Energia e clima 2

Seminario SSST

Torino, 14 Ottobre 2010

Sala Principi D'Acaja - Università di Torino

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Outline

Focus on Energy Sources: Prospects and Policy (3 hours)

- Introduction to energy security
- Perspectives and specific policies for
- Coal (with and without carbon sequestration)
- Oil
- Gas
- Nuclear
- Renewables
- Energy efficiency

Is there enough energy?

Depends on the energy source:

- **"By 2015, growth in the production of easily accessible** oil **and** gas **will not match the projected rate of demand growth. However, unconventional shale gas may solve part of the problem.**
- **While abundant** coal **exists in many parts of the world, transportation difficulties and environmental degradation ultimately pose limits to its growth.**
- **Meanwhile,** alternative energy sources **such as biofuels may become a much more significant part of the energy mix — but there is no "silver bullet" that will completely resolve supply-demand tensions."** **Source:** Shell energy scenarios to 2050 **(2008)**
- **Uranium is also abundant. The issues posed by nuclear energy are related to the risk posed: nuclear accidents, nuclear proliferation, long run waste disposal.**

Is it "secure"?

IEA's define Security of Supply (SoS) as "*the availability of a regular supply of energy at an affordable price*"

The state of the art in the field of security of supply is dominated by a lack of precision and quantification.

Many disciplines have traditionally dealt with the issue of security of supply (economics, geopolitics, and engineering) so that under the label of "security of supply" many different visions and concerns need to be accommodated and a common ground established in order to arrive at a consistent, interdisciplinary framework.

Security of supply is more than the availability of enough energy.

Many indicators have been used to quantify security of supply , mainly in negative sense (in terms of of "dependency " and vulnerability").

Dependency and Vulnerability

Dependence is a measure of how much the domestic economy relies on sources of energy that are not under its control. Physical measures of dependence include:

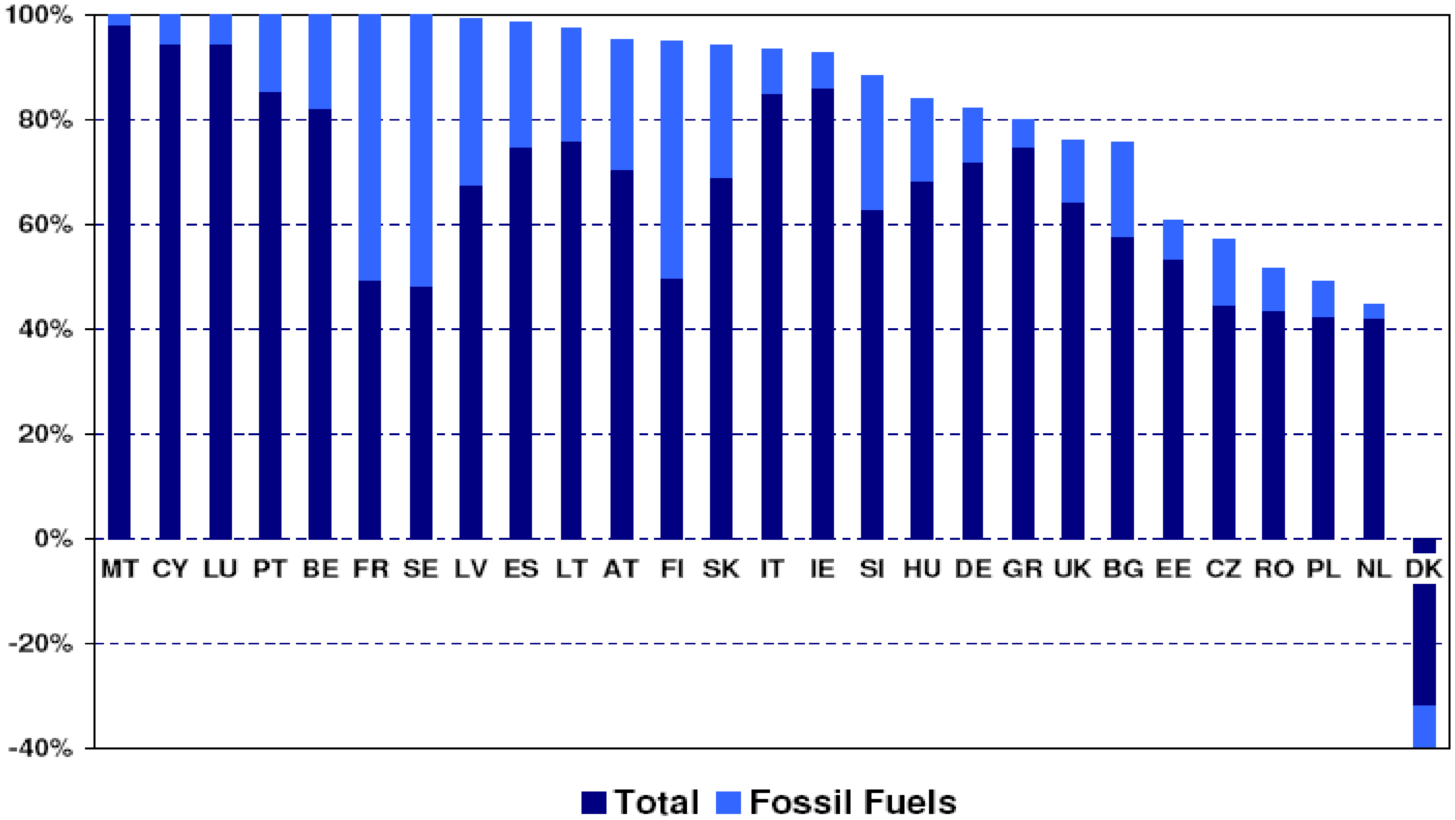
- imports of energy as a percent of total imports,
- oil imports as a percent of total oil consumption,
- gas imports as a percent of total gas consumption.

Economic measures of dependence are oil and gas consumption in physical units per $ of real GDP.

Vulnerability is a measure of the likelihood of domestic disruption in case some external energy source is reduced or cut off. Physical measures of vulnerability include

- the amount of imported oil used in transportation relative to total energy used in transportation,
- amounts of imported oil and gas fired electricity generation relative to total electricity generation,
- degree of supply concentration and
- the Shannon-Weiner diversity index.

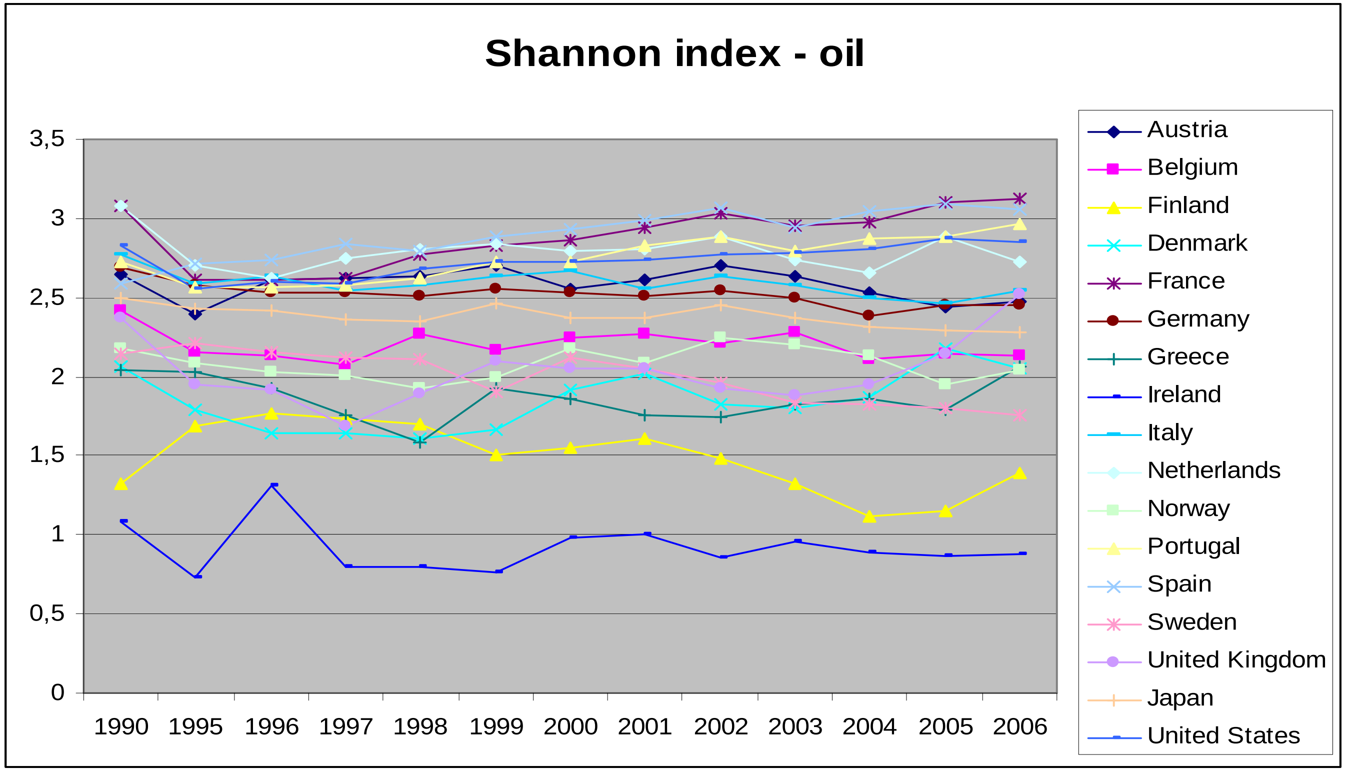
SoS indicators: Dependency - Net Imports/Gross Inland Consumption



Source A. Pototschnig , Florence School of Regulation

SoS indicators: Vulnerability- Shannon Weiner index

$$SW = -\sum_i x_i \ln x_i$$



The Shannon index places greater weight on smaller suppliers, the number increasing as the number of different suppliers increases. It reaches a max when all producers sell to the country under scrutiny, and they have the same size (in terms of oil sold)

source: SECURE project

“Enough” for a given demand

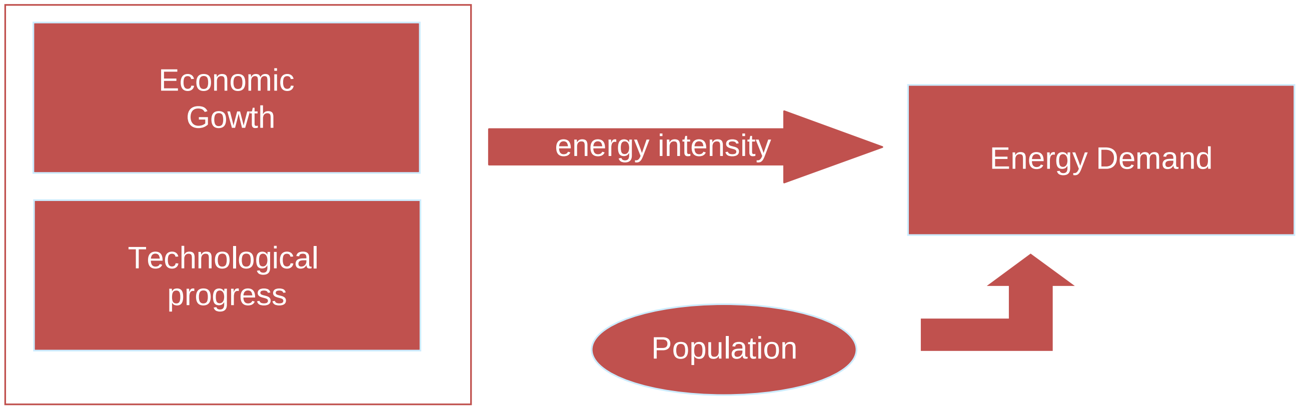
$$ED=f(Y,P,T)$$

“World population has more than doubled since 1950 and is set to increase by 40% by 2050.

