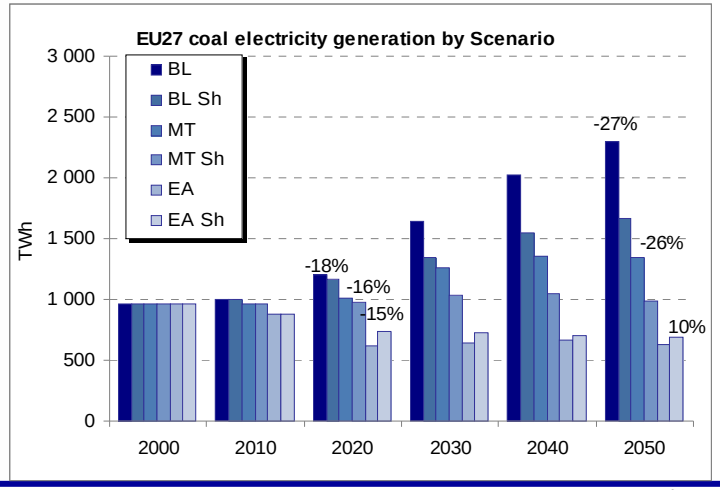
Impact of Oil&Gas shock on the electricity mix

- The mix of EU27 electricity generation is impacted significantly promoting nuclear and handicap the others



