Security of energy supply for the European Union

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Security of energy supply is a recurrent concept in national energy policies and also at the European and worldwide levels. In November 2000, the European Commission issued a green paper "Towards a European Strategy on Energy Supply Security". This report carried a strong warning about European dependence on imported energy that could increase from 50 percent in 2000 to 70 percent in 2020-2030. The European Parliament and the Council passed their agreements, stressing the importance to minimize the risks of dependency both by the EU and the member states. Since then, terrorist attacks, storms, accidents, blackouts, wars, surges in fuel prices are threatening directly energy supply. In August 2005, Hurricane Katrina in the Gulf of Mexico brought a new dimension to security of energy supply. Unlike the crises of the '70s or the Gulf crisis of 1990-91, Katrina did not involve just crude oil supply: It includes natural gas production, oil and gas transport, refineries and electricity in one of the most energy intensive area in the world. The whole tightly interconnected energy system has been hit. Proponents of oil security reserves in the United-States and at the OECD level never thought that the second major use of reserves – the first being in the 1990-91 Gulf crises – would be for a domestic oil supply disruption in the US.

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At the world level, the more visible energy hunger of the world population raise some questions about supply. The debate concerning the peak oil reminds us that the resources of fossil fuels are physically limited, that price ultimately guarantees the balance between supply and demand. In this context, the United-States, China, India and other countries are fighting to secure access to oil and gas resources while oil and gas rich countries strengthen the control over their domestic resources. The increasing US demand for imported natural gas disrupts the world gas market. All these elements are bringing new threats for Europe's energy supply and they could comfort the trend toward higher prices. On the other hand, the question of climate change is more and more considered as a very serious question which could oblige us to change our pattern of energy consumption. This general situation of uncertainties and tensions is providing new reasons to think about security of energy supply and to envisage actions for improving it.

A Standard definition of security of supply is a flow of energy supply to meet demand in a manner and at a price level that does not disrupt the course of the economy in an environmental sustainable manner.[2] The concept is vast, multiform as it encompasses the whole physical and non physical supply chain. It has also important time, space and social dimensions. It can be more precisely defined as

- A reliable supply of energy. Choices both for primary energy sources and geographical suppliers ought to be as plentiful as possible, within a competitive framework, in order to reduce dependence on only one or two. Diversification in these two areas – primary energy sources and suppliers – is key to ensuring security of supply.

- A reliable transportation of supply. Transportation networks ought to be physically available to qualified players, well maintained, and expanded as required, and should offer as many competitive route options as possible.

- A reliable distribution and delivery of supply to the final customer. Energy ought to be efficiently delivered to the final customer according to particular time and quality standard without discrimination.

[2] Cambridge Energy Research Associates (CERA) *Global Energy and Energy Security: A New Agenda* 2001. *European Energy: Revisiting Security of Supply* 2005. Also Jean-Marie Chevalier: "Les grandes batailles de l'énergie", Gallimard, Folio 2004.

- At "reasonable price" over a continuous period. In theory, "reasonable" price means marginal cost reflective. In practice the price range between 22 and 28 dollars per barrel, maintained by OPEC between 1999 and 2003 was implicitly considered by most market participants as "reasonable".

The time dimension of security of supply is very important.

- In the short term a sudden unexpected disruption may happen in the supply of electricity, natural gas, oil or coal. It can be caused by a variety of reasons: political decisions, accident, sabotage, strike and other social demonstration, unusual climatic event. In the very short term, such disruption may be alleviated by rapid repair, military or police intervention, use of available storage, price adjustment. For electricity, a sudden disruption may be caused by an insufficient available capacity in which case neither storage nor price may provide an adjustment. The concept of security of supply involves technology, politics, economics, investments planning and weather conditions.

- In the medium and long term, security of supply may be threatened by long lasting political or social turmoil, lack of available resources but also, more prosaically, because the needed investments in productive capacity, transmission and storage were not made or delayed. Security of supply has an important investment component.

The space dimension indicates that disruption in energy supply may have local, national, but also international causes and implications. Some components of supply are exogenous (world oil price, storms), some are endogenous related for example to the organization of the energy industries, to safety standards or storage obligations.

The social dimension reflects the fact that security of supply has a cost and when there is a price shock, it is much more difficult for the poor to afford their energy supply. This social dimension can be seen within a given country through what is called "fuel poverty" when the amount spent for buying energy represents a substantial share of the budget. It also reflects the difficulties encountered by the poorest countries that are importing their energy needs.

