ENERGIE-CITES

Facing the Challenge of Energy and Climate Change
Local actors working together more effectively

WORLD ENERGY SURVEY

Past, Trends and…

Future?

Delft-Zoetermeer, 23-24 March 2006

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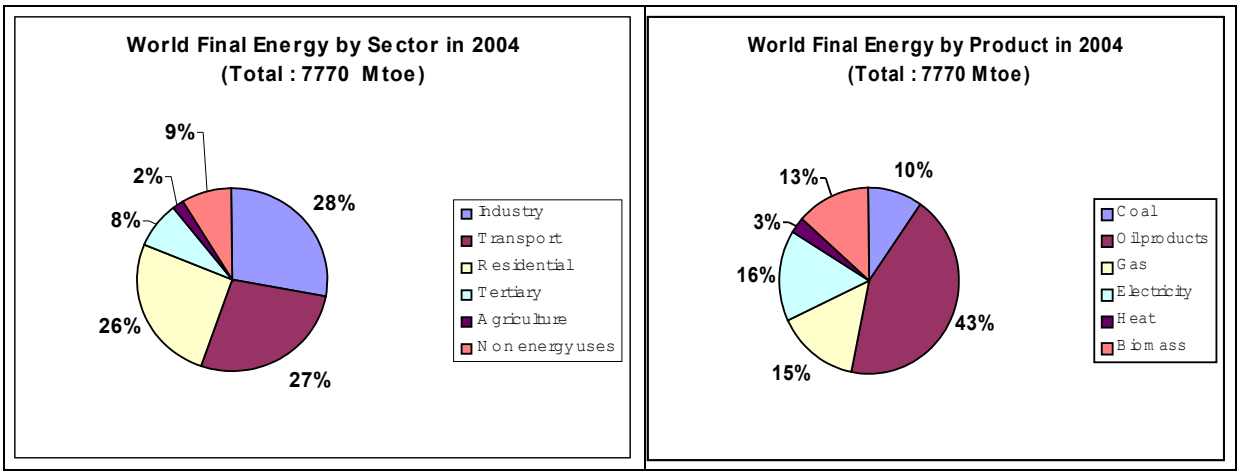
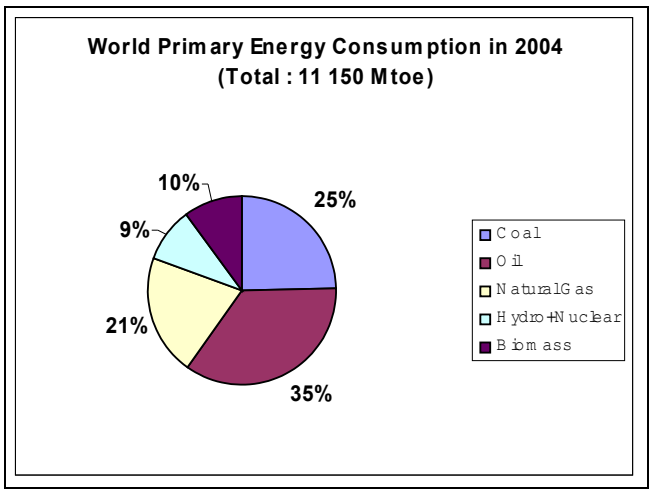
1. World Energy in 2004[1]

"Final Energy" indicates the quantity of energy products which are delivered to and consumed by the final economic and social activities (industrial and tertiary enterprises, households, public services…) in order to fulfil the needs for production, comfort, travelling and transport of goods, health and education, etc. Final energy consumption represents the "**demand side**" of the energy system.
"Primary Energy" indicates the quantity of basic energy sources which are consumed in order to provide the appropriate quantities of final energy required by the consumers. Primary energy covers fossil resources (coal and lignite, oil, natural gas), renewable resources (hydro, wind, solar, bio-mass) and nuclear resources (energy produced by fission in nuclear reactors). Primary energy production and transformation, in particular power production) represents the "**supply side**" of the energy system.



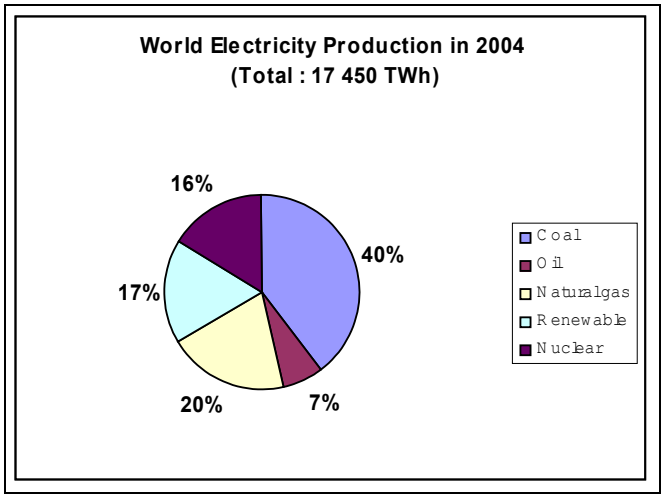
The grouping "Residential and Tertiary", for which the heating (and cooling) of buildings is the first energy use, comes first, well ahead "Industry" and "Transport", the latter almost exclusively consumer of oil products which are by far the first component of world **final energy consumption**.