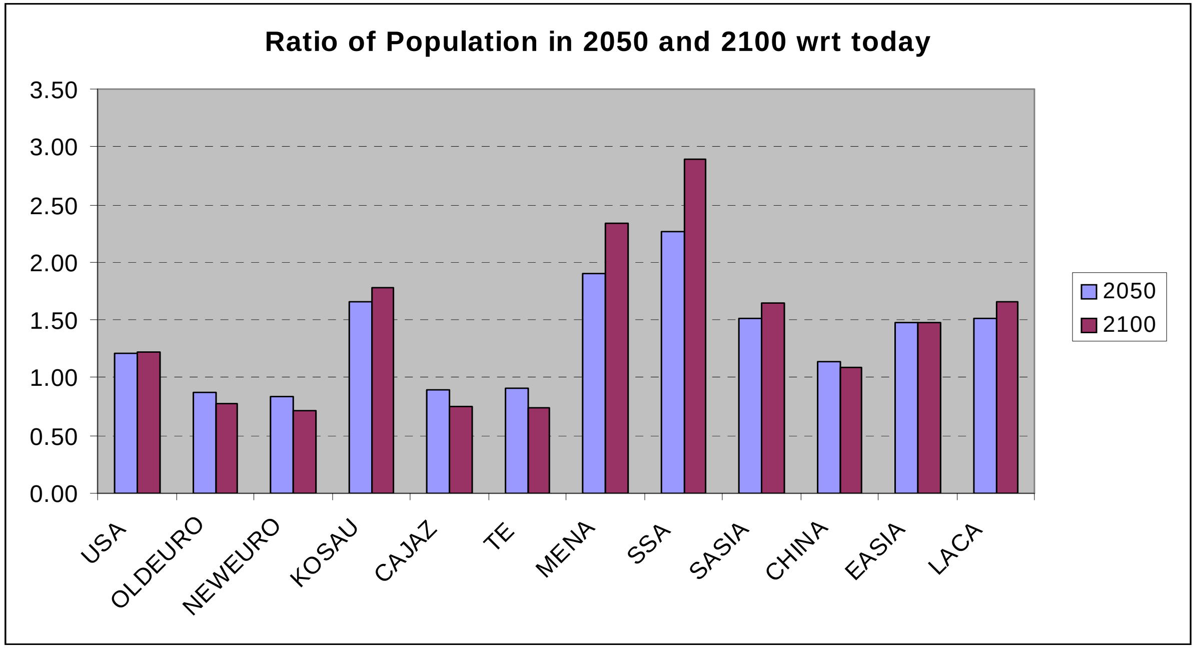
History has shown that as people become richer they use more energy.

Population and GDP will grow strongly in non-OECD countries

and China and India are just starting their journey on the energy ladder.” **Source:** Shell energy scenarios to 2050 **(2008)**

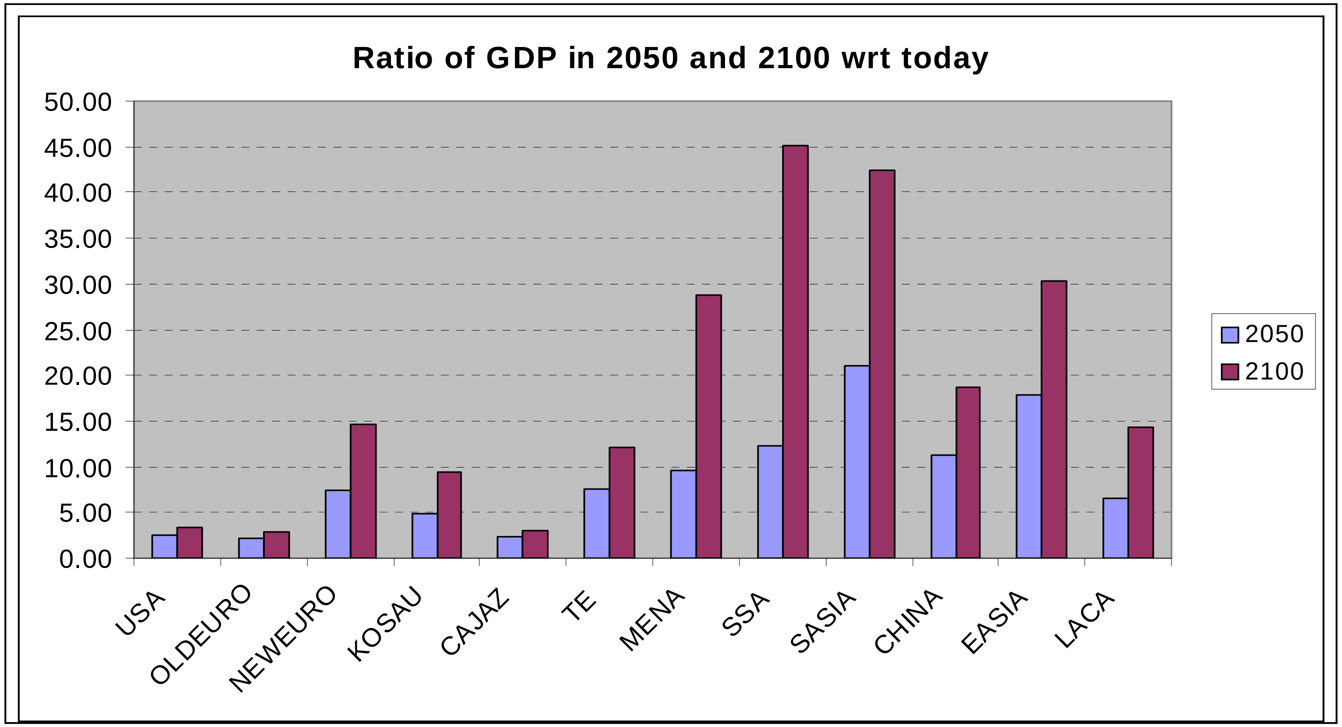


Population



Source: WITCH (FEEM) elaborations based
on UN medium variant Word Population Prospects (http://esa.un.org/unpp/)

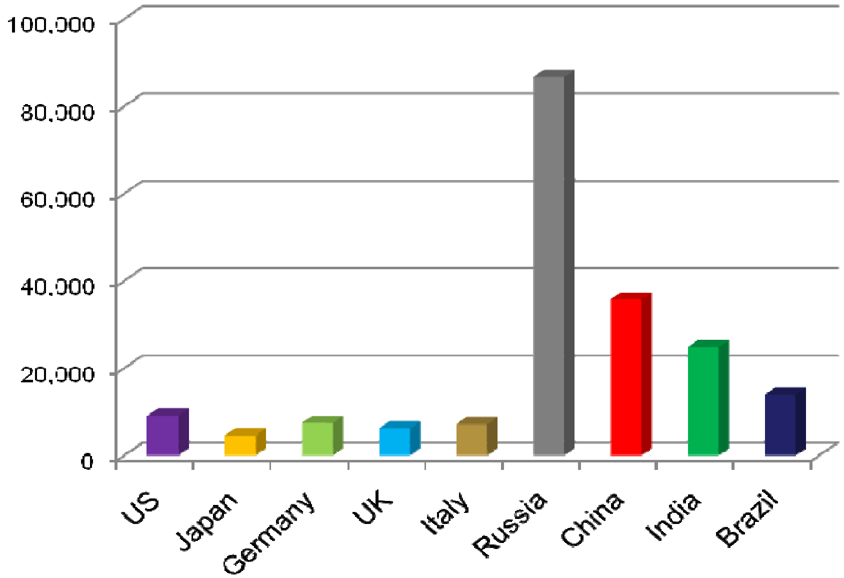
Economic Growth



Energy intensity: international comparisons

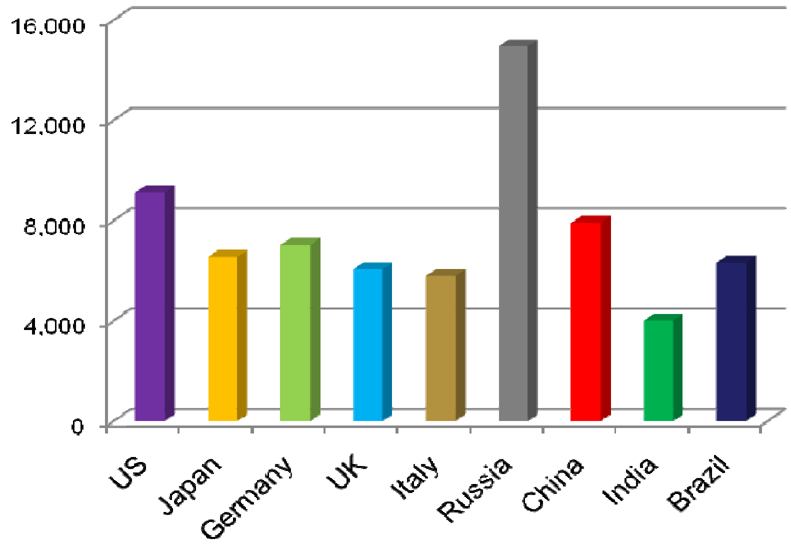
2005 Energy Intensity of selected countries measured in MER