It has also to be recalled that security of energy supply has a significant military dimension. Energy supply is crucial for military forces which are heavily dependant on oil products (particularly on jet fuel) for their national and international activities.

What is new about security of energy supply since the 2000 green paper is the exacerbation of uncertainties that are surrounding the world energy scene. Four broad categories of uncertainties can be identified: environmental, geopolitical, regulatory uncertainties and finally "The unexpected".

Climate change uncertainties and environmental policies uncertainties

Climate change is now considered a reality, but it is much more difficult to assert the coming short, medium and long term consequences of the phenomenon, what actions are really needed and what policies will be decided. The Emissions Trading Scheme has been launched in 2005 and the price of CO2 is a new element to be taken into account for investment decisions. If the damage to the environment proves to be more destructive than anticipated, new measures, new taxes and new forms of action might be taken at various levels (Europe, nations, municipalities or local communities). The possibility of such actions increases drastically market risks in term of price and volume. In addition, the opening of new sites for building energy facilities, is increasingly long and difficult. As far as CO2 is becoming a high social cost, diversity of fuel use will be encouraged. Oil share will be reduced, gas share should increase.

Geopolitical Uncertainties

Since September 11, geopolitical uncertainties have been aggravated, especially in the large oil and gas exporting countries. For Europe, the increasing amount of imported fuel comes from producing and transit countries that are facing unstable or potentially unstable political and social situations. In 2003, the interruptions of exports from Venezuela, considered as one of the most reliable supplier since World War II, removed more oil from the world market than the cessation of Iraqi supplies did during the 2003 war.[3] These tensions are key drivers for higher prices, tight market and price volatility. They also emphasize the importance of diversified sources of energy.

[3] Daniel Yergin "Energy Security and Markets". CERA 2005.

Regulatory uncertainties

The European process of energy market liberalization was expected to bring competition, liquidity, to encourage fuel substitution and therefore to enhance security of supply. In fact, the road to competition is longer and more complex than it was anticipated. New forms of combination between market mechanisms and public regulatory interventions have to be implemented. For energy investors, the risk of regulatory changes has to be taken into account.

The unexpected

Within and besides the different forms of uncertainties, there are also a number of events that are almost or totally unpredictable. They illustrate what is known as Thatcher's law: "The unexpected happens!"[4] In recent years, the world experimented a number of unexpected events including terrorist attacks, civil unrest, wars, heat waves, hurricanes, earthquakes (the tsunami), SARS. Some unexpected events may disrupt seriously the conditions of energy consumption and supply. Hurricane Katrina has been an integrated energy disaster on a scale not seen before, and the impact of the price spikes and dislocation rolled across the entire economy.[5] These are the risks of the unknown, the unexpected, the unthinkable, the unpredictable…. Energy facilities, networks and infrastructure were not designed and built to resist the unexpected when it happens. A study by the United States Energy Association identified three different kinds of threats over energy systems. One is *attacks on energy systems*. The second is an *attack by an energy system*—for instance, using a power plant cooling tower to disperse chemical or biological agents. The third are *attacks through an energy system*—for instance, spreading chemical or biological agents through underground conduits.[6]

The concept of security of energy supply refers to the notion of energy dependence, a notion which is relevant for households, industry and services, state and local administrations, nations. Modern economies are dependent on global energy supply, they have also more specific dependences on electricity, oil and natural gas. After analysing these various forms of dependence, recommendations will be made for strengthening

[4] Quoted by Daniel Yergin and Joseph Stanislaw: *The Commanding Heights,* Touchstone Book, Simon & Schuster 1998.
[5] Daniel Yergin "The Katrina Crisis" *Wall Street Journal* September 2, 2005.
[6] United States Energy Association, *National Energy Security Post 9/11* (Washington, D.C.: United States Energy Association, 2002), 54.

security of energy supply at local, national, European and international level.

1. Global energy dependence and security of supply

The energy dependence of a given economy may be measured by energy intensity, i.e. the amount of energy which is necessary to produce one unit of GDP. In Europe (25), energy intensities vary between 0.10 and 0.32 tons of oil equivalent/€ 1000 of GDP. In the last thirty years energy intensity was reduced by about 35 % reflecting at the same time a substantial improvement in energy efficiency and also a profound structural change in the structure of production. However, global evolution hides disparities. The energy efficiency of the transport sector improved drastically with regular decrease of cars' consumption in litres/100 km. However, part of the gain is offset by a shift to larger and heavier cars. Finally, the energy total consumption of the sector increases substantially, following the share of the sector in GDP.