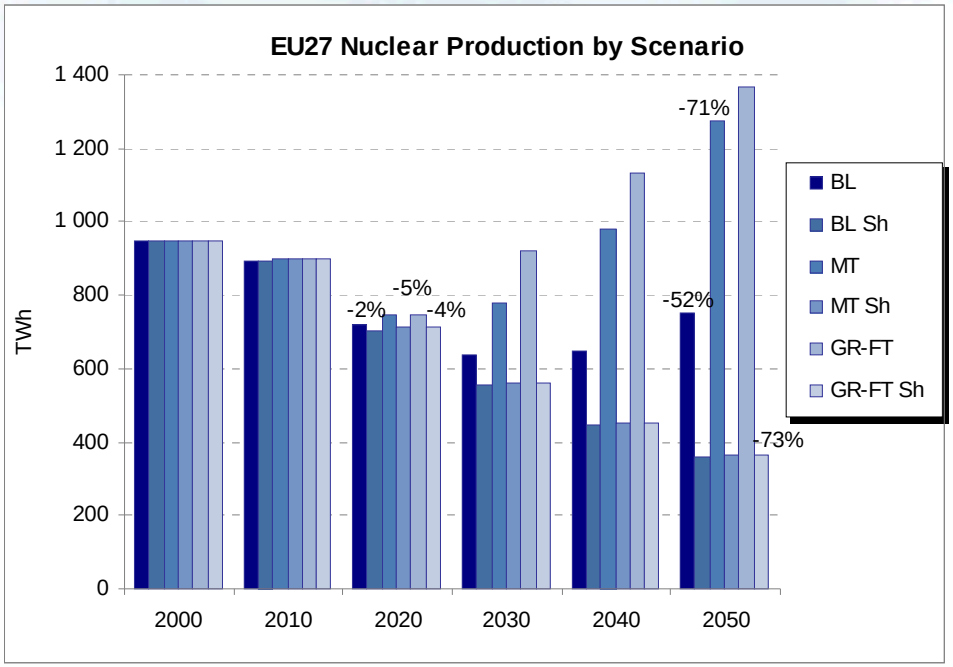


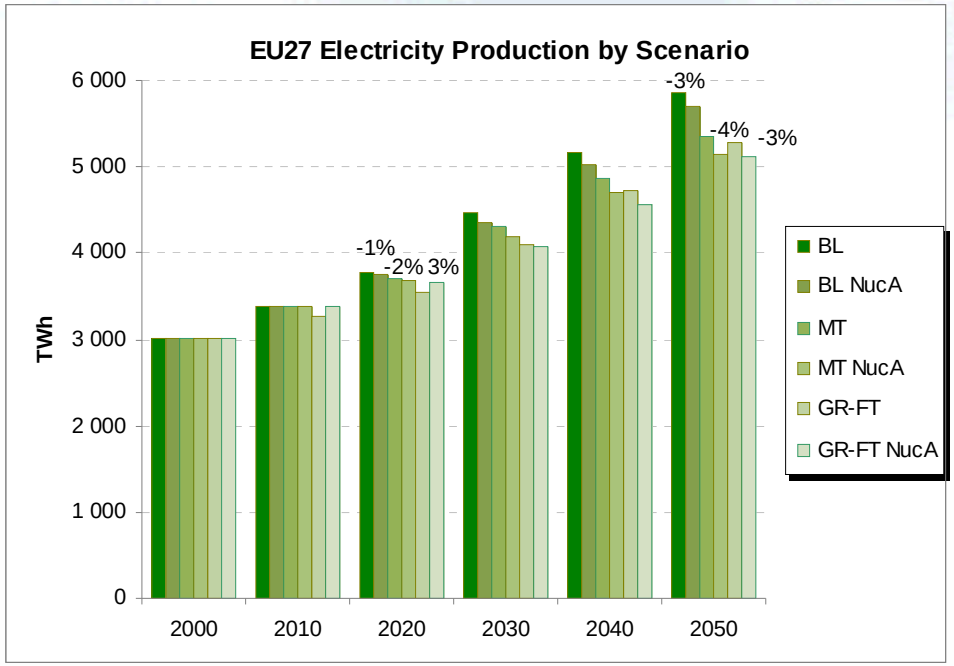




Impact of Nuclear accident + Phase-out

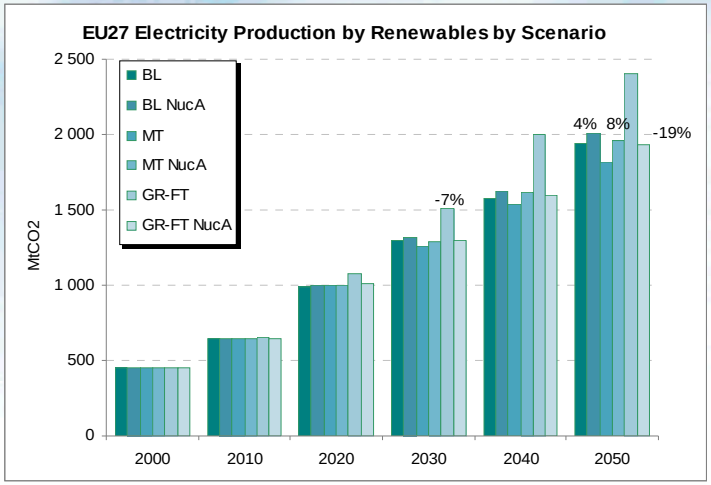
- Assumption : nuclear accident in 2015 => no more new capacities + normal phase out
- No significant differences of nuclear production in Europe in 2020, but cutting by more then three in 2050.
- In global level EU27 electricity production decrease slightly (3%, 4% and 3% in BL Sh/BL, MT SH/MT, GR-FT Sh/ GR-FT in 2050)

