UNIVERZA V LJUBLJANI
FAKULTETA ZA DRUŽBENE VEDE

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ENERGY SECURITY
PURSUING A STRATEGY OF DIVERSIFICATION
USA AND EU
A COMPARATIVE APPROACH

magistrsko delo

Ljubljana, 2007

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ABBREVIATIONS

ACI	Andean Counterdrug Initiative
AEI	Advanced Energy Initiative
AUA	Australian Uranium Association
bcm/y	billion cubic metres per year
BP	British Petroleum
BTC	Baku-Tbilisi-Ceyhan (pipeline)
BTL	Biomass-to-liquids
CAFE	Corporate Average Fuel Economy
CNPC	China National Petroleum Corporation
CONCL	Council of the European Union
CTL	Coal-to-liquids
DOE	(US) Department of Energy
EC	European Commission
ECSC	European Coal and Steel Community
ENP	European Neighbourhood Policy
EPACT92	Energy Policy Act of 1992
EPACT05	Energy Policy Act of 2005
EPE	Energy policy for Europe
EC	European Commission
EIA	Energy Information Administration
ESA	Euratom Supply Agency
EU	European Union
EURATOM	European Atomic Energy Community
FSU	Former Soviet Union
GDP	gross domestic product
GTL	Gas-to-liquids
GW	gigawatt (1 watt × 10^9)
GWh	gigawat-hours
HEI	Hemispheric Energy Initiative

IEA	International Energy Agency
INOGATE	Interstate Oil and Gas Transport to Europe
ITER	International Thermonuclear Experimental Reactor
Km	kilometre
l/100 km	litres per 100 kilometres
LNG	liquefied natural gas
mpg	miles per gallon
mt	million tonnes
mt/y	million tonnes per year
mtoe	million tonnes of oil equivalent
NCEP	National Commission on Energy Policy
NEP	National Energy Policy
OPEC	Organization of the Petroleum Exporting Countries
PDVSA	Petroleos de Venezuela SA
PV	photovoltaic
R/P ratio	reserves to production ratio
SPR	Strategic Petroleum Reserves
TACIS	Technical aid to the Commonwealth of Independent States
TEN	trans-European networks
toe	tonnes of oil equivalent
UAE	United Arab Emirates
UK	United Kingdom
USA	United States of America
USDA	US Department of Agriculture
WEC	World Energy Council
WNA	World Nuclear Association

1. INTRODUCTION

In the developed world the usual definition of energy security is simply the availability of sufficient supplies at affordable prices, although different countries interpret differently what the concept means for them. In the EU (European Union) the major debate centres on how to manage dependence on imported natural gas – and in most countries, whether to build new nuclear power plants and perhaps to return to (clean) coal. The US (United States) must face the uncomfortable fact that its goal of "energy independence" – a phrase that has become a mantra since it was first articulated by Richard Nixon four weeks after the 1973 oil embargo was put in place – is increasingly at odds with reality (Yergin, 2006: 71).

Since Churchill's day, the key to energy security has been diversification. Both entities of comparison (the US and the EU) refer to the strategy of diversification as the main way to reduce their dependence on foreign sources of energy supply. The Bush administration sees diversification as a vital effort to multiply the number of petroleum suppliers and to prod all those producers into vastly increasing their output (Klare, 2005: 113). Alternative transportation fuels, renewable energy, and advanced technologies such as clean coal and next generation nuclear should be aggressively pursued (Committee on government reform, US House of representatives, 2006: 3). EU energy cooperation with third countries remains a top priority. Diversity of type of energy, of country of origin, and of country of transit is essential to ensure the EU's access to clean and secure energy (Paper from Commission/SG/HR for the European Council 2006: 5).

The main hypothesis that I am dealing with in this thesis is: The US and the EU carry out the strategy of energy diversification differently. As I will explain later: "The focus of comparative research is on similarities and differences between units" (Neuman, 2003: 422). Concretely, I would like to find out the meaning of geographical diversification for the US and the EU; which are the preferred countries and regions of choice and the policies that are leading to such decisions. I would also like to find out if there is a common trend towards a certain type of primary energy and what the trends are for the future.

In this work I am dealing with the strategy of energy diversification of the US and the EU. The second chapter of my thesis explains the place of energy diversification within the broader context of energy security.

The third chapter focuses on the strategy of energy diversification in each case. Firstly, the policies and the most important relevant policy documents of the US and the EU are presented. Then, according to the importance of crude oil (and non-conventional oil) and natural gas for the diversification strategy the greatest stress is on geographical diversification, since most of crude oil and natural gas are imported and their share in primary energy mix is going to increase. I will present relations of the US and the EU with the most important producing and transit states, where they get the most of crude oil and natural gas from and why. All this will be presented in the context of decreasing domestic production and increasing imports and other relevant trends (crude oil and natural gas production in 2030, the importance of alternative transportation fuels and efficiency). Competition for scarce resources is another significant factor worth explaining, especially in connection to the pipeline politics and the role of other emerging powers (especially China). The third part of the third chapter is about further diversification of the type of energy. It is focused on internal sources of energy (coal, nuclear and renewable energy) as a contrast to the mostly imported sources of energy which cause dependency and vulnerability. The fourth part of the third chapter summarizes all five types of primary energy of the US and the EU. It also explains the trends in the primary energy production, consumption and net imports. Lastly, the importance of energy efficiency is explained.

The conclusion verifies my initial hypotheses and some other trends on the basis of findings from the previous chapters. It must be said that there are two overviews (partial conclusions) before the final conclusion that deals with the hypothesis only. Chapter 3.2.9 compares geographical diversification by countries of origin of the US and the EU. Chapter 3.4 compares primary energy trends in general and import dependency of the US and the EU. These two partial conclusions actually summarize the main characteristics of my work.

The most important research method of my thesis is a comparative research method. The focus of comparative research is on similarities and differences between

units (Neuman, 2003: 422). “Comparative researchers tend to look for differences among their cases. They examine patterns of similarities and differences across cases and try to come to term with their diversity” according to Ragin (1994: 107). Comparative research also has limitations. It is more difficult, more costly and more time consuming than research that is not comparative. Another limitation is the number of cases. Sufficient information is not available for all the nations in the world. A third limitation is that comparative researchers can apply, not test theory and can make only limited generalizations (Neuman, 2003: 423).

I am comparing two units: the US and the EU. Although the EU is not a country formally like the US, I am still regarding it like an uniform entity to make comparison possible. Taken together their characteristics regarding population and wealth are “quite similar” (Table 2 and 3) what make comparison credible. Besides they are all influential and technically developed international actors.

The EU Member States have the sole right to decide about their energy supplies or nuclear energy. There has been a gradual developing of a kind of a common foreign policy and there is no common energy policy yet. There exist some common guidelines, such as Commission’s Green paper – A European strategy for sustainable, competitive and secure energy or priority axes for crude oil and natural gas pipelines. It would be beyond the scope of this paper to present the characteristics of individual Member States and on the other side it would also make the comparison much more difficult. Policies and other activities of the Member States will be presented only when necessary. It means, for example that the data regarding quantities of imported crude oil or natural gas, domestic production of crude oil or natural gas or the quantity of nuclear energy produced will be presented at the EU level only (as a sum of Member States’ quantities). But for example, the important role of Great Britain in the EU’s domestic production of crude oil and natural gas or the German stance towards nuclear energy will be mentioned briefly (and not explained in detail).

On the other side, when comparing policies, it would be impossible to describe and explain all aspects and details of different policies that the US and the EU carry out in such a great policy spectre in such a small space. That is why I decided to study only a

limited aspect of government policies (especially foreign and energy policy) carried out regarding producing states and in connection with the geographical diversification.

An obvious source for comparative information is the data published on a yearly or quarterly basis by national or international statistical agencies (Pennings et al, 2006: 56). I got the most important data used for comparison (which is personalized in Table 25 and 26) from two official sources: US Department of Energy, Energy Information Administration (EIA) (which is an independent statistical unit of the Department of Energy) and its publication "Annual energy outlook, with projection to 2030"; and European Commission, Directorate-General for Energy and Transport and its publication "European energy and transport, trends to 2030 – update 2005". The most helpful, regarding world energy statistics, was EIA. I also used well-known "World energy outlook 2004" (which was the last one freely available on the internet) made by the Paris-based International Energy Agency (IEA), "Statistical review of World energy, June 2006" made by the British Petroleum (BP) and Eurostat data. The greatest limitation of these statistical data was the lack of information about particular years, especially about the year 1990. I needed to search for information somewhere else or just did not mention it if I could not find it. I tried to find statistical data in a time span of 1990-2030 to compare past and future trends, especially "before" (from 1990 to 2004/05) and "after" (from 2004/05 to 2030). As a result I also get a kind of a case study of the US and the EU energy development and a trend analysis. The next problem was the use of different units, especially the American ones (feet, barrel, short tonne, British thermal unit) that had to be converted into the European ones (Table 1). In the fourth part of the third chapter I used "tonnes of oil equivalent" (toe) as an uniform unit that helps to connect all different energy units.

In my thesis I used qualitative research method only, although it seems that I used quantitative research method too because of so much data. But even if you use a lot of statistical data it does not mean that you use quantitative research methods because "quantitative researchers choose from a specialized, standardized set of data analysis techniques that are highly developed and build on applied mathematics. By contrast, qualitative data analysis is less standardized" (Neuman, 2003: 439). Qualitative research means presenting data analysis in the form of diagrams and charts that help organize

ideas and systematically investigate relations in the data, as well as communicate results to the reader. Data display is a critical part of qualitative analysis (Neuman, 2003: 461). That is a reason I created so many figures and maps.

DATA DEFINITION

- EU means EU25 (not EU27) – because most data is for the EU25 only. The year 1990 includes the sum of all 25 countries that comprised the EU (till January 1, 2007, when Bulgaria and Rumania joined the EU).
- Primary energy refers to energy in its initial form, after production or transportation. It consists of crude oil, natural gas, coal, nuclear and renewable energy.
- Oil/Crude oil. In this work I am dealing with crude oil where possible. Crude oil is oil in its initial form – when it is pumped out of the ground. Oil has much wider meaning than crude oil. IEA (2004a: 553) in its World energy outlook defines oil as including crude oil, natural gas liquids, refinery feedstocks and additives, other hydrocarbons and petroleum products (refinery gas, ethane, liquefied petroleum gas, aviation gasoline, motor gasoline, jet fuels, kerosene, gas/diesel oil, heavy fuel oil, naphtha, white spirit, lubricants, bitumen, paraffin waxes, petroleum coke and other petroleum products). The problem for me was that the countries are not importing only crude oil but oil as well. This is the case for the US especially, since it imports a lot of oil from refineries in the Caribbean and even from Europe. On the other hand, the EU is also importing some oil from Russia. In that way, the traces from where one country really gets its oil could be hidden. So, for example, the US is not importing crude oil from Iran but it gets some oil from the EU Member States' refineries, which are importing oil from Iran. However, because of the importance of crude oil as a raw material for oil (oil could be also made from unconventional oil and other processes such as from gas or coal which is explained separately) and to crystallize (and simplify) from where the countries gets oil in its initial form I decided to use crude oil in my statistic where possible. Sometimes it is difficult to differentiate between the terms because some authors are using them as they would have the same meaning. In general political speaking, in speeches and even in documents, the most often is the word oil and not crude oil.

It the same story with gas which has wider meaning as natural gas. According to the IEA (2004a: 553) gas includes natural gas (both associated and non-associated with petroleum deposits but excluding natural gas liquids) and gas-works gas. I used natural gas data only.

Table 1: Conversion factors used to count comparable data

	multiply by			
From to	ton of oil	cubic meter of gas	ton of coal	mtoe*
Barrel of oil	0,1364			
Cubic feet of gas		0,0283		
Short ton of coal			0,9072	
Trillion Btu				0,0252

Source: BP (2006: 46); IEA (2006: 58).

* million tonnes of oil equivalent

1 barrel = 159.0 litres

- Maps – maps (unless otherwise noted) are based on Wikipedia (the free encyclopedia) World blank map, http://en.wikipedia.org/wiki/Image:BlankMap-World.png (10.12.2006).

Table 2: US – Main characteristics

	2004	2010	2020	2030
Population (mio)	294.1	310.1	337.0	364.8
Number of households (mio)	113.6	122.9	137.2	149.8
Average household size (pers.)	2.6	2.5	2.5	2.4
GDP ($billion, $'00)*	10 756 (7 995)	13 043 (9 695)	17 541 (13 038)	23 112 (17 179)
GDP per capita ($'00)*	36 573 (27 184)	42 061 (31 263)	52 050 (38 687)	63 355 (47 090)

Source: DOE/EIA (2006b: 139, 161).

*numbers in brackets are in Euros (European Central Bank exchange rate at the 17 August 2007, which was: 1€ = $1.3454)

Table 3: EU – Main characteristics

	2000	2010	2020	2030
Population (mio)	452.9	464.1	469.3	469.4
Number of households (mio)	185.5	205.2	220.9	232.7
Average household size (pers.)	2.4	2.3	2.1	2.0
GDP (€ billion, €'00)	8,947.0	10,946.8	13,656.3	16,051.4
GDP per capita (€'00)	19,754	23,589	29,101	34,198

Source: COM (2006a: 17, 54).

2. ENERGY SECURITY

The current energy security system was created in response to the 1973 Arab oil embargo to ensure coordination among the industrialized countries in the event of a disruption in supply, encourage collaboration on energy policies and deter any future use of an "oil weapon" by exporters. Its key elements are the Paris-based International Energy Agency (IEA), whose members are the industrialized countries; strategic stockpiles of oil; continued monitoring and analysis of energy markets and policies; and energy conservation and coordinated emergency sharing of supplies in the event of a disruption. Since the system's inception, a coordinated emergency drawdown of strategic stockpiles has occurred only twice: on the eve of the Gulf War in 1991 and in the autumn of 2005 after Hurricane Katrina (Yergin, 2006: 75). Each IEA member that is a net oil importer is required to hold stocks equal to 90 days or more of its net imports. The IEA maintains agreed mechanisms for coordinating the use of these stocks in responding to a physical supply disruption (National energy policy development group, 2001: 8-16). Nevertheless, such mechanisms are severely limited especially since crises often have more to do with market economics than with physical disruption of supply. The experience of negotiations within the IEA demonstrates that effective coordination and cooperation are extremely difficult to achieve in practice. During the Gulf War of 1991, as again today, it has been left to the US Strategic Petroleum Reserves (SPR) to spearhead pro-active intervention in the oil markets. At the EU level, there is no centralised decision-making mechanism through which oil could be released onto the market. If oil prices were to rise to unreasonable levels, the EU would find it had little power to act. In order to reduce the risk of a crisis as a result of their dependence on external energy, a number of Member States have set up independent inventories of strategic reserves for certain energy products (COM, 2000, 0769 final: 19). A simulation of crisis situation conducted in 2005 by the National Commission on Energy Policy (NCEP) revealed that the SPR offers only very limited protection against a major supply disruption. Emergency reserves cannot sustain the US through a prolonged crisis, and it would be extremely difficult to reach political consensus on when it is appropriate to begin using them (Hormats, 2006: 6).

Experience has shown that to maintain energy security countries must abide by several principles. The first and most familiar is what Churchill urged more than 90 years ago: diversification of supply. He said (Yergin, 2006: 69): “Safety and certainty in oil lie in variety and variety alone”. Multiplying one’s supply sources reduces the impact of a disruption in supply from one source by providing alternatives, serving the interests of both consumers and producers, for whom stable markets are a prime concern. But diversification is not enough. The other principles are: resilience, a “security margin” in the energy supply system that provides a buffer against shocks and facilitates recovery after disruptions (spare production, strategic reserves, storage capacity); recognizing the reality of integration and the importance of information (Yergin, 2006: 76).

At its most basic level, energy security is the ability to meet immediate energy demand – that is, to produce adequate volumes of fuel and electricity at affordable prices and to move that energy to the countries that need it, when they need it, to keep their economies running and their people fed and their national borders defended (Roberts, 2005: 238).

On the other hand, the world will have to get used to living in what Mr West calls an “age of energy insecurity” (The Economist, 7.1.2006: 65). Until the world weans itself off of oil, there is no escaping the grim realism offered by James Schlesinger, former secretary of defence: “Instead of energy security, we shall have to acknowledge and to live with various degrees of insecurity” (The Economist, 7.1.2006: 65).

3. STRATEGY OF DIVERSIFICATION

3.1. STRATEGIES AND POLICIES OF THE US AND THE EU

3.1.1. US

In the US energy security is a fundamental component of national security. It is focused primarily on oil. NCEP (Grumet, 2006: 1) stated that "oil security is one of our nation's foremost economic, national security and energy challenges". This is understandable since the US is self-sufficient in virtually all energy resources except oil, of which they import 52 % of their net requirements, and natural gas, of which they import 15 % of their net requirements, primarily from Canada.

Current Bush administration sees diversification as a vital effort to multiply the number of petroleum suppliers and to prod all those producers into vastly increasing their output. It would both expand the net supply of global energy and diminish the impact of an interruption in any one of them. With this critical goal in mind, the National Energy Policy (NEP) calls on public servants from the president on down to do everything in their power to encourage production increases in areas outside the Gulf, especially Africa, Latin America, and the Former Soviet Union (FSU). "Diversity is important not only for energy security, but also for national security", Bush declared in May 2001 (Klare, 2005: 114). "Over-dependence on any one source of energy, especially a foreign source, leaves us vulnerable to price shocks, supply interruptions, and, in the worst case, blackmail" (Klare, 2005: 114).

The NCEP believes that there are three essential elements to enhanced oil security: increasing supply, reducing demand, and developing alternatives. The first of these imperatives can be seen as buying time to achieve the more fundamental benefits of a diversified portfolio of transportation fuels. The Commission's specific recommendations on the supply side include (Grumet, 2006: 5):

1. Expanding and diversifying conventional supplies of oil, both at home and abroad;
2. Expanding the global network of strategic petroleum reserves; and

3. Exploring technologies and processes that would allow for the use of unconventional oil resources in a manner that is compatible with climate change and other environmental concerns.

The basis of the Bush administration's energy policy – *the National Energy Policy* – focuses on research and development of energy-saving technology, conservation and increasing domestic and foreign supply of energy resources. The NEP praises improvements in exploration and production technology, as well as the trend toward opening new areas around the globe for exploration and development that have yielded significant dividends (National energy policy development group, 2001: 8-1):

- The US and world economies have diversified their sources of oil supplies, largely through increased production in the Western Hemisphere, the North Sea and Africa.
- The world's fuel mix is also more diverse, primarily because of greater reliance on natural gas and nuclear power.

A primary goal of the NEP is to add supply from diverse sources. This means domestic oil, gas and coal. It also means hydropower and nuclear power. And it means making greater use of non-hydro renewable sources now available (National energy policy development group, 2001: xiii).

In *Securing America's energy future,* the Committee on Government Reform recognizes a dramatically altered world energy supply and demand situation, as well as a fundamentally changed geopolitical environment. The Committee proposes that a clean energy revolution must come to fruition over the next several decades. It also stressed the mistake of de facto moratorium on the construction of new nuclear generating plants. The main findings of the Committee's report are (Committee on government reform, US House of representatives, 2006: 2-3):

- The US must promote production and conservation.
- To reduce US dependency on oil, effective demand-reduction policies must focus on transportation sector that consume more than two-thirds of oil. Corporate Average Fuel Economy (CAFE) standards must be strengthened.
- Alternative transportation fuels, renewable energy, and advanced technologies such as clean coal and next generation nuclear must be aggressively pursued.

- To enhance competitiveness and protect American jobs, natural gas must not be used for baseload electricity generation, nor for new generating capacity. Natural gas should be reserved for industries that use it as a feedstock or for primary energy – and cannot substitute for it by fuel-switching.
- Nuclear energy must become the primary generator of baseload electricity, thereby relieving the pressure on natural gas prices and dramatically improving atmospheric emissions.

In 2005, Congress passed the first comprehensive energy legislation in over a decade – *the Energy Policy Act of 2005* (EPACT05). This historic bill follows many of the principles outlined by President Bush to strengthen America's electrical infrastructure, reduce dependence on foreign sources of energy, increase conservation, and expand the use of clean renewable energy (National economic council, 2006: 14).

Since 2001, the Administration has spent nearly $10 billion to develop cleaner, cheaper, and more reliable alternative energy sources. As a result, America is on the verge of breakthroughs in advanced energy technologies that could transform the way of producing and using energy. To build on this progress, the President's *Advanced Energy Initiative* (AEI) provides for a 22 % increase in funding for clean-energy technology research at the Department of Energy in two vital areas (National economic council, 2006: 1):

1. Changing the way we fuel our vehicles. We can improve our energy security through greater use of technologies that reduce oil use by improving efficiency, expansion of alternative fuels from home-grown biomass, and development of fuel cells that use hydrogen from domestic feedstocks.
2. Changing the way we power our homes and businesses. We can address high costs of natural gas and electricity by generating more electricity from clean coal, advanced nuclear power, and renewable resources such as solar and wind.

Michael Klare, the author of Resource Wars, criticizes the NEP and its authors because the whole emphasis is on increasing supply: "NEP never envisions any reduction in our use of petroleum. Instead, it proposes steps that would increase consumption while making token effort to slow, but not halt, our dependence on foreign providers. In fact, the essence of the NEP is a commitment to the expansion of America's oil economy"

(Klare, 2005: 60). That could lead to increased American military involvement abroad to protect the oil infrastructure. He called this approach: *the strategy of maximum extraction*. It is aimed primarily at boosting the oil output of the major Gulf producers (Klare, 2005: 83). This is the goal to which the Bush administration's strategy of diversification is largely devoted. The NEP had called on federal officials to persuade oil-rich countries to ramp up their production and to clear the way for American private sector investment in new drilling projects (Klare, 2005: 118).

On the other side, even the authors of the NEP do not really believe in the promise of renewable and alternative energy and put their widespread use far to the future: "Renewable and alternative fuels offer hope for America's energy future. But they supply only a small fraction of present energy needs. The day they fulfil the bulk of our needs is still years away. Until that day comes, we must continue meeting the nation's energy requirements by the means available to us" (National energy policy development group, 2001: x).

The US's energy policy has been poorly managed for years and it has not been seen from the general perspective. The general debate was mainly about tax breaks for expanded production, access to public land and nuances in electricity regulation – difficult issues, but inadequate for the larger challenges the US faces. What is needed is purposeful, strategic energy policy, not a grab bag drawn from the interest-group wish list (Wirth et al, 2003: 133). The 1970s provided the last clear articulation of an attempted national energy strategy – and this was largely in response to global energy events. The 1970 Arab oil embargo prompted the development of the SPR, the adoption of CAFE standards and the formation of IEA. Domestic natural gas shortages and the prospect for declining oil supplies prompted President Carter's decision to lift oil price regulation and pursue energy sector transformation, ushering in a new era in US policy driven by the market (Verrastro, 2006). All US presidents since then have pledged to steer the nation toward greater energy security, but the problem has only grown worse. Imports have passed 50 % of total oil consumption and are projected to reach more than 60 % by 2010 (Wirth et al, 2003: 134). On the eve of September 11, 2001, the need to reduce radically the US reliance on oil was not clear to many and in any case the path of doing so seemed a long and difficult one. Today both assumptions are being undermined by the risks of the

terrorism, by oil prices, by increased awareness of the vulnerability of the oil infrastructure and by technological progress in fuel efficiency and alternative fuels (Woolsey, 2005: 1).

The US and the rest of the world have come to depend on much less stable suppliers than in the past. Many of these new suppliers are politically and economically unstable. This instability has complicated Washington's efforts to diversify its oil supplies beyond the problematic Middle East, focusing more on oil producers in Latin America, West Africa, and the FSU – a strategy the US developed after the 1973 Arab oil embargo (Billig, 2004: 3). Since the end of the Cold War, securing access to vital materials has again assumed a central position in American security planning. Evidence of this revival of interest in resources was especially plentiful during the global shortage of petroleum and natural gas. President Bill Clinton flew to Africa in August 2000 with the hope of obtaining additional oil from Nigeria and prodded Caspian states to accelerate the construction of new pipelines to Europe and the Mediterranean (Klare, 2001: 51).

The top six sources of US's oil imports, Canada, Mexico, Saudi Arabia, Venezuela, Nigeria and Iraq account for 65.1 % of all foreign crude oil reaching US and 38.9 % of total domestic consumption. Of these, four, Saudi Arabia, Venezuela, Nigeria and Iraq provide 38.2 % of oil imports and 22.6 % of total consumption. For a variety of reasons, none of the four can be considered a reliable source of supply (Copulos, 2006: 2):

- Venezuela's president Hugo Chavez is a vocal opponent of the US who has threatened to cut off oil shipments to the US.
- Nigeria's production has been repeatedly disrupted by civil unrest, and some 18 414 tonnes of oil per day are lost to theft.
- A terrorist attack on the massive Saudi oil processing facility at Abqaiq was barely thwarted in February 2006. In the summer of 2002, Saudi Interior Ministry forces blocked an al-Qaeda plot to attack and cripple the loading dock at Ras Tanura which handles 10 % of the world's oil supplies.
- Attacks on oil facilities in Iraq are a frequent occurrence.

The structural shifts in global energy markets are also working against American interests. Leverett (2006: 1-2) explains two important trends:

1. The first is the tightening of margins between global demand for crude oil and installed upstream productive capacity.
2. The second important structural shift is the progressive concentration of the world's oil reserves under the control of national governments and national oil companies, especially in the Middle East and the FSU.

There are many examples of how resource nationalism can challenge a wide range of American interests. These include (Leverett, 2006: 2):

- Russia's application of energy "levers" to re-establish its hegemonic position in the post-Soviet space and bolster its strategic position vis-à-vis Europe and East Asia;
- Venezuela's exploitation of its dominant position as a Western hemisphere energy producer and exporter to weaken America's standing in parts of Latin America; and
- Saudi Arabia using its unique status as the "swing producer" for the global oil market to cultivate a deepening strategic relationship with China as a "hedge" against precipitous deterioration in the Kingdom's traditional strategic partnership with the US.

As a result, Klare (2005: 115) does not believe in the promise of diversification. He referred to the major and most suitable oil producing countries (listed in the NEP) as *the Alternative Eight*: Mexico, Venezuela, Colombia, Russia, Azerbaijan, Kazakhstan, Nigeria and Angola. Several factors will keep these countries from achieving or sustaining much higher production and export capacities: rising domestic consumption, significant oil-field depletion, and an uninviting investment climate. Additionally, all these alternative producers face a high risk of supply disruptions and shutdowns as a result of political discord and conflict (Klare, 2005: 66).

3.1.1.1. TOO MUCH NATURAL GAS, TOO LITTLE NUCLEAR ENERGY

Despite the closure of several less efficient plants during the 1990s, the 103 US nuclear energy plants currently operating produce more electricity today than at any time in their history. There are a number of reasons why the expansion of nuclear energy

halted in the 1980s. Regulatory changes implemented after the Three Mile Island incident in 1979 lengthened the licensing period to an average of fourteen years, resulting in large cost overruns. Increased public concern about the safety of nuclear energy after the accident often resulted in active opposition to proposed plants. As a result, the last completed nuclear energy plant in the US was ordered in 1973 (National energy policy development group, 2001: 5-15). In "Saving America's energy future" the Committee on Government Reform called for increasing nuclear electricity production. This increase would free-up natural gas supplies for critical uses in manufacturing processes, reduce electricity costs to the consumer and pave the way for drastically reduced petroleum dependency should next generation nuclear technology be used to produce hydrogen in sufficient quantities to power a critical mass of emission-free automobiles (Committee on government reform, US House of Representatives 2006: 25). On August 8, 2005, President Bush signed into law the EPACT05, which calls for novel incentives for private institutions to build and operate nuclear facilities.

Despite these new incentives, and notwithstanding the President's Nuclear Power 2010 initiative, the US is no closer to energy security because the scope of energy policy has been too narrow. Assuming the 6 GW (gigawatt) increase contemplated by EPACT05 is realized, by 2019 nuclear power's share of electricity generation would actually shrink to only three-quarters that of today – down to 15 %. For nuclear power to maintain its 20 % share of the nation's electricity generation, 41 new 1 GW plants would be needed by 2025 (Committee on government reform, US House of Representatives, 2006: 26). The electricity outlook is heavily influenced by the 1992 Energy Policy Act (EPACT92), which has had far reaching consequences. It opened access for interstate wholesale bulk power transactions. New generation companies not subject to price generation were created and separated from ownership of the grid. An important consequence of EPACT92 is the boom in electricity produced by natural gas-fired units. Since the 1990s, almost all new plants are powered by natural gas. From 1996 to 2000, the use of natural gas for electricity grew 11 % per year. According to EIA, of the 94 GW of planned additions in electricity generating capacity through 2009, 80 % will be fuelled primarily by natural gas, 14 % by coal, and no new additions will be nuclear (Committee on government reform, US House of Representatives 2006: 26-27). However, the effects of

high natural gas prices are already being seen in today's marketplace. The percentage of new power plants fuelled by natural gas has declined from more than 90 % when President Bush took office to 64 % today. Thanks in part to Administration policies, only 31 % of new power plants projected to be built by 2025 will use natural gas (National economic council, 2006: 10).

3.1.2. EU

In 2003, the EU imported 51 % of its total energy requirements. Forecasts indicate that the EU's energy imports will represent 70 % of its total energy requirements by 2030. This reality called for a comprehensive energy supply security strategy, whose guidelines, as well as a set of issues that were opened for debate, were summarised in *the Green Paper – Towards a European strategy for the security of energy supply* adopted in 2000. The debate confirmed the European Commission's (EC) view that supply security is not a question of seeking to maximise energy self-sufficiency or to minimise dependence, but rather to produce policies aimed at reducing the risks linked to such dependence by balancing between, and diversifying across, the various sources of supply by energy source and by geographical region (COM, 2006b: 27).

The need for a coherent external energy policy has been recently highlighted in *the Green Paper – A European strategy for sustainable, competitive and secure energy* and confirmed in the Presidency conclusions of the European Council of 23-24 March 2006. The European Council called for an Energy policy for Europe (EPE), which should be developed with adequate knowledge and understanding of Member States' energy needs and policies. Three main objectives of the EPE are security of supply, competitiveness and environmental sustainability. Security of supply could be achieved through (CONCL, 2006: 14):

- Development of a common external policy approach in support of energy policy objectives, and the furthering of energy dialogues between the EU and its Member States on the one hand, and their main partners, be they producer, transit or consumer countries on the other hand, in the synergy with relevant international organisations.

- Intensified diversification with respect to external as well as indigenous sources, suppliers and transport routes supported by investments in the necessary infrastructure, including liquefied natural gas (LNG) facilities.

The EC and The High Representative for the common foreign and security policy prepared a common paper *An external policy to serve Europe's energy interests*, where they stated that: "External energy relations cannot be separated artificially from the wider question of what sort of energy policy the EU and its Member States want". They then explained two building blocks of energy security: functioning markets and diversification. Regarding diversification they said: "The EU's energy security can be enhanced by diversifying energy sources and geographical origin as well as transit routes. The EU should facilitate the maintenance and upgrade of existing energy infrastructure in neighbouring countries of key importance to the EU as well as the development of new infrastructure" (Paper from Commission/SG/HR for the European Council, 2006: 2-3).

In order to enhance the external security of energy supplies of the EU, it is important that a coherent approach be adopted that pursues the following objectives (Paper from Commission/SG/HR for the European Council, 2006: 2):

1. Promoting transparency and improved governance in the energy sector through energy partnerships with third countries, the objective being to create mutually beneficial, open, transparent, non-discriminatory and stable legal conditions for energy investment and trade.
2. Improving production and production and export capacities in producer countries and developing and upgrading energy transportation infrastructure in producer and transit countries.
3. Improving the climate for European companies' investments in third countries and opening up the production and export of energy resources to EU industry.
4. Improving conditions for trade in energy through non-discriminatory transit and third party access to export pipeline infrastructure.
5. Enhancing physical and environmental security as well as the energy infrastructure safety.
6. Encouraging energy efficiency, use of renewable energies including biofuels, low emission technology and rational use of energy worldwide.

7. Implementing the relevant Kyoto Protocol mechanisms.
8. Diversifying energy imports by product and country.
9. Creating an international regime for the supply of enriched uranium to countries that have chosen the nuclear option, in line with non-proliferation commitments and taking into account the EURATOM (European Atomic Energy Community) Treaty provisions.
10. Promoting strategic reserve stocks and encouraging joint stock holding with partner countries.

The EU is especially concerned about the rising global demand for energy and rising emissions of greenhouse gases: "Against this backdrop, it is clear that the EU and the rest of the world have not reacted quickly enough to increase the use of low-carbon energy technologies or to improve energy efficiency. As a consequence, climate change has become a real threat and security of energy supply is worsening" (COM, 2006d, yyy final: 3). Europe's[1] energy system must rapidly progress on four main fronts according to the proposed *European Strategic Energy Technology Plan* (COM, 2006d, yyy final: 3-4):

- The efficient conversion and use of energy in all sectors of the economy, coupled with decreasing energy intensity.
- The diversification of the energy mix in favour of renewables and low-carbon conversion technologies for electricity, heating and cooling.
- The decarbonisation of the transport system through switching to alternative fuels.
- Full liberalisation and interconnection of energy systems, incorporating "smart" information and communication technologies to provide a resilient and interactive (customers/operators) service network.

The Plan includes the vision of a European Union with a thriving and sustainable economy, with world leadership in a diverse portfolio of clean, efficient and low-carbon energy technologies as a motor for prosperity and a key contributor to growth and jobs. For 2050 and beyond, the switch to low carbon in the European energy system should be completed, with an overall European energy mix that could include large shares for renewables, sustainable coal and gas, sustainable hydrogen, and, for those member states

[1] The text has EEA (European Economic Area) relevance; it includes some non-EU Member States: Norway, Switzerland, Iceland and Liechtenstein.

that want, Generation IV fission power and fusion energy (COM, 2007, 1 final: 16; COM, 2006d, yyy final: 4).

Each Member State and energy company chooses its own energy mix. However, choices made by one Member State inevitably have an impact on the energy security of its neighbours and of the Community as a whole, as well as on competitiveness and the environment. For example (COM, 2006, 105 final: 9):

- Decisions to rely largely or wholly on natural gas for power generation in any given Member State have significant effects on the security of supply of its neighbours in the event of a gas shortage.
- Decisions by Member States relating to nuclear energy can also have very significant consequences on other Member States in terms of the EU's dependence on imported fossil fuels and CO_2 emissions.[2]

The legitimate right of individual Member States is to pursue their own external relations for ensuring security of energy supplies and to choose their internal energy mix. That is why the EU still does not have a common energy policy. In the Treaty establishing the European Economic Community, the Member States chose not to lay foundations of a common energy policy. Subsequent attempts to include a chapter on energy, during the negotiations on the Maastricht and Amsterdam Treaties, ended in failure. Energy receives no more than a mention in the preamble to the Amsterdam Treaty (COM, 2000, 0769 final: 6). As a result, over the last 40 years, the EU has failed to develop a consistent common energy policy. For years, the "Community approach" was quite simply ignored. For a long time, the Member States maintained their control over the development of energy sector, with an approach to their management based on intergovernmental cooperation. As a result, on the symbolic date of 31 December 1992, by which the "Single Market" was to be achieved, the energy sector was still largely unaffected by the movement to integrate national markets. As its previous efforts had not proved very fruitful, the EC decided in 1999 to give a new impetus to these two policies.

[2] For example, the Swedish Government's decision to shut down the nuclear facility in Barsebäck on 30.11.1999, after 23 years, creates a production shortfall of 4 billion KWh per year, which has to be made up by electricity imports from coal-fired Danish and German power stations. This leads to an indirect increase in Sweden's CO_2 emissions of around 4 million tones per year, i.e. about 8 % of total emissions in Sweden (COM, 2000, 0769 final: 21).

To demonstrate its determination, responsibility for energy and transport policy was given to a single Commissioner and the management of these two policies was entrusted to a single Commission Directorate-General (COM, 2004: 1).

At the Conference entitled "Towards an EU external energy policy to ensure a high level of supply security" that took place in Brussels in November 2006, Javier Solana – the High Representative for the common foreign and security policy – said: "Let us be clear: we do not yet have an external energy policy for Europe. And we are not fully implementing our internal energy policy". He then warned: "Our energy needs may well limit our ability to push wider foreign policy objectives, not least in the area of conflict resolution, human rights and good governance". He then agrees that securing future energy resources depends mainly on diversification: "That means accepting that we will continue to depend heavily on oil and gas. But it also means spreading our sources of supply and the routes to get this supply delivered to the EU" (S324/06: 2).

The most acute case of Community dependence is oil, where 76 % of demand is met from external sources. In the long term, geographical diversification will not be as easily achieved as for natural gas, since the world's remaining oil reserves will increasingly be concentrated in the Middle East (COM, 2000, 0769 final: 14). Regarding natural gas, the Green Paper is aware of a rising dependence on Russian and Algerian supplies. It therefore concluded that geographical diversification would appear desirable, particularly in form of LNG (COM, 2000, 0769 final: 28). The attacks of September 11, 2001, the context of uncertainty and economic slowdown created by the military intervention in Iraq reopened debate on the security of hydrocarbon supplies (COM, 2004: 10).

3.1.2.1. THE BEGINNING – COAL AND NUCLEAR ENERGY

Two of the treaties establishing the European Communities are about energy: the European Coal and Steel Community (ECSC) Treaty and the EURATOM Treaty. These two treaties were adopted primarily to ensure regular and equitable supplies of coal and nuclear energy in the Community.

Following the first oil crisis, the Member States and the EU sought to minimise their quantitative reliance on external energy sources (COM, 2000, 0769 final: 17). The issue of security of energy supply was back on the agenda. The aim of EURATOM Treaty was to provide the European Community with an alternative source of indigenous energy supply in order to bring a halt to the growing dependence on oil from the Middle East. The Treaty was meant to enable Europe to develop its know-how and obtain the means of exploiting nuclear energy for civilian purposes (COM, 2000, 0769 final: 20). The use of coal was one of the policies that helped to counter the oil shocks. Ambitious programmes were set up at Community level, and national strategies to counter oil dependence focused, among other things (like stockpiling and promotion of energy efficiency), on encouraging coal production in the Community and coal imports from third countries (COM, 2000, 0769 final: 68).

While security of supply was the watchword of the 1970s, the 1990s saw the emergence of environmental concerns. It was becoming increasingly obvious that coal could only play a part in energy supply if it managed to control its impact on the environment (COM, 2000, 0769 final: 68). The ECSC Treaty, which was the basis of European coal policy, expired in July 2003. On that occasion a new system of aid was introduced, intended to encourage Member States to restructure the sector, while taking into account, on the one hand, the social and regional repercussions of reducing activity and, on the other, the need to maintain indigenous sources of energy to ensure the security of the Union's supplies (COM, 2004: 20).

The arrival of pressure groups and ecological parties onto the political stage of the Member States and the Chernobyl accident (April 26, 1986) marked a turning point in the development of Europe's nuclear policy. Five out of eight Member States with nuclear power have adopted or announced a moratorium (COM, 2000, 0769 final: 21).[3] Three countries have policies in place to phase out nuclear power. The German government and the country's electricity industry agreed in June 2000 to a phase-out of existing nuclear stations after about 32 years of operation. Belgium plans to shut down its nuclear stations

[3] Sweden (1980), Spain (1984), Netherlands (1994), Germany (1998), Belgium (1999), while France, the United Kingdom (UK) and Finland have not taken a decision to stop nuclear energy, but except Finland, there are no new reactors likely to be built soon. Italy renounced nuclear energy following a referendum in 1987, Germany has announced its decision to shut down its last reactors in 2021 and Belgium will do the same in 2025 (COM, 2000, 0769 final: 21).

after 40 years of operation. Sweden's parliament has voted to phase out nuclear power, but the timing is not yet clear. In Spain, the new government has talked about phasing out nuclear power but there is no firm decision yet. France and Finland plan to increase their use of nuclear power. In France the National Assembly has endorsed nuclear power as a priority and France plans to put a demonstration European Pressurized Reactor in place in about a decade to replace existing reactors, which are to be shut down after 40 years of operation (IEA, 2004a: 210). Following the accession agreement with the EU some nuclear power plants[4] will have to be closed for security reasons. For all these plants, an agreement was reached about the dates for definitive closure of the reactors (COM, 2004: 59).

3.2. GEOGRAPHICAL DIVERSIFICATION (CRUDE OIL AND NATURAL GAS)

3.2.1. OVERVIEW OF WORLD RESERVES AND PRODUCTION

3.2.1.1. CRUDE OIL AND NATURAL GAS RESERVES

World proven crude oil reserves equal 174.21 billion tonnes (Table 4). The total amount of oil that would ever be produced (called the ultimate recoverable reserves) is much greater. US Geological Survey puts the remaining ultimately recoverable reserves at 358.5 billion tonnes (IEA, 2004a: 94). The number is important in the peak-oil debate (see section 3.2.1.4.). Proven reserves mean hydrocarbons that have been discovered and for which there is a reasonable certainty that they can be extracted profitably (on the basis of assumptions about cost, geology, technology, marketability and future price). The source of data – the Oil and Gas Journal – is one of the most widely quoted primary source of global reserves data. It includes all proven (Canadian) sands reserves, which they estimate at 23.73 billion tonnes (IEA, 2004a: 87, 90). R/P ratio – reserves to production ratio shows how long – under current production – the reserves will hold.

[4] The power station in Ignalina in Lithuania; two reactors at the Bohunica plant in Slovakia and four reactors at the Kodloduy plant in Bulgaria (COM, 2004: 59).

Table 4: World crude oil (billion tonnes) and natural gas (trillion cubic metres) reserves (2005). Countries with more than 0.1 billion tonnes of crude oil or more than 0.1 trillion cubic metres of natural gas reserves are included.

