



Energy Systems of the Near Future: Is Climate Change the Real Loser?

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The Message (I)

- Currently, Climate Change is not the essential driving force in shaping the energy systems of the next decades: energy security and economics are dictating choices. It does not mean that Climate Change is completely forgotten: the trends towards energy sources emitting less GHGs is maintained but it is driven in some cases by other considerations: carcinogenic local pollution, job creation

The Message (2)

- Trump cards for a sustainable future:
 - Energy savings
 - Energy storage systems
 - Smart grids
 - Carbon Capture and Storage

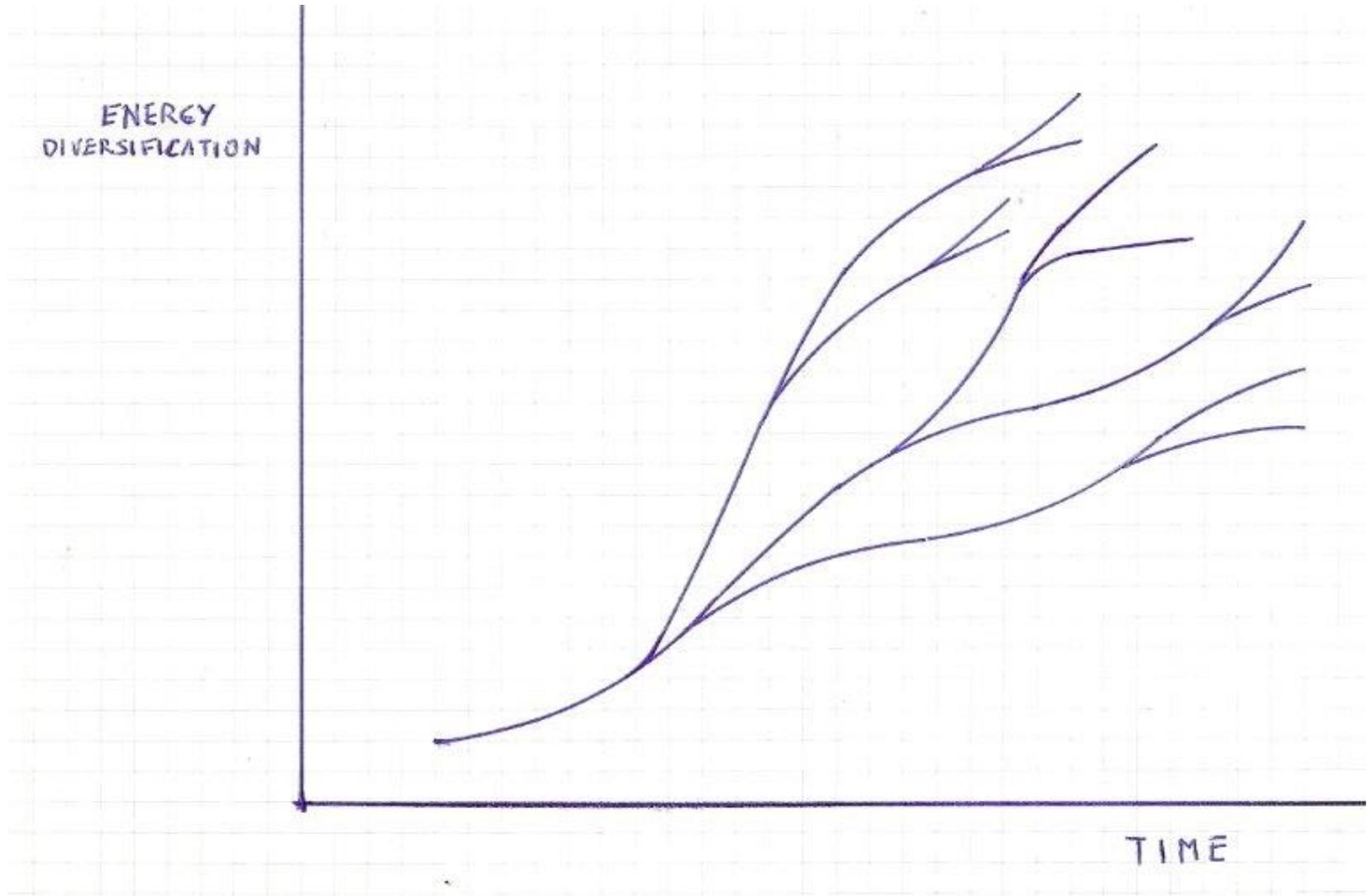
Evolution of Energy Systems (I)