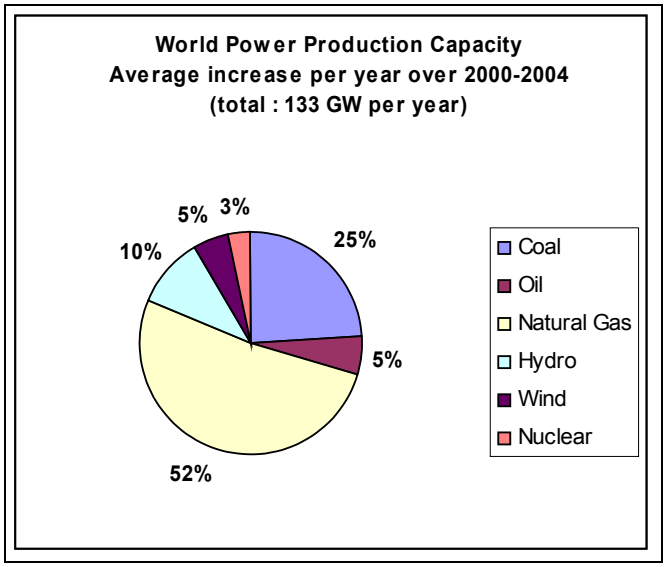
As expected from final energy demand, oil comes first as **primary energy source**, followed by coal and natural gas : fossil fuels represents 81% of world energy supply. The share of "primary electricity" (renewable, essentially hydro, and nuclear) remains limited (9%).

[1] Source : all data presented in this document come from the ENERDATA data base (see www.enerdata.fr).

For electricity production, coal comes first, by far, followed by natural gas and a small contribution of oil. Renewable energy sources (96% hydro, 3% wind, 1% geothermy) are slightly ahead nuclear .



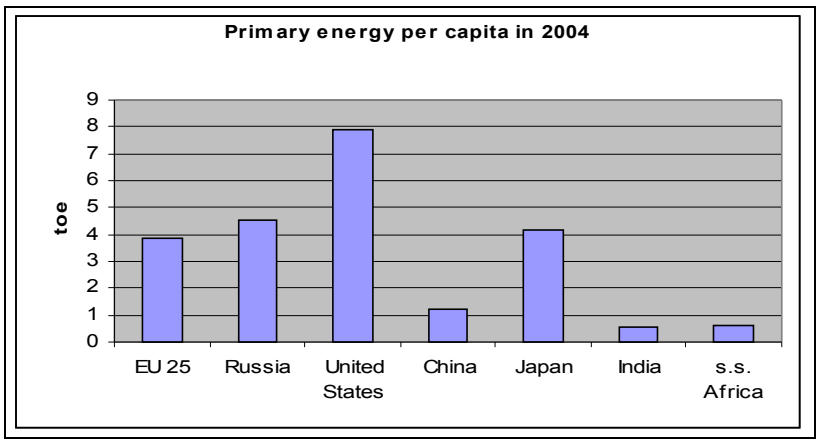
The average per year increase of World power (or electricity) production capacity over 2000-2004 shows the size of the present power plants market : more than 50% of the new power plants are gas fired (with a majority of combined cycle), followed by coal (25%), renewable (hydro and wind : 15%) and, well behind, nuclear (3%).



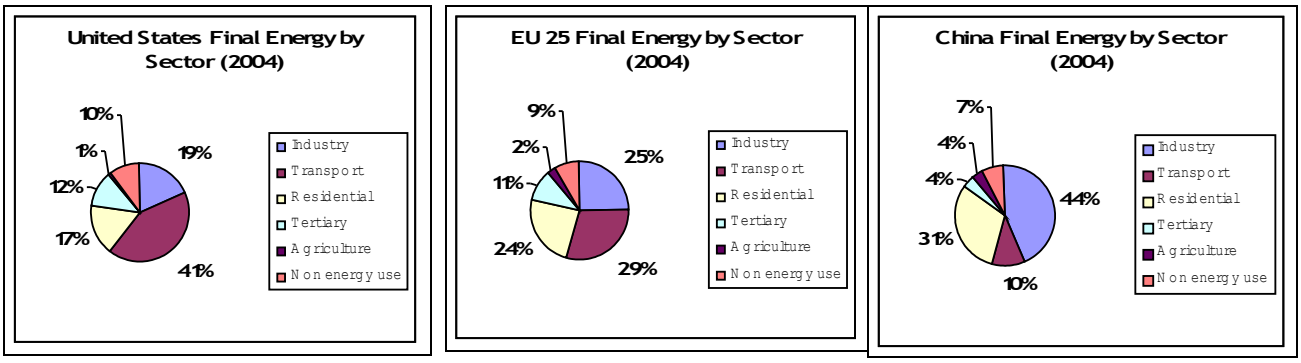
2. Disparities and inequalities

World energy consumption is marked by deep discrepancies by regions and countries : with 18% of the world population (6340 millions), the OECD countries absorb 50% of total primary energy (11 150 Mtoe).

A more detailed distribution by selected countries and regions shows a factor of sixteen between the higher per capita consumption for United States and the lowest, for sub-saharan Africa (the consumption being even much lower for the poorest countries of this zone).