		Crude oil	**%**	**R/P ratio (years)**			**Natural gas**	**%**	**R/P ratio (years)**
1	Saudi Arabia	35.72	20.5	65.6	1	Russia	47.54	27.8	80
2	Canada*	(0.64) 24.39	14.0	(14.8) +100	2	Iran	26.60	15.6	+100
3	Iran	17.16	9.9	93	3	Qatar	25.75	15.1	+100
4	Iraq	15.69	9.0	+100	4	Saudi Arabia	6.65	3.9	99.3
5	Kuwait	13.84	7.9	+100	5	UAE	6.00	3.5	+100
6	UAE●	13.34	7.7	97.4	6	USA	5.45	3.2	10.4
7	Venezuela	10.53	6.0	72.6	7	Nigeria	4.98	2.9	+100
8	Russia	8.18	4.7	21.4	8	Algeria	4.54	2.7	52.2
9	Libya	5.32	3.1	63	9	Venezuela	4.27	2.5	+100
10	Nigeria	4.80	2.7	38.1	10	EU**	3.22	1.9	21
11	USA	2.91	1.7	11.8	11	Iraq	3.11	1.8	+100
12	China	2.49	1.4	12.1	12	Indonesia	2.56	1.5	36.3
13	Qatar	2.07	1.2	38	13	Malaysia	2.12	1.2	41.4
14	Mexico	1.99	1.1	10	14	Norway	2.08	1.2	28.3
15	Algeria	1.61	0.9	16.6	15	Turkmenistan	2.01	1.2	49.3
16	Brazil	1.45	0.8	18.8	16	Uzbekistan	1.87	1.1	33.2
17	Kazakhstan	1.23	0.7	79.6	17	Kazakhstan	1.84	1.1	+100
18	Norway	1.16	0.7	8.9	18	Egypt	1.66	1.0	54.4
19	EU***	1.03	0.6	6	19	Canada	1.60	0.9	8.6
20	Azerbaijan	0.95	0.5	42.4	20	Kuwait	1.57	0.9	+100
21	Sudan	0.87	0.5	46.3	21	China	1.51	0.9	47
22	Oman	0.75	0.4	19.6	22	Libya	1.47	0.9	+100
23	Angola	0.74	0.4	19.9	23	Ukraine	1.12	0.7	58.7
24	India	0.73	0.4	20.7	24	India	0.85	0.5	36.2
25	Indonesia	0.64	0.4	10.4	25	Azerbaijan	0.85	0.5	+100
26	Ecuador	0.63	0.4	25.6	26	Oman	0.83	0.5	56.9
27	Yemen	0.55	0.3	18.3	27	Australia	0.82	0.5	67.9
28	Egypt	0.50	0.3	14.6	28	Pakistan	0.76	0.4	32.2
29	Malaysia	0.41	0.2	13.9	29	Trinidad	0.73	0.4	18.8
30	Argentina	0.36	0.2	8.7	30	Bolivia	0.68	0.4	71.1
31	Syria	0.34	0.2	17.5	31	Argentina	0.61	0.4	11.1
32	Gabon	0.34	0.2	25.8	32	Yemen	0.48	0.3	+100
33	Equat. Guinea	0.24	0.1	13.6	33	Mexico	0.42	0.2	10.4
34	Colombia	0.21	0.1	7.3	34	Brunei	0.39	0.2	28.3
35	Congo	0.21	0.1	19.3	35	Thailand	0.38	0.2	16.5
36	Australia	0.20	0.1	20.0	36	Papua NG	0.35	0.2	+100
37	Vietnam	0.18	0.1	21.8	37	Bangladesh	0.30	0.2	30.7
38	Brunei	0.18	0.1	14.9	38	Burma	0.28	0.2	38.5
39	Trinidad ●●	0.14	0.1	13.0	39	Brazil	0.25	0.1	27.3
40	Romania	0.13	0.1	11.3	40	Peru	0.25	0.1	+100
41	Peru	0.13	0.1	27.1	41	Syria	0.24	0.1	57.3
42	Cuba	0.10	0.1	30.9	42	Vietnam	0.19	0.1	45.6
					43	Mozambique	0.13	0.1	+100
					44	Colombia	0.11	0.1	18.5

					45	Cameroon	0.11	0.1	+100
					46	Philippines	0.11	0.1	37.0
					47	Rumania	0.10	0.1	48.6
	World total	**174.21**	**100.0**	**40.6**		**World total**	**171.04**	**100.0**	**65.1**

Source: DOE/EIA (2006e), according to Oil & Gas Journal; R/P ratio: BP (2006: 6, 22); other R/P ratios counted from: DOE/EIA (2006d) and DOE/EIA (2006f).

* Numbers in brackets mean conventional oil reserves only (DOE/EIA, 2006e: according to World Oil). R/P ratio for Canadian conventional oil reserves is 14.8 years.

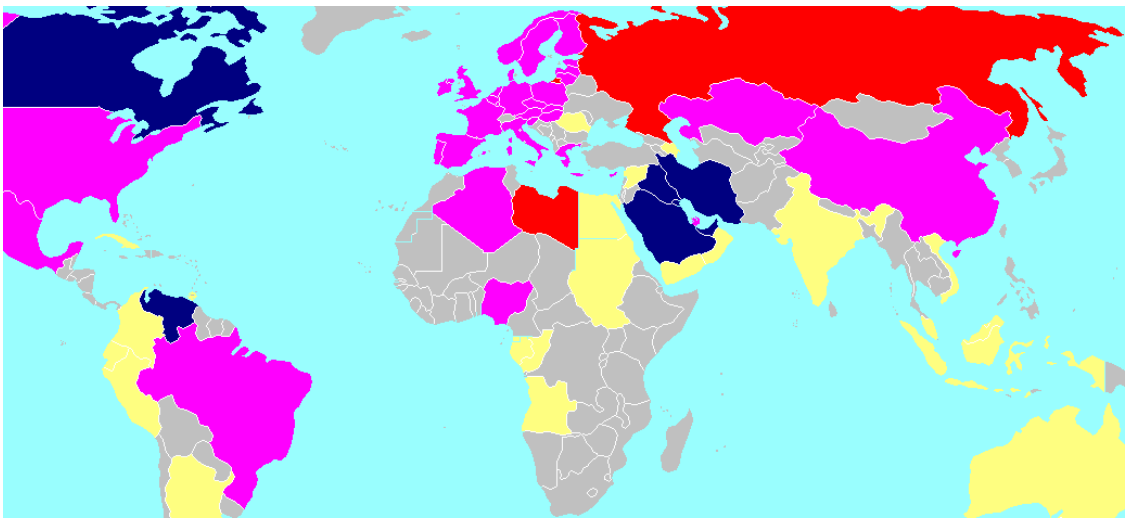
** The biggest contributors: Netherlands (1.75), UK (0.59), Germany (0.28), Italy (0.23); R/P ratio (UK): 6; R/P ratio for the EU based on data from Table 26.

*** The biggest contributors: UK (0.61), Denmark (0.18); R/P ratio (UK): 6.1; R/P ratio for the EU based on data from Table 26.

● United Arab Emirates

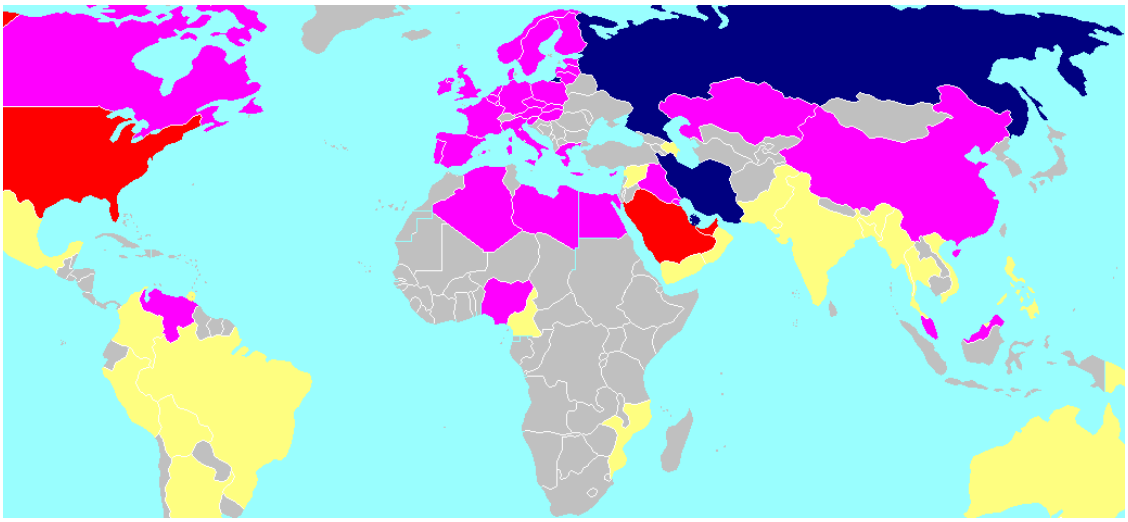
●● Full name is Trinidad and Tobago, hereinafter referred to as Trinidad.

Map 1: World crude oil reserves by country



Source: map based on Wikipedia (2006); data based on Table 4.

Map 2: World natural gas reserves by country



Source: map based on Wikipedia (2006); data based on Table 4.

Legend (Map 1 and 2):

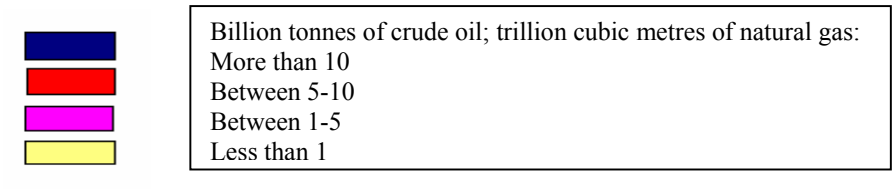


Table 5: Crude oil (billion tonnes) and natural gas (trillion cubic metres) reserves by region (2005)

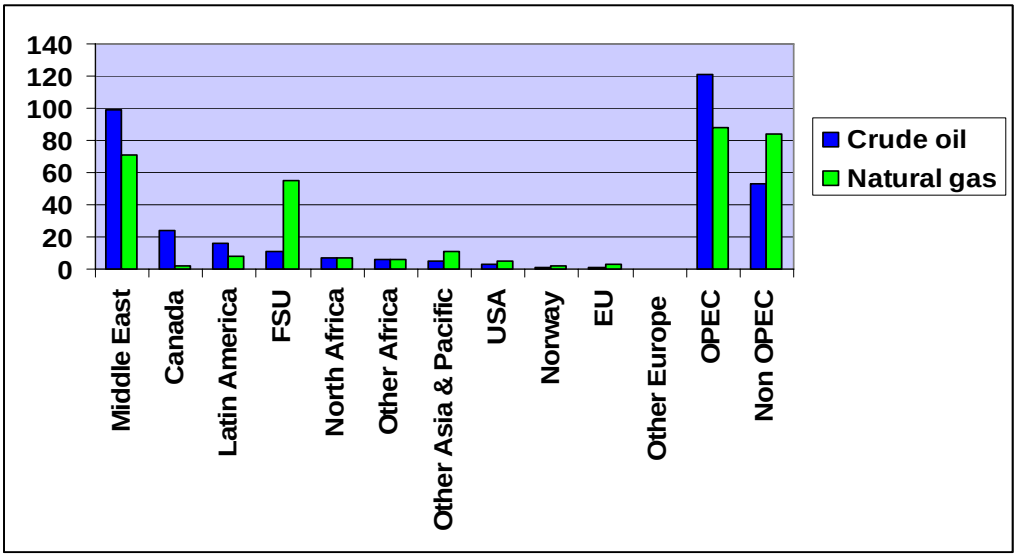
	Crude oil	**%**		**Natural gas**	**%**
Middle East*	99.48	57.1	Middle East	71.37	41.7
Canada	24.39	14.0	FSU	55.26	32.3
Latin America	15.71	9.0	Other Asia & Pacific	10.86	6.3
FSU	10.61	6.1	Latin America	7.51	4.4
North Africa	7.48	4.3	North Africa	7.38	4.3
Other Africa	6.26	3.6	Other Africa	6.02	3.5
Other Asia & Pacific	4.93	2.8	USA	5.45	3.2
USA	2.91	1.7	EU	3.22	1.9
Norway	1.16	0.7	Norway	2.08	1.2
EU	1.03	0.6	Canada	1.60	0.09
Other Europe	0.18	0.01	Other Europe	0.10	0.006
World total	**174.21**	**100.0**	**World total**	**171.04**	**100.0**
Gulf	97.84	56.2	Gulf	69.78	40.8
Africa	13.74	7.9	Africa	13.40	7.8
OPEC**	120.74	69,3	OPEC	87.51	51.2
Non OPEC	53.47	30.7	Non OPEC	83.53	48.8

Source: DOE/EIA (2006e). For the definition of regions see Appendix 1.

* The most widely cited data is that the Gulf (and the Middle East, since the difference in reserves is small) contains 65 % of the world's crude oil reserves, which is true if we do not consider Canadian unconventional oil.

** Organization of the Petroleum Exporting Countries; OPEC data regarding natural gas reserves are added for comparative purposes only.

Figure 1: Regions – crude oil (billion tonnes) and natural gas (trillion cubic metres) reserves



Source: Data based on Table 5.

Of the world's total proven crude oil reserves, 57.1 % are located in the Middle East (Table 5, Figure 1). Among the top 20 oil reserve holders, 10 are OPEC member countries that together account for 69.3 % of the world's total reserves.

Almost three quarters of the world's natural gas reserves are located in the Middle East and the FSU. Russia, Iran and Qatar combined account for about 58 % of the world's natural gas reserves. LNG is expected to become an increasingly important source of supply to meet the world's demand for natural gas. Although there were only 12 LNG-exporting countries in 2004, the number is increasing (DOE/EIA, 2006a: 40). Natural gas is widely named as a "bridge fuel" – the one existing fuel that can

simultaneously power much of our current energy economy and drive the transition to a more ideal system in the future. It can be used in everything from power plants to gas-powered buses and taxis. It can be converted to liquefied fuels and compete directly with oil. Natural gas also contains less carbon and more hydrogen than either oil or coal does, so not only does it emit less pollution and climate-altering CO_2, but it is also easily refined into pure hydrogen to power fuel cells and other energy technologies of the future (Roberts, 2005: 167).

Just thirty years ago, oil dominated the energy economy utterly, accounting for nearly 50 % of global demand, and leaving just 31 % to coal and barely 20 % to natural gas. Since then, natural gas has emerged as the fuel of choice for everything from power generation and industrial heating to home furnaces and cooking. Gas's share of the world energy mix now matches that of coal, and by as early as 2025, gas not oil, could be the world's dominant energy source (Roberts, 2005: 166-67).

3.2.1.2. OPEC CRUDE OIL PRODUCTION

Within OPEC, Middle Eastern countries will account for most of the production increase. This region holds about 65 % of the world's proven oil reserves. Production costs there are among the lowest anywhere in the world, averaging less than $2 per barrel in the Persian Gulf countries. Investment costs are also very low. Saudi Arabia, Iraq and Iran are likely to contribute most of the increase in Middle East production.

Saudi Arabia plays a central role in OPEC and in balancing the world market, not only because of the size of its production but because of its spare capacity. The country's official policy is to maintain from 75 to 100 million tonnes per year (mt/y) of the spare capacity for the foreseeable future (IEA, 2004a: 110-111). The near term prospects for oil production in Iraq remain very uncertain, although it has the potential to increase its production capacity to 250-300 mt/y. Crude oil production potential in Iran is also very large. Currently its output remains far from its historical peak of 300 mt/y in 1974. Ambitious plans to increase production to 400 mt/y in 2020 are made. US's companies are not allowed to invest in Iran under sanctions imposed by the US Congress in 1995. Several projects are under way in the UAE to increase production capacity. Outside the

Middle East, Venezuela is the OPEC country with the largest reserves and the greatest potential for expanding production. Libya is considered a highly attractive oil province because production costs are low, it is close to Europe and has well developed infrastructure. In September 2003, the United Nations lifted economic sanctions against Libya (IEA, 2004a: 112-113).

3.2.1.3. NON-OPEC CRUDE OIL PRODUCTION

The expectation in the late 1980s and early 1990s was that non-OPEC production in the longer term would stagnate or decline gradually in response to resource constraints. However, despite several periods of relatively low prices, non-OPEC production has risen every year since 1993, adding almost 400 mt/y from 1990 to 2004 (Table 6). Non-OPEC supply has become increasingly diverse over the past three decades and growth in non-OPEC oil production has played a significant role in the erosion of OPEC's market share, which has fallen from 52 % in 1973 to 39 % in 2003. North America dominated non-OPEC supply in the early 1970s, the North Sea and Mexico evolved as major producers in the 1980s and much of the new production in the 1990s came from the economies of South America, West Africa, the non-OPEC Middle East and China (DOE/EIA, 2006a: 31).

Oil producers in South America have significant potential for increasing output over the next decade. Brazil became a million barrel per day (50 mt/y) producer of crude oil in 1999, with considerable production potential waiting to be tapped. Colombia's current economic downturn and civil unrests have delayed development of its oil production infrastructure. In both Brazil and Colombia, the oil sector would benefit from the creation of favourable climates for foreign investment (DOE/EIA, 2006a: 32).

North African producers Egypt and Tunisia produce mainly from mature fields and their output will decline gradually. Sudan is expected to produce significant volumes by the end of the decade and could exceed 25 mt/y in 2030 (DOE/EIA, 2006a: 32).

West African producers – Angola, Cameroon, Chad, DR Congo[5], Equatorial Guinea, Gabon, Mauritania, Niger, Sao Tome and Principe and Ivory Coast – are

[5] Full name is Democratic Republic of the Congo, hereinafter referred to as DR Congo.

expected to reap the benefits of substantial exploration activity, especially if current high oil prices persist. Angola became a million barrel per day (50 mt/y) producer in 2004, and given the excellent deepwater exploration results, it could produce up to 170 mt/y (DOE/EIA, 2006a: 31).

Over the past five years, Russia's oil fields have been central to the growth of worldwide supply, providing almost 40 % of the world's total production increase since 2000 (Yergin, 2006: 74). The Russian increases have come as a surprise, especially for OPEC. As recently as 1996, oil output from the FSU amounted to barely 350 mt/y. Many people forgot that Moscow's state owned enterprises once produced more than 620 mt/y before the Soviet collapse – the largest amount of oil ever produced by a single country, representing one fifth of global production (Morse et al, 2002: 17). Nevertheless, Russia cannot be compared to Saudi Arabia, because it lacks spare production capacity and on the other hand it has only 5 % of the world's proven oil reserves. Caspian region output is projected to increase steadily, although there is still uncertainty about export routes from the region. Caspian countries will experience the fastest growth (220.3 %), their exports are projected to rise from 115.5 mt/y in 2004 to 369.9 mt/y in 2030 (Table 4).

In 1998, Russian government agreed in principle to cooperate with OPEC on production and export policies aimed at stabilizing world market prices at that time. In practice, this involved imposing some volume restrictions on oil exports by pipeline, but those limits were largely circumvented by oil shipments by truck and rail. They were quickly lifted once prices rebounded. The government has not officially indicated whether it would limit output again in the future, though President Vladimir Putin declared in September 2003 that Russia would cooperate with OPEC in the event of a severe weakening of prices (IEA, 2004a: 294). Of course, prices have actually risen sharply since then causing Russian producers to maximise their output in order to increase profits. That has cooled relations with OPEC because Russia is decreasing their market share. On the other hand, OPEC members do not want to increase their output in order to maintain high oil prices.

According to some, the Arctic will become the next great prize in oil. The US Geological Survey declared that a quarter of the world's undiscovered reserves lay under

the Arctic Ocean. As the ice retreats, oil companies are scrambling to open a new frontier (Adam, 2006: 11).

3.2.1.4. MAXIMIZING PRODUCTION

Under the strategy of maximum extraction, the US government is aimed primarily at boosting the oil output of the major oil producers. This is the goal to which the Bush administration's strategy of diversification is largely devoted. The NEP had called on federal officials to persuade oil-rich countries to ramp up their production and to clear the way for American private sector investment in new drilling projects (Klare, 2005: 118). The EU is currently working on how to increase pipeline connections capabilities between the Member States and the oil and gas rich neighbouring counties, notably Algeria, Libya and Russia. So, the EU too is devoted to a kind of a strategy of maximum extraction.

World oil production is projected to grow from 4100 mt in 2004 to 5865 mt in 2030. To meet the projected increase, total petroleum supply in 2030 will need to increase by 1760 mt. OPEC producers are expected to provide 620 mt of the increase. Higher oil prices cause a substantial increase in non-OPEC oil production – 665 mt (Table 4).

Table 6: Evolution of world crude oil (mt/y) production

	1990	**2004**	**2030**	**90-04**	**04-30**	**%** (90-04)	**%** (04-30)
Canada****	99.57	119.49	71.19	+19.92	-48.30	+20.0	-40.4
Mexico	149.36	204.12	249.43	+54.76	+45.31	+36.7	+22.2
Russia	562.58	462.51	560.59	-100.07	+98.08	-17.8	+21.2
Indonesia	74.68	69.20	54.27	-5.48	-14.93	-7.3	-21.6
Nigeria	89.61	97.58	151.85	+7.97	+54.27	+8.9	+55.6
Algeria, Libya	134.42	148.36	174.25	+13.94	+25.89	+10.4	+17.5
Venezuela	114.51	140.40	206.11	+25.89	+65.71	+22.6	+46.8
EU	120.40	134.11	43.45	+13.71	-90.66	+11.4	-67.6
USA	447.20	351.04	308.70	-96.16	-42.34	-21.5	-12.1
Brazil	39.83	84.64	159.32	+44.81	+74.68	+112.5	+88.2
Iran	159.32	209.10	214.08	+49.78	+4.98	+31.2	+2.4
Iraq	109.53	114.51	273.82	+4.98	+159.31	+4.6	+139.1
Kuwait	84.64	119.49	224.04	+34.85	+104.55	+41.2	+87.5
Qatar	24.89	44.81	39.83	+19.92	-4.98	+80.0	-11.1
Saudi Arabia	428.16	527.73	851.34	+99.57	+323.61	+23.3	+61.3

UAE	124.47	164.29	229.02	+39.82	+64.73	+32.0	+39.4
Middle East	866.28	1145.58	1691.73	+279.30	+546.15	+32.2	+47.7
Gulf	801.55	1057.95	1546.85	+256.40	+488.90	+32.0	+46.2
Latin America	268.84	554.62	804.04	+185.78	+249.42	+106.3	+45.0
Africa	333.57	422.19	725.88	+88.62	+303.69	+26.6	+71.9
Other Asia & Pac.	333.56	414.72	383.35	+81.16	-31.37	+24.3	-7.6
FSU***	562.58	578.02	930.50	+15.44	+352.48	+2.7	+61.0
Caspian Area**	39.68	115.50	369.91	+75.82	+254.41	+191.1	+220.3
OPEC	1214.78	1513.49	2133.33	+298.71	+619.84	+24.6	+41.0
Non-OPEC	2095.99	2494.28	3158.42	+398.29	+664.14	+19.0	+26.6
Total	**3310.77**	**4007.77**	**5291.75**	**+697.00**	**1283.98**	**+21.1**	**+32.0**
+Unconventional*	0.0	97.58	573.53	**+97.58**	**+475.95**	/	+487.8
Total	**3310.77**	**4105.35**	**5864.79**	**+794.58**	**1759.44**	**+24.0**	**+42.9**

Source: data on crude oil: DOE/EIA (2006b: 162); data on 1990: DOE/EIA (2006a: 158); data on the EU and USA: (Table 25 and 26); data on Iran, Iraq, Kuwait, Qatar, Saudi Arabia and UAE: DOE/EIA (2006a: 155) for year 2003 and mean "oil production capacity", so the numbers are somewhat higher and are not included in totals (they are already mentioned under Middle East); data on Caspian Area (1990): DOE/EIA (2006d) and is for the year 1992;

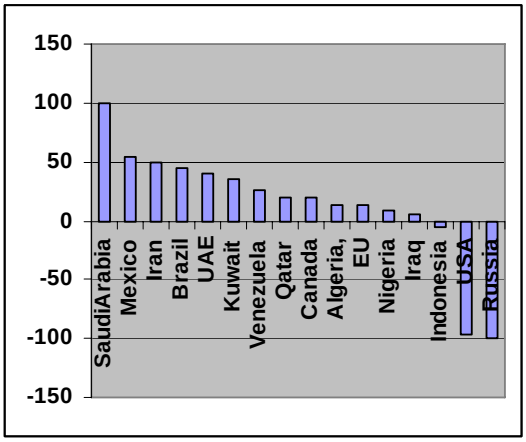
* Non-conventional oil includes production from oil sands, ultra-heavy oils, GTL (Gas-to-liquids) and CTL (Coal-to-liquids) technologies, biofuel technologies and shale oil. For complete data on unconventional oil production by regions see Table 13.

** Caspian Area is also counted under the FSU.

*** As recently as 1996, oil output from the FSU amounted to barely 350 mt/y, that is why the change would have been even greater, because after the collapse of the FSU, oil production decreased substantially.

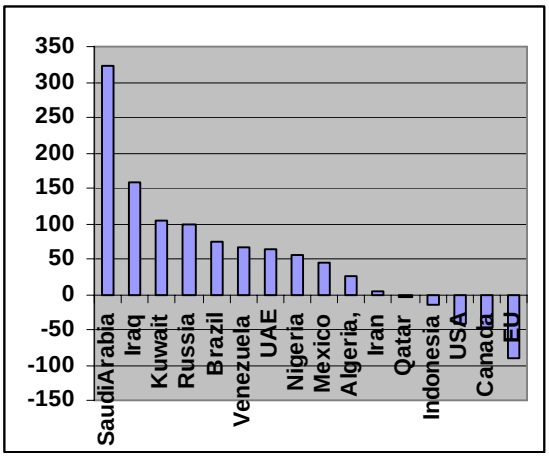
**** It includes conventional oil production only.

Figure 2: Increases and decreases in world crude oil production in 1990-2004 (mt)



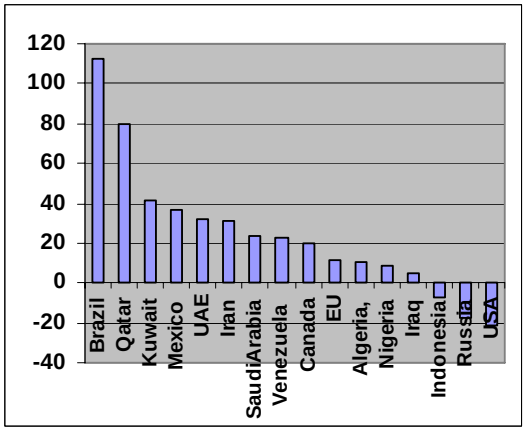
Source: Data based on Table 6.

Figure 3: Increases and decreases in world crude oil production in 2004-2030 (mt)



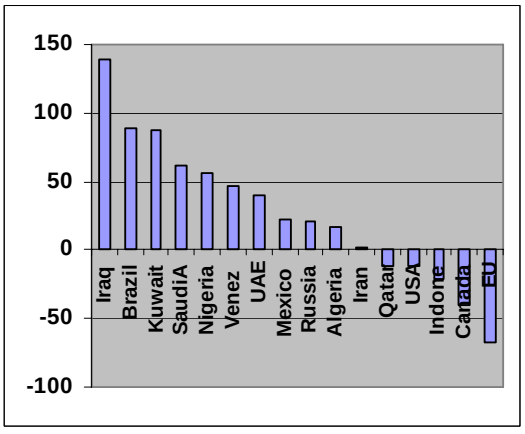
Source: Data based on Table 6.

Figure 4: Increases and decreases in world crude oil production in 1990-2004 (%)



Source: Data based on Table 6.

Figure 5: Increases and decreases in world crude oil production in 2004-2030 (%)

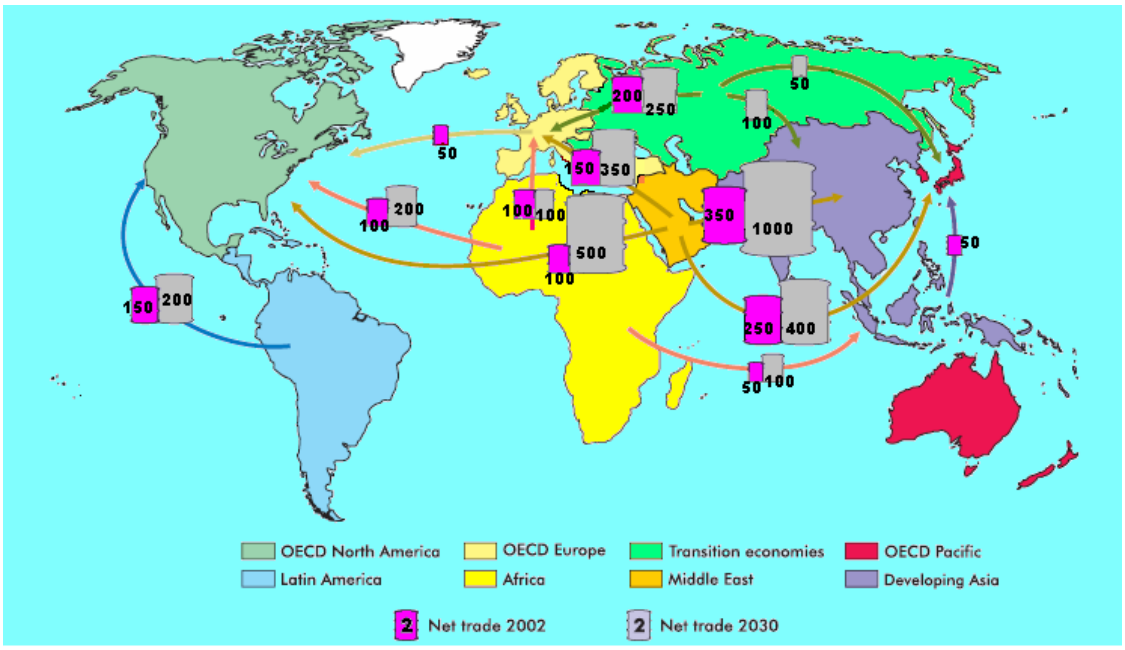


Source: Data based on Table 6.

The most worrying trend is projected concentration of crude oil production in certain Middle Eastern countries by 2030. Saudi Arabia, Iraq and Kuwait are projected to increase their output by more than 100 mt/y each (Figure 3). Iraq's crude oil production is projected to grow by 139.1 % from 2004 to 2030 (Figure 5). Fortunately for the US's

strategy of diversification, there are four countries of the so called group of the Alternative eight between the top ten countries according the absolute increase of crude oil production (Mexico, Venezuela, Nigeria, and Russia). More worrying is the fall in Canadian conventional oil output, but which will be more than compensated by the rising production in Brazil. US crude oil production is projected to decrease slowly, while the EU's output is going to fall significantly (from 134.11 mt in 2004 to 43.45 mt in 2030) (Table 6). It is telling that the US's crude oil production in 2030 is projected to be 7.1 times greater than that of the EU (now it is 2.6 times greater). US's natural gas production in 2030 is projected to be 6.8 times greater than that of the EU (now it is 2.4 times greater) (Table 7). Good news for the EU is the rise of crude oil production in Russia, Caspian Area and North Africa. All the trends are also clearly seen on Map 3 (although the numbers may not be the same because the projection is relatively old).

Map 3: Major net inter-regional oil trade flows, 2002 and 2030 (mt/y)



Source: IEA (2004a: 116), numbers (million barrels per day) were converted into mt.

Russia has been and is going to remain the biggest natural gas producer (Table 7), what should be good news for the EU, putting aside some problems relating transit disputes. Other Asia & Pacific is going to add the most new natural gas capacity by 2030.

Middle East, Africa and Latin America are all going almost double their natural gas output (Figure 7 and 9). Natural gas production is therefore going to be more diversified regionally than that of crude oil. US's natural gas production in 2030 is projected to be 6.8 times greater than that of the EU (now it is 2.4 times greater).

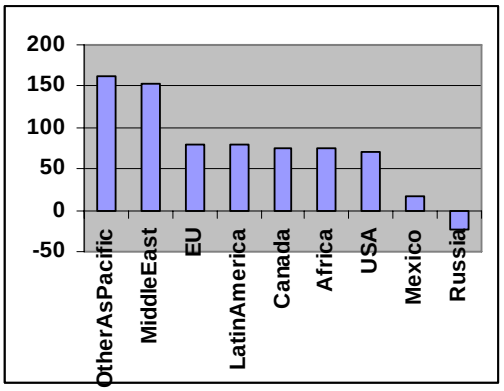
The security situation regarding natural gas is better than that of crude oil. But what falls into the eyes immediately is that the EU is much closer to the major reserves of crude oil and natural gas, while the US stands alone in the middle of the oceans, far away from the resource centres. Latin America is going to satisfy even lesser amounts of the US's future energy needs. On the other hand, the EU can rely on reliable resources from North Africa and the FSU. It is also increasingly adding or planning new pipeline connections with these places what is considered safer as carrying crude oil by tankers or natural gas as LNG by ships.

Table 7: Evolution of world natural gas production (billion cubic metres per year (bcm/y))

	1990	**2003**	**2030**	**90-03**	**03-30**	**% (90-03)**	**% (03-30)**
Canada	108.93	183.95	175.46	+75.02	-8.49	+68.9	-4.6
Mexico	25.55	42.45	84.90	+16.90	+42.45	+66.1	+100.0
Russia	640.03	616.94	1174.45	-23.09	+557.51	-3.6	+90.4
EU	139.72	219.09	88.67	+79.37	-130.42	+56.8	-59.5
USA	461.82	532.50	600.54	+70.68	+68.04	+15.3	+12.8
Latin America	82.55	161.31	481.10	+78.76	+319.79	+95.4	+198.2
Africa	69.59	144.33	523.55	+74.74	+379.22	+107.4	+262.7
Middle East	105.16	257.53	741.46	+152.37	+483.93	+144.9	+198.9
Other Asia & Pac.	154.04	316.96	908.43	+162.92	+591.47	+105.8	+186.6
Total	**2082.09**	**2694.16**	**5139.28**	**+612.07**	**+2445.12**	**+29.4**	+90.8

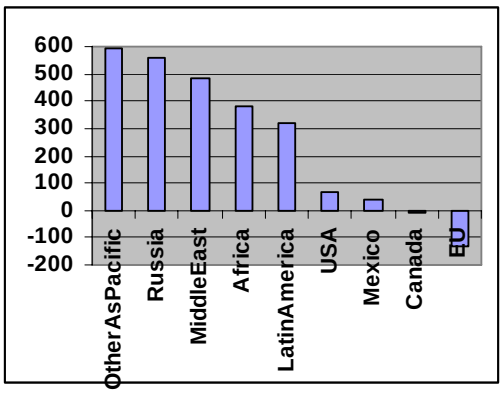
Source: DOE/EIA (2006a: 40); data on 1990: DOE/EIA (2006f); data on the US and EU are from Table 25 and 26.

Figure 6: Increases and decreases in world natural gas production in 1990-2003 (bcm)



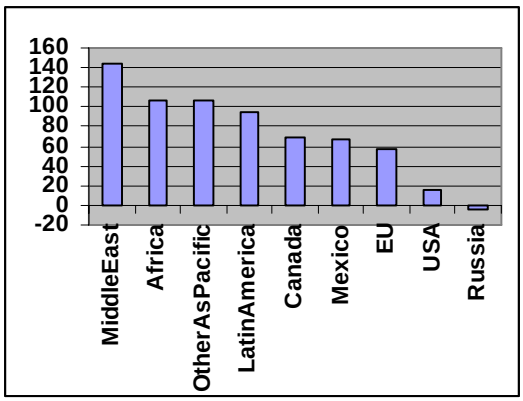
Source: Data based on Table 7.

Figure 7: Increases and decreases in world natural gas production in 2003-2030 (bcm)



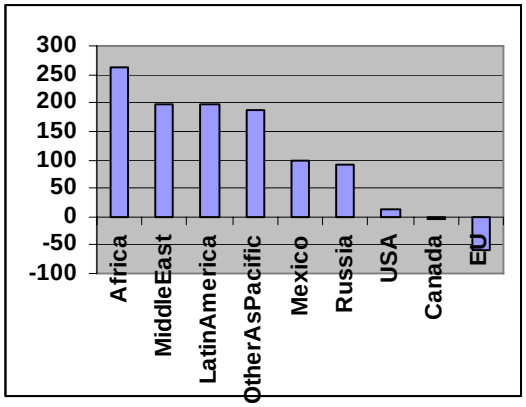
Source: Data based on Table 7.

Figure 8: Increases and decreases in world natural gas production in 1990-2003 (%)



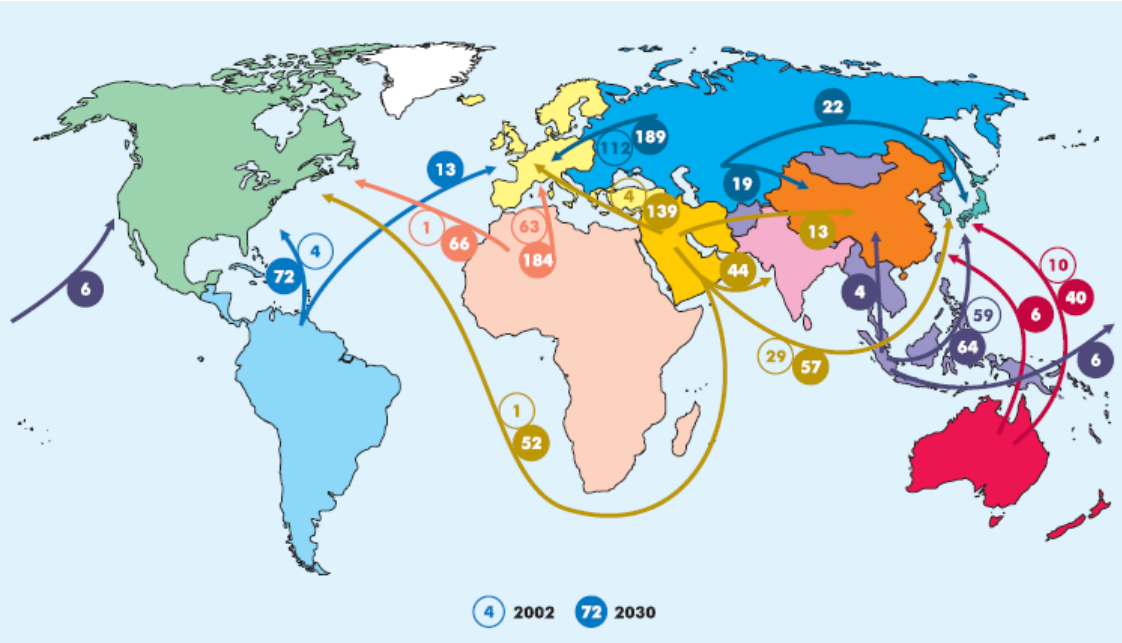
Source: Data based on Table 7.

Figure 9: Increases and decreases in world natural gas production in 2003-2030 (%)



Source: Data based on Table 7.

Map 4: Major net inter-regional natural gas trade flows, 2002 and 2030 (bcm/y)



Source: IEA (2004a: 143).

Boosting crude oil production capacity will require large amounts of investment, sometimes simply to maintain existing capacity which has been neglected. International oil companies, which normally are expected to increase production in an environment of high oil prices, lack access to resources in some key oil rich countries. In Mexico, with the exception of some foreign oil services companies, no exploration permits have been awarded to companies other than Pemex, the national oil company. The situation is the same in Saudi Arabia and Kuwait. Even in areas where foreign investment by international oil companies is permitted, the legal environment is often unreliable and lacks clear and consistent rules of operation. For example, Venezuela is now attempting to change existing contracts in ways that may make oil company investments less attractive. In 2005, Russia announced a ban on majority foreign participation in many new natural resources projects and imposed high taxes on foreign oil companies (DOE/EIA, 2006b: 32). Long-term sanctions against Iraq, Iran and Libya, both US and international, have reduced their contribution to world supply. The sanctions imposed upon various rogue nations, by reducing world supply, have resulted in higher prices (Schlesinger, 2005: 3-4). For that reason, the NEPD Group recommended that the US's

Government initiate a comprehensive review of sanctions eyeing at the energy security as one of the factors considered (National energy policy development group, 2001: 8-6).

Investment risk in Nigeria is high because of political instability and corruption. The flow of funds to certain oil-producing countries has financed widespread corruption, perpetuated repressive regimes, funded radical anti-American fundamentalism, and fed hatreds that derive from rigid rule and stark contrasts between rich and poor. Terrorism and aggression are by-products of these realities (Wirth et al, 2003: 135; Robinson, 2006: 22-25). Research points to natural resources being a key cause of civil war, and oil has been directly or indirectly linked to violence in the Niger Delta, in Cabinda in Angola, to the 2003 and 2004 coup and coup attempts in Sâo Tomé and Príncipe and Equatorial Guinea, and to DR Congo's civil wars of the 1990s (Shaxson, 2005: 311-212).

In the future, most of the increases of world oil production will have to come from the Middle East. But because of the underinvestment and worsened geological conditions (and assuming that global demand of oil rises at the average rate of the last 30 years – 1.5 %) Middle East countries will fail to meet global demand by as soon as 2011 (Leggett, 2005: 91; Simmons, 2005). To make matters worse, OPEC countries exaggerated their crude oil reserves to get greater production quotas within OPEC. There is a 41 billion tonnes exaggeration in OPEC crude oil reserves (Leggett, 2005: 91).

There is a debate today about when the world will reach the topping point[6] – when there will be maximum production of oil, because after that point, a serious economic crisis is predicted in case the world is not going to find a substitute until then. Reserves are largely irrelevant to the peak. Production capacity is the important thing – how quickly you can get it out. If only 1 trillion barrels (136.4 billion tonnes) remain (claimed by some prominent geologists), the topping point will arrive some time soon and certainly before this decade is out. The growing and cheap parts of the oil-supply equation become impossible and there probably is not even enough time to make a sustainable transition to alternatives. If 2 trillion barrels (272.8 billion tonnes) of oil or

[6] The first man who started thinking about the topping point was King Hubert (that is why the topping point became known as "Hubert's curve"), a geologist who worked at Shell in the USA. In 1956 he calculated that oil production would peak in the "lower 48" states of America in 1971. Almost nobody believed him. Oil production was rising steadily at the time, and the whole thing seemed incredible. Unfortunately, he war right. The peak even came a year ahead of estimate, in 1970. Since then, production has sunk down the second half of the curve at a steady rate (Leggett, 2005: 54).

more indeed remain (what governments, oil companies and scientists claim), the topping point lies far away in the 2030s. The growing and cheap parts of the oil-supply equation are feasible until then, at least in principle, and there is enough time to bring in the alternatives to oil (Leggett, 2005: 24-25, 91). Natural gas is facing the same destiny. The global plateau of production is expected during the period of 2015-2040, with production falling over a cliff beyond that (Leggett, 2005: 74).