- Globalization favors a certain uniformity in our world, people try giving common solutions to common problems. It is not the case in the field of energy where the differentiation between countries in their approach to energy issues is noticeable; we have to accept the existence of a large diversity of systems. “One size fits all” is not the solution to our problems

Evolution of Energy Systems (2)

- The evolution of energy scenarios follows the pattern of chaotic systems described by Ilya Prigogine, i.e. segments of deterministic progression (dictated by technological advancement, industrial and regulatory time lags, availability of financial resources, etc.) punctuated by points of bifurcation

Evolution of Energy Systems (3)



Evolution of Energy Systems (4)

En ces points {de bifurcation}, le comportement du système devient instable et peut évoluer vers plusieurs régimes de fonctionnement stables. En de tels points, une “meilleure connaissance” ne nous permettrait pas de déduire ce qui arrivera, de substituer la certitude aux probabilités

(Ilya Prigogine et Isabelle Stengers

Entre le Temps et l'Eternité)

Evolution of Energy Systems (5)

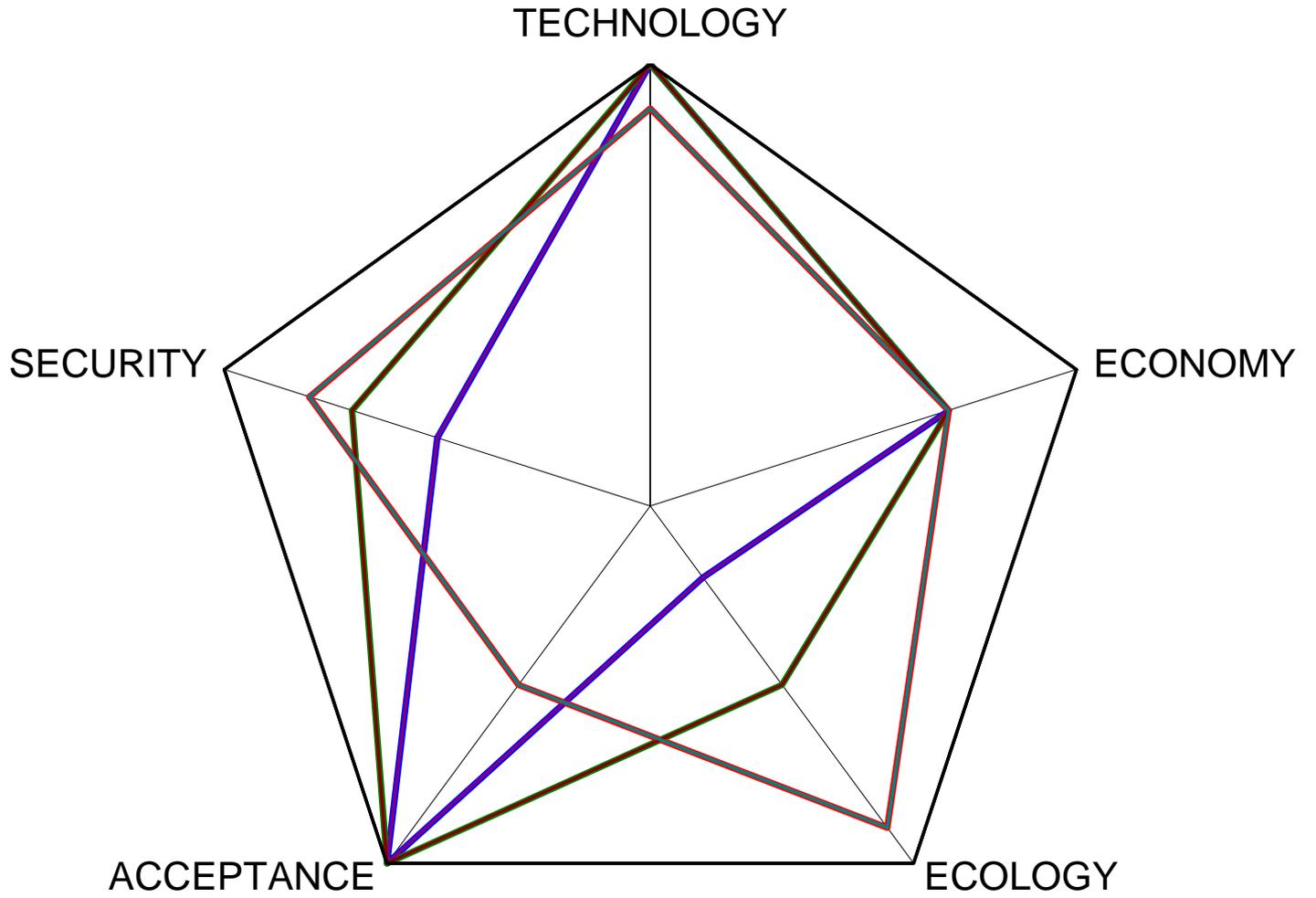
- When bifurcations occur, governments and civil society in different countries react in different ways, this leads to increasingly fragmented systems and further chaos rather than to a stabilized new system. The real challenge is coping with such a situation in a world prone to energy exchanges, hence a pronounced trend towards energy security and a different organization of energy fluxes

