Jacques Percebois Receives Outstanding Contributions to the Profession Award

Editor's Note: Jacques Percebois, Professeur des Universites, Universite de Montpellier received the IAEE *Outstanding Contributions to the Profession* award at the Florence IAEE regional conference on 11 June. Following are his acceptance remarks.

Past President Jean-Philippe Cueille presents award to Jacques Percebois

I would like to say that I am extremely honored to receive this award. When I look at the list of well-known researchers who have received this award before me, I realize the significance of this prize and thank the organizers for their trust.

Through my teaching and research activities, I have studied nearly every type of energy, i.e., oil, gas, coal, renewable and nuclear energy. However, I have specialized in two major fields: the economics of natural gas and energy pricing, which involves price determination for the final consumer or Third Party Access on the networks.

During the next few minutes, I would like to share some personal views regarding the international energy outlook.

Today, the main issue is to determine whether fossil energy depletion will occur in the short or the long-term. If this depletion is to take place in the near future, what energy mix is to be chosen as a substitute? This decision is difficult to make in a context where the main uncertainty concerns future technological progress. In the past, potential technological progress has often been underestimated over the entire energy chain. However, progress in the energy field has always been slow as energy consumption often relies on equipment with a long service life. Therefore, in order to develop energy substitutes, it would be necessary to modify the structure of energy production and user facilities. It should be recalled that fossil energy still represents 88 % of primary energy consumed in the world.

The Peak Oil Delayed Again?

Today, the ratio of proved reserves to the worldwide yearly crude oil production is equal to 44 years compared to 30 years in 1973, 41 years in 1960 and 22 years in 1950. Therefore, this ratio which represents a "snapshot" of the resources depletion rate must be examined with care. Due to the rise of oil prices, market operators are increasingly developing crude oil explorations in areas which are not readily accessible, thus more costly, and also reinforcing research and development efforts resulting in new technological advances (for example, horizontal drilling and exploitation of sea-bed resources). Proved reserves are the amount of oil which is technically and economically exploitable, with a probability of 95%. Probable reserves represent the amount of oil which will be produced with a probability of 50%. Possible reserves represent the amount of hypothetical oil which will only be produced if its selling price strongly increases due to high extraction costs. This will occur with a probability of 5%.

The peak oil theory, which was developed in 1959 by the Texan geologist Dr. Hubbert, shows that the production of an oil reservoir varies according to a Gaussian curve, i.e., it is at its maximum when half the reserve is reached. Consequently, in theory, the date of an oil field peak can be determined based on the amount of proved reserves as well as that extracted from initial exploitation. The peak is reached when extracted quantities are equal to the amount of oil still to be extracted. The problem we are faced with is that the accurate level of proved reserves remains uncertain. This level is based on the oil price and the potential of technological advance observed in the exploitation-production phase. According to Dr. Hubbert, an acceptable approximation of the production is achieved by offsetting the oil strike curve by 35 years. Thus, in 1959, he predicted that the USA oil production would reach its maximum at the beginning of the 1970s, given that the oil strike peak was observed in 1940. This theory was confirmed and thus became famous. However, the question is whether this theory can be extrapolated.

According to the IEA, international proved reserves exceed 1,200 billion oil barrels, whereas according to the ASPO (the Association for the Study of Peak Oil) they do not exceed 780 billion oil barrels. As a result, some experts predict that peak oil will be reached in 2010; others believe it will occur in 2030 or even in 2050. It should be noted that oil reserves estimations made by oil companies and States are

often "strategic"; they are either overestimated or underestimated. In some cases, certain companies or countries refuse to provide this type of information, such as Russia today.

The percentage of oil strikes depends on the strategy of oil producers. It should be recalled that in 2005, international oil consumption amounted to 85 million barrels/day, i.e., nearly 4,200 million tons/year, compared to 56 million barrels/day in 1973. The 5 oil majors (ExxonMobil, ChevronTexaco, BP, Royal Dutch Shell and Total) represent 15% of international oil production, control 5% of proved reserves and make 30% of exploration-production investments. National companies from OPEC countries are responsible for 36% of the world production, control around ¾ of proved reserves, but only make 8 to 10% of exploration-production investments.