Much more serious is debate of how much carbon can the world afford to burn. Assuming that the world wants to stay below the 2^{0}C threshold of global-warming danger identified by the EU, we can afford to burn no more than 400 billion tonnes more of carbon from fossil fuels (presently the world burn carbon in excess of seven billion tonnes per year from fossil fuels). If we assume that two trillion barrels (272.8 billion tonnes) of crude oil remains this amounts to a total of some 270 billion tonnes of carbon. Unconventional oil adds 440 billion tonnes of carbon. Then comes 500 plus billion tonnes of carbon in gas, excluding any methane hydrates. On the top of the 1 200 plus billion tonnes of oil and gas comes coal, where the totals exceeds 3 500 billion tonnes. The implication is clear: we cannot afford to burn all the oil, much of the gas must remain below ground, and the great majority of the coal should not even be considered (Leggett, 2005: 127-128).

3.2.2. US – CRUDE OIL

Crude oil production in the US and the entire North American region is expected to pick up slightly in the next few years, mainly thanks to a surge in output in the Gulf of Mexico. But, starting in the 2010s, the region is expected to resume its long-term downward trend, as output in Alaska, Western Canada and continental US tails off. Older fields in the Gulf of Mexico will also peak soon. New fields in ultra-deep offshore waters will not be able to compensate for this decline. The lifting of a moratorium on drilling in the Arctic National Wildlife Refuge could temper the decline. Similarly, higher output from the Alaskan Naval Petroleum Reserve west of Prudhoe Bay may be possible (IEA, 2004a: 106-107).

US crude oil production is projected to increase from 269 mt in 2004 to a peak of 294 mt in 2014 as a result of increased production offshore. Total domestic petroleum supply (crude oil, natural gas plant liquids, refinery processing gains and other refinery inputs) follows the same pattern as crude oil production, increasing from 428 mt in 2004 to a peak of 522 mt in 2021, then declining to 518 mt in 2025 and remaining at about that level through 2030 (DOE/EIA, 2006b: 8).

US petroleum imports from the Persian Gulf increase by more than 40 % from 2003 to 2030. At the same time more than 40 % of its imports in 2030 are expected to come from Atlantic Basin producers and refiners, with significant increases anticipated in crude oil imports from Latin American producers, including Venezuela, Brazil, Colombia and Mexico. West African producers, including Nigeria and Angola, are also expected to increase their export volumes to the US. Caribbean Basin refiners are expected to account for most of the increase in imports of refined products (DOE/EIA, 2006a: 33).

3.2.2.1. RELATIONS WITH MAJOR PRODUCING COUNTRIES

By 2020, *Gulf* oil producers are projected to supply between 54 % and 67 % of the world's oil. Thus, the global economy will continue to depend on the supply of oil from OPEC members, particularly from the Gulf. That is why the NEP (National energy policy development group, 2001: 8-5) stresses: "The Gulf will remain vital to US interests … The Gulf will be a primary focus of US international energy policy, but our engagement will be global, spotlighting existing and emerging regions that will have a major impact on the global energy balance". *Saudi Arabia*, the world's largest oil exporter, has been in a centre of the US policy towards the Gulf. It is the only major supplier that can significantly increase its deliveries of oil in times of crisis, because it has sufficient spare capacity. Not only does this spare capacity help the Kingdom keep prices in check, but it also serves to link Riyadh with the US and other key oil-importing countries. It is also the centrepiece of the US – Saudi relationship. The US relies on that capacity as the cornerstone of its oil policy. That arrangement was fine as long as US protection meant Riyadh would not "blackmail" Washington – an assumption that is more difficult to accept after September 11, 2001 (Morse et al, 2002: 19-20). Until

recently, the US maintained large military presence in Saudi Arabia. On February 16, 1943, President Roosevelt declared that "the defense of Saudi Arabia is vital to the defense of the United States" (Klare, 2005: 33). The security relationship that Roosevelt and Ibn Saud initiated has evolved considerably since then. But its basis was fully established during World War II, when American officials first identified the oil fields of Saudi Arabia as a vital national interest. Later (1980), President Carter decreed that the US would assume the primary responsibility for the defense of the Gulf. Access to Persian Gulf oil was a vital national interest, Carter declared, and to protect that interest the US was prepared to use "any means necessary, including military force" (Klare, 2005: 46). The primary goal of the Gulf war of 1991 was to prevent Saddam Hussein from seizing the control of the Saudi oil fields.

Canada and Mexico are part of a continental energy market and under the terms of the North American Free Trade Agreement (Phillips, 2003: 467). Canada's deregulated energy sector has become America's largest overall energy trading partner, and leading foreign supplier of natural gas, oil, and electricity. The US is especially interested in developing of Canadian resources of non-conventional oil: "Their continued development can be a pillar of sustained North American energy and economic security" (National energy policy development group, 2001: 8-8). To their embarrassment, Canadians see China's potential investment in the tar sands as a major opportunity. In April 2004, PetroChina and the Canadian giant Enbridge signed a memorandum of understanding to build a $2 billion pipeline that would carry oil to the western coast of Canada for shipments to Asia. The deal could create tensions between the US and China, as well as between the US and Canada, particularly since the NEP emphasized the importance of Canada's tar sands to the US energy security[7] (Zweig et al, 2005: 31). Besides being a major oil supplier, Mexico is increasingly developing into an energy hub for the American Southwest. Drawn by the insatiable North American market, companies (like Sempra) are already planning at least five LNG regasification terminals for Baja Peninsula and another dozen projects are under consideration. From there, a pipeline will carry the gas to several sites near the US-Mexican border, where gas-fired power plants

[7] PetroChina is pulling out of a US$3.8 billion Alberta to British Columbia pipeline project that would have supplied crude oil to China from Canada's oil sands. The company was tired of the lack of Canadian government and producer support for their business (AP, 2007).

will turn most of it into electricity for the local market or send it north to power-starved Southern California. Critics, attacking the project as "energy colonialism", say that the only reason Sempra has come to Mexico is that the rich residents of Southern California, where most of the electricity is headed, won't allow Sempra to locate the enormous LNG facilities there (Roberts, 2005: 165). The problem for the American strategy of maximum extraction is that Mexico so far continues to bar foreign investment in its upstream oil and gas sector and that despite increased production there will be less energy available for export due to the increased domestic consumption. That is also true for other South American countries.

Latin America is a strategic region for US's foreign policy. In the energy sphere, the hemisphere provides the US with a large portion of the diversity of oil and gas supplies. *Venezuela* is one of the world's largest oil exporters, and the third largest oil supplier to the US. Trinidad's progressive investment code has made it the hemisphere's largest supplier of LNG to the US (Table 18). Ecuador, Colombia and Brazil have also become important suppliers of oil to the US. Unfortunate for the US interests is the rising state control of energy resources – in Venezuela, Argentina, Bolivia and Ecuador in particular. The concern here is that this trend will limit the growth of global supplies of oil and gas undermining the value of existing investments, discouraging future investment or barring foreign investment altogether. The consequence is that the hemisphere will contribute less to the diversification of oil supply, thereby increasing the importance of OPEC supply and over time undermining economic development in the region. Foreign investment in the oil sector is shifting away from South America to North America, particularly to Canada's oil sands. The political consequences of these trends in the short run is the decline of US influence in the region to competing ideologies (arising primarily from Venezuela) (Goldwyn, 2006: 1-4; The Economist, 14.5.2006: 24). A 1994 initiative – "Energy integration of the Americas", which had as its objective to build an integrated energy data bank, to evaluate existing interconnections among the countries, and to identify barriers for a larger integration and eventual undertaking of reforms and agreements, with the ultimate objective of having a seamless energy platform that would benefit all countries – lost momentum in the next few years and eventually faded out (Giusti, 2006: 11-12). The premier multilateral energy forum was the Hemispheric

Energy Initiative (HEI), a multilateral meeting of the hemisphere's energy ministers, with many active subgroups, which was co-chaired by the US and Venezuela. The HEI is dormant due to the status of strained US-Venezuelan relationship (Goldwyn, 2006: 7). As if that would not be enough, Venezuela's president Chavez continuously threatens the US government with suspending exports to the US, and has indicated that those exports would most likely be diverted to China. In December 2004 he told a group of Chinese business executives: "We have been producing and exporting oil for more than 100 years. But these have been 100 years of domination by the US. Now we are free, and place this oil at the disposal of the great Chinese fatherland" (Zweig et al: 2005: 33). However, Giusti claims, that exporting oil to China would be practically impossible, because the refining network in China is mostly primitive and incapable of refining Venezuela's sour and heavy crude oil. The only real risk represented by the current Venezuelan administration is the lack of investment in the oil sector what would not significantly increase the future oil output (Giusti, 2006: 9). *Columbia* has become increasingly important in US energy calculations. Between 1980 and 1999, the country's oil production increased from 5.0 mt/y to around 42.0 mt/y. Under the "Andean Counterdrug Initiative" (ACI), the country gets the lion's share of aid. In the words of Assistant Secretary for International Narcotics and Law Enforcement Affairs, Robert B. Charles, ACI "is a regional hemispheric and national security programme" (Stern, 2005: 177). Most of the money is devoted to helping the Columbian government protect its oil pipelines from guerrilla attack (Klare, 2005. 141).

West Africa is expected to be one of the fastest-growing sources of oil and gas for the American market. In 2000, OPEC member *Nigeria* exported 43.7 mt/y to the US, out of its total production of 104.6 mt/y (Table 6). *Angola's* growing offshore oil industry, with participation by US and international oil firms, is also a major source of growth. The Bush administration is also forging closer ties with *Libya*, which has the largest crude oil reserves in Africa, safely distant from the Persian Gulf, and has historically cosy relations with American oil firms. Libya has also been important in countering al-Qaeda and its offshoots (The Economist, 20.5.2006: 55). The Americans also fear that Islamist terror could spread from the Sahara into the oil-producing coastal countries of West Africa (The Economist, 3.9.2005: 5).

A new relationship between the US and *the Caspian* republics began to take shape in the mid-1990s. American energy firms concluded major oil deals with the governments of *Azerbaijan and Kazakhstan*. The countries became recipients of American aid and established military ties with the US. The presence of Western oil companies on Russia's borders and high political profile given to Central Asia raises fears in Russia, especially since most of the former Soviet republics were included in NATO's (North Atlantic Treaty Organization) Partnership for Peace programme (Jaffe et al, 2001: 141). President Bill Clinton was a vigorous advocate for American companies seeking drilling rights in the Caspian basin, and he explicitly designated the area's energy resources a matter of national security. He told the Azeri president in 1997: "In a world of growing energy demand, our nation cannot afford to rely on any single region for our energy supplies. By helping Azerbaijan to develop its untapped oil reserves, we not only help Azerbaijan to prosper, we also help diversify our energy supply and strengthen our nation's security" (Klare, 2005: 133). In the Caspian region, US support East-West pipeline routes. The policy centrepiece, the Baku-Tbilisi-Ceyhan (BTC) pipeline, is intended to isolate Iran and offer an alternative transport route that avoids Russia and the crowded Bosporus (Jaffe et al, 2001: 147). The area is a place of the new "great game" between regional and global powers. China is trying to deepen cooperation with Central Asian countries. It created Shanghai Cooperation Organisation[8] whose main principles are: "slaking China's thirst for energy, protecting member states as they tyrannise dissidents and curbing America's influence in the region" (The Economist, 9.7.2005: 51).

Russia's increased crude oil (and natural gas) production is sometimes seen as a way to grab power in the global arena. But Russia's petroleum revival has also coincided with the terrorist attacks of September 11, which have provided Moscow a chance to displace OPEC as the key energy supplier to the West. The new geopolitics of energy can help Moscow gain both economically and politically. In economic terms, energy production lets Russia integrate itself into the industrialized West. In political terms, energy resources can be used to buttress Moscow's goal of becoming a key partner of the US (Morse et al, 2002: 17-18). Four Russian oil companies are preparing a large new port

[8] Member states: China, Russia, Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan; often nicknamed the "Shanghai Six".

in Murmansk as part of a plan to supply more than 10 % of total US oil imports within a decade. US and Russian governments have created a special working group on energy cooperation. Victor[9] is relating to the new Russian-American relationship in the oil sector as the "axis of oil" (Victor et al, 2003: 48).

On the other hand, Leverett[10] stays concerned about the possibility of deepening cooperation between China and Russia on energy matters which would create a Sino-Russian "axis of oil" as the principal counterweight to America's global hegemony. This would be the most profound challenge to US pre-eminence during the next 25 years (Leverett, 2006: 1). The Americans are also getting nervous and angry because oil and gas wealthy Russia is starting to set the international agenda. The US wants to prevent it but have very limited means to do it (Traynor et al, 2006: 20).

Table 8: US – crude oil imports by country of origin (mt/y)

		1993	**2000**	**2005**	**(93-00)**	**(00-05)**	**% (2005)**	**% (93-00)**	**% (00-05)**
1	Canada	44.81	67.28	81.32	+22.47	+14.04	16.1	+50.1	+20.9
2	Mexico	42.96	65.54	77.47	+22.58	+11.93	15.4	+52.6	+18.2
3	Saudi Arab.	63.80	76.05	71.92	+12.25	-4.13	14.3	+19.2	-5.4
4	Venezuela	50.28	61.07	61.78	+10.79	+0.71	12.3	+21.5	+1.2
5	Nigeria	35.95	43.67	53.61	+7.72	+9.94	10.6	+21.5	+22.8
6	Iraq	0	30.94	26.26	+30.94	-4.68	5.2	/	-15.1
7	Angola	16.74	14.71	22.70	-2.03	+7.99	4.5	-12.1	+54.3
8	Ecuador	3.87	6.23	13.74	+2.36	+7.51	2.7	+61.0	+120.6
9	Algeria	1.19	0,54	11.37	-0.65	+10.83	2.3	-54.6	+2005.6
10	Kuwait	17.12	13.14	11.28	-3.98	-1.86	2.2	-23.2	-14.2
11	UK*	15.55	14.50	11.13	-1.05	-3.37	2.2	-6.8	-22.1
12	Russia	0	0.35	9.91	+0.35	+9.56	2.0	/	+2731.4
13	Colombia	7.03	15.86	7.78	+8.83	-8.08	1.5	+125.6	-50.9
14	Gabon	7.50	7.13	6.34	-0.37	-0.79	1.3	-4.9	-11.1
15	Norway	6.81	15.09	5.93	+8.28	-9.16	1.2	+121.6	-60.7
16	Brazil	0	0.25	4.70	+0.25	+4.45	0.9	/	+1780.0
17	Chad	0	0	3.68	0	+3.68	0.7	/	/
18	Eq. Guinea	0	0.28	3.37	+0.28	+3.09	0.7	/	+1103.6
19	Trinidad	2.76	2.77	3.16	+0.01	+0.39	0.6	+0.4	+14.1
20	Argentina	0.58	2.64	2.81	+2.06	+0.17	0.6	+355.2	+6.4
21	Libya	0	0	2.17	0	+2.17	0.4	/	/
22	Vietnam	0	0.45	1.55	+0.45	+1.10	0.3	/	+244.4
23	Congo	2.62	2.10	1.26	-0.52	-0.84	0.2	-19.8	-40.0
24	China	2.51	1.66	1.17	-0.85	-0.49	0.2	-33.9	-29.5

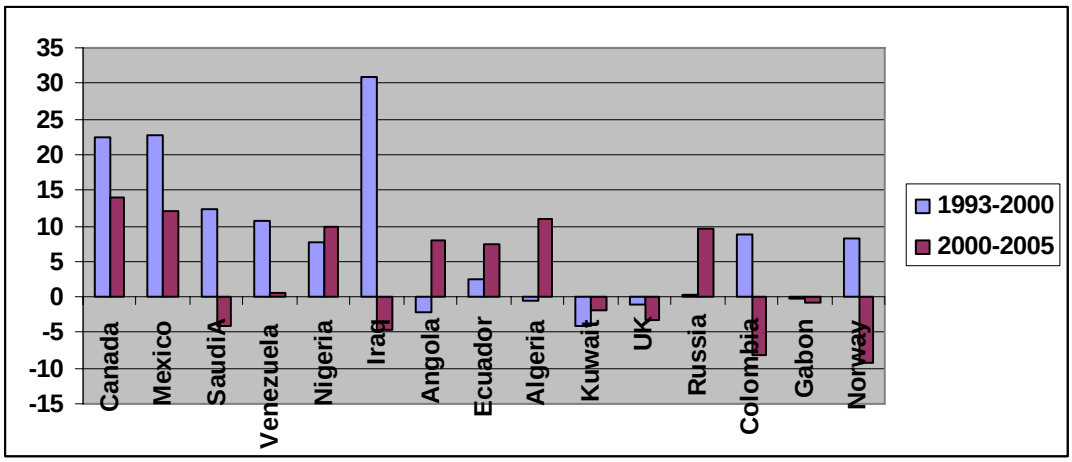
[9] David G. Victor is Director of the Program on Energy and Sustainable Development at Stanford University and Adjunct Senior Fellow at the Council on Foreign Relations.
[10] Flynt Leverett is Senior Fellow and Director of the Geopolitics of Energy Initiative at the New America Foundation.

25	Oman	0	0.11	1.11	+0.11	+1.00	0.2	/	+909.1
26	Indonesia	3.26	1.82	0.93	-1.44	-0.89	0.2	-44.2	-48.9
27	Brunei	0	1.05	0.71	+1.05	-0.34	0.1	/	-32.4
28	Yemen	0.32	1.34	0.58	+1.02	-0.76	0.1	+318.8	-56.7
29	Malaysia	0.50	1.46	0.50	+0.96	-0.96	0.1	+192.0	-65.8
30	Australia	0.90	2.44	0.48	+1.54	-1.96	0.1	+171.1	-80.3
	Total imp.	**337.89**	**452.82**	**504.13**	**+114.93**	**+51.31**	**100.0**	**+34.0**	**+11.3**

Source: DOE/EIA (2006c). Countries with more than 1 mt/y are included.

* Imports from other EU Member States are negligible (Denmark and Netherlands: 0.38 mt/y in 2000).

Figure 10: US – crude oil imports by country of origin (top 15 countries) – increases and decreases of imports in 1990-1993 and 2000-2005 (mt)



Source: Data based on Table 8.

Figure 10 shows us that the US has been really trying to decrease its crude oil imports from the Middle Eastern states since 2000. Additions to crude oil imports from 2000 to 2005 are negative for Saudi Arabia (decrease from 76.05 mt in 2000 to 71.92 mt in 2005), Iraq and Kuwait. Greater additions have occurred regarding new prospective African (Angola, Algeria, Nigeria, Chad, Equatorial Guinea) and Latin American countries (Ecuador, Brazil) and Russia. Latin America and Canada provided 50.1 % of US crude oil imports in 2005 (Table 9), in 2000 the number was 49.2 % and in 2030 the Western hemisphere is projected to supply 53.2 % of US crude oil imports. Still, according to my opinion, the trend is too slow to change anything. Especially because in 2030 the share of Middle East in US crude oil imports is going to increase from 22.1 %

(2005) to 23.5 % in 2030. The US is hoping for a much greater (non-conventional) oil imports from Canada, which is already a major oil exporter to the US (Map 5).

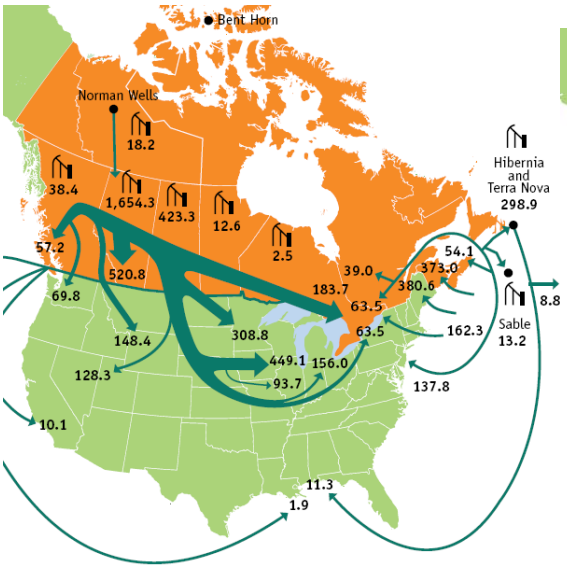
Table 9: USA – crude oil imports by region (mt/y)

	1993	2000	2005	2030	% (2005)	% (93-00)	% (00-05)	% (05-30)
Latin America	107.48	155.56	171.21	224.53	34.0	+44.7	+10.1	+31.1
Middle East	81.83	121.71	111.58	158.32	22.1	+48.7	-8.3	+41.9
Other Africa	64.11	68.55	92.21	/	18.3	+6.9	+34.5	/
Canada	44.81	67.28	81.32	133.92	16.1	+50.1	+20.9	+64.7
UK	15.55	14.50	11.13	20.91*	2.2	-6.8	-23.2	/
North Africa	4.56	0.54	13.73	/	2.7	-88.2	+2442.6	/
FSU	0	0.35	10.51	/	2.1	/	+2902.9	/
Norway	6.81	15.09	5.93	/	1.2	+121.6	-60.7	/
Other Asia & Pac.	7.46	9.11	5.52	/	1.1	+22.1	-39.4	/
Total imports	**337.89**	**452.82**	**504.13**	**673.60**	**100.0**	**+34.0**	**+11.3**	**+33.6**
Gulf	81.51	120.27	109.89	155.83	21.8	+47.6	-8.6	+41.8
Africa	68.67	68.80	105.94	111.52	21.0	+0.2	+54.0	+5.3
OPEC	171.60	226.86	239.75	307.18	47.6	+32.2	+5.7	+28.1
Non OPEC	166.29	225.97	264.38	366.42	52.4	+35.9	+17.0	+38.6

Source: DOE/EIA (2006c); data on 2030: DOE/EIA (2006o).

* Includes complete North Sea.

Map 5: Canada – Crude oil production and equivalent supply and distribution (thousands barrels per day)



Source: Centre for energy (2006).

Map 6: Canada – Natural gas production and distribution (billion cubic feet per day)



Source: Centre for energy (2006).

3.2.3. EU – CRUDE OIL

With a moderate decline in North Sea production, the EU is expected to import increasing amounts of oil from the Persian Gulf producers and Russia. Substantial imports from the Caspian region are also expected. Production from Norway, Europe's largest producer, is expected to peak at about 180 mt in 2006 and then decline to about 125 mt in 2030 with the maturing of some of its larger and older fields. The UK sector of the North Sea is expected to produce about 110 mt in 2010, followed by a decline to 70 mt in 2030 (DOE/EIA, 2006a: 31). The UK is the EU's main source of domestic crude oil production. In 2004 it produced 74 % of the EU's crude oil. Denmark is next with 13 %.

Norway possesses the largest hydrocarbon reserves in Western Europe. It is the world's third largest oil exporter, as well as the second largest supplier of oil and gas to the EU, after Russia. The county is a member of the European Economic Area and has secured access to European markets by a partial aligning of its own energy legislation with the EU's Directives on electricity and gas market opening. It provides 11 % of the EU's gas consumption which is set to increase with future market penetration, provided that the necessary infrastructure is put in place (COM, 2006b: 88).

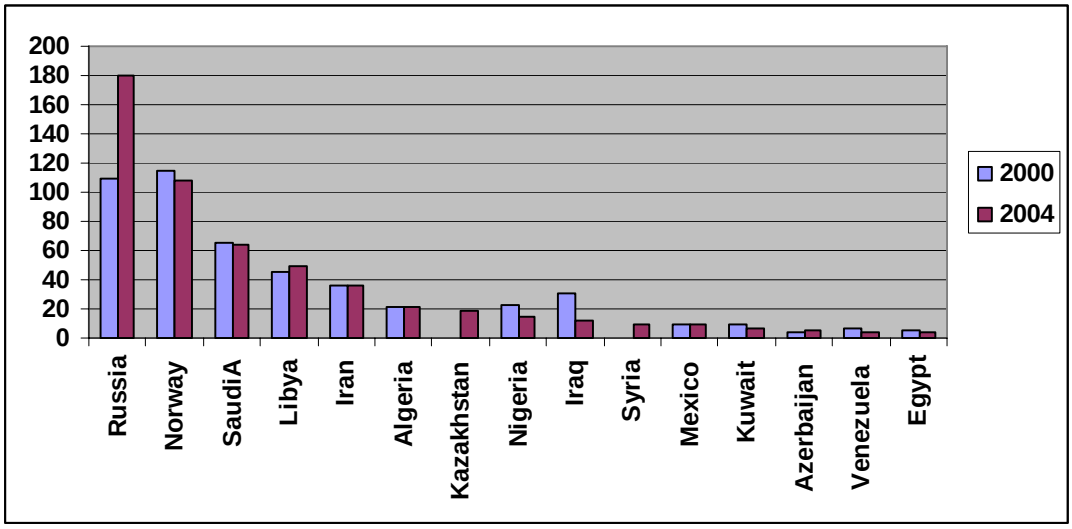
In 2004, 74.2 % of the EU's crude oil imports came from Russia (31.9 %), Norway (19.3 %), Saudi Arabia (11.5 %) and Libya (8.9 %). The EU has increased diversification and augmented supply security by increasing the shares of oil imported from the FSU and Norway – with which it has signed energy security agreements – and by reducing its imports from some Gulf sources such as Saudi Arabia and Kuwait. There is also a clear shift away from OPEC countries towards non-OPEC producers (Table 11). From 2000 to 2004 imports of crude oil increased primarily from Russia, Kazakhstan, Syria, Libya and Angola, while the greatest decreases came from Iraq, Nigeria, Norway and Kuwait (Table 10, Figure 11). Imports from Saudi Arabia, Iran and Algeria remained basically constant. Imports from Norway will be smaller and smaller due to the decline in production, imports from Iraq slowed because of ongoing violence and damaged oil infrastructure. Nigeria, on the other hand, is starting to direct its crude oil exports primarily to the US (compare with Table 8).

Table 10: EU – crude oil imports by country of origin (mt/y)

		2000	2004	(00-04)	% (2004)	% (00-04)
1	Russia	109.30	179.59	+70.29	31.9	+ 64.3
2	Norway	114.90	108.62	-6.28	19.3	- 5.5
3	Saudi Arabia	65.14	64.46	-0.68	11.5	- 1.0
4	Libya	45.54	49.99	+4.45	8.9	+ 9.8
5	Iran	35.47	35.94	+0.47	6.4	+ 1.3
6	Algeria	21.42	21.61	+0.19	3.8	+ 0.9
7	Kazakhstan	/	18.18	+18.18	3.2	/
8	Nigeria	22.41	14.86	-7.55	2.7	- 33.7
9	Iraq	31.25	12.55	-18.70	2.2	- 59.8
10	Syria	/	9.08	+9.08	1.6	/
11	Mexico	9.77	8.81	-0.96	1.6	- 9.8
12	Kuwait	9.77	6.60	-3.17	1.2	- 32.4
13	Azerbaijan	3.71	5.19	+1.48	0.9	+ 39.9
14	Venezuela	6.95	4.32	-2.63	0.8	- 37.8
15	Egypt	5.58	3.95	-1.63	0.7	- 29.3
16	Angola	/	3.42	+3.42	0.6	/
17	Cameroon	3.07	2.92	-0.15	0.5	- 4.8
18	Brazil	/	1.77	+1.77	0.3	/
19	Tunisia	1.45	1.48	+0.03	0.3	+2.1
	Total imports	**544.87**	**562.44**	**+17.57**	**100,0**	**+ 3.1**

Source: Eurostat (2006a). Intra-EU trade is not included in total imports. Countries with more than 1 mt/y are included.

Figure 11: EU – crude oil imports by country of origin (top 15 countries) – increases and decreases of imports from 2000 to 2004 (mt)



Source: Data based on Table 10.

Table 11: EU – crude oil imports by region (mt/y)

	2000	**2004**	**% (2004)**	**% (00–04)**
FSU	142.95	207.30	36.9	+ 45.0
Middle East	142.04	128.79	22.9	-9.3
Norway	114.90	108.62	19.3	- 5.5
North Africa	73.99	77.03	13.7	+ 4.1
Other Africa	33.64	26.75	4.8	- 20.5
Latin America	16.95	14.90	2.6	- 12.1
Other Asia & Pac.	0.00	0.00	0.0	/
Total imports	**544.87**	**562.44**	**100.0**	**+ 3.23**
Gulf	141.92	119.71	21.3	- 15.6
Africa	107.63	103.78	18.5	- 36
OPEC	238.23	210.49	37.4	- 11.6
Non OPEC	306.64	351.96	62.6	+14.8

Source: Eurostat (2006a).

3.2.3.1. NEIGHBOURING COUNTRIES – EU ENERGY PARTNERS

Neighbouring countries to the EU play a vital role in the Union's energy policy. They supply a major part of the EU's requirements of natural gas and oil and ensure the transit of primary energy to the EU. They will progressively become full, important and equal players in the EU's internal gas and electricity markets (COM, 2003, 262 final: 4). That is why, the European Commission recommends extending of the EU's energy market to include its neighbours within a common regulatory area with shared trade, transit and environmental rules (Paper from Commission/SG/HR for the European Council, 2006: 3). The EU is surrounded by almost 80 % of the world's hydrocarbon resources. There are important energy producers in the Mediterranean, Black Sea, Caspian, Middle East and the Gulf regions as well as in the North (Norway), with which the EU is building strengthened cooperation. The aim is to create a wide network of countries around the EU, acting on the basis of shared rules or principles derived from the internal market (COM, 2006, 590 final: 5). There are different tools that could be used to pursue this goal. There are the existing and future bilateral agreements with energy producer and transit countries, such as the post-Partnership and Cooperation Agreements, the Memorandum of Understanding on Energy Cooperation with Ukraine and the Association Agreements with Mediterranean countries. In addition, there are the European Neighbourhood Policy Action Plans, the foreseen memoranda of understanding

with Algeria, Azerbaijan and Kazakhstan; Euro-Mediterranean energy cooperation; the Baku initiative; and the EC-Norway energy dialogue. Energy relations have also been reinforced with other important energy producers such as OPEC and countries in Latin America and Africa, which are increasing their hydrocarbon output and have the potential to go even further (COM, 2006, 590 final: 5).

The European Neighbourhood Policy (ENP) was developed as a response to the new geopolitical situation following the May 2004 enlargement. This policy lays the foundations for a much deeper political and socio-economic relationship with EU's neighbours[11] and aims to increase mutual prosperity, stability and security. It takes full account of the vital role that the EU's neighbours play in the EU's energy security either as supplier or transit countries (S710/06: 3).

Russia is already the largest single energy partner of the EU. In 2004, 31.9 % of total net EU crude oil imports and 41.6 % of EU gas imports came from Russia (Table 10 and 16). In October 2000, President Vladimir Putin signed a strategic energy partnership with the EU that will allow natural gas exports to Europe to rise to 200 billion cubic metres by 2008 (Jaffe and Manning, 2001: 137). As Buchan[12] (2002: 108) observed: "The only supply problem in the post-Soviet era has arisen because Ukraine, short of money to pay for Russian gas, has on occasion held up or diverted Russian gas piped across its territory to Western Europe". Ukraine owes Russia over $2 billion for gas imports and is accused of siphoning off gas destined for European customers. Ukraine's massive debt to Moscow stands in sharp contrast to Western Europe, which is the highest-paying market for Russian gas. Conversely, Russia is Europe's cheapest supplier, given the lower cost of transport (Jaffe and Manning, 2001: 137). Russia's new pipelines and export routes will simply bypass Ukraine. The best example is a North European Pipeline that would go under the Baltic Sea and will bypass all possible transit countries. To be completed in 2010, it will be 30 % costlier than an overland version, but offers Russia a direct link with its main west European markets. It will bypass Poland, the

[11] The ENP applies to the EU's immediate neighbours by land or sea – Algeria, Armenia, Azerbaijan, Belarus, Egypt, Georgia, Israel, Jordan, Lebanon, Libya, Moldova, Morocco, the Palestinian Authority, Syria, Tunisia and Ukraine. Although Russia is also a neighbour of the EU, the relations are instead developed through a Strategic partnership covering four "common spaces" (What is the ENP? http://www.ec.europa.eu/world/enp/policy_en.htm (15.6.2007).

[12] David Buchan was energy correspondent and is now foreign editorial writer for the Financial Times.

Baltic states and Ukraine which had hoped for an alternative route bringing them extra transit fees. Russia could, at least in theory, cut off gas to them for political reasons, while continuing to supply Western Europe. That is bad news for the Baltic states but hardly matters for Poland, which "does not want a single bucket more of Russian gas" according to one official. In the end, small countries such as the Baltic states, or even a large one like Poland, can do little on their own to ensure their energy security. The east Europeans' hopes rest mainly on a common European energy policy (The Economist, 7.1.2006: 64).

According to Jaffe and Manning[13] (2001: 139), EU-Russia natural gas pact has clear strategic implications. Accompanying this pact was an EU statement framed in far milder language with regard to Russia's military operation in Chechnya than a previous EU statement in 2000, which had strongly condemned Russia's intervention. The deal and its accompanying soft line statement raised eyebrows in the US, but was hailed in Europe as a constructive way to eliminate Russia's burdensome debt while enticing Moscow to moderate its positions on European security. The EU wanted to change the commercial relationship into a long term strategic partnership that will help stabilise Russia, which is in the interest of all parties. Economic motivations are clearly central to both Russia and Europe, though key EU members, such as Germany and France, appear to have an appreciation of other benefits – such as long-term political benefits of an established economic relationship. From a Russian perspective, it brings Moscow closer to Europe, and creates larger stakes for both in mutual energy security.

The *Ukraine* is the most important transit country for Russian gas to Western Europe, with between 80 % and 90 % of Russian gas exports moving over Ukrainian territory. A major challenge is the need to guarantee the overall performance, safety and security of the Ukrainian network, what has been one of the main objectives of the Enhanced EU-Ukraine energy cooperation since 2001 (COM, 2003, 262 final: 13).

In the framework of the Barcelona Process, initiated between the EU and the 10 Mediterranean Partners[14], *the Euro-Mediterranean Energy forum* was established in

[13] Amy Myers Jaffe is a Senior Energy Adviser at the Baker Institute for Public Policy at Rice University; Robert A. Manning is Senior Fellow and Director of Asian Studies at the Council on Foreign Relations.
[14] The 12 Mediterranean Partners are: Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, Palestinian Authority, Syria, Tunisia and Turkey. Libya has observer status since 1999.

1997. The purpose of the Forum covers both the objectives of reinforcing political dialogue between the Mediterranean Partners and, at the more technical level, promoting projects and measures of common interest. A first action plan, covering the period 1998-2002, set security of supply, through the development and diversification of energy sources, as one of the objectives in the energy sector. The so-called Trans-Euro-Mediterranean Networks, to ensure gas and electricity interconnections South-South and South-North in the region, have been identified as a clear priority (COM, 2003, 262 final: 9-10). Maintaining access to Algeria's gas reserves is of primary importance to the EU if it wants to keep its dependency on energy imports from Russia to a minimum. The Algerian economy is largely dependent on hydrocarbons, which make up 97 % of exports, contribute 30 % of GDP, and fund 65 % of the state budget. The EU takes 62.7 % of Algeria's exports and supplies 58 % of its imports (EurActiv, 2005).

The European Commission has initiated *the Energy Community*, which binds the European Union and Contracting parties in a common Energy market with set of rules based on EU norms. The Energy Community replicates the Internal Energy market in its essentials: the rules on the gas and electricity markets are there, competition rules, renewables, environmental safeguards etc. At present, the full participation in the Energy Community is limited to *the countries of South East Europe*[15]. However, an observer status was granted to four countries: Moldova, Norway, Turkey and Ukraine (S712/06: 3). There are two long term aims regarding natural gas: To secure an alternative supply of gas for the EU via Turkey and to expand the market for gas in South Eastern Europe, particularly in the Western Balkans where there are currently no gas networks (Ryding, 2004: 2). From the EU viewpoint, the Energy Community will provide energy interconnections with South East Europe and through it to the Middle East and the Caspian region. It will end the network isolation of Greece and provide a platform to diversify sources of supply for the EU.

As highlighted in the Commission's Green Paper on the Security of Energy Supply (COM, 2000, 0769 final), the EU has a specific interest in the extensive oil and gas reserves of *the Caspian Basin* which will, in the future, contribute to security of

[15] Member states: Albania, Bosnia Herzegovina, Bulgaria, Croatia, Former Yugoslav republic of Macedonia, Moldova, Montenegro, Romania, Serbia and Turkey.

supply in Europe. Caspian oil production, currently some 70 mt/y, could reach 200 mt/y by 2010. The key will be to facilitate the transportation of Caspian resources towards Europe, be it via transit through Russia or through other transport routes. Discussions on energy cooperation have started in the framework of the Partnership and Cooperation Agreements with Azerbaijan and with Kazakhstan, in addition to energy related technical assistance performed under the TACIS[16] (Technical aid to the Commonwealth of Independent States) Programme (COM, 2003, 262 final: 12).

The Black Sea region is a production and transit area of strategic importance for the EU energy supply security. It offers significant potential for energy supply diversification. The EU is working closely with regional partners to enhance energy stability through the upgrading of existing and the construction of new energy infrastructure. In this context, the European Commission is developing, in cooperation with its partners, a new trans-Caspian trans-Black Sea energy corridor. The corridor will include several technical options for additional gas exports from Central Asia through the Black Sea region to the EU (COM, 2007, 160 final: 4-5).

Important tools for enhancing security of supply and energy cooperation are the Baku initiative and the INOGATE (Interstate Oil and Gas Transport to Europe) Programme. *The INOGATE Programme* addresses the security of supply related to the oil and gas transport networks of hydrocarbons in the INOGATE Participating Countries[17] in Eastern Europe, Caucasus and Central Asia. It is funded mainly under the EU's TACIS Regional Cooperation Programme (INOGATE, 2004a: 6). *The Baku initiative* is a policy dialogue aimed at enhancing energy cooperation between the EU and countries of the Black Sea, the Caspian Basin and their neighbours[18]. The initiative began as a result of

[16] Launched by the EC in 1991, the TACIS Programme provides grant-financed technical assistance to 12 countries of Eastern Europe and Central Asia, and mainly aims at enhancing the transition process in these countries (The EU's relations with Eastern Europe & Central Asia: Tacis, http://ec.europa.eu/ external_relations/ceeca/tacis/index.htm (20.6.2007)).

[17] INOGATE Participating Countries: Albania, Armenia, Azerbaijan, Belarus, Bulgaria, Croatia, Georgia, Greece, Kazakhstan, Kyrgyzstan, Latvia, the Former Yugoslav Republic of Macedonia, Moldova, Romania, Serbia, Montenegro, Slovakia, Tajikistan, Turkey, Turkmenistan, Ukraine, Uzbekistan.

[18] The partner countries of the Baku initiative: Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Ukraine, Uzbekistan, Tajikistan, Turkey, Turkmenistan, Russia (observer), Iran (political conditions permitting).

the conclusions reached at the Energy ministerial Conference which took place in Baku on 13 November 2004[19].

At the Energy Conference that took place in Brussels in November 2006, Benita Ferrero-Waldner –European Commissioner for External Relations and European Neighbourhood Policy concluded: "Strategic energy infrastructure linking Europe with the Mediterranean Sea, African Sub Sahara, the Caspian Basin, Central Asia and Middle East should be the cement of our common energy security" (S710/06: 6).

3.2.4. DIVERSIFICATION OF OIL

A number of technological solutions and programmes for developing oil from non-conventional sources (such as oil shale, coal, gas, biomass or corn) stand to reduce the scope of US and EU dependence on imported oil. The transportation sector – currently the largest consumer of oil – has also seen an increase in the use of alternative energy sources, including electricity and hydrogen, both being used in hybrid vehicles.

3.2.5.1. NON-CONVENTIONAL LIQUID FUELS[20] (NON-CONVENTIONAL OIL)

Higher prices for crude oil and refined petroleum products are opening the door for non-conventional liquids to displace petroleum in the traditional fuel mix. Growing world demand for diesel fuel is helping to jump-start the trend toward increasing production of non-conventional liquids and technological advances are making them more viable economically (DOE/EIA, 2006b: 51).

This chapter deals with the alternatives to conventional oil, that is the diversification of fuel types coming from other sources (usually coal and gas or from renewable sources like corn) to respond to the ever-increasing depletion of oil, higher demand and energy security. Non-conventional liquid fuels are a part of alternative transportation fuels which also include hydrogen and electricity.

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[19] Baku initiative, http://www.inogate.org/inogate/en/baku-initiative (10.12.2006).
[20] More common expression is "non-conventional oil". However I decided for the term "non-conventional liquid fuels", as it is defined in an EIA study and presented here (DOE/EIA, 2006b: 52).

The term "non-conventional liquids" applies to three different product types (DOE/EIA, 2006b: 52):

1. Syncrude (synthetic crude oil) derived from the bitumen in oil sands, from extra-heavy oil, or from oil shales;
2. Synthetic fuels created from coal, natural gas or biomass feedstocks;
3. Renewable fuels, primarily ethanol and biodiesel, produced from a variety of renewable feedstocks.

3.2.5.1.1. SYNTHETIC CRUDE OILS

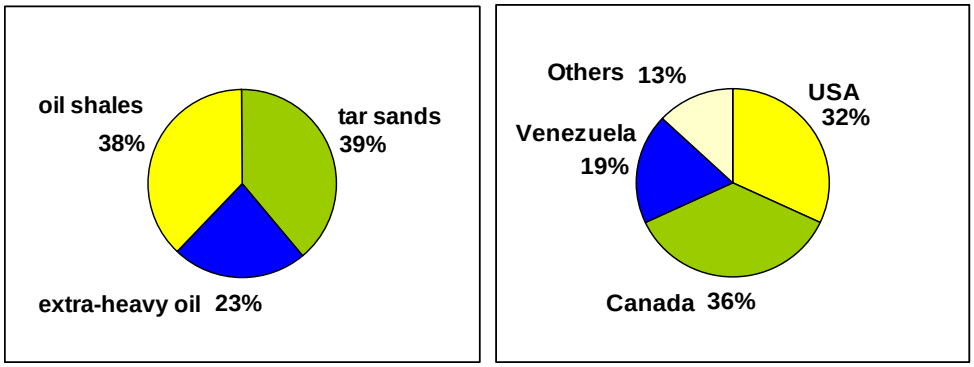
At present two non-conventional oil resources – bitumen (oil sands) and extra heavy crude oils – are actively being developed and produced. Development of a shale oil is more speculative. The greatest risks facing syncrude production are higher production costs and lower crude oil prices. Production of syncrude worldwide is projected to increase to 261.38 mt/year in the reference case[21] and 423.18 mt/year in the high price case in 2030 (Table 12).