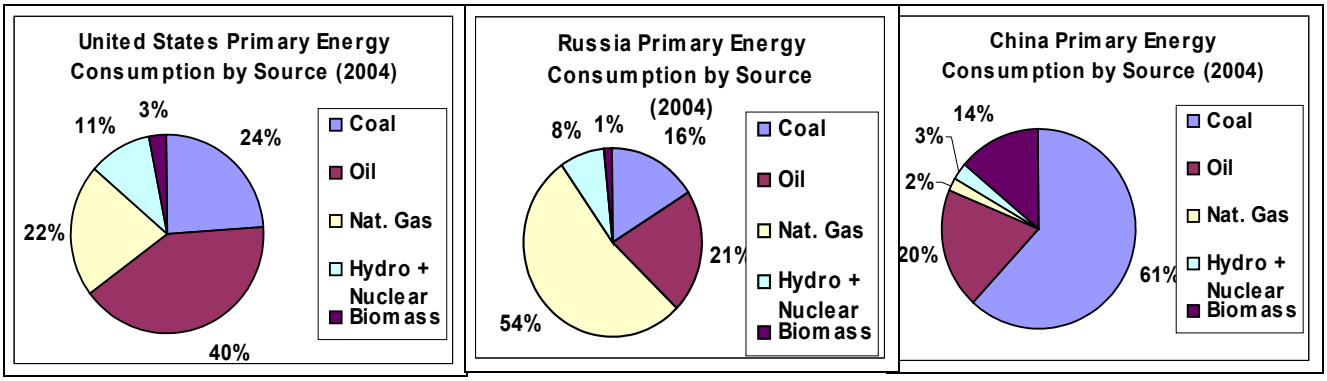
Beyond the absolute consumption values, the consumption patterns are also different, both for final and primary energy consumption.



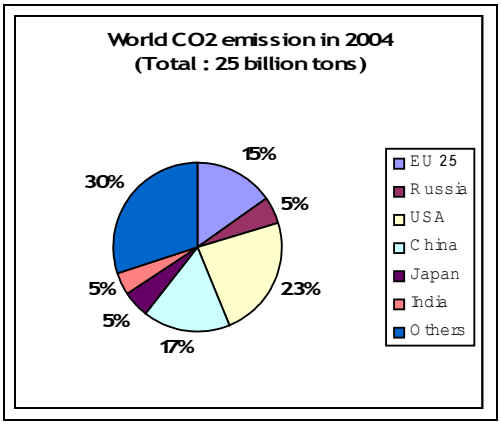
In the United States, the Transport sector is dominant, even higher than the "Residential and Tertiary" grouping which ranks first for EU, while Industry dominates China's energy consumption.

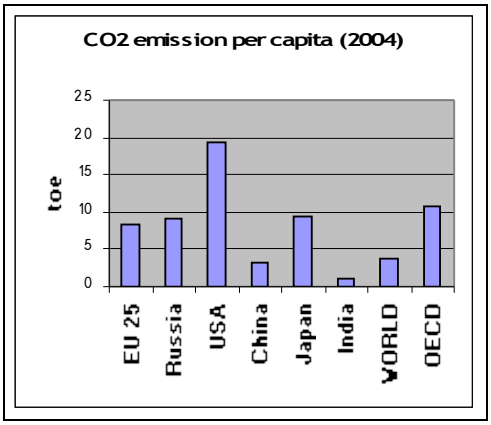
Primary energy consumption is dominated by oil in the United States (the same is true for the EU), while natural gas ranks first in Russia and coal, by far, in China.

The primary energy pattern is directly linked with the demand requirements (transports for the US) and the abundance of the local energy resources (natural gas for Russia and coal for China).



CO2 emissions linked with the energy activities are distributed roughly with the same shares among the main energy consumers.
CO2 emissions per capita are distributed in function of the primary energy consumption per capita value and the carbon content of primary energy, i.e. as a first approximation, the share of coal in the primary energy balance.