unit: Btu/$ in 2000 price



2005 Energy Intensity of selected countries measured in PPP

unit: Btu/$ in 2000 price



Data source: EIA, International Energy Annual 2007

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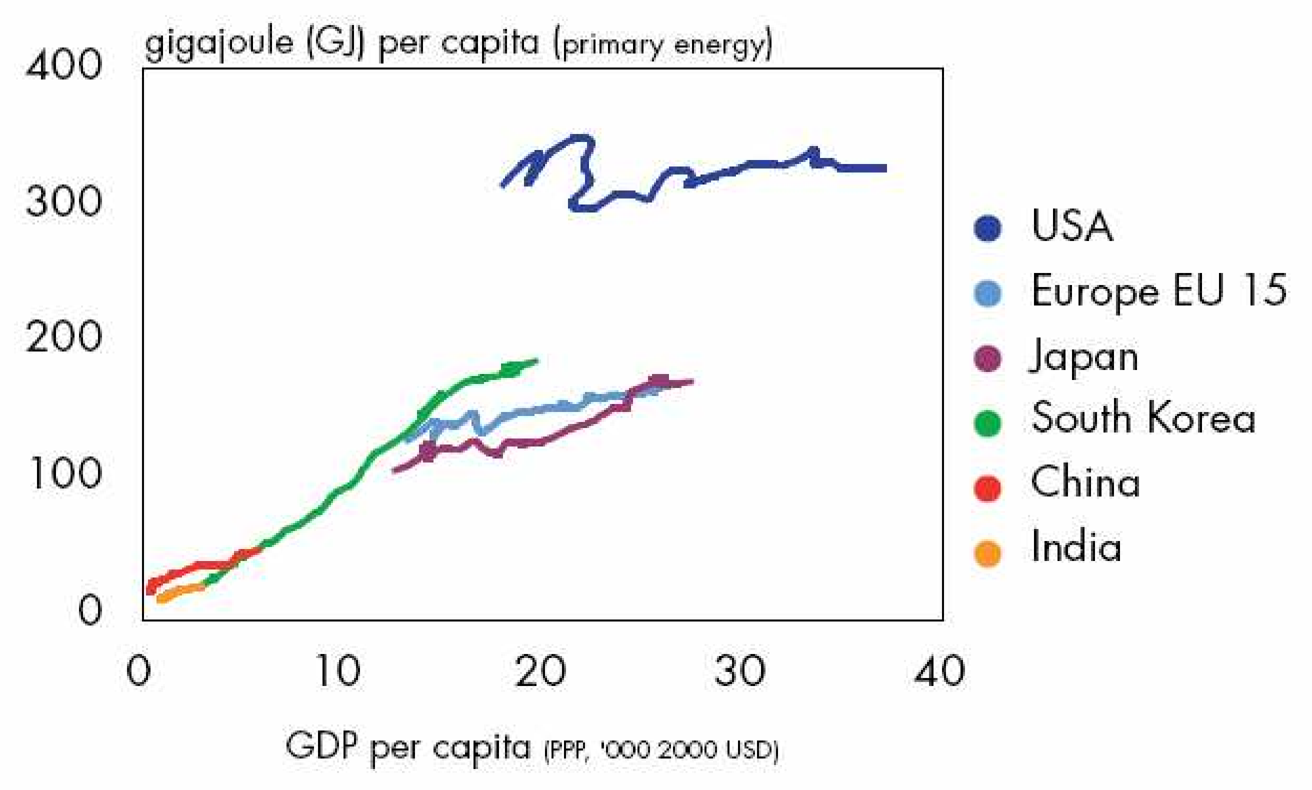
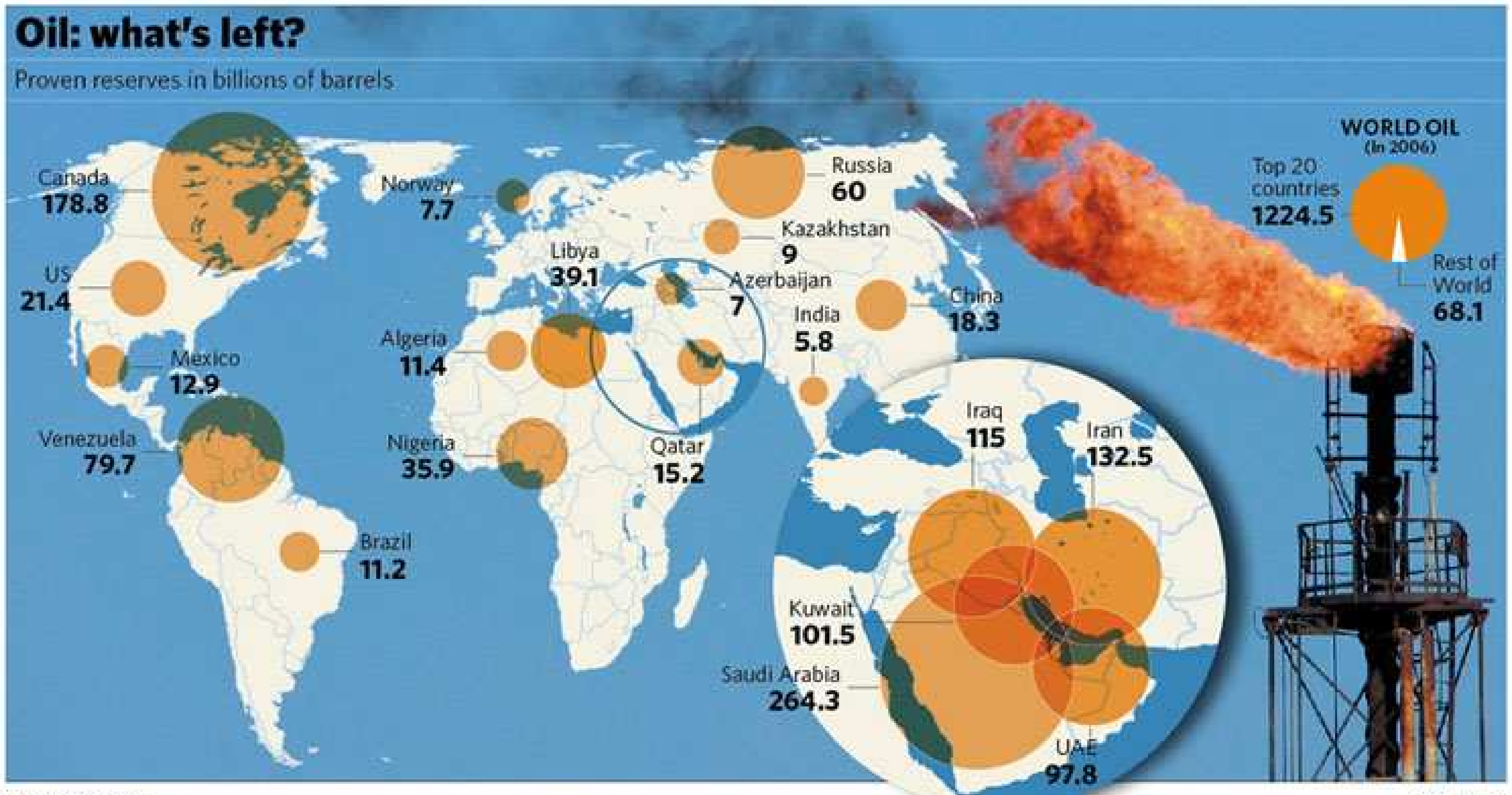
Per capita primary energy consumption vs per capita income 1970-2005



source:WEC 2009

Oil: proven reserves



Source: Oil & Gas Journal

Photograph: EPA

"current oil reserve estimates should be downgraded from between 1150-1350 billion barrels to between 850-900 billion"

Owen et al. The status of conventional world oil reserves--Hype or cause for concern? *Energy Policy*

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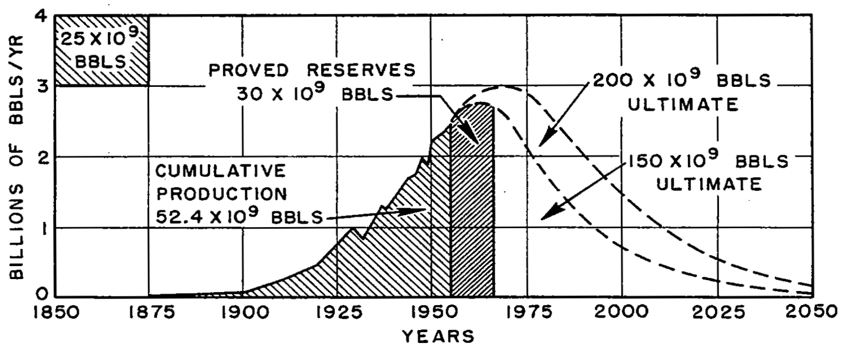
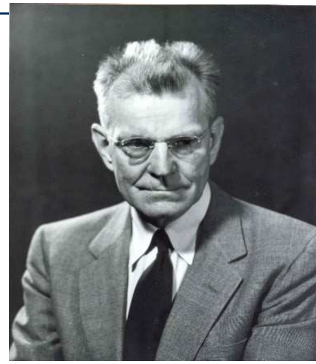
Oil- Hubbert's curve



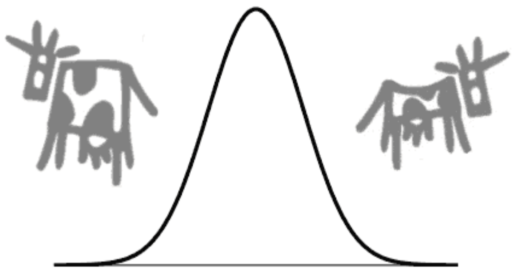
M.K. Hubbert's 1956 graph

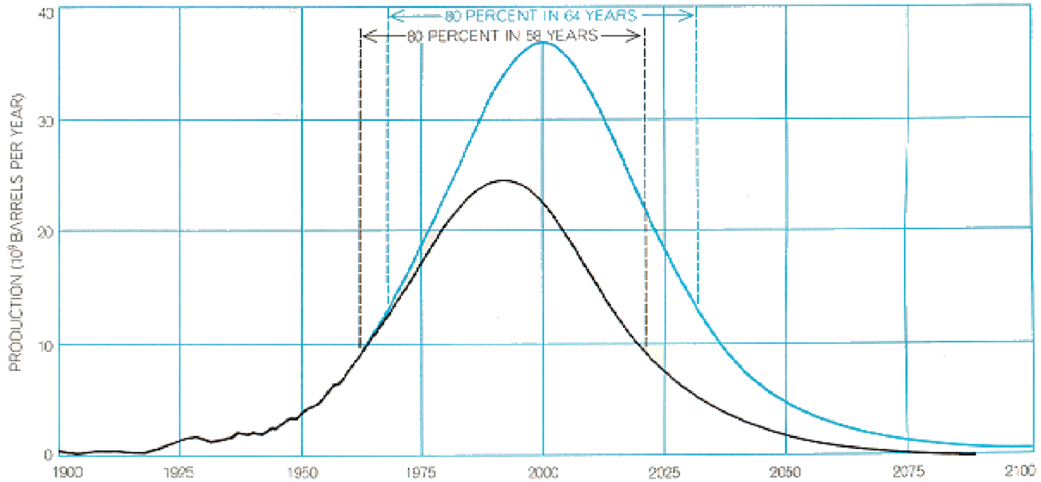
Source: Nuclear Energy and the Fossil Fuels" Publication No. 95. Houston: Shell Development Company, Exploration and Production Research Division, 1956



M. King Hubbert

1903 -- 1989

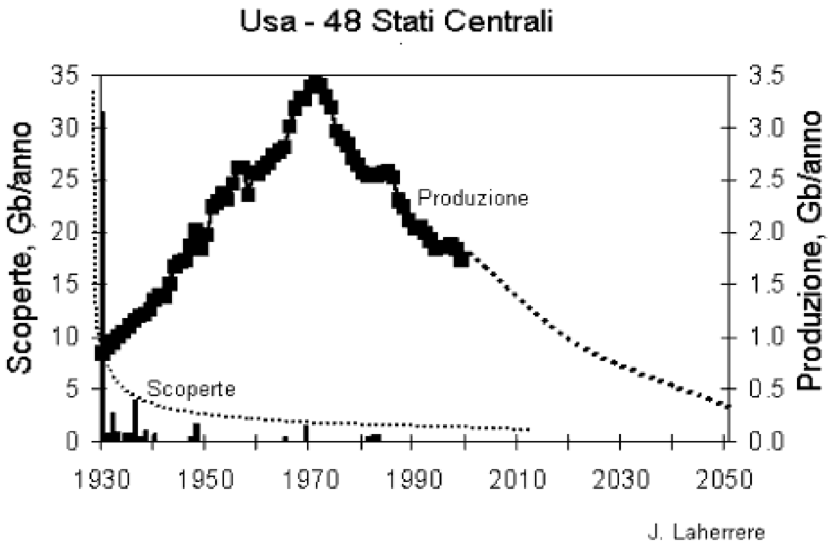




CYCLE OF WORLD OIL PRODUCTION is plotted on the basis of two estimates of the amount of oil that will ultimately be produced. The colored curve reflects Ryman's estimate of $2{,}100 \times 10^9$ barrels and the black curve represents an estimate of $1{,}350 \times 10^9$ barrels.