Non-conventional oil initially in place could amount to as much as 955 billion tonnes. Extra heavy oil in Venezuela, tar sands in Canada and shale oil in the US, amount for more than 80 % of these resources (Figure 12-13). However the amount of oil that could be recovered from these resources is very uncertain (IEA, 2004a: 95).

The US sees the development of non-conventional oil reserves in the Western Hemisphere as an important factor that promises to significantly enhance global oil reserves and production diversity. The NEP states: "Recent Canadian and Venezuelan success in making heavy oil deposits commercially viable suggests that they will contribute substantially to the diversity of global energy supply, and to our own energy supply mix over the medium to long term" (National energy policy development group, 2001: 8-7).

[21] In the reference case, world crude oil prices, in terms of the average price of imported low-sulfur, light crude oil to the US refineries, decline from current levels to about $47 per barrel (2004 dollars) in 2014, then rise to $54 per barrel in 2025 and $57 per barrel in 2030. The high price case assumes that the worldwide oil resource is 15 % smaller and is more costly to produce than assumed in the reference case. As compared with the reference case, the world oil price in 2030 is 68 % higher in the high price case (around $95) (DOE/EIA, 2006b: 32-33).

Figure 12-13: Synthetic crude oils initially in place



Source: IEA (2004a: 96).

3.2.5.1.1.1. OIL SANDS

Bitumen, the "oil" in oil sands is composed of carbon rich, hydrogen poor long chain molecules. Its viscosity is so high that it does not flow in a reservoir (DOE/EIA, 2006b: 52). Canada's resource of 341 billions tonnes of in-place bitumen is estimated to be 81 % of the world total. Economically recoverable deposits amount to about 42 billion tonnes of bitumen under current economic and technological conditions, and in 2004 Canada shipped more than 11.9 million tonnes of light syncrude. If fully developed, the bitumen resources in Canada could supply more than 40 years of US oil consumption at current demand level (DOE/EIA, 2006b: 52). When the oil sands became recognized as economically viable in 2003, Canada suddenly emerged as holder of the world's second-largest oil reserves, behind Saudi Arabia. But the price is high: Each barrel of oil requires two to five barrels of water, carves up four tons of earth, uses enough natural gas to heat a home for one to five days, and adds to the greenhouse gases. The oil sands mines have become the largest contributor to Canada's increase in greenhouse gas emissions, according to Pembina's research, an Alberta-based nonprofit organization that conducts research on environmental issues (Struck, 2006).

3.2.5.1.1.2. EXTRA-HEAVY OIL

Unlike bitumen, extra-heavy oil will flow in reservoirs, albeit much more slowly than ordinary crude oil. Extra-heavy oil deposits are located in at least 30 countries. One singular large deposit, representing the majority of the known extra-heavy oil resource is located in the Orinoco oil belt of eastern Venezuela. Petroleos de Venezuela SA (PDVSA) estimates that 185.5 billion tonnes of extra-heavy oil are in place in the Orinoco belt, with an estimated 36.8 billion tonnes of currently recoverable reserves. Production in 2004 totalled 20.6 million tonnes (DOE/EIA, 2006b: 53). It is not clear that PDVSA can continue to provide the massive capital investment necessary to sustain the growth of its extra-heavy oil production in the future. Relationships with possible foreign investors have been strained due to actions by the Venezuelan government to renegotiate existing contracts and to structure new ones so as to sharply reduce potential returns to investors. In addition, the recent deterioration of political relations between Venezuela and the US could limit the market for Orinoco-produced extra-heavy crude oils (DOE/EIA, 2006b: 53).

3.2.5.1.1.3. SHALE OIL

The term “oil shale” is something of a misnomer. The rock involved is not a shale but a calcareous mudstone known as marlstone which does not contain crude oil but an organic material, kerogen, that is a primitive precursor of crude oil. The synthetic liquid distilled from oil shale is commonly known as shale oil. The global resource of oil shale base is huge – estimated at a minimum of 395 billion tonnes of recoverable oil, including 102 billion tonnes in the US, mostly in Utah, Wyoming and Colorado, which could supply more than 100 years of US oil consumption at current demand levels, if fully developed (DOE/EIA, 2006b: 53).

In the US, the commercial viability of syncrude produced from oil shale largely depends on oil prices. Although the production costs for oil shale syncrude decline through 2030 it becomes economical only in the high price case, with production starting in 2019 and increasing to 20.2 millions tonnes in 2030, when it represents 4 % of US petroleum production (DOE/EIA, 2006b: 93). A comprehensive in situ process is currently under experimental development by Shell Oil. However it could take as long as

15 years to demonstrate its commercial viability (DOE/EIA, 2006b: 53-54). Production is also uncertain from an environmental perspective because of its potential environmental impacts, involving scenic vistas, waste rock disposal and remediation, water availability and contamination (DOE/EIA, 2006b: 93).

3.2.5.1.2. SYNTHETIC FUELS

Synfuels (synthetic fuels) can be produced from coal, natural gas or biomass feedstocks through chemical conversion into syncrude and/or synthetic liquid products.

3.2.5.1.2.1. COAL-TO-LIQUIDS

There is currently only one commercial scale CTL plant, operated by South Africa's Sasol. Capital costs for such plants are high but operating costs are moderate, particularly in the light of current world oil prices and if low-cost coal feedstocks are available. The US and especially China, due to large coal reserves, are interested in developing CTL projects (DOE/EIA, 2006a: 187). Regarding the US, CTL fuels are predicted to enter the market in 2011 in the reference case. Production in 2030 would be 39.8 million tonnes in the reference case and 84.6 millions tonnes in the high price case. Worldwide CTL production in 2030 totals 89.6 millions tonnes in the reference case and 144.5 millions tonnes in the high price case (Table 12) (DOE/EIA, 2006b: 97).

3.2.5.1.2.2. GAS-TO-LIQUIDS

GTL plants are expected to emerge as a major new market for natural gas, making use of cheap reserves located far from traditional markets. Interest in developing GTL projects has grown rapidly in recent years due to technological advances that have greatly reduced production costs and to higher oil prices. Holders of gas reserves that can not be transported economically to market by pipeline may now be able to turn to GTL as an alternative or complement to LNG. In practice, where a choice will need to be made between GTL and LNG, it will be driven mainly by financial considerations. But GTL

can help to diversify oil companies' activities and reduce their overall portfolio risk. On the other hand, further declines in LNG supply costs could undermine the attraction of GTL (IEA, 2004a: 133).

There are currently only two commercial scale GTL plants in operation: one in South Africa, which started up in 1991, and one in Malaysia, which was commissioned in 1993. Several other plants are currently under construction or planned, most of them in Qatar (five) and one in Nigeria and Australia each (IEA, 2004a: 134). Global GTL capacity is projected to reach 129.4 millions tonnes in 2030 in the high price case (Table 12).

In the US, domestic GTL production originating in Alaska, reflecting a longstanding proposal to monetize stranded natural gas on the North Slope is projected. GTL liquids would be transported to the continental refining system. In 2030, US GTL production totals 20 millions tonnes in the high price case, even though it competes directly with the Alaskan natural gas pipeline project (DOE/EIA, 2006b: 56).

3.2.5.1.2.3. BIOMASS-TO-LIQUIDS (BTL)

BTL encompasses the production of fuels from waste wood and other non-food plant sources, in contrast to conventional biodiesel production, which is based primarily on food-related crops. Therefore it does not conflict with increasing food demands, although crops grown for BTL feedstocks would compete with food crops for land. BTL originates from renewable sources, including wood waste, straw, grain waste, crop waste, garbage and sewage/sludge (DOE/EIA, 2006b: 56).

BTL plants face several challenges. They have high capital and operating costs, and their feedstock handling costs are especially high. The first commercial-scale BTL plant, with a capacity just over 545 thousands tonnes per year, is planned to begin operation in Germany after 2008, followed by four additional facilities (DOE/EIA, 2006b: 45, 56).

The liquefaction industry is still in its infancy. At present there are no commercial GTL or CTL plants in the US other than pilot plants. Worldwide, GTL capacity is nearly

3.0 mt/y (Malaysia and South Africa) and global CTL capacity totals 7.5 mt/y at the original development plants in South Africa. There is no commercial BTL capacity in the US or elsewhere in the world, except for pilot plants (DOE/EIA, 2006b: 57).

3.2.5.1.3. RENEWABLE BIOFUELS

Not to be confused with BTLs are the renewable biofuels, ethanol and biodiesel. These fuels can be blended with conventional fuels, which enhance their commercial attractiveness. As petroleum becomes more scarce and expensive, biofuels could become important alternatives (DOE/EIA, 2006b: 56). Biofuels are the only practical means of reducing the dependence on oil use in transport. The best way to promote long-term security of energy supply is to diversify energy sources. In transport, energy diversity is rather low. Biofuels add to energy diversity by increasing the diversity of fuel types and of regions of origin of fuels (COM, 2006, 845 final: 11).

3.2.5.1.3.1. ETHANOL

Ethanol is the most widely used renewable biofuel and can be produced from any feedstock that contains plentiful natural sugars. Popular feedstocks include sugar bets (Europe), sugar cane (Brazil) and corn (US). Ethanol can be blended into gasoline readily up to 10 % by volume. All cars and light trucks built for the US market since the late 1970s can run on gasoline containing 10 % ethanol. Automakers also produce a limited number of vehicles for the US market that can run on blends of up to 85 % ethanol (DOE/EIA, 2006b: 45, 56).

Limitations to the ethanol production from starchy and sugary crops (DOE/EIA, 2006b: 45, 57):

- All such crops are also used for food and only a limited fraction of the available supply could be diverted for fuel use without driving up crop prices to the point where ethanol production would no longer be economical.
- There is a limit to the amount of suitable land available for growing the feedstock crops.
- A risk of drought.

- Only a portion of the plant material can be used to produce ethanol.

Based on current land use, it is estimated that annual corn ethanol production in the US is limited to approximately 45.42 billion litres to avoid disrupting food markets (DOE/EIA, 2006b: 57). The underutilization of crop residue has driven decades of research into ethanol production from cellulose, which is still not available on a commercial scale. Cellulose-to-biofuel (bioethanol) can use a variety of feedstocks, such as forest waste, grasses, and solid municipal waste to produce synthetic fuel (DOE/EIA, 2006b: 45, 57). Cellulosic ethanol is chemically identical to corn-based ethanol and is equally compatible with existing vehicle technology and fuelling infrastructure. The added advantages lie in its significantly lower energy inputs and greenhouse gas emissions, its much large base of potential feedstocks and its greater potential to become cost-competitive with gasoline at very large production volumes. Under current assumptions, it would take 72.85 million hectares or roughly 40 % of the land already in cultivation in the US to fuel half the current vehicle fleet with cellulosic ethanol. Estimated land requirements can be reduced dramatically – to approximately 12.14 million hectares – if one assumes steady but unremarkable progress over the next two to three decades to double yields of switchgrass, increase the conversion efficiency of ethanol production by one-third, and double the fuel economy of vehicle fleet (Grumet, 2006: 13). The critical first step in this direction, the EPACT05 contains at least ten major programs to promote ethanol derived from cellulosic feedstocks. These programs include explicit authorization for more than $4.2 billion over the next decade to support critical research as well as “first mover” commercial facilities through a combination of grants, loan guarantees and production incentives (Grumet, 2006: 14). One of the goals of the AEI is to foster the breakthrough technologies needed to make cellulosic ethanol cost-competitive with corn-based ethanol by 2012 (National economic council, 2006: 2).

3.2.5.1.3.2. BIODIESEL

Biodiesel is produced from a variety of feedstocks including soybean oil (US), palm oil (Malaysia) and rapeseed and sunflower oil (Europe). Generally the term applies to methyl or ethyl esters of vegetable oil or animal fat. The technology is mature and

proven. In principle, biodiesel can be blended into petroleum diesel fuel or heating oil in any fraction. But it has technical limitations: blend instability and a tendency to form insoluble matters. In practice, the use of ester products as a fuel has been too expensive (DOE/EIA, 2006b: 44, 58).

3.2.5.1.3.3. US AND EU POLICIES ON RENEWABLE BIOFUELS

Government policies are in place to spur biofuels consumption in several countries, especially in the US, the EU, India and in Brazil[22].

The 12.87 billion litres of ethanol blended into gasoline in 2004 amounted to about 2 % by volume of all gasoline sold in the US (National economic council, 2006: 5). The market share of biodiesel is negligible. The energy bill (EPACT05) signed by the President in 2005 established a renewable fuels standard to require the use of 7.5 billion gallons of ethanol and biodiesel by 2012, and extended tax benefits enabling both fuels to compete in today's market (National economic council, 2006: 3). The mandated target of producing 28.39 billion litres of ethanol fuel by 2012 translates into production of roughly 24.4 mt/y, representing approximately 3 % of projected domestic transportation fuel needs in 2012 and less than 5 % of total gasoline demand (Verrastro, 2006). Biodiesel production is assumed to increase to 2.65 billion litres in 2011/12 and then level off. Cellulosic-based production of renewable fuels is assumed to meet the minimum specified in the EPACT05 of 0.95 billion litres in 2013 and subsequent years (USDA, 2007).

In 2003, the EU set an indicative target for its member countries to replace 5.75 % of the gasoline and diesel they use in transport with biofuels before the year 2010. But the target is not mandatory and no specific measures are indicated on how to reach it (IEA, 2004a: 242). However, under current trends the EU will miss the target by 1-2 percentage points (COM, 2006, 105 final: 12). The even more ambitious aim of increasing the level of biofuels in the transport fuel sector to at least 10 % by 2020 was added later (Energy

[22] The greatest successes of biofuels have been scored in Brazil, where ethanol based on sugar cane is blended with gasoline in a proportion that varies between 20 % and 25 %. In 2003, "flex fuel" cars were launched in the Brazilian market and they now represent 18 % of new car sales. These vehicles can run on gasoline, ethanol or any blend of the two. In addition to ethanol, the Brazilian government is also aiming at blending 5 % of biodiesel with ordinary diesel by 2010 (IEA, 2004a: 242).

for a changing world, 2007: 3). In 2005 the market share of biofuels was 1 %, and of that biodiesel accounted for about 80 % and bioethanol 20 % (COM 2006, 845 final: 7).

In 2004, the EU produced 2.1 mtoe of biofuels, while the US produced 7.1 mtoe of ethanol used for gasoline blending (Eurostat, 2006c; DOE/EIA, 2006b: 159).

While the US has more than enough crops to produce biofuels (the US is the largest exporter of corn and soybean), the EU is increasing rapeseed oil imports from Russia and Ukraine. The EU also imports more palm oil from Southeast Asia, as well as some biodiesel from palm oil processed in Southeast Asia. The EU's corn imports from Eastern Europe are expected to increase (USDA, 2007).

Worldwide ethanol production (including biodiesel) in 2030 is projected to be nearly 84.6 million tonnes in the reference case and 149.4 million tonnes in the high price case (Table 12). In the US production totals 34.8 and 44.8 million tonnes respectively. Production of biodiesel is small (1.0 and 1.5 million tonnes respectively).

3.2.5.1.4. NON-CONVENTIONAL LIQUID FUELS – OVERVIEW

Table 12: Non-conventional liquid fuels production in 2030 (mt/y)

	Synthetic crude oils			Synthetic fuels			Renewable fuels		
	Oil sands	Extra heavy oil	Shale oil	CTL	GTL	BTL	Biodiesel	Ethanol*	**Total**
Reference case									
USA	-	-	-	39.83	-	-	1.00	34.85	**74.68**
World	144.38	114.51	2.49	89.62	54.76	-	-	84.64	**492.88**
High price case									
USA	-	-	19.91	84.64	9.96	-	1.49	44.81	**159.32**
World	243.95	154.34	24.89	114.51	129.44	-	-	149.36	**816.49**
Profit** ($)	30	8–11	70–95	42	25	80	80	60***	

Source: DOE/EIA (2006b: 52); data on profitability: DOE/EIA (2006b: 53-56) and The Economist (22.4.2006: 82).

* World includes biodiesel

** For example: CTL is profitable when crude oil price exceeds $42 per barrel.

*** US corn based ethanol, excludes the impact of tax credits; EU's ethanol production costs are about 65 % higher than in the US (The Economist, 14.5.2005: 77).

Table 13: Non-conventional oil production (mt/y)

	2004	2010	2020	2030	% (2004)	% (2030)	% (04-30)
USA	10.95	23.90	46.80	74.68	11.2	13.0	+582.0
Mexico, Canada	45.80	89.12	132.93	178.23	46.9	31.1	+289.1
Western Europe*	1.49	4.48	5.97	6.47	1.5	1.1	+334.2
Asia	9.96	33.85	62.23	102.56	10.2	17.9	+929.7
Middle East	0.50	26.39	36.34	53.77	0.5	9.4	+10654.0
Africa	3.98	3.98	26.39	42.32	4.1	7.4	+963.3
South and Central America	24.40	56.26	88.62	115.01	25.0	20.1	+371.4
Total	**97.58**	**244.45**	**399.28**	**573.53**	**100.0**	**100.0**	**487.8**

Source: DOE/EIA (2006b: 162). Non-conventional oil includes production from oil sands, ultra-heavy oils, GTL and CTL technologies, biofuel technologies and shale oil.

* Western Europe include: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Luxembourg, Netherlands, Portugal, Slovenia, Spain, Sweden, United Kingdom; Switzerland, Norway, Iceland, Bosnia and Herzegovina, Croatia, Macedonia and Yugoslavia.

In 2004, the US, Canada and Mexico accounted for 58.1 % of non-conventional oil production - 83.1 % including South and Central America (Table 13). In this case, the non-conventional oil production favours the Western hemisphere and therefore enhances US energy security, although the numbers are still low. In 2004, the US produced only 10.95 mt of non-conventional oil, while at the same time it imported 504.13 mt of crude oil in 2005. The US production of non-conventional oil is projected to increase by 582.0 % from 2004 to 2030. According to Table 13 (it includes only 15 EU countries and some other European states) the role of the EU is and will stay marginal in the field of non-conventional oil.

3.2.5.2. ALTERNATIVE TRANSPORTATION FUELS

Alternative fuels are any transportation fuels made from a non-traditional source, including ethanol, biodiesel and other biofuels. These can be made from biomass resources, including liquid fuels (ethanol, methanol, biodiesel) and gaseous fuels (hydrogen and methane). Biofuels are primary used to fuel vehicles, but can also fuel engines or fuel cells for electricity generation. Alternative fuels also include traditional

energy sources, such as natural gas and liquid propane that are traditionally not used as a transportation fuel (National energy policy development group, 2001: 6-7). Electricity also has a great potential to contribute to diversity as a transportation "fuel". These alternative fuels reduce dependence on petroleum and reduce or entirely eliminate harmful emissions. With the exception of natural gas and propane, these fuels have the potential of being generated from renewable sources (National energy policy development group, 2001: 6-8).

AEI states three goals for research and policies in order to improve future energy security and to reduce demand for oil (National economic council, 2006: 2):

1. Develop advanced battery technologies that allow plug-in-hybrid-electric vehicles to have a 40-mile range operating solely on battery charge.[23]
2. Foster the breakthrough technologies needed to make cellulosic ethanol cost-competitive with corn-based ethanol by 2012.
3. Accelerate progress towards the President's goal of enabling large numbers of Americans to choose hydrogen fuel cell vehicles by 2020.

AEI explains the vision: "Through the large scale replacement of gasoline with electricity and hydrogen produced from clean coal, nuclear, and renewable technologies, we could dramatically reduce future oil use, balance-of-payment deficits, and emission of air pollutants and greenhouse gases" (National economic council, 2006: 5).

In his 2003 State of the Union Address, President Bush announced a $1.2 billion *Hydrogen Fuel Initiative* to reverse America's growing dependence on foreign oil by developing the technology for commercially viable hydrogen-powered fuel cells to power cars, trucks, homes, and businesses with no pollution or greenhouse gases (National economic council, 2006: 6).

On January 9, 2002, Energy Secretary, with the heads of General Motors, Ford Motor Co. and the Chrysler arm of DaimlerChrysler, announced a new partnership, *FreedomCAR* (Cooperative Automotive Research), to promote the development of hydrogen as the primary fuel for cars and trucks. The "FreedomCAR" program embraces

[23] Current battery technologies used in today's hybrid-electric vehicles store only enough energy to drive the vehicle in an electric-only mode at a low speed for a very short range (1-2 miles). To address the issue, advanced battery technologies such as "lithium-ion" batteries, similar to batteries used in cellular phones and other consumer electronics, can be adapted for vehicle use (National economic council, 2006: 4).

the long-term strategic goal of developing a new breakthrough technology – the hydrogen-powered fuel cell – with a vision of ultimately eliminating American reliance on foreign oil.[24] The Department of Energy estimates that, if hydrogen reaches its full potential, the Hydrogen Fuel Initiative and FreedomCAR program could reduce US oil demand by over 550 mt/y by 2040 – approximately the same amount of crude oil America imports today (National economic council, 2006: 7).

The US and the EU take part in the *International partnership for a Hydrogen Economy*, which is aiming at advancing the global transition to the hydrogen economy, with the goal of making fuel-cell vehicles commercially available by 2020.[25]

In the same manner, the EU – under proposed *Strategic Energy Technology Plan* – is proposing greater research and development towards (COM, 2007, 1 final: 16):

- More efficient buildings, appliances, equipment, industrial processes and transport systems.
- Developing biofuels, in particular second generation biofuels, to become fully competitive alternative to hydrocarbons.
- Using fuel cells and hydrogen technologies to exploit their benefits in decentralised generation and transport.

The vision of Strategic Energy Technology Plan in a transport sector predicts:

- By 2030, transport will need to increasingly adapt to using second generation biofuels and hydrogen fuel cells.
- For 2050 and beyond, an overall European energy mix should include large shares of sustainable hydrogen (and other fuels of the energy mix).

In the long term, the growth of substitute fuels, including biofuels, could technically enable 20 % of diesel and petrol consumed by road transport to be replaced by the year 2020 (COM, 2004: 51-52). At the moment, the EU is assisting cities which are seeking to introduce innovative solutions for developing more balanced and cleaner urban mobility, particularly through the use of substitute fuels or by greater access to public transport.

[24] The White House (2002): *Global climate change policy book*. http://www.whitehouse.gov/news/releases/2002/02/climatechange.html (23.11.2006).
[25] The White House (2005): *Climate Change Fact Sheet*. http://www.whitehouse.gov/news/releases/2005/05/20050518-4.html (23.11.2006).

There is a large-scale demonstration of the potential offered by hydrogen (the introduction of fuel-cell buses) (COM, 2004: 52).

In the long run, alternative energy technologies such as *hydrogen* show great promise. Hydrogen is the most common element and can be made from water. Energy for extracting hydrogen could come from existing, traditional (fossil) fuels, nuclear or renewable energy sources. In the future, hydrogen may be able to be used in furnaces and as a transportation fuel. Hydrogen could also be converted directly into electricity by fuel cells[26]. Still, in the short or even near-term, hydrogen powered fuel cells as a transportation fuel face many obstacles. Current transportation infrastructure is committed to oil and oil-compatible products. Mowing toward automotive fuel cells would require major infrastructure investment and restructuring. It is because of such complications that the NCEP concluded in its December, 2004, report "Ending the Energy Stalemate" that "hydrogen offers little to no potential to improve oil security and reduce climate change risks in the next twenty years" (cited in: Woolsey, 2005: 2). To have an impact within the next decade or two, any competitor of oil-derived fuels will need to be compatible with the existing energy infrastructure and require only modest additions or amendments to it (Woolsey, 2005: 2). This is where plug-in-electric cars and biofuels come into question.

3.2.5.3. ENERGY EFFICIENCY AND DEMAND REDUCTION IN TRANSPORT SECTOR

After the oil shocks of the 1970s, the developed world introduced powerful policies to encourage energy efficiency. In Europe and Japan, these took the form of energy taxes; America chose instead to regulate the car industry through the CAFE law (The Economist, 30.4.2005: 16).

[26] Fuel cells can produce electricity and heat from hydrogen, natural gas, and petroleum fuels, and fuel gases derived from coal and biomass. What makes fuel cells unique is that they can use fuels without combustion, simply by chemical reactions, making them extremely clean and efficient (National energy policy development group, 2001: 6-11).

There are three primary options for reducing demand for (conventional) oil in the transportation sector (Committee on government reform, US House of representatives, 2006: 21):

1. Widespread development of alternative fuels.
2. Increasing gasoline taxes.
3. Aggressively revising fuel economy standards.

Alternative fuels and ethanol are undergoing welcome and rapid development, but their gasoline reduction impact will not be realized on a great scale until well into the future (Committee on government reform, US House of representatives, 2006: 21). Unless the vehicle fleet becomes more fuel-efficient, efforts to promote a greater reliance on alternative fuels will likely falter due to inadequate supply or inadequate driving range. For example, the land requirements for ethanol production or the battery requirements for a plug-in-electric vehicle become much more manageable if the vehicles that employ these fuels or technologies are also highly efficient to begin with (Grumet, 2006: 12). A 50 mpg (miles per gallon) (4.7 l/100 km – litres per 100 kilometres)[27] hybrid gasoline-electric vehicle, on the road today, if constructed from carbon composites would achieve at least 100 mpg (2.3 l/100 km). If it were also a Flexible Fuel Vehicle able to operate on 85 % cellulosic ethanol, it would be achieving hundreds of miles per gallon (of petroleum derived fuel). If it were also a plug-in, operating on either upgraded nickel-metal-hydride or newer lithium-ion batteries, so that 30-mile (48 km) trips could be undertaken on its overnight charge before it began utilizing liquid fuel at all, it could be obtaining in the range of 1000 mpg (0.2 l/100 km) (of petroleum). If it were a diesel utilizing biodiesel or renewable diesel fuel its petroleum mileage could be infinite (Woolsey, 2005: 9). The US could reduce oil consumption in 2015 by 110 mt/y by implementing a 40 % improvement in gasoline vehicle efficiency. If a significant fraction of fuel-efficient hybrid vehicles were added to the mix, the savings would rise to roughly 175 mt/y. Under the most aggressive scenario considered, US oil consumption could be reduced by nearly 250 mt/y if the new vehicle fleet in 2025 were comprised of a

[27] In this section the fuel efficiency – measured in litres per 100 km ("European way") – is given in brackets.

combination of efficient gasoline, gasoline hybrid and plug in hybrid vehicles (Grumet, 2006: 11).

Improving passenger vehicle fuel economy is by far the most significant and reliable oil demand reduction measure available to US policy makers. CAFE standards played an important role in substantially reducing the oil intensity of the US economy between the late 1970 and early 1990s. However, a long-standing political stalemate has blocked significant progress in fuel economy for over two decades (Grumet, 2006: 8-9). Fuel economy has stagnated since 1985, greatly contributing to US oil dependence since the transportation sector consumes the bulk of oil. US industry found it easier to lobby against CAFE increases as an impediment to business operations than to keep making strides in fuel efficiency. Advances in automotive technologies in the domestic market have gone to increased horsepower and vehicle size (Committee on government reform, US House of representatives, 2006: 21). At the time of passing the CAFE laws, light trucks were allowed to meet a lower fuel economy standard because they constituted only 20 % of the vehicle market and were used primarily as work vehicles. Today, light trucks comprise nearly 50 % of the new-vehicle market, and are used primarily as passenger cars. Fuel economy standards are now 27.5 mpg (8.6 l/100 km), and for light trucks 20.7 mpg (11.5 l/100 km); fleet average is 24 mpg (9.9 l/100 km) (Leggett, 2005: 181-182; Woolsey, 2005: 5). For example, the current EU fleet average for new vehicles is 42 mpg (5.6 l/100 km) (the current Japanese average is 47 mpg (5.0 l/100 km)). The main reason is substantial penetration of diesels into the private vehicle market in Europe (Woolsey, 2005: 5, 7). Aware of the situation, the current US Administration increased CAFE standards for light trucks and sport utility vehicles for the first time in a decade, raising the standard from 20.7 mpg to 22.2 mpg (from 11.5 to 10.6 l/100 km) for the current model year 2007 vehicles (National economic council, 2006: 3).

In the US, raising gasoline taxes to greatly reduce demand would harm the economy, disproportionately impact rural areas, and is (therefore) not politically feasible (Committee on government reform, US House of representatives, 2006: 21).

Table 14: US and EU – Fuel taxes and fuel economy

	US	**EU**
Taxes and duties on petrol	18	52.6
and diesel as % of final price	18	47.1
Fleet average fuel economy for new vehicles (l/100 km)	9.9	5.6

Source: COM (2006b: 51), EU taxes and duties are based on the EU average; fuel economy: see previous paragraph.

Oil security objectives have always meant that the US has sought to be without restraint in its ability to consume oil; this focus on the supply side of the equation has meant that the taxation of oil and gas has been far lower than in Europe. Increasing taxes on oil and oil products would now mean political suicide for any party considering it, and as such it is not even considered as a policy tool. There has been interest in improving fuel efficiency, but the carrot approach has been preferred over the stick (COM, 2006b: 111). On the other hand, the EU member states have always favoured demand oriented policy. The EU has very little scope to influence energy supply conditions; it is essentially on the demand side that the EU can intervene, mainly by promoting energy saving in buildings and the transport sector (COM, 2000, 0769 final: 7).

3.2.5. US – NATURAL GAS

US natural gas demand is projected to increase by 19.9 % from 2004 to 2030. A growing share of the US natural gas needs will have to be imported in the future. Natural gas production is struggling to keep pace with demand, which has pushed up prices and increased the use of LNG terminals. Natural gas resources in the region are meagre compared to most other parts of the world. Proven reserves amounted to 7.5 trillion cubic metres at the beginning of 2004, which equals to ten years of production at current rates (IEA, 2004a: 148). In the next two decades or so, production from relatively undeveloped basins and new areas is expected to offset fully declines in the main established basins in the US and Canada. These new sources include deepwater locations in the US Gulf of Mexico, Canadian offshore reserves in Labrador, Newfoundland and Nova Scotia, and the undeveloped Mackenzie River Delta/Beaufort Sea region in northern Canada. The

Alaskan North Slope is also expected to augment supply, although delivering Alaskan gas and gas from northern Canada to market will require the construction of a large-diameter, long distance pipeline (IEA, 2004a: 150).

Canada, currently the source of almost 90 % of US net natural gas imports (Table 15), remains the primary source of natural gas imported into the US until 2010. After 2010, LNG imports from overseas replace Canadian imports as the primary source (Figure 14). The decline of Canada's largest producing basin coupled with 1.9 % projected average annual growth in Canada's domestic consumption, leaves less Canadian natural gas available for export to the US. (DOE/EIA, 2006a: 41). Net exports of US natural gas to Mexico decrease from 2004 through 2011, as new LNG terminals are built in Mexico (DOE/EIA, 2006b: 86).

Table 15: US natural gas imports by country of origin (bcm/y)

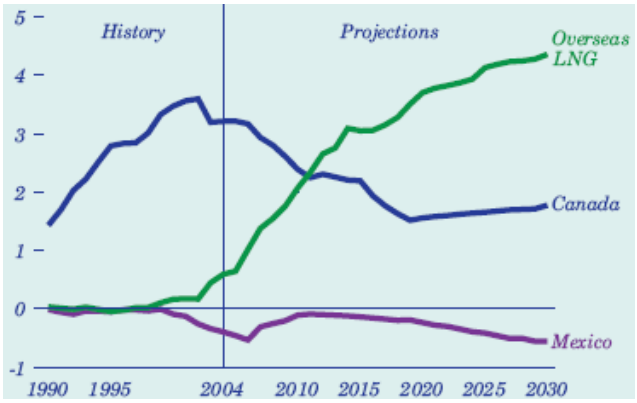
		1990	**2000**	**2005**	**% (2005)**	**(90-00)**	**(00-05)**	**% (90-00)**	**% (00-05)**
1	Canada	40.98	100.29	104.72	85.2	+59.31	+4.43	+144.7	+4.4
2	Trinidad	0	2.80	12.43	10.1	+2.80	+9.63	/	+343.9
3	Algeria	2.38	1.33	2.75	2.2	-1.05	+1.42	-44.1	+196.8
4	Egypt	0	0	2.05	1.7	0	+2.05	/	/
5	Mexico	0	0.33	0.26	0.2	+0.33	-0.07	/	-21.2
6	Malaysia	0	0	0.25	0.2	0	+0.25	/	/
7	Nigeria	0	0.36	0.23	0.2	+0.36	-0.13	/	-36.1
8	Qatar	0	1.30	0.08	0.07	+1.30	-1.22	/	-93.8
9	Oman	0	0.28	0.07	0.06	+0.28	-0.21	/	-75.0
10	Australia	0	0.17	0	0	+0.17	-0.17	/	/
	Total imports	**43.36**	**107.02**	**122.85**	**100.0**	**+63.66**	**+15.83**	**+146.8**	**+14.8**

Source: DOE/EIA (2007a).

High gas prices continue to spur interest in developing LNG projects to supply North American markets. Currently, the US has five LNG import facilities in operation, with a combined peak annual capacity of 45.3 bcm (billion cubic metres). Three additional terminals under construction in the Gulf of Mexico will add a combined peak annual regasification capacity of 56.6 bcm, more than doubling US LNG import capacity. US annual peak LNG import capacity in 2030 is projected to be 167 bcm, with actual imports of 124.5 bcm. The growth of US LNG import capacity is expected to be strong through 2015 and then to slow as high natural gas prices begin to slow the growth of domestic consumption (Figure 14). LNG imports into Canada are also expected to

contribute to the supply of Canadian natural gas available for export to the US. LNG is expected to be a significant contributor to supply in the US, indicative of the country's growing dependence on imports and the increasing globalization of natural gas markets (DOE/EIA, 2006a: 42). Russia's giant gas company Gazprom has pre-sold 80 % of the LNG it will produce over 20 years (in "Sakhalin II" area) to Japan, South Korea and North America (via Mexico) (The Economist, 8.10.2005: 90).

Figure 14: US net imports of natural gas by source, 1990-2030 (trillion cubic feet)



Source: DOE/EIA (2006b: 86).

Non-conventional reserves – coal-bed methane, tight gas (extracted from low-permeability sandstone) and shale gas – mostly found in the US Rocky Mountains will also provide a major new source of supply. These sources of gas have become an important component of US gas supply since the late 1980s, accounting today for around a quarter of total gas production. In the rest of the world, non-conventional gas production is still modest. Although resources are thought to be abundant in many parts of the world, they are generally costly to produce and so have not been appraised in detail (IEA, 2004a: 139).

3.2.6. EU – NATURAL GAS

EU natural gas production amounted to around 240 bcm in 2003. The UK provided 49 % of the EU's natural gas production (Netherlands 28 %, Germany 8 % and

Denmark 4 %) in 2004. There is limited potential for increasing natural gas production in the region as resources are small. Proven reserves are less than 3.4 tcm, or 2 % of the world's total. Production from the North Sea is expected to decline steadily. The UK will become a major net importer of natural gas before the end of the decade. Total EU natural gas production is projected to decline down to 147 bcm in 2030. Production in Norway, most of which is exported to the EU, is expected to continue to grow, from 77 bcm in 2003 to 135 bcm in 2030. Rising demand and stagnating production will result in a surge in net imports, from 233 bcm in 2002 to 639 bcm in 2030 (IEA, 2004a: 155).

Diversification has been more important in the EU's imports of natural gas than in the imports of crude oil. The share of natural gas imported from the two traditional sources – Russia and Algeria (Algeria was the second biggest source of natural gas between 1990-2000) – have been replaced by other imports, mainly from Norway, Nigeria, Libya, Egypt, Qatar and other sources (including Trinidad, Oman, and UAE), although imports from Russia and Algeria increased too (Table 16). The EU will also import a mixture of piped natural gas and LNG from other African and FSU countries, the Middle East and Latin America. Russia will remain the largest single supplier in 2030, exporting around 155 bcm compared with 105 bcm in 2002. But the biggest increase in supplies will be from the Middle East, mostly in the form of LNG, although increasing quantities of natural gas are expected to be transported to Europe by pipeline from Iran and possibly Iraq lately. Other new sources of natural gas are expected to include the Caspian region (by pipeline), Libya (via under-sea pipeline), Egypt and Qatar (both LNG). Venezuela could emerge as a LNG supplier in the long term (IEA, 2004a: 155).

Table 16: EU natural gas imports by country of origin (bcm/y)

		1990	**2000**	**2005**	**% (2005)**	**(90-00)**	**(00-05)**	**% (90-00)**	**% (00-05)**
1	Russia	97.33	113.71	123.20	41.6	+16.38	+9.49	+16.8	+8.3
2	Norway	26.77	52.67	70.11	23.7	+25.90	+17.44	+97.1	+33.1
3	Algeria	28.93	58.45	59.88	20.2	+29.52	+1.43	+102.0	+2.4
4	Nigeria	0	4.56	11.58	3.9	+4.56	+7.02	/	+153.9
5	Libya	1.12	0.89	5.56	1.9	-0.23	+4.67	-20.5	+524.7
6	Egypt	0	0	5.37	1.8	0	+5.37	/	/
7	Qatar	0	0.33	5.19	1.8	+0.33	+4.86	/	+1472.7
8	Other FSU*	0	1.06	4.80	1.6	+1.06	+3.74	/	+352.8

9	Oman	0	0	1.89	0.6	0	+1.89	/	/
10	Trinidad	0	0.96	0.79	0.3	+0.96	-0.17	/	-17.7
11	Malaysia	0	0.08	0.29	0.1	+0.08	+0.21	/	+262.5
12	UAE	0	0.16	0.26	0.1	+0.16	+0.10	/	+62.5
13	others	0	2.76	7.45	2.5	+2.76	+4.69	/	+169.9
	Total imports	**154.15**	**235.63**	**296.37**	**100.0**	**+81.48**	**+60.74**	**+52.9**	**+25.8**

Source: Eurostat (2006b); intra-EU trade is not included

* It includes FSU less Russia; according to the BP (2006: 30): Turkmenistan 1.10 and Ukraine 1.50 in 2005.

3.2.7. TRANSPORT ROUTES

Increased trade, especially from the Middle East, will strengthen the mutual dependence among exporting and importing countries. But it will also intensify worries about the world's vulnerability to oil-supply disruptions, as much of the additional trade will involve transport along routes that are at risk of sudden closure. Some of the principal maritime routes that oil and LNG tankers are obliged to follow have narrow sections that are susceptible to piracy, terrorist attacks or accidents. The world will also rely more on oil shipped through pipeline systems, which are also vulnerable to accidental or deliberate disruptions (IEA, 2004a: 118). Since alternative routes are lacking, the effect of a major blockage at one of these points could be devastating.

The US protects the global oil trade routes. In part, this is because the US has unmatched military capabilities. But another reason is that other nations know the US military is out there doing the job. Nearly all of US military commands handle oil security tasks. Central Command guards access to oil supplies in the Middle East. Southern Command defends Columbia's Cano Limon pipeline. Pacific Command patrols tanker routes in the Indian Ocean, the South China Sea, and the Western Pacific. European Command is involved in oil security all the way from the Caspian Sea to West Africa (Wald, 2006: 2-3).

3.2.7.1. SEA TRANSPORT ROUTES

Today more than 1742 million tonnes of oil pass through the channels every year (Map 7). A disruption in supply at any of these points could have a dramatic impact on

oil prices, especially in case of very tight oil supplies. As global oil trade expands, these strategic channels will become even more heavily used. Traffic through the Straits of Hormuz and Malacca and the Suez Canal is projected to more than double till 2030 (Table 17). The share of oil imports through the Straits of Malacca in total world oil demand will grow from 14 % in 2002 to 20 % in 2030 (Map 7). LNG trade through these channels will rise even more (IEA, 2004a: 119). Currently, the EU imports more than two times more LNG than the US (Table 18).

Table 17: Oil and LNG tanker traffic through strategic maritime channels (oil: mt/y, gas: bcm/y)

		2002		2030	
		Volume	Share of global interregional net trade (%)	Volume	Share of global interregional net trade (%)
Straits of Hormuz	Oil	748	44	2141	66
	LNG	28	18	230	34
Straits of Malacca	Oil	548	32	1195	37
	LNG	40	27	94	14
Suez Canal	Oil	50	4	149	4
	LNG	4	3	60	9

Source: IEA (2004a: 119).

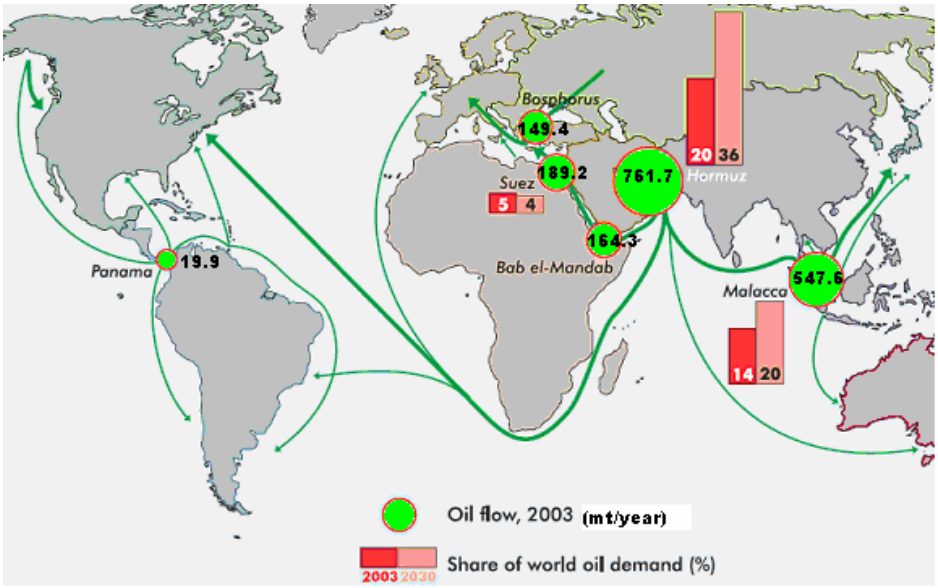
Table 18: US and EU – Natural gas imports by pipeline and LNG (bcm)

	USA	**2005**	**%**		**EU**	**2005**	**%**
	Pipeline				**Pipeline**		
1	Canada	104.18		1	Russia	121.53	
2	Mexico	0.03		2	Norway	79.38	
	Total pipeline	**104.21**	**85.4**	3	Algeria	37.78	
	LNG			4	Libya	4.49	
1	Trinidad	12.44		5	Other Europe & Eurasia	3.25	
2	Algeria	2.75		6	Ukraine	1.50	
3	Egypt	2.05		7	Turkmenistan	1.10	
4	Malaysia	0.25			**Total pipeline**	**249.03**	**85.4**
5	Nigeria	0.23			**LNG**		
6	Qatar	0.08		1	Algeria	19.0	
7	Oman	0.07		2	Nigeria	10.78	
	Total LNG	**17.87**	**14.6**	3	Egypt	4.58	
	Total imports	**122.08**	**100.0**	4	Qatar	4.56	
				5	Oman	1.73	
				6	Libya	0.87	
				7	Trinidad	0.65	

				8	UAE	0.31	
				9	Malaysia	0.16	
				10	Australia	0.08	
					Total LNG	**42.72**	**14.6**
					Total imports	**291.75**	**100.0**

Source: BP (2006: 30).