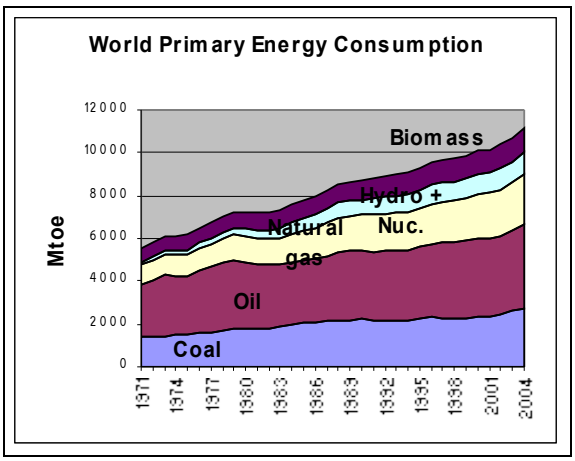


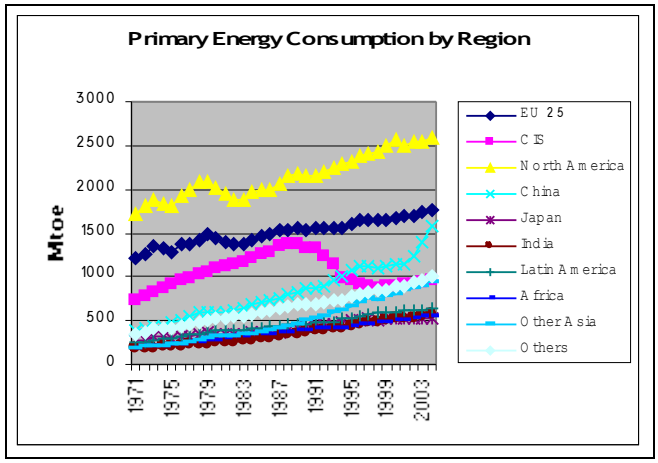


3. SINCE 1971

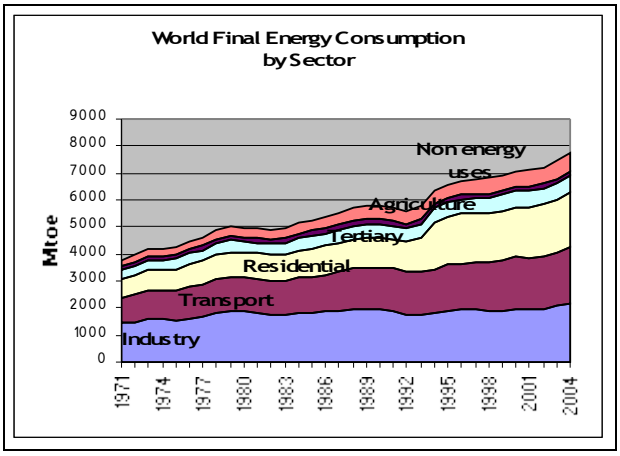
Total Energy

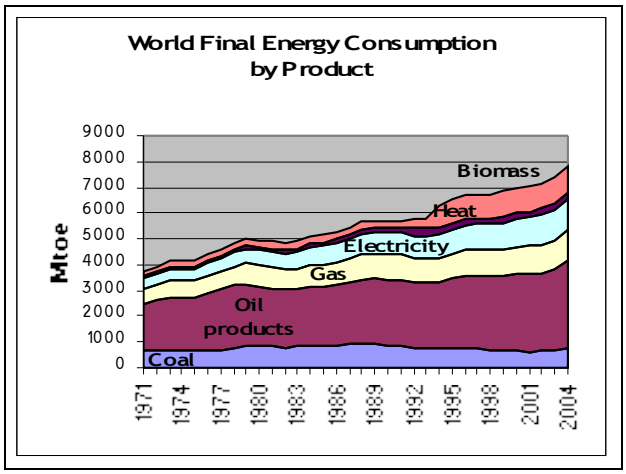
World population increased from 3 750 to 6 341 millions from 1071 to 2004, by a factor of 1.7.
World primary energy consumption grew by a factor of 2.
Oil remained the first energy source over the period, its share decreasing however from 44% in 1971 to 35% in 2004 to the benefit of coal and natural gas.



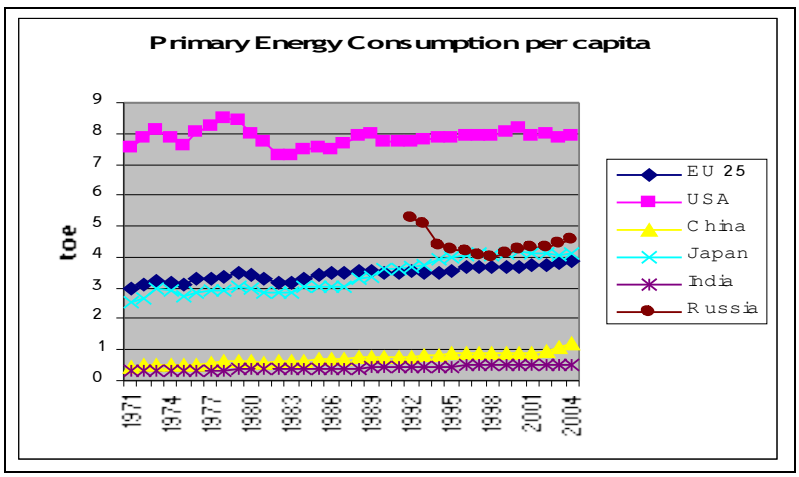


World final energy consumption doubled also over the period. First consuming sector in 1971, "Industry" is now second behind "Residential and Tertiary". "Transport" is very near and increasing faster. Oil products remain the first final energy product (in relation with Transport).



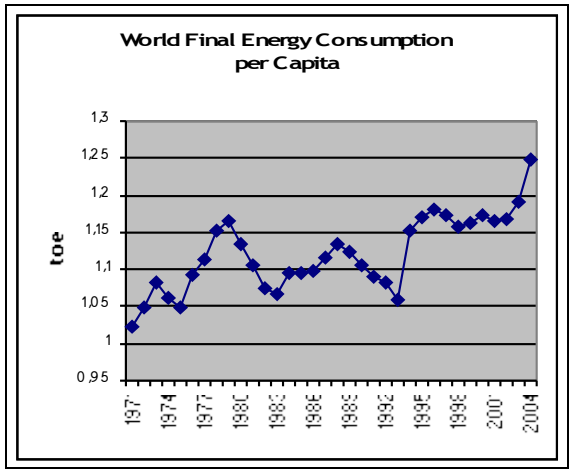


Energy par Capita



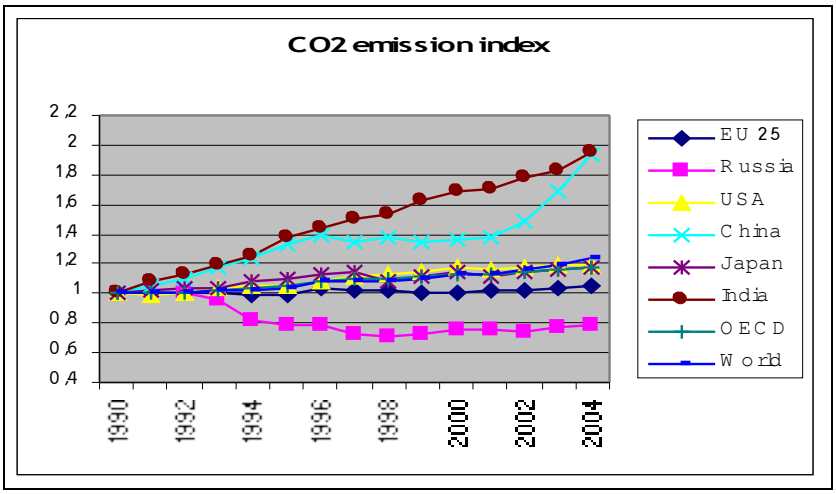
Per capita primary energy consumption of the United States roughly stabilised over the past thirty years. It remains well ahead those of EU, Russia (which is again on a growth trend) and Japan practically stabilised. Emerging countries like India and China remain far below, with a sharp increase of China's energy consumption since 2001.

