



FONDAZIONE ENI
ENRICO MATTEI



SECURE – Main Results and Policy Recommendations

Final Conference of the SECURE project :
“EU Security of Energy Supplies in the International Context”

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The SECURE Project

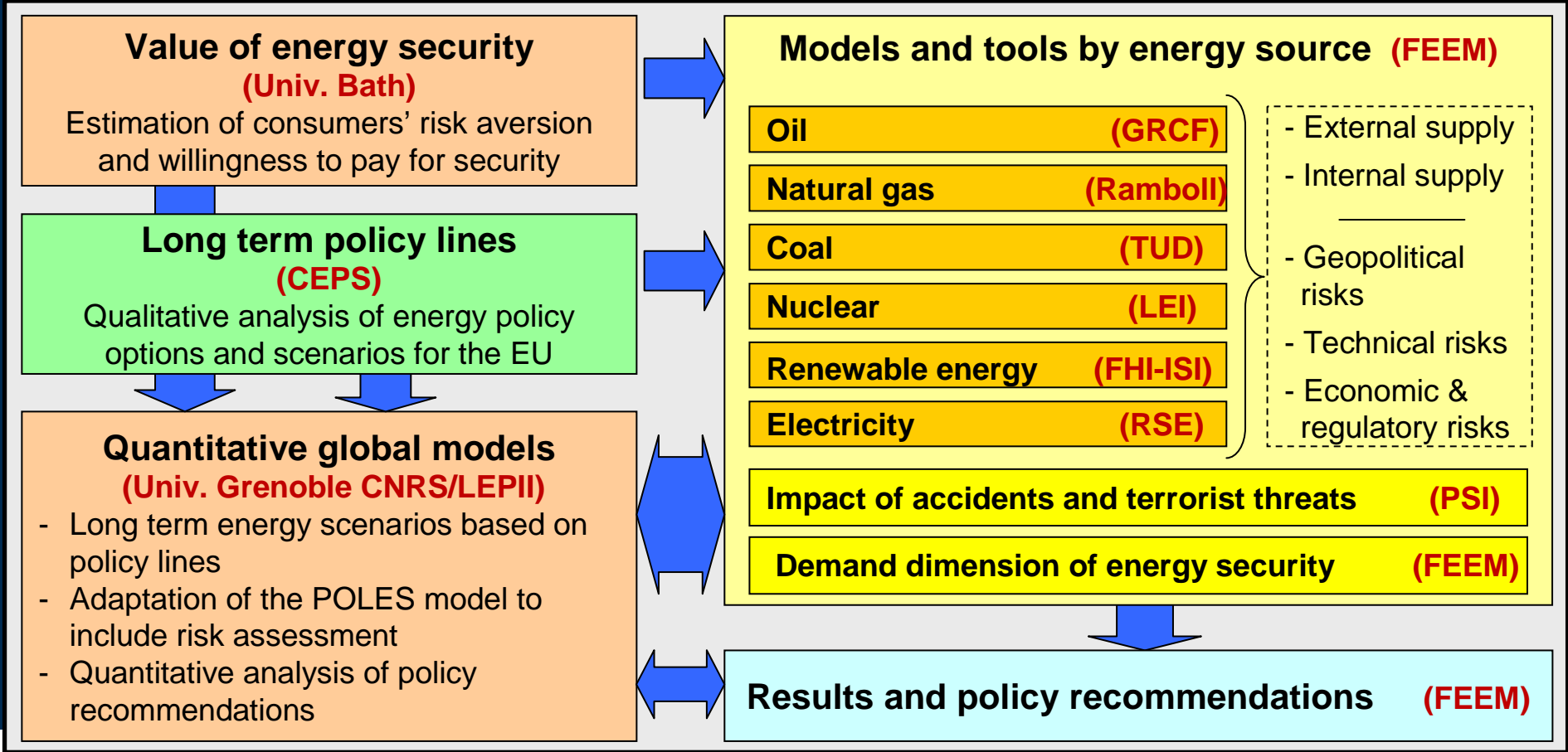
Security of Energy Considering its Uncertainty, Risk and Economic implications

- **Comprehensive framework** of all major issues related to energy security including **geopolitics, economic/regulatory and technical** design of energy markets **both inside and outside the EU**
- Analysis of **all major energy sources and technologies** (*oil, natural gas, coal, nuclear, renewable and electricity*) from upstream to downstream (*supply and demand side approach*)
- **Development of tools, methods and models** (global and sectoral) to measure and assess security of supply
- **Policy recommendations** on how to improve energy security taking into account costs, benefits and risks of various policy choices

SECURE Project partners: 15 leading and prestigious European research institutions

	Partner		Country
<i>Coordinator</i>	Observatoire Méditerranéen de l'Energie	OME	France
<i>Scientific Coordinator</i>	Fondazione Eni Enrico Mattei	FEEM	Italy
	Ramboll Oil & Gas	RAMBOLL	Denmark
	Lietuvos Energetikos Institutas	LEI	Lithuania
	Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V.	Fraunhofer	Germany
	Joint Research Centre	JRC	Belgium
	Technische Universität Dresden	TUD	Germany
	Paul Scherrer Institut	PSI	Switzerland
	Ricerca sul Sistema Energetico	RSE	Italy
	Energy Research Institute Russian Academy of Sciences	ERI RAS	Russian Federation
	The University of Bath	Bath	U.K.
	Gulf Research Center Foundation	GRCF	Switzerland
	Centre for European Policy Studies	CEPS	Belgium
	Vienna University of Technology, Energy Economics Group	TU-WIEN	Austria
	Centre National de la Recherche Scientifique	CNRS	France

Methodological developments (FEEM)
Definition of concepts and general methodology of the project



Stakeholders consultations and dissemination (CEPS)

Scientific coordination (FEEM)

Administrative management (OME)

Intensive Stakeholder Consultations and Dissemination

Timing	Workshop (WS)	Location	Organizer
29 Jan 09	Thematic WS: Methodology and scenarios	Brussels	CEPS
26 Nov 09	Thematic WS: oil, gas, coal	Paris	OME
18-19 Jan 2010	Thematic WS: Nuclear, Renewables, Electricity, Accidents & Terrorism, Demand, Value)	Milan (2 days)	ERSE
29 Sept 2010	Workshop Results & Policy Recommendations	Brussels	CEPS
2 July 2010	Regional WS " Russia & CIS "	Moscow	ERI RAS
19 Oct 2010	Regional WS " North Africa "	Cairo	OME
9-10 Nov 2010	Regional WS " Gulf "	Bahrain (2 days)	GRCF
16 Nov 2010	Policy event with the European Parliament	Brussels	CEPS
25 Nov 2010	Final Conference	Brussels	CEPS

- SECURE SCENARIOS

Energy and climate: two « bathtub problems »

- Between now and 2050, humanity have to face a double problem:
 - The growing scarcity of oil (... and gas, but not of coal !)
 - The accumulation of GHGs in the atmosphere
- These « bathtub 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” should combine the security and sustainability dimensions**

SECURE:

5 scenarios + 3 sensitivity studies with the POLES model

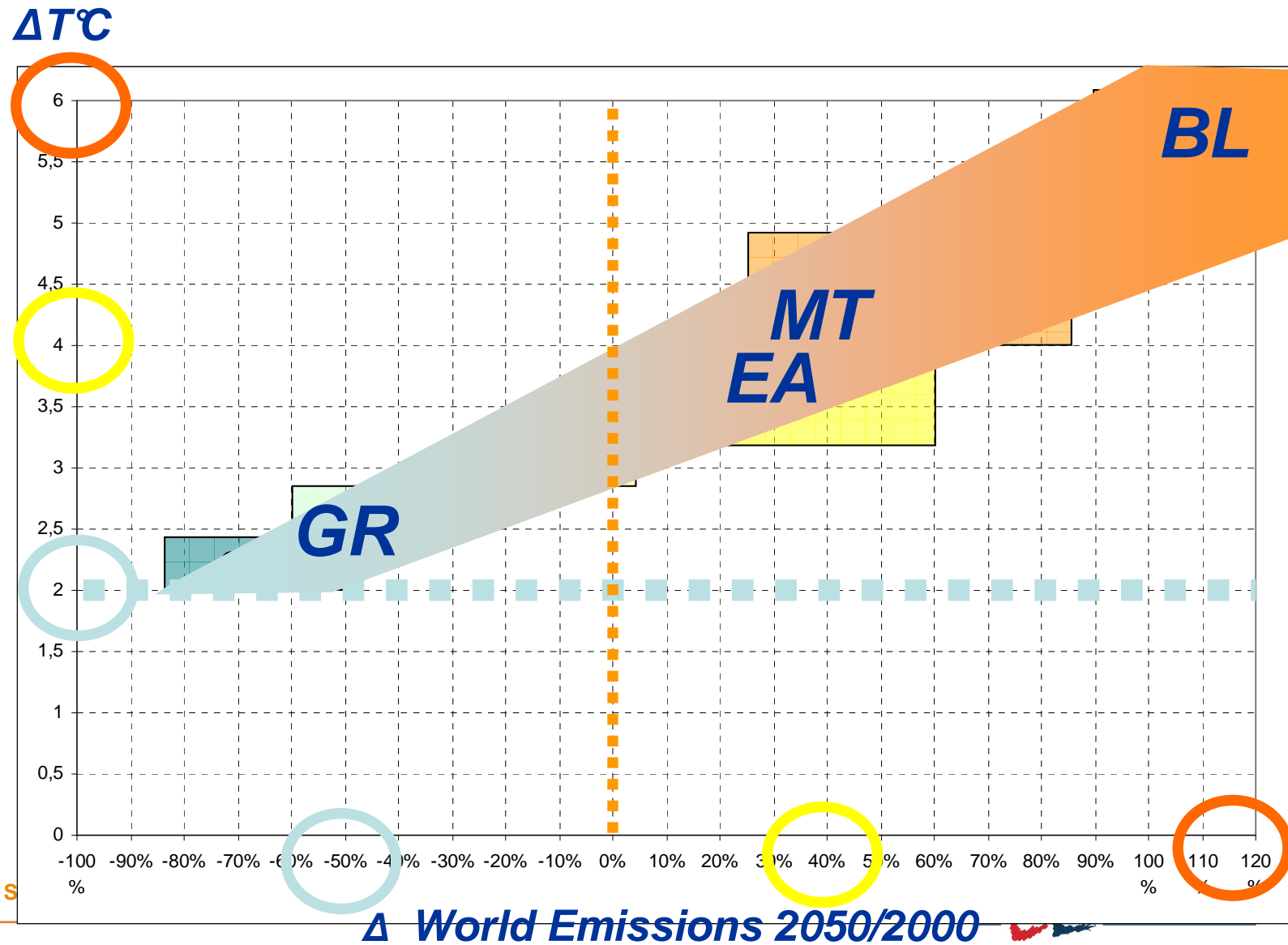
➤ Scenarios

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°C target

➤ Sensitivity studies and shocks

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

SECURE scenarios and IPCC AR4 categories



SECURE scenarios, hypotheses and outcomes

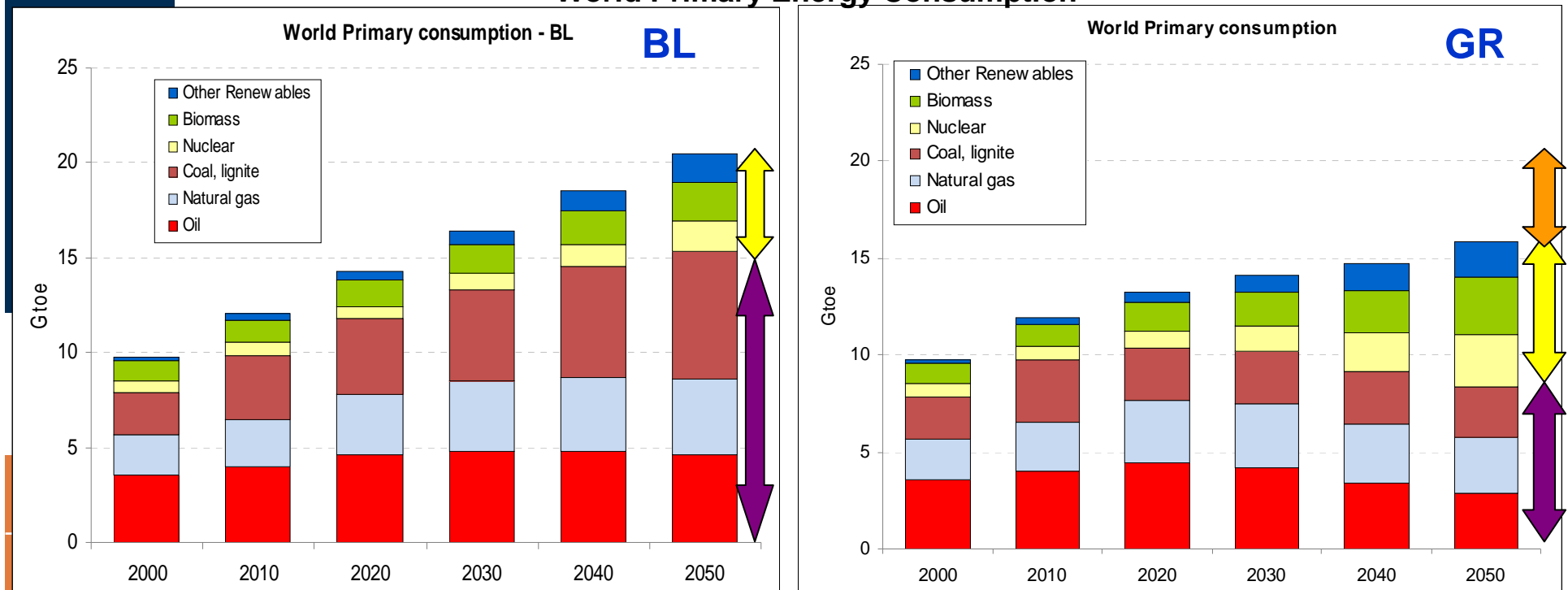
	Carbon Price 2050 (€/tCO ₂)	Emissions 2050 / 1990	AR4 categories
<i>Baseline</i>	0	134%	Type VI (5-6°C) 700 CO ₂
<i>Muddling Through</i>	40 in Eur 32 in RoW	72% (EU: -21%)	Type IV (3-4°C) 500 CO ₂
<i>MT E+</i>	89 in Eur 32 in RoW	67% (EU: -40%)	Type IV (3-4°C) 500 CO ₂
<i>Europe Alone</i>	185 in Eur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

From the Baseline to the Global Regime case

- In the Baseline case, World energy consumption and CO₂ emissions double by 2050: this is not sustainable neither from the climate perspective nor from the resource availability perspective
- The Global Regime induces a fully different picture with lower total consumption and a much higher share of non fossil ($\approx 50\%$)