Map 7: Oil flows and major chokepoints, 2003



Source: Map and data based on IEA (2004a: 120).

3.2.7.2. PIPELINES

3.2.7.2.1. US

North America's energy infrastructure and energy flows are increasingly interconnected. Cross border oil flows are very important to the region's economies. Canada and Mexico are key suppliers of crude oil to the US (Maps 8-11). Distant resources require infrastructure for transport. Canada's crude oil in the west (Alberta) and in Newfoundland is both distant from key markets in Ontario, Quebec and the US. Mexico's production requires transport both inland and across the Caribbean. The US transports oil great distances from Alaska (North American energy working group, 2002b). The Trans-Alaska Pipeline System is the single most important crude oil pipeline

in the US. The pipeline system has carried nearly one-fifth of all domestically produced oil for the last two decades. Since beginning operations in 1977, it has transported more than 1.77 billion tonnes of oil from Alaska's North Slope across 800 miles to the port of Valdez (National energy policy development group, 2001: 7-10).

Map 8: US and Canada – crude oil pipelines



Source: Centre for energy (2006). Proposed pipelines are dotted.

Map 9: US and Canada – major natural gas pipelines



Source: Centre for energy (2006). Proposed pipelines are dotted.

Rising natural gas prices would make it economical for two major North American pipelines that have long been in the planning stages to come online. The first, a Canadian pipeline to transport natural gas from the MacKenzie Delta, is expected to become operational in 2011. The second, an Alaskan pipeline, is expected to begin transporting natural gas from Alaska to the central US (the lower 48 states) in 2015, contributing significantly to the domestic supply. From 2003 to 2030, Alaska's natural gas production accounts for most of the growth in domestic US conventional natural gas production, with flows on the pipeline exceeding 56.6 bcm in 2030 (DOE/EIA, 2006a: 41-42). Although the Alaska Natural Gas Pipeline Act signed by the President in 2004 contained numerous incentives for the industry and the State of Alaska to reach

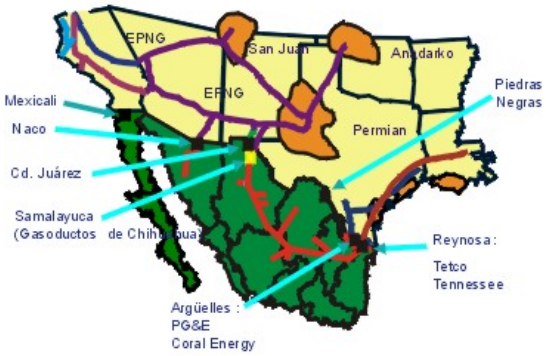
agreement in those items needed to build the pipeline, no agreement has been reached yet (National economic council, 2006: 15).

Map 10: Mexico – oil pipelines



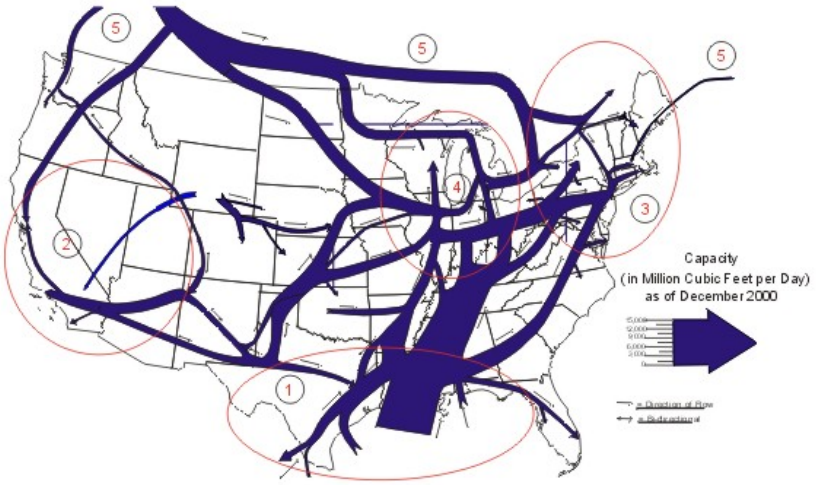
Source: North American energy working group (2002b).

Map 11: Natural gas interconnections between Mexico and the US



North American energy working group (2002a).

Map 12: Natural gas pipeline capacity serving the US marketplace



Source: North American energy working group (2002a).

A large portion of natural gas pipeline capacity (Map 12) within the US is directed from major production areas (1) of Texas and Louisiana to markets in the Western (2), North-eastern (3) and Midwestern (4) regions of the country. In the past ten years increasing levels of gas from Canada (5) have targeted these markets as well. There are numerous pipeline connections between the US and Canada. Major connections join Texas and north-eastern Mexico. Infrastructure growth in the Baja California region in Mexico is expected (North American energy working group, 2002a).

Hurricanes Katrina and Rita (August and September 2005) delivered a devastating blow to the nation's energy infrastructure because of the Gulf of Mexico's central role in production and refining. According to the Federal Reserve Bank of Dallas' Houston Branch, 26.4 % of the nation's domestic crude oil production and 21.3 % of natural gas production takes place in the Gulf of Mexico. Almost 40 % of the nation's crude oil refining capacity is located on the Gulf Coast (Committee on government reform, US House of representatives, 2006: 10). The domestic US oil and gas industry has come to be precariously dependent on production in the hurricane-prone Gulf of Mexico, in part because lawmakers have enacted off-shore drilling bans for the Gulf coast of Florida and most of the Atlantic and Pacific coasts (Chow et al, 2005: 147). Map 12 shows the centrality of the Gulf of Mexico for the distribution of natural gas.

3.2.7.2.2. EU AND THE ROLE OF RUSSIA

Increased Russian exports to the EU will require substantial additions to pipeline capacity. Two major oil pipelines that transport Russian crude oil to the Europe are the Druzhba pipeline (59.7 mt/y) and the Baltic pipeline system (49.8 mt/y), which carries crude oil to Baltic Sea ports (IEA, 2004a: 118). Russian exports of crude oil and refined products are limited by a lack of transportation and terminal capacity. Net exports of crude oil are mostly shipped by pipeline – either cross-border or to sea terminals. The crude oil pipeline system – built during the Soviet era and controlled entirely by Transneft, a state monopoly – is far from utilized. Large parts of the system, including some lines in Latvia and Ukraine, are no longer used because patterns of supply have shifted. But there are still bottlenecks along some export routes, especially in the Black

Sea ports (IEA, 2004a: 305). The Energy Charter Treaty[28], which Russia has signed but not yet ratified, sets out rules on energy trade, investment protection, transit and dispute resolution. Ratification of the treaty, as well as agreement on the Transit Protocol currently being negotiated by Treaty members, could encourage investment in long-distance pipelines (IEA, 2004a: 325).

In order to increase production, new pipelines should be built. One is expansion to the Caspian Pipeline Consortium pipeline that runs from Kazakhstan through Russia to Ukraine; its capacity will rise to over 50 mt/y by 2010. The other is newly opened BTC pipeline (44.8 mt/y) that is bringing Azeri oil across Georgia to the deep-water port of Ceyhan on Turkey's Mediterranean coast. Much of the increase in Russian oil exports will go to Europe, Asia and the Pacific region. If the pipeline to Murmansk is built, oil could be exported to the US as well (IEA, 2004a: 108, 323).

Russia alone and much of Europe was affected in January 2006 when Russia, in dispute over contract prices, cut off natural gas supplies to Ukraine. That is why the EU is trying to construct gas pipeline under the Baltic Sea that would bypass traditional transit states and avoid such disruptions in the future. On the other hand, where possible, the EU (and other regional states as well as the US) is supporting pipelines that would bypass Russia alone. For example, a new pipeline system is being built that will carry gas from Azerbaijan to Turkey via Georgia. A further important pipeline project is the Nabucco which will span 3400 kilometers and which will bring 31 billion cubic tons of natural gas per year from the eastern end of Turkey across Romania, Bulgaria and Hungary into Austria. Nabucco is geo-politically significant because it will bypass Russia, much like the BTC. The project is to be completed by 2013 (EurActiv, 2005).

Russia is trying to remain influential in the Caspian region. Over 1 trillion cubic metres of the region's gas reserves of 8 trillion cubic metres have already been sold to Russia's Gazprom[29] under long-term deals signed in 2002 and 2003. Those deals will

[28] The Energy Charter Treaty is an international agreement originally based on integrating the energy sectors of the former Soviet Union and Eastern Europe at the end of the Cold War into the broader European and world markets.

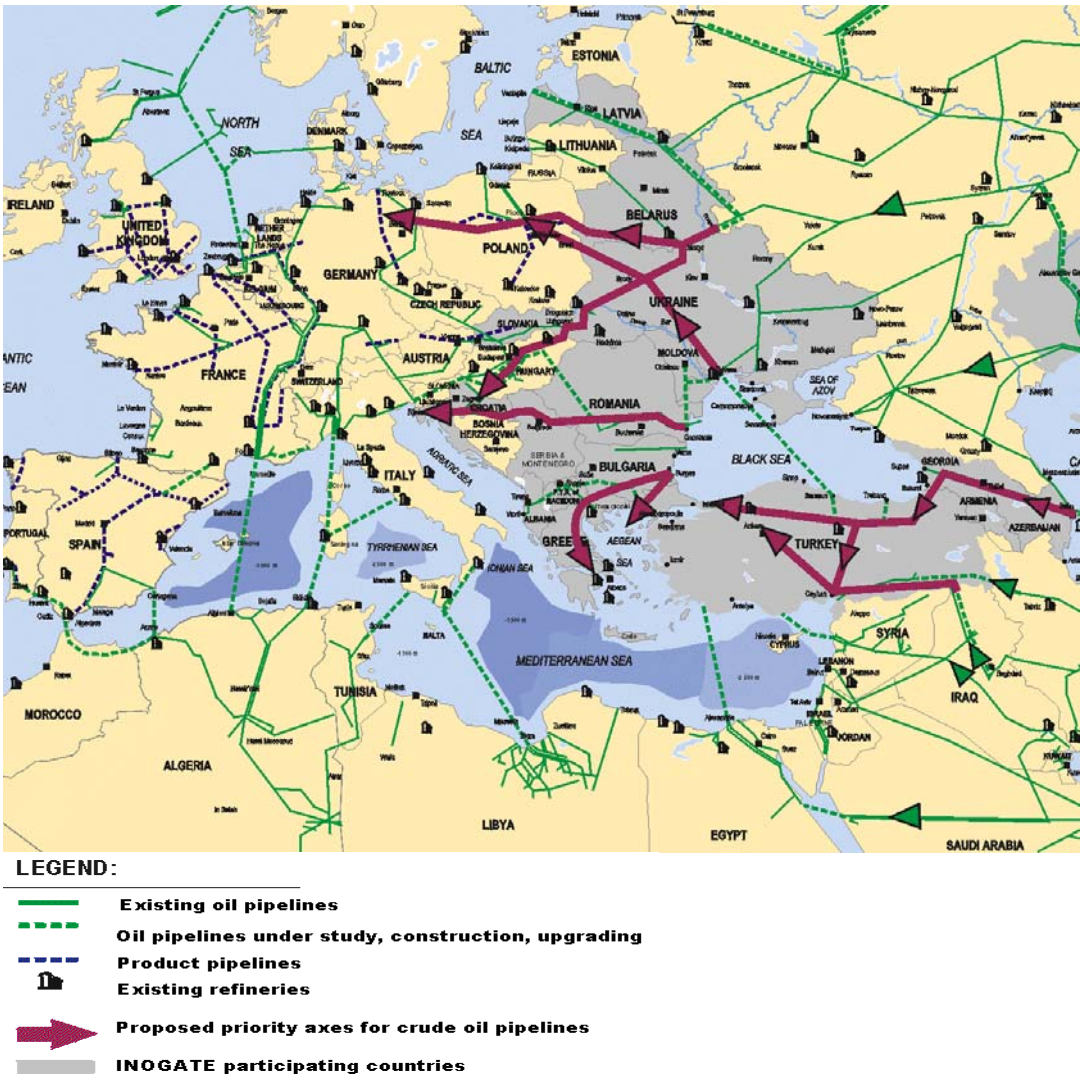
[29] In 2004 Gazprom produced 20 % of the world's gas. It has 60 % of Russia's gas reserves and 16 % of the world's. If it were a country, its oil and gas reserves combined would rank only behind Saudi Arabia's and Iran's (The Economist, 8.10.2005: 87).

postpone the need for Gazprom to invest in developing more expensive indigenous supply sources. They will also effectively eliminate those countries as direct competitors for export sales to Europe. Gazprom has also restricted their national gas companies' access to its transmission system, impeding their ability to sell directly to European buyers (IEA, 2004a: 160).

Given the increasing density of the maritime traffic in the waters around the EU and in the enclosed Black Sea, it is of utmost importance to give a higher priority to considering, where economically and technically feasible, the alternative of transporting oil by pipelines, which is considerably safer and more environmentally friendly. In this context, the priority axes for crude oil pipelines are as follows (Map 13) (INOGATE, 2004a):

- Upgrading and enhancing the whole Druzhba pipeline, in particular across northern Europe as an alternative to increasing maritime oil transportation in the Baltic Sea, and the reversal of the Adria pipeline in Croatia and Hungary.
- Extending the Odessa-Brody pipeline to Plock.
- Building a Constanta-Omisalj-Trieste pipeline.
- Building a Burgas-Alexandroupolis pipeline, that would reduce the increasing pressure of maritime oil transport through the Bosphorus.

Map 13: Proposed priority axes for crude oil pipelines



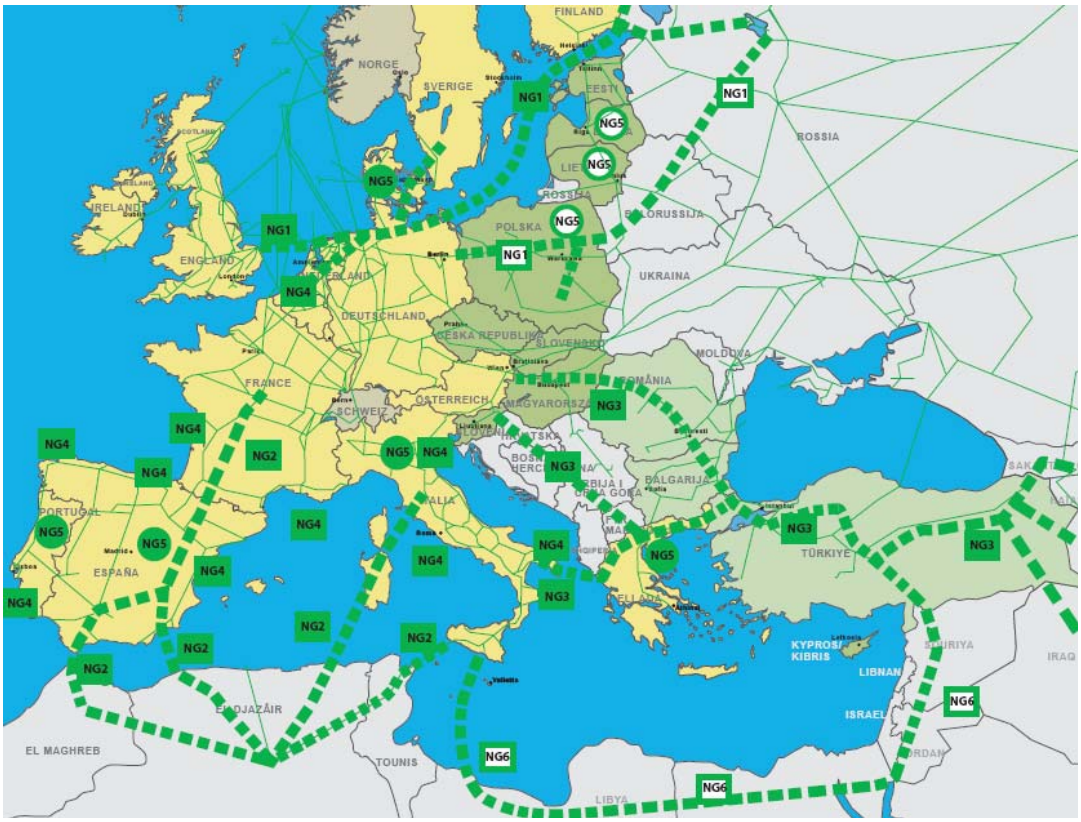
Source: Inogate (2004b).

3.2.7.2.2.1. TRANS-EUROPEAN NETWORKS

The concept of trans-European networks (TEN) emerged in the late 1980s as a necessary condition for the proposed Single Market. TENs have been defined for the three main network industries: energy, transport and telecommunications. One of the main changes introduced by the 2003 Council guidelines (and adopted by the European Parliament in 2004) was the identification of priority projects and the broader concept of priority axes, which have been identified as most important for supply security concerns

or for the competitive operation of the internal market. Five priority axes (Map 14) were identified regarding natural gas (COM, 2006b: 36-37).

Map 14: EU – Natural gas networks – axes for priority projects



Source: COM (2004: 32).

Natural gas priority projects already agreed (COM, 2004: 32):

NG1: United Kingdom – northern continental Europe – Russia, including Netherlands, Denmark and Germany (with connections to the Baltic Sea region countries)

NG2: Algeria – Spain, Italy, France – northern continental Europe

NG3: Caspian Sea countries, Middle East – EU

NG4: LNG terminals in Belgium, France, Spain, Portugal and Italy

NG5: Underground storage in Spain, Portugal, Italy, Greece and the Baltic Sea region

Proposed additional natural gas priority project:

NG6: Mediterranean member states – East Mediterranean gas ring

The first priority axis (the North European Pipeline) is seen as a way of enhancing EU supply security, since it would bypass both Belarus and Ukraine. It is projected to be constructed under the Baltic Sea.

3.2.8. THE INFLUENCE OF OTHER POWERS

The fastest growth in oil demand is projected for the Asian developing economies, what represent the greatest shift in world oil consumption patterns. The rising dependence of China and other developing Asian countries on Middle Eastern oil suppliers has geopolitical implications both for relations between the two regions and for the oil-consuming world as a whole. The increase in dependence will be most dramatic in China, which only became a net oil importer in 1993. By 2030 imports will meet 74 % of China's oil demand, what is equal to 500 mt/y, the current volume of imports into the US (Table 19). Consumption of natural gas is expected to grow faster in developing Asia than in any other major region. Primary demand is expected to expand more than threefold, from 208 bcm in 2002 to 322 bcm in 2010 and 672 bcm in 2030 (Figure 15).

Table 19: Oil and gas import dependence in Developing Asia* (net imports, %)

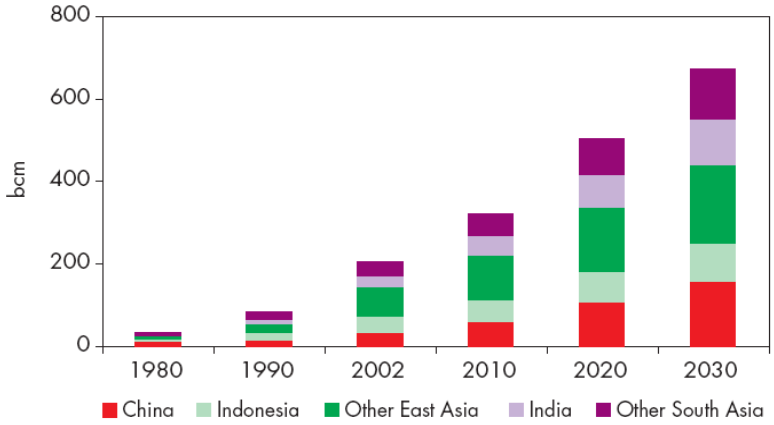
	Oil**				Gas					
	2002	2010	2020	2030	2002		2010		2030	
					bcm	%	bcm	%	bcm	%
China	34	55	68	74	0	0	9	15	42	27
India	69	80	87	91	0	0	10	23	44	40
Other	40	54	68	76						
Total	43	59	72	78						

IEA (2004a): 117, 140 (gas).

* Developing Asia includes Asia less FSU, Middle East, Turkey, Japan and South Korea.

** Includes non-conventional oil.

Figure 15: Primary gas demand in developing Asia



Source: IEA (2004a: 161).

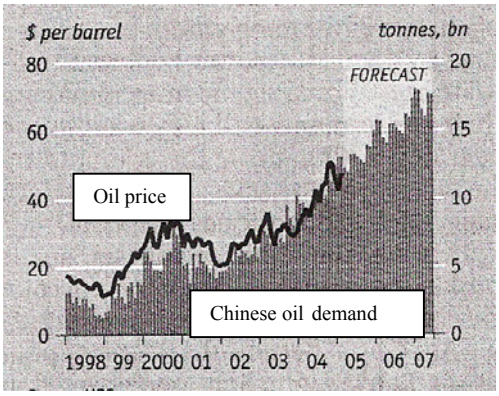
China became a net importer of petroleum products and crude oil in the early 1990s. The change prompted increased exploration for oil within its territory, but that has not shown significant results. Over the past three years there have only been modest new oil and gas discoveries. China's growing energy needs are bound to have profound impacts on a geopolitical scale, especially since Chinese energy policy focuses on managing rather than reducing its import requirements, mainly through supply diversification, but also through direct investments in oil and gas producing states (COM, 2006b: 110). China has met its rapidly growing oil import needs in recent years by shifting from Asian sources to a few Middle East countries – particularly Oman, Yemen and Iran – and, increasingly, to Africa, Russia and Central Asia (Jaffe et al, 2002: 119). The insecurity of Middle East supply, China's discomfort with US domination of important sea lanes and other accompanying problems have led the Chinese to consider inland alternatives. One option is to put greater emphasis of supplies from countries that border China – notably Russia and Kazakhstan (Jaffe et al, 2002: 125). Another of Beijing's strategies to reduce China's oil-supply insecurity is a move to internationalise the Chinese oil industry. Starting in 1996, the government unveiled a plan to attain around a third of its energy needs through international exploration and acquisition activities. China National Petroleum Corporation (CNPC) initiated investments in international oil fields in such locations as the Sudan, Venezuela, Kazakhstan and Peru (Jaffe et al, 2002: 122). The most concerning for the US are the arrangements with Saudi

Arabia, China's role in Central Asia, transfers of weapons to certain Middle Eastern countries and cooperation with anti-American regimes such as Venezuela and a spoiling game in Sudan. The answer, according to Chinese strategists, is to focus China's international exploration drive on countries where Western, predominantly US, firms cannot so easily get in the way. Countries under US unilateral oil sanctions are therefore prime Chinese investment targets. Chinese oil-industry sources complain that CNPC's legal and financial inexperience makes it difficult to compete with the major international oil companies to gain oil-exploration rights in promising areas. Foreign policy analyst Yishan Xia puts it in rather traditional terms (Jaffe et al, 2002: 126-127):

> Western monopoly capital, with the support and assistance of their governments, has scrambled and seized the main oil and gas resource markets in all parts of the world. Almost all good resources markets in the world have been occupied and possessed by them. There is intense competition among different groups of Western monopoly capital. All of them will certainly try even harder to impede Chinese companies from obtaining these oil resources.

China's petroleum imports are expected to grow fourfold from 2003 to 2030, with much of the increase coming from Persian Gulf suppliers. In 2003, China imported 44.8 mt of oil from Persian Gulf OPEC members (total oil imports equal 139.4 mt), and in 2030 its Persian Gulf imports total 288.8 mt (total oil imports equal 542.7 mt) (DOE/EIA, 2006a: 25, 34). Although China accounts for only 8 % of global oil consumption, well below America's 25 %, it has accounted for as much as one third of the increase in global oil demand over the past three years, almost twice as much as America. Figure 33 shows a correlation between rising world crude oil prices and Chinese growth of oil imports (The Economist, 19.2.2005: 78).

Figure 16: China's growing imports of oil and rising world crude oil prices



Source: The Economist (19.2.2005: 78).

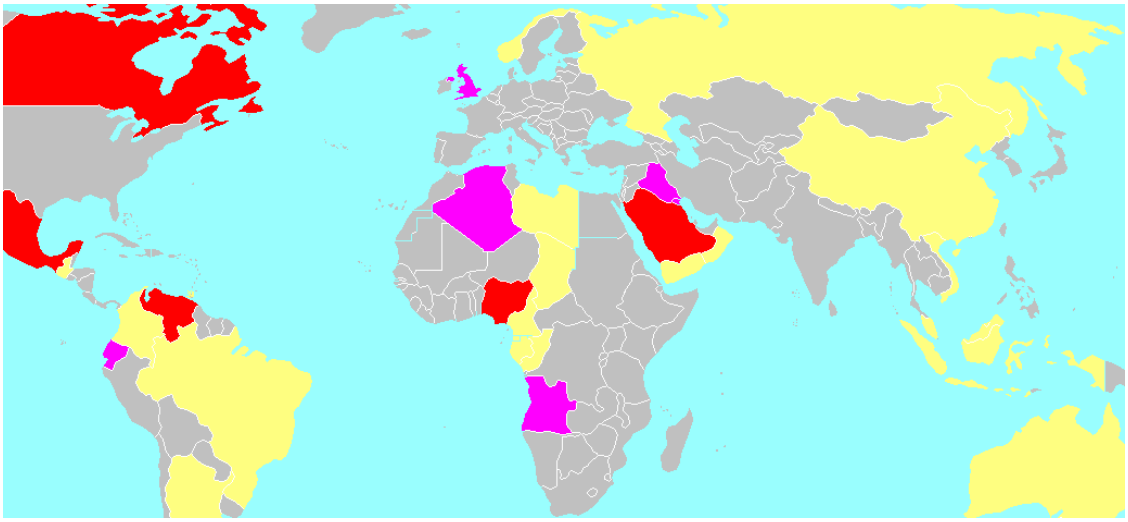
3.2.9. GEOGRAPHICAL DIVERSIFICATION – OVERVIEW

3.2.9.1. CRUDE OIL IMPORTS BY COUNTRY

US crude oil imports are geographically more diversified than the EU's. Russia and Norway, followed by Saudi Arabia are sources of the majority of EU crude oil imports. US crude oil imports are based (in 2005) on quite equal imports from five countries: Canada, Mexico, Saudi Arabia, Venezuela and Nigeria (Map 15 and 16, Figure 19 and 20). The US is also reducing its crude oil imports from Middle Eastern countries and countries that are geographically farther from the US and increasing imports from Latin American and African countries and Russia (Figures 17, 21, 23). The EU is also decreasing crude oil imports from Middle Eastern countries and increasing imports from the FSU and African countries (Figures 18, 22, 24).

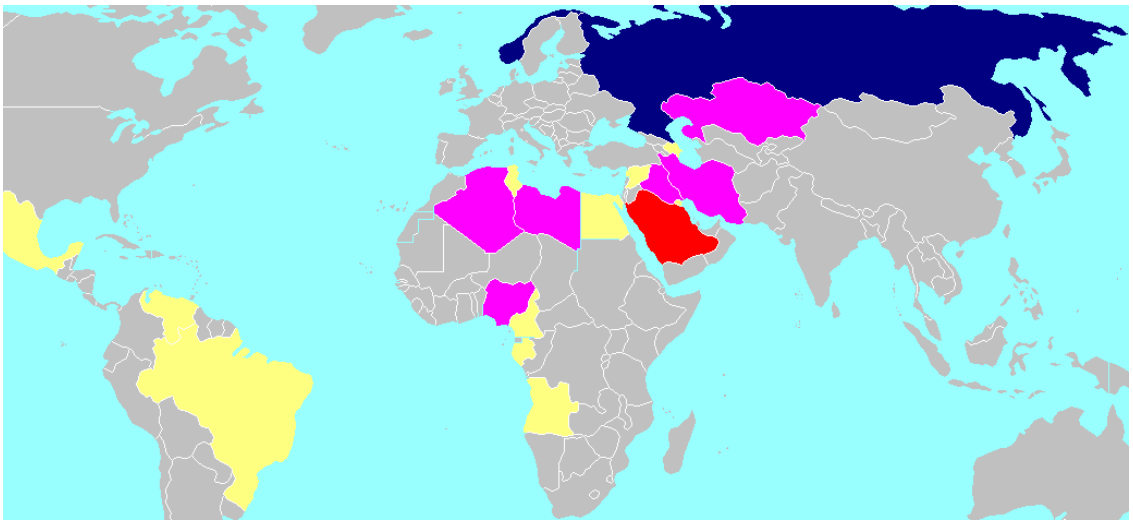
Although the US crude oil imports are geographically more diversified, the EU crude oil imports could be considered safer. The EU gets most of its crude oil from stable neighbouring countries like Russia, Norway, FSU and North Africa.

Map 15: US – crude oil imports by country of origin (2005)



Source: map based on Wikipedia (2006); data based on Table 8.

Map 16: EU – crude oil imports by country of origin (2004)



Source: map based on Wikipedia (2006); data based on Table 10.

Legend (Map 15 and 16):

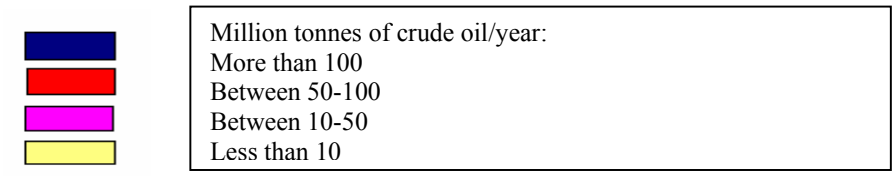
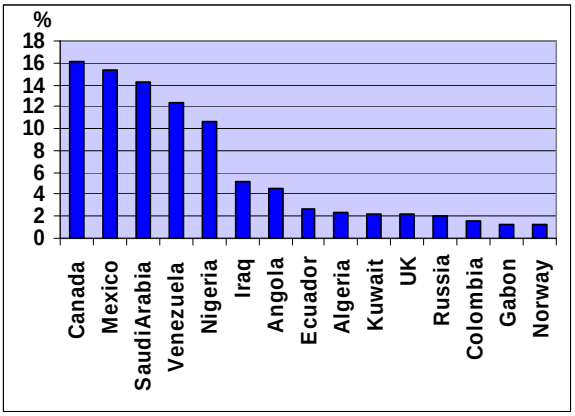
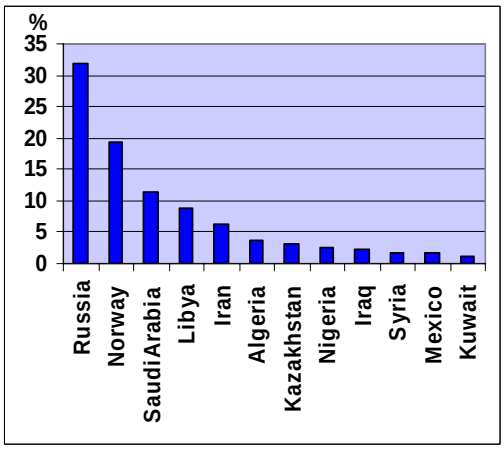


Figure 17: US – shares of crude oil imports by country of origin (2005). Countries with more than 1 % share are included.



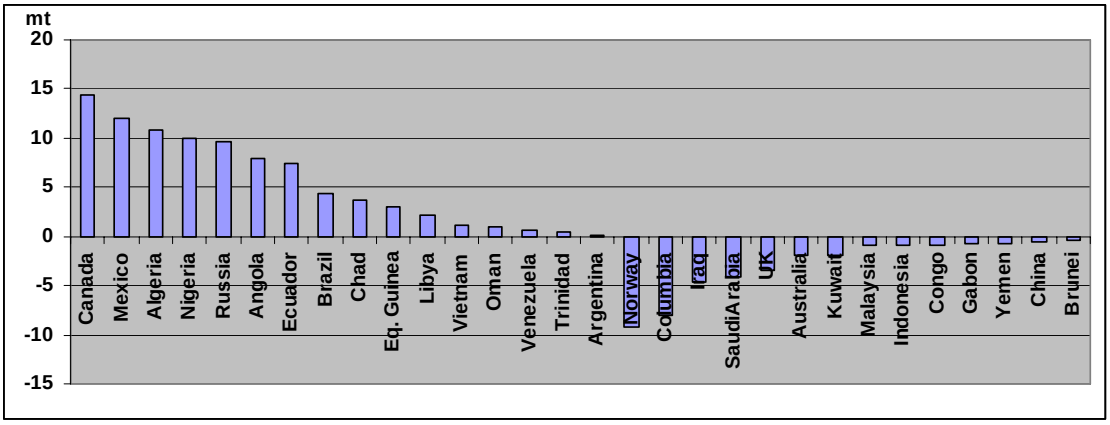
Source: Data based on Table 8.

Figure 18: EU – shares of crude oil imports by country of origin (2004). Countries with more than 1 % share are included.



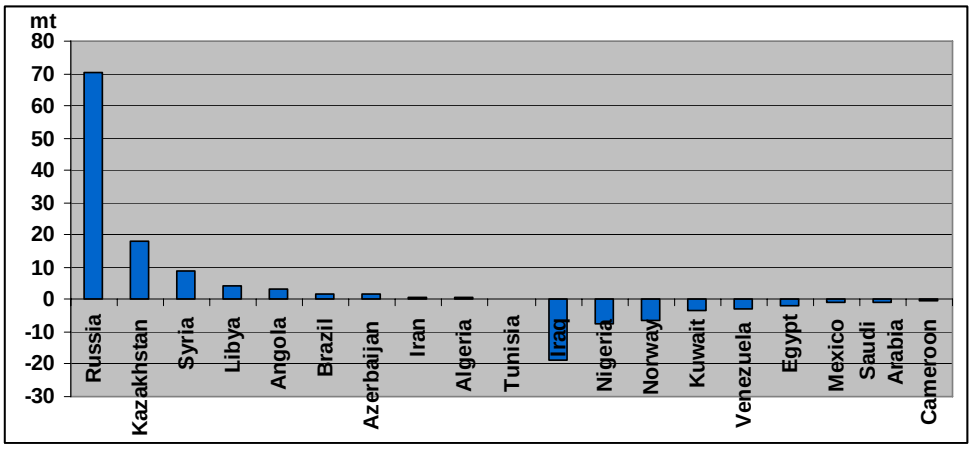
Source: Data based on Table 10.

Figure 19: US – Crude oil imports by country of origin – increases and decreases of imports in 2000-2005 (mt)



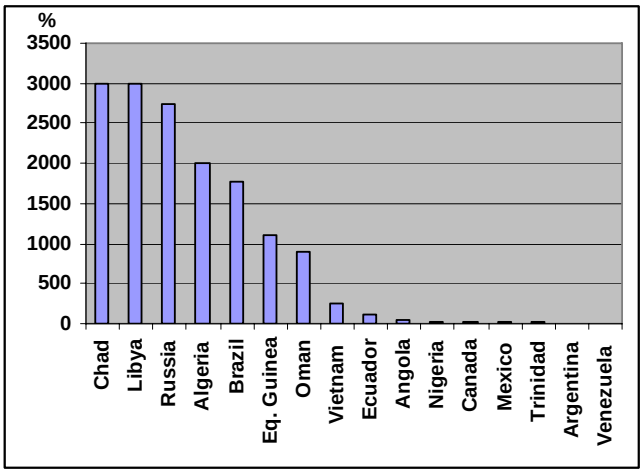
Source: Data based on Table 8.

Figure 20: EU – Crude oil imports by country of origin – increases and decreases of imports in 2000-2004 (mt)



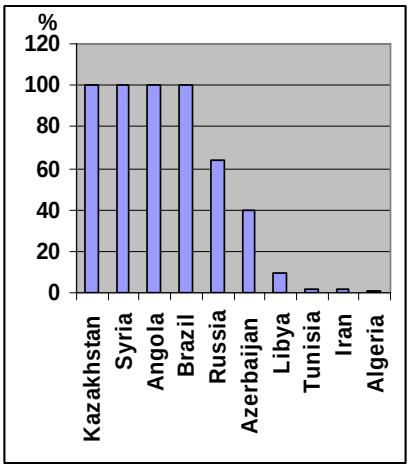
Source: Data based on Table 10.

Figure 21: US – Crude oil imports by country, positive increases of imports in 2000-2005(%)



Source: Data based on Table 8.

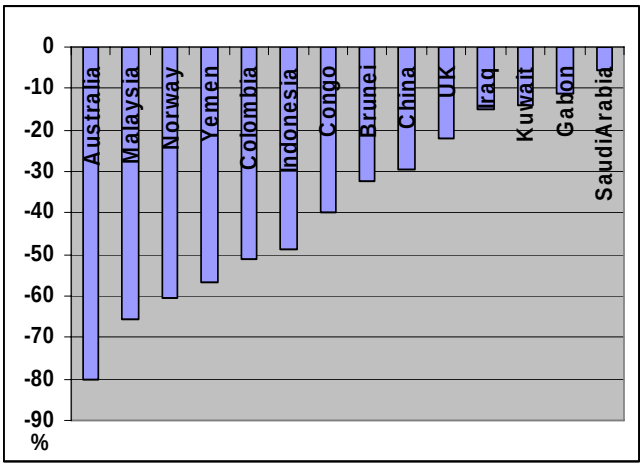
Figure 22: EU – Crude oil imports by country, positive increases of imports in 2000-2004 (%)



Source: Data based on Table 10.

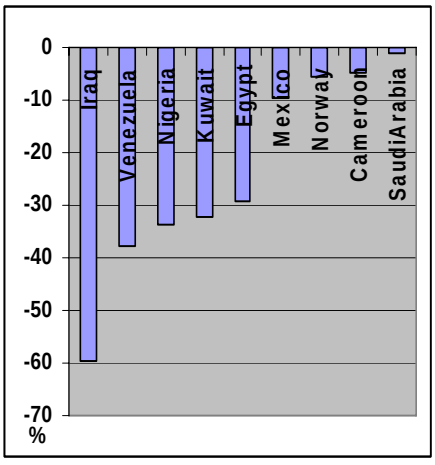
Chad and Libya by the US and Kazakhstan, Syria, Angola and Brazil by the EU were given provisional values that are higher than all the others because the import from these countries increased from zero – that means the most in %.

Figure 23: US – Crude oil imports by country – decreases of imports in 2000-2005 (%)



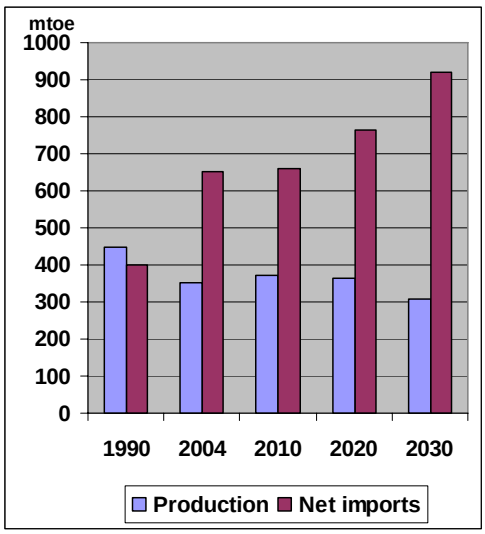
Source: Data based on Table 8.

Figure 24: EU – Crude oil imports by country – decreases of imports in 2000-2004 (%)



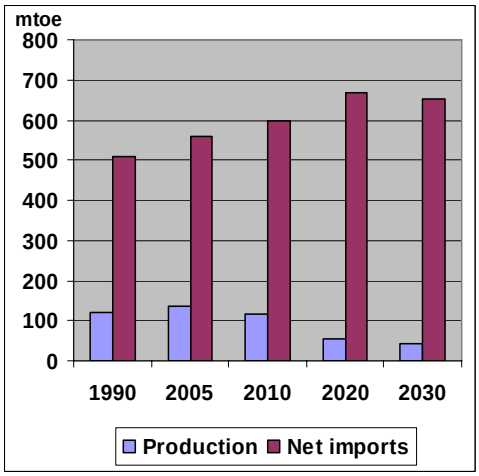
Source: Data based on Table 10.

Figure 25: US – Crude oil supply balance



Source: Data based on Table 25.

Figure 26: EU – Crude oil supply balance



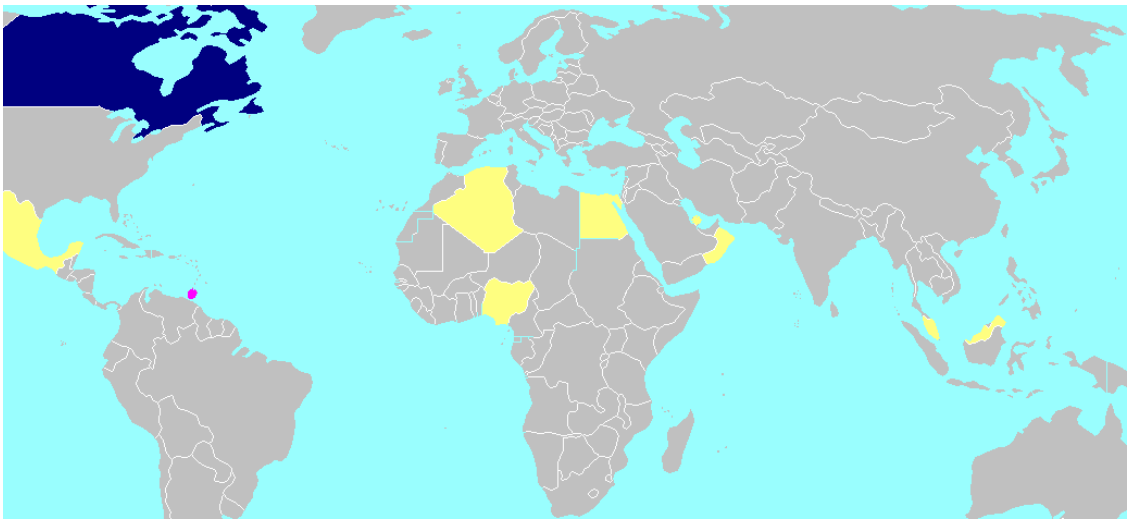
Source: Data based on Table 26.