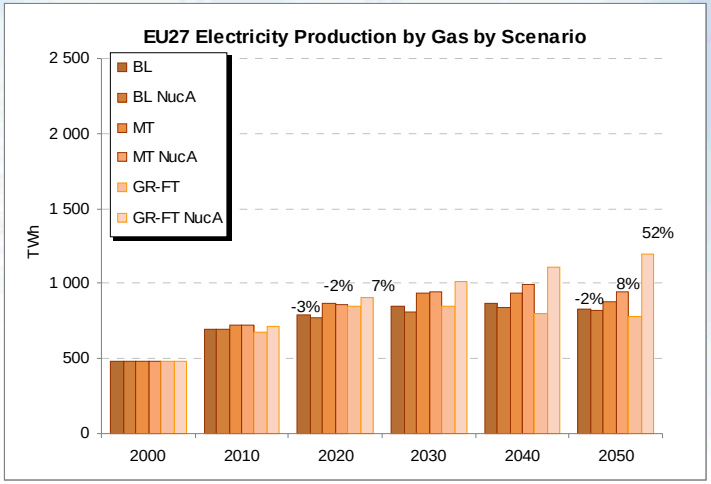


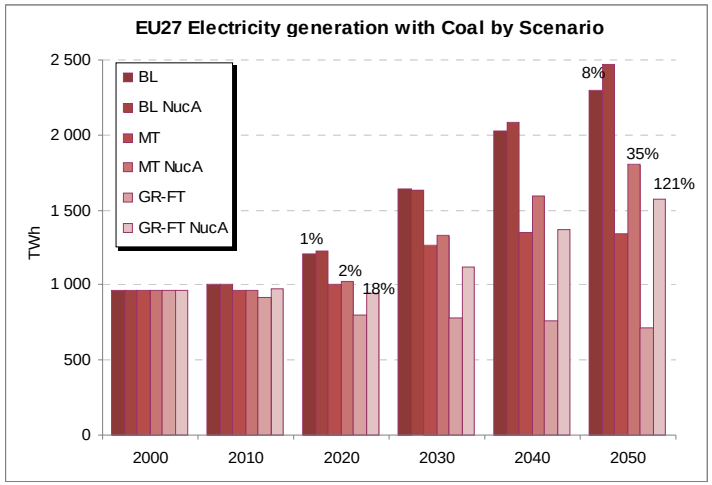


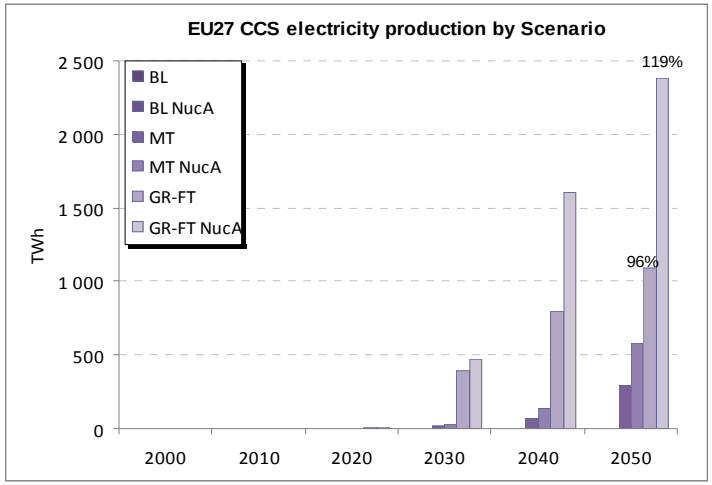
Impact of Nuclear accident + Phase-out

- Important impact on EU27 electricity mix
- Increase of fossil share (coal & gas), also of CCS (incl bcs).