Another question related to security of supply is the share of imported energy over primary energy total consumption. On that point, one may notice that imports are not necessarily bad if cheap abundant energy is available on world markets. The growth of the Japanese economy has been founded upon imported energy. A premium on domestic production may be considered but very frequently large amounts of subsidies for maintaining domestic productions are not economically founded although socially demanded. Energy "independence" is not a target per se. Its real cost has to be taken into account. In addition, the domestic contribution to energy consumption does not necessarily guarantee security of supply. In the 1970's coal miners strikes in the UK hurt seriously the British economy. In Scandinavia and Spain, the occurrence of a very dry year reduces considerably the contribution of hydro electricity, calling for substitution or power imports. In 2005, hurricane Katrina devastated part of the Gulf of Mexico energy complex that constitutes US most important domestic energy asset.

Energy intensity and energy dependence have to be considered in volume – the number of barrels of oil equivalent to produce value – but also in value, by taking in account the price of oil and the evolution of exchange rates. It raises the question of the energy bill and the economic dependence over energy prices. At a macro level, the question of how energy prices variations

impact economic growth is a difficult question.[7] When looking at the past, it is quite clear that the rise in oil prices imposed by OPEC at the second oil shock was not tolerable by the world economy. High prices had a strong negative impact on economic growth and oil demand. At that time, however, economies were much more oil intensive and also the price level in constant terms was much higher that the level reached in 2004-2005.

In constant 2004 dollars, the oil price averaged 76 dollars in 1980, but, for a time, in late 1980, it reached 90 dollars. When one tries to assess the impact of oil prices on the economy, one has to take into account not only the variation in oil intensity but also the actual oil input cost. If oil prices increase at a faster rate than economic growth, then the energy cost intensity of the economy can actually rise, as it had been the case since 2004.

In 2004-2005, the impact of higher prices on economic growth was much more difficult to measure. The impact is not the same for all countries. For the poorest countries that are oil importers, high oil prices bring a very strong economic and financial burden. In rich countries the oil intensity has decreased since the second oil shock and, for some of them (Europe), the weight of taxes plays the role of a shock-absorber. Globally, it seems that the increase in oil prices didn't modify the trend of economic growth which was observed in the United-States and Europe. A recent CERA's analysis categorizes the macroeconomic impacts of energy price changes in the last three decades. It shows that the current oil price changes (2005) are less harmful to the economy than the past price spike.[8]

2. Dependence on electricity and security of supply

Any blackout, anywhere in the world, demonstrates the high dependence of modern economies regarding electricity supply. The violent storm which devastated France in 1999 provides a good illustration of the phenomenon. In two days, the 26th and 28th of December 1999 two violent storms occurred, the first over the Southern part of France, the second over the Northern part. Electricity supply was cut for more than 3.5 million of households. Some households were without power for several weeks in a row. This exceptional climatic event showed the vulnerability of a large modern interconnected grid and also the damages that can be caused by a

[7] Awerbuch S. & R. Sauter : *Exploiting the Oil GDP Effect to Support Renewables Deployment.* SPRU Paper n° 129, Jan. 2005.
[8] CERA World Oil Watch: *Do High Oil Prices Matter ? $ 1.6 Trillion Say Yes.* 2005.

long blackout. A blackout hits immediately lighting, electrical heating, TV, computers, all electrical appliances, and may disrupt the public transportation system. After a few hours, it hits the whole chain of frozen foods and large heating, water distribution and telecommunication systems. Over the last fifty years the developed world has built a very strong dependence on electricity although we have to keep in mind that there are more than one and a half billion people who don't have access to electricity, a prerequisite for economic development. Electricity has become "an essential good". The EU directive 2003/54/EC set up the universal service and a recent French law on electricity (2000) set up a "right to electricity". In Europe, and elsewhere in the world, (United-Sates, Canada, United Kingdom, Scandinavia, Italy), a number of recent blackouts have reinforced the question of security of supply which is directly related to two major elements: a sufficient available generating capacity and an appropriate and secure transmission and distribution grid. The vulnerability of power systems has several dimensions.