Evolution of Energy Systems (6)

- Significant points of bifurcation have been:
 - The exploitation of oil (1863)
 - The peaceful use of nuclear energy (1950)
 - The use of natural gas for energy purposes (1960)
 - The oil crisis (1973)
 - The large scale use of renewables and of cogeneration (1990s)
 - Chernobyl (1983) and Fukushima (2011)
 - The reduction of subsidies to renewables following the financial crisis (2009)
 - The exploitation of tight and shale gas (2010)
 - The exploitation of clathrates (2012) (?)

Evolution of Energy Systems (7)

- So far, nations have reacted not only to the challenge of energy security but also to four other factors, hence the pentagon of:
 - *Security*
 - *Technology*
 - *Economy*
 - *Ecology*
 - *Acceptance, safety as determined by experts being overshadowed by its perception by Society*



Evolution of Energy Systems (8)

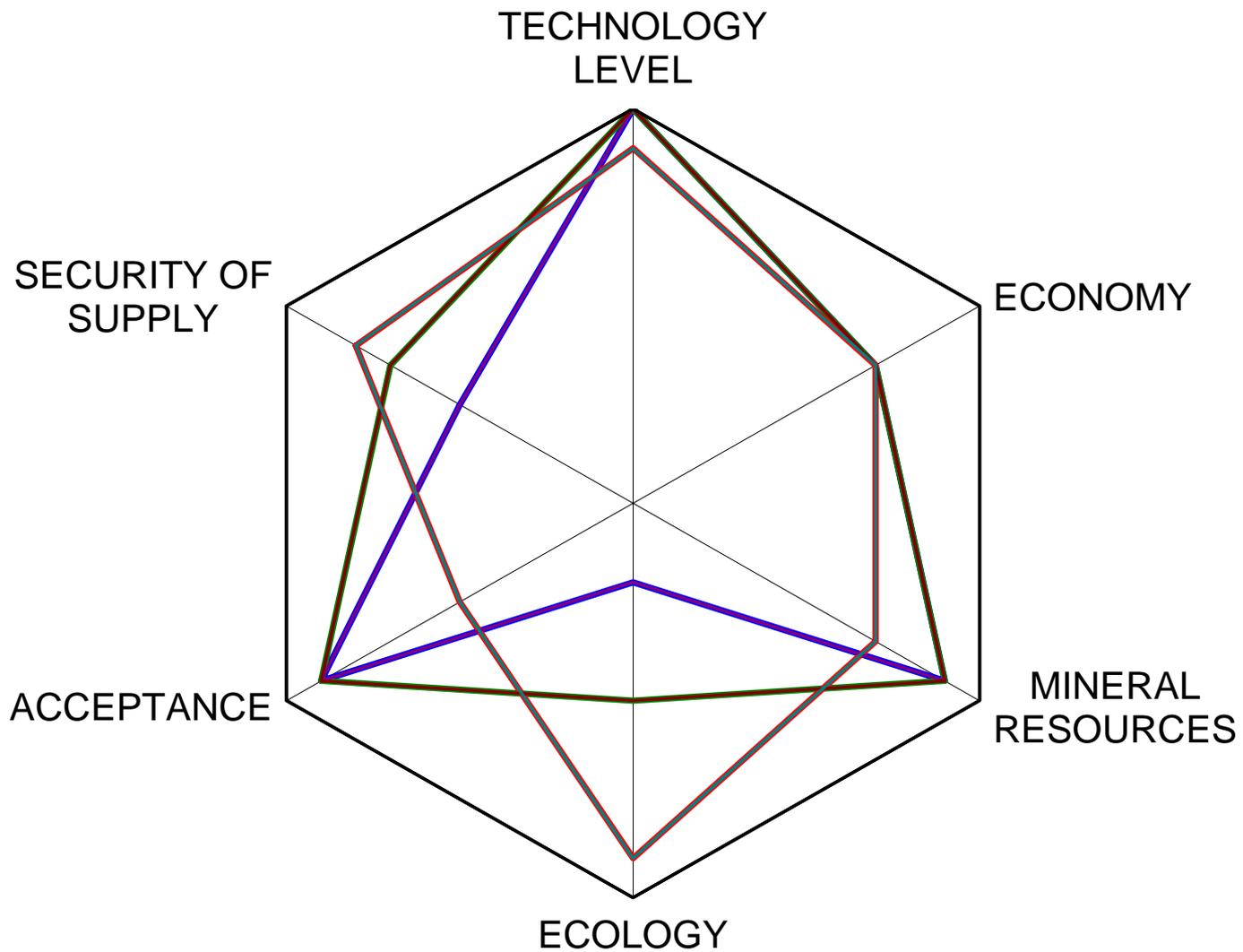
- In the future, there will be the need to add a new additional factor i.e. mineral resources. The pentagon becomes a hexagon. Managing adequate mineral resources becomes a new technological challenge for energy production. Secondary (recycled) rather than primary materials should be the choice for the future but it might take another 20 to 30 years before exploiting the right technologies for recycling

Mineral Resources (I)

- Study by B. Goffé (U.Aix-Marseille) and O.Vidal (U. Joseph Fourier Grenoble) of the limitations for renewable energies development through availability of earth mineral resources (Pour la Science, n°431, Sept. 2013)
- Last generation wind generators consume per kWe produced, 20 to 40 times more steel and 6 to 15 times more concrete than a nuclear reactor of the EPR type