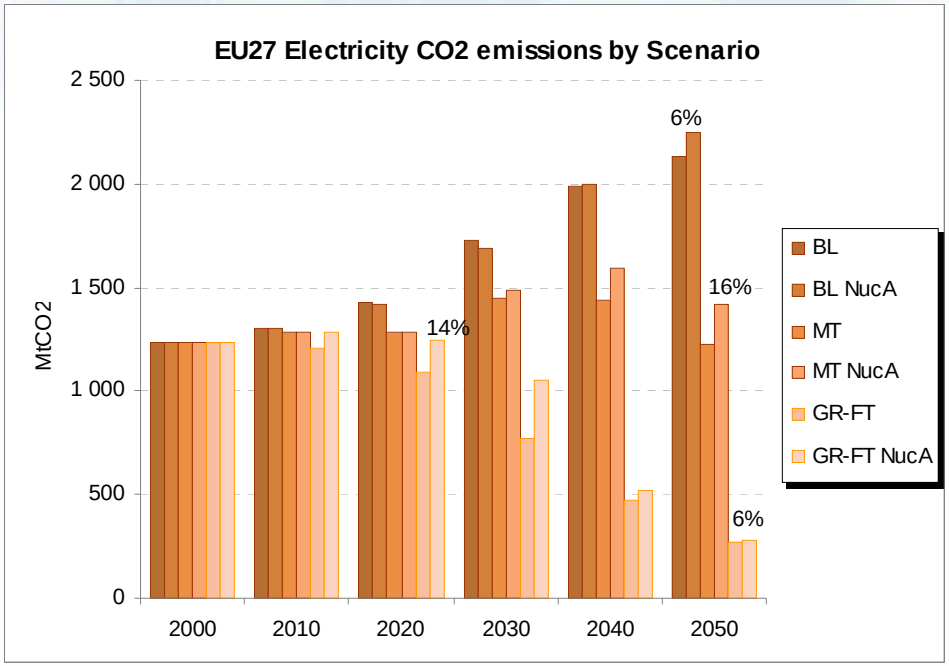


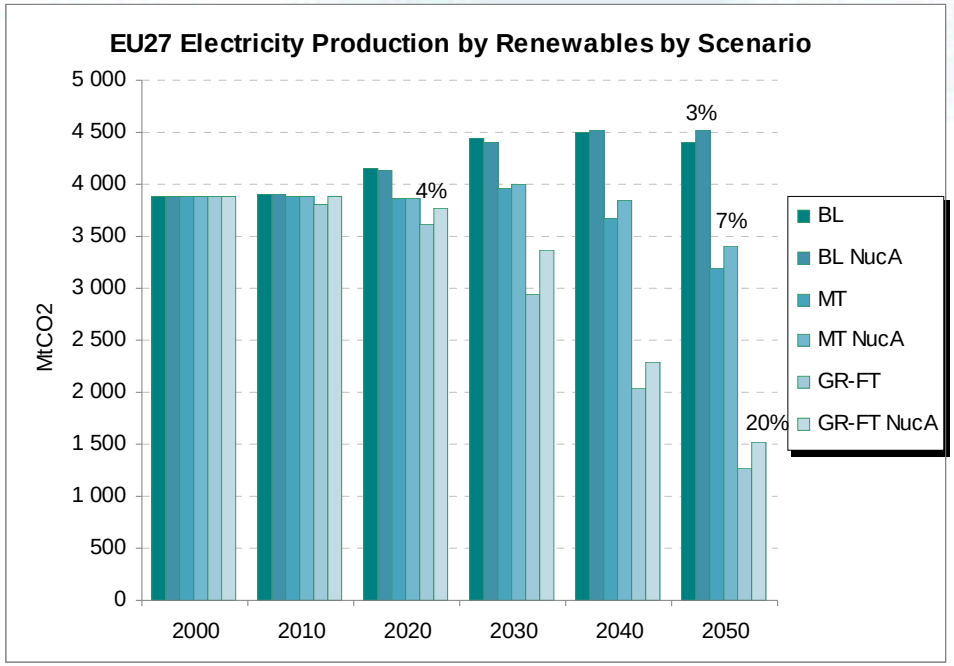




Impact of Nuclear accident + Phase-out

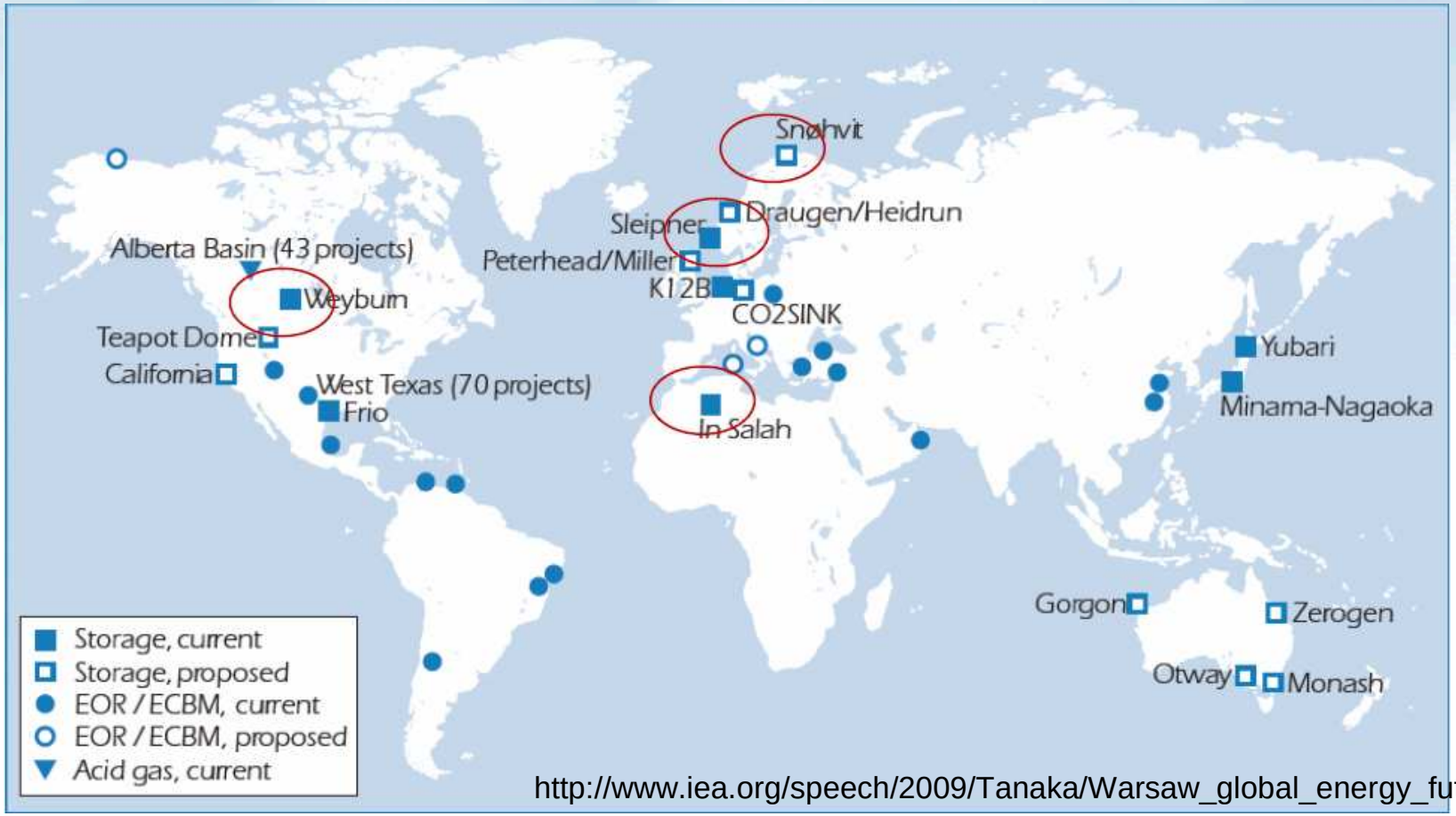
- CO2 emissions from electricity generation increase respectively 6%, 16% and 6% in BL Sh/BL, MT SH/MT, GR-FT Sh/ GR-FT
- While total CO2 emissions increase respectively 3%, 7% and 20% in BL Sh/BL, MT SH/MT, GR-FT Sh/ GR-FT
- Emissions from BCS are deducted, that explains the low increase of the emissions from electricity in GR-FT Sh/ GR-FT in 2050.