- The first source of fragility is related to weather conditions: unusually high or low temperature have a direct impact on demand. Long periods of cold or warmth make more difficult supply demand equilibrium with some possible secondary effects on the cooling of thermal plants. Dry seasons reduce the hydro potential and the cooling capacity. Wind is also an important factor in countries such as Spain and Germany where wind farms have been developed. A sudden wind interruption might shut down immediately several GW of capacity. At last, storms, snow, flooding regularly damage parts of electricity systems.

- Another form of vulnerability is related to technology. A technological problem can be a reason for shutting down capacity for a short or long period of time. In 2003, for example, in Japan, eighteen nuclear plants were shut down for several months for technical and safety reasons.

- Accidents, sabotage or terrorist attacks may also damage severely power systems. A number of programs have been developed, particularly in the United-States, for reinforcing protection, prevention and to set up a program of action in case of occurrence. A special concern is given to nuclear facilities and to LNG terminals.

- Vulnerability of power system may be also related to the supply of primary fuel: coal, fuel oil or natural gas. It didn't happen in Europe in the last fifty years except during the coal miners' strikes in the United Kingdom. In this country, the 1982's coal miners strike hurt the industry but it precipitated a shift away from high cost local coal and ushered in the "dash for gas".

- A new source of vulnerability results from the current process of electricity liberalization and deregulation, at least in continental Europe, which is bringing new uncertainties for investors. The building of a single electricity market should bring more interconnections and less vulnerability to any form of disruption. In reality, capacity margins tend to decrease, new generating capacities and priority interconnections transmission are not built at the right moment (for a number of different reasons, some of them being related to the change, some other, such as the environmental resistance being non related). This is for the time being a real subject of worrying. Recent blackouts can be explained by weather conditions but they are also explained by insufficiencies in organization and regulation of the industry.

- Paradoxically, the increased interconnection of power networks can also lead to power disruptions in the case there is not enough coordination between the TSOs. Communication and coordination between them is therefore a key aspect of security of supply as regional power markets have now emerged. Any incident requires real time reporting of information as it takes a few minutes for a system to collapse. The blackout in Italy in 2003 was aggravated by a lack of coordination.

To face the vulnerabilities of power systems, there is a need for improving cooperation between transmission and system operators. There is an urgency to take measures, taking in account that several of the above vulnerabilities may occur at the same time. A combination of low reserve margin, poor hydro and wind availability, unexpected plant outage with extreme weather condition may lead to very high price spikes and possibly blackouts, unless systems operators are informed in a timely fashion of developments in other dispatch areas and have developed suitable contingency plans for balancing reserves, disconnections. The cost of the "missing kWh" is very high and the question of the appropriate level of available capacity margin is a key question for debate and decisions between European TSOs.

3. Oil dependence and security of supply

The oil contribution to world primary energy consumption is 37 percent. In European countries, oil contribution varies from 16 to 90 percent of total energy demand. After the first oil shocks, some countries like France or Belgium have lessened their oil dependence by developing nuclear power while others have accelerated natural gas or coal substitution.

The vulnerability of countries to oil disruption or to oil price shocks may be measured by a ratio which was proposed by the World Bank.[9] This ratio can be understood as the product of three terms, each of which has an important interpretation:

Oil imports/GDP = (oil imports/total oil use) x (total oil use/total energy use) x (total energy use/GDP)

The ratio (oil imports/total oil use) measures the self sufficiency in oil production. This ratio can be improved by domestic exploration, discovery and production. The second ratio (total oil use/total energy use) measures the real dependence on oil. It can be affected by policies to encourage inter fuel substitution or diversification of the energy portfolio. The third ratio (total energy use/GDP) measures energy intensity. It can be improved by energy efficiency measures and also by a shift in the pattern of production from energy intensive activities to less energy intensive sectors.

Despite these changes, the transport system and, consequently the military forces, remains heavily dependant on oil products and vulnerable to supply disruptions and oil price shocks. In Europe, only trains, tramways and a few busses fleets (using natural gas) escape from oil dependence.

Oil supply, oil reserves, and oil future potential are highly concentrated in the hands of a few countries. 82 per cent of oil reserves are located in OPEC countries, Russia and Mexico. According to CERA's analysis the concentration of oil productive capacity is expected to increase in the future. In 2004, OPEC and other countries "at risk" represented 64 percent of the worldwide liquids capacity and this share should increase to 70

[9] UND/ESMAP (World Bank) : « The Impact of Higher Oil Prices on Low Income Countries and on the Poor", March 2005.

percent by 2010.[10] According to the same analysis, oil reserves are in place, there is no "peak oil" problem before 2020, and, when the peak does come, it will not be followed by a precipitous decline in production capacity. CERA expects the worldwide capacity profile to track an undulating plateau for many years, if not decades.