Mineral Resources (2)

- The production of renewable energy systems require notably Fe, Cu, Al, concrete (cement, sand), glass (sand plus various minerals, with high purity for guaranteeing transparency), chemicals derived from hydrocarbons (resins, plastics), In (for PV panels), Nd and Dy for wind energy electric generators
- Ores are getting lower in useful concentration due to exhaustion and they require increasing quantities of energy for extraction and processing: in 2010, they represented 22% of the energy consumption of the world industry (US DoE)



Evolution of Energy Systems (9)

- In some European countries, employment created by a greater recourse to renewables is considered as an additional factor. In Belgium, if the transition to an energy system based at 100% on renewables in 2050 would be made, the job creation would be between 21 000 and 65 000 full time equivalents before 2030, a non negligible figure as the number of unemployed in 2012 was 368 000. BUT, even taking account technological progress, the cost of such a system would be 20% higher than a system still using fossil fuels

Evolution of Energy Systems (10)

- Hence, will in the future the hexagon become a heptagon with employment as an additional factor?
- Where does climate change stand among all these often opposing driving forces? Mitigation of climate change in the energy sector requires a limitation of GHG emissions. Which are the best energy sources in this respect? Electricity production being a good indicator, the following table gives, for various energy sources, the emission level in kg of CO₂eq per MWh produced, taking into account their own production process.