Source: Poles

World Primary Energy Consumption

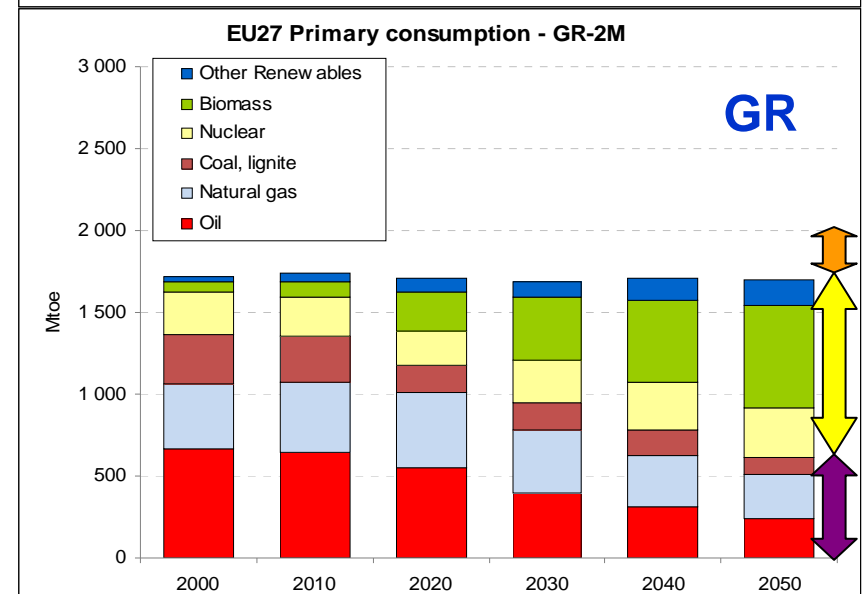
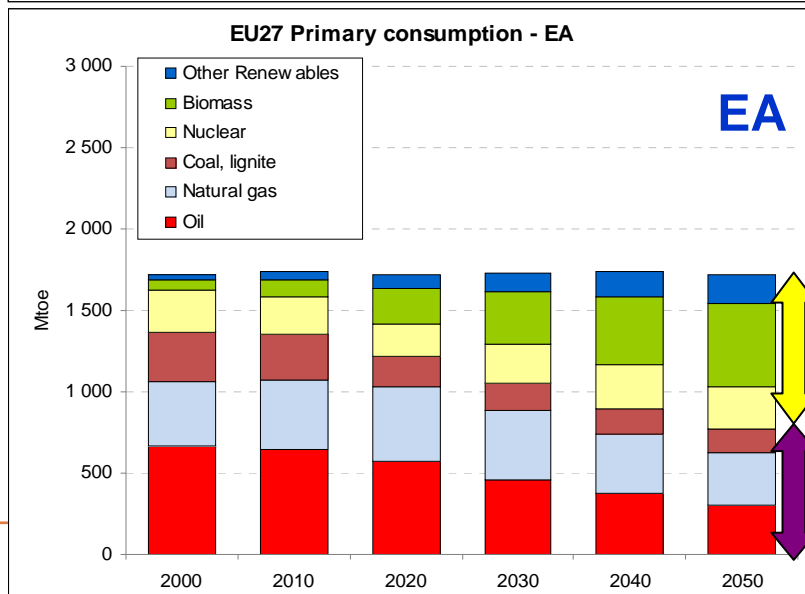
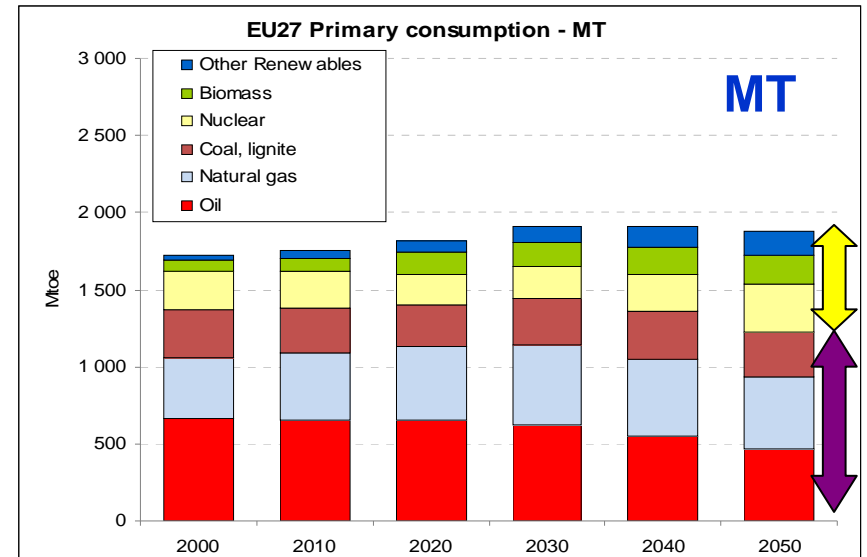
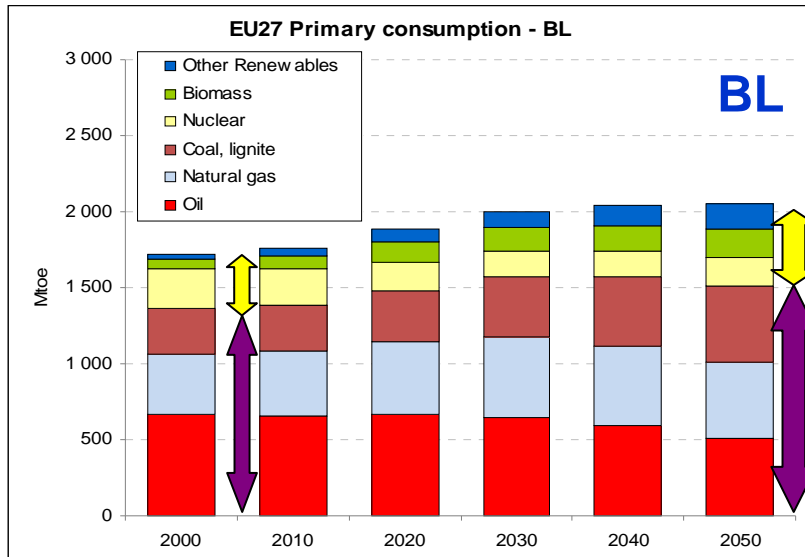


Global outcomes of the SECURE scenarios

- The ***Muddling Through*** implies:
 - a significant increase in emissions in 2050 (+ 40%, + 4-5°C)
 - very high production levels for oil and gas with risks of crises
- The ***Europe Alone*** case somehow alleviate tensions, but it will not 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°C target
 - lower energy prices (60 \$/b, instead of more than 100 \$/b)

EU-27 primary mix by scenario

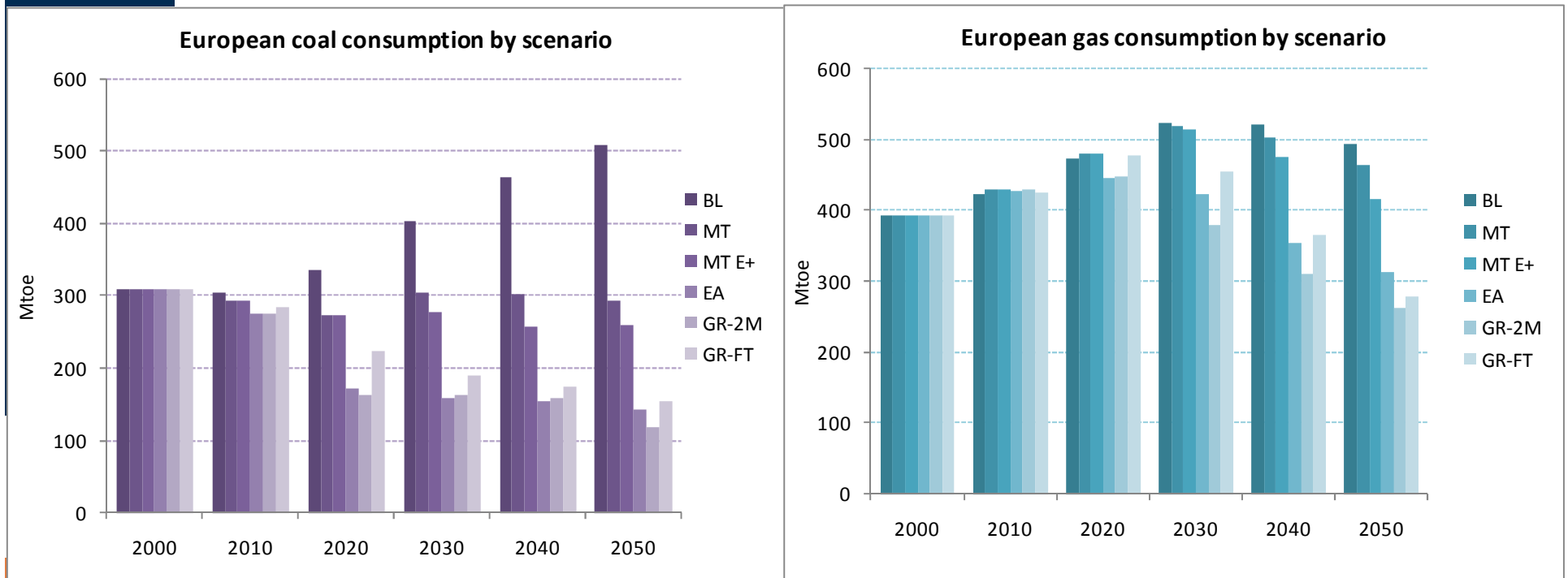
- ◆ In the Global Regime EU total demand is 20% lower in 2050 than in the Baseline
- ◆ And non fossil sources represent almost two thirds of supply, compared to only one fourth in the baseline