It has to be recalled that, in 1973, at the first oil shock, the ratio between proven recoverable reserves and annual consumption was 30 years. In 2005, over thirty years later, and with annual consumption considerably higher, the ratio is 40 years. In fact, the amount of proven reserves has a certain responsiveness, meaning that it can be increased automatically by technology and prices. Technological improvements are expected to increase the productivity of exploration, field management and the rates of recovery. "A major technological revolution is unfolding with the "digital oil field of the future," or DOFF. A panoply of information and control technologies, remote-sensing mechanisms, "intelligent drilling" techniques, and highly accurate measurement tools is making exploration and production more exact and targeted. As a result, it is economically feasible to search for and extract oil and gas from reserves that were once too expensive or too difficult to reach. The impact of DOFF will be enormous: In the next ten years, DOFF could expand recoverable world oil reserves by 125 billion barrels—more than the currently proved reserves of Iraq."[11]

However, existing reserves and discoveries have to be transformed into productive capacity. To do this, a huge amount of investment is required and there is a time lag between investment decision and production. In oil rich countries, investments are frequently reserved to state-owned companies that are willing to invest but, on the opposite, governments are eager to capture oil money for social expenditures. Many oil rich countries are totally or partly closed to international investors. All these elements bring some uncertainties about the amount and the timing of the investment that have to be done and some worry about the expected evolution of oil price and the possibility of oil price spikes. Until the end of 2003, OPEC had a spare capacity allowing OPEC countries to maintain oil price within the OPEC price range, between 22 and 28 dollars/b. In 2004, spare capacity has vanished and also has vanished OPEC capacity to moderate or stop increases in prices. Nevertheless OPEC still have the power to prevent prices lower than 50 dollars per barrel by restricting its

[10] CERA Private Report: *Worldwide Liquids Capacity Outlook to 2010: Tight Supply or Excess of Riches?* 2005.
[11] Daniel Yergin : « Security of Energy Supply », 2005

production.

Since World War II, world oil supply was threatened several times: by nationalizations, the Suez crisis, Arabic producers' embargoes, the Iranian revolution, Iraq's wars and then, surprisingly, by hurricane Katrina, which shut down 20 % of US domestic oil production and 16 % of gas production in the Gulf of Mexico. The liquidity of the market and the willingness of some countries to compensate prevented long disruptions. These compensations, that have a vital importance for worldwide security of oil supply, are made on the supply side, either by using spare capacity (OPEC in 2003), either by a release of strategic oil inventories (1990-91 crisis, Katrina crisis). Several times, the risk of serious and long lasting oil supply disruption was dampened by military intervention.

On the other hand, domestic factors, either natural or social had sometimes caused disruptions. This includes storms, hurricanes but also strikes (coal, electricity) and social demonstrations such as when truck drivers in France, the United Kingdom, and Germany blocked the access to oil refineries.

Today, major oil exporting countries are exposed to domestic political turbulences, including local wars and terrorism. In addition, OPEC's power of regulation is weak. Supply disruptions due to political factors are not restricted to the Middle East. Asia (Indonesia), Africa (Nigeria, Sudan), Latin America (Venezuela, Bolivia, Columbia, Ecuador) are very sensitive regions. Therefore, local disruptions can be expected from many places in the world with, at the same time, insufficient investments and possible claims for higher prices. The oil dependence is a serious matter.

Since the first oil shock, many countries have built oil stocks in order to alleviate the risk of supply disruption. Member states of the International Energy Agency who are net importers have a treaty obligation to hold 90 days of net imports (crude oil or products). The twelve member countries holding government reserve stocks account for nearly 1.3 billion barrels which could cope with the largest historical supply disruption.[12] European Union's oil stock policy is more stringent since the 90 days obligation concerns three categories of products: gasoline, middle distillates and heavy fuel oil. France has introduced a special provision (80 days) for jet fuel which has a very strategic importance for military forces. The US Strategic Petroleum Reserves and the IEA member states' reserves are not supposed

[12] International Energy Agency: *Energy Policies of IEA countries*. 2003 review.

to be used for short term market regulation but only for more serious disruptions. They were used twice; for the 1990-91 Gulf War and for the Katrina crisis in September 2005.