Final energy consumption per capita historical record illustrates the effect on energy of the two oil shocks of 1973-74 and 1979-80 (strong reduction of energy demand), the growth following the 1985-86 "counter-shock" and the economic crisis in the former USSR during the early 90s.
After a period of stabilisation from 1995 to 2002, World energy consumption is again rising due to the fast economic growth of China, the consumption per capita of which remains low compared to that of the industrialised countries.



CO2 emissions

The next figure shows the evolution of these emissions since 1990 (1992 for Russia), the reference year for the Kyoto Protocol.

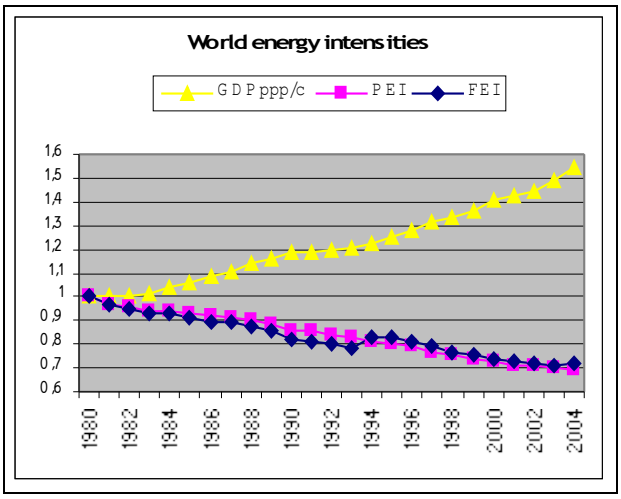


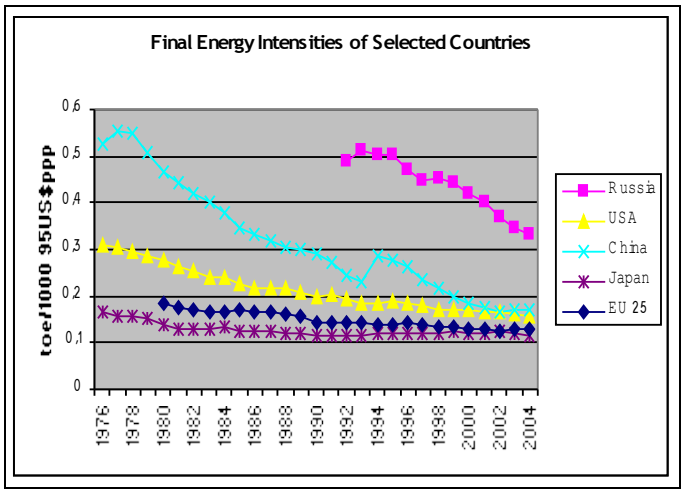
Total World emissions increased by 20% over the period 1990 – 2004. EU 25 emissions roughly stabilised with a slight increase in the early 2000s. United States and Japan increased by about 20%; Russia's decreased during the 90s due to the economic crisis but are on a slow growth trend since year 2000.

4. Energy Intensities

Apart from energy consumption per capita, another global indicator is widely used to assess the energy situation of a country and its evolution and to compare different countries or regions : the "energy intensity", ratio of the energy consumption (final or primary) over GDP expressed at purchase power parity (ppp). Energy intensity, expressed in toe per GDP unit, is the quantity of energy consumed during a given year per unit of GDP. This value depends on several factors : climate, size of the country, structure of the economic activities (economy dominated by industry, or tertiary activities, importance of the transport sector, etc.), the "way of life" (different between USA and Western Europe for example) and, above all, by the degree of efficiency of the energy consumption patterns and techniques (the "demand side") and of the energy production and transformation system ("supply side"). Energy intensity indicates if a country's (or a region's, or the World's) economic and social activities are globally more or less "energy intensive".

As a first approximation, energy intensities gives a rough idea of the efficiency of the demand side (final energy intensity : FEI = FEC/GDPppp) and of the total energy system (primary energy intensity : PEI = PEC/GDPppp). The value of this global indicator as a measure to compare the energy efficiency of different countries economic and social activities is of course better if these activities are not too different.





World is much less energy intensive in 2004 than in 1980. Both final and primary energy intensities decreased over 24 years by roughly 30%. The fact that this decrease has the same value for both indicators shows that this was due to the modification of the demand side, through the change in the structure of the economy and the improvement of the efficiency of energy consumption.

Data from year 1976 for selected countries (the largest consumers) show the general dynamics of the decrease of final energy intensity for different types of economies. Over this almost thirty year period, the value for USA was divided by 2, starting from high and still higher than EU[2] and Japan. The decrease for China is spectacular and is due simultaneously to deep structural changes and real energy saving on the demand side. In spite of an important decline since 1996, Russia remains by far the most energy intensive economy in the world.

This evolution is extremely important to envisage the future of energy systems : structural changes will occur, in particular in "emerging" economies like those of China and India, and those countries can exploit and amplify the experience gained by the OECD countries over the past thirty years to build a much less energy intensive civilisation.