Emissions in kg CO²eq/MWh (UK source)

TYPE	EMISSION
Coal	870
Oil	650
Gas	487
Geothermal high enthalpy	100
Solar	72
Hydropower	10-30
Wave	18
Nuclear	16
Wind	11
Geothermal low enthalpy	10

Sustainable Energy Systems (I)

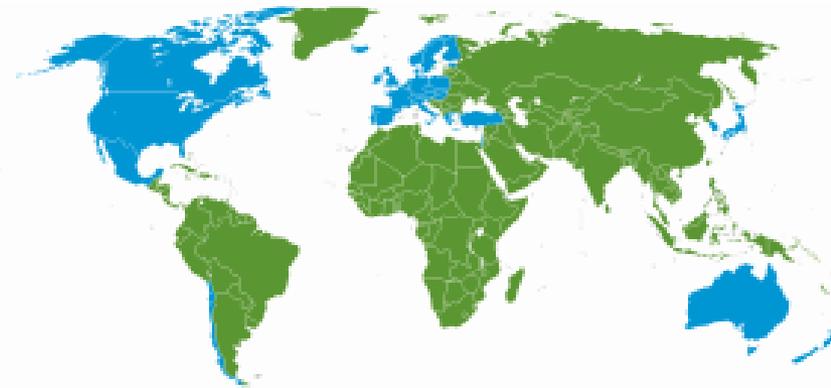
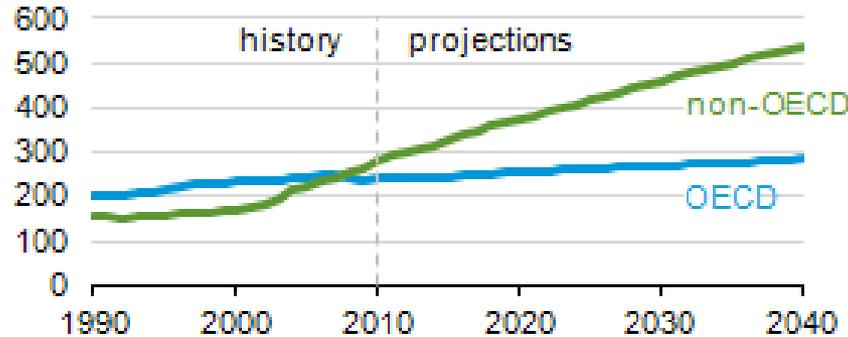
- In terms of GHG emissions, the renewables and nuclear energy are the most favorable
- There is a significant controversy on the use of nuclear energy; nations in various regions of the world adopt different positions; we have to accept this diversity dictated generally by other factors than Climate Change

Sustainable Energy Systems (2)

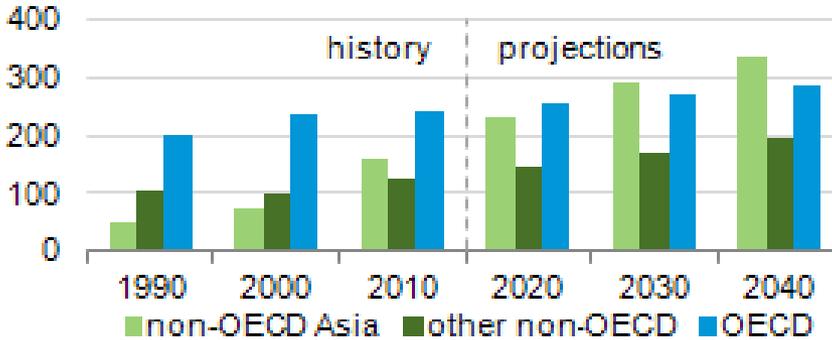
- Renewables are still overshadowed by hydrocarbons (oil, coal, gas) due to several considerations, energy security, energy independence and economics being dominant. The trend should continue as projected by the following diagram from the US EIA