It should be noted that the first 12 international companies are public organizations based on the classification of available oil reserves. The first private oil company is Exxon, which is only in the 13th position. Even if the oil incomes of Arab-Persian Gulf countries exceeded 300 billion dollars in 2005, it is obvious that they have not been entirely reinvested in the energy sector.

The significant rise in crude oil prices observed in 2005 and 2006, which can be explained by economic issues (high increase in Asian demand) as well as political considerations (conflicts in the Middle East), has increased the profitability of Canadian bituminous shales. As a result, Canada reached the second position in the world in terms of crude oil proved reserves with 14% of international reserves, behind Saudi Arabia (21%). If crude oil prices remain stable between 50 and 60$ in the future, we may assume that new oil reserves will be discovered all around the world. The main question is to define whether the oil demand will continue to grow knowing that the increase in price will favor energy savings and the use of alternative energies (in particular, nuclear, gas and coal). However, it should be recalled that there are many captive uses for oil, especially in the transport field, and oil often represents the "swing" energy in energy balances. As opposed to alternative energies (gas or coal), oil is easy to transport. Pessimistic observers believe that the oil percentage in the energy mix will strongly decrease by 2030, whereas optimistic observers think that it will remain the main source of energy in the international primary energy balance until 2040, and even until 2050.

Natural Gas: Is There a Decreasing Trend?

Natural gas represents 24% of the world energy balance and has two main characteristics: as opposed to oil, its transport is costly and there are no captive uses for this type of energy. It is an accepted fact that natural gas is "cleaner" than oil regarding CO_2 emissions, and compared to other energies, its market penetration rate has been the highest over the last years, especially in the power generation field. The worldwide ratio of proved reserves to yearly production amounts to 65 years. The major part of produced gas is consumed locally, as opposed to oil; 55% of the world oil production is marketed internationally. The percentage of gas sold on the world energy market amounts to around 23%; the major part is distributed essentially via gas pipelines (80%) and the remainder as liquefied natural gas (LNG) (20%). In actual fact, there are three main actors in the international gas market: the American, European and Asian areas. Selling conditions vary greatly from one area to another.

The United States represents a major gas importer and imports 16% of its gas needs, mainly from Canada via gas pipelines (the Province of Alberta). It is also possible to observe that LNG is imported from the Arabo-Persian Gulf and Africa. The American production is ensured by 6,800 producers, including 21 "majors". It is a very fragmented and competitive market where gas is negotiated through spot contracts and medium-term contracts (1 or 2 years) which are index-linked to spot prices. North-American gas reserves are strongly diminishing, and as a result, the United States should import increasing amounts of LNG from the rest of the world. In the European Union, including 25 State Members, natural gas represents 24% of the energy balance and half of the needs are currently imported from three countries: Russia, Algeria and Norway. This dependency rate should reach 80% in 2030. Imported gas exchanges are based on long term contracts (20 to 25 years), including relatively strict clauses: take-or-pay clauses which require importers to pay for the gas even if their deliveries are voluntarily interrupted, indexation clauses based on crude oil and petroleum product prices. A similar system is employed in Asia, where the main importer is Japan.

Gas prices tend to vary according to oil prices either due to a formal price indexation, or because a certain correlation is observed in the markets due to arbitrations between both substitutes. Today, the amount of proved natural gas reserves is similar to that of crude oil, but because gas production is lower than oil production, the ratio of proved natural gas reserves to yearly production is greater. It should be noted that three countries possess 60% of world natural gas reserves: Russia (30%), Iran (15 to 16%) and Qatar (15 to 16%). As natural gas is a cleaner energy compared to oil and as it represents a diversification

factor, and, therefore, reduces vulnerability, this energy has been favored in industrialized countries over the last years. By 2030, 50% of the new power generation should be ensured by natural gas in OECD countries (IEA source) and 50% of the new natural gas consumed within the OECD should be used for power generation.

However, this trend favoring natural gas has to be limited for two reasons: the increase of political risks and the preservation of index clauses. The "gas war" between Russia and the Ukraine in 2006, as well as political tensions between Russia, on the one hand, and Bielorussia and Georgia, on the other hand, have induced European countries to focus more on supply security. The rise in gas prices, in correlation with oil prices, has encouraged market operators to geographically diversify supply sources (Egypt, Nigeria and, in the long term, Iran), and to consider increasing coal use for power generation.

