

“From Russia with Gas” Forthcoming Political disasters for Europe in Energy Supply

Dr.-Ing. Hildegard von LIECHTENSTEIN

This contribution is the transcription of Dr.-Ing. Hildegard von LIECHTENSTEIN's intervention at the Convention on International Law and Politics organized by The University of St.Gallen in St.Gallen (Switzerland), to discuss "The Quest for Energy" (30th November-2nd December 2006). Powerful and realist, this analysis cleaves to the Note Dr.-Ing. Hildegard von LIECHTENSTEIN published in March 2006 with the Thomas More Institute: *European Energy Policies: 10 questions, 10 answers for the Future*¹. It is also in line with the Working Paper published by Jean-Sylvestre MONGRENIER, Associate Fellow of the Thomas More Institute, on the occasion of the Helsinki Summit, in November 2006: *The stakes of EU/Russia summit in Helsinki : Brussels and Moscow between energetic partnership and "geoeconomic struggle"*².

From Kosovo, to the American missile shield issue, and including energy stakes, numerous disagreements appeared between Moscow and Brussels as the EU-Russia Summit of Samara (Russia) is to take place on the 18th of May. The debate about energy, although a priority of the German presidency of the EU, does not seem to have made any progress on fundamental options: declarations of principles on renewable energies, strong resistance against the choice of nuclear energy, etc. As the European dependence on Russian supplies provide Moscow with an opportunity to pressure numerous member-states, Europe seems unable to adopt a clear, ambitious, and voluntarist strategy. In this context, the energy issue is to become a major political and geopolitical stakes. Dr.-Ing. Hildegard von LIECHTENSTEIN's contribution is a call for realism and political voluntarism: "Nuclear is not the only solution, but there is no solution without".

Hildegard von LIECHTENSTEIN, PhD in engineering. After her studies of Bio-engineering and Pharmacy, she is an Approved Pharmacist, wrote her thesis on the effects of nuclear technology on the environment. She was the first female member of the "Heinrich Hertz Gesellschaft" (Technical University of Karlsruhe, Germany).

For years now, I have been trying to grasp what is really going on in energy politics, as most of the commonly available information on energy issues is either muddled and misleading or patently wrong. This is especially true when such information is provided by politicians who frequently either have only a limited understanding of physics or natural sciences, or may even be pursuing different interests or agendas, not necessarily in the common interest of securing energy supply in the future. Within the framework of my own activities in the field of energy policy and with the invaluable support of the Thomas More Institute, I published a paper in March 2006 which I now wish to update with my observational research of the last 12 months.

So yet again my questions are:

- **Do we really face huge problems connected with energy supply, climate change or geopolitical clashes?**

- **And what about the nightmare vision of a total dependence on Russia as Europe's main energy supplier?**

In November 2006, I again attended a conference in France on energy and geopolitics: "La Ville et la sécurité énergétique", within the framework of the fifth forum on Energy and Geopolitics organised by the *Club de Nice* of the Institut Européen des Hautes Etudes Internationales³. Besides the French attendants, there is traditionally a high participation of Eastern-European specialists (especially Russians), but almost no-one from Germany or English-speaking countries is present. This conference was again very revealing and in many of my following statements, I will rely on information given by Russian specialists on the following issues:

- European energy supply;
- Russia as a geopolitical challenge for Europe and its reliability as an energy supplier especially of natural gas.

Obviously I base myself on a number of other sources such as the International Energy Agency Outlook 2006, on data obtained of Swiss power generation companies such as Axpo and Atel, and on scientific studies of Stuttgart University⁴ and the Paul-Scherrer-Institute (Switzerland).

1. Our Present Situation in Global Energy Supply

In order to describe our present situation it is important to keep in mind the following related facts:

- 1) The global consumption of raw materials and energy is proportional to the demographic and economic evolution.
- 2) Facilities for the production of both raw materials and energy supply are highly equipment intensive i.e. any increase in capacity raises the current demand for raw materials.
- 3) The production of raw materials is highly energy-consumptive. It therefore follows that the growing shortage of raw materials, including primary energy, will increase not arithmetically but exponentially for a long time to come. Timid efforts by developed industrial states to reduce energy consumption are hopelessly over-compensated by the demand of the so-called emerging countries.

To think that the quite unrealistic aim of reducing the yearly European growth of energy consumption from 2.1% to zero—or even achieving negative growth—will solve our problems any time soon is absurd.