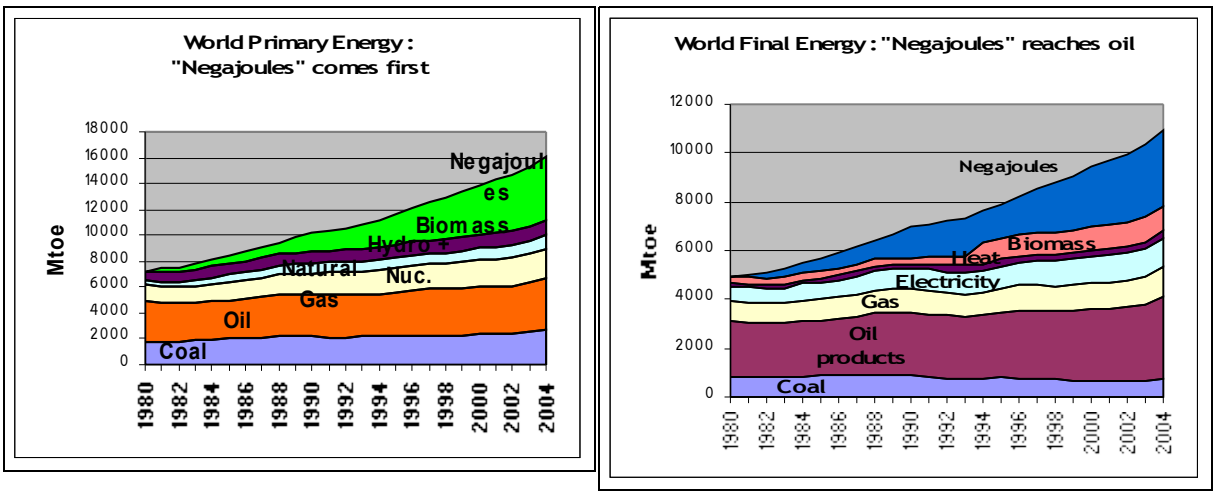
[2] Denmark has the less energy intensive demand : its 2004 final energy intensity is 0.10.

5. The hidden resource : Negajoules

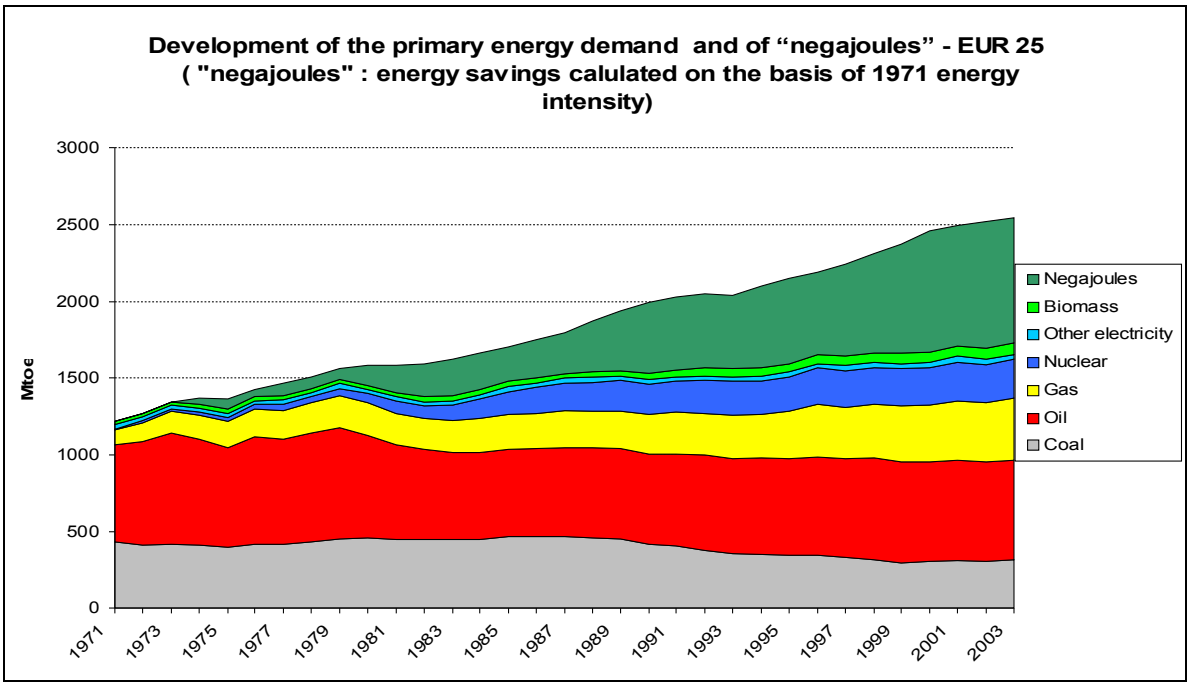
In 1980, the World primary energy intensity was 0.340 toe/1000US$95. It decreased to 0.237 in 2004. If the energy intensity had remained constant over the 1970-2004 period, the energy consumption would have been much higher : the difference are the "Negajoules" saved year after year, due to the decrease in energy intensity. The remarkable feature is that, in 2004, the contribution of "Negajoules" is more important than the primary consumption of oil : 4875 Mtoe versus 3921 Mtoe : "Negajoules" accumulated since 1980 ranks first in the world energy balance.

The same is true for final energy consumption : World final energy intensity decreased from 0.232 in 1980 to 0.166 in 2004. The "Negajoules" contribution in total final energy consumption in 2004 is 3088 Mtoe, just after oil products (3385 Mtoe).

This comparison confirms that the main contribution of "Negajoules" is on the demand side : structural changes and improved energy efficiency.

