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Groupe Agence Française de Développement

"Energy Efficiency"

Index

EDITORIAL

Current debates on oil price and the looming energy crisis seem like a repeat of the controversies that occurred during the 1970s and the early 1980s. At the time the first two oil shocks had shattered any illusions of cheap energy, the growth of developing countries seemed to become a key factor in the long-term global demand for energy, supply security was turning into a major concern and, as suggested in the report presented by Thierry de Montbrial at the Club of Rome in 1978, it sounded as if the "count down" had begun. It may well have gotten off to a good start, but over the next two decades these concerns were once again pushed to the side. In the wake of energy scarcity came a period of low-cost energy, causing alarmist forecasts and energy conservancy and policy issues to be quickly forgotten.

The current energy crisis has refocused attention on these concerns. Could this lead to a more stable awareness of the long term problems facing mankind? The inability of our societies to think in terms of a common future may lead us to believe that it will not. The current crisis differs in many ways, however, to the crises of the 1970s. The established economic take-off of China, India, Brazil and of other emerging countries no doubt gives more credence to forecasts of increased energy demand, as we know much more about the planet's geological resources today. Scarcity is, however, a somewhat elusive notion, and if the major emerging countries were to make appreciable progress with regard to energy efficiency, and policies and technical progress were to focus on switching to renewable forms of energy? which is currently a key objective? then people could lose interest and old illusions could resurface in the most ordinary, cyclical way.

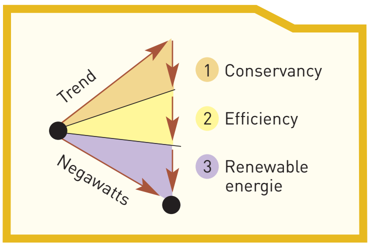
In contrast, the other major difference relates to the relationship between energy and climate change. The reality of climate change provides a non-cyclical argument for introducing fundamental changes in the way that energy is consumed. This, however, will not be an easy task, since it will involve short-term costs for long-term benefits and be dependent on collective efforts that will undeniably prove difficult to orchestrate. This letter analyzes various aspects of this issue, focusing on energy efficiency, thermal retrofitting of buildings, the development of biofuels and possible incentives for action.

Pierre Jacquet
Chief Economist, AFD

" Reviving and Globalizing Energy Management "

Christian de Gromard
Energy Project Manager AFD
Environment and Equipment Department

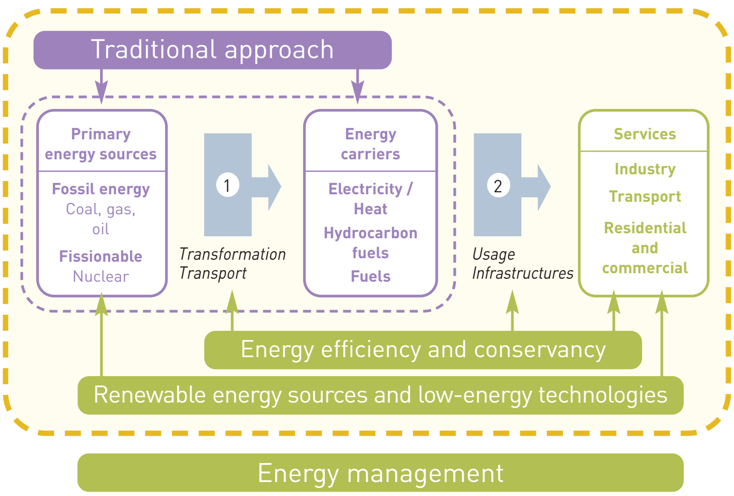
First introduced in France in 1981 in the wake of the two oil shocks, the notion of "energy management" has once again become a central item on the world agenda after being more or less forgotten during the fifteen years that followed the 1985 oil shock. Energy management aims to reduce the consumption of fossil-based or fissionable energy, while at the same time providing the same level of efficiency. Instead of producing more watts, energy management generates "Negawatts," as per the concept introduced by Amory Lovins (founder of the Rocky Mountain Institute).



Energy Management Levers

Energy management encompasses two types of complementary interventions which, when combined, are more effective. These are the development of energy savings and the promotion of renewable energy.

ENERGY SAVINGS are achieved through **energy conservancy measures** which depend on individual and collective efforts to eliminate waste and prevent excessive consumption, and on **energy efficiency investments** investments that aim to increase energy output from equipment or housing.



There are two categories of **RENEWABLE ENERGY:** (i) **renewable energy sources** – hydraulic, wind, solar and geothermal energy sources which are abundantly available on the planet but are variable (ii) **bioenergy** (wood and various types of biomass) which is a renewable source of energy and can be used as a substitute for such limited resources as coal, oil or natural gas.

Energy decentralization

Energy management also brings with it a trend towards **ENERGY DECENTRALIZATION**. The introduction of short energy production/usage cycles makes it possible to reduce the amount of waste that occurs during transport and to recycle heat emissions inherent in all energy systems (combined production of industrial heat and power, for example). The harnessing of renewable resources is also, by nature, most often decentralized (solar collectors incorporated into buildings, agro-industrial or agricultural waste recovery, run-of-river power stations, etc.). Energy decentralization promotes the development of organized networks of "self-producers." Energy-efficient housing, combined industrial electricity production, farms that produce bio-energy are all part of a trend similar to that seen in the information sector with the development of the internet.
Economic stakeholders become both consumers and producers, with multiple exchanges taking place within the network. Institutional frameworks must therefore be adapted to cope with this new system of energy distribution and our relationship towards energy reevaluated, allowing for the emergence of smaller production units.