Source: Poles

Europe's coal and natural gas consumption

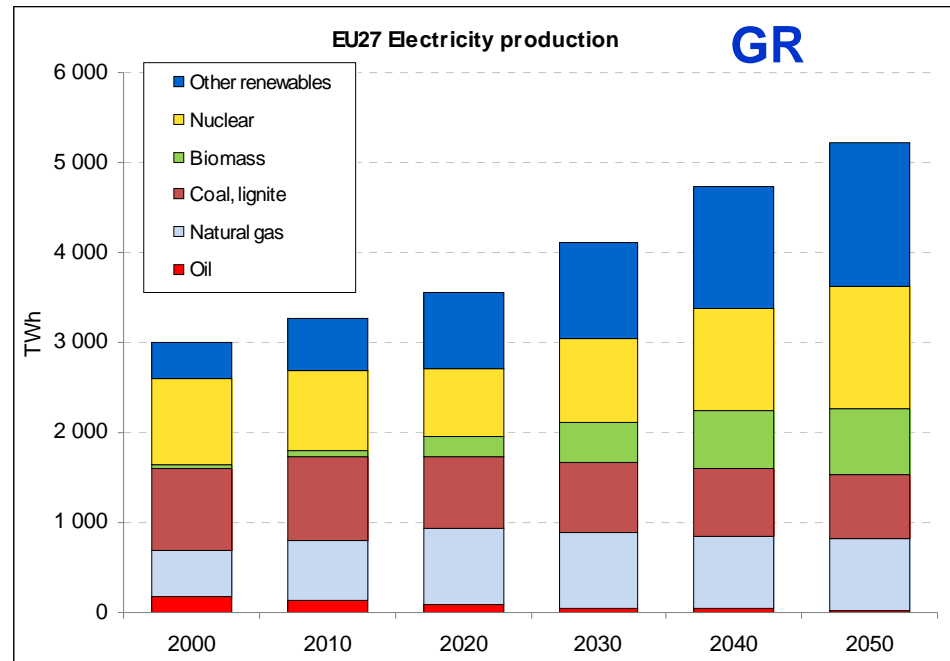
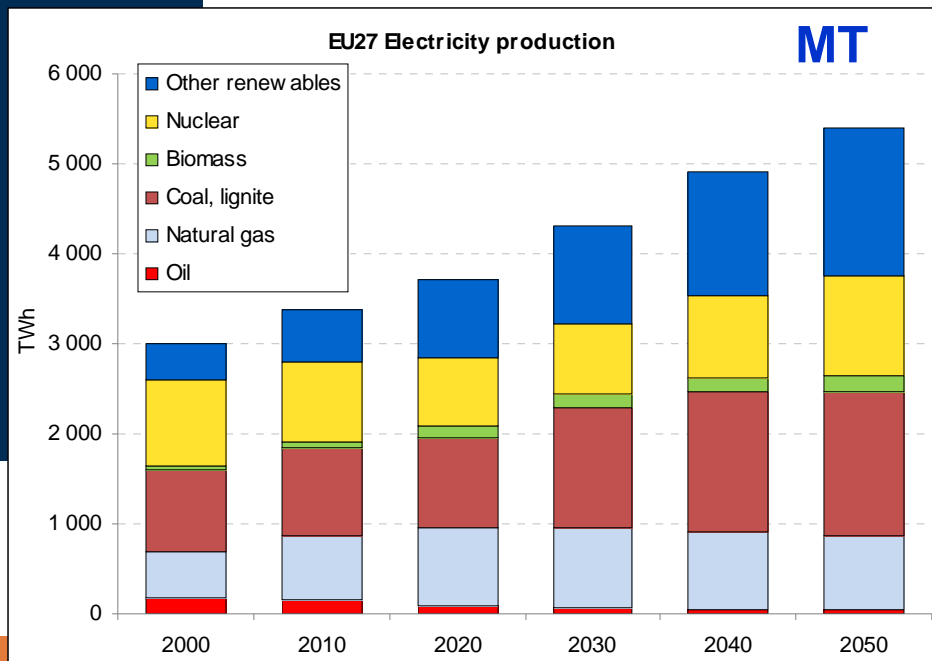
- Natural gas, as a non CO₂ intensive fossil is much less impacted by climate policies than coal
- Total 2020 gas supply decreases only from 480 to 450 Bcm between the two extreme cases, however in 2050 it decreases from 500 to 265 Bcm



European ELECTRICITY production by source

➤ A strong carbon constraint implies

- more renewables and nuclear
- substitution of coal-based by biomass-based generation
- CCS development (on coal, gas and biomass)
- natural gas power generation is hardly impacted

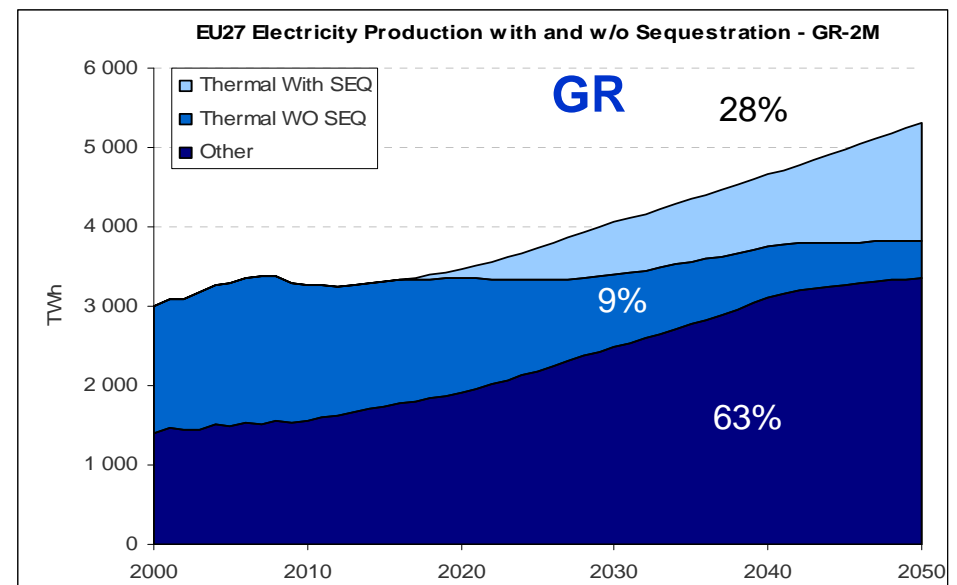
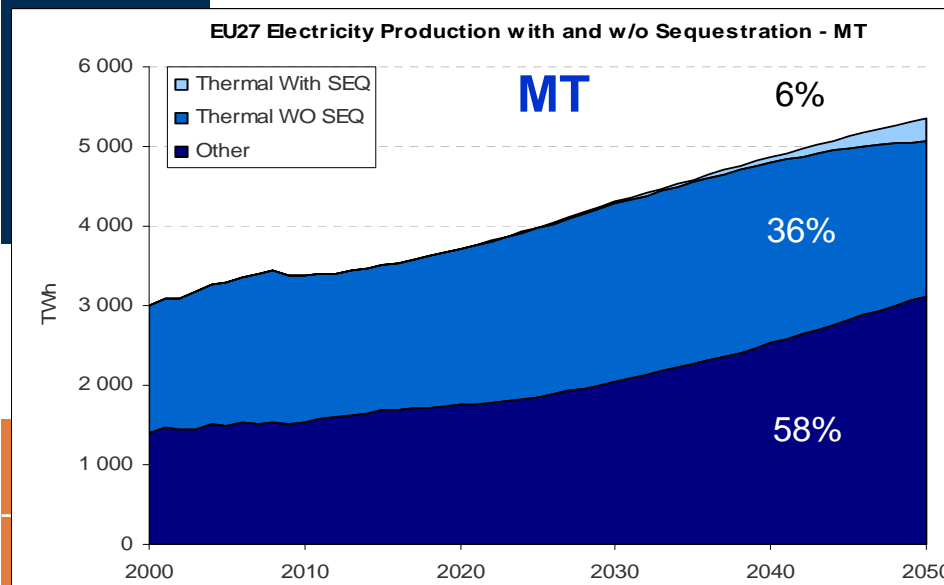


European electricity production: CCS

- Total electricity is not impacted as it is a major carrier of decarbonisation
- However the share of thermal production without CCS decreases dramatically when the emission constraint is reinforced
 - 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