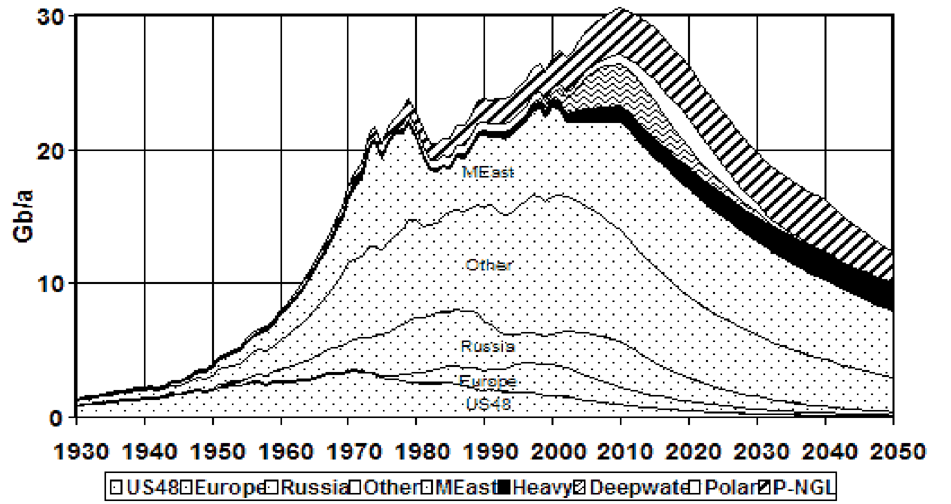
from Energy and Power, A Scientific American Book, 1971, pg 39

Oil- Hubbert’s curve



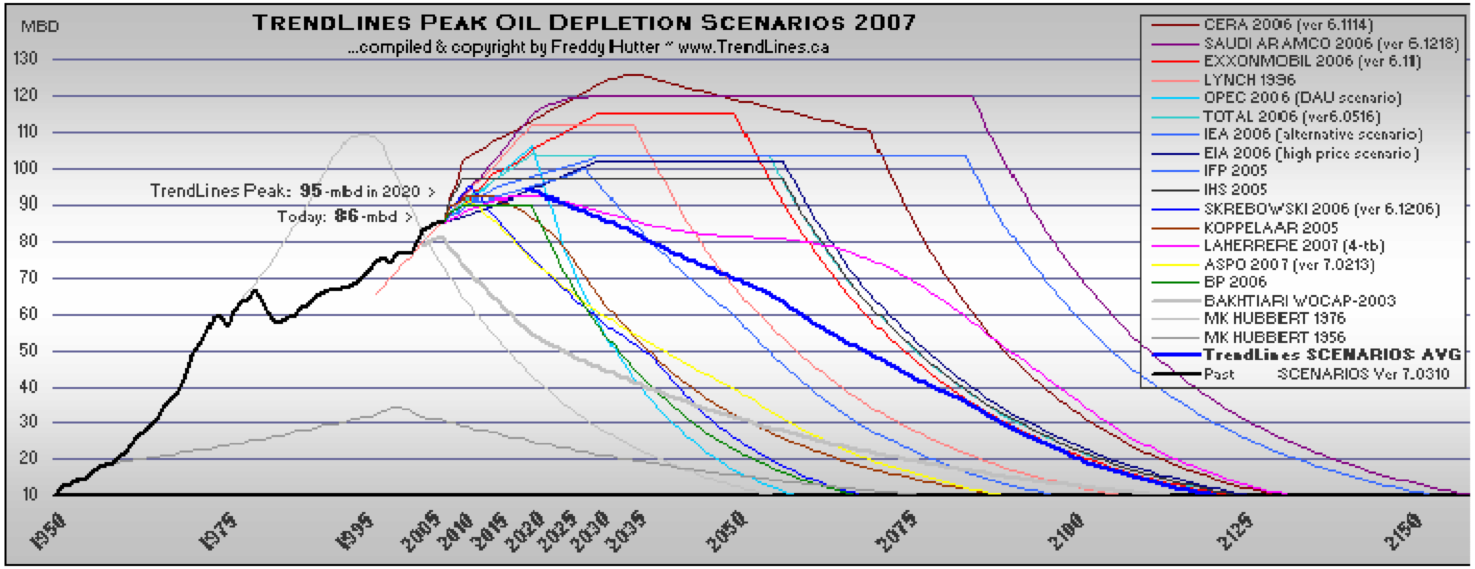
Hubbert was right about the US

For the whole word the situation is less clear. This is one possible scenario…



Oil - The peak oil puzzle

…but many more have been proposed. There is uncertainty about when or (if) oil production will peak



Uncertainty stems from:

•reserves: how much oil is there in the ground, really?
•no major new discoveries, but
•recoverability: is it feasible and how much does it cost to recover unconventional oil? now it looks easier and cheaper.
•oil producers' behaviour: a single world market , but an oligopolistic one

Natural Gas: Reserves (according to WEC – SER 2007)

“

Since 1980, the world’s proved reserves of natural gas have increased at an average annual rate of 3.4% (compared with 2.4% for oil), owing to a number of exploration successes and improved assessments of some existing fields. At the present level, global gas reserves are equivalent to more than 56 years’ production (net of re-injection) at the 2005 rate.

Some 44% of total proved reserves is concentrated in about twenty mega and supergiant fields, within which the world’s largest non-associated gas field accounts for very nearly half. There is […] a high degree of consensus regarding most of the main players, notwithstanding differences in detail and in a few cases sharp disparities in definitions

The amount of natural gas remaining to be discovered has been consistently and significantly underestimated. …Gas exploration is at a less mature stage than that for crude oil. Many territories have been only partially explored. Improvements in the economics of transportation are opening-up access to hitherto ‘stranded’ deposits, while advances in technology will enable exploration and production activities to be undertaken in deeper and more complex horizons.

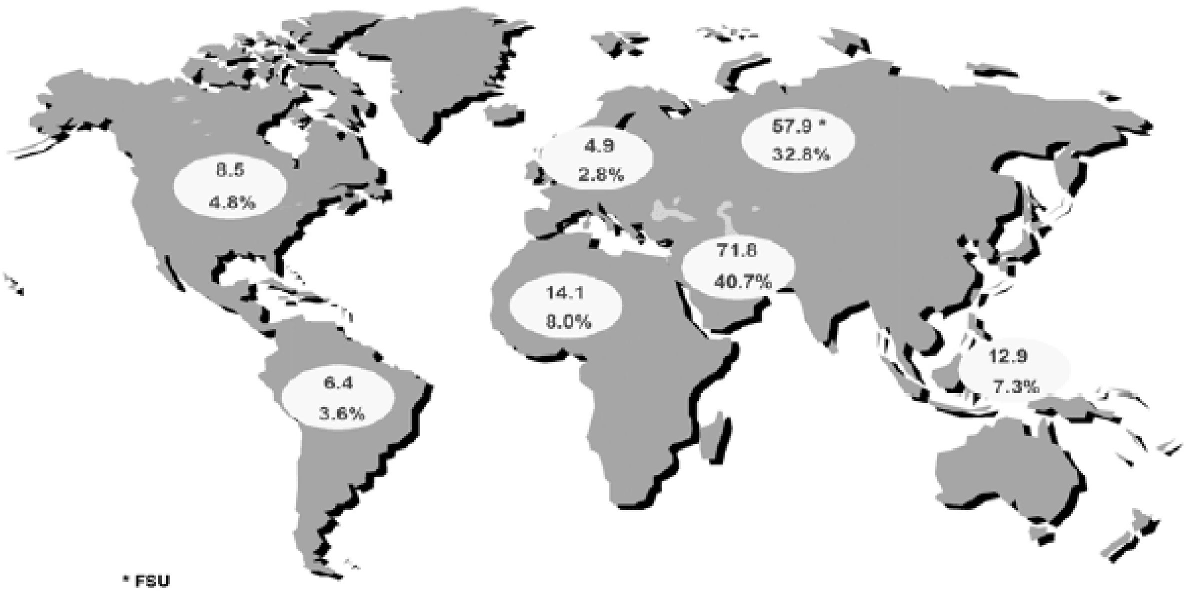
Conventional sources of natural gas are already augmented by substantial quantities of coal-bed methane (CBM), and other non conventional sources (e.g. tight gas sands, gas shales and possibly gas hydrates) will come to play a part in gas supply.

Cedigaz… give natural gas a lifetime probably in excess of 130 years, at the current rate of consumption.

”

Latest developments: demand decrease (7% in 2009) due to recession; more LNG; shale gas in USA. -> decupling gas prices and oil prices

Natural Gas Reserves



Proved natural gas reserves as at end-2005 (tcm and % of world)
Source: World Energy Council SER 2007

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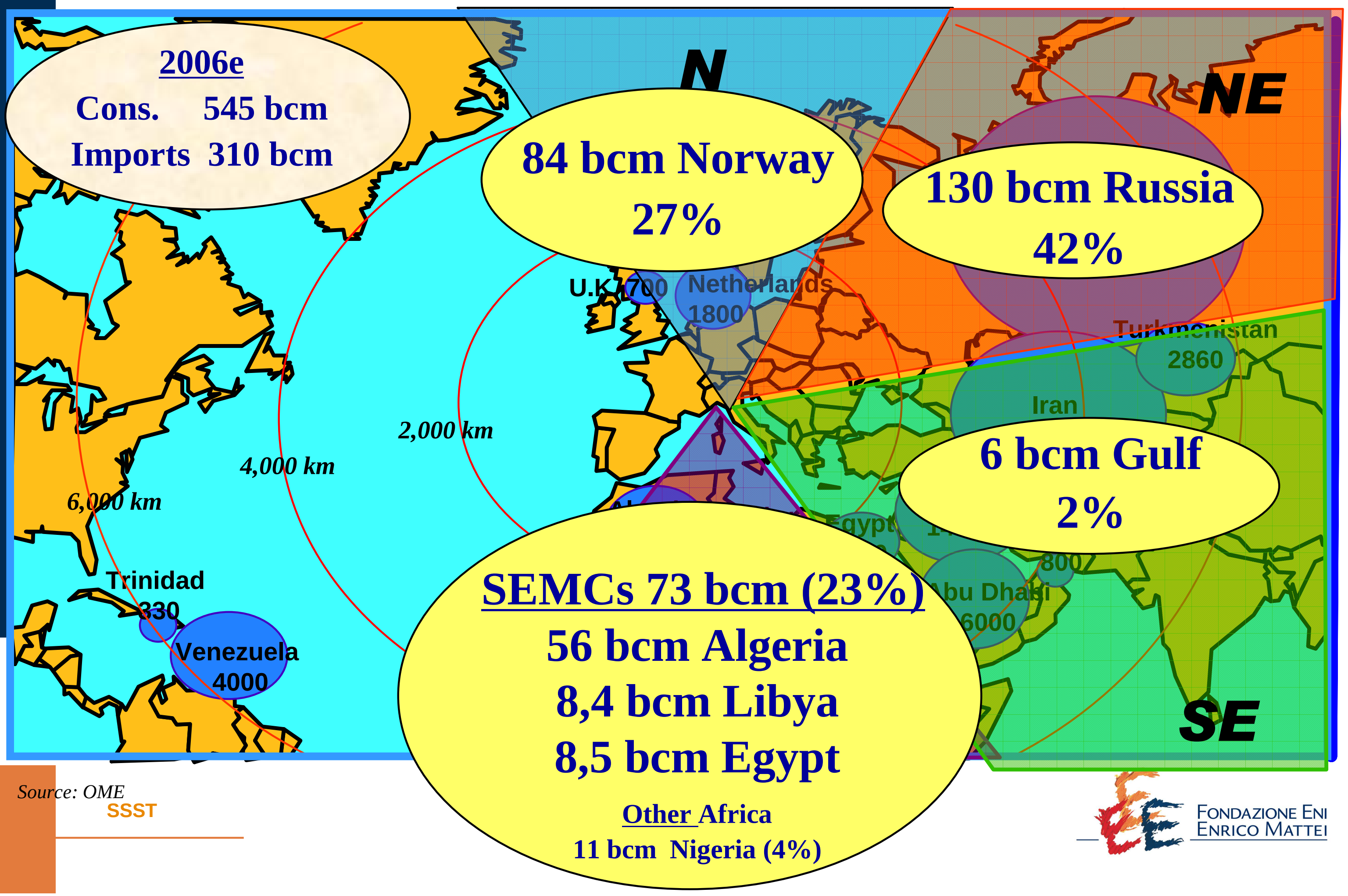
2006 : Gas Supply for EU-27