4. Natural gas dependence and security of supply

The dependence on natural gas is somehow different than for oil. Gas is the less polluting of the three major fossil fuels and Europe's gas demand has been growing at over 3 percent over the last few years and is expected to grow at rates between 1.8 and 2.6 per cent on average in the next two decades. Gas differs from oil because the cost of transmission is much higher (7 to 10 times higher on energy equivalence) and gas has no real captive market at the end user level. In many cases, gas can be substituted by oil products or electric heating. The high cost of transmission implies long gas lines with a direct link between the field and the burner tip. The financing of these lines requires long and rigid contractual agreements between the seller and the buyer. The European gas industry has been developed in Europe on this basis and the current liberalization process cannot, for the moment, break totally long term contracts that are necessary to build new gas lines, although some quantities of "free gas" could be required by competition authorities. The importance of bilateral trade give gas supply more security than oil supply. Both parties are interested in maintaining a profitable trade. Since the beginning of European gas imports and despite political turmoil in Russia, Algeria and Nigeria there was no disruption of supply. However, in 2006, a dispute between Russia and Ukraine threatened for a few weeks the gas supply of Western Europe.

The world geopolitics of natural gas is very similar than for oil, except for the exceptional position of Russia which holds about one third of world natural gas resources. Russia accounts for about 35 percent of European (25 countries) natural gas imports. Other imports come from Norway, Algeria, Nigeria and Libya. The rapid development of LNG and the building of new gas lines should enable Europe to diversify its sources of supply.

One fundamental change has happened in the past few years as the gas market has evolved from a regional European market with dedicated sources of supplies to a world market where Europe has to compete for the very same supplies with other gas-thirsty markets, especially the United States and very soon Asia. This is first due to the rapid increase of LNG share in worldwide gas markets and also European supplies, making Europe

more dependent on the North American gas price environment. Such dependence is expected to grow in the future as over 120 Bcm new LNG capacity is planned to come on stream by 2012 in Europe. In the medium term, suppliers such as Russia and Norway are also looking at the North American market to export their gas and will play on the Atlantic Arbitrage. Supplies from the Caspian region could also either go to the European market but also feed the increasing Asian market.

Natural gas prices are, for the time being, linked to crude oil and oil products prices through contractual formula. Price risks are similar. In the future, supply diversification, LNG development, the growth of gas fuelled power generation could weaken the link between oil and gas and also between euro prices and dollar prices. Gas pricing conditions will probably be more diversified in the future, taking into account the actual competition of gas on final markets.

The vulnerability to potential disruptions in gas supply can be analysed through different factors. On the supply side, key metrics to consider are the country's reliance on gas and on non-European gas imports, the diversity of suppliers and of physical routes (gas lines and LNG import facilities) and the country's bargaining power relative to that of its suppliers. On the demand side, key metrics are the amount of available storage capacity, the amount of fuel switching capability, and the share of gas sold under interruptible contracts.

5. European action to strengthen security of energy supply

The analysis of energy dependence within the world energy scene shows a number of important facts: the world energy situation is more than ever in the past full of uncertainties – investment decisions are the key drivers – pure market mechanisms are not sufficient to build a sustainable energy future – security of supply is an important matter which implies national and multilateral actions.

To answer these questions, the European Union has, for the moment, no common energy policy but, one may say, however, that the 25 European countries share a "common energy vision" with the aim to reducing greenhouse gas emissions, enhancing the competitiveness of the European economy, and ensuring security of supply. The vision is reflected in the 2006 Commission's green paper: *"A European strategy for a Sustainable,*

Competitive and Secure Energy". The question of security of energy supply by itself has two dimensions: one national dimension, in line with energy policies of each member states and one European dimension which clearly has to be strengthened. Perhaps time has come to define a European energy policy.

Any discussion about security of supply tends to show the limits of a pure economic approach since a great number of conflicting elements have to be taken into consideration: economic and financial costs, but also externalities and all social and political costs that are associated with energy matters. Any drastic increase in the energy bills becomes a political problem. The cost of security storage, the cost of reducing emissions, the cost of diversifying the energy mix constitute a burden for the competitiveness of the European industry. In short, there is no general solution to ensure security of supply, a concept which finally appears as being a permanent trade off between conflicting interests.