The U.S. Energy Information Agency projects that World Energy Consumption will increase 56% by 2040

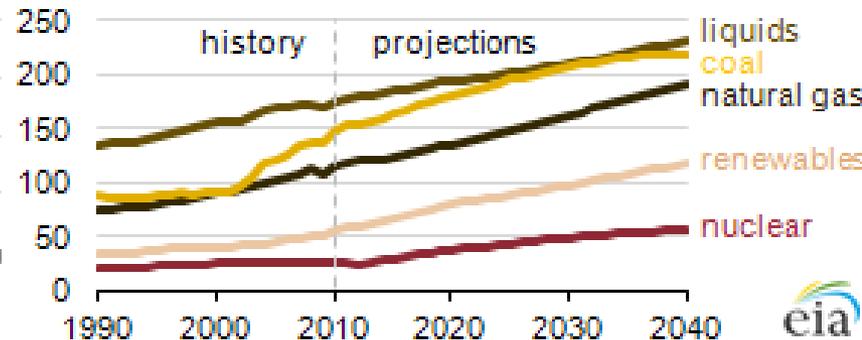
World energy consumption
quadrillion Btu



World energy consumption
quadrillion Btu



World energy consumption by fuel
quadrillion Btu



Oil

- Oil continues playing a significant role: not dead yet (as frequently announced), still leading in world energy consumption. Many countries still consider oil as an important asset for their future (Southern Atlantic, South East Asia), unconventional oil (e.g. deep sea) is taking over and transport (air, rail, road and sea) constitutes still a captive market.

“The Stone Age did not end for lack of stone
The Oil Age will not end for lack of oil”

Coal

- The importance of coal persists: it will rejoin oil as top energy in 2030. Use of coal has skyrocketed in emerging economies in the past 50 years: Brazil 7 times, Turkey 8 times, Taiwan and Mexico 13 times, S. Korea 15 times, China & Hong Kong nearly 16 times, Indonesia 34 times!
- Why? Energy security constitutes the main driving force

Gas

- Gas is the ascending energy source: some countries joined recently the club of conventional gas producers, e.g. Israel, transport of LNG attracts again the attention but the real revolution comes from unconventional gas, fracking gas (followed maybe by methane hydrates). The production of fracking gas in the US has changed not only energy fluxes but also geopolitics. Argentina and Poland could follow the same pattern
- Energy security but also climate change drive this ascent: gas is much cleaner than coal and oil and could be used, with new technologies, in sea and rail transport

Renewables (I)

- The utilization of most renewables depends on local conditions with fortunate and less fortunate nations; the latter can't change their geographical position.
- Besides geography, the most negative factors are economical (required investments, higher operational costs) as well as societal (recourse to large quantities of mineral resources and problems of local acceptability e.g. wind generators in rural areas)

Renewables (2)

- The main advantages lie in their environmental friendliness (Climate Change, local pollution) and the jobs which they create
- Their competitive position would be largely improved if more efficient and cheaper energy storage systems developed (hydrogen, superconducting magnets, compressed air)
- Small hydropower, biogas and low enthalpy geothermal energy sources are on the move
- A great hesitation exists about wave energy utilization: is it an issue of cost or the problem of collecting the energy produced?

Renewables (3)