Sector-based approach to energy management

Energy management must be approached in terms of the different areas of use, namely the three key sectors that traditionally consume energy: housing, transport and industry. It also relates to the agricultural sector (which produces biomass energy) and to the energy production/ distribution sector (electricity, hydrocarbon fuels and fuels) which is the main consumer of fossil and fissionable energy.

As shown in the table hereafter, each of these sectors can be reorganized to combine energy conservancy (consuming less), energy efficiency (consuming in a better way) and the replacement of fossil energy (consuming renewable energy).

	DEMAND MANAGEMENT	ENERGY EFFICIENCY	USE OF RENEWABLE ENERGY
INDUSTRY	Consumption statement/audit Sector-based benchmarking (quotas)	Efficient equipment/processes Heat recovery Variable frequency motors	Agro-industrial waste
HOUSING	Consumption measuremen Labeling	High-efficiency construction Bioclimatic housing Efficient household appliances	Solar water heaters Biomass fuel boilers Geothermal heating
TRANSPORT	Urban transport plan Modal transfers (rail/road) Alternatives to cars	Low-energy vehicles Rail electrification Combined road/ rail freight transport	Pedestrian/bicycle transport Biofuel vehicles
ENERGY	Pricing to promote efficiency Energy taxation	Combined production Reduction of waste during	Renewable electricity Biofuels Biomass fuels
AGRICULTURE - FORESTS	Regulation of urban domestic fuels	Water-efficient irrigation No ploughing/organic fertilizer	Energy crops Recycling of plant by-products

Intervening simultaneously at the intangible and tangible levels

Energy savings opportunities are dependent on individual and collective efforts to manage energy (the intangible level) and facilities/equipment characteristics (the tangible level). Exploiting such potential therefore requires dual action with various levels of intervention.

There is often a tendency to neglect the initial evaluation, even though it is a necessary first step, since it can be costly and does not yield any return. This type of investment therefore requires government support. Analyzing and influencing behaviors, as well as adjusting machinery and other equipment, are not very costly since these activities are intangible in nature and yield a high return. This process does, however, often require a radical change in our relationship towards energy and can be difficult to manage. When carrying out an analysis of the last two stages of a given energy saving process, bankers tend to invest in new infrastructures rather than upgrade existing ones. This is not just because upgrading is often more complex but because it means that no new assets are created. Thus new facilities are being built, neglecting the nonetheless important prior steps.

The Negawatt economy

"Negawatts" is the term used for energy savings investments to reduce the consumption of energy and avoid or postpone the construction of additional generation capacities.

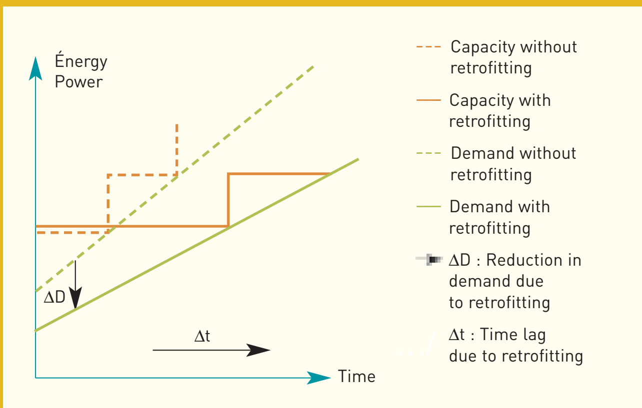
Due to economies of scale, investments to improve the insulation of a housing unit can therefore generate a profit. If, for example, all the buildings in a housing development are thermally retrofitted then the development's existing boiler will have the capacity to provide heating for a greater surface area. If there are new constructions in the area or if old buildings are retrofitted then the developer no longer needs to install a new boiler and will only have to connect the new buildings to the existing heating network. All the stakeholders then benefit from postponing a major investment.

The same logic can be applied to electricity. Insulation can avoid the need for air-conditioning during peak usage periods. This delays the need to build new power stations or increase existing capacities while at the same time reducing consumption and lowering household bills.

The dual energy savings effects are shown in the diagram below where ΔD measures the reduction in consumption and Δt is the time lag in consumption increases due to thermal retrofitting.

A comparison between scenarios with and without thermal retrofitting makes it possible to assess the global financial return of producing negawatts. Such comparison often yields very high rates of return. By contrast, it measures the cost of inefficient energy use which is shared between the consumers, the energy producers and, in the case of housing, the intermediaries (developers).

Impact of thermal retrofitting of housing on energy demand and production



The thermal retrofitting of buildings in China[1]

Ji Qi
Engineer, Ecole nationale supérieure des Mines de Paris

Over the next 20 years China will build the equivalent of a city of one million inhabitants every month. The benefits that can be achieved through the retrofitting of buildings are a key factor with regard to the issue of providing energy efficient housing. The theoretical cost effectiveness of this type of project is, nevertheless, not enough to guarantee its support and regulations must be reformulated in order to overcome this market failure.

The energy challenge

China's GDP, measured in constant dollars, increased 11-fold between 1978 and 2006, and energy consumption, measured in coal-equivalent tons, tripled. Energy intensity was cut by a third, but even so, it is 10 times higher than in Japan and 6 times higher than in Europe.