Two further important points are:

- 4) One must differentiate between raw materials and energy: raw materials can be recycled, energy is consumed.
- 5) With regards to energy suppliers, one must distinguish between two sorts of primary energy. The one of which is easily transportable, easy to store and easily drawn by producers and distributors (an example of which is hydropower, or fuel rods used in nuclear power plants). The other kind of primary energy is difficult or bulky to store, costly to transport and/or its availability is highly volatile. Natural gas can only be stored in relatively small quantities—about two weeks consumption's worth—and can only be transported over high distances at great cost. The delivery of natural gas in Europe is therefore limited to a few specific producers and is supplied just in time.

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As to our present situation, I have two pieces of good news before coming to some very bad news. Two problems are no-problems, although they are advertised as such! However I see major and very

real problems ahead, mainly in relation with the coming power gap. And, personally, I do not see an imminent solution for them. I will explain myself later.

The good news is that:

- 1) Enough reserves and provisions of primary energy sources exist. At present, there are enough global resources in total, however not sufficient in each category. So: sufficient Uranium, Thorium, Coal and also Natural Gas, but not enough Conventional Oil and at present prices. Of course and from a European viewpoint, we have to take into consideration the fact that oil and gas reserves are unevenly distributed around the globe, and that the largest reserves are situated in politically or economically unstable regions. North Sea oil and gas fields have already been exploited beyond their peak, leaving Europe dependent on non-EU countries for future supply. I will come back to this typically European problem later (Chapter 5).

At this point I would like to comment on the assumption that the global peak oil is imminent within the next few years, as it can often be read. While the expanding economies of China and India have caused an enormous rise of crude oil demand, geopolitical tensions have resulted in a decrease in supply. Accordingly, the current price per barrel has increased to around 60 US dollars. This run up in commodity prices has enabled big oil-companies to economically produce unconventional hydrocarbons such as:

- Heavy Oil from oil sands in Canada
- Heavy Oil from tar sands in Venezuela
- Tight Gas
- Coal Bed Methane
- Shale Oil
- "North Sea carbon cycle" Oil and Gas production⁵

Up to now, only 8% of these unconventional resources came into production, but analysts⁶ are convinced of the existence of global probable reserves of 3600 billion boe (barrels of oil equivalent), which is about the double of conventional oil reserves. In comparison: the global forecast⁷ of oil-consumption in 2007 is at 31 billion barrels. As for natural gas, Wood Mackenzie predicts a supply of 40% of natural gas from unconventional resources for the USA.

- 2) No technological problems or lack of new technologies. This is if we use rationally the known techniques and do not exclude important ones for emotional or irrational reasons. We especially don't have a problem concerning our western-style nuclear power technologies, which are highly developed and safe for physical reasons. Whatever some people tell you about it!

Sure it would be nice to have some techniques at hand to deal with the storage and transportation problem in electricity supply, as for example batteries with much higher capacity for hybrid cars or superconductivity which would allow Russia to produce electricity in Siberia and bring it over to Europe (you wouldn't believe it, but they already include this in their forecasts). And there are some technological devices of which we only know the name of up to now, like nuclear fusion or exothermal reaction of silanes. Those techniques will come... perhaps, but you may forget about them for the next 30 years to come concerning public electricity supply.

2. The Future Situation in Europe: A Huge Power Gap

Now I come to our real problem, the power gap: The underlying reason is political and emotional. The power gap in Europe is a certainty, the only remaining question is: when?

Together with France, Switzerland is in the most favourable position as far as the security of supply is concerned. The reason is that electric power generation is mainly based on nuclear and hydropower.

However, even the Swiss must import power from France in the six winter months (in winter the availability of hydropower declines). The Swiss utility industry anticipates production shortfalls already within the next five to six years. This will happen especially if negative factors intervene such as low precipitation in summer or the extended shutdown of nuclear power stations for technical reasons as in 2005.

As a forecast, the power gap in Switzerland will amount to 15-33% of anticipated consumption in 2030.

But in Europe as a **whole, the situation is much worse**. The growing shortages in Europe in the transmission and production of electricity will amount to around 1800 TWh (Terawatt hours) by 2030, which is equal to ninety times the Swiss power gap (20 TWh). In a few years, France will require all its power generation capacity for its own needs, and what is more, none of the remaining Western European countries will be able to produce sufficient power to cover their own national needs. It is absurd to hear the ministries responsible for energy supply in virtually all EU countries reckoning with importing electricity to cover their capacity deficits.