Coal: A Big Cemeback?

Regarding the level of reserves, coal is the most abundant energy source as the ratio of proved reserves to yearly production exceeds 250 years. The worldwide distribution of reserves is relatively homogeneous even if some countries are better endowed than others. This is the case for the United States (whose resource endowment amounts to 25% of world reserves, i.e., 5 times the crude oil reserves in Saudi Arabia), China, India, Russia, South Africa, etc. A great part of coal consumed in the world is used for power generation; 40% of the power generated in the world comes from coal against 15% from nuclear energy. Nevertheless, the CO_2 content per kWh produced from coal is twice as much as the CO_2 content per kWh produced by a gas turbine. For many observers, as coal represents around 26% of the world primary energy balance, its comeback could represent a major threat for the environment. Certain authors believe that technological progress could solve this issue as coal could be employed for more diversified uses in the future, such as hydrogen and liquid fuel production.

"Clean coal" techniques for producing electricity as well as the development of "CO_2 storage" technologies should promote the use of coal. Increasing productivity in a coal-fired plant enables a reduction in the amount of CO_2 emitted per kWh.

Today, Europe represents the third coal consumer in the world behind China and the United States. These three countries represent 71% of the worldwide coal consumption. Faced with the decline of its own production, Europe has increased its imports. In 2005, Europe imported 40% of its coal and this percentage should reach 66% in 2030. Because its price is not index-linked to oil and gas prices and does not significantly depend on political uncertainties, coal remains in great demand. Many experts assume that the price of coal should remain stable in spite of the worldwide concentration of major providers and the relatively significant price rise observed over the last months due to the increasing demand and the difficulties encountered by some coal exporters.

Nuclear: A Newly Convincing Option?

Nowadays, nuclear power satisfies only 7% of the world primary energy consumption, 15% in the European Union of 25 State Members and 38% in France. This represents 15% of the power generated in the world, 32% in the European Union and 78% in France. There are 442 nuclear power reactors in the world; 143 are installed in the European Union (59 in France) and 103 in the United States. All around the world, many supply contracts have been cancelled since the end of the 1970s and many European countries have decided to stop using nuclear energy by 2020 or 2030. Only Finland, France, Russia and Asian countries (Japan, China, Korea, Taiwan, and India) are currently developing projects. Some countries have decided not to build new nuclear power reactors for economic or environmental reasons, such as, the existence of low-priced coal in the United States, the fear of a nuclear accident and the opposition of populations to the construction of new nuclear plants and to nuclear waste storage in Europe. Above all, certain economic and environmental issues could explain the possible "revival" of nuclear energy: the rise in oil and gas prices and especially the desire to reduce global warming due to CO_2 emissions. As a result, The United States, Great Britain and even Italy wonder what option to choose.

Nuclear energy is an unpopular type of energy, however it has many advantages. The "border station" cost per nuclear kWh is more competitive when hydrocarbon prices are high. Nuclear has the advantage relative to coal of not generating any CO_2 emissions, and this advantage is considered as a significant asset when priority is being given to restricting global warming. However, nuclear energy can be frightening for two main reasons: firstly, due to its military origin and to the accidents which have occurred in the past (such as Chernobyl), and secondly, due to the management of nuclear waste whose lifetime can exceed dozens, and even hundreds, of thousands of years.

According to the European Commission, the nuclear option is to be considered seriously insofar as it

may be the best solution for improving energy independence of the European Union in the fight against global warming.

Renewable Energy: A Concept Which is Slowly Emerging

Promoting energies without greenhouse gases currently involves favoring wind, photovoltaic and thermal solar energies as well as nuclear energy. Around the world, wind energy is being particularly encouraged with a far from negligible global capacity of 58,264 MW at the end of 2005, the equivalent of the nuclear power generated in France. Several countries have large wind farms, 18,445MW in Germany, 10,027MW in Spain, 9,181MW in the USA, 4,253MW in India and 3,122MW in Denmark. By 2010, we are expect global capacity to be around 150,000MW. In 2005, France decided to favor the use of its modest wind farms (800MW), and, therefore, develop the use of renewable energy sources so that by 2010, 10% of primary energy consumption (21% of electricity consumption) will be provided by hydraulic and wind energy. This objective will undoubtedly not be met in 2010, but it could be as early as 2013.