Accelerated growth in the last 7 years indicates that the goal of quadrupling the GDP between 2000 and 2020 will probably be achieved, or indeed exceeded. While there may be a relative reduction in the industrial-use energy consumption level, there is likely to be a sharp increase in residential sector consumption. In fact, by 2020, China will be more urban than rural and the population of the cities will increase by around 200 million people. The focus on the construction of new buildings should not be a reason to overlook energy issues relating to existing infrastructures.

City dwellers were not able to own housing until 1992. Housing belonged to the authorities or to their employers. Since then, home ownership has been encouraged, a reform that started with the sale of public housing to employees and continued with the very rapid expansion of real-estate development (sales increased tenfold between 1992 and 2004, from 38 to 340 million square meters).

The State set up two funds to support this reform:

- The first is aimed at maintaining public buildings and collective facilities, and is financed by proceeds from the sale of public housing and from taxation on the sale of new buildings.
- The second fund is financed by employees and companies to help them buy housing.

Thermal efficiency and economic rate of return on thermal retrofitting

Studies carried out as part of a project currently led by the *Fonds Français pour l'environnement mondial* (French Global Environment Fund) and AFD (FFEM/AFD) in the northern province of Harbin –where temperatures are harsh and heating expenses high–as well as available data relating to housing in Shanghai–where households use much less energy for heating (through the use of backup electric heaters) than for air-conditioning–show that investments in thermal retrofitting yield a very high rate of return in both cases.

In Harbin, this consisted of insulating the walls and the roofs, and installing triple-pane windows and airlocks. An investment of €24 per square meter reduces energy loss by approximately 50%.

This investment benefits two groups:

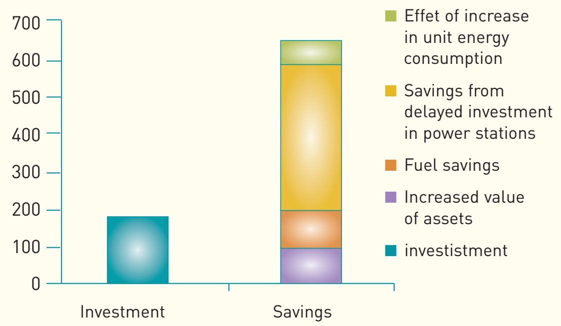
- Housing co-owners who benefit from a reduction in their energy bills [2] (determined exclusive of depreciation in order to take the importance of the energy input into account) and from a higher assessment of the value of their property. With a discount rate of 6%, the investment has a net present value (NPV) of €3 per square meter.
- Heating producers who, thanks to the reduction in consumption, can reduce or, in any event, delay investments. This saving is, however, limited since the most costly element of providing heating is the network, the cost of boilers accounting for up to 25% of the investment. The same calculation results in an NPV of €2.6 per square meter.

Overall, if you combine the benefits on both sides and compare the situation with project to the situation without project then the analysis indicates an internal rate of return of 11.2% and a return on investment in 6.5 years. Including the expected increase in unit energy consumption based on increased revenue leads to a slightly higher internal rate of return (IRR).

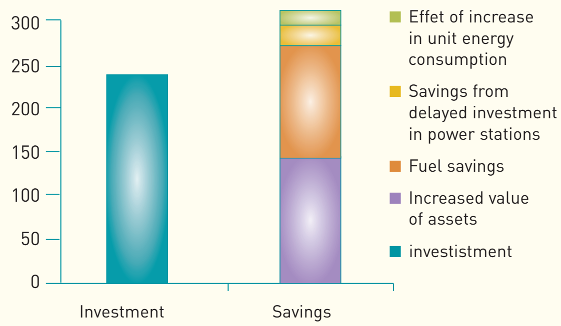
(1) Article based on a study on thermal retrofitting of housing in China, dir. Christian de Gromard (AFD), Pierre-Noël Giraud (ENSMP), with the assistance of Michel Raoust and Yazhong Liu (consultants).

(2) They can also decide to increase their level of comfort by keeping their energy expenditure the same, which leads to an improved sense of well-being without saving energy. The planned projects will focus on low-income households who will probably use the resulting savings for other purchases

Air-conditioning + Individual Back-up Electric Heating in Shanghai



Collective Heating in Harbin



Interpretation of the table: The left column shows the difference, in net present value, in investment required to achieve the energy efficiency project, and the difference in the time lag for required investments. The right column shows the savings that have been made, also in net present value.

Housing improvements in Shanghai, estimated at €19 per square meter, could cut heating and air-conditioning requirements in half. Slightly less investment was required than in Harbin but benefits are expected to be greater since energy efficiency for air-conditioning is very low and the electricity producers can reduce power requirements for peak usage by half.

The cost effectiveness of the project is assessed by comparing the costs and benefits of the different scenarios (with project and without project). These include, on the one hand, the investments which must be made (housing improvements) or postponed (electricity production) and, on the other hand, income flows, taking into account the reduction in fuel resulting from the reduction in electricity consumption. This comparison provides a significant rate of return of 186%.

Overcoming a market failure

Highlighting this cost-effectiveness is, however, not enough to guarantee support for the project. Such "market failure" acts as a general deterrent to energy saving projects and, in order to overcome it, the issues affecting the various stakeholders must be identified in advance.

- Since heating and electricity sales are guaranteed for producers, there hardly is any incentive for the latter to take part in retrofitting projects. These projects allow them to postpone investments in production, but will, nevertheless, lead to slower turnover growth.