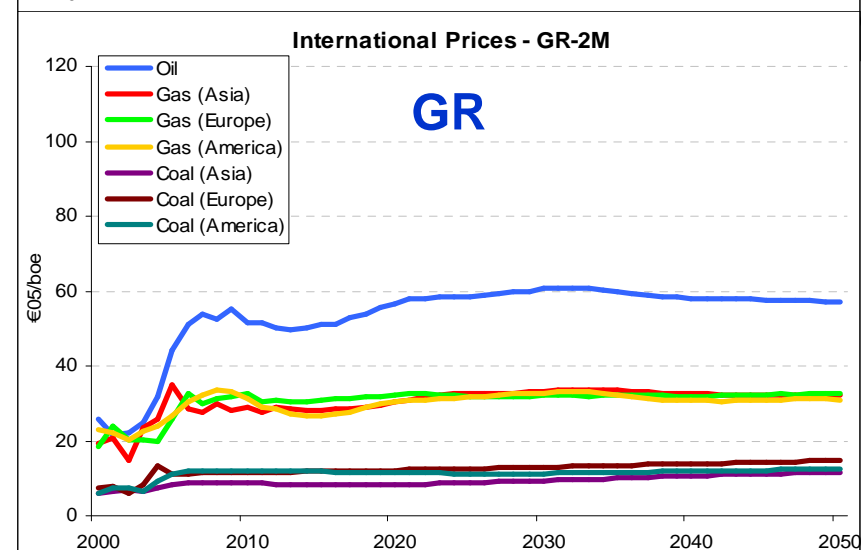
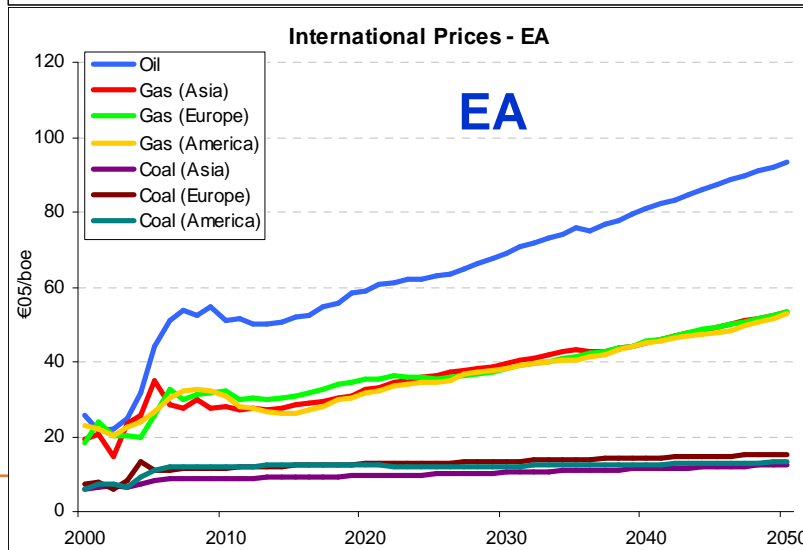
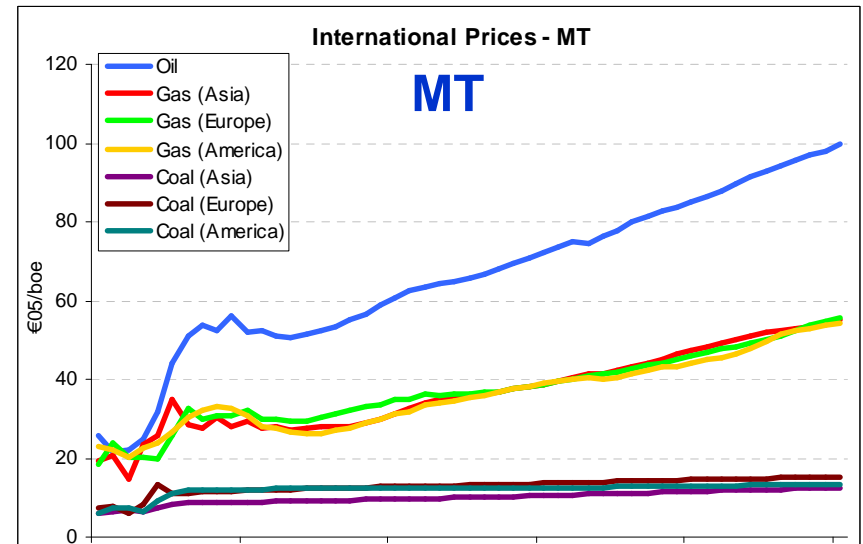
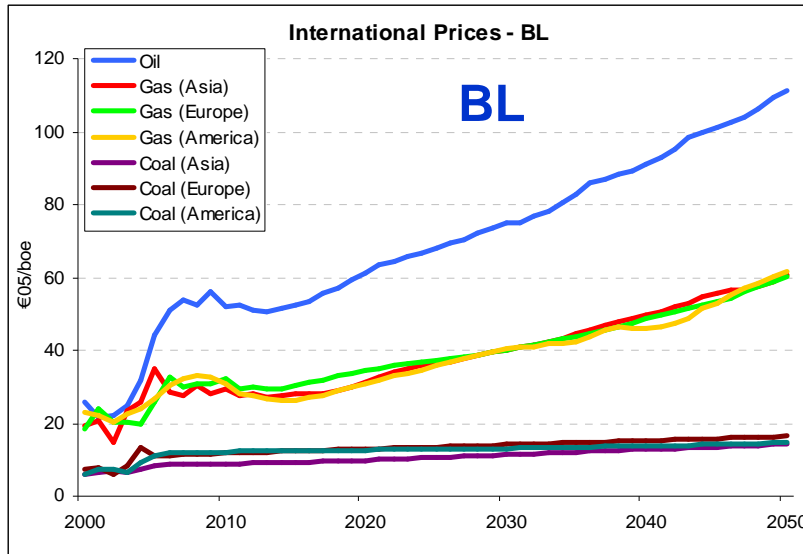
This poses the problem of the industrial capability of industry to bring in CCS at such a high speed

Source: Poles



International energy prices

- ◆ In 2050, international oil and gas prices are about twice lower in the Global Regime than in the Baseline
- ◆ GR: the market is much less tense and the risks of price shocks is much lower than in the Baseline



Source: Poles

Security of supply risks and climate-energy policies

$Risk_{c/e} =$	Probability _e	x Magnitude _e	x Vulnerability _{c/e}
<i>Muddling Through</i>	High	High	High
<i>Europe Alone</i>	High	High	Low
<i>Global Regime</i>	Low	Low	Low

- ◆ European climate policies may bring a double dividend in terms of reduced vulnerability to energy shocks, even in a non-cooperative framework
- ◆ The counterpart is the risk of loss of competitiveness

Conclusions: consequences for cooperation

- **The SECURE scenarios illustrate that strong climate policies may also alleviate the Security of Supply problem of Europe**
- **But the implementation of these policies, although probably desirable from the long term perspective, is uncertain both in its principle and intensity**
- **This creates a serious Security of Demand problem for the investments of exporting countries or regions**
- **The challenge is to explore the economic and institutional conditions that may allow for an even development of energy supply investments, while taking into account the interests of both sides**

Conclusions (2): other issues

- 1) Across the different scenarios total electricity consumption remains strong as it is the main carrier of decarbonisation
 - The power generation technology mix changes a lot with more renewables, nuclear and CCS, but natural gas is little impacted
 - But many issues should be kept in mind, in particular the institutional dimension. A need for a:
 - **Higher degree of integration of the European electricity and gas systems**
 - **Framework and incentives for electricity investment, including for renewable and nuclear development**
 - **Framework and incentives in new technology chains (scaling-up of CCS)**
- 2) Scenarios produced with models provide consistent images of the future under different policy settings and they explore their consequences and feasibility conditions
 - but do not allow for the taking into account of **geopolitical disruptions** or of **chronic market instabilities**

- OIL

Potential threats to oil security

- Resource Nationalism
- Political Instability
- Export restrictions
- Armed conflict:
 - Interstate War
 - Civil (Intrastate) Wars
 - Violent Non-State Actors
- Maritime logistics

Oil and Gas - geopolitics

Conclusions on Resource Nationalism

- Financial instability, negative returns on financial assets and protectionism against the oil producing countries' industrial exports all contribute to supporting the view that it is best to keep oil and/or gas in the ground.
- Also, the adoption of EU aggressive policies aimed at decarbonisation, and if these policies are then not implemented, may have a counterproductive effect in terms of security of supply
 - **Policy Indication for the EU: Do not entertain policy objectives which cannot realistically be reached, and emphasise cooperation and pragmatism rather than confrontation and maximalism**

Oil and Gas Geopolitics

Conclusions on Armed Conflicts

- **Oil and gas installations appear to be much more resilient to armed conflict than is normally acknowledged**
 - Interstate wars are a low-probability event; they are generally confined to two main belligerents and contained
 - Civil wars or violent action on the part of non-state actors are phenomena whose frequency has not diminished at the global level
- **Civil wars cause only little damage to energy installations but hinder investments**

Policy recommendation:

- **Encourage producers to invest in reserve (unused) capacity, and secondarily, to maintain stocks.**

Oil shipping – restrictions of passage

- The most dramatic situation for World oil supply would be the closure of the Strait of Hormuz.
 - This is not easily accomplished.
 - A good part of Gulf oil could be sent from other ports of the region.
 - Recommendation:
 - maintain readiness to reorient oil flows as necessary.
 - Maintain the military capability to reopen the Strait of Hormuz in the unlikely event that it might effectively be closed
- The EU should aim at mitigating the danger of closure of other critical sea lanes which might be caused by navigation accidents through congested passages (Bosphorus, Danish Straits).
 - Turkish Straits:
 - An option would be to seek revision of the Montreux convention of 1936, to allow the imposition of size limitations and passage charges on tankers, to discourage free riding and create conditions for the commercial development of pipeline by-passes.
 - Maritime logistics are unlikely to generate major crises, but require constant attention
- The EU should aim at facilitating investment in infrastructure adapted to reduce the danger of accidents and vulnerability, by offering financial incentives and promoting even more stringent regulations for oil and chemical tankers

Volatile and unpredictable OIL PRICES

- Energy security is primarily a function of investment
- Investment in a market economy is a function of the expected revenue stream, which in turn is a function of prices
- A well-functioning market is therefore a key component of security
- The main obstacle to oil and gas security of supply is the growing volatility of prices and their fundamental unpredictability
- Security itself is also dependent on prices. Customers feel secure if they can buy all the energy they need at prices that they can afford
- The root cause of price volatility is the rigidity of demand and supply in the short term. These are impossible to change and can only be alleviated through:
 - ❑ Encouraging the accumulation of larger stocks
 - ❑ Increasing the relative weight of trading in real “wet” oil barrels rather than future paper contracts and their multiple derivatives.