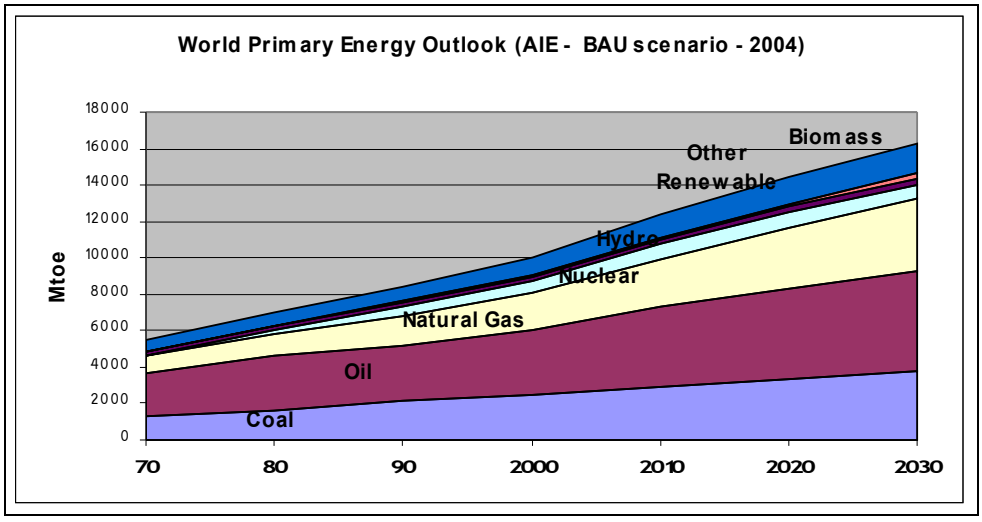


The European Commission Green Paper on Energy Efficiency (2005) presents a very interesting figure on the importance of energy efficiency in the development of the EU primary energy demand from 1971 to 2003 with the share of "negajoules" (energy savings calculated on the basis of 1971 energy intensity – *Source* : ENERDATA).



6. "Business as Usual" : a Warning Scenario

The International Energy Agency (IEA) produces regular publications on "World Energy Outlook", from on an analysis of demand and supply evolution for the next decades. The "Business as Usual" (BAU) scenario is based on the assumption that current energy policies continue.
In this BAU scenario, World primary commercial energy demand[3] would increase steadily from 9,200 Mtoe in year 2000 to 15,300 Mtoe in 2030. Fossil fuels would remain dominant in 2030 (about 89%) with natural gas growing more quickly than oil and coal.
62% of the increase in world demand would come from developing countries, especially in Asia. Almost all the increase in production would occur outside the OECD. OECD countries would become more and more dependent on energy imports.
The anticipated total world energy investment over the thirty year period in this scenario is 16 trillion dollars, of which 60% for electricity (46% in power generation and 54% in transport and distribution).



The IEA Executive Director's comment on this "business as usual" scenario is sharp : ***"But this is not sustainable!".***

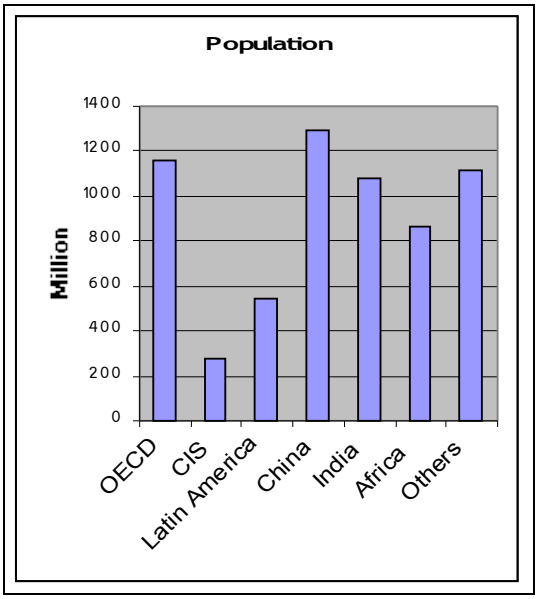
To pursue the present path for energy systems development leads to growing insecurity of supply and unacceptable increase in greenhouse gas emissions : in the IEA scenario, world energy-related CO_2 emissions increases by 1.8% per year to 38 billion tonnes in 2030, 70% above the 2000 level. Furthermore, the increase in energy prices due to the magnitude of energy investments and the announced limitation of oil and gas medium and long term low cost resources would increase the already existing disparities on access to energy between the rich and poor countries.

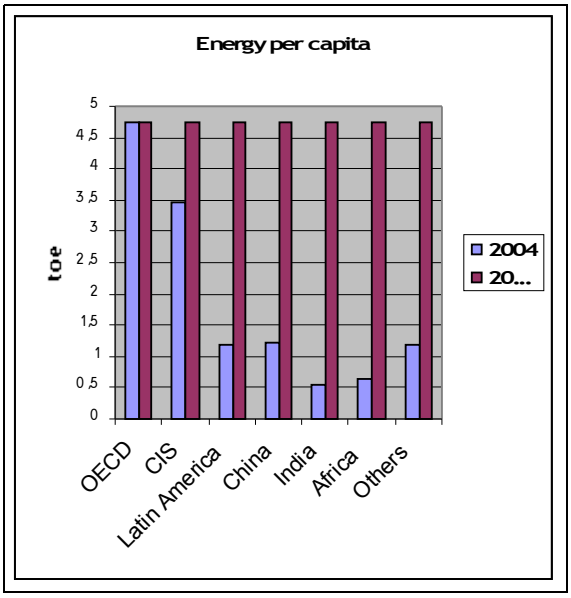
[3] Traditional use of biomass is not included.