Some economists still think that optimal solutions do exist. As far as security of supply and energy policy are concerned, it seems that experimentation is needed within a general environment which is full of uncertainties. All energies sources and a great number of energy technologies have a role to play in building the energy future. Europe, where a common energy vision is combined with subsidiarity, provides a wide range of opportunities for experimenting, testing, comparing various manners to deal with the energy challenges. Learning by doing, benchmarking and the replication of best practices open the way for building collectively the future. The most promising general orientations are: to improve energy efficiency - to diversify energy supply in terms of technologies, primary sources and geographical diversity of imports – to reinforce the common European energy vision through a process of "regulation in concert".

Efficiency: a major political priority for to-day and to-morrow

Since the first oil shock, energy efficiency has always been on the agenda. Substantial progresses have been made but the potential for energy efficiency is still there for buildings, appliances, lighting and the political sensitive field of transports. To-day, energy efficiency is an actual imperative for at least three major reasons: growing concern for climate change implies a reduction of greenhouse gas emissions to-day and to-morrow – the

expectation of persisting high prices for oil and gas increases the economic value of efficiency improvement which could become in the long term a serious competitive advantage – reduction in energy consumption should lessen market tightness and therefore improve the volume and price dimensions of security of energy supply.

Energy efficiency is a priority on the agenda of the new European Commission.[13] It is also a recent and firm priority of the International Energy Agency.[14] Substantial improvements in energy efficiency imply a number of conditions. Information has to be collected and widely distributed and advertised. A great number of national, regional and local relays are necessary. Energy efficiency has to become a priority for member states governments. State administration and local communities must be mobilized on that objective. There is probably no single model to promote energy efficiency. A number of different instruments are to be used, tested, and experimented. Taxes, incentives, white certificates are instruments among others. One of the greatest difficulties is the financing of projects leading to an improvement in energy efficiency in buildings. Some municipalities have set up innovative mechanisms with an important role given to private energy services companies (the case of Berlin).

Research and development are also an important component of energy efficiency. There are potential business opportunities for inventing and promoting energy efficient and clean technologies that will be needed all over the world. Investments on the energy demand side reduce risks exposure to price escalation and other uncertainties.

Energy diversity

There is no perfect energy technology for producing and supplying energy. Each form of energy has an economic cost but also a social cost which covers all the negative externalities that any given form of energy transfers to the society. The European Commission has undertaken an important work to measure part of energy social costs (ExternE).[15] It is extremely important to improve the knowledge of social costs, since they will have to be more and more internalized, in order to correct the decisions that result

[13] European Commission: *Green Paper on Energy Efficiency or Doing More With Less,* June 2005. A new paper was issued in October 2006;
[14] IEA 2005 : *Save Oil in a Hurry* and *Save Electricity in a Hurry*
[15] European Commission : *External Costs. Research Results on Socio-Environmental Damages Due to Electricity and Transport.* Directorate General for Research. 2003.

from pure individual profit oriented decisions. The internalization of external costs is likely to increase energy diversification although it is also likely to increase dependence on imported gas.

The uncertainties that surround the energy industry provide a strong argument for energy diversity and also for greater flexibility in inter-fuel substitution. We do not know accurately what is, and what will be, fuel prices and the exact economic and social cost of each energy technology. We do not know what form of actions nations will be forced to take in order to manage properly climate change and its unknown effects. These are strong arguments for energy diversity following a basic principle of not putting all one's egg in the same basket, meaning also "Il faut faire feu de tous bois".

A number of recent macroeconomic studies have tried to measure energy diversity and emphasise the importance of a diverse technology-mix to maintain security of supply.[16] They develop diversity indicators in order to quantify the ideal country technology mix. Awerbuch and Berger (2003) apply portfolio theory to identify what could be Europe's best fuel mix. More recently, Newbery & al. apply Monte-Carlo simulation, portfolio theory and Real Options models to compare coal, gas and nuclear technologies for building new power plants. All these studies open the door for discussions. They tend to demonstrate that diversity has a value, either for a given power company or for the entire society, although these do not necessarily coincide.