- Housing co-owners in China do not, for the most part, belong to any organized groups. To make matters worse, they sometimes have no incentive to reduce their energy consumption. In Harbin, the heating bill is based on a set fee, prorated according to the size of the housing unit. In addition, in China, as elsewhere in the world, they implicitly adopt a very high discount rate to assess investment opportunities in energy conservation.

- Real-estate companies benefit from reduced electricity or heating costs.

- Local authorities benefit indirectly from retrofitting through taxes on building works and the increased value of property.

- Lastly, the country and the planet can expect to see a reduction in carbon emissions.

In order to push this project through, public authorities must introduce new game rules. The development of new regulations does in fact play a much greater role in ensuring the project's success than technical adjustments or the formulation of financial terms.

This became clear in the Harbin project, which required pricing regulations to be modified and profit-sharing among stakeholders to be introduced. From 2003, the authorities began to transfer the subsidies absorbed by the employers to salaries and pensions, which meant that heating would be paid for by those who benefited from it. The second step was to introduce a payment system based on consumption, initially measured by building, with increased assistance for disadvantaged households. At the same time, local authorities introduced more competition into the heating supply market (delegated management, public-private partnerships).
Lastly, using the expected annual income from retrofitting (€43 million) based on the stakeholders, investment was distributed among occupants (10%),

employers (15%) and heating companies (25%), with the remainder (50%) being granted by the city, province and state[3].

The occupants can use funds in their home savings account. The employers and heating companies can apply for bank credit. Support from local authorities includes (i) relief on taxes levied by the city, (ii) a reduction or cancellation of the building lease levied by the province, (iii) the availability of State-subsidized credit for professional stakeholders. In addition the city has the possibility of setting up a financing fund with contributions from the "Public building and facilities maintenance fund", credit subsidized by the Province and concessional loans from international donors such as AFD.

Analysis of this project shows that in order to encourage the various stakeholders (developers, co-owners, companies) to commit to the retrofitting process a financial mechanism would need to be developed, combining (i) a credit tool specifically designed for thermal retrofitting (ii) an incentive-based energy pricing system and, additionally, (iii) tax adjustments to provide a more equitable distribution of the costs and benefits linked to these investments among stakeholders.

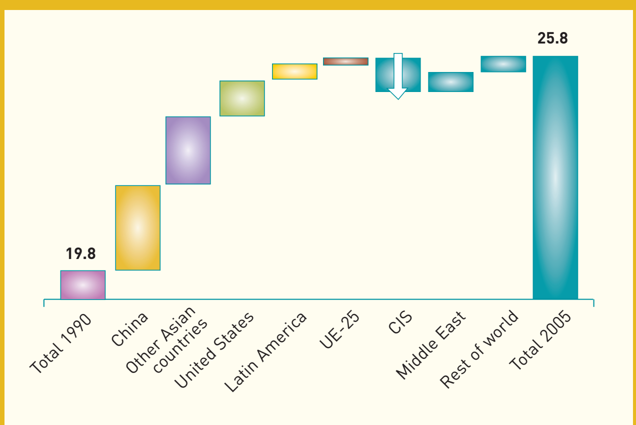
(3) See "*Programme de réhabilitation de logements dans Heilongjiang*" (Energy Saving Housing Program in Heilongjiang), Third progress report, by Rober Celaire, Alain Enard, and Claude Taffin.

"China: Example of an AFD research program supported by Ademe,

on the financial mechanisms for upgrading the energy efficiency of buildings in Wuhan (Hubei)"

Nils Devernois,
Economist –
AFD Research Department

Increase in CO2-energy emissions (1990-2005, GtCO2)



Source: Ademe, Enerdata.

Upgrading the energy efficiency of existing buildings, both residential and in the service industry, will be a key issue during the next two or three decades. This sector alone effectively consumes almost 40% of world energy. This is also true for energy consumption in China, where non-energy-efficient buildings cover an area of almost 40 billion square meters. There is good reason to focus on this sector and China, given the country's role in increased world CO2 emissions, as shown in the table opposite. AFD has therefore launched a major research partnership with the Hubei Province Construction Commission (Provincial Ministry) to deal with this issue, in collaboration with ADEME (Agency for the Environment and Energy Management) and with the participation of the International Energy Agency (IEA), the Zurich Institute of Technology (ETH) and the Karlsruhe *Fraunhofer Institut für System und Innovationsforschung* (ISI).

This research program was initiated by AFD in response to local demand, prompted by the 11th Chinese five-year plan whose objective is to reduce energy intensity by 20% between 2006 and 2010. This multi-year research program uses financial mechanisms to develop energy efficiency policies that can be implemented at the level of a provincial capital in China (8 million inhabitants) and then applied to the whole province. A Franco-Chinese partnership was therefore developed, with both partners being closely involved?each financing its own teams and working on the basis of a jointly defined methodology.

Upgrading the energy efficiency of existing buildings is, in general, a complex process that calls for the mobilization of major financial resources, as well as for innovative incentive measures to make up for payback periods on investments that often exceed the average norm.

This research program focuses on all aspects of thermal retrofitting, including technical (materials, equipment), economic, social and environmental (cost-benefit ratios and impact), and financial (financing mechanisms and incentives to investment). While improving techniques and technologies has made it possible to significantly reduce payback periods on investments, many programs to improve energy efficiency have failed due to the lack of suitable and incentive-based financial tools for the various users. This program will initially focus on all public buildings as well as those in the service industry, which for the city of Wuhan alone represents an area of 70 million square meters.