Carbon Capture and Storage

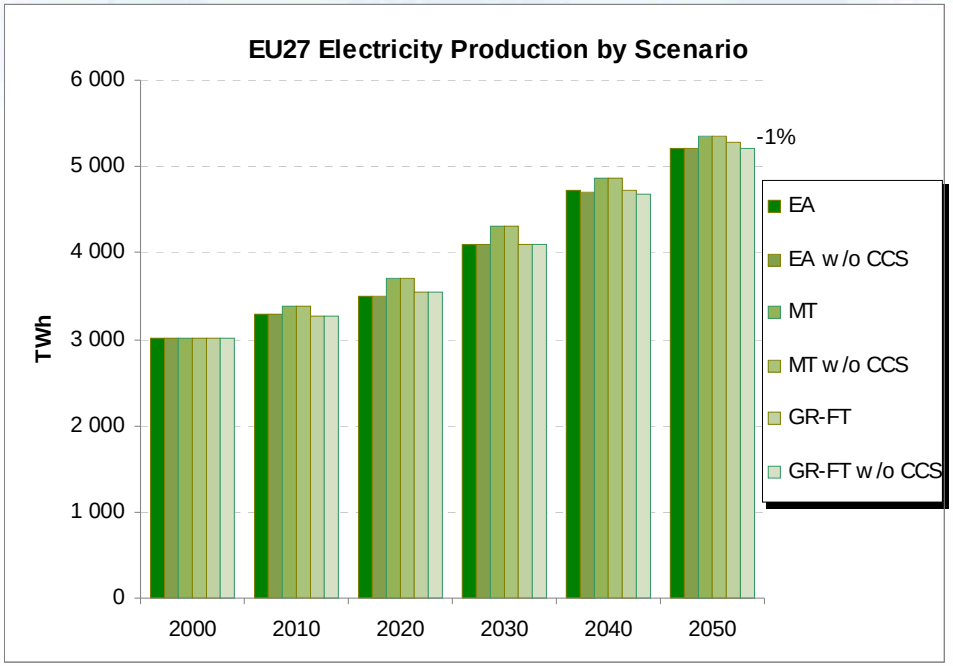
- Only 4 full-scale projects exist today
- G8 goal: 20 full-scale demonstrations announced by 2010