Source: OME

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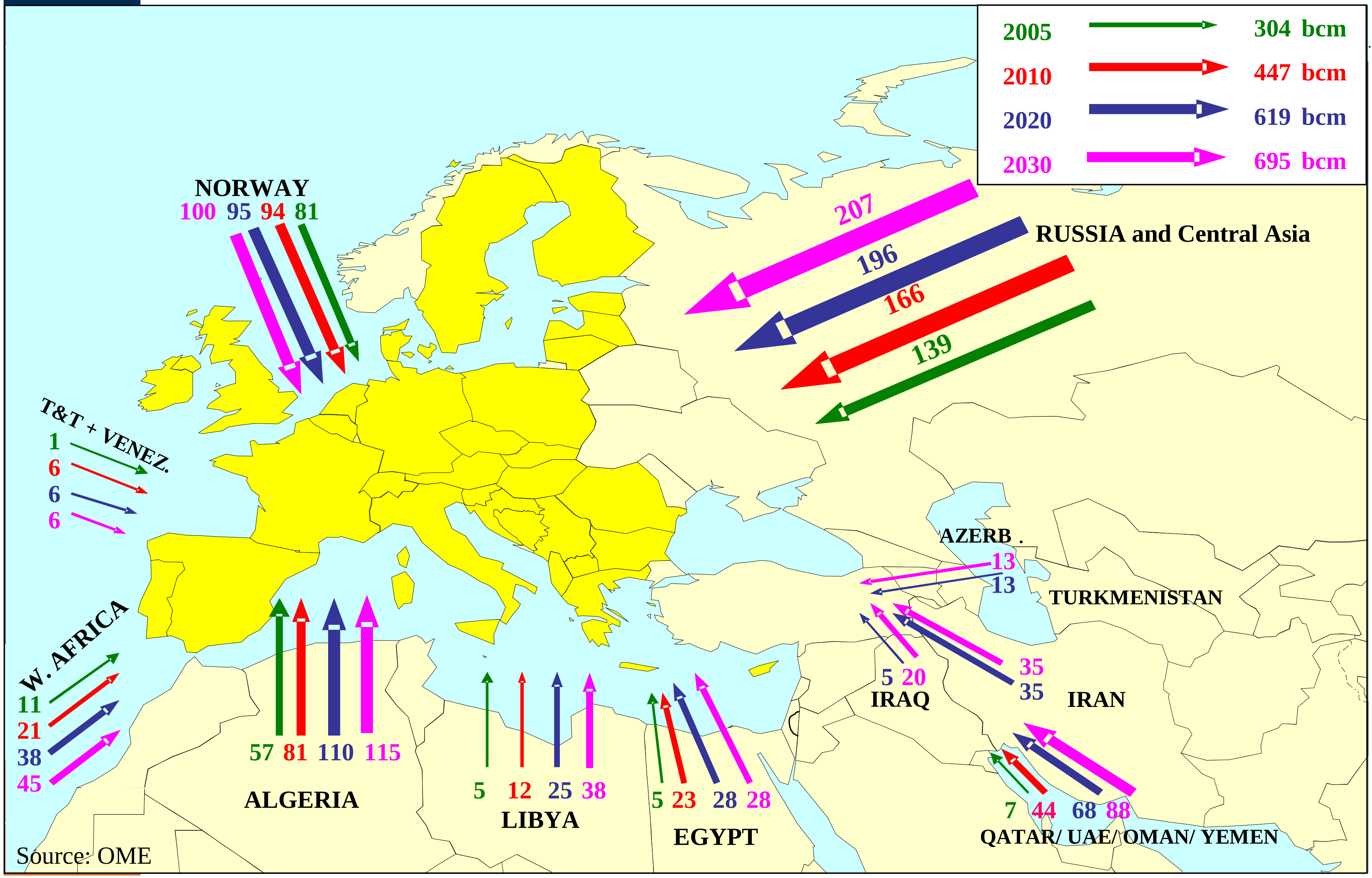
Future gas export potential for Europe

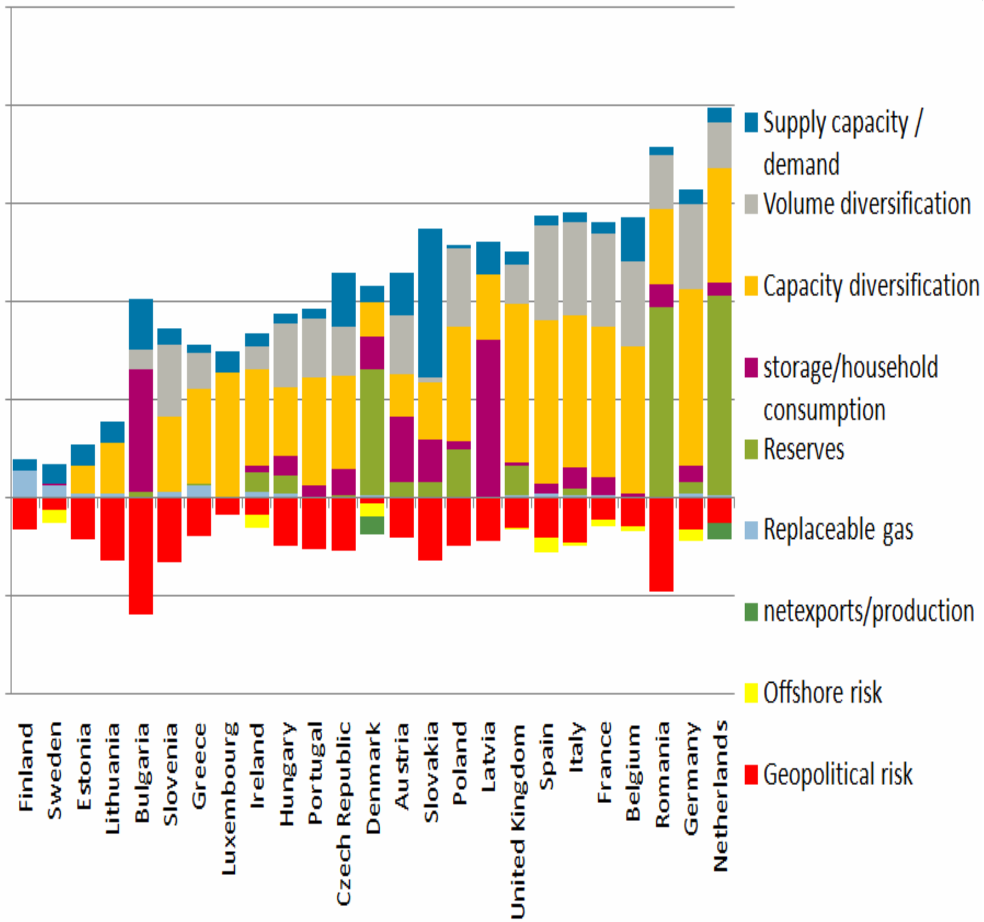


Natural Gas: infrastructure- Pipelines

Source: OME & Eurogas

Natural Gas

- Natural gas security is not only a question of the external dimension such as diversification of supply sources and routes. Demand side and internal factors are as important.
- Many parameters are at play – and these parameters can change over time e.g. as the consequence of policy
- Thus securing supply is a mix of measures and forward looking policies.



Source: Ramboll Secure SoS index

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Natural Gas

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

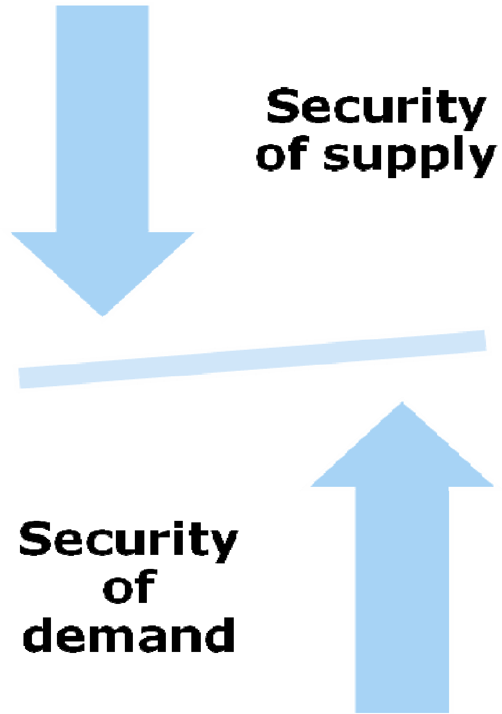
Internal market development

- Reverse flow and removal of bottlenecks
- To allow the gas to go where it is needed
- To optimise utilisation of SoS measures
- To allow for solidarity between consumers and between consumers and producers

External dimension

- Develop an external infrastructure policy
- Focus on stable diversified gas import and transit
- Clear EU signals and policy on natural gas
- Long term contracts
- Diversification of supply

Gas prices should reflect supply and demand in the long run



source: SECURE project

Natural Gas

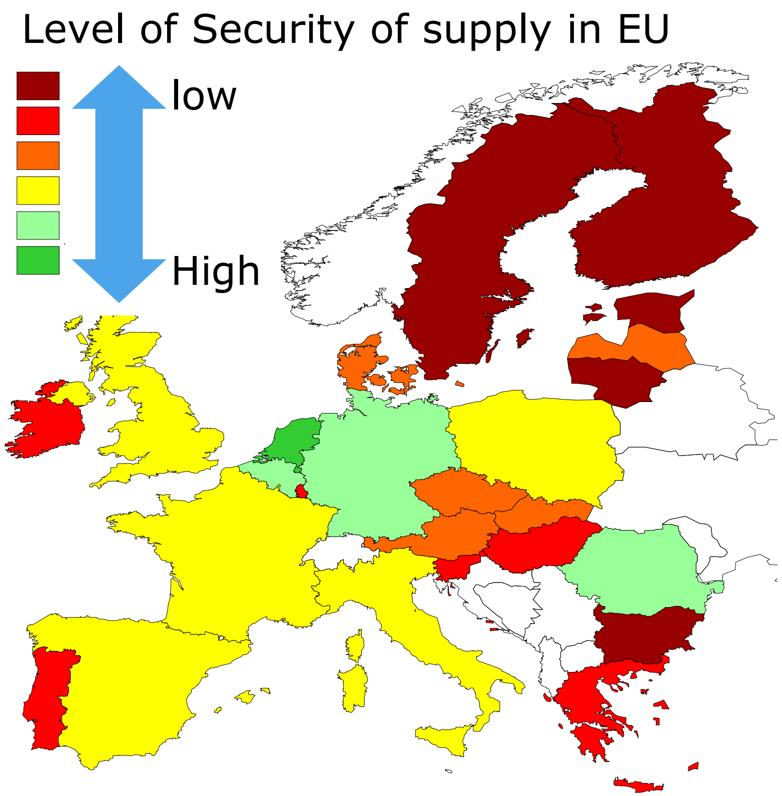
There is enough gas around Europe to secure the EU gas supply to 2030 – the issue is investment upstream as well as infrastructure

But what about after 2030?