Following this approach, one may argue that different forms of energy have to be jointly developed, tested and experienced in order to meet the dynamic uncertainties of the future. The evolution of the world energy/environment context will make clear what is the most appropriate energy mix. Pure market mechanisms might not lead automatically to energy diversity which includes renewable energy, but also nuclear, clean coal technologies, and biofuels under different forms. If Europe really wants to reduce its emissions and to set up the right energy model, the nuclear option has to be left open. Some signs of "nuclear Renaissance" are visible in Finland and France. The debate will be open or re-open in the United-

[16] Stirling A. « On the Economics and Analysis of Diversity » SPRU working paper n° 28, Oct. 1998. Awerbuch S. and M. Berger "Energy Security and Diversity in the European Union: A Mean Variance Portfolio Approach" IEA Research paper Feb. 2003.
Fabien Roques, David Newbery, William Nuttall, Stephen Connors, Richard de Neufville: Valuing Portfolio Diversification for a Utility. Application to a Nuclear Power Investment when Fuel, Electricity, and Carbon Prices are Uncertain. MIT/Cambridge May 2005.

Kingdom and probably in some other countries.

To build up the right fuel mix of a sustainable future, some forms of political implications are necessary within a process of "regulation in concert".

Regulation "in concert"

The European Commission, national governments, local entities and the energy industry have to develop together a common approach of security of energy supply which is founded upon more coordination and international action.

Coordination

Recent blackouts, notably in Italy, have revealed a lack of transparency and coordination between power grids. For electricity, but also for natural gas and oil inventories, more transparency and coordination are necessary for identifying and preventing any risk of disruption. More flexibility could also be required for some categories of end users. Coordination and dialogues are also necessary between the Commission, the International Energy Agency and other organizations such as the World Bank. A great number of important actions have been undertaken, all over the world, in the energy field for improving energy efficiency and security of supply, but these actions are not systematically identified, evaluated, compared, and, possibly, replicated.

More generally, political entities and industry's participants have to build together the right combination of market liberalisation, market mechanisms and also complementary incentives and guidelines in order to enhance short, medium and long term security of supply. All the forums (Madrid, Florence), common organisations such as the Council of European Energy Regulators (CEER), the European Regulators Group for Electricity and Natural Gas (ERGEG), Eurelectric, Eurogas, have an important role to play. The European Transmission Systems Operators (ETSO) should have a more active role (as it was recently proposed) to identify generating and transmission capacity needed in order to accelerate the establishment of a single electricity market enabling an actual European electricity solidarity. More cooperation is also necessary for the protection of the most vulnerable facilities, safety standards, and the simulation of local or

international crisis.

International actions cover several fields: diplomacy, protection of sensitive transit routes, climate change, energy treaties and the like. For Europe, diplomacy for energy is mainly focused on the relationship with major supplying countries. The so called "Prodi initiative" aiming to reinforce the energy cooperation between Europe and Russia provides a good illustration with the recent establishment of ad hoc committees. In this context, the building of new gas lines, the development of new fields, the careful monitoring of Kyoto, of the Emission Trading Scheme, the monitoring of the nuclear industry are questions that ought to reinforce our mutual interdependence. The ratification of Kyoto by Russia opens a great number of opportunities for business and cooperation. Similar initiatives have to be developed with other large exporting countries. Europe has its own "energy vision", very different from the American one and a great number of countries are willing to share the European perspective which really cares about sustainable development of the planet. What is still lacking is Europe speaking on the same voice about these issues.

The protection of strategic and sensitive areas is crucial for ensuring security of energy supply. This is particularly true for oil shipping transiting a number of key passages: the Straits of Ormuz, Bab El Mandeb, Malacca, the Bosphore, the Suez canal, the Sumed pipeline (which is parallel to the Suez canal). An international military protection is already in place and should be reinforced in concert.

Security of energy supply reinforces the need for a better regulation of the world economy. Globalization calls for regulation on a number of matters. Climate change is one of the first priorities. Climate is a public good which belongs to 6 billion people that will be 9 billion before the end of the century. Climate change has to be managed through multilateral action. Kyoto is a first step but the "Beyond Kyoto" has now to be planned. Regarding oil and gas supply, the key question as it was explained above, concerns the investments of the future amidst uncertainties. On that matter, the Extractive Industries Transparency Initiative (EITI) represents a progress. It calls for transparency of financial transactions related to oil, gas and mining activities. It calls companies to "Publish what you pay". More transparency is a factor for reducing country risks. According to the IMF, as countries adopt the initiative, it could increase the ability of national oil companies to obtain credit from private capital markets for investing in oil and gas projects and also encourage the current flow of foreign direct

investments.

For improving security of energy supply of the world economy, the European Union has clearly a very important role to play. Through energy efficiency, energy diversity, regulation "in concert", diplomacy and international action, Europe should play a key role in building the sustainable energy and economic model of the future.