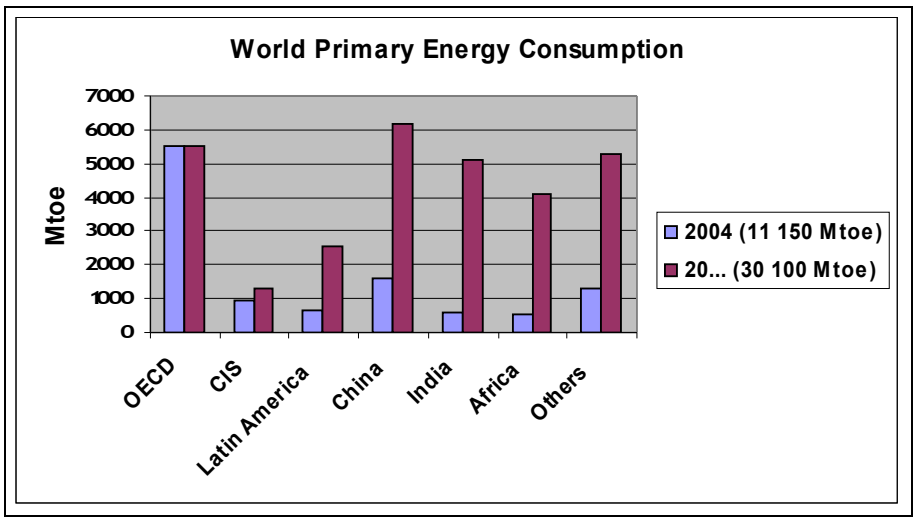
7. WHAT IF?

If the energy model of ever growing energy supply to sustain ever growing energy demand was limited to the OECD (or "rich") countries, it could probably go on during a number of decades. But if one recognises the legitimacy of economic and social development of such countries and regions as China, India and the rest of the world, the development of energy systems based on the present trends and business as usual policies is simply impossible.

The following figures show what would be the World primary energy consumption, if China, India and the other large regions of the planet reached, an unknown year of the XXIst century, the same level of primary energy consumption as the OECD group of countries today, assuming a constant population for each region and that energy consumption per capita of OECD would not increase.







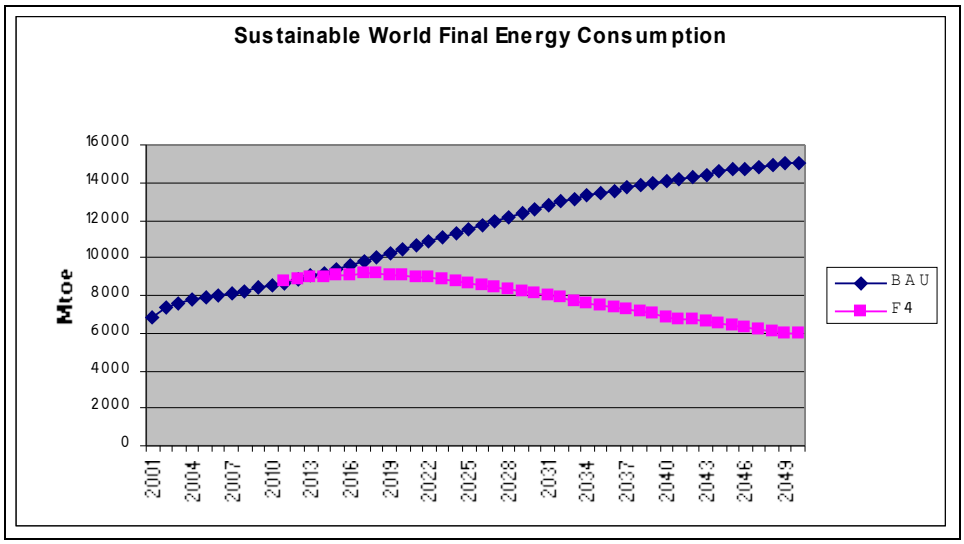
Even with a constant population, the total primary energy consumption would reach 30 000 Mtoe, that is about three times the present consumption.

If, as expected, the World population reached 9 to 11 millions, the total consumption would be of the order of 50 000 Mtoe.

This is clearly not only ***unsustainable*** but ***impossible*** (in terms of resources, economic costs, environmental damages, etc.). The energy supply system would never be able to sustain such a demand : ***three to four "Planet Earth" resources would be necessary!***

8. Sustainable Energy Demand Futures

Several World Energy scenarios have been developed, in particular under the "World Energy Assessment" (WEA) study led for UNDP by Professor J. Goldemberg[4].
A recent study[5] by ENERDATA and IEPE-LEPPI, two well known research institute on energy and environment forecast, presents two World energy scenarios at 2050 : the first scenario is a business as usual scenario (BAU) and the second (F4) is built in order to ensure a division by a factor of 4 of the CO2 emissions (in 2050 compared to 1990) due to the energy production, transformation and use.
The above figure presents the results obtained on the final energy consumption. The stabilisation around 2020 of the final energy consumption, followed by its decrease from 2020 to 2050 is obtained by the implementation, in all sectors, of a vigorous energy efficiency policy in all countries.
Several expert teams or institutes have developed such scenarios at World or regional level, including Europe. There is a need for an EU official "high efficiency and renewable energy" scenario to show to the decision makers, at all levels, the potentials and impacts (for security, environment and economic and social development) of a "Sustainable Energy Future".



[4] See also *"Energy for a Sustainable World",* José Goldemberg, Thomas B. Johansson, Amulya K.N. Reddy, Robert Williams – 1988 – Wiley-Eastern Editions, New-Delhi, India.
[5] *"Etude pour une prospective énergétique concernant la France",* French Ministry for Economy, Finance and Industry, February 2005.