Trading of major crude oil streams

- Encourage the freer trading of major crude oil streams, notably those from the Gulf
- Establish “crude oil exchanges”
 - Based on auctions of forward contracts for different qualities of crude
 - Allowing secondary trading
 - Preferably based in “third” countries and close to key loading/unloading points: Ceyhan, Alexandria, Bahrain; Rotterdam, Trieste

Encourage vertical integration

- Encourage national oil companies of the oil producing countries to integrate downstream in refining and marketing in the importing countries (and promote access of European firms into producing countries)
- Rationale: producers will not fall short in supplies to refineries and distribution networks which they own

Enhance storage opportunities

- **Increase oil storage capacity in proximity to market and establish an oil lending window**
- **The EU should establish a public agency to invest in large storage facilities to be offered for use to oil producers (NOCs, IOCs) at low cost.**
 - **The Agency should be empowered to issue certificates convertible in physical barrels.**
 - **Certificates should be designed in such a way that they will be accepted as collaterals by financial institutions.**
 - **The availability of an “Oil Bank” of this kind, would encourage investment in capacity additions in anticipation of demand, thus contributing to more comfortable supply conditions.**
- **Rationale:**
 - **producers would be encouraged to produce a bit more and store, and to invest in capacity increases**
 - **Oil stored is more secure than oil in the ground**
- **Japan has set the example**
- **Storage to be built at major loading points – reinforces proposal for crude oil exchanges**

Enforce an internationally agreed price band

- In a context in which oil is a source of oil revenue for both sides, mutual revenue guarantees are possible and would strengthen the credibility of the band
- **Governments of producing and consuming countries would exchange a collar, whereby**
 - if prices go above the upper strike producers transfer revenue to consumers, and
 - if price goes below the lower strike, consumers transfer revenue to producers

- GAS

Over the last three years European GAS markets have profoundly changed

- Economic recession => gas demand in 2009: -6%
- Unprecedented increase in global LNG supply
- Mass production of unconventional gas in the US
- Collapse in the spot gas market
- Market decoupling spot / oil-indexed
- Major Ukraine-Russia gas crises in January 2009
(lesson learned: the internal market did not function)
- 4 B€ EU Stimulus package for the Energy sector:
 - More than half goes to EU gas and electricity interconnections to increase the physical functioning of the internal market and thus improve security of supply.
 - It also addresses sustainable development by giving support to offshore wind and for carbon capture and storage.
- New EU natural gas security of supply regulation discussed

Internal market needs to be further strengthened This will be beneficial for SoS

Allow the gas to go where it is needed, when it is needed

- Systematic reverse flow and removal of bottlenecks
 - Storage access
 - Increased production
 - Alternative imports (pipeline and LNG)
 - Market concentration
-
- ❑ National and regional differences imply that SoS mitigation tools will differ between countries
 - ❑ Special effort is needed for the Balkan and the Baltic countries

Security of Supply /Security of Demand : two sides of the same coin

- Importers require Security of Supply
- Exporters require security of Demand (on which to base on their investments)

- EU should provide clearer signals regarding future gas demand in Europe to facilitate investment both internally and externally
- Underinvestment may threaten EU's long term security of supply
- The EU should develop a gas demand forecast which is an amalgamation of energy policies and individual national plans

Other SoS recommendations for Europe

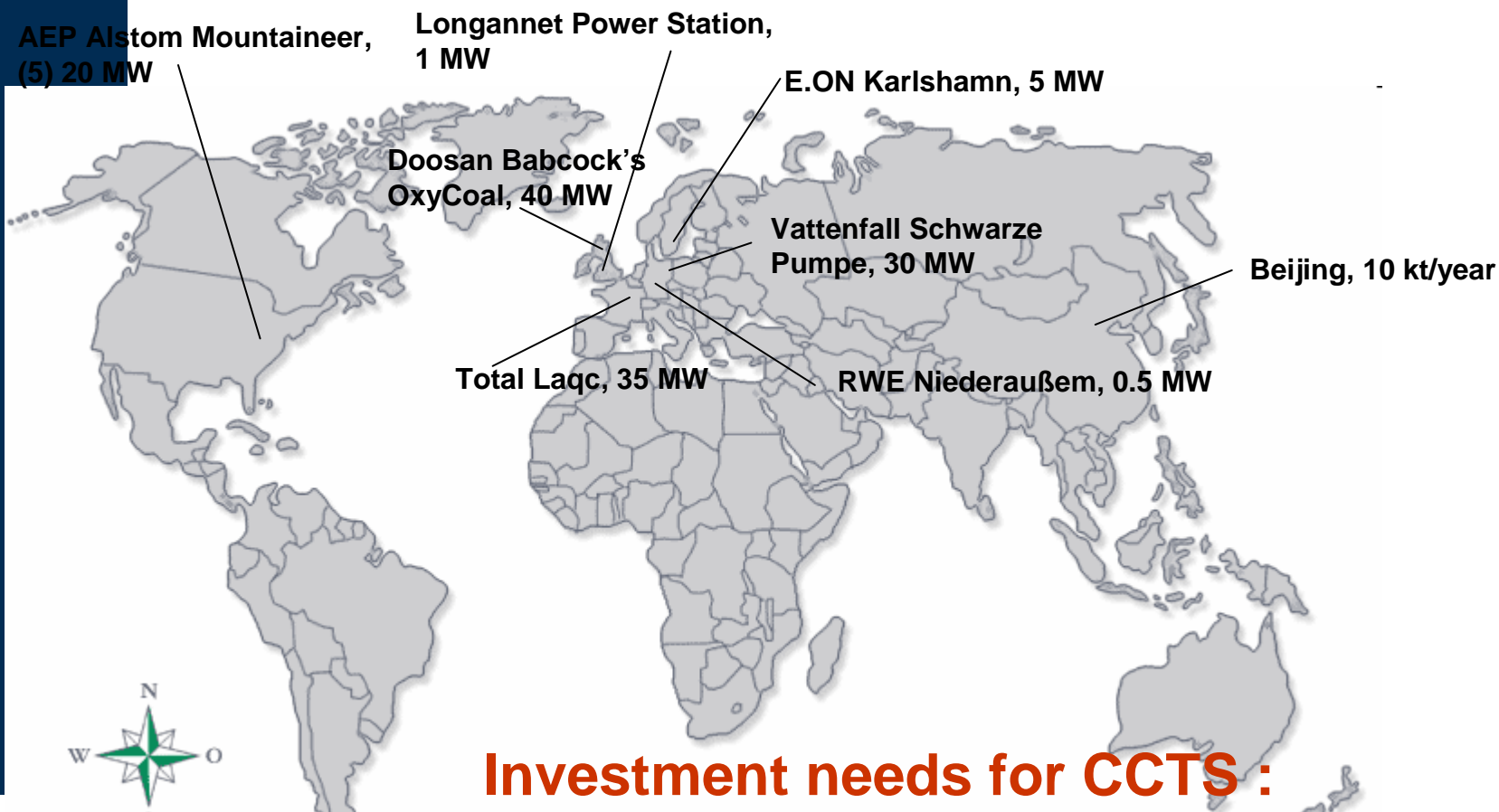
- **Demand flexibility / fuel switching** should be studied further regarding its ability to mitigate SoS issues in the EU
- Development and strengthening of **early warning and crisis prevention mechanisms** as well as the **implementation of regional emergency plans** should be encouraged
- **Transit across Ukraine:** the possibility of an independent Transmission System Operator (composed of Ukrainian, EU and Russian operators) should be seriously evaluated (=> reduction of disputes and increased investment)
- **Unconventional gas:**
 - legislation should be streamlined and reviewed in order to accompany any potential unconventional gas development
 - Generate an accurate survey of recoverable resources and production potential of unconventional gas in Europe, and evaluate its potential impact
- **Partnership with Suppliers:** Europe needs to have a robust policy with Russia, but also the Caspian and MENA regions showing pragmatism, partnership and commitment in respect to their development of gas export partners with Europe (also as they are expected to play a more important role in European gas supply after 2030 when the relevance of Norway and Algeria might decline)