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The question is: **power imports from whom?**

By the way: The idea of closing this huge power gap by heavily investing in renewable energies is so illusory, that it is not even worthwhile discussing it. Nonetheless, I will briefly take up the theme of renewables in Chapter 6 in order to highlight the facts, and comment on some ominous illusions.

3. How Comes that We Find Ourselves in Such a Position?

I think we can find the reasons in all political areas

a.) **Emotions in internal politics.**

These are based on non-information, disinformation and fear. Those fears are willingly raised by two groups with their own agendas: politicians and political parties, willing to be elected, and NGOs such as Greenpeace. Stirring fear is a powerful instrument—comparable to envy—to acquire public support (votes) or to raise funds. Fears regarding nuclear energy and greenhouse gases are successfully stoked. Both anxieties contradict each other and have fatal consequences on our European energy policies, bringing serious planning to a standstill. Salvation is then sought after in methods of generating energy which exclude both nuclear and fossil fuels. Emotions dangerously frustrate rational decisions and lead to a gigantic misallocation of funds and efforts. For instance: solar or wind power, although useful for specific solutions, will not solve the overall problem, but have a feel-good effect. Energy reduction measures would be more helpful, but very costly and they require 10 to 15 years to generate a substantial cut down of energy consumption. At any rate, the so-called 2000 Watt society is not possible, if we don't consider accepting the living standards of 100 years ago for example *without* one's own car, non-essential air travel, PC, washing machine, tumbler, dish washer, TV set, aluminium products etc.

b.) **Fiscal reasons:** High taxes on gasoline and mineral oil.

Revenues from these taxes are very important. In France, as a consequence, a project to link levies on motorcars with gasoline consumption, was refused. The state cannot afford the consequent reduction of tax revenues on gasoline.

c.) **Ecological paralysis** of necessary investments.

Ecologically motivated initiatives prevent important investments to an unsuspected degree, astonishingly in the field of renewables as well:

- The construction of reservoirs for storage power stations, obstructed by landscape protectionists. Those reservoirs could enhance the increase in capacity of hydroelectric power, thereby avoiding the construction of gas power stations to ensure supply.
- The expansion of the electricity networks is also obstructed by ecologists, who thereby absurdly inhibit electricity transport from future wind parks in the North Sea to industrial conglomerations in the south.
- Long-distance heating for settlements, using waste heat from nuclear power plants. Ecologists cannot accept that there is anything positive in nuclear power.

d.) **Political inconsistencies:** ecological and economical ones.

The Kyoto protocol as an instrument of self-deception!

- In the EU, operators of thermal power plants based on coal receive state subsidies by being given CO2 certificates, which are negotiable on the stock market. Coal plants would not be competitive without such subsidies.
- Biomass fuel leads to a shortage of foodstuffs (corn for ethanol production in USA) and to the destruction of rain forests through the production of palm-oil used for power generation here in Europe.
- Environmental pollution through combustion of biomass fuel with inefficient total energy balance.
- The export of energy intensive production processes in non-European countries, which does not reduce global CO2 emissions, but allows European politicians to show improvements on the CO2 front, while causing economic damage.

e.) **Geopolitical risks**—which stand for the most dramatic risk—and the question: what about Europe’s political dependency on its energy suppliers—and the Hitchcock-like scenario of Russia paralysing Europe within hours by closing the gas cock (pipelines)?

4. Let’s Face our Situation: Dependence on a new Gas Cartel under Russian leadership

Europe’s manufacturing, and especially the German, is widely dependant on the supply of primary energy. Our own European gas and petroleum reserves will be heavily depleted in the next 10 years. The oil supply as such is not the main problem, as on the one hand petroleum and derived refinery products can be stored fairly easily (see chapter II.5.), and on the other hand the percentage of oil needed for power generating in Europe is steadily diminishing, in favour of coal and natural gas. Above all the red/green groups are urging to increase the contribution of natural gas to total supplies, out of environmental reasons.

True, immense reserves of natural gas have recently been discovered in Norway and on the Norwegian shores. It is however uncertain when and at what costs these reserves can be brought to production. This may take at least 15 years.

This means that we increasingly become dependent on continuing and reliable Russian natural gas supplies. While other geopolitical risks may affect Europe only through rising prices for fossil fuels, this is not true concerning our neighbour and main supplier: Russia. Germany's natural gas imports already derive to 35% from the tundra, with an increasing tendency, and the figure for the new EU member states in the East touches 100%.