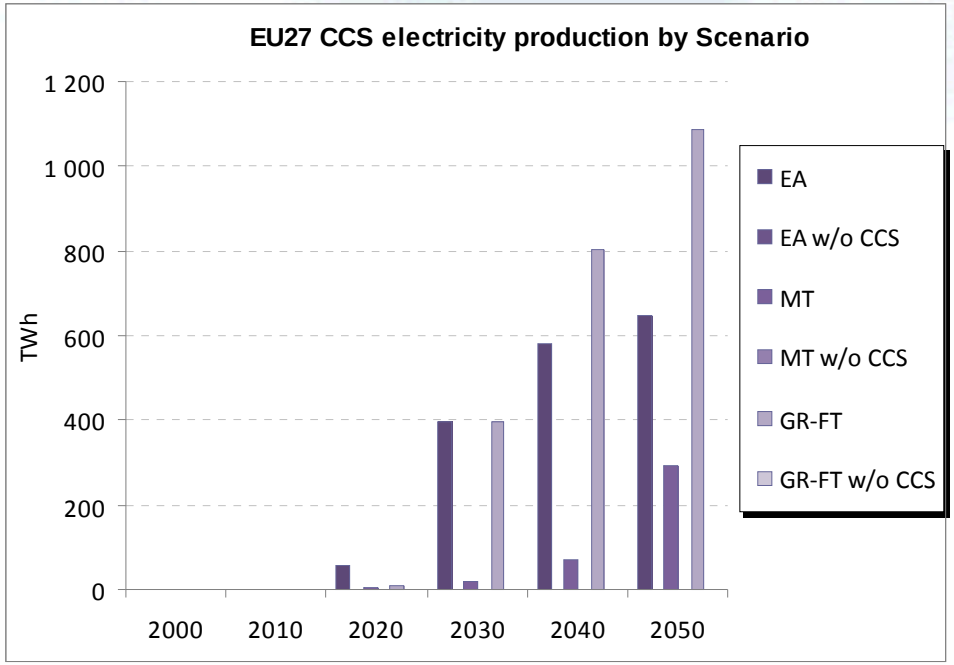


http://www.iea.org/speech/2009/Tanaka/Warsaw_global_energy_future.pdf

Barriers to Safe and Cost Effective Deployment of CCS

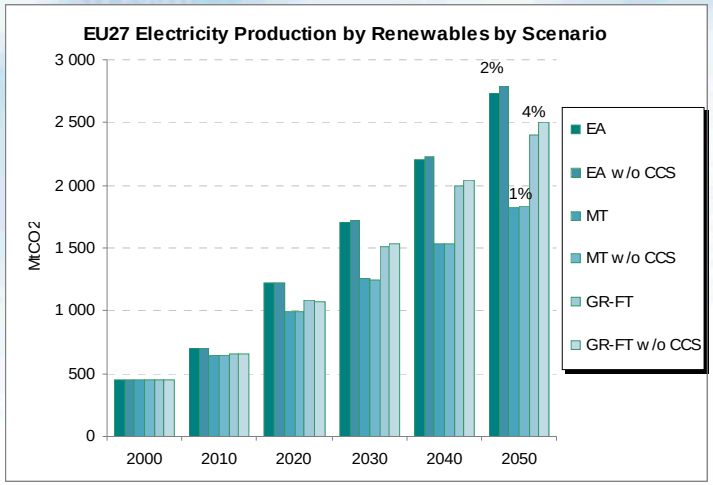
- Assumption : No Deployment of CCS.
- In global level, EU27 electricity production does not change
- In 2050 647, 295 and 1089 TWh must be replaced by other technologies respectively in EA w/o CCS, MT w/o CCS and GR-FT w/o CCS.

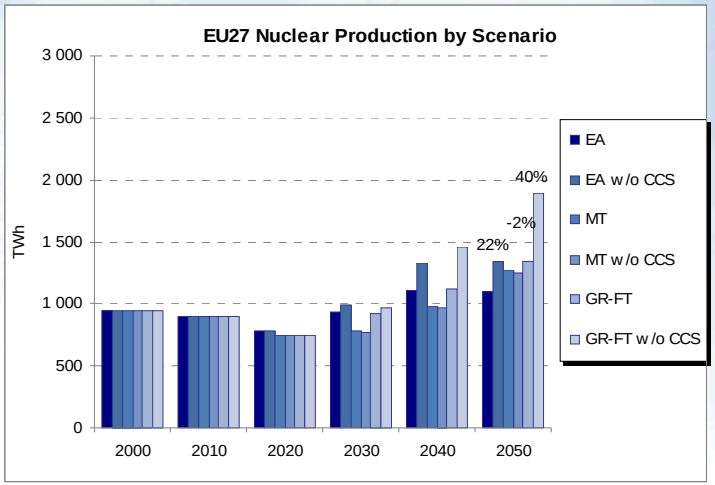


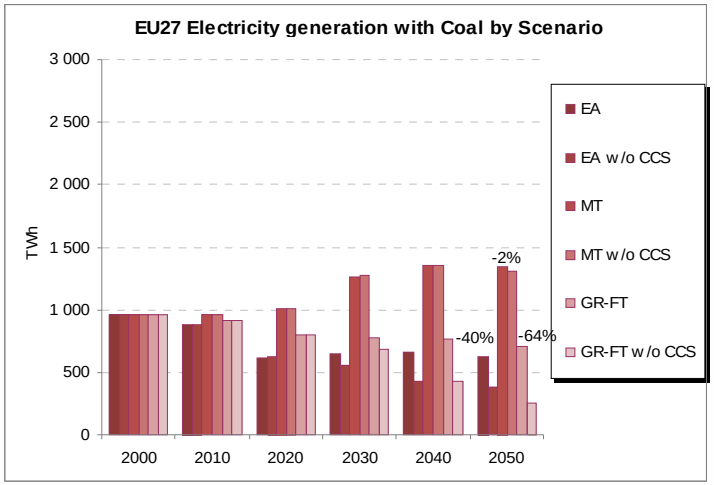


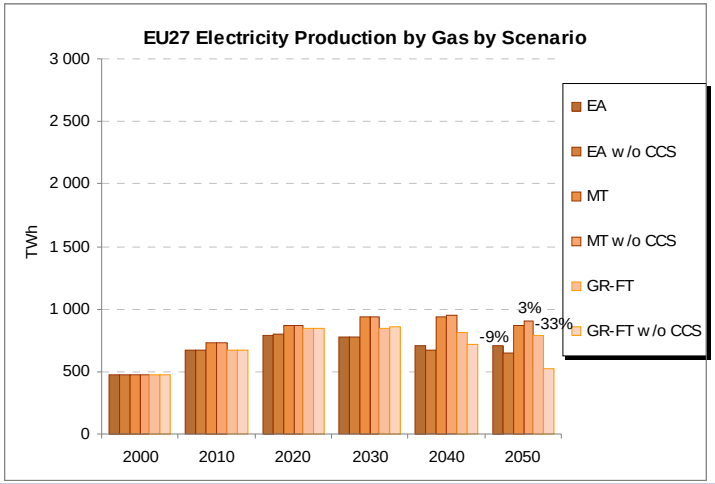
Barriers to Safe and Cost Effective Deployment of CCS

- Important impact on EU27 electricity mix
- Fossil fuels decrease considerably, weak impact on renewables, so the increase of nuclear replace the lack of CCS .