3.2.9.2. NATURAL GAS IMPORTS BY COUNTRY

Natural gas imports of both the US and the EU show concentration on few countries. On the other hand, the market for LNG is projected to develop further what will increase geographical diversification. Both the US and the EU are importing natural gas mostly from their neighbouring countries. The US gets almost all its natural gas from Canada and Trinidad while the EU imports natural gas mostly from Russia, Norway and Algeria (Map 17 and 18, Figure 27 and 28). The trend will be cemented after the completion of planned natural gas pipelines connecting Russia and Algeria to the EU. The EU is far more dependent on imports of natural gas than the US (Figure 35 and 36). Some interesting patterns could be noticed in natural gas imports since 1990. Between 1990 and 2000, the US increased its imports of natural gas significantly, mostly from Canada but also from Trinidad and Qatar (Figure 33). Imports have slowed after 2000 and show an inclination towards diversification. Between 2000 and 2005, the US increased its natural gas imports mostly from Trinidad and to a lesser extent from Canada, Egypt and Algeria (Figure 31). The EU has also diversified its natural gas imports. In the 1990s, its natural gas imports increased mostly from Algeria, Norway,

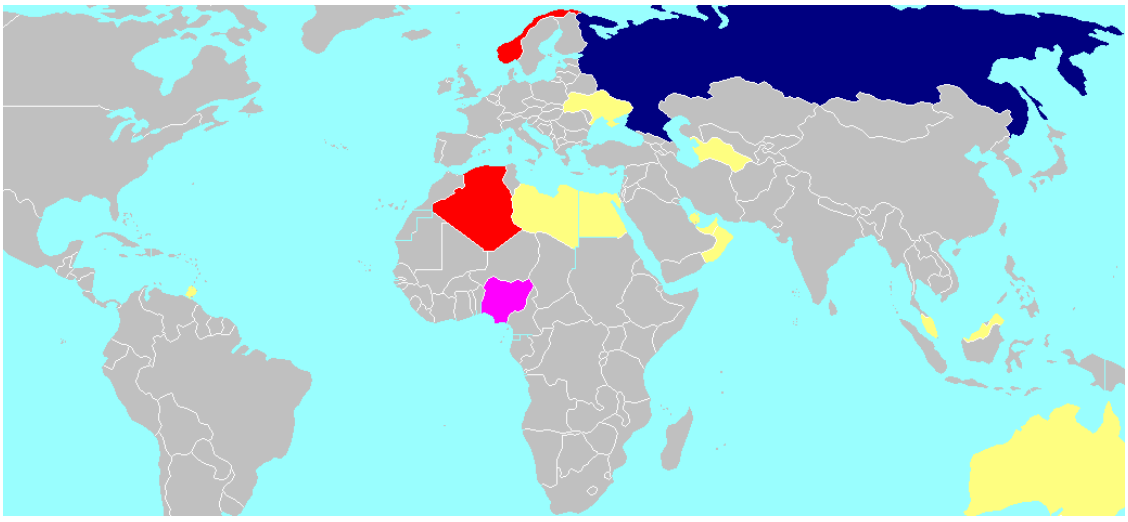
Russia and Nigeria (Figure 34) while after 2000 some other North African and Middle Eastern countries have been added (Figure 32).

Map 17: US – natural gas imports by country of origin



Source: map based on Wikipedia (2006); data based on Table 15.

Map 18: EU – natural gas imports by country of origin



Source: map based on Wikipedia (2006); data based on Table 16.

Legend (map 17 and 18):

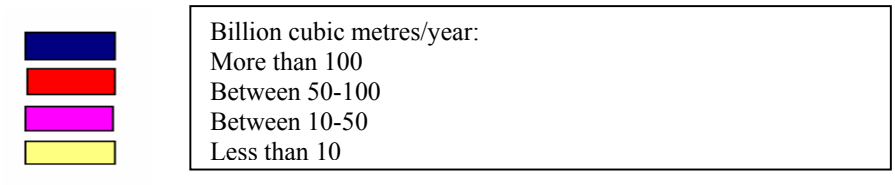
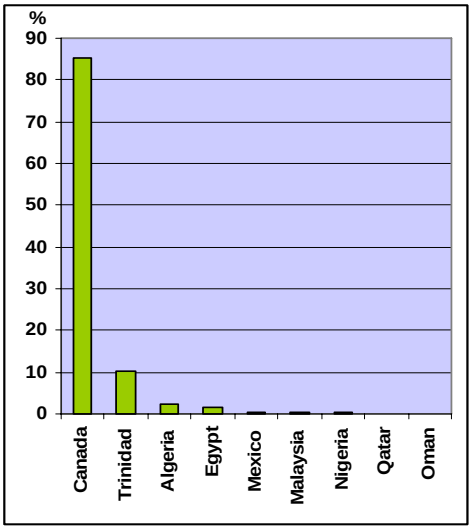
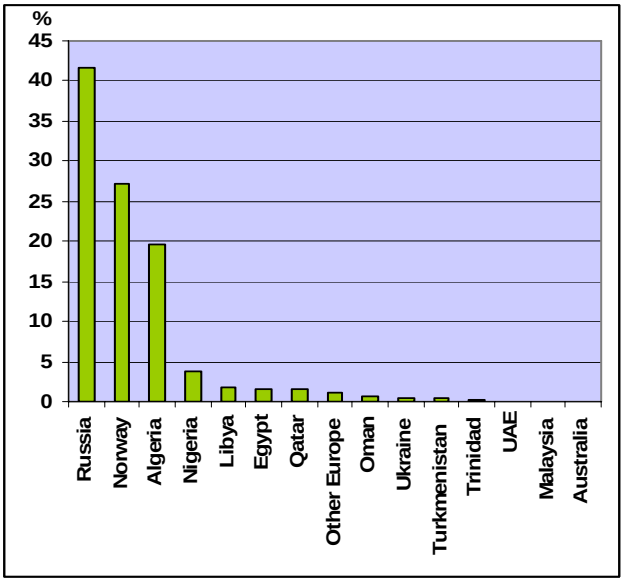


Figure 27: US – shares of natural gas imports by country of origin (2005)



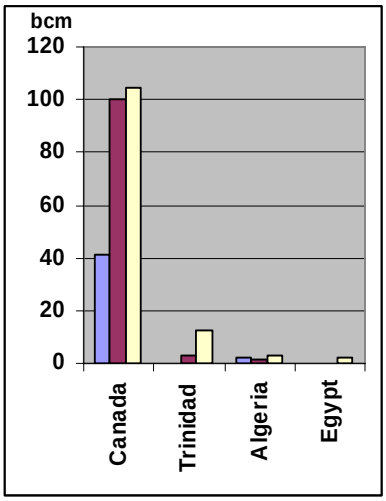
Source: Data based on Table 15.

Figure 28: EU – shares of natural gas imports by country of origin (2005)



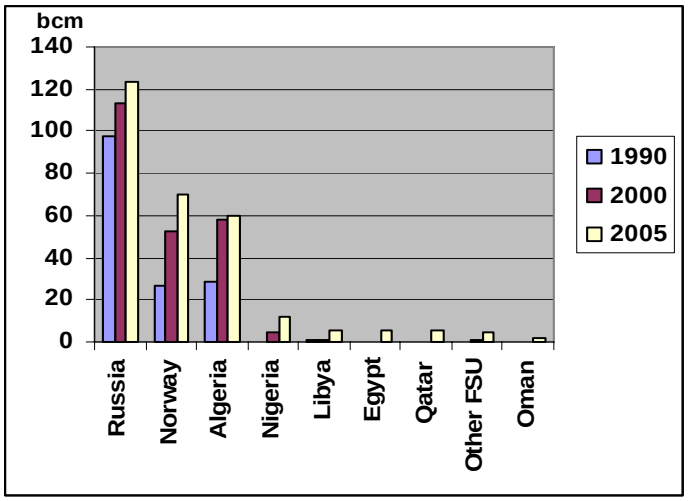
Source: Data based on Table 16.

Figure 29: US – Natural gas imports, key countries (bcm/y)



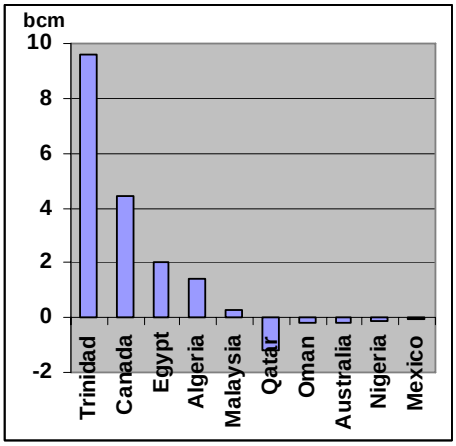
Source: Data based on Table 15.

Figure 30: EU – Natural gas imports, key countries (bcm/y)



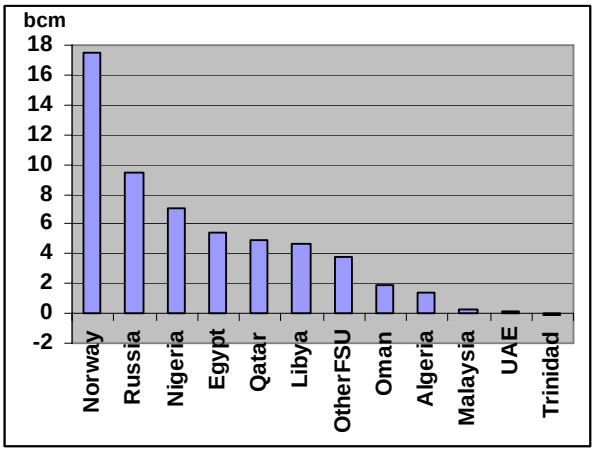
Source: Data based on Table 16.

Figure 31: US – Increases and decreases of natural gas imports in 2000-2005



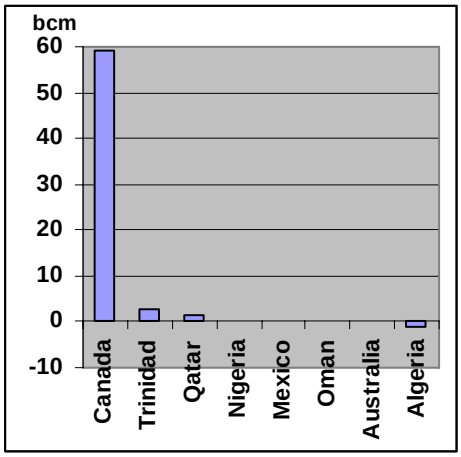
Source: Data based on Table 15.

Figure 32: EU – Increases and decreases of natural gas imports in 2000-2005



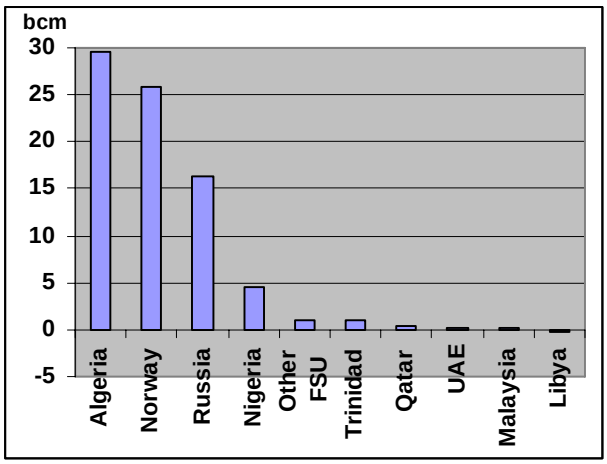
Source: Data based on Table 16.

Figure 33: US – Increases and decreases of natural gas imports in 1990-2000



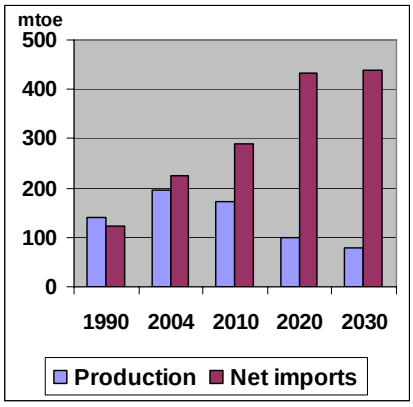
Source: Data based on Table 15.

Figure 34: EU – Increases and decreases of natural gas imports in 1990-2000



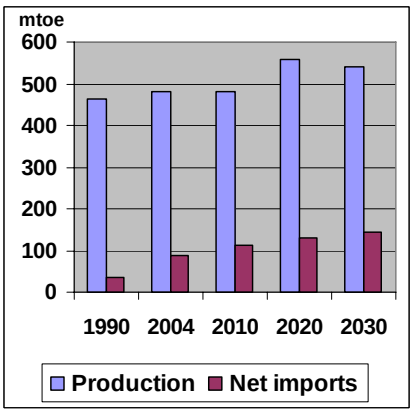
Source: Data based on Table 16.

Figure 35: US – Natural gas supply balance



Source: Data based on Table 25.

Figure 36: EU – Natural gas supply balance



Source: Data based on Table 26.

3.2.9.3. IS GEOGRAPHICAL DIVERSIFICATION THE REAL ANSWER?

What is so alarming about this push for geographic diversification is that it must ultimately fail; at best its impact is limited. Diversification of oil imports is not an adequate answer. The US could shift all its purchases to sources that are relatively safe politically, such as Canada and Mexico, and it would still not be protected. The global price is what matter most (Wirth et al., 2003: 134). On the other hand, looking for oil around the world can only temporarily delay the day when the US and other big importers must return to the Middle East. The Persian Gulf region remains central to the global oil market and will become even more in the future. US or EU imports from outside the Middle East will not change this fact (Telhami et al, 2002: 167). Richard G. Lugar (2005: 1), Chairman of U.S. Senate Committee on Foreign Relations explains: "Our current rate of oil consumption coupled with rapidly increasing oil demand in China, India and elsewhere will leave us vulnerable to events in the tumultuous Middle East and to unreliable suppliers such as Venezuela. Any solution will require much more than a diversification and expansion of our oil supply".

3.3. INDIGENOUS ENERGY SOURCES (COAL, NUCLEAR, RENEWABLES)

Use of energy produced from indigenous energy sources enhances diversification and leads to greater energy security. There are three primary energy sources in this section:

1. Coal. The US has the greatest coal reserves in the world that could be used for about 240 years under the current rate of production. The EU's reserves are almost ten times smaller and would last 60 years under the current rate of production. Moreover, the EU is increasingly importing coal. After 2020 the EU is predicted to import more than 50 % of the coal it consumes. Fortunately for the EU, the sources of coal are well diversified and do not carry the worries of oil or gas supply.
2. Nuclear energy. Nuclear power stations need uranium as a fuel to produce electricity. Fortunately there has been enough of it so far and the sources of uranium are well diversified around the world. Despite it, nuclear energy is widely considered to be indigenous.
3. Renewable energy sources are the most indisputably indigenous energy sources since they could produce energy solely on the basis of energy sources that are already present: water, biomass, wind, sun or Earth's temperature.

Both the USA and the EU are calling for greater development of indigenous energy sources in order to enhance energy security, increase diversification and promote jobs and growth. The latter especially in connection with the renewable energy sources (including biofuels described in chapter 3.2.5.1.3.).

The US President's AEI proposes significant new investment and policies in three promising areas: clean coal-technology, nuclear power and renewable solar and wind energy (National economic council, 2006: 10):

- Complete the President's commitment to $2 billion in clean coal technology research funding, and move the resulting innovations into the marketplace.
- Develop a new Global Nuclear Energy Partnership to address spent nuclear fuel, eliminate proliferation risks, and expand the promise of clean, reliable, and affordable nuclear energy.

- Reduce the cost of solar photovoltaic technologies so that they become cost-competitive by 2015 and expand access to wind energy through technology.

In Securing America's Energy Future, US Committee on Government Reforms proposes: "Policymakers must continue to provide incentives for technologies such as advanced nuclear, clean coal, and renewables over the medium and long-term" (Committee on government reform, US House of representatives, 2006: 9).

In the same way the EU – under the proposed *Strategic Energy Technology Plan* – is proposing greater research and development towards (COM, 2007, 1 final: 16):

- Getting large scale offshore wind competitive within the short term and paving the way towards a competitive European offshore grid.
- Getting photovoltaic electricity competitive to harness solar energy.
- Sustainable coal and gas technologies, particularly carbon capture and storage.
- The EU should maintain its technological lead in fourth generation fission nuclear reactors and future fusion technology to boost the competitiveness, safety and security of nuclear electricity, as well as reduce the level of waste.

3.3.1. COAL

The world coal market is a stable market, with abundant resources and a wide geopolitical diversity of supply. Even in the long term, with growing world demand, the risk of any prolonged disruption of supply, even if it cannot be ruled out altogether, is minimal (COM, 2000, 0769 final: 12). The six largest exporters of coal in 2004 were Australia, Indonesia, China, South Africa, Colombia and the USA. Among regions, Other Asia & Pacific, USA and FSU have the largest coal reserves (Table 20). Australia and Indonesia have large reserves of high quality coal that is suitable for both electricity generation and industrial applications. They also profit from their highly productive mines and proximity to Asian markets. In the projections Australia (348.7 mt) remains the world's foremost coal exporter through 2030, while Indonesia (145.1 mt) holds a distant second place (Map 20). Most of the countries that consume large amounts of coal have their own domestic coal resources. For that reason, the volume of world coal trade tends to be small relative to worldwide coal consumption. In 2003, only 13 % of the coal

consumed around the world was imported (DOE/EIA, 2006a: 57). Coal is a key contributor to the security of energy supply and diversification. Coal represents the fossil fuel with by far the largest and most widely distributed global reserves, estimated to last 155 years. However, coal can continue to make its valuable contribution only with technologies allowing for drastic reduction of the carbon footprint of its combustion.

Table 20: World coal reserves (billion tonnes), as of 2006. Countries with more than 1 billion tonnes of coal reserves are included.

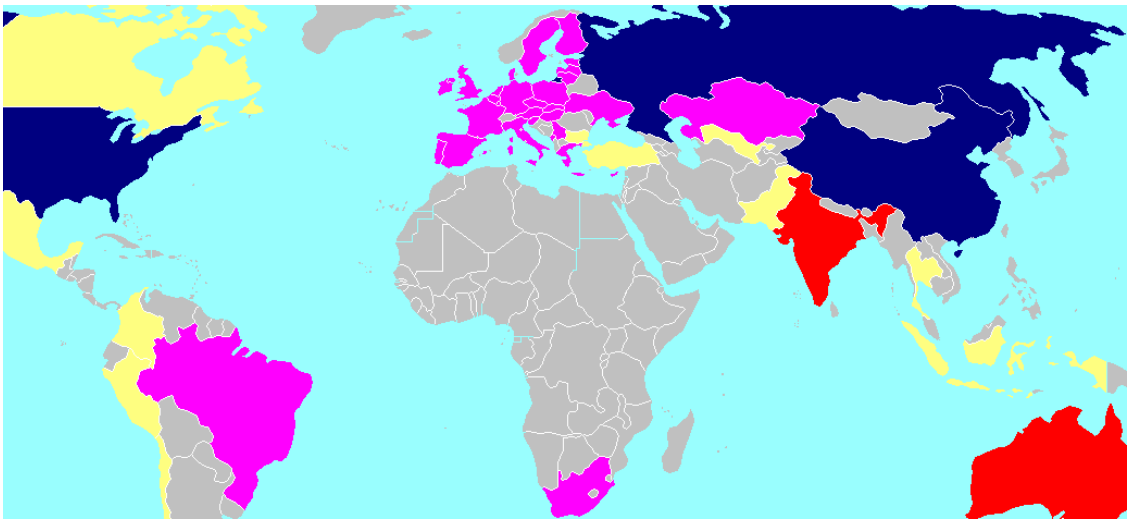
			%	R/P ratio (years)	regions		%
1	USA	242.51	26.8	240	Other Asia & Pac.	301.08	33.3
2	Russia	157.01	17.4	+500	USA	242.51	26.8
3	China	114.50	12.7	52	FSU	227.26	25.1
4	India	92.45	10.2	217	Other Africa	50.28	5.6
5	Australia	78.50	8.7	213	EU	35.36	3.9
6	South Africa	48.75	5.4	198	Latin America	21.10	2.3
7	EU*	35.36	3.9	60	Other Europe	20.13	2.2
8	Ukraine	34.15	3.8	436	Canada	6.58	0.7
9	Kazakhstan	31.28	3.5	362	Middle East	0.42	0.05
10	Serbia and Montenegro	16.59	1.8	408	North Africa	0.06	0.007
11	Brazil	10.11	1.1	+500	Norway	0.005	0.0006
12	Colombia	6.61	0.7	112	**World total**	**904.94**	**100.0**
13	Canada	6.58	0.7	101			
14	Indonesia	4.97	0.5	37	Africa	50.34	5.6
15	Turkey	4.19	0.5	68	Gulf	0.42	0.05
16	Uzbekistan	4.00	0.4	+500	OPEC**	6.10	0.7
17	Pakistan	3.05	0.3	+500	Non OPEC	898.84	99.3
18	Bulgaria	2.19	0.2	83			
18	Thailand	1.35	0.1	64			
20	Mexico	1.21	0.1	121			
21	Chile	1.18	0.1	+500			
22	Peru	1.06	0.1	+500			
	World total	**904.94**	**100.0**	**155**			

Source: DOE/EIA (2006g); R/P ratio: BP (2006: 32), data on other R/P ratios counted from DOE/EIA (2006m).

* Total EU production is 585.67 mt (DOE/EIA, 2006n); therefore R/P equals 60.38 years.

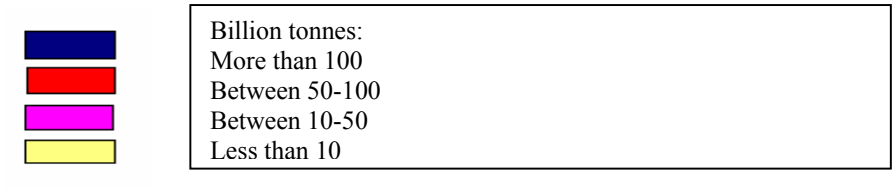
** Added only for comparative purposes.

Map 19: World coal reserves (billion tonnes)

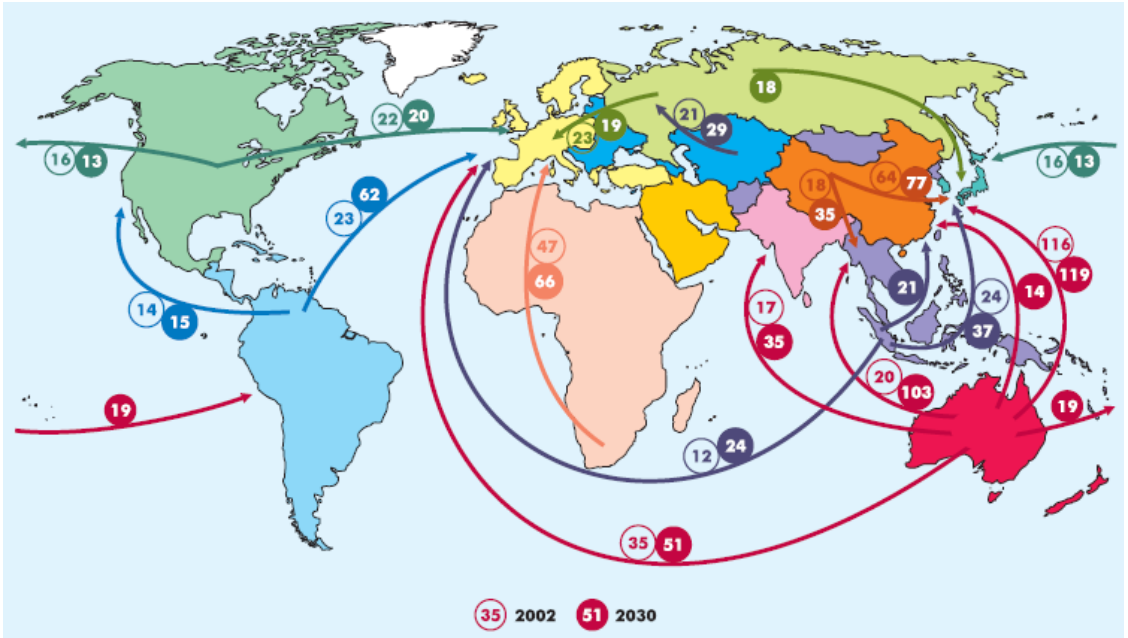


Source: map based on Wikipedia (2006); data based on Table 20.

Legend:



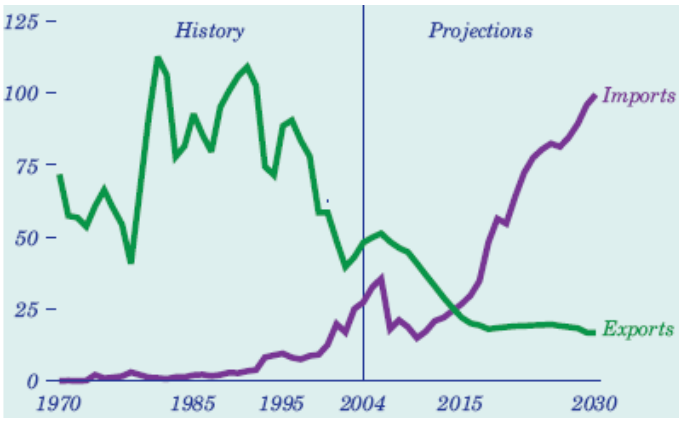
Map 20: Major inter-regional coal trade flows, 2002-2030 (mt)



Source: IEA (2004a: 177).

The US has substantial coal reserves and has come to rely heavily on coal for electricity generation (for the shares of coal and other primary energy fuels in electricity generation see Appendix 2). Coal is America's most abundant fuel source. Coal power plants account for over 50 % of all US electricity generation (National energy policy development group, 2001: 5-13). Until around 2020, the US is projected to be self-sufficient on coal in terms of net imports (Figure 40). US imports of low-sulphur coal rise from 25 mt in 2004 to 90 mt in 2030 (Figure 37). In addition to further displacement of more expensive Central and Southern Appalachian coal at existing power plants, imports fuel some of the new coal-fired generating capacity expected to be built in the US East and Southeast. Much of the additional import tonnage originates from mines in Colombia, Venezuela and Indonesia. US coal exports have been in steady decline from their 1996 level of 90 mt, falling to 40 mt in 2002 (DOE/EIA, 2006b: 100).

Figure 37: US coal exports and imports, 1970-2030 (million short tonnes)



Source: DOE/EIA (2006b: 100).

The EU is relying more and more on imported coal, mainly for environmental (imported coal contains less toxic elements) and economical reasons (domestic production is expensive, mines are closing, there is pressure on Member States to reduce or to abolish subsidies). The future of coal in the EU lies in global terms of security of supply and diversification since it has no prospect for the competitiveness. This is explained primarily by increasing unfavourable geological conditions through the gradual exhaustion of the most readily accessible deposits and the relatively low level of the price

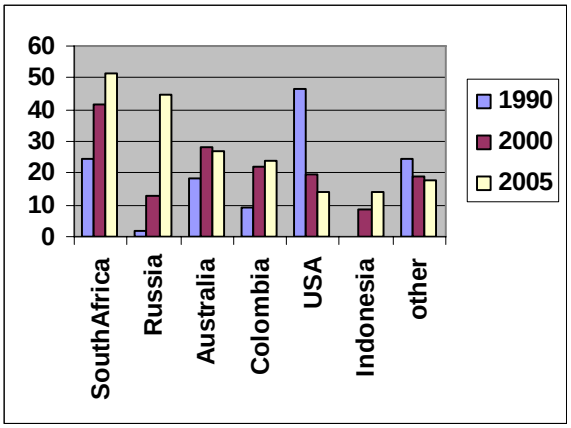
of coal on international markets (COM, 2000, 0769 final: 68). Since 2000, the EU is rapidly increasing imports of coal, mainly from South Africa, Russia and Indonesia, while the imports from the US and Australia are decreasing (Table 21, Figure 38 and 39). On the other hand, consumption of coal in the EU has decreased from 431.94 mtoe in 1990 to 305.04 mtoe in 2005 and it is projected to fall to 293.12 mtoe in 2030 (Table 26).

Table 21: EU – imports of coal (mt)

	1990	**2000**	**2005**	**(90-00)**	**(00-05)**	**% (2005)**	**% (90-00)**	**% (00-05)**
South Africa	24.59	41.51	51.60	+16.92	+10.09	26.7	+68.8	+24.3
Russia	2.11	12.60	44.53	+10.49	+31.93	23.0	+497.2	+253.4
Australia	18.51	28.37	26.86	+9.86	-1.51	13.9	+53.3	-5.3
Colombia	9.11	22.31	24.16	+13.20	+1.85	12.5	+144.9	+8.3
USA	46.75	19.39	14.37	-27.36	-5.02	7.4	-58.5	-25.9
Indonesia	0.24	8.66	14.25	+8.42	+5.59	7.4	+3508.3	+65.5
other	24.43	18.87	17.79	-5.56	-1.08	9.2	-22.8	-5.7
Total imports	**125.67**	**151.39**	**193.56**	**+25.72**	**+42.17**	**100.0**	**+20.5**	**+27.9**

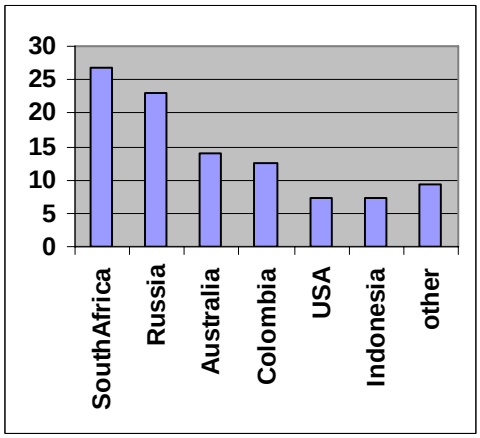
Source: COM (2006c: Table 2.2.5.).

Figure 38: EU – Evolution of coal imports (mt)



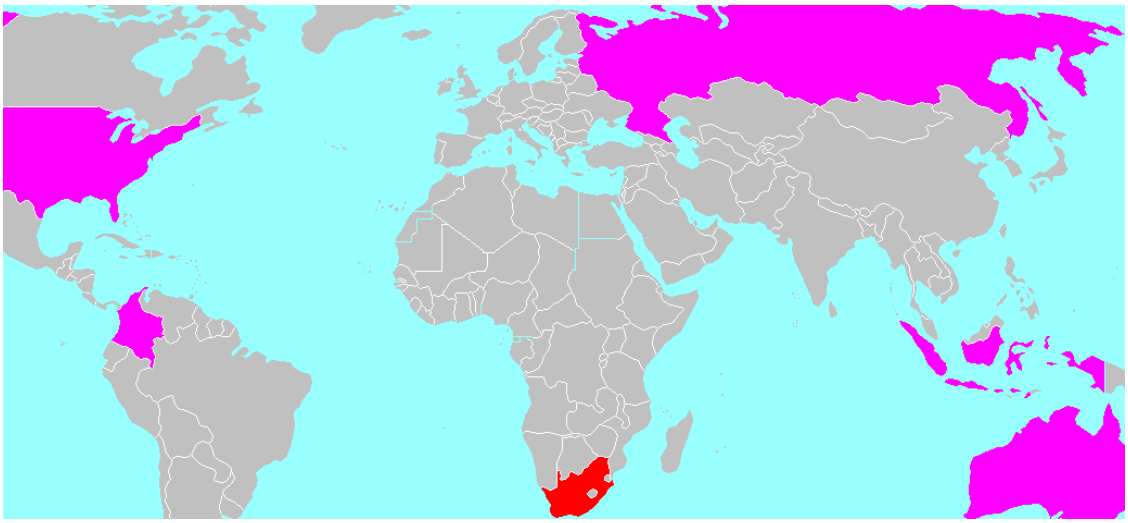
Source: Data based on Table 21.

Figure 39: EU – Coal imports by country in 2005 (%)



Source: Data based on Table 21.

Map 21: EU – Coal imports by country of origin (2005)



Source: map based on Wikipedia (2006); data based on Table 21.

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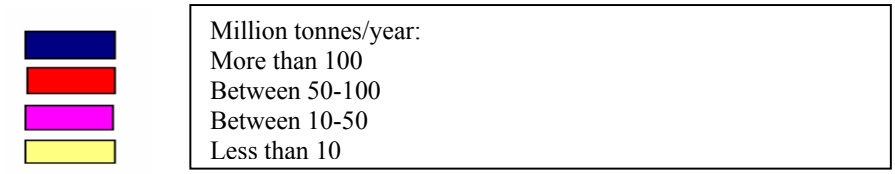
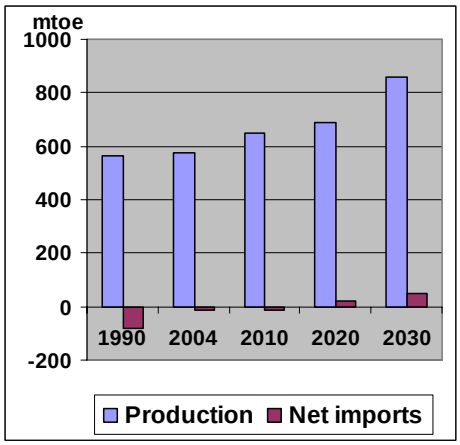
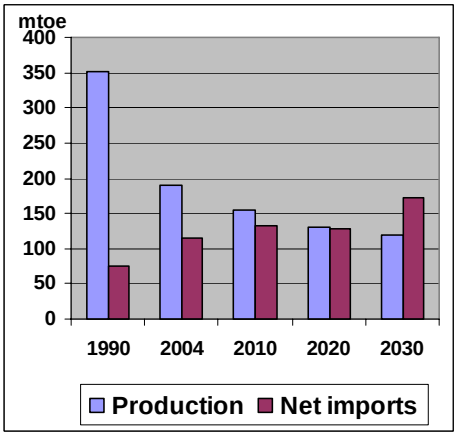


Figure 40: US – Coal supply balance



Source: Data based on Table 25.

Figure 41: EU – Coal supply balance[30]



Source: Data based on Table 26.

[30] The EU imports mostly high quality coal, but produces relatively low quality coal, that is why when converted into the oil equivalent the proportion produced/imported coal is much smaller than if we compare the weight only.

3.3.1.1. CLEAN COAL TECHNOLOGIES

Clean coal technologies are defined as technologies designed to enhance the efficiency and the environmental acceptability of coal extraction, preparation and use (IEA, 2004a: 172). Capturing CO_2 from the combustion of fossil fuels may allow for their continued use without significant additional contributions to greenhouse gas emissions and global warming. Currently, however, sequestration technologies are too costly for implementation on a significant scale. Carbon storage will most likely be underground. For example, enhanced oil recovery technologies pump CO_2 into depleted oil and natural gas fields to extend their yields and lifetimes. Other options include placing the CO_2 in coalbeds and saline formations. Ocean storage is a possibility, although the potential environmental impacts are unknown. Preliminary geological studies have shown that underground storage, if successful, has the potential to store all the CO_2 from the industrial and power sector emissions for several decades (DOE/EIA, 2006b: 47).

Using available technology and technology under development, the US government, in partnership with industry, plans to build a prototype zero-emission coal plant. The programme, known as the Integrated Sequestration and Hydrogen Research Initiative, or *FutureGen*, will cost $1 billion. The plant will have a capacity of 275 MW (megawatt) and will also produce hydrogen (IEA, 2004a: 173). Fuelled by coal, it will include carbon capture and sequestration equipment to limit greenhouse gas emissions. The sequestered CO_2 (approximately 1 million tonnes of CO_2 annually) will be used to enhance oil recovery in depleted oil fields. If the project proves to be technically and economically successful, it could offer a partial solution for the continued use of fossil fuels without contributing further to rising atmospheric concentrations of greenhouse gases (DOE/EIA, 2006b: 46).

The USA and the EU (as well as 15 other countries) are working together in the *Carbon Sequestration Leadership Forum* which is focused on the development of improved cost-effective technologies for the separation and capture of carbon dioxide for its transport and long-term storage. The purpose of the Forum is to make these technologies broadly available internationally, and to identify and address wider issues

relating to carbon capture and storage. At the Ministerial meeting in 2004, ministers approved 10 capture and storage projects as well as a Technology Roadmap to provide future directions for international cooperation.[31]

The other project came in 2006 from industry through the *Zero Emission Fossil Fuel Power Plant Technology Platform*. Major energy companies involved in coal-fired generation announced their plans to 10-12 large-scale demonstration plants testing various ways of integrating clean coal and sequestration in coal and gas-fired power generation (COM, 2006c, yyy final: 6).

The EU recognises the importance of fossil fuels and particularly the contribution of coal to the security of energy supply. At the same time, the EU Commission stresses that the future use of coal in particular must be made compatible with sustainability objectives and climate change policy (COM, 2006c, yyy final: 14). The EU Commission will substantially increase funding for research in the energy area, making the demonstration of Sustainable Fossil Fuels technologies one of the priorities for 2007-2013 (COM, 2006c, yyy final: 6). In case of successful large-scale demonstrations, Sustainable Coal should become the business model of choice for coal-fired power generation in the period after 2020. Incentives may be justified to discourage traditional coal-based power generation and foster wide penetration and use of Sustainable Coal technologies. On the basis of the information currently available, the EU Commission believes that by 2020 all new coal-fired power plants should be built with carbon capture and storage technologies. Existing plants should then progressively follow the same approach (COM, 2006c, yyy final: 10).

One of the most promising new approaches to using coal for clean production of electricity is integrated gasification combined-cycle technology. Such power plants convert coal to a gaseous fuel, from which most of the impurities are removed prior to combustion, and then use the gaseous fuel in a combustion turbine to produce electricity. Waste heat from the turbine is used to generate steam and drive a steam turbine, to produce more electricity (National energy policy development group, 2001: 3-5). Coal gasification is among the major rational responses to present and foreseeable natural gas

[31] The White House (2005): *Climate Change Fact Sheet*. http://www.whitehouse.gov/news/releases/2005/05/20050518-4.html (23.11.2006).

shortages. It is also the coal technology bridge to the hydrogen economy because it is the only technology that can directly convert coal to hydrogen (Ferguson, 2003). Two plants demonstrating coal gasification technology have already been built in the US (National energy policy development group, 2001: 3-5).

In the words of Brian Ferguson (2003), Chairman and Chief executive officer of Eastman Chemical Company, that pioneered coal gasification technology, the future of coal is bright:

> In the absence of substantial nuclear power or renewables growth, medium and long-term actions will require reversal of the decline in the proportion of coal-based electricity generation, and improvement in coal-fleet productivity not seen since before the early 1960s. […] In the future, America's electricity requirements may be met primarily by renewable energy sources such as wind and solar or perhaps even by nuclear fusion. However, it is obvious that clean coal can and must continue to play a leading role over the next several decades (at a minimum).

As we have already seen (Chapter 3.1.1., page 22), such realism (according to environmentalists, it is fatal pessimism) has already been presented by the NEP. There appears to be no way of escaping the use of fossil fuels. Instead of oil, there will be coal. The precondition is that previously described technologies will eventually work. Even the Chairman of Shell admitted: "… if we don't have sequestration then I see very little hope for the world" (cited in: Leggett, 2005: 130). You would think that the EU is less committed to the use of coal because of its externalities. But even for the "green" EU stands (COM, 2006c, yyy final: 4):

> Coal is a key contributor to the EU's security of energy supply and will remain so. Coal represents the fossil fuel with by far the largest and most widely distributed global reserves … Even with strategies to increase energy efficiency and the use of renewable sources, coal should remain an important option in the coming decades for covering essential electricity needs not satisfied by renewable energies.

3.3.2. NUCLEAR ENERGY

Nuclear energy can contribute to diversification and long-term energy security of energy supply for the following reasons (COM, 2006b, yyy final: 10-11):

- The limited importance of the raw material – natural uranium – and its availability.
- The geopolitical distribution of uranium resources, producers and suppliers. The geopolitical distribution of uranium resources is diverse, with most of them coming from politically stable regions of the world.

Uranium is relatively common metal, found in rocks and sea water. It is a metal approximately as common as tin or zinc. Current usage is about 66 500 tonnes per year. Thus the world's present measured resources of uranium (4.7 mt) in the cost category somewhat above present spot prices and used only in conventional reactors, are enough to last for some 70 years. Furthermore, World Nuclear Association (WNA) (2005: 2) assures that there is no fear of quick depletion: "There is every reason to expect that the world supply of uranium, as of other metals, is sustainable, with adequate known resources being continuously replenished at least as fast as they are being used and at costs affordable to consumers". This represents a higher level of assured resources than is normal for most minerals. Further exploration and higher prices will certainly, on the basis of present geological knowledge, yield further resources as present ones are used up (WNA, 2007a). The biggest producer remained Canada with 9 862 tonnes, whereas Australia and Kazakhstan hold greater reserves (Table 22). Moreover, primary uranium production (mining) has regularly filled no more than 60 % of annual requirements in the period after 1985 as excessive commercial inventories were run down and as East-West arms control began to achieve substantial dismantling of nuclear warheads, yielding commercially usable fissile material (WNA, 2005: 6). For the EU, average rector needs for natural uranium over the next 10 years are forecast to be 19 840 tonnes, while average net requirements are about 17 840 tonnes per year (ESA, 2006: 16). There are now 104 fully licensed nuclear power reactors in the US, though only 103 are operational (AUA, 2007). In the EU, there are 152 reactors spread across 15 Member States (ESA, 2006: 15).