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According to Russia's own acknowledgement (M.Valerie Kostyuk, General Secretary of the Academy of sciences in Russia) Europe already now imports 44% of its demand of natural gas from Russia. Gazprom, which itself stands for about 90% of Russian natural gas-production, delivers 70% of its product to Europe. Russia goes to great lengths to outwardly present itself as a peaceful and reliable trade partner.

The object is to pretend that Russia is clearly more dependent on us as clients as we are on Russia as a provider. This argument is of course quite absurd, and it does not gain credibility as President Putin talks up "energetic interdependence" via large media campaigns (e.g. "Figaro", "Frankfurter Allgemeine Zeitung", November 2006). Europe has a huge world-wide competition on the demand-side; especially China which has now loudly begun to demand Russian oil and gas supplies and, military wise, they are undoubtedly the strongest pressure group.

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It is of crucial importance to Europe to face the fact that in 2030 there will be only two net importers of energy resources in the world, Europe and Asia, and only two net exporters, Russia and the Middle East. The plans approved by German Chancellor G. Schröder and President Vladimir Putin for the construction of a further natural gas pipeline under the Baltic Sea give grounds to fear that the enormous risks of becoming dependant on the reliability of supplies from an authoritarian state have been recognised neither by Western politicians nor by the general public.

Naturally, the new EU countries in the East take an entirely different view. Mister Lech Kaczynski, Poland's Prime Minister, has declared the problem of energy imports to be a matter of public security, his primary economic policy objective being to find alternatives to Russian supplies. Poland is still in trauma following Russia's dispute on prices with White Russia in 2004, in which Russia simply cut off supplies to the White Russians, thereby severing the supply to Poland. The same can happen to us.

Yet another politically very unsettling Russian measure is the founding, in Russia, of an organisation of gas exporting countries, called "MANNGO". This organisation is to be an equivalent to OPEC and have the same purpose, that is to control the natural gas market with respect to consumer countries. This could have a drastic effect on future gas-prices and on holding consumer countries on ransom, especially in the EU.

Russia can stop gas supply through pipelines at any moment. This would have an immediate effect: German manufacturing and parts of infrastructure like heating systems, trains and lights, would instantly break down. Imagine the consequences! The consequence on Russia of loosing the European market or the momentary income from gas exports would not be immediate and is not very likely. Because of the above, Western Europe would make all the concessions required in their appeasement politics towards Russia. I could imagine Russia pursuing several goals, for instance the retreat of NATO from the Baltic States, Poland, Hungary etc., not to speak of drastically rising gas and oil prices.

Another telling comment (Mr. Kostyuk again) is, that Moscow will refuse to sign the European Energy Charta, as it is not in Russia's best interest. That sounds logical as such a decision would imply the end of Gazprom's monopoly on the natural gas exports.

This growing concern of Europe's dependency on Russian natural gas supplies is aggravated by Russia's new alliances with other suppliers. An indication of this market strategy is the new partnership between Gazprom and the Algerian public group Sonatrach, which happens to be an important supplier of EU gas demand. Already in 2005, I was told by a

French insider, that an agreement to implement a common strategy had been reached between Russia and Algeria regarding both pricing and volume, which would leave Europe defenceless.

Yet another politically very unsettling Russian measure is the founding, in Russia, of an organisation of gas exporting countries, called "MANNGO" (Prof. Elena Telegina, Director of the Institute of Geopolitics and Energy in Moscow). This organisation is to be an equivalent to OPEC and have the same purpose, that is to control the natural gas market with respect to consumer countries. This could have a drastic effect on future gas-prices and on holding consumer countries on ransom, especially in

the EU. A treaty was signed on August 4th 2006, causing unease among European customers about the apparition of this kind of Gas-OPEC.

This policy is complemented by on-going negotiations with Western European energy providers, aiming at obtaining important stakes in these companies. Investors in big projects like Sakhalin and Shtokman are forced to accept a status as subcontractor and at the same time are obliged to cede stakes in their own downstream business.

To this aim any excuse is good enough to terminate existing contracts.

The evident political goal of the Kremlin's is to control via Gazprom strategic participations in Western utilities and crucial energy distribution.

As you all can see, this represents an enormous danger!