- Will the EU be prepared for a post gas peak in many of its current suppliers, and how?

Gas security has to be addressed in a global perspective, and throughout the gas chain.

=> **Need to promote healthy relations between producers, consumers, transit countries and between national and international companies.**



Source: Ramboll Secure SoS index

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Coal

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.**

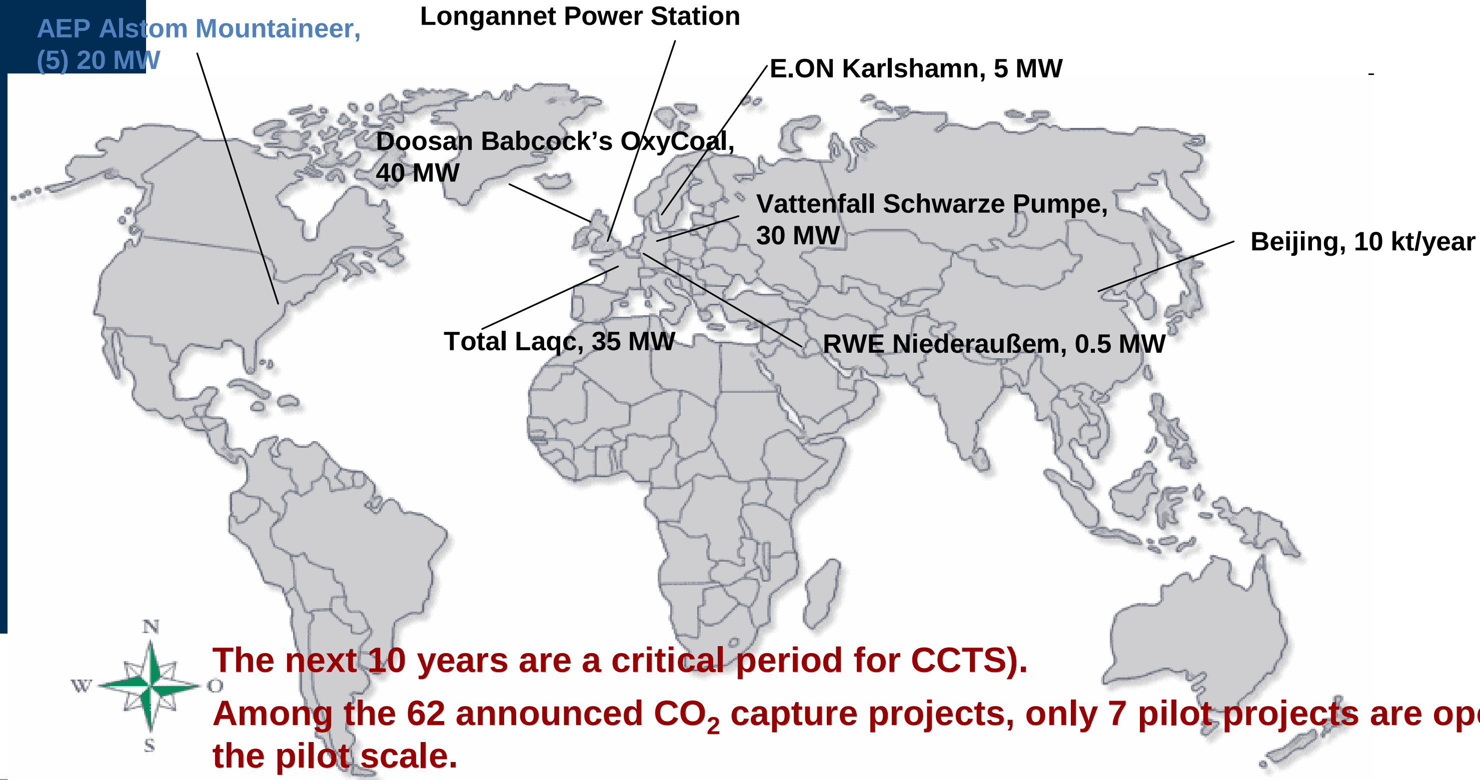
Upstream, there are little worries about the supply security of (steam) coal

- 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"

source: SECURE project

Investment needs for CCTS

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



The next 10 years are a critical period for CCTS).

Among the 62 announced CO_2 capture projects, only 7 pilot projects are operating on the pilot scale.

Assuming that all of the announced projects are realized by 2050 there still remains a gap of 40 projects to reach the IAE blue map scenario.

source: SECURE project

Coal: CCTS

- **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.**
- 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 CO_2 the revenue stream strongly depends on future regulatory decisions; these should be made explicit as soon as possible.

source: SECURE project

Coal: CCTS

- The financial uncertainty surrounding future projects should be reduced. In the absence of clear CO_2 price corridors and signals, regulatory certainty can be created, e.g., by obliging new power plants in include a "capture-ready" option
- Future regulation needs to specify the allocation and financing principles for pipeline and storage, and access for 3rd parties
- The state bares 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 industrial applications
- Alternative uses of CO_2 (to replace CCTS) should be further explored

(e.g. methanol, chemicals)

source: SECURE project

Nuclear energy

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).

source: SECURE project

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. And contrary to the general energy capital cost index which has fallen by 20-30% since its peak in 2008, nuclear costs do not seem to have fallen over the last year ;

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 raise some doubts on the ability of nuclear power to foster a decrease in prices.

source: SECURE project

Renewable energy sources (RES)

By definition, not depletable; however some may have limited potential in many countries due to geographical, orographic, meteorological conditions (e.g hydro, wind, solar)

According to IEA (http://www.iea.org/textbase/papers/2006/renewable_factsheet.pdf) they can be divided into first, second and third generation RES:

- **1st: mature technologies like hydropower, biomass combustion, and geothermal power and heat**
- **2nd: technologies recently developed but commercially viable (at least in some countries and in some case with government support: solar heating and cooling, wind power, modern forms of bioenergy, and solar photovoltaics.**
- **3rd: are still under development and include concentrating solar power, ocean energy, enhanced geothermal systems, and integrated bioenergy system**

The key is their cost compared to traditional fossil energy sources

Also as they are mostly emission free, they interact with the sustainability issues; however there is no impact-free energy source:

- **hydro: water use, quality and water rights; land use; local pollution**
- **biomass: CO_2 efficiency varies with crop; competition with food crops, cattle, forests**
- **wind: landscape impacts; migratory birds, LCA emissions**

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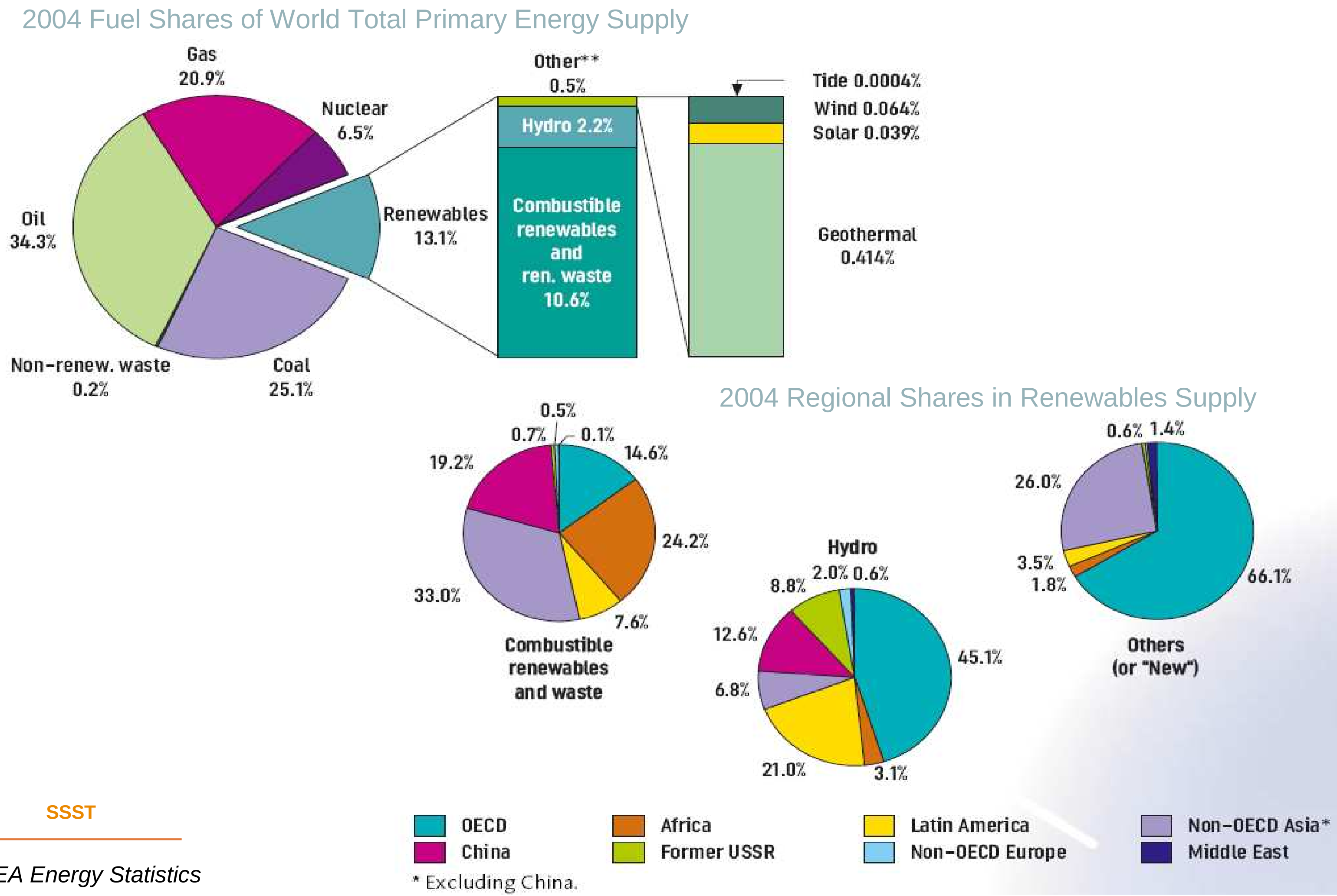
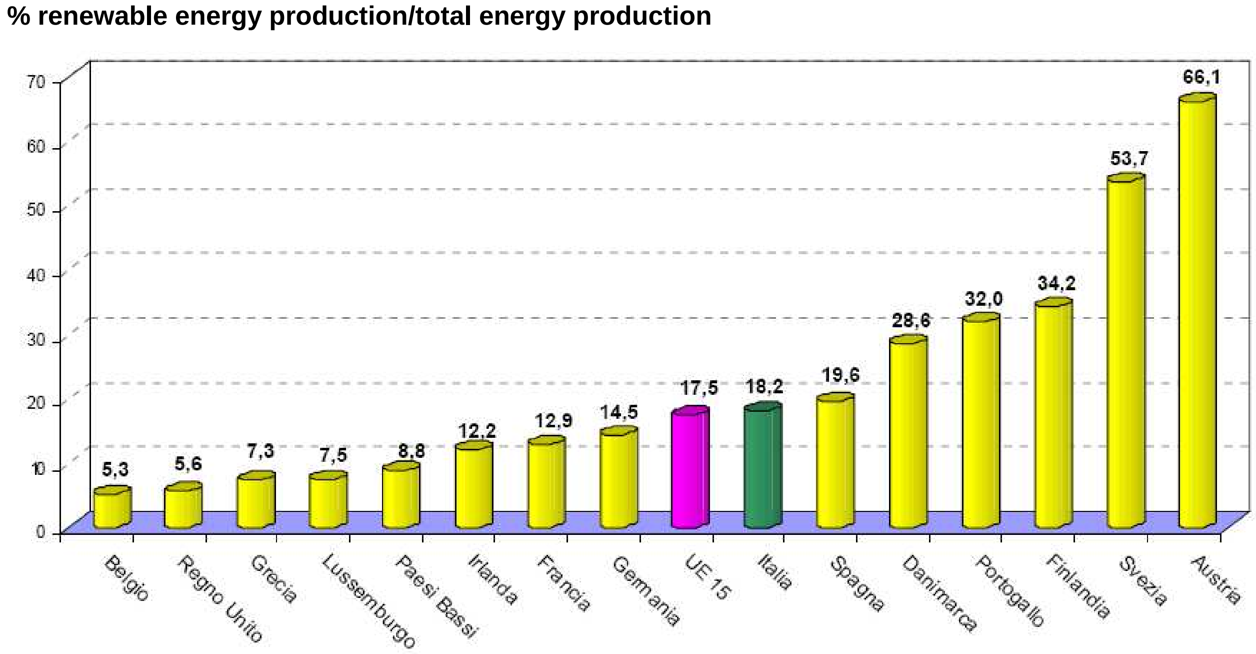
Renewable energy sources (RES)