The Chinese partners have set up a team of some thirty people including experts from the Hubei Construction Commission, specialists from Wuhan city's Bureau of Civil Engineering Energy Savings and from the city's Property Management Bureau, researchers from the Huazhong University of Science and Technology, as well as economists and financiers from banking institutions. The Chinese research team is split into three groups, with each group benefiting from the support of one or several French experts. This program constitutes a pioneering and innovative approach for AFD. Implementing policies to promote energy efficiency does in fact require an extended period of preliminary investigations which can only be carried out with the help of local partners and away from the more traditional project financing procedures that are not well suited to this type of process.

"Biofuels: Assessment and perspectives for Africa[4]"

Jordi Rodriguez Samaniego
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The rise in oil prices and the will to reduce carbon emissions and energy dependence have contributed to the "rediscovery" of biofuels by many countries, with the exception of the United States and Brazil, which have been pursuing efforts initiated after the first oil crisis. The current Latin-American situation illustrates the problems raised by these substitutes when they compete[5] with food crop production: the leap in the per-barrel price has led to a concurrent rise in the price of corn, with consequences such as a sharp increase in the price of tortillas in Mexico that affected the poorest populations[6].

This article presents an economic and environmental assessment of biofuels, and discusses their potential for Africa. Evaluation of the various biofuel substitutes was based on comparisons with a reference fuel (gasoline or diesel).

The principal biofuel substitute for gasoline is ethanol. For diesel, vegetable oils or biodiesel (esterified oils) may be substituted. The biofuel balance varies greatly within the same biofuel category depending on the raw material used.

Ethanol: a substitute for gasoline

Ethanol is derived from two major types of crops: sugar-based (sugar beet and sugar cane) and starch-based (mainly wheat and corn). The basic reaction is sugar fermentation by micro-organisms, yeasts and bacteria. Low-ethanol content mixtures (5 to 10% of ethanol incorporated into gasoline) are interchangeable with pure gasoline and do not require engine modification, whereas higher-ethanol content mixtures require specially designed engines. The environmental balance of biofuels compares pollutant emissions, energy impact and greenhouse gas (GHG) emissions. Fuel combustion creates chemical compounds harmful to both the local environment and public health, including carbon

(4) Article based upon: Rodriguez Samaniego, Jordi, « Les biocarburants et l'Afrique », dir. Dimitri Kanounnikoff, École Nationale des Ponts et Chaussées, 2006. The Editor wishes to thank Jean-Raphaël Chaponnière, Michel Griffon and Denis Loyer for their reviews and contributions.

(5) See C. Ford Runge and B. Senauer: *How the biofuels could starve the poor*, Foreign Affairs, May/June 2007, excerpts of which appeared in *Courrier International* No. 864 of 24 May 2007.

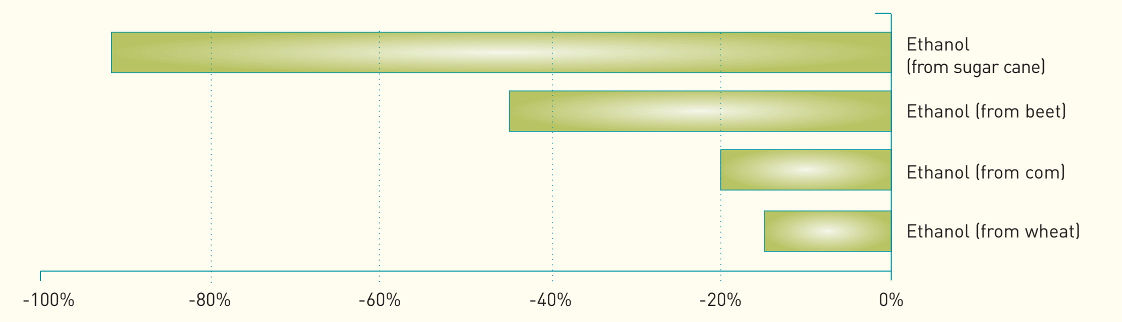
(6) The International Policy Research Institute estimates that, by 2010, the high price of oil could lead to a price increase of 20% for corn, 26% for soy, rapeseed and sunflower, and of 33% for cassava.

monoxide (CO), particulate materials (PM), nitrogen oxides (NOx), hydrocarbons, sulphates and ozone. Use of ethanol reduces emissions of all of these compounds except NOx–the effect of ozone emissions being still under debate–compared to the use of pure gasoline.

The GHG emission balance does not take into account the CO2 emitted during fuel combustion because it is re-absorbed during growth of the plants used to produce ethanol. The carbon balance is thus based on the entire lifecycle of the biofuel, from raw material to end user (with a special focus on emissions resulting from the use of manure, the transport of raw materials, their transformation into ethanol, etc.).

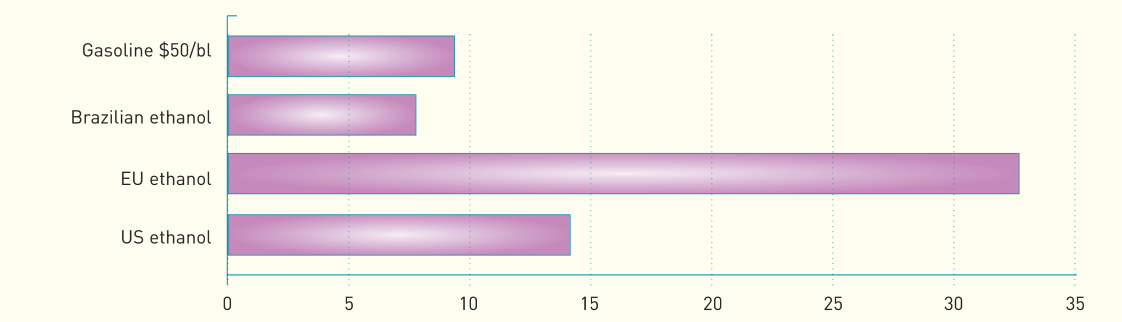
Results vary significantly from one study to the other depending on the methodology used to assess the by-products. Orders of magnitude of the reduction of GHG emissions from ethanol combustion vs. oil consumption appear in Figure 1.