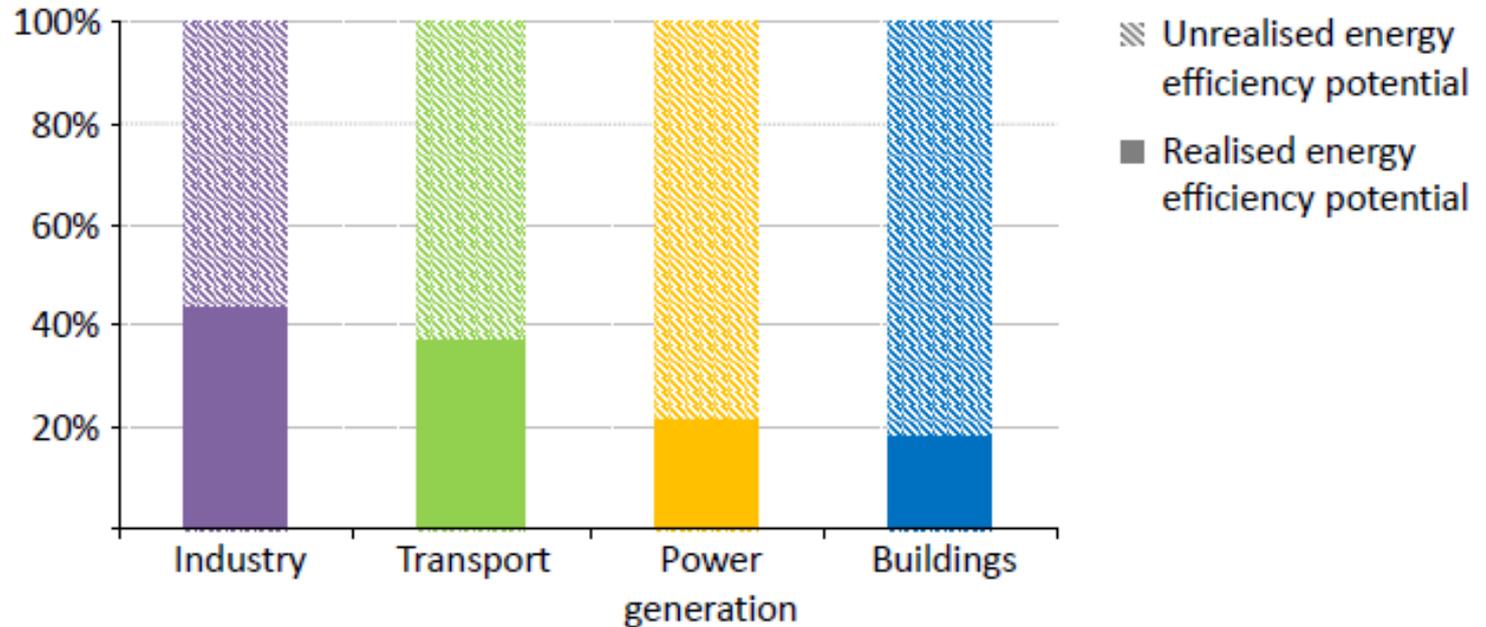
- The utilization of renewables is favored by the right choice of electricity distribution systems, smart grids being the keyword, leading to the decentralization of networks up to the level of groups of buildings

The Trump Cards (I)

- The implementation of energy efficiency measures: a way for improving energy security, reducing the energy bill and giving the possibility for growth in energy consumption in developing countries; energy savings are still not fully exploited

Unrealized Energy Savings in the EU

Energy efficiency potential used by sector in the New Policies Scenario



Two-thirds of the economic potential to improve energy efficiency remains untapped in the period to 2035

The Trump Cards (2)

- The promising potential of carbon capture and storage: its development requires good knowledge in chemistry and in geology
- Beyond direct utilization in the chemical and food industry as well as its physical storage, chemical and bio transformations of CO² can be considered (algae)

The Interest of Oil Companies for Carbon Capture and Storage (I)

- Dirk Smit, a Vice-President of Royal Dutch Shell, emphasized on October 9, 2013 the expertise of oil companies in geophysics which could be key to developing CCS. “For pumping CO² underground, no one has a better head start on knowing how to do it than oil companies. One unresolved issue relates to how long the CO² can be stored. The experience of oil companies in characterizing reservoirs could help answer the question”

The Interest of Oil Companies for Carbon Capture and Storage (2)

- Earlier in October 2013, Shell's CEO Peter Voser mentioned that CCS, along with biofuels and natural gas for transportation “could be the bedrock of our future competitiveness”, an encouraging statement

In Conclusion

- In a very complex global environment, climate change does not constitute currently the main driving consideration in the choice for energy systems and this position does not help in reducing GHG emissions BUT some emerging trends show that the path to sustainability is not fully abandoned, trump cards should be played promptly



***спасибо за ваше
внимание!***
Thank you for your attention!