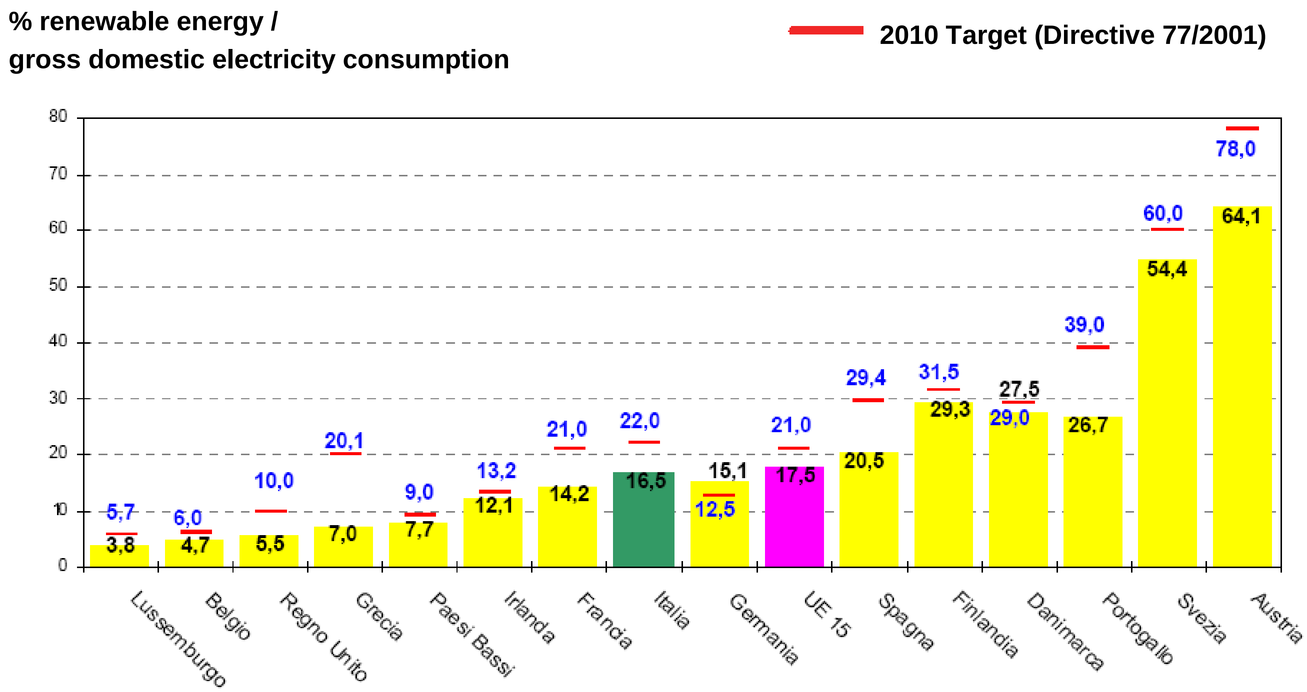
Source: IEA Energy Statistics

Renewable energy production the EU



Source: GSE 2009

Renewable share on gross domestic electricity consumption in Europe



Source: GSE 2009

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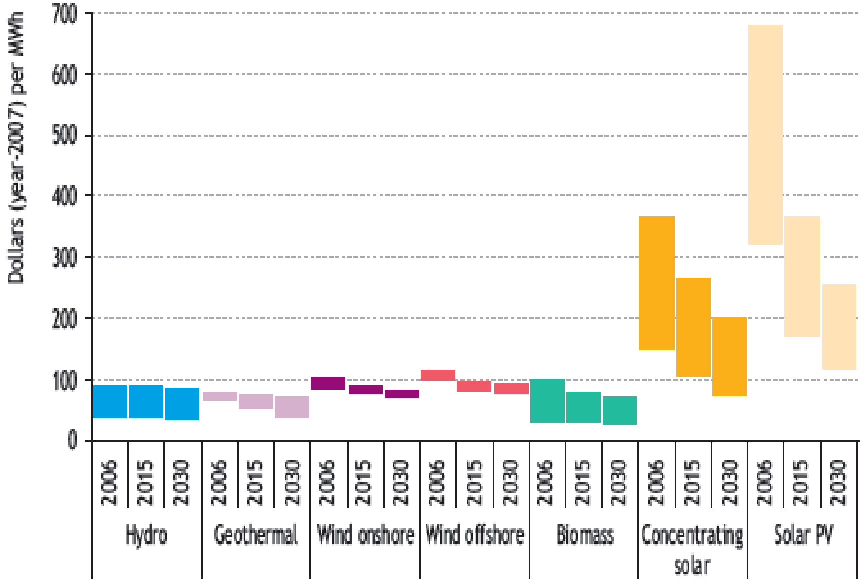
Outlook on electricity generation costs from renewable sources



WEO, 2008

- Generation costs are expected to decrease given the decrease in investment costs due to technological progress and scale economies
- Mature technologies' costs (geothermal and wind) will decrease less
- In reality costs vary substantially due to the expected life of the technology, the proximity of demand, the local availability of the renewable energy source.
- Output characteristics of various technologies also matter. Large hydro storage capabilities increase the value of this technology and hence its competitiveness

The way forward for renewables in Europe

A high share of renewable energies in the mid- to long-term cannot be reached without strong increases in all three sectors: renewable electricity, heat and 2nd generation biofuels. The current policy framework in the individual Member States does include an extensive set of supporting mechanisms for RES-E and to some extent for biofuels, but the current limited and dispersed support for RES-H needs to be addressed in the future.

Level playing field. The general approach should be to 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.

Temporary application of technology-specific support instruments: The present technological uncertainty suggests 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. Consequently, any future policy framework should consider providing technology-specific support to the various RES options. However, this policy should entail periodic reviews of the incentive schemes, in the light of a possible future phasing out.

Efforts are needed in all Member States. The uneven distribution of RES potentials and costs emphasises the need for intensified cooperation between Member States, where suitable accompanying flexibility mechanisms can assist the achievement of national RES targets in an efficient and effective manner.

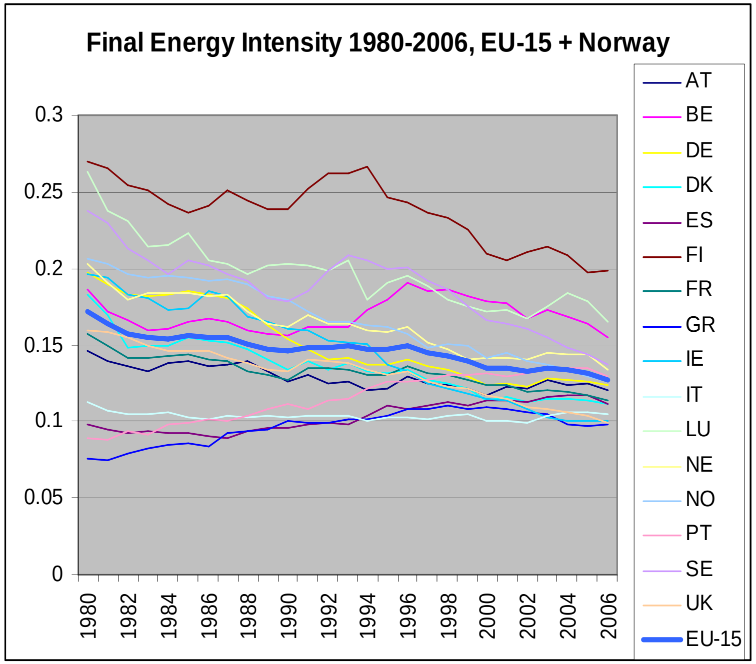
RES policies should be supported by a strong energy efficiency policy. Modelling results indicate that in the absence of strong energy efficiency policies energy demand is higher and more RES is required in order to achieve the targeted share of 20% by 2020. Consequently, more expensive RETհave to be utilised and the average yearly policy costs are expected to increase largely. To face the challenges resulting from an increased share of fluctuating wind electricity, several potential remedies may be applied.

The ability of the system to deal with imbalances should be improved: “smart” and extended grids, intraday market , demand side management, storage devices can help.

source: SECURE project

Energy efficiency indicators

- *Energy Intensity:* ratio between final energy consumption and Gross Value Added (GVA). It is an economic measure of the energy requirement that a country, or one of its industries, needs to fulfil for its production;
- *Energy Efficency* is measured as the variation of energy consumption for unit of product with respect to a base year. A downward trend indicates a progressive improvement of the country's energy efficiency.
- *Carbon Intensity* is the ratio of CO_2 emission equivalents generated (in terms of Mton of CO_2) to the indicator of economic activity, GVA. It measures the degree of carbonisation of an economy or of a given productive sector.



Unit of measure: ktoe/00$ppp

SSST

source: SECURE project

Energy Intensity in the Industry Sector, 1980-2006, ktoe/00$ppp.