Figure 1:
Reduction of GHG emissions (in % compared to gasoline)



The high results observed with sugar-cane-based substitutes are attributed to, among other factors, the use of *bagasse* in cogeneration technologies that produce the electricity and the heat required to operate ethanol cane-processing factories. The economic balance for ethanol depends on the raw material used and on the characteristics of the producer countries (Brazil, the United States and, to a lesser extent, Europe). Brazilian ethanol is produced exclusively from sugar cane, whereas the United States derives it mostly from wheat and the European Union from beets and corn. Current production costs of European, Brazilian and American substitutes are shown in Figure 2. When considering costs from the sole energy content viewpoint, ethanol made from sugar cane appears more advantageous than gasoline when the price per barrel of gas-oil exceeds US$30, whereas corn- or wheat-based ethanol becomes more competitive when the price per barrel exceeds US$60 [7]. Including biofuel tax exemptions or integrating the cost of negative externalities into the price of gasoline can also decrease the high cost of biofuel.

Figure 2:
Average ethanol production cost by producer country in US$/GJ



(7) In 2007, the United States refused to eliminate the 54-cent per gallon tax on biofuel imports.

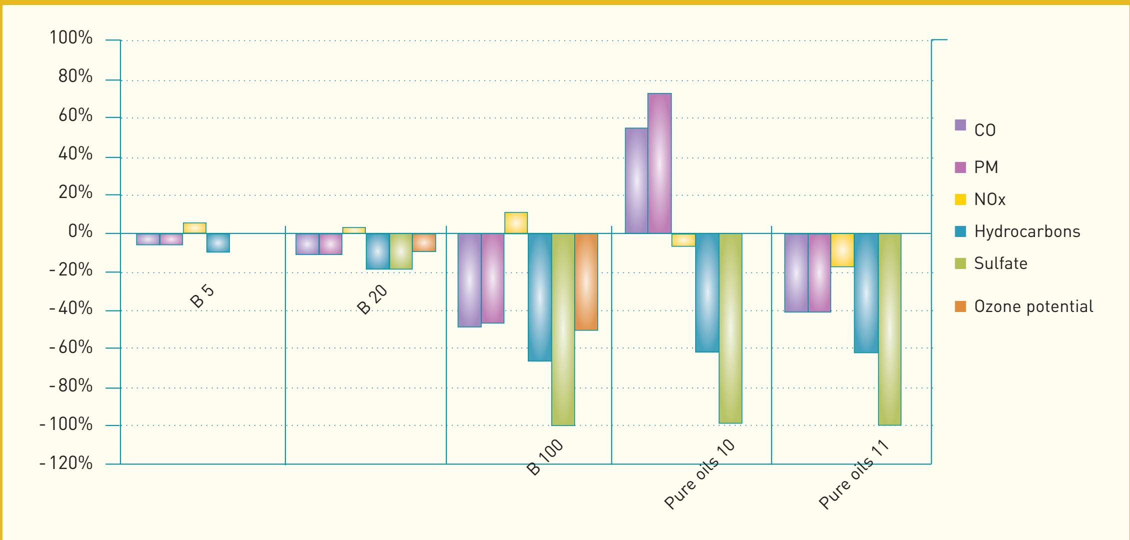
Biodiesel and vegetable oils: Substitutes for gas-oil

Two major types of biofuels can be used as substitutes for gas-oil: biodiesel and pure vegetable oils obtained from various oleaginous crops (rapeseed, corn, soy, cotton, palm, jatropha, etc.). Depending on the type of engine used (indirect- or direct-injection) these fuels can be used as they are, or transformed. Most engines cannot accommodate the direct use of vegetable oils, which must then be transformed into biodiesel via an industrial cross-esterification process.

Engines can also be adapted using a special kit. Like ethanol, biodiesel can be mixed with gas-oil: for ethanol content up to 30% (B30), no engine modification is required. Ethanol content can be as high as 100% (B100), but this mixture is seldom used.

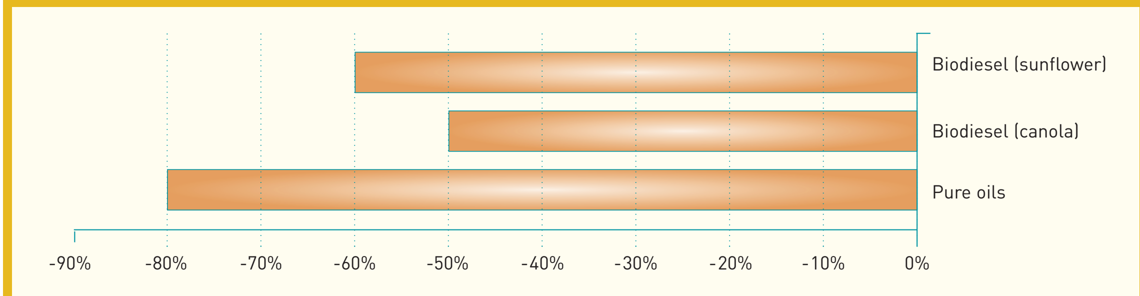
The environmental balance varies according to engine type and mixture. Direct fuel injection engines are the most prevalent and tend to be used with farm machinery. Use of pure oils in these engines after their adaptation does not have a clearly positive effect on the local environment.