Already in December 2004, the International Energy Agency in its report on energy policy warned of this dependency and drew attention to the necessity of diversifying natural gas imports to assure the security of Europe's supplies. In my opinion, it is almost too late to do anything about it. We will have to hurry up.

5. European Incense: Renewables Without any Greenhouse Gas Emissions, Power for Free?

Earthquakes Instead of Geothermic Power? Petrol Instead of Bread? Biomass Instead of Rainforests?

At the European Union's Council meeting of March 9th, 2007, the decision was reached to reduce greenhouse gas emissions until the year 2020 by 20% compared to 1990. This is equal to a reduction of CO₂ emissions of around 34%, i.e. one third of the current level. This ambitious goal is to be reached within the next twelve years and will cause substantial problems for the member states. At the same time, 20% of total power requirements should be covered by so called renewable energy sources and the share of biofuel should be increased to a minimum of 10%, both equally ambitious goals. How to solve these problems is left up to the individual countries, with heavy implications such as:

- 1) enormous costs
 - to adapt all buildings to energy efficient systems mainly by insulation
 - to convert all roofs to hold photovoltaic cells or solar thermal facilities
 - to restructure the farming industry into the cultivation of biomass for energy generation
 - to develop the existing grid and constructing new electricity networks for the transport of wind power from the north sea southwards
 - to maintain stand-by power generation capacity, in case the sun does not shine and the wind does not blow
- 2) unrealistic time frame for planning, development and construction
- 3) heavy interference in personal freedom on account of a plethora of new regulations

The only result of these challenging plans that can be predicted with certainty is a substantial increase in subsidies from Brussels for the development of renewable energy. The alleged possibility of meeting resolutions made in Brussels by generating electricity through solar and wind power on the one hand and by way of solar and geothermic energy⁸ on the other hand is of particular interest.

After deduction of hydropower (1,5%), renewable energies in the European Union today account for 4.9% of the total power requirement, of which 0.04% are allocated to photovoltaic. An investigation by SATW (Schweizerischen Akademie der Technischen Wissenschaften) predicts a tenfold increase in solar energy until the year 2020, equivalent to 0.5% of total electricity production, and up to 8% until 2050, implying the roofing with solar panels of ALL existing buildings.

The potential of wind energy, currently contributing on average approximately 0.3% in the European Union, is hardly superior to present levels in view of the understandably growing resistance from the general public, from ecologists, ornithologists or game preservers. Erecting vast offshore wind parks is technically questionable and expensive. In addition, a substantial increase in electricity production in northern Europe would require the construction of large, new electricity networks, as existing grids are already overstrained—increasing black-outs in the near future can be expected. Highly praised geothermal energy systems, though theoretically with much potential, are as yet not perfected. Moreover, earthquakes in Basel (Switzerland) have put a damper on this technology and caused the pilot project to be suspended. Before beginning a new project meticulous and time consuming geological explorations are imperative.

Applying solar and geothermic energy systems to supply buildings with hot water, heating or air conditioning would certainly make sense and save considerable quantities of heating oil. However, little contribution would be made towards reducing CO2 emissions in the next twelve years.

The Brussels resolution to increase the portion of biomass to 10% of total fuel consumption also presents certain problems. An automobile travelling 20.000 kilometres per year and consuming 7 litres of petrol would require the conversion of 3.5 tons of cereals per year. In comparison, a human being consumes 0.5 tons of cereals per year! Accordingly, the space requirement to grow this amount of crop would be gigantic. The European Union calculates that 20% of the entire European cropland would be needed to generate only 5.75% of fuel demand from biomass. The projected increase to 10% before the year 2020 can only be achieved if methods are developed that do not compete with food production and result in substantially lower CO2 emissions than today⁹.

The European Union calculates that 20% of the entire European cropland would be needed to generate only 5.75% of fuel demand from biomass. The projected increase to 10% before the year 2020 can only be achieved if methods are developed that do not compete with food production and result in substantially lower CO2 emissions than today.

The simplest solution today for providing biomass for diesel production or to charge power plants is to import palm oil. However, the production of this source of energy has disastrous consequences, as vast surfaces of rainforest, especially in Southeast Asia, are being sacrificed to ensure production.

At the risk of destroying any remaining illusion, I must unfortunately also mention that biogas, timber and biomass are also pollutants, emitting substances like nitrogen oxides and sulphur oxides, responsible for acid rain. The environmental impact of generating such energy is significant.