The US has 7 % of the world's uranium reserves; the EU has barely 2 % (Table 22). EU's uranium mines have closed principally because the deposits have been exhausted and it is expensive to extract relative to the world price, and because world physical stocks of nuclear fuel are very high (COM, 2000, 0769 final: 12). The only

remaining uranium mine in the EU – in the Czech Republic – has extended its operation until 2010 (ESA, 2006: 4). In the 1950s, the US had a great deal of uranium mining, promoted by federal subsidies. Peak production since 1970 was 16 800 tonnes in 1980, when there were over 250 mines in operation. This number abruptly dropped to 50 in 1984 when 5700 tonnes were produced, and then there was a steady decline until 2003, with most US uranium requirements being imported. By 2003 there were only two small operations producing a total of less than 1000 tonnes per year (AUA, 2007).

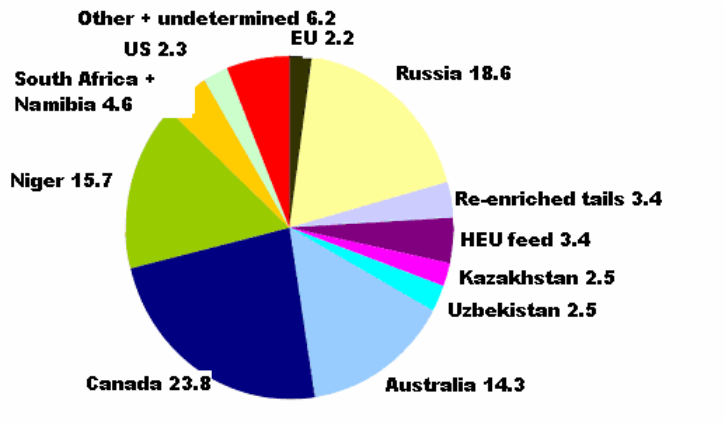
Table 22: World known recoverable reserves of uranium (2005) and natural uranium production in 2000 and 2006

RESERVES	**(000) tonnes**	**%**	**PRODUCTION**	**2000 (tonnes)**	**2006 (tonnes)**	**% (2006)**	**% (00-06)**
Australia	1 143	24	Canada	10 590	9 862	24.9	-6.9
Kazakhstan	816	17	Australia	7 609	7 602	19.2	-0.1
Canada	444	9	Kazakhstan	1 740	5 283	13.4	+203.6
US	342	7	Niger	2 900	3 431	7.4	+18.3
South Africa	341	7	Russia	2 500	3 300	8.7	+32.0
Namibia	282	6	Namibia	2 714	3 067	7.8	+13.0
Brazil	279	6	Uzbekistan	2 350	2 260	5.7	-3.8
Niger	225	5	US	1 456	1 618	4.1	+11.1
Russia	172	4	Ukraine	500	800	2.0	+60.0
Uzbekistan	116	2	China	500	769	1.9	+53.8
Ukraine	90	2	South Africa	878	534	1.3	-39.2
Jordan	79	2	Czech rep.(EU)	507	360	0.9	-29.0
India	67	1	Others	942	681	1.7	-27.7
China	60	1	**Total**	**35 186**	**39 567**	**100.0**	**+12.5**
Other	287	6					
World total	**4 743**	**100**					
EU*	/	2					

Source: reserves: WNA (2007a: Table – Known recoverable resources of uranium); production: data on 2006: ESA (2006: 11), data on 2000: WNA (2007b: Table – Uranium production figures, 1998-2006).

* Data from 1999 shows 66 700 tonnes (WEC, 2001: Table 6.1).

Figure 42: Sources of uranium delivered to the EU utilities in 2006 (%)



Source: ESA (2006: 21).

EU uranium supplies are well diversified. Canada, Russia, Niger and Australia currently supply 72.4 % of the EU uranium requirements (Figure 42). North American uranium reserves are also more than sufficient for the foreseeable future (National economic council, 2006: 11). Almost half of the uranium used in US nuclear power plants currently comes from Russian weapons-grade military uranium, downblended in Russia (AUA, 2007). Other comes mostly from Canada and Australia.

Nuclear energy is the second largest source (20 %) of the US electricity generation. It is used exclusively to generate electricity (National energy policy development group, 2001: 1-6). Nuclear generating capacity in the US is projected to increase from about 100 GW in 2004 to about 109 GW in 2019 and to remain at that level through 2030. The total projected increase in nuclear capacity between 2004 and 2030 includes 3 GW expected to come from uprates of existing plants that continue operating and 6 GW of capacity at newly constructed power plants, stimulated by the provisions in EPACT05, that are expected to begin operation between 2014 and 2020 (DOE/EIA, 2006b: 7). The US Department of Energy has put in place a programme to identify sites for new nuclear power plants, to develop advanced nuclear plant technologies and to demonstrate new regulatory process. Nuclear capacity in the region is expected to increase in the medium term, as some shut-down reactors in Canada are brought back to operation (IEA, 2004a: 217). There are three regulatory initiatives which boost the

prospects of building new plants in the next few years: the Design Certification process, there is provision for Early Site Permits and Combined Construction-Operating Licences. As about 15 companies and consortia prepare to lodge combined construction and operation licence applications for up to 33 new reactors, the US Nuclear Energy Institute says that they will have invested at least $2 billion by the end of 2007. This money is being spent on design and engineering work for new reactor types, on preparation of licence applications and in procurement of long-lead equipment such as reactor vessels and steam generators. While not all the proposals are likely to go forward in the short term, some 40 GWe of new capacity is involved. Financing will be a major challenge (AUA, 2007).

One of the AEI's goals is to develop a new Global Nuclear Energy Partnership to address spent nuclear fuel, eliminate proliferation risks, and expand the promise of clean, reliable, and affordable nuclear energy (National economic council, 2006: 8). In "Securing America's Energy Future", the Committee on government reform stressed the importance of emission-free nuclear power which should become the primary source of baseload electricity and the choice for new units to generate electricity. It denounced the reliance on natural gas as the preferred source of fuel for new electricity generation that has put the US in a precarious position both economically and geopolitically (Committee on government reform, US House of representatives, 2006: 37). An independent task force organized by the Council on Foreign Relations saw a great promise of the plug in hybrid vehicles in conjunction with greater use of nuclear power (Stuntz, 2007: 3). Generation IV nuclear reactors are designed in particular to produce hydrogen. The project is led by the US and there are 11 other countries participating, including the EU (AUA, 2006).

Nuclear energy represents a substantial component of EU's energy mix and is a considerable asset: it generates over one third (32 % in 2006) of the electricity consumed in the EU and allows the saving of 300 million tonnes of greenhouse gas emissions per year, or half the annual emissions from all the vehicles on the roads of Europe (COM, 2004: 51). Member States' position over nuclear power continues to be a controversial issue within the EU. Several Member States have increased their nuclear capacity since 1995, mainly through expansion of existing reactors, and 4 new plants were built in the

Czech Republic and Slovakia between 1998 and 2003. The large capacity increase in France as well as the all the other smaller expansions have mainly occurred through ongoing increases of existing reactor capacity. These augmentations were partly offset by decommissioning of capacity reductions in Slovenia, the UK, Germany, Sweden and the Netherlands. In all, the EU nuclear capacity grew by 5 % (6.1 GW) between 1995 and 2003 (COM, 2006b: 72). In the long run, however, nuclear power generating capacity will decrease from 141.1 GW (2000) to 101.2 GW in 2030. Its share in power generation will also decrease substantially from 21.3 % (2000) to 9.2 % in 2030 (COM, 2006a: 34).

The US and the EU (together with Canada, China, Japan, South Korea and Russia) are partners in the ambitious international programme ITER (International Thermonuclear Experimental Reactor) intended to support research and development in the field of nuclear fusion, a source of energy for the future, which is almost inexhaustible and creates little pollution. The plant, situated in at Cadarache, in the south of France, should be able to produce, within 30 years, clean and safe energy at a pre-industrial stage, particularly from hydrogen, by reproducing the fusion that occurs in stars (COM, 2004: 63). The basic fuels, deuterium (a heavy form of hydrogen) and lithium are abundantly available for all nations for thousands of years. There are no emissions from fusion, and the radioactive wastes from fusion are short lived, only requiring burial and oversight for about 100 years. In addition, there is no risk of a melt-down accident because only a small amount of fuel is present in the system at any time. Finally, there is little risk of nuclear proliferation because special nuclear materials, such as uranium and plutonium, are not required for fusion energy. Fusion system could power an energy supply chain based on hydrogen and fuel cells, as well as provide electricity directly (National energy policy development group, 2001: 6-11).

3.3.3. RENEWABLE ENERGY SOURCES

In the face of international concern over greenhouse gas emissions, the eventual peaking of oil production and volatility of fossil fuel prices, renewable energy sources are seen as promising. They are accepted as being nondepletable on a time scale and tend to

have low and stable operating costs. To date, however, market adoption of most renewable technologies has been limited by the significant capital expense of capturing and concentrating the often diffuse energy fluxes of wind, solar, ocean and other renewable sources (DOE/EIA, 2006b: 47). Renewable energy helps to improve the security of energy supply by increasing the share of domestically produced energy, diversifying the fuel mix and increasing the proportion of energy from politically stable regions.

3.3.3.1. HYDRO

Capacity expansion in hydropower plants is projected to be rather limited both in the US and the EU as a result of the already high exploitation of suitable sites and environmental restrictions. This results in a decreasing share for hydro plants. In addition to conventional hydro power stations, there are a number of technologies that could harness energy directly from ocean waters. They include wave energy technologies (which indirectly harness wind energy, in that ocean waves usually are driven by surface winds), tidal energy technologies, "in stream" hydropower, and ocean thermal energy technologies. Although a number of wave energy technologies are under development, there are only a handful of tidal power stations around the world that operate on a commercial basis (DOE/EIA, 2006b: 47).

3.3.3.2. BIOMASS AND WASTE

Production of biomass and waste is going to increase significantly in the future, mostly as a result of government policies to promote renewables or to increase the use of combined heat and power (Figure 43 and 44). Three fuel types contribute to the total biomass generation: solid biomass, biogas and the biodegradable fraction of municipal solid waste (COM, 2006a, yyy final: 11). Other forms of biomass (BTL, biofuels) were presented in Chapter 3.2.4.

3.3.3.3. GEOTHERMAL

Geothermal energy is the use of steam and hot water generated by heat from the Earth to produce electricity or to provide direct heat for buildings (National energy policy development group, 2001: 6-5). The US is the largest producer of geothermal electricity in the world at 15 000 GWh (gigawat-hours) in 2002 (IEA, 2004a: 237). The most readily accessible resources for geothermal power generation are located in the West, Alaska, and Hawaii (National energy policy development group, 2001: 6-5). However, commercial development has been limited to hydrothermal deposits at relatively shallow depths, where hot rock close to the surface heats naturally occurring groundwater, which is extracted at relatively low cost to drive a conventional generator (DOE/EIA, 2006b: 48). The large geothermal uses in Europe are not in the electricity sector but in heating use with a large majority being exploited in the building sector through geothermal heat pumps (COM, 2006a, yyy final: 16).

3.3.3.4. WIND

Through a combination of significant cost reductions over the past 20 years and policy support in the US, Europe and elsewhere, electricity generation from wind energy has increased substantially over the past five to ten years. In fact, in some areas of Western Europe, viable new sites for wind are seen as severely limited, because the best sites already are being exploited, leaving sites with poor resources, too close to populated areas, and/or in otherwise undesirable locations. In response, a number of European countries have begun to build wind plants offshore, where they are more remote from population centres and can take advantage of better resources. The US has substantially larger and better wind resources (especially in the West, the Great Plains and New England) than most countries of Europe (DOE/EIA, 2006b: 47). Nevertheless, the EU remains the global leader in wind power with 60 % of world market share. In 2002, 80 % of world capacity was installed in Germany and Spain. In 2005, this share was 56 %. Since 2000, wind power capacity has increased by more than 150 % in the EU. The amount expected in the White Paper on renewable energies of 40 GW was reached five years ahead of schedule. New wind power represents 33 % of the new electricity

generating capacity in the EU. The remaining 67 % is mainly conventional thermal power stations (COM, 2006a, yyy final: 10).

The problems connected to the use of wind power: intermittency, low reliability and problems involved in connecting to the grid. Alternative generating capacity must be available to supply when there is no wind (IEA, 2004a: 235). "This is where fuel cells, hydrogen and batteries enter the equation" replied Leggett (2005: 201). They can all store energy and release it evenly when needed.

3.3.3.5. SOLAR

Sunlight, or solar energy, can be used to generate electricity; heat water; and heat, cool and light buildings. Photovoltaic (solar cell) systems use semiconductor materials to capture the energy in sunlight and to convert it directly into electricity (National energy policy development group, 2001: 6-6). Sunlight is a renewable source that is almost universally available. Electricity generation from solar power is expected to reach 119 000 GWh in 2030, mostly in form of photovoltaics (PV), while the rest will be produces in solar thermal power plants. Most current PV is decentralised in buildings. It is economically attractive in areas with abundant sunshine and high electricity prices (IEA, 2004a: 237).

Solar photovoltaic energy starts emerging mainly beyond 2020 accounting for 0.9 % of total installed capacity by 2030 (COM, 2006b: 33). Total installed PV capacity in the EU has been growing at an unprecedented average annual growth rate of 70 % over the last five years (COM, 2006a, yyy final: 15).

Table 23[32]: US – production of renewable energy sources (mtoe)

	1990	**2004**	**2010**	**2020**	**2030**	**% (90)**	**% (04)**	**% (30)**	**% (90-04)**	**% (04-30)**
Hydro	25.37	22.54	25.11	25.20	25.20	25.0	22.4	14.1	-11.2	+11.8
Biomass & Waste	65.50	65.02	78.88	86.18	94.50	64.5	64.8	53.0	-0.8	+45.3
Geothermal	8.47	7.56	9.83	23.18	38.81	8.3	7.5	21.8	-10.7	+413.4

[32] The decrease of production of renewable energy (between 1990 and 2004) may look surprising, but the fact is that the production of hydroelectricity, for example, varies widely from year to year mainly due to the weather (lack of rain) conditions.

Wind	0.73	3.53	13.10	15.62	16.63	0.7	3.5	9.3	+383.6	+371.1
Solar	1.51	1.76	2.02	2.52	3.02	1.5	1.8	1.7	+16.6	+71.6
Total	**101.58**	**100.41**	**128.94**	**152.70**	**178.16**	**100.0**	**100.0**	**100.0**	**-1.2**	**+77.4**

Source: DOE/EIA (2006b: 159); data on 1990: DOE/EIA (2006n: 12).

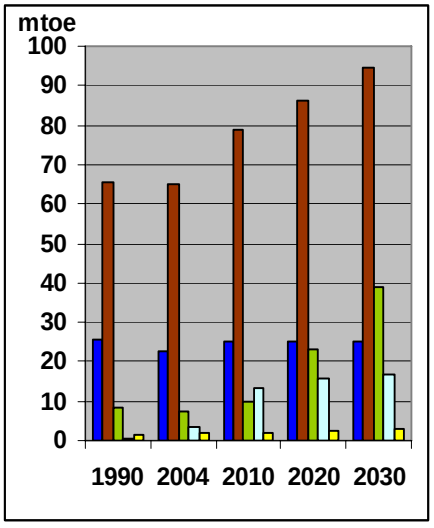
Table 24: EU – production of renewable energy sources (mtoe)

	1990	**2005**	**2010**	**2020**	**2030**	**% (90)**	**% (05)**	**% (30)**	**% (90-05)**	**% (05-30)**
Hydro	23.39	28.90	29.88	32.20	33.88	34.0	25.6	14.7	+23.6	+11.4
Biomass & Waste	42.15	72.60	92.41	129.19	148.88	61.2	64.4	64.5	+72.2	+105.1
Geothermal	3.10	3.69	4.19	5.11	5.75	4.5	3.3	2.5	+19.0	+55.8
Wind	0.07	6.49	15.79	26.24	37.94	0.1	5.8	16.4	+9171.4	+484.6
Solar and others	0.15	1.05	1.49	2.75	4.39	0.2	0.9	1.9	+600.0	+318.1
Total	**68.86**	**112.73**	**143.76**	**195.49**	**230.84**	**100.0**	**100.0**	**100.0**	**+63.7**	**+104.8**

Source: COM (2006a: 74).

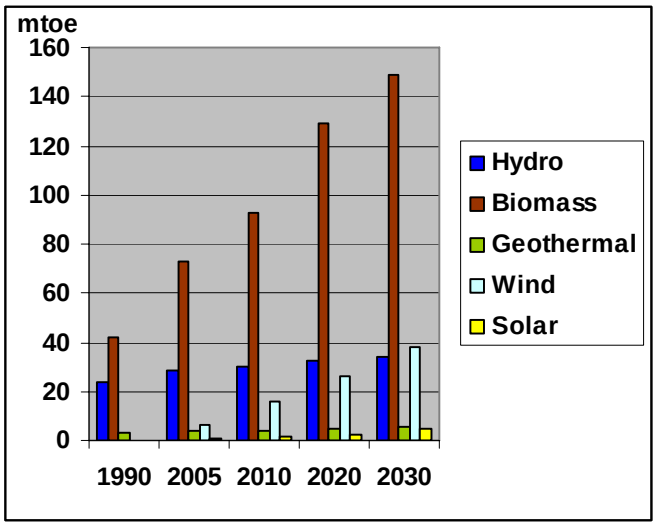
In absolute terms, the EU is a greater producer of renewable energy than the US. The difference is projected to increase by 50 mtoe in 2030. The EU leads in production of renewable energy from hydro, biomass, waste and wind, while the US leads production in geothermal and solar energy sources (Table 23 and 24).

Figure 43: US – Production of renewable energy sources, 1990-2030 (mtoe)



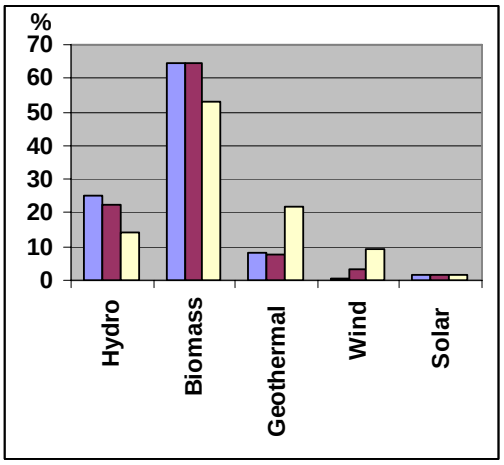
Source: Data based on Table 23.

Figure 44: EU – Production of renewable energy sources, 1990-2030 (mtoe)



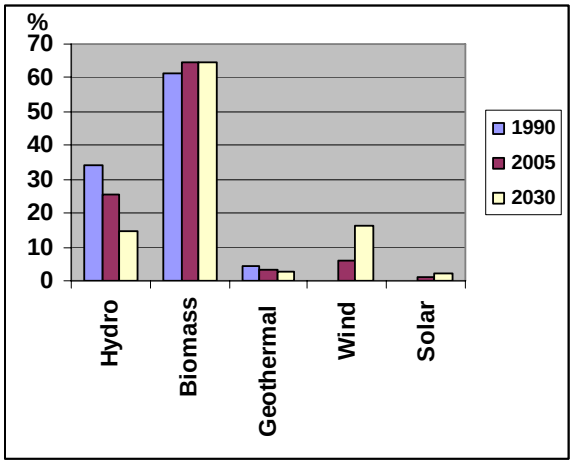
Source: Data based on Table 24.

Figure 45: US – Production of renewable energy sources (%)



Source: Data based on Table 23.

Figure 46: EU – Production of renewable energy sources (%)



Source: Data based on Table 24.

Production of renewable energy sources within the EU Member States varies widely. The largest producers were France, Sweden, Germany, Italy and Spain. The first two countries derived their production from their natural endowment of hydro power as well as from the combustion of biomass and wastes, mainly from woodlands; in France that is complemented by the country's policy of power generation from municipal waste incineration. Wind energy is by far the most dynamic segment and is mostly concentrated in Germany (43 % of total wind in 2003), Spain (27 %) and Denmark (13 %). Italy, the Netherlands and the UK also contributed to wind energy with around 3 % each. Though its contribution remains small in respect of the EU total consumption of energy, the production of wind energy grew by an astonishing 36.5 % per year between 1990 and 2003. Geothermal energy production is almost entirely concentrated in Italy (93 % of total geothermal production). The main producers of solar energy are Germany (39 % of total solar energy production in 2003), Greece (17 %), Austria (13 %), Spain (8 %) and Cyprus (6 %) (COM, 2006b: 86-87).

The development of renewable energy is a key element of the energy policies of all EU countries. Since 1990, the EU has been engaged in an ambitious and successful plan to become world leader in renewable energy. A 1997 EU White Paper on Renewable Energy sources proposed a target of 12 % for the share of renewables in total energy

consumption in 2010, compared with 6 % in 1995. In 2001, the EU adopted a directive aimed at increasing the share of renewables in electricity generation from 13.9 % in 1997 to 22.1 % in 2010 (IEA, 2004a: 370). A number of countries are showing a rapid increase in renewable energy use through supportive national policy frameworks. But under current trends, the EU will miss the target by 1-2 percentage points (COM, 2006, 105 final: 12).

3.4. PRIMARY ENERGY - OVERVIEW, TRENDS

This chapter resumes basic characteristics of fuel mix in the US and the EU. Shares of all types of primary energy are presented in a time range: 1990-2030, where I am primarily interested in changes during 1990-2004/2005 and 2004/2005-2030. The first period shows trends that happened in the years after the end of the cold war until "now", which in my case means 2004 (data for the US) or 2005 (data for the EU). The next period shows possible trends that are going to develop until 2030. It also shows the consequences of different policies of diversification that have been implemented in recent years.

Table 25: US – Primary energy production, net imports, consumption and trends (mtoe)

						Change (mtoe)		**Change (%)**	
Prod.	**1990**	**2004**	**2010**	**2020**	**2030**	**90-04**	**04-30**	**90-04**	**04-30**
Oil	447.20	351.04	373.72	363.12	308.70	-96.16	-42.34	-21.5	-12.1
Gas	461.82	479.30	482.08	556.67	540.54	+17.48	+61.24	+3.8	+12.8
Coal	565.89	576.07	649.66	687.96	859.32	+10.18	+283.25	+1.8	+49.2
Nuclear	153.82	207.40	212.69	229.07	229.07	+53.58	+21.67	+34.8	+10.4
Renew.	153.72	144.65	178.42	201.60	227.30	-9.07	+82.65	-5.9	+57.1
Total	**1783.93**	**1774.58**	**1950.98**	**2118.06**	**2251.87**	**-9.35**	**+477.29**	**-0.5**	**+26.9**
Net imp.									
Oil	398.34	652.18	660.74	765.83	919.55	+253.84	+267.37	+63.8	+41.0
Gas	35.38	87.95	112.14	129.78	144.14	+52.57	+56.19	+148.6	+63.9
Coal	-82.63	-10.58	-14.62	22.68	50.90	-72.05	+40.32	/	/
Total	**349.70**	**729.54**	**758.21**	**918.29**	**1114.60**	**+379.84**	**+385.06**	**+108.6**	**+52.8**
Cons.									
Oil	845.54	1010.02	1087.13	1213.13	1350.22	+164.48	+340.20	+19.5	+33.7
Gas	497.20	581.36	605.81	698.04	697.03	+84.16	+115.67	+16.9	+19.9
Coal	483.26	567.76	632.27	696.78	869.15	+84.50	+301.39	+17.5	+53.1
Nuclear	153.82	207.40	212.69	229.07	229.07	+53.58	+21.67	+34.8	+10.4
Renew.	153.72	144.65	178.42	201.60	227.30	-9.07	+82.65	-5.9	+57.1
Total	**2133.63**	**2511.94**	**2718.32**	**3039.88**	**3373.78**	**+378.31**	**+861.84**	**+17.7**	**+34.3**

Source: DOE/EIA (2006b: 11); data on 1990 and 2000: consumption: DOE/EIA (2006h), DOE/EIA (2006i), DOE/EIA (2006j), DOE/EIA (2006k), DOE/EIA (2006f), DOE/EIA (2006a: 91); production: DOE/EIA (2007b: 5).

Table 26: EU – Primary energy production, net imports, consumption and trends (mtoe)

						Change (mtoe)		Change (%)	
Prod.	**1990**	**2005**	**2010**	**2020**	**2030**	**90-05**	**05-30**	**90-05**	**05-30**
Oil	120.40	134.11	117.18	52.96	43.45	+13.71	-73.73	+11.4	-67.6
Gas	139.72	197.20	172.18	98.35	79.81	+57.48	-117.39	+41.1	-59.5
Coal	351.65	189.65	154.53	131.08	120.20	-162.00	-69.45	-46.1	-36.6
Nuclear	196.92	251.35	248.78	228.64	210.81	+54.43	-40.54	+27.6	-16.1
Renew.	68.86	112.73	143.76	195.49	230.84	+43.87	+118.11	+63.7	+104.8
Total	**877.54**	**885.03**	**836.42**	**706.52**	**685.10**	**+7.49**	**-199.93**	**+0.9**	**-22.6**
Net imp.									
Oil	510.02	560.23	599.70	669.87	652.45	+50.21	+92.22	+9.8	+16.5
Gas	123.65	225.53	290.05	431.31	438.00	+101.88	+212.47	+82.4	+94.2
Coal	75.45	115.39	132.29	128.40	172.92	+39.94	+57.53	+52.9	+49.9
Total	**711.30**	**903.66**	**1024.28**	**1231.69**	**1265.57**	**+192.36**	**+361.91**	**+27.0**	**+40.0**
Cons.									
Oil	595.75	649.22	668.72	669.95	640.47	+53.47	-8.75	+9.0	-1.3
Gas	260.55	422.73	462.23	529.66	517.80	+162.18	+95.07	+62.2	+22.5
Coal	431.94	305.04	286.82	259.48	293.12	-126.90	-11.92	-29.4	-3.9
Nuclear	196.92	251.35	248.78	228.64	210.81	+54.43	-40.54	+27.6	-16.1
Renew.	68.86	112.73	143.76	195.49	230.84	+43.87	+118.11	+63.7	+104.8
Total	**1556.19**	**1743.57**	**1812.53**	**1885.34**	**1895.24**	**+187.38**	**+151.67**	**+12.0**	**+8.7**

Source: COM (2006b: 74).

The projections are based on a high oil price environment with oil prices of $55 per barrel on average in 2005 and $58 per barrel in 2030. US assumptions are based on comparable crude oil prices (see Footnote 21).

3.4.1. PRODUCTION

Total US primary energy production fell by 9.3 mtoe between 1990 and 2004, mainly due to the sharp decrease in oil production and is projected to expand considerably by 477.3 mtoe up to 2030. Current projections have oil production declining by 12.1 %, gas production would be 12.8 % higher and coal production is expected to grow by 49.2 %. Nuclear and renewable energy generation is expected to increase too. The use of renewable technologies for electricity generation is projected to grow, stimulated by improved technology, higher fossil fuel prices and extended tax credits in EPACT 2005 and in State renewable energy programs (DOE/EIA, 2006b: 8). Total

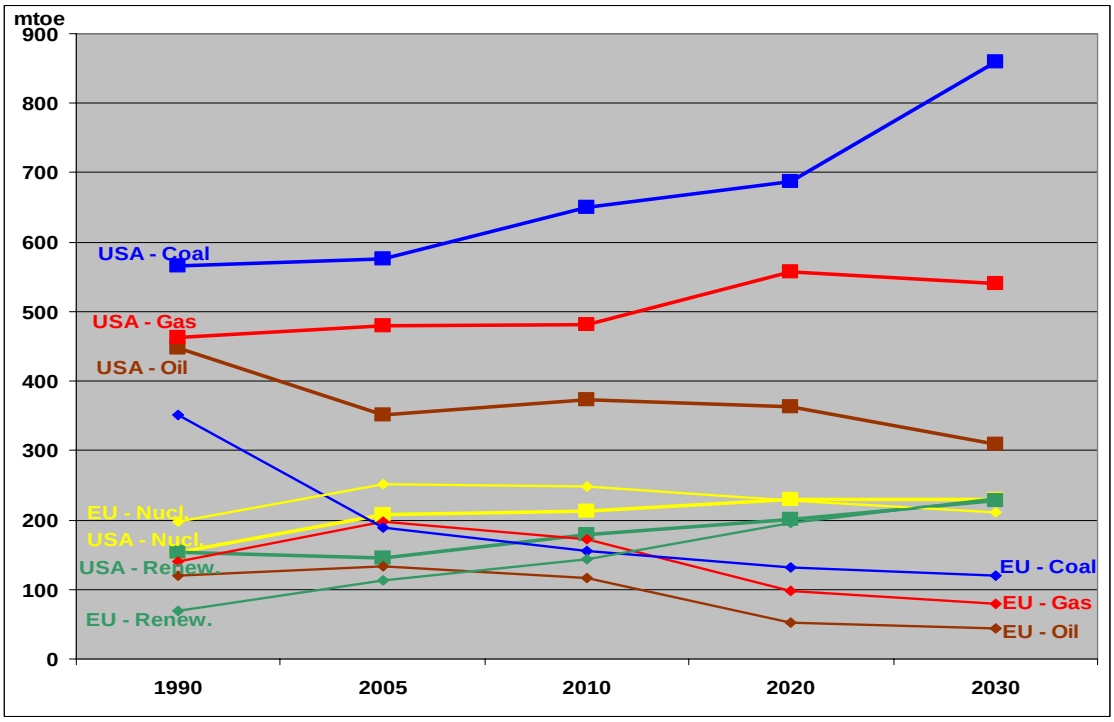
renewable generation is projected to grow from 144.6 mtoe in 2004 to 227.3 mtoe in 2030 (Table 25).

While EU energy consumption increases at a rather low pace through 2030, there is a steep decline in indigenous production, in particular of hydrocarbons, coal and nuclear. Only renewables production is expected to increase by 2030. Current projections have oil production declining by 67.6 %, gas production would be 59.5 % lower and coal production is expected to sink by 36.6 %. Nuclear generation might decrease by 16.1 %, whereas the production of renewables should more than double between 2000 and 2030. All together, total indigenous energy production would be 22.6 % lower than it was in 2005. Between 1990 and 2005, total primary energy production increased by 0.9 %, mainly due to the increased oil and gas production in the North Sea and increases in nuclear and renewables production capacities. On the other side, production of coal fell dramatically (Table 26).

Following the political decisions on nuclear-phase out in certain old member states and the closure of plants with safety concerns in some new member states, nuclear is smaller in 2030 than it was in 2005 (minus 16 %). Although nuclear generation has been rising in recent years, after 2010 the agreed policies on nuclear and the replacement cycles for older plants lead to more nuclear plant closure than there will be new investment. Nevertheless, high fossil fuel prices encourage investment in new nuclear power stations in several member states (COM, 2006a: 7). Under projection, a predominant role in the replacement of retired nuclear plants will be played by advanced coal technologies (including clean coal technologies) as they are projected to become cost-effective option in the long run (COM, 2006a: 33).

There is a sharp contrast between US and EU primary energy production. US primary energy production is currently more than 100 % higher than that of the EU. By 2030 it is projected to be almost 230 % higher. The US is planning to increase the production of all forms of primary energy except oil. The EU has, according to the projection, only one option to keep up with demand – to increase the production of renewable energy sources. The inferior position of the EU is clearly demonstrated by Figures 47-52.

Figure 47: US and EU – Primary energy production (mtoe)



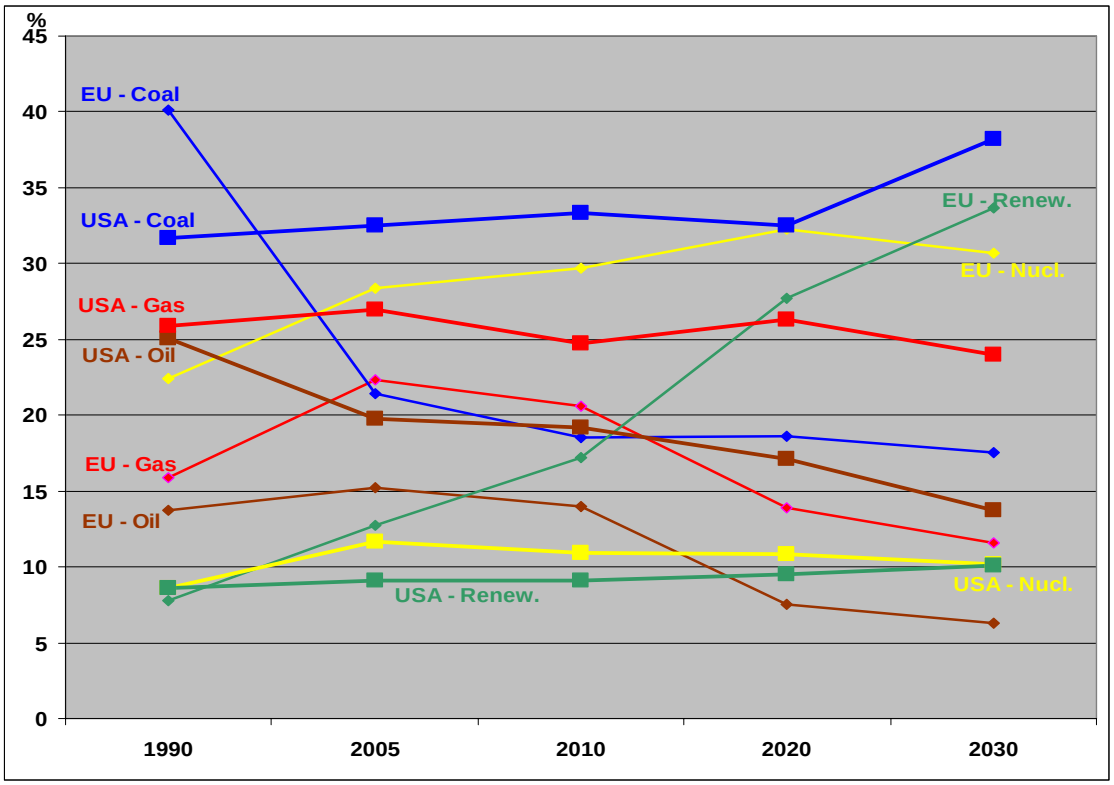
Source: Data based on Table 25 and 26.

Table 27: US and EU – Share of energy sources in primary energy production (%)

	1990		2004	2005	2010		2020		2030	
	USA	EU	USA	EU	USA	EU	USA	EU	USA	EU
Oil	25.1	13.7	19.8	15,2	19.2	14.0	17.1	7.5	13.7	6.3
Gas	25.9	15.9	27.0	22.3	24.7	20.6	26.3	13.9	24.0	11.6
Coal	31.7	40.1	32.5	21.4	33.3	18.5	32.5	18.6	38.2	17.5
Nucl.	8.6	22.4	11.7	28.4	10.9	29.7	10.8	32.3	10.2	30.7
Renew.	8.6	7.8	8.2	12.7	9.1	17.2	9.5	27.7	10.1	33.7

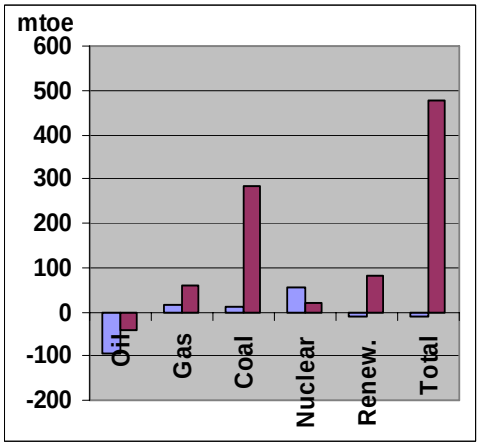
Source: Data based on Table 25 and 26.

Figure 48: US and EU – Share of energy sources in primary energy production (%)



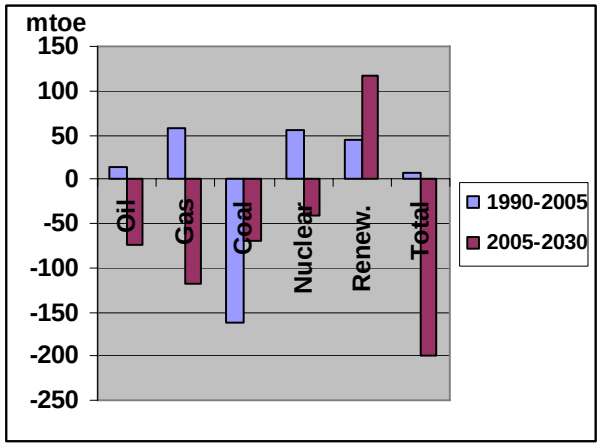
Source: Data based on Table 25 and 26.

Figure 49: US – Primary energy prod.



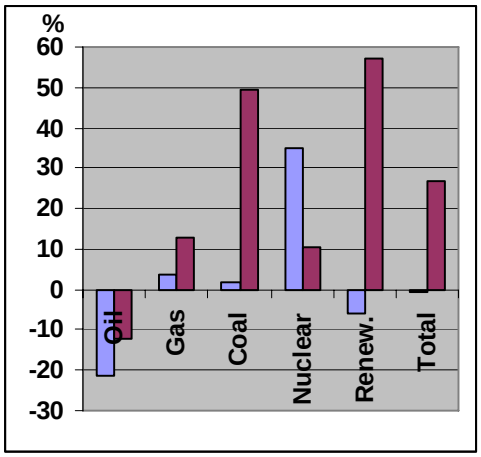
Source: Data based on Table 25.

Figure 50: EU – Primary energy production



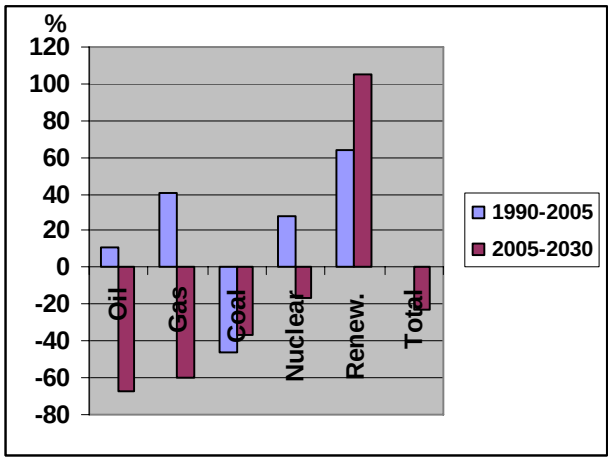
Source: Data based on Table 26.

Figure 51: US – Primary energy prod.



Source: Data based on Table 25.

Figure 52: EU – Primary energy production (%)



Source: Data based on Table 26.

3.4.2. CONSUMPTION

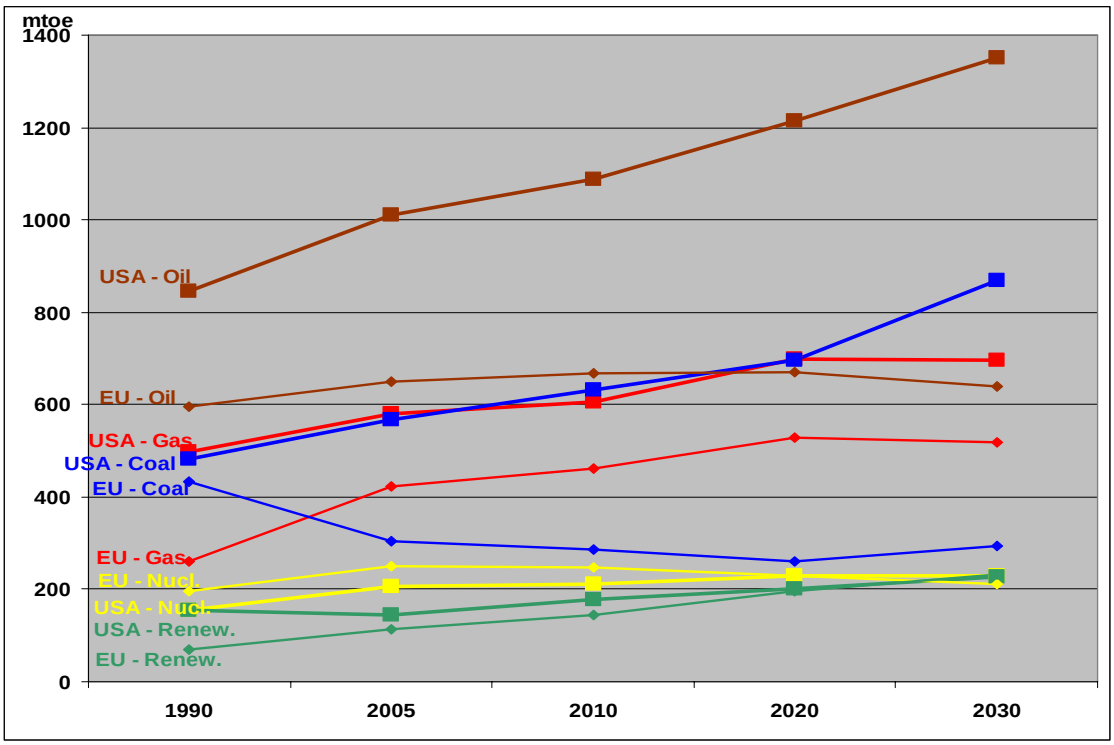
Total US petroleum consumption is projected to grow from 1010.0 mtoe in 2004 to 1350.2 mtoe in 2030. Total consumption of natural gas is projected to increase from 581.4 mtoe in 2004 to 697.0 mtoe in 2030 (Table 25). After peaking at 698.0 mtoe in 2020, natural gas consumption is projected to fall slightly by 2030, as higher natural gas prices result in a larger market share for coal in the electric power sector. Total coal consumption is projected to increase from 567.8 mtoe in 2004 to 869.1 mtoe in 2030. Coal consumption is projected to grow at a faster rate after 2020, as coal captures market share from natural gas, and as coal use for CTL production grows (DOE/EIA, 2006b: 6).

Total EU primary energy consumption continues to increase up to 2030. In 2030 energy consumption is 8.7 % higher than it was in 2005. The growth rates of energy become smaller over time with consumption virtually stabilizing post 2020 reflecting low economic growth, stagnating population, saturation effects and a more service oriented economy (COM, 2006a: 6). The energy consumption increase of 151.7 mtoe between 2005 and 2030 will be met by natural gas and renewables, which are the only energy sources that increase their market shares. Oil remains the most important fuel for the EU, although its consumption in 2030 should not exceed the current level. Natural gas consumption is expected to expand considerably by 95.1 mtoe up to 2030 after the

substantial increase already seen in the 1990s. Consumption of coal is projected to decrease by 2020 and to come back almost to the current level in 2030 following high oil and gas prices and the nuclear phase-out in certain member states. Renewables increase more than all other fuels in relative terms (more than doubling their contribution from current levels by the year 2030). In absolute terms they increase by 118.1 mtoe from 2005 to 2030.