Figure 3:
Impact of gas-oil substitute fuels on the local environment



The GHG emission balance depends upon the biofuel's lifecycle. Most available carbon balance analyses focus on EU-developed substitutes and do not take into account the effects of land use changes, which can be significant. Figure 4 shows the carbon balance for the best-known substitutes, yet data is lacking for less prevalent crops such as soy, palm or jatropha.

Figure 4:
GHG emission reduction (in % compared to gas-oil)



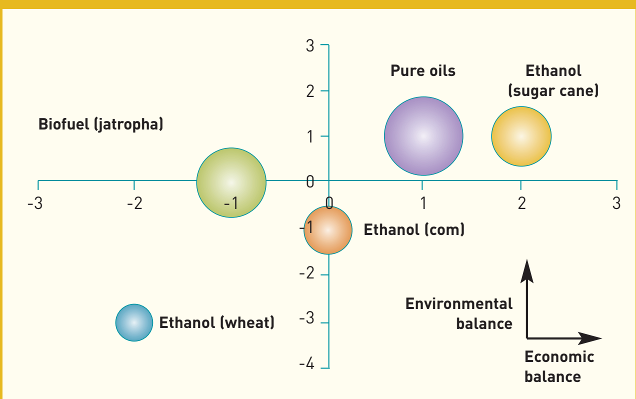
Biodiesel substitutes developed in Europe and the United States are not yet competitive in comparison with gas-oil. Moreover, the strong demand for food oil in countries such as India and China has curtailed the development of these substitutes.

Potential in the least developed countries

Brazil is the top world producer of biofuels. However, many African countries have characteristics conducive to the development of such products (cheap labor, favorable climate and plentiful supply of land). The Association of Non-Oil Producing African Countries (*Association des Pays Africains non Producteurs de Pétrole* - PANPP), created in 2006, committed Member States to implement an institutional and regulatory framework as well as incentives for the development of biofuels. This focus is supported by Brazil, which aims to establish agro-industrial complexes to develop the production of bio-ethanol. Promotion of this substitute requires a legislative framework (setting mandatory mixture rates, for example) as well as tax incentives (such as exemptions). The substitutes best-suited for Africa include those derived from sugarcane and vegetable oils (cotton and jatropha, which, under irrigation, have the same energy efficiency as sugarcane).

Availability of arable land remains an obstacle to the development of these substitutes, which compete with other land uses and can threaten food security or deplete forest resources. The risk of competition between energy and food uses is higher in countries with weak precipitation. Based on the IMAGE model, CIRAD has thus measured the available supply of land through 2030 and 2050, taking into account improvements in agricultural output.

Figure 5:
Efficiency of the various biofuel categories



Its study showed that Angola, Congo, the Central African Republic and Zambia have (and will have) a sufficient supply of land that could, however, integrate the use of jatropha, which can be cultivated on impoverished land and whose use appears promising in many countries.

Valorization of by-products or excess production of existing crops represents an interesting potential. Biofuels are currently produced directly from dedicated crops in Brazil, Europe and the United States, but they can also be produced from by-products of other existing crops. For example, ethanol can be obtained by processing molasses resulting from cane sugar production, and vegetable oils can be extracted from excess cottonseed production. While the development of these substitutes does not pose the problems evoked above, production volumes remain tied to available crop outputs.

Large-scale use of pure oils seems rather unrealistic even if they can be produced on a relevant scale locally. Considering that a large percentage of African vehicles are relatively old, and that most of them have diesel motors with indirect-injection engines, they could be fueled with pure oils. However, pressure to expand the use of direct fuel injection engines (which are less detrimental to the environment) and competition from the food oil market make the large-scale development of these substitutes more or less irrelevant. Furthermore, the use of pure oils have mixed impact on the local environment.

Figure 5 roughly evaluates the various substitutes in terms of sustainable development. The value '0' represents the average performance of all substitutes under study; the score attributed to each substitute represents the differential compared to this average. The circles' dimension represents the biofuel categories' social performance (based on debatable figures on labor intensity). This figure provides an overall idea of the potential of various biofuel categories that could be explored in less developed countries. These substitutes do not all have an environmental and economic balance positive enough to justify their development. While pure oils and sugarcane–based ethanol stand out clearly in relative terms, wheat-based ethanol–despite its environmental advantages in absolute terms–remains behind the other main biofuel categories.

Reading Notes

"The Stern Review on the Economics of Climate Change"

Jacques Loup,
conseiller du chef économiste de l'AFD.

At the end of October 2006, Sir Nicholas Stern presented his review on the economics of climate change prepared at the request of the British government. This bulky document was extensively covered by the media and raised some wide-ranging debates, particularly among economists [8]. Somewhat simplifying the content of 700 pages of text, the media have essentially focused on its most striking conclusion: if no corrective action is taken, the ongoing climate change could cost the world economy 5% to 20% of the global GDP starting today and for centuries to come. However, policies aimed at reducing greenhouse gas (GHG) emissions, which could limit the adverse effects of climate change, would cost "only" the equivalent of 1% of the global GDP.