- **Best performance in Ireland, Denmark & Greece**
- **The average and median values show how energy intensity has improved and converged among all countries.**

3-year Average Centered on 1985			3-year Average Centered on 1995			3-year Average Centered on 2005	
IT	0.113		IE	0.110		IE	0.063
ES	0.120		DK	0.113		DK	0.088
UK	0.121		IT	0.120		GR	0.108
DK	0.122		UK	0.123		UK	0.117
GR	0.125		GR	0.125		IT	0.126
AT	0.136		AT	0.130		NO	0.131
PT	0.150		ES	0.137		AT	0.139
FR	0.163		DE	0.137		DE	0.139
DE	0.165		FR	0.167		ES	0.142
IE	0.173		PT	0.184		FR	0.154
BE	0.209		NO	0.195		PT	0.201
NE	0.227		NE	0.215		SE	0.210
NO	0.240		BE	0.278		NE	0.234
SE	0.252		SE	0.285		LU	0.240
FI	0.330		LU	0.315		BE	0.297
LU	0.391		FI	0.370		FI	0.318
Average	0.190			0.188			0.169
Median	0.164			0.152			0.140
Minimum	0.113			0.110			0.063
Maximum	0.391			0.370			0.318

source: SECURE project

Percentage Change of Energy Efficiency in the EU-15 Countries and Norway, 1980-2004. Household sector.

In the household sector Norway and Portugal have achieved significant improvements in terms of energy efficiency, due to the policies introduced by these countries in order to boost energy savings and energy conservation.

Large potential for improvement in the EE for the less performing countries such as Italy, where the improvement in EE achieved by this sector has been equal to a tenth of the improvement registered by more efficient countries (namely, Portugal and Denmark).

HOUSEHOLD (% change in EE Index over period)

1980 - 2004			1980 - 1992		1992 - 2004	
PT	-49.8%		-31.7%	DK	PT	-42.4%
DK	-43.4%		-18.0%	SE	DK	-17.2%
SE	-28.5%		-12.9%	PT	AT	-16.3%
AT	-24.9%		-10.3%	AT	SE	-12.8%
FR	-17.1%		-10.0%	FR	NO	-11.7%
FI	-16.1%	Median	-7.9%	FI	FI	-8.9%
DE	-10.5%		-6.9%	UK	DE	-8.5%
UK	-8.7%		-2.2%	DE	FR	-7.9%
IT	-4.2%		0.5%	IT	IT	-4.7%
NO	2.2%		15.8%	NO	UK	-1.9%
ES	142.7%		40.5%	ES	ES	72.7%
BE	n / a		n / a	BE	BE	n / a
EL	n / a		n / a	EL	EL	n / a
IE	n / a		n / a	IE	IE	n / a
LU	n / a		n / a	LU	LU	n / a
NL	n / a		n / a	NL	NL	n / a
Average =	-5.3%		-3.9%			-5.4%
Median =	-16.1%		-7.9%			-8.9%
St. Dev =	0.516		0.188			0.280
Minimum =	-49.8%		-31.7%			-42.4%
Maximum =	142.7%		40.5%			72.7%

SSST

source: SECURE project

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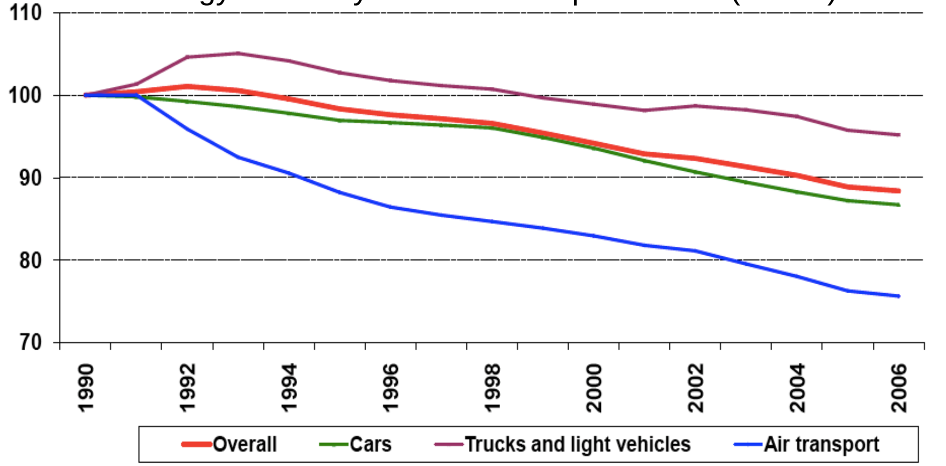
Disaggregating the E.E. index by transport modes, a regular improvement of the energy efficiency of transport (12%) takes place in the EU over the period 1990-2006.

The lower progress can be blamed on the road transport of goods, while the best performance in the index takes place in the air transport.

For the transport sector as a whole, Ireland and Greece reported the best performances in the period 1980-2004.

By contrast, performances in the energy transport sector have worsened in Spain.

Energy efficiency index for transport EU-27 (ODEX).

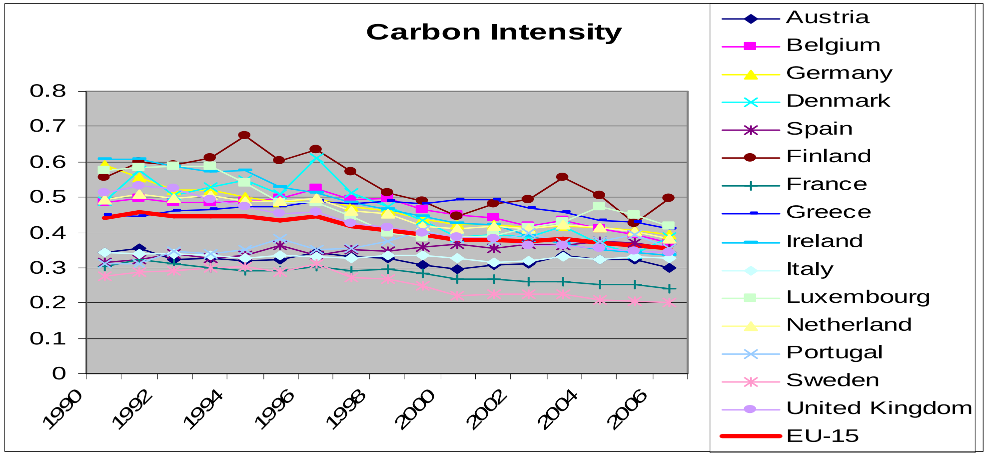


source: SECURE project

Definition: Carbon Intensity is the ratio of CO_2 emission equivalents generated (in terms of Mton of CO2) to the indicator of economic activity, GVA. It measures the degree of carbonisation of an economy or of a given productive sector.

Looking at the average of EU-15 Countries, carbon intensity decreased from 1990 to 2006 of about 20 percent, although in Spain and Portugal, the index increased.

The best performances are attained by Ireland and Germany, which show a variation of about -45 and -33 percent respectively between 1990 and 2006.



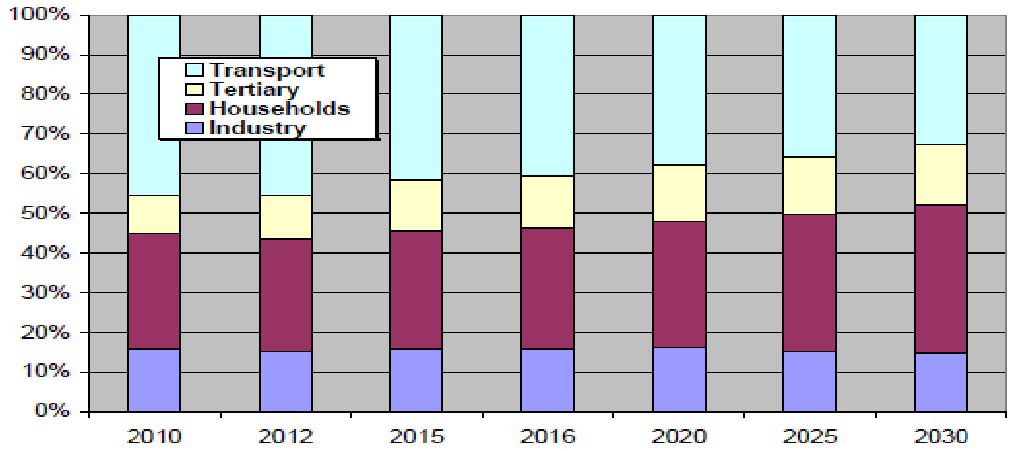
Source: Authors' computation on data from ENERDATA, EUROSTAT, OECD.

Energy savings potentials

According to the study of the European Commission (2009) on Energy Savings Potentials, in the short run (2010) transport, non-EU ETS sectors (in particular crosscutting technologies such as electric motor applications) and electric applications in the residential/tertiary sectors may have the largest potentials.

In the medium run (2020) the contribution from the building sector (residential and tertiary) to the potentials grows larger.

Sectoral contributions to the Energy savings potentials over time in relative terms.



source: SECURE project

2009 Two important pieces of **EU regulation** adopted

Worse recession after the great depression

Worse Gas Crisis in European history

3rd Energy Market Package (sept. 2007):

3rd package: agreed May 09
Green package: agreed April 09
SER-2: under discussion

Competitiveness
"LISBON"

Sustainable Development
"KYOTO"

Security of Supply
"MOSCOW"

2nd Strategic Energy Review, november 2008

Green Package (jan. 2008):

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EU Stimulus package

Financial crisis + worse recession after the great depression

Worse Gas Crisis in European history

EU Stimulus package for the energy sector 3.98 B€

- **Gas and Electricity interconnections** (2.29 B€)
  - Baltic interconnection
  - Southern Gas Corridor
  - LNG
  - Mediterranean
  - Central and Southeast Europe
  - North See offshore grid
- **Offshore Wind Programme** (315 M€): Baltic and North Sea
- **Carbon Capture and Storage (CCS)**: 1.05 B€

More than half of the EU stimulus package for the energy sector goes to EU gas and electricity interconnections to increase the physical functionning of the internal market and thus improve security of supply.

11

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Energy Policy in the EU (2/2)

Security of supply, sustainability and competitiveness are not independent objectives;

Need to have a consensus view about the current situation and a (long-run) policy to deal with it.

The Green Paper (2006) “A European strategy for sustainable, competitive and secure energy” [COM(2006) 105 final]:

- Identifies priority areas and lists proposals to meet and fine-tune three core objectives:
    1. Increasing **security** of supply;
    2. ensuring the **competitiveness** of European economies and the availability of affordable energy, and;
    3. promoting environmental **sustainability** and combating climate change.

The “20-20-20” objectives : By 2020

- 20% reduction in CO_2 emissions
- 20% increase in renewable source share in TPES
- 20% increase in energy efficiency

EU policies promoting energy saving and efficiency

Energy efficiency is identified as a key ingredient to improve self-sufficiency and reducing GHG emissions.

GP on “Energy Efficiency or doing more with less” (2005):

- to cut energy consumption by 20% by 2020.
  - ⇒ to reduce the dependency on imported oil and gas
  - ⇒ to reduce the energy bill by an estimated 100 billion euro every year.

The EU has proposed directives and regulations concerned with areas where there is potential for energy savings:

- End-use Efficiency & Energy Services;
- Energy Efficiency in Buildings;
- Eco-design of Energy-Using Products;
- Energy Labeling of Domestic Appliances;
- Combined Heat and Power (Cogeneration).

Policy reccomendations for Low Carbon energy (Renewables, nuclear, CCTS)

- supporting further integration of electricity markets;
- levelling the playing field for low carbon technologies;
- guiding investor assurances in licensing procedures;
- support improvements in energy efficiency

As member states retain sovereignty over energy mixes, local political/public consent and support seems to be vital.

The most efficient way for the EU to develop cost-effective low carbon power sources is to have a viable EU-wide emission trading system capable of delivering standardized carbon prices and/or an effective EU-wide carbon tax.

source: SECURE project

Grazie!

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