- COAL

COAL Security of Supply: the issue is CCTS

- **The real issue in European supply security regarding coal is not the resource availability, but the absence of an economically and politically sustainable use of coal for electricity, liquefaction, gasification, industrial applications etc., due to obstacles in the implementation of a CCTS (carbon capture, transportation, and storage) value-added chain.**
- Upstream, there are little worries about the supply security of (steam) coal
 - Market monitoring should be continued, in particular on developments and prices in specific regions (e.g. China)
 - Competition authorities should continue to monitor international coal markets, with a special focus on mergers & acquisitions of “Big Coal”

The IEA Blue Map Scenario outlines a need of 100 serious CCTS demonstration projects until 2020



Investment needs for CCTS :

The next 10 years are a critical period for CCTS !

- Among the 62 announced CO₂ capture projects, only 8 pilot projects are operating on a pilot scale.
- Assuming that all of the announced projects are realized by 2020 there still remains a gap of 40 projects to reach the IAE blue map scenario.

- **There is a real danger that the ambitious development plans in CCTS demonstration over the next decade will not be met; policies should aim on the acceleration of the development process**
- **The real bottleneck towards CCTS is the transport and storage infrastructure. Legal and technical uncertainty needs to be resolved**
- The important and readily available funds for CCTS should be rapidly deployed. If industry does not respond to current incentives, the level of incentives needs to be raised to a reasonable level or pilot and demonstration projects should be carried out by public research institutions.
- Due to the lack of an inherent value of CO₂ the revenue stream strongly depends on future regulatory decisions; these should be made explicit as soon as possible

- The financial uncertainty surrounding future projects should be reduced. In the absence of clear CO₂ price corridors and signals, regulatory certainty can be created, e.g., by obliging new power plants to include a “capture-ready” option
- Future regulation needs to specify the allocation and financing principles for pipeline and storage, and access for 3rd parties
- Early planning of transportation routes is of utmost importance. The **State** bears a crucial role in the development of the transportation and storage infrastructure; the execution of the construction and operation of the transport network can be tendered to the private sector, or carried out by a state-owned network company.
- Synergies with the other energy network infrastructure (gas, electricity) should be considered
- The strong focus on the implementation of CCTS in the power sector in the past should be enlarged to industry which can be highly vulnerable to an abandonment of coal
- Alternative uses of CO₂ (to replace CCTS) should be further explored (e.g. methanol, chemicals)

- NUCLEAR

Contribution of Nuclear energy to SoS

- **In order to respect climate policy goals, also nuclear needs to play an increasingly important role in worldwide and EU long term energy balances.**
- However, according to IEA and EC energy scenarios, the EU nuclear share is expected to reduce by half between now and 2030. As nuclear is presently providing two thirds of all low carbon electricity in the EU, this will create an even larger strain on fulfilling CO2 targets.
- In fact, the so often announced nuclear renaissance is having a difficult birth: With 148 aging reactors in operation in 15 Member States, there are presently just 4 reactors under construction in the EU (Finland 1, France 1, Bulgaria 2).

Nuclear energy

Reasons for the stalling renaissance of nuclear energy are:

- **social acceptability** (political opposition) for a technology which is perceived as dangerous and for which the permanent waste disposal issue has still not been solved,
- **lack of human capacity** (Europe's industrial capacity of building nuclear power plants is said to be limited to maximum 4 per year, other regions seem to have the same problem of aging workforce) which is expected to worsen over the next years as specialists retire;
- **strongly increasing investment cost for nuclear power** due to, among others, improved safety and environmental standards.
- **technical problems** with the new 3rd generation designs of all major manufacturers resulting in huge cost-overruns for the first realizations of the new designs;
- the **difficulty to finance hugely capital intensive plants in a market environment** and in particular after the financial crises;
- the increasing uncertainty on construction costs raises some doubts on the ability of nuclear power to foster a decrease in electricity prices.

Policy Recommendations for Nuclear energy

In this context government action is essential to:

- **promote public debates on nuclear safety, energy security of supply and climate change issues**
- **assure that legal, regulatory conditions for nuclear energy are clear and stable**
- **promote human capital building;**
- **Implement the planned waste repositories to demonstrate practically their feasibility**
- **exploring regional centres for high level waste disposal;**
- **create a level playing field for low carbon technologies via an effective EU-wide emission trading system or carbon tax**

Policy Recommendations for Nuclear

- The same safety standards as for nuclear reactors must be applied to all elements of the fuel chain and associated infrastructure.
- They must be strictly applied in any country using nuclear energy
- The EU should put all its geopolitical weight to make sure that these rules are respected everywhere and to promote non-proliferation.
- In fact, a major nuclear accident anywhere in the world could have dramatic consequences also on European nuclear development

- ELECTRICITY

Security of Supply in the electricity sector

- **Electricity security of supply has implications along the whole chain:**

- ⇒ **Generation**
- ⇒ **Transmission**
- ⇒ **Distribution**
- ⇒ **Demand**



Security of Supply in the electricity sector

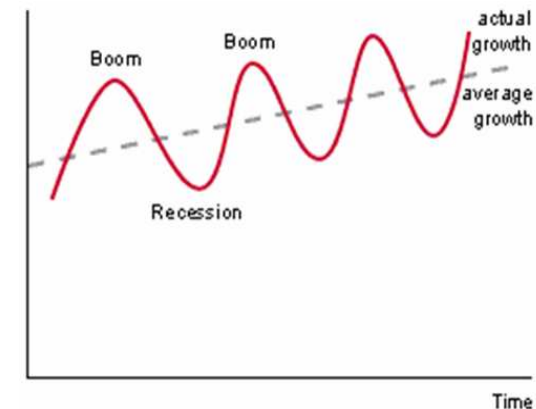
- **Electricity security of supply has implications along the whole chain:**

- ⇒ **Generation**
- ⇒ **Transmission**
- ⇒ **Distribution**
- ⇒ **Demand**



Power Generation *adequacy*

- Necessity to ensure *adequacy* of the generation system, i.e. its capability to keep the supply/demand balance
- Need for a sufficient reserve margin and for a generation set well adapted to the load and to intermittent sources
- Adequacy is not a priori guaranteed in a liberalized electricity market, with no more centralized planning
- Risk of *boom-and-bust cycles*, with security of supply at risk during bust periods

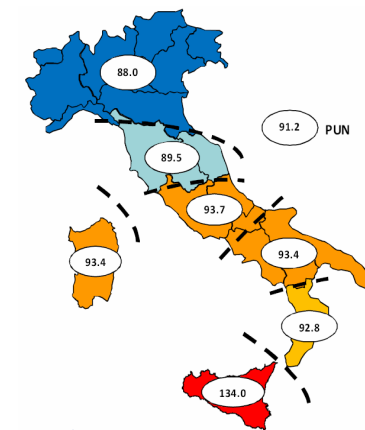


Power Generation – policy recommendations

- TSOs should have the task to determine how much new generation capacity of the different types (e.g. base load, mid-merit, peakers) is needed, when and where (the location in the network is very important)
- Regulators should consequently set up incentive / obligation schemes (tendering procedures, capacity payments, capacity markets/obligations, call options, etc.) to push investors to pursue the “optimal” development of the generation set outlined by TSOs
- The process should be coordinated and harmonized at the EU level (by ENTSO-E and ACER) to increase its effectiveness and to avoid market distortions

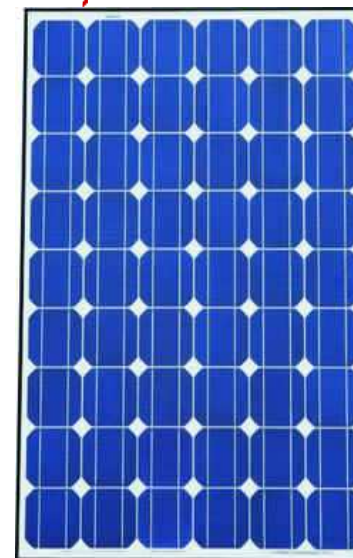
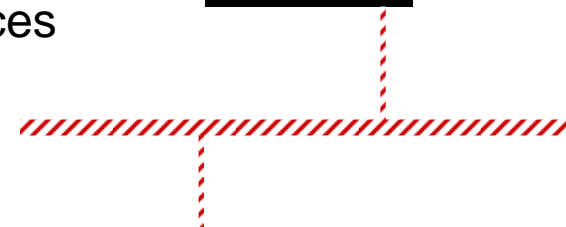
Power Transmission – policy recommendations

- Measures to reduce uncertainties for investors (TSOs / merchant):
 - pursue a more stable and harmonized regulatory framework at the European level, under control of the ACER
 - pursue more efficient authorisation procedures at all administrative levels, requiring the compliance with general framework guidelines
 - gain social acceptance by clearly stating and quantifying the public benefits of the projects in terms of security of supply, sustainability and economics: let people know that the realization of network projects will reduce their electricity bills (by imports of cheaper energy, direct compensations, congestion reduction ...)
 - Provide “*locational signals*”, i.e. the spatial (zonal/nodal) differentiation of electricity prices and of transmission charges, to optimize short-term operation and long-term siting, thus harmonizing generation and transmission development.