The report itself is much more complex than this mere conclusion would suggest. It insists namely on the fact that the GDP, consumption, or "utility" (to use economists' jargon), are but a few of the conceivable criteria and that many other dimensions (ethical, cultural, or social) must also be taken into consideration. The review equally brings to the forefront the gaps in existing scientific research (for example, the relationships between GHG concentrations, average temperatures, and regional climate change, and feedback or non-linear effects). Hence, the cost-benefit analysis which is at the center of the review is far from being the only element that justifies implementing a climate change policy: it is also a question of preparing for an uncertain and potentially catastrophic future.

The review's economic analysis is based on a model (PAGE, 2002) developed by Cambridge researchers. The latter determines, according to different scenarios, the average GDP per head of the entire planet and the individual utility of this GDP per head at any time t from 2001 to infinity. It then calculates the total utility of the global population (by multiplying the average utility at time t by the corresponding global population) and sums this utility from 2001 to infinity. Comparing the different scenarios then makes it possible to measure the "costs" and "benefits" of potential policies.

Typically, marginal utility is expected to decrease along with the GDP (or consumption) per head. Moreover, the hypotheses made about the utility function suggest writing the discount rate ρ as: $\rho = \eta g + \delta$, where η represents the elasticity of the marginal utility of consumption per head, g the annual growth of this consumption per head, and ‰ the "pure" discount rate.

Debates between economists have largely focused on the values used for defining variables η (criticism by Partha Dasgupta) and δ (William Nordhaus). It seems to me that in his review (and in its postscripts), Sir Nicholas Stern responds to these critics in a convincing manner. In fact, the sensitivity analyses carried out by his team in response to such criticism demonstrate that for all the possible fields of variation of η and δ, the conclusions of the "costs-benefits" analysis remain valid: the costs associated with climate change are always far superior to those of implementing policies aimed at cutting GHG emissions.

There are, however, other critics that seem more pertinent to me. William Cline, for example, points out that according to the very logic of the model, 93% of costs linked to climate change would not occur until after 2200. But, how reliable can cost estimates be when based on forecasts spanning two centuries into the future of such data as GHG concentration, temperatures, or climate system trends?

One key limitation of such an approach seems to be due to the fact that it is not regionalized, but rather proceeds according to an **average** global GDP or consumption per head. But, if we accept the common notion that individual marginal utility decreases along with consumption per head, as the review rightly does, then the **total utility of the entire world** will no longer depend on the average consumption per head but also on the way that consumption is distributed among the different

[8] Editor's note: Also note the publication of "Factor 4" scenarios following the study carried out by economists and energeticists on behalf of the French government, which came to similar conclusions but according to a different programming approach.

Reading Notes (Continued)

individuals and countries that make up the global population. While revenue redistribution or a shift in consumption from rich countries to poor countries would not affect the global average, it would, however, have an immediate positive impact on the total utility. Hence, even if we establish one overall global growth rate, the total utility still differs according to whether or not this growth is forecast in rich countries or poor countries.

Moreover, as shown by the most recent IPCC report, the costs of climate change will be highly variable according to country and region. The mere knowledge that, based on a worldwide average, these costs will significantly exceed those required for a global policy for reducing GHG emissions will not be convincing enough for political leaders, who would rather see a cost-benefit analysis for their own country. Yet, effectively performing such an analysis would require using a disaggregated model that distinguishes between major regions, or even countries. Such an analysis might then indicate that although for certain countries (in Sub-Saharan Africa, in particular) the cost of climate change would exceed their contributions to policies aimed at limiting that change, for others (rich countries in temperate zones), however, the opposite would be true.

On the whole, the Stern review has not convinced certain skeptics, such as Bjorn Lomborg, one of the fathers of the "Copenhagen Consensus." Even if we admit that the benefits of a policy for cutting GHG emissions outweigh the cost of doing nothing, we could, after all, say the same for many other public policies and it remains unclear why fighting climate change should be more urgent than fighting malaria or illiteracy, for example. If we adopted the "utilitarian" approach, as was done in the Stern review, and used a regionalized model, we would, in all likelihood, come to opposing conclusions. Without even mentioning the positive effects well-used aid could have on the growth of developing countries, a simple policy of transferring more resources from rich to poor countries would, according to the logic of the model, generate a significant increase in the global utility and would cost (as calculated for the entire world) close to nothing. According to this logic, even poorly used development aid will always produce a benefit/cost ratio far superior to that of a policy for climate change.

Using the same logic as the Stern review, such argument relativizes the urgency of cutting GHG emissions and highlights the limits of the simple cost/benefit approach and of the quibbles associated with such an approach. Yet the main justification for policies to cut GHG emissions? which the Stern review may have omitted to emphasize–remains that they are needed today in order to avoid global catastrophes tomorrow. As shown by the report, even if the concentrations of GHG were stabilized at their current level (a goal that unfortunately is impossible to reach), the probability that the overall rise in temperature (worldwide average as compared to pre-industrial temperatures) be greater more than 3° C is roughly 20%. This probability will be greater than 50% by the middle of the century if the concentration of CO_2 continues growing at its current rate. As stated in the report, above this threshold of 3° C, we run the risk of witnessing irreversible phenomena with unforeseeable consequences–ice melting in Greenland and western Antarctica, the disappearance of the Amazon rainforest or the slowdown of thermohaline circulation, not to mention widespread famine. Is devoting merely 1% of the global GDP really too much to pay to avoid such dire risks?

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