There is a sharp difference between US and EU primary energy consumption. US primary energy consumption is currently 44.1 % higher than that of the EU. By 2030 it is projected to be 78.0 % higher. The trend is highlighted by Figures 53-58. The US is projected to increase the consumption of all forms of primary energy while the EU is going to increase the consumption of gas and renewable energy sources only. The EU is projected to increase the consumption of primary energy by 8.7 % by 2030 while the US is going to increase consumption by 34.3 %. Although the trend favours the EU, due to the lower increase in consumption, the EU is still in an inferior position because of smaller reserves of hydrocarbon energy sources. This means that the EU is going to be much more dependent on energy imports than the US (Tables 29-30).

Figure 53: US and EU – Primary energy consumption (mtoe)



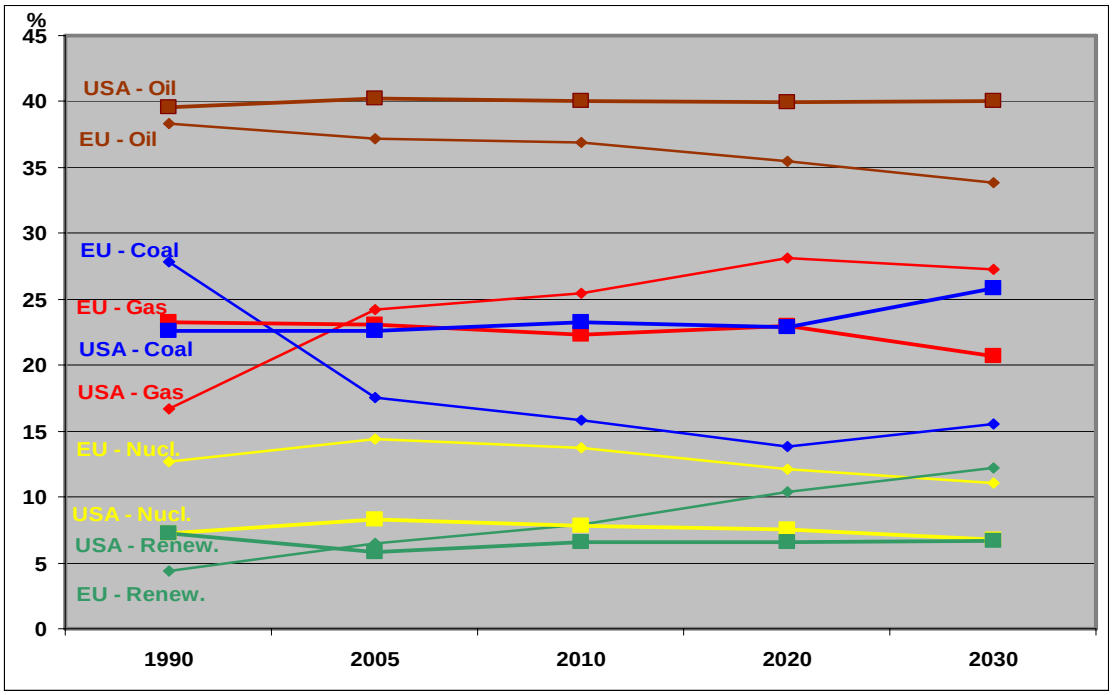
Source: Data based on Tables 25 and 26.

Table 28: US and EU – Share of energy sources in primary energy consumption (%)

	1990		2004	2005	2010		2020		2030	
	USA	**EU**	**USA**	**EU**	**USA**	**EU**	**USA**	**EU**	**USA**	**EU**
Oil	39.6	38.3	40.2	37.2	40.0	36.9	39.9	35.5	40.0	33.8
Gas	23.3	16.7	23.1	24.2	22.3	25.5	23.0	28.1	20.7	27.3
Coal	22.6	27.8	22.6	17.5	23.3	15.8	22.9	13.8	25.8	15.5
Nucl.	7.2	12.7	8.3	14.4	7.8	13.7	7.5	12.1	6.8	11.1
Renew	7.2	4.4	5.8	6.5	6.6	7.9	6.6	10.4	6.7	12.2

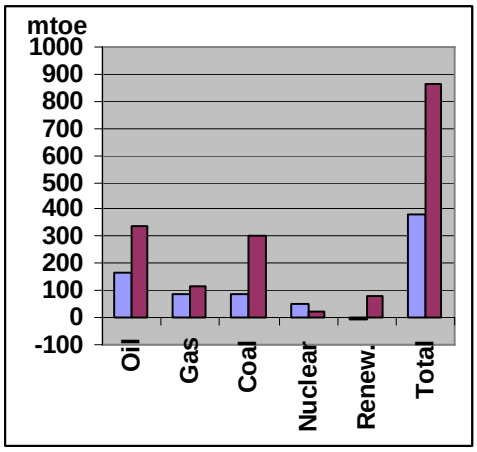
Source: Data based on Table 25 and 26.

Figure 54: US and EU – Share of energy sources in primary energy consumption (%)



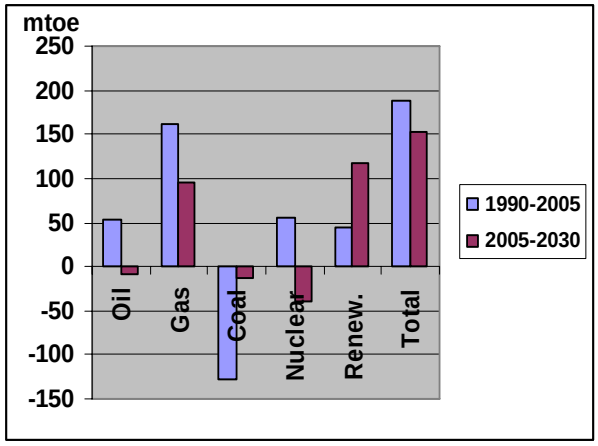
Source: Data based on Table 25 and 26.

Figure 55: US – Primary energy cons.



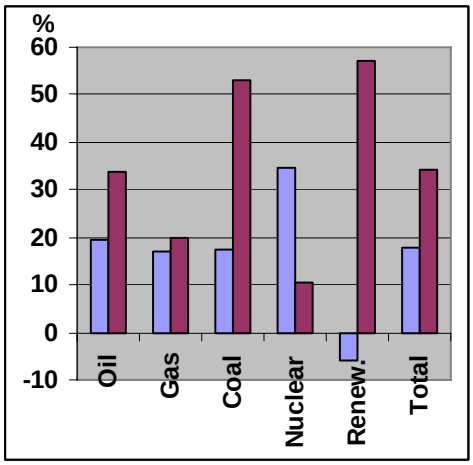
Source: Data based on Table 25.

Figure 56: EU – Primary energy consumption



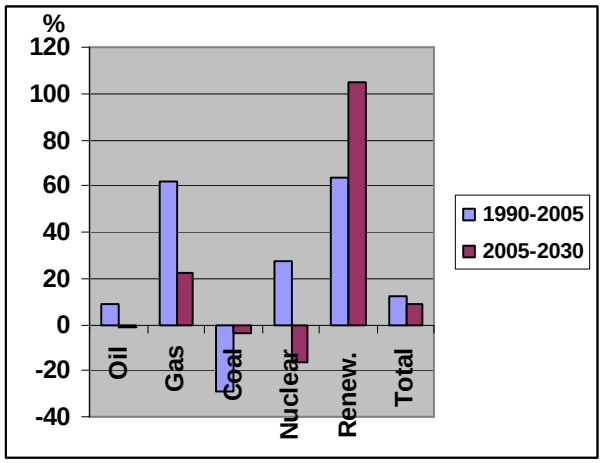
Source: Data based on Table 26.

Figure 57: US – Primary energy cons.



Source: Data based on Table 25.

Figure 58: EU – Primary energy cons. (%)



Source: Data based on Table 26.

3.4.3. IMPORT DEPENDENCY

The US has significant domestic energy resources, and remains a major energy producer. Between 1996 and 2000, production of coal, natural gas, nuclear energy, and renewable energy increased. However, these increases have been largely offset by declines in oil production (National energy policy development group, 2001: 5-1). As a result, the US will rely increasingly on imports of both natural gas and oil from Canada,

and imports of oil and LNG from producers across the globe (National energy policy development group, 2001, 5-3). Between 1973 and 2000, US dependence on foreign oil rose from about 35 % to more than 52 % of US consumption. During the same period, the import share of natural gas consumption climbed from less than 5 % to more than 15 % and continues to rise (National energy policy development group, 2001: 2-9). Net imports of energy are projected to meet a growing share of total US energy demand (Figure 59). Net imports are expected to constitute 33.0 % of total energy consumption in 2030, up from 29 % in 2004 (Table 29).

The increasing dependence of the EU energy system on energy imports raises significant concerns as regards the security of supply in the long run. This is especially the case for natural gas given the increasing dependence upon gas imports from a limited number of suppliers and the need for long distance transport infrastructures, as well as the increasing natural gas demand in other world regions such as Asia. In the oil market, supply is increasingly concentrated in the Middle East while North Sea production declines. On the other hand, the world coal market remains well diversified with abundant supplies. Import dependency continues growing to two thirds in 2030, which is up nearly 15 % from today's level. Import dependency for oil continues to be highest reaching 93.8 % in 2030. Gas import dependency rises substantially from 53.4 % at present to 84.6 % in 2030. Similarly, coal supplies will be increasingly based on imports reaching 59.0 % in 2030 (Table 30).

Currently, the EU imports 51.8 % of primary energy sources (903.7 mtoe) while the US imports 29.0 % of primary energy sources (729.5 mtoe). In 2030, the EU is projected to import 64.9 % (1265.6 mtoe) of its primary energy needs. The US is projected to import 33.0 % (1114.6 mtoe) of its primary energy needs (Tables 25-26 and 29-30). The EU imports little more than the US in absolute terms, but compared to relative terms the difference is significant. The US net imports are staying at one third of its primary energy needs while the EU imports increase from one half to two thirds of its primary energy needs. The EU is projected to increase imports of hydrocarbons significantly while the US only marginally. All these trends are explained by Figures 60-65. In the period of 1990-2004, the US started importing hydrocarbons at a high pace which is projected to slow by 2030 (Figure 64). The EU, on the other hand, is projected

to continue importing hydrocarbons (except coal) by 2030 at the same pace as before 2004 (Figure 65).

Table 29: US – Import dependency (%)

	1990	**2004**	**2010**	**2020**	**2030**
Oil	47.1	65.2	65.6	70.1	77.1
Gas	7.1	15.1	18.5	18.6	20.7
Coal	-17.1	-1.9	-2.3	3.3	5.9
Total	**16.4**	**29.0**	**27.9**	**30.2**	**33.0**

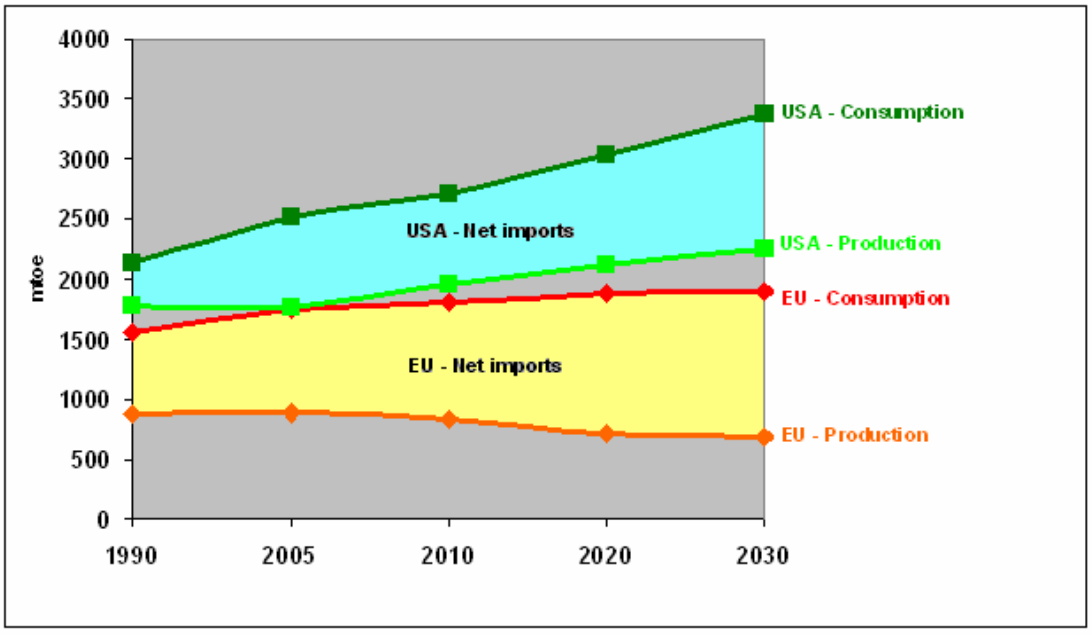
Source: Data based on Table 25.

Table 30: EU – Import dependency (%)

	1990	**2005**	**2010**	**2020**	**2030**
Oil	80.9	79.3	83.7	92.7	93.8
Gas	47.5	53.4	62.8	81.4	84.6
Coal	17.5	37.8	46.1	49.5	59.0
Total	**44.7**	**51.8**	**55.0**	**63.5**	**64.9**

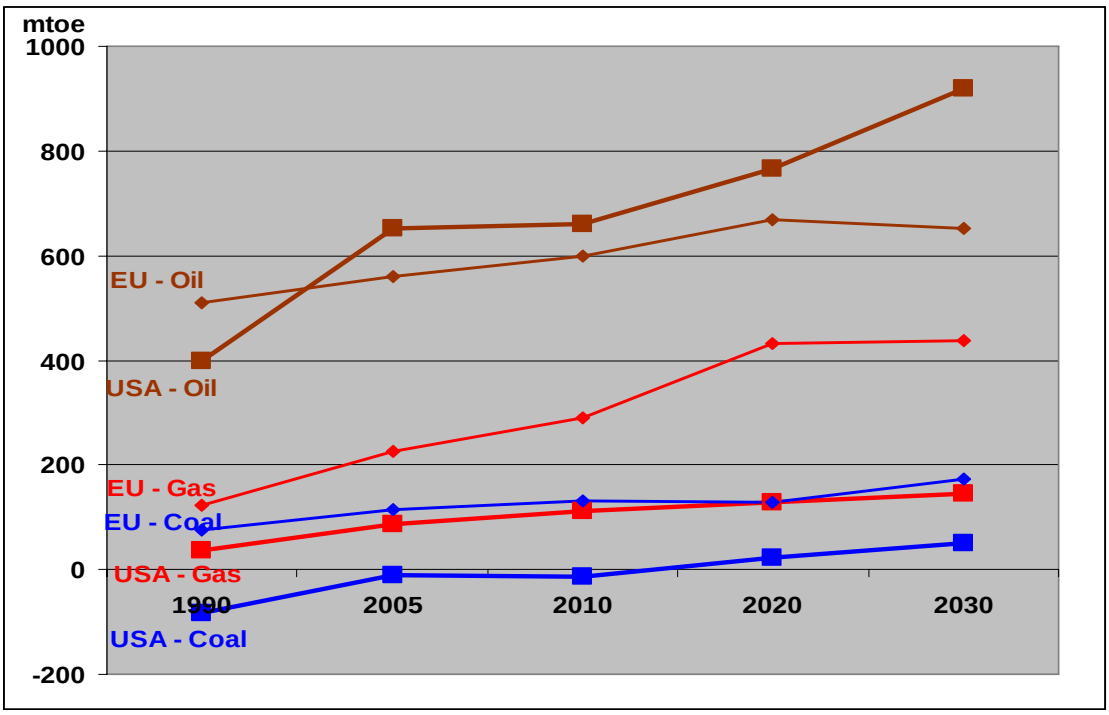
Source: Data based on Table 26; COM (2006a: 26).

Figure 59: US and EU – Total primary energy production, consumption and net imports



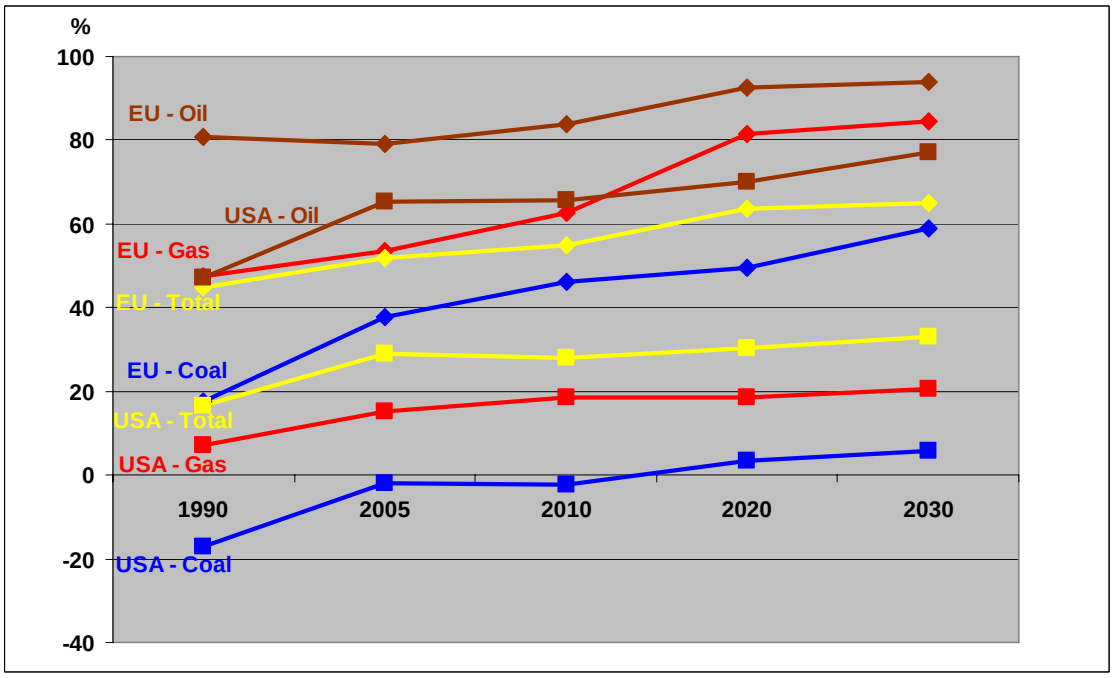
Source: Data based on Table 25 and 26.

Figure 60: US and EU – Import dependency (mtoe)



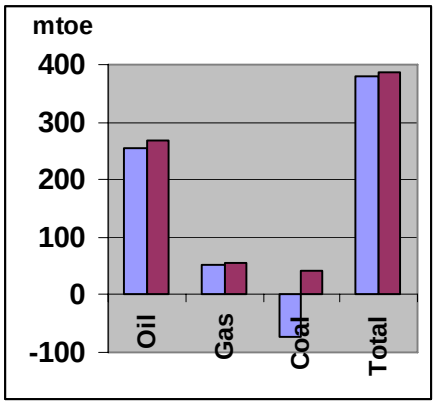
Source: Data based on Table 25 and 26.

Figure 61: US and EU – Import dependency (%)



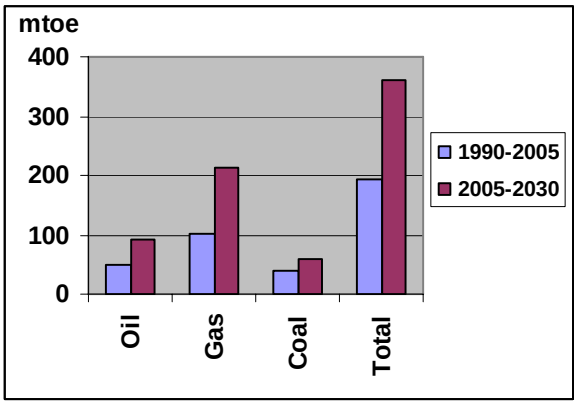
Source: Data based on Table 29 and 30.

Figure 62: US – Net imports (mtoe)



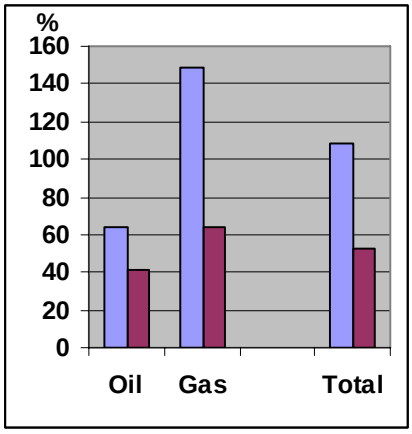
Source: Data based on Table 25.

Figure 63: EU – Net imports (mtoe)



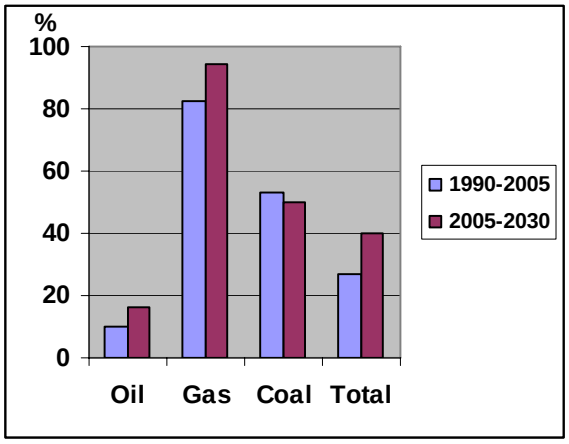
Source: Data based on Table 26.

Figure 64: US – Net imports (%)



Source: Data based on Table 25.

Figure 65: EU – Net imports (%)



Source: Data based on Table 26.

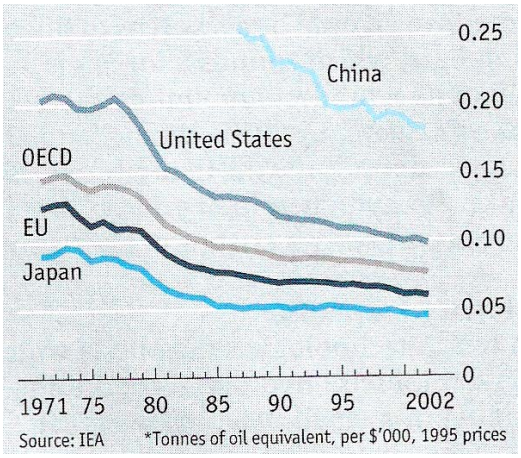
3.4.4. ENERGY EFFICIENCY – OVERVIEW

Enhancing energy efficiency is a way of increasing energy security because it means doing more with less. Unfortunately, gains in efficiency are eroded by the growth of economies and population, despite decoupling of the GDP (gross domestic product) growth and energy consumption. However – because the purpose of this work is to define different possibilities of energy diversification (as a way to enhance energy security) and not *all* ways of enhancing energy security in general – the energy efficiency will be

presented here only very briefly. However, the importance of energy efficiency has been explained on many occasions so far in the text, especially concerning transport sector (see Chapter 3.2.5.3.). Moreover, different upgrades can increase the output of all kinds of power plants thus increasing efficiency etc.

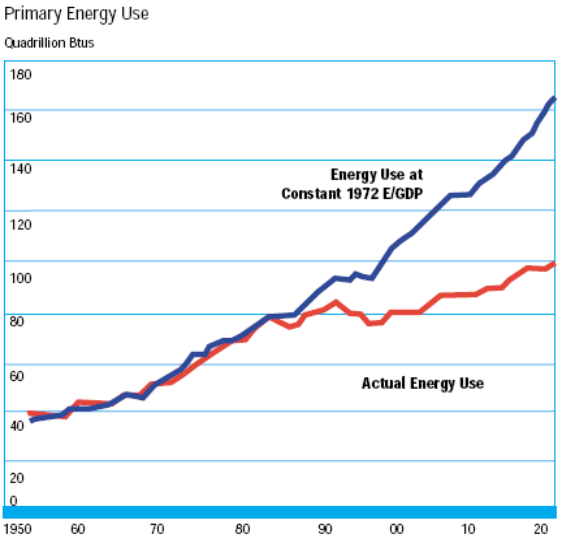
One of the greatest challenges faced today, and perhaps one of the strongest drivers towards increased efficiency, is rising energy costs. Since 2002, real oil prices have been growing rapidly. There is increasing consensus among experts that this is not a temporal shift, and that oil prices have in fact risen to a new price band, implying that the return to the low prices of the late 1980s and 1990s is increasingly unlikely (COM, 2006b: 123). In the US, the problem has been magnified by rising natural gas prices. After the oil shocks of the 1970s, the developed world introduced powerful policies to encourage energy efficiency. Thanks chiefly to government policies, growth in the rich world's energy use and GDP decoupled, and the OECD countries became much more energy-efficient (Figure 66) (The Economist, 30.4.2005: 16). From 1980 to 1995, the amount of energy used in the US per constant dollar of GDP declined from $16.47 to $13.44. Europe and Japan made even bigger gains in efficiency (Jaffe et al, 2000: 20). Over the past 30 years, US GDP has grown by 150 %, while US energy consumption has grown by only 25 %. In the 1970s and 1980s, many considered that kind of decoupling impossible, or at least certain to be economically ruinous. Many of the gains in energy efficiency have come because the US economy is "lighter" – that is, GDP today is composed of less manufacturing and more services (Yergin, 2006: 80-81). If the intensity of US energy use had remained constant since 1972, consumption would have been about 70 quadrillion Btus (1764 mtoe) (74 %) higher than it actually was (Figure 67).

Figure 66: Ratio of oil use to GDP



Source: The Economist (30.4.2005: 17).

Figure 67: US – Decoupling of GDP growth and energy use



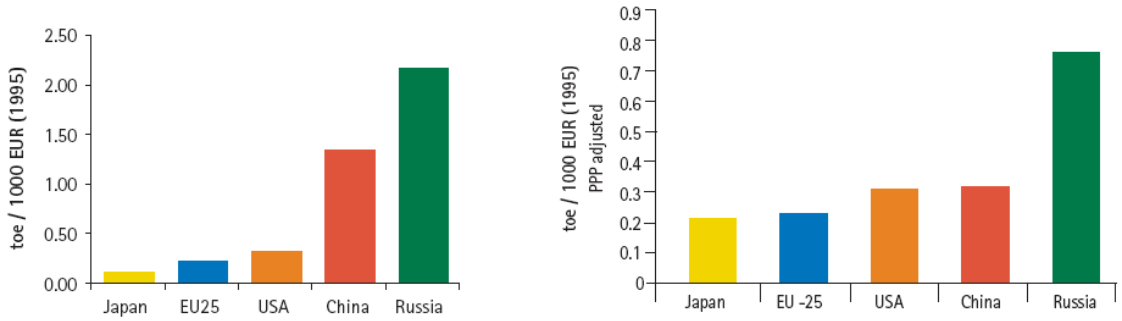
Source: National energy policy development group (2001: xi).

However, some believe that simply conserving energy and using it more efficiently cannot solve the problem, because consumption has been increasing even faster and the carbon emissions are consequently rising. Although efficiency has improved on average by almost 2 % annually over the last 20 years, GDP has grown at over three percent annually (data for the US). Moreover, even at that rate, efficiency cannot improve indefinitely, because manufacturers and entrepreneurs exploit the easiest way of saving energy first, and so it may be harder and more expensive to achieve more gains (Friedmann et al, 2004: 74).

An indicator of energy efficiency is *energy intensity* (energy consumed per unit of GDP output). An economy with low energy intensity is not necessarily more efficient than one with a higher intensity for a number of reasons. These include climatic conditions, the chosen level of heating comfort, size and type of industrial manufacturing base, geography. However, there are still unmistakable patterns between developed and less developed countries. In the US, energy intensity fell by 12.4 % between 1990 and 2002, mainly due to good economic performances of its less energy-intensive sectors. Intensity decreases were much more moderate in the EU, driven by higher relative energy

prices (from taxes to other structural conditions), and a less dynamic growth of their economies. For instance, whereas consumption in the EU and the US rose nearly the same amount (in the vicinity of 9.3 %) between 1990 and 2003, the US economy grew by 28.7 % over the period, while the EU economy only grew by 18.6 %. The reduction of energy intensity in the EU was lower because its intensity is already one of the lowest among the countries considered; both in absolute and in Purchasing Power Parity-adjusted terms (Figures 68-69) (COM, 2006b: 114). Energy intensity in the EU was 0.204 toe/€1000 (1995) in 2003. Since 1995, intensity in the EU has fallen on average by 1.4 % per year. In comparison, energy intensity in the US for 2003 was 0.313 toe/€1000 (1995) and only fell by an average 0.8 % over the same period (COM, 2006b: 124).

Figures 68-69: Energy intensity



Source: COM (2006b: 114).

The EU Commission's first broad strategy on energy efficiency dates back to 2000, when the Action plan for Energy Efficiency, an umbrella document outlining programmes of Community legislative and non-legislative efficiency-enhancing actions, was adopted. In June 2005, the Commission adopted the Green Paper "Energy Efficiency or Doing More with Less", which seeks to put energy savings on the top of the energy agenda. It is intended to start a discussion on how to save energy and lists a number of options to achieve a 20 % savings of energy consumption by 2020 in a cost effective way, mainly through changes in consumer behaviour and energy efficient technologies. Estimates suggest that the Community's energy consumption is approximately 20 % higher than can be justified on economic grounds. Significant energy savings can be

realised through energy services and other end-use efficiency measures (COM, 2006b: 26).

On 19 October 2006 the EU Commission adopted the Energy Efficiency Action Plan, containing measures that would put the EU well on the path to achieving a key goal of reducing its primary energy use by 20 % by 2020. If successful, this would mean that by 2020 the EU would use approximately 13 % less energy than today, saving €100 billion and around 780 million tonnes of CO_2 each year. However, this will require significant efforts both in terms of behavioural change and additional investment (COM, 2007, 1 final: 12).

All American documents considered in Chapter 3.1.1 promise greater efficiency and conservation, but as Klare (2005: 59) noted: "they pay lip service to energy efficiency, but the whole emphasis is on increasing supply". Although the president's rhetoric stressed a commitment to conservation and self-sufficiency, a close reading of the NEP reveals the opposite (Klare, 2005: 60).

In the same way, different EU papers – already considered – are promising to increase energy efficiency and even to achieve a 20 % savings of energy consumption by 2020. The plan is certainly overambitious, as even the Commission itself admitted. The plan will fall short with some goals like the plans to increase electricity generation from renewable energy sources from 13.9 % in 1997 to 22.1 % in 2010 and the plan to replace 5.75 % of the oil used in transport with biofuels by 2010.

4. CONCLUSION

To answer the hypothesis: the US and the EU (hereinafter referred to as both), carry out basically the same strategy of diversification regarding primary energy. It could be said that plans for diversification are more or less alike, only the starting point is different. Both share the same vision in "the large scale replacement of gasoline with electricity and hydrogen produced from clean coal, nuclear, and renewable technologies" (National economic council, 2006: 5; or COM, 2007, 1 final: 16). For 2050 and beyond, an overall European energy mix should include large shares of sustainable hydrogen (COM, 2007, 1 final: 16). To get enough hydrogen for the future "hydrogen society", both are developing new nuclear power plants that would primarily produce hydrogen (generation IV, ITER). However, actual deployment of such nuclear power plants lies far in the future. On the other hand, there has been little interest in the last two decades to build new nuclear power plants to produce electricity but the prospects are a little more optimistic regarding rising energy prices. On the other hand there has been a renaissance of using coal as a fuel for generating electricity. Especially the US, due to its large coal reserves, sees coal as a way to increase energy independence. The US and the EU are both (jointly) developing clean coal technologies. There has also been a growth in renewable energy production. It is telling that in 2030 renewable energy sources are projected to be the greatest primary energy producer in the EU while in the US they are projected to produce the lowest amount of primary energy. So, there is little difference regarding indigenous energy sources. Their use, after a stalemate, needs to be increased to produce more home-made energy to increase energy security and to enhance diversification. The point is that it will reduce imports of other primary energy sources – crude oil and natural gas (for more on primary energy and import dependency, see Chapter 3.4. which discusses the main findings).

A more interesting field is geographical diversification. Basically, both have the same aims regarding crude oil and natural gas. Both are trying to diversify their sources of supply that can be seen especially after the year 2000 (geographical diversification comparably is explained in detail in Chapter 3.2.9.). The US is reducing crude oil imports from Middle Eastern countries and countries that are geographically farther from the US

and increasing imports from Latin American and African countries and Russia. The EU is also decreasing crude oil imports from the Middle Eastern countries and increasing imports from the FSU and African countries. Natural gas imports of both the US and the EU show concentration on a few countries. On the other hand, the market for LNG is projected to develop further what will increase geographical diversification. Both are importing natural gas mostly from their neighbouring countries.

Both are trying to develop special relations with the producer countries. The EU has developed a wide set of formal relationships aimed at tying neighbouring and FSU countries (the European Neighbourhood policy, the Euro-Mediterranean Energy Forum, the Energy Community, the Baku initiative, the INOGATE programme) while the US relies more on informal relationships (with Saudi Arabia and other Gulf countries) and to a greater extent on military power (which is used to protect sea lanes and also pipelines increasingly). Besides, critics say that the US Latin American energy policy is in disarray.

The difference between the US and the EU lies in greater resource availability (of crude oil, natural gas and coal) in the US while the EU is comparably resources-lacking. This is also the main reason that the EU is currently importing 51.8 % of its primary energy needs while the US imports only 29 %.

It is widely perceived that at least in the short and near term oil will remain the main fuel of the transportation sector. Until the more developed fuel cells based on hydrogen (or any other breakthrough technology) develop the world will have to live with oil (and the Middle East). That is why both are trying to develop alternative fuels, especially those based on ethanol and biodiesel although the US currently produces more than three times more biofuels than the EU. There are plans to produce more oil from non-conventional sources, but there is potential only for the US and Latin America in general. That is why the EU is acting more on the demand side, taxes and duties on petrol are almost three times greater in the EU than in the US and energy efficiency in general is greater in the EU.

All policy papers considered are supporting these findings. However, they tend to be overambitious, especially the EU ones. On the other hand, all the projections should be taken with reserve, because the political atmosphere and the oil prices on which they

are based are changing frequently and nobody really knows whether the considered technologies will really work and, if they do, they will become operational only decades later. Still, there is always a chance that a breakthrough technology emerges that would solve the problem of oil dependence. Gradually, hydrogen could take the lead. If we also take peak oil debate and global warming in consideration, the situation is urgent. Diversification is therefore not only a means to reduce dependence on imported energy, but to develop fuels and technologies that would gradually replace hydrocarbons in energy mix.

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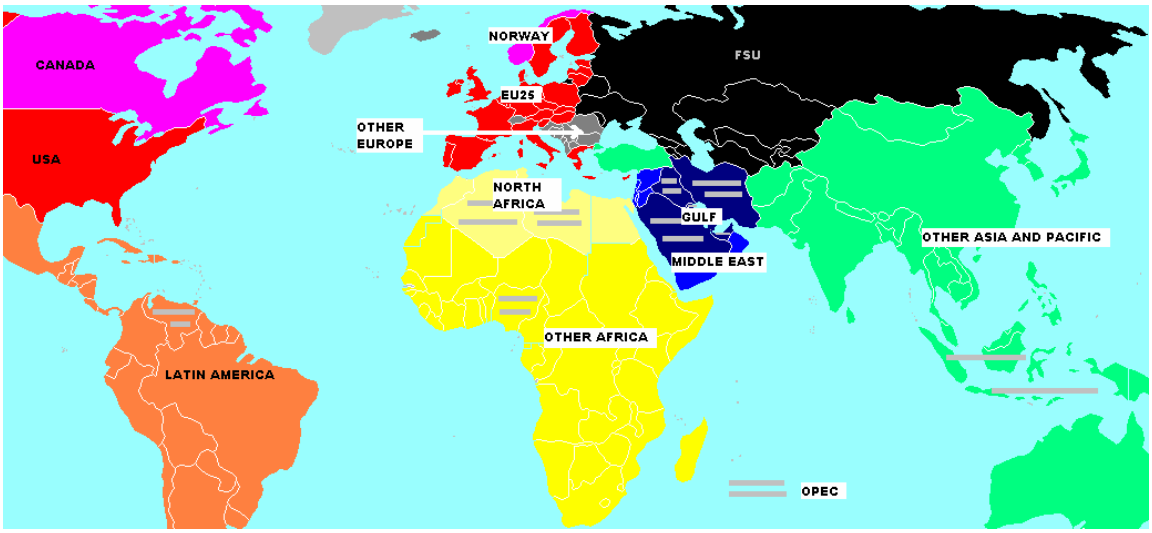
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APPENDIX

1. DEFINITION OF REGIONS

1. Research objects:
- USA
- EU25 – European Union of 25 Member States
2. Regions (countries) of great importance for the USA and the EU25 (considered as very stable):
- Canada
- Norway
3. Other regions:
- Latin America: North and South America less Canada and the USA
- FSU – Former Soviet Union
- Other Europe: European countries not included in EU25, FSU and less Norway: Iceland, Switzerland, Croatia, Bosnia and Herzegovina, Serbia, Montenegro, Former Yugoslav Republic of Macedonia, Albania, Bulgaria and Rumania
- North Africa: Morocco, Algeria, Tunisia, Libya, Egypt
- Other Africa: Africa less North Africa
- Gulf – Persian (Arab) Gulf countries: Bahrain, Iran, Iraq, Kuwait, Qatar, Saudi Arabia and the United Arab Emirates
- Middle East: Gulf + Syria, Israel, Lebanon, Jordan, Oman, Yemen
- Other Asia and Pacific: Asia less Asian part of the Middle East and the FSU + Pacific (mostly only Australia and New Zealand) and including Turkey
- OPEC: Algeria, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates and Venezuela.

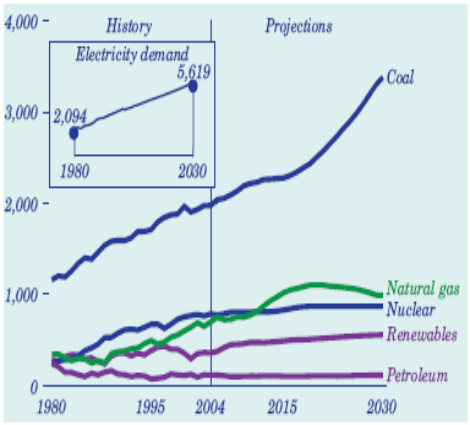
Map 22: World regions



Source: map based on Wikipedia (2006).

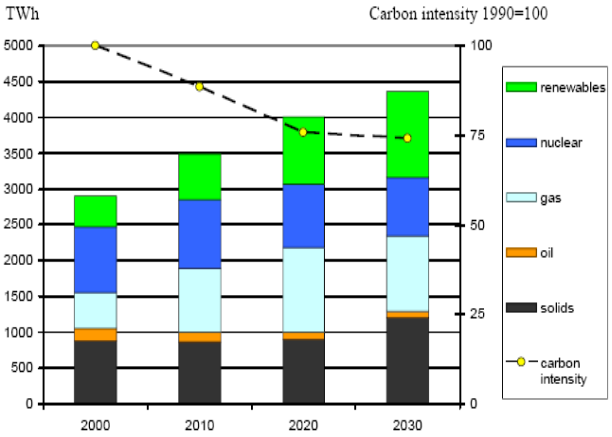
2. US and EU electricity production by fuel.

Figure 70: US – Electricity production by fuel (TWh)



Source: (DOE/EIA, 2006b: 7).

Figure 71: EU – Electricity production by fuel



Source: (COM, 2006a: 10).

POVZETEK V SLOVENSKEM JEZIKU

V razvitem svetu energetska varnost ponavadi pomeni dostop do potrebnih energetskih virov po zmernih cenah. Že Churchill je dejal, da je ključ do energetske varnosti v različnosti (diverzifikaciji) energetskih virov. Diverzifikacija pomeni, da države niso preveč odvisne le od enega elementa ponudbe: držav, geografskih regij, vrste goriva ali infrastrukture. Tako ZDA kot EU se poslužujeta strategije diverzifikacije kot glavnega elementa za zmanjšanje odvisnosti od tujih dobaviteljev energije.

Evropske države se soočajo z odvisnostjo od uvoza ruskega zemeljskega plina in v veliko evropskih držav teče razprava o morebitni gradnji novih jedrskih elektrarn ali povečani uporabi premoga. Za Bushevo administracijo pomeni diverzifikacija povečanje števila dobaviteljev nafte in prepričevanje le-teh v znatno povečanje proizvodnje. Uvoz nafte bo kljub poskusom diverzifikacije še vedno naraščal, tako v ZDA kot v EU. Da bi vsaj malo omilili odvisnost od Bližnjega Vzhoda, kjer ležita dve tretjini vseh znanih zalog nafte, si ZDA in EU prizadevata za to, da bi čim več nafte prišlo iz drugih regij, hkrati pa pospešujeta uporabo zemeljskega plina kot nadomestila za nafto, saj le-ta leži v manj nevarnih regijah sveta, ZDA pa ga zaenkrat kar 85 % proizvedejo doma.

ZDA in EU podpirata razvoj obnovljivih in alternativnih virov energije, ker pa le-ti kmalu še ne bodo mogli nadomestiti pomena nafte in zemeljskega plina, oboji razmišljata o vrnitvi na premog (kateremu bi v procesu odvzeli okolju škodljive snovi, predvsem pline, ki bi jih predvidoma uskladiščili pod zemljo) in jedrsko energijo. V transportnem sektorju si tako ZDA kot EU prizadevata zmanjšati delež nafte, predvsem s proizvodnjo obnovljivih biogoriv (pri čemer prednjačijo ZDA) in uvedbo hibridnih vozil na vodik.

Na splošno so ZDA zaradi večjih energetskih rezerv in relativno precej manjšega uvoza tako nafte, zemeljskega plina in premoga v boljšem položaju kot EU. ZDA so torej energetsko bolj neodvisne kot EU, vendar pa to v svetovnem merilu ne pomeni veliko, saj je za normalen gospodarski razvoj pomembna predvsem (nizka) cena nafte, ki pa je po vsem svetu enaka. Poleg tega trendi napovedujejo, da bodo tudi ZDA v prihodnje morale povečevati uvoz naštetih surovin zaradi vse večje domače porabe.