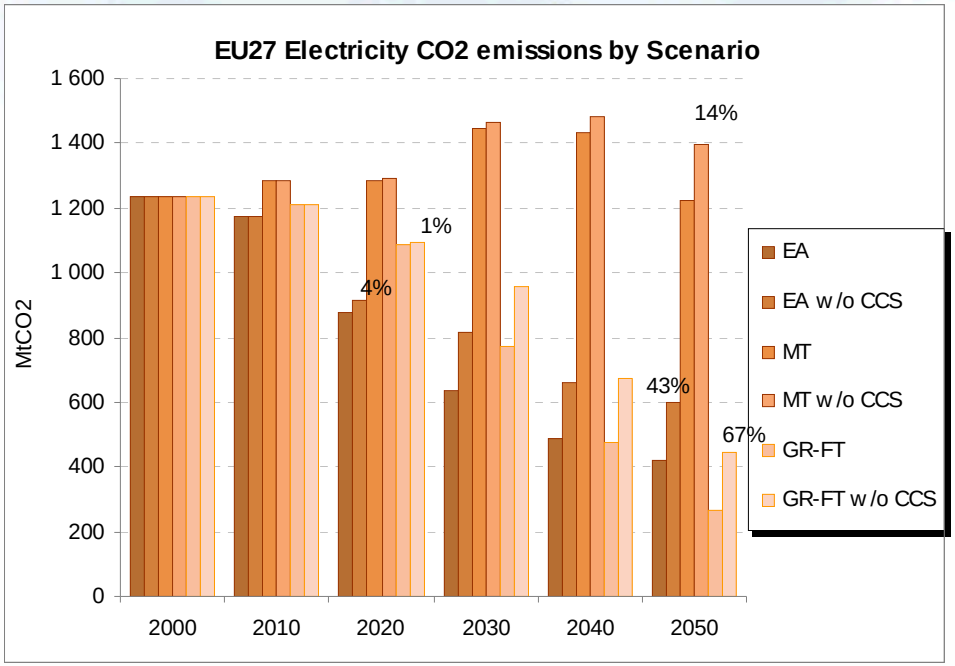


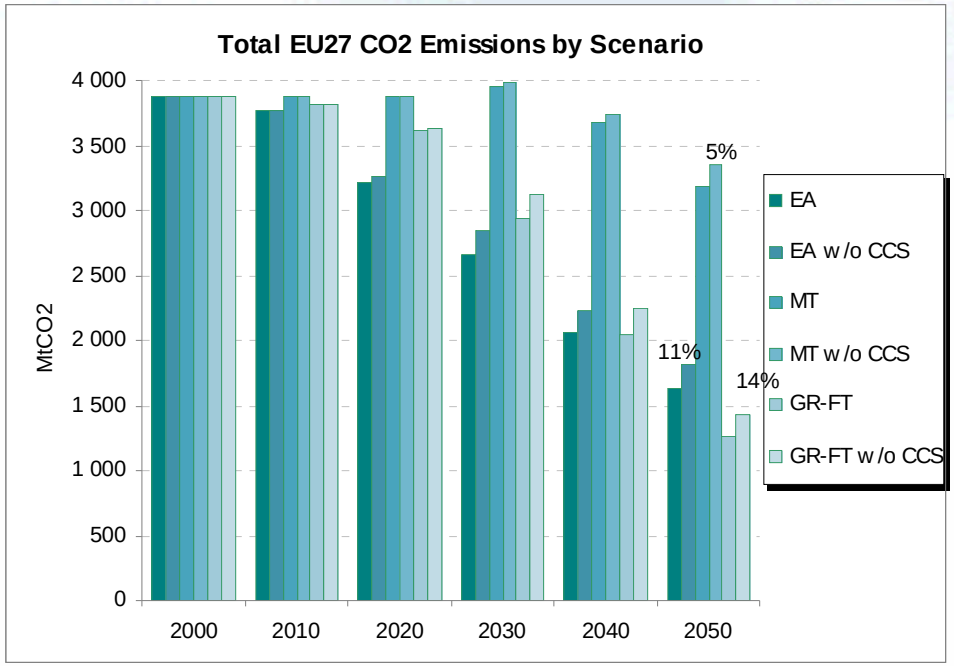




Barriers to Safe and Cost Effective Deployment of CCS

- Put away CCS from possible clean technology portfolio, means an increase of +43%, +14% and +67% of the EU electricity CO2 emissions then in respective scenarios with CCS MT, EA and GR-FT by 2050.
- Total emissions increase respectively +11%, +5% and +14%.
- In the scenario GR-FT without CCS, carbon value must be increased 30% in 2050 in order to have the same profile of emissions as in GR-FT with CCS.