Electricity Distribution – towards *active and smarter networks*

- Encourage cooperation among standardization bodies, regulatory authorities, grid operators and manufacturers to set **open standards to ensure interoperability** of smart grid devices and systems so as to avoid any technical barrier to their deployment
- Support DSOs' investments in “smartness” through incentive / minimum requirements regulation based on the **quantification** of their **effects and benefits**, through appropriate **indicators**
- encourage **Demand Response** (more on this later)



- RENEWABLE ENERGY

Renewable energy

Renewables can help to decrease import dependency of the European energy system, the **increased use of RES should be supported in the electricity, heat (heating and cooling) and transport (biofuels) sectors. To this aim:**

- The current limited and dispersed support for RES-based heat needs to be improved.
- Focus on the develop second generation biofuels
- Keep a level playing field among different technologies, so that most efficient solutions can emerge from market forces, rather than being selected by policy makers.
- The present technological uncertainty suggests the need to maintain some public support to a wide range of technologies, at least until the relative merits of different solutions emerge on the basis of solid experience.



Renewable energy

- Efforts to support RES are needed in all member states. The uneven distribution of RES potentials and costs emphasizes the need for intensified cooperation between member states.
- RES policies should be supported by a strong energy efficiency policy.
- In the longer term, a beneficial political and regulatory framework promoting solar energy imports from North Africa should be created, including options for granting these projects priority status under EU infrastructure projects as well as promoting the development and operation of European and trans-Mediterranean super-grids.



Renewable energy

To face the challenges resulting from an increased share of **fluctuating wind electricity**, several potential remedies may be applied:

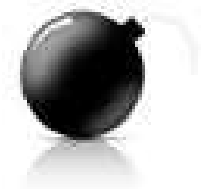
- **Forecasting tools** and imbalances management should be improved.
- **Trading at the intra-day** market platform would imply a correction of all the imbalances whereas the imbalance payments only apply for the net system imbalances.
- **Storage systems** such as pumped-storage hydropower plants, hydro reservoirs, compressed air storage, flywheels or batteries may be used
- **Smart grids** may contribute to the operation of the electricity system. By enabling intelligent monitoring and an improved control of supply and demand, system reliability and the security of supply can be improved.
- Finally, the reinforcement and, if necessary, the extension of the **electricity grid** represents one main option of how large amounts of fluctuating electricity can be integrated into the electricity system.



- ACCIDENTS AND TERRORISM

Severe Accidents and Terrorism

- In industrialized countries estimated expected accident risks are by far the **lowest for hydro and nuclear power** while **fossil fuel** chains exhibit the **highest risks**. The maximum credible consequences of low frequency hypothetical severe accidents, are by far **highest for nuclear and hydro** in the middle range for fossil chains and **very small for solar and wind**. For nuclear, the maximum consequences are expected to be substantially reduced for fourth generation plants.
- The overall accident risk for EU 27, depends on domestic accidents, but can be strongly affected by its total energy import share and actual composition of import countries, which is predominantly an issue for fossil energy chains. Risk reduction measures should aim to decrease import dependency, and to achieve a higher diversity among importing countries.
- SECURE's analysis indicates that the frequency of a successful **terrorist attack** with very large consequences is of the same order of magnitude as can be expected for a disastrous accident in the respective energy chain. Large energy installations are hard targets and relatively easy to protect, requiring sophisticated attack scenarios to cause significant damage and lasting impacts. Historically, terrorists prefer to attack soft targets that are more vulnerable and may cause a larger number of fatalities and do not require the mobilisation of large resources.



Severe Accidents and Terrorism

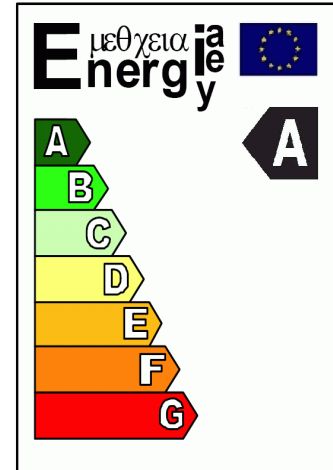
- Allocating appropriate resources for maintaining high safety standards of nuclear power plants and hydro dams is of central importance also for security of supply.
- In the case of oil and natural gas the attention should be focused primarily on the exploration and production (E&P) sector as well as the major transportation routes by tankers and pipelines, in regard to ensure comfortable safety levels.
- There is a need to integrate expert knowledge from a wide range of actors involving political sciences and intelligence information on the motivation of terrorists, military knowledge on scenario planning, and physical assessment of consequences. Such a comprehensive coverage could also contribute to reduce overall uncertainties in risk quantification.



- DEMAND

The Demand Dimension of Energy Security

- In general, the promotion of end-use energy efficiency should be a priority, since actions in this field are the most economically efficient.
- Efficiency policies in the EU do work, but there is no silver bullet able to successfully address energy security and energy efficiency, unless it is so general that naturally encompasses different sectors and energy uses.
- The EU policy mix is quite effective, but more fine-tuning and coordination among member states is needed.
- EU Action Plans should be continued and made binding wherever effective, taking into account differences in the responsiveness of energy consuming sectors to efficiency policies. For instance mandatory standards for electrical appliances seem to work better for the residential sector, whereas measures supporting information, education and training are more effective in the industrial sector.



The Demand Dimension of Energy Security

- Cross cutting measures, in particular those related to marked-based instruments, have the strongest influence both on energy security and energy efficiency. It is recommended to consider the development of White Certificate market models at EU-level. Due account should be taken of successful deployment in some member states.
- Demand Response should be encouraged, with a rapid and extensive deployment of enabling technologies, such as smart metering, following best practices (e.g. Italy). Market design is crucial as it should exploit all the potential of DR.
- Demand Response programs should be designed so as to provide strong (i.e. able to ensure a substantial economic convenience in case of response) signals, as well as be simple and easily understandable by consumers.



Conclusions

- Smart” energy policies must combine security of supply, sustainability and competitiveness without neglecting the international relations context .
- European climate policies bring a significant double dividend in terms of reduced vulnerability to energy shocks. However low carbon energy scenarios require:
 - an improved framework and incentives for electricity investment (including renewables),
 - a high degree of integration of the European electricity systems,
 - a favourable institutional and regulatory framework for Carbon Capture Transport and Storage (CCTS),
 - no foreclosure towards nuclear development,
 - strong demand policies.
- The transition path to a low carbon economy is not granted. Adequate governmental support might be necessary.

- CONCLUSIONS

Conclusions

- The **most efficient way** for the EU to develop cost-effective low carbon energy use is to have a **generalized and viable EU-wide emission trading system** capable of delivering standardized carbon prices **or an effective EU-wide carbon tax**.
- Energy security of supply and competitiveness converge when it comes to internal market's development. Integration of markets by developing regulatory policies, which enhance interconnections in gas and electricity infrastructure and thus foster competition, would be a big step in the right direction for European security of supply.
- The **unsatisfactory** functioning of the **international oil markets** and the **resulting uncertainty and volatility in oil prices is the main security threat** for future oil supplies because it hinders investment. Measures to reduce this artificially increasing volatility should be envisaged.
- Climate policies strongly influence the menu of policy solutions to energy security problems. Related uncertainties will affect policy making in the next decades. **Institutional solutions should be combined with a dialogue with EU's partners** on a medium term programming of investments in the energy sector, in a balanced perspective of mutual understanding.

Thank you!

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