Promoting renewable energies requires both research funding and financial incentives. It should be recalled that all energies have, at a certain point in time, been helped by governments: the very high national coal subsidy, the tax benefits given to the petroleum industry in order to encourage renewed exploration as well as military and civil nuclear research subsidies. Today there are three instruments enabling promotion of wind or photovoltaic energies: the very profitable feed-in tariffs (the additional cost being paid by the consumer or the tax payer), "green certificate" programs in which electricity providers have to acquire a minimum amount of green electricity produced by operators holding a certificate, and government biddings to develop such facilities. However, efforts in favour of renewable energies are not limited to the electricity industry. This also concerns bio-fuels, the petroleum products preserve. A 2003 European directive set at 5.75% the amount of bio-fuels to be incorporated in petrol and diesel for 2010, and the objective is to reach 20% by 2020 in Europe.

Energy Savings: The Real Energy Revolution

We can ask ourselves if the real energy revolution will not be, in the near future, the significant decrease in the energy content of the GDP, in other words, large scale energy saving. The potential for energy savings is considerable. It depends on promoting technologies, on the one hand, and favoring new behaviours, on the other hand. The energy efficiency of the European Union has improved since the first oil crisis but few efforts have been made over the last few years. Whereas technical progress remains irreversible, the same cannot be said for the behaviour of economic agents. The recent increase in hydrocarbon prices should logically lead to more concerted efforts. When the access costs to energy are high, a "price transparency" policy is required in order to rationalise energy uses. Two sectors are particularly concerned because of the potential energy savings they represent, plus the fact that they largely relate to individual behaviours: the transport and housing sectors.

The residential sector represents nearly 40% of final energy consumed in Europe. Current available technologies allow us to develop the construction of energy saving buildings even with a "positive energy coefficient", meaning that the buildings generate more energy than they consume. Nevertheless, there is much inertia and the setting up of a "white certificate" (energy savings) system from 2006, in France as in several countries, should lead to substantial gains.

The transport sector represents more than 30% of final energy consumption in the European Union, but this sector did not succeed in terms of energy efficiency. Even if today motors are more fuel efficient, the savings achieved in this area are more than offset by the growing number of vehicles. Hybrid petrol/electric vehicles have been developed, but their capacity remains limited due to electricity storage issues. As for vehicles powered by hydrogen cells, they are still at the prototype stage. In order to promote the use of public transport, a behavioral revolution is required and technical progress in itself is not enough.

Strategies known as "factor 4" aiming to divide greenhouse gas emissions by four by 2050 are realistic, but they require political support which is often lacking globally, if the implementation of Kyoto obligations is something to judge this by. The objective is to divide the energy content in half and to divide at the same time by half the "greenhouse gas" content of this energy.

The heart of the current problem does not involve the scarcity of energy resources. Fossil fuel reserves will be undoubtedly abandoned well before being exhausted. The problem is about the rational and economic uses of these resources aiming at avoiding irreversible damage to our environment as a result of global warming. Three objectives are considered as global priorities, although their respective

importance can vary between countries. However, it should be recalled that policies are not always easily compatible:

1) the search for competitive energy where the access cost must reflect the positive and negative externalities that are associated with it. Confidence in the mechanisms of market is the rule and the role of the government should be limited to creating the conditions for externality contracts (CO_2 emission trading, green or white certificates, etc.)
2) the search for supply security, in order to give the priority to national resources and favoring the diversification of imported energy sources. The role of the government here is to finance the search for new technologies and to do this in a way which is often protectionist or even "patriotic".
3) The fight against global warming aiming to implement joint and cooperative policies with other States, in the hope of preserving a threatened environment considered as a "common public good". The approach here is resolutely altruistic as, without minimal cooperation, this objective is unobtainable.

The search for an acceptable compromise between confidence in the market, regarding prices, recourse to state intervention, in relation to promoting new technologies, and the wish for a cooperative strategy concerning environmental issues, all constitute a major challenge for energy, but it should be recalled that State preferences are not always compatible in this area.

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Further, IAEE has also launched a Scholarship Database, open at no cost to different grants and scholarship providers in Energy Economics and related fields. This is available at http://www.iaee.org/en/students/ListScholarships.aspx

We look forward to your participation in these new initiatives.