France has adopted the argument that nuclear energy falls into the category of renewable energies, possibly even with success.

A further sticking point is that the initial positions of each country and the consequences of implementing the Brussels plans vary from country to country. Poland, for example, produces its electricity requirement almost exclusively from coal, while 78% of France's needs are covered by nuclear energy.

It is interesting to note, that in relation to the discussion surrounding commitments and burdens, France has adopted the argument that nuclear energy falls into the category of renewable energies, possibly even with success. Physically speaking, France's argument is correct, especially considering the latest nuclear technology, for instance fast reactors of the 4th generation. In addition, nuclear energy causes low levels of pollution compared to any other source of energy. Poisonous exhaust gases and waste are not blown into the air but captured inside in the fuel rod.

I hope that the above EU decision will not share the fate of the year 2000 “Lisbon Strategy” which goal was to make of the EU the world’s most competitive economy by 2010.

6. Finding a Way out of the Dilemma

As I have illustrated in chapter III and IV, there is no long term problem in energy supply or power generation. But we do have a sincere problem with a near term and medium term power gap. By way of example, Swiss experts expect first shortfalls in electric power supply to occur within the next five years. And the energy department in Bern is already busy working on a so-called cut-off plan. Electricity suppliers are already counting on periodic power cuts to entire towns and industrial zones within the next years. Today we cannot begin to imagine twelve hour power cuts in entire cities like Zurich or Frankfurt. What would the consequences be for electronic data, especially in the banking system? The economic fall-out could be catastrophic.

The question is therefore how quickly the power gap can be closed, taking into account the decision making process, planning and construction of power plants. In the short term, within the next five years, electricity can only be produced through new construction of gas power stations. Consequently it is understandable that the European utility industry is busy obtaining appropriate licenses. Unfortunately this short term solution increases our dependence on gas supplies and the emission of greenhouse gases. This is a particular problem for France and Switzerland, as today their electricity production is not based on fossil fuels (Switzerland) or only to a minor degree (France).

In comparison the construction of a nuclear power station, including licensing requirements, takes as a minimum 15 years, assuming that an existing technique is applied. Nuclear power stations of the 4th generation will only be developed in a 20-year time, and can therefore only be operative in 2050. However such new power plants have the advantage of considerably improving today still existing problems such as the proliferation of nuclear material, the amount and the half-life period of radioactive waste, and the residual risk of operating such a plant. But, as I already mentioned, this cannot happen before 2050, even if we massively increase our current efforts.

And now, I would like to draw your attention to the fact, that the geopolitical independence of European operators of nuclear power stations stands in sharp contrast to thermal power stations based on fossil fuels.

Uranium and Thorium ores are present in all continents and in the oceans as well, and ready-made fuel elements may be stored for years in relatively small facilities. Fuel reserves for 5 to 10 years may be conveniently held in stock without the need for substantial investment. **Nuclear is not the only solution, but there is no solution without.**



¹ Hildegard von LIECHTENSTEIN, *European Energy Policies: 10 questions, 10 answers for the Future*, March 2006, Note N°7 of the Thomas More Institute, available in English and in French at <http://www.institut-thomas-more.org/showNews/85>.

² Jean-Sylvestre MONGRENIER, *The stakes of EU/Russia summit in Helsinki : Brussels and Moscow between energetic partnership and "geoeconomic struggle"*, November 2006, WP N° 5 of the Thomas More Institute, available in English and in French at <http://www.institut-thomas-more.org/showNews/117>.

³ See http://www.iehei.org/Club_de_Nice/accueil.htm.

⁴ See www.energie-fakten.de

⁵ Improving the recovery factor of oil wells by 3% to 15%. See Wood Mackenzie. *Upstream Insights Europe*. July 2006.

⁶ *Unconventional Hydrocarbon*, interview with Dr. Rhodri Thomas. February 2007, Wood Mackenzie. Available at: <http://www.woodmacresearch.com/cgi-bin/wmprod/portal/energy/highlightsDetail.jsp?oid=825093>. And *World Heavy Oil Conference*. November 12th-15th 2006, Beijing.

⁷ Based on analyses from the International Energy Agency.

⁸ For CO2 reduction purpose concerning heating, cooling and Electricity in households.

⁹ The overall CO2 balance sheet of biomass production and conversion into fuel is quite poor, when considering included processes as fertilizer production, agricultural machines etc.

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By Laurent LEMASSON (Tribune N°3, december 2004, Fr).

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