Scenarios and their policy settings

Main results of the SECURE scenarios

Impacts of scenarios on EU and its Southern Neighbours

Main results of the SECURE exercises

Impacts of scenarios on European imports

Dependence rate, by energy and global

- The dependence rate for each fossil source does not change very much from one scenario to the other
- While global dependence rate (on total GIC) is significantly altered, due to domestic sources

			2000	2010	2020	2030	2050
Baseline	Dependance rate	Coal, lignite	30%	33%	39%	48%	[illegible]
		Oil	76%	81%	84%	87%	86%
		Natural gas	46%	69%	83%	90%	[illegible]
		Total	45%	53%	58%	61%	**58%**
Muddling Through	Dependance rate	Coal, lignite	30%	32%	35%	44%	[illegible]
		Oil	76%	81%	83%	86%	85%
		Natural gas	46%	69%	83%	91%	96%
		Total	45%	53%	57%	60%	**53%**
Europe alone	Dependance rate	Coal, lignite	30%	31%	28%	35%	42%
		Oil	76%	81%	81%	82%	78%
		Natural gas	46%	69%	79%	81%	76%
		Total	45%	52%	51%	45%	**31%**
Global Regime	Dependance rate	Coal, lignite	30%	32%	33%	39%	[illegible]
		Oil	76%	81%	82%	85%	83%
		Natural gas	46%	61%	73%	77%	[illegible]
		Total	45%	50%	51%	47%	**29%**

GIC and volume of fossil imports

- Dependence may be lower and also applied to smaller quantities
- In terms of global vulnerability, importing 40% of 200 Mtoe is not equivalent to 40% of 400 Mtoe

			2000	2010	2020	2030	2050
Baseline	GIC (Mtoe)		1725	1764	1883	2004	2053
	Imports (Mtoe)	Coal, lignite	-94	-102	-130	-191	-285
		Oil	-505	-532	-560	-564	-440
		Natural gas	-180	-293	-393	-473	-475
Muddling Through	GIC (Mtoe)		1725	1759	1820	1911	1881
	Imports (Mtoe)	Coal, lignite	-94	-95	-96	-132	-146
		Oil	-505	-532	-543	-537	-399
		Natural gas	-180	-298	-399	-471	-448
Europe alone	GIC (Mtoe)		1725	1741	1723	1731	1724
	Imports (Mtoe)	Coal, lignite	-94	-88	-50	-58	-61
		Oil	-505	-524	-466	-378	-235
		Natural gas	-180	-292	-365	-350	-245
Global Regime	GIC (Mtoe)		1725	1748	1802	1845	1723
	Imports (Mtoe)	Coal, lignite	-94	-91	-76	-80	-73
		Oil	-505	-526	-497	-428	-216
		Natural gas	-180	-260	-351	-359	-206

Value of energy imports

- From 1.8% of EU GDP (EA) to 2.2% (BL) in 2020 and from 0.5%(GR) to 2.5% (BL) in 2050.

			2000	2010	2020	2030	2050
Baseline	Value of imports (G€05)	Coal, lignite	4.9	8.8	12.3	19.7	34.1
		Oil	96.1	202.6	250.6	310.6	359.1
		Natural gas	24.1	69.0	99.9	139.5	210.2
		Total	125.1	280.4	362.8	469.8	**603.5**
Muddling Through	Value of imports (G€05)	Coal, lignite	4.9	8.2	9.0	13.2	19.4
		Oil	96.1	202.7	240.7	284.4	291.3
		Natural gas	24.1	70.3	101.5	133.8	183.1
		Total	125.1	281.2	351.2	431.5	**490.9**
Europe alone	Value of imports (G€05)	Coal, lignite	4.9	7.5	4.7	5.7	6.8
		Oil	96.1	196.3	201.6	191.9	160.2
		Natural gas	24.1	69.1	94.6	98.1	95.3
		Total	125.1	272.9	300.9	295.7	**262.4**
Global Regime	Value of imports (G€05)	Coal, lignite	4.9	7.8	6.8	7.6	7.9
		Oil	96.1	197.8	208.8	199.8	70.6
		Natural gas	24.1	61.9	87.5	91.0	45.5
		Total	125.1	267.5	303.1	298.3	**124.1**

Risks and vulnerability in climate-energy policies

$Risk_{c/e}$ =	$Probability_e$	x $Magnitude_e$	x $Vulnerability_{c/e}$
Muddling Through	High	High	High
Europe Alone	High	High	Low
Global Regime	Low	Low	Low

- For Europe climate policies bring a significant double dividend in terms of reduced vulnerability to energy shocks, even in a non-cooperative framework

Conclusions

- **Beyond modeling exercises, many issues should be kept in mind, in particular the institutional dimension:**
  - Framework and incentives for electricity investment
  - Degree of integration of the European electricity system
  - Institutional factors in new technology chains (scale-up of CCS)
  - Regulatory framework for nuclear development
- **Across the different scenarios total electricity consumption remains strong as it is the main carrier of the decarbonisation**
- **The power generation technology mix changes a lot with more renewables, nuclear and CCS, but natural gas is almost not impacted**
- **Climate policies strongly impact the energy-security problem and illustrate the type of uncertainties that EU will have to face in the next decades**