

Energy Conservation Potential in the Housing and in the Industrial Sectors in France: What is the Real Potential ?

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1. SYNOPSIS

Considering the efforts realised in energy savings those 20 last years, we can wonder whether there still exists an important energy conservation or no.

2. ABSTRACT

Since the beginning of the 1990's, France has experienced a slow-down in its energy efficiency trend which is a cause of concern. Is there any more achievable energy efficiency potential? Are the barriers to energy efficiency more heavy, since energy prices remain low and since less direct incentives are provided to users? How many more opportunities to improve energy efficiency could be realised in order to face global warming issues?

To answer to these crucial issues, we refer to several studies aiming at assessing the energy conservation potential both in the industry and space heating in the housing sector for the year 2005 and 2015. Based on very desagregated approaches (180 technologies for the industry and 11 measures for 782 categories for the housing sector), cost conservation curves have been built up from assessment of the speed of diffusion and cost of each technic. Results show that there is still a important potential for energy conservation of which the amount is in the same order of magnitude than of the achieved energy saving during the last 20 years. Results will be presented at a desagregated level illustrating the discrepancies among fuels, sub-sectors or categories of households. For the industrial sector, an assessment of the CO₂ emissions evicted will be provided as well as the impact of the CO₂ tax on the level of the energy conservation potential.

3. BACKGROUND

Energy efficiency in France increased greatly between 1973 and 1990. Energy intensity, measured as the ratio between energy consumption and gross domestic product (GDP) fell, partly because energy uses became more efficient, but also due to the rising share of services in GDP, replacing heavy industry. The actors in the economy have invested and changed their behaviour to achieve greater efficiency, in response to high energy prices, energy conservation policies and technical progress. The French economy thus saved 28 million tonnes-oil-equivalent (Mtoe) in 1992, compared to 1973 (Bosseboeuf and Richard 1993). That is to say, if energy-consuming technologies and behaviour had stayed the same as in 1973, an extra 28 Mtoe would have been consumed in 1992.

Since 1990, energy efficiency has stopped improving, and has even begun to backslide, as the result of several factors. The main reason is the on-going erosion of oil prices and the subsequent drop in the attention paid to energy efficiency, by public authorities as well as by individuals. After fifteen years of steadily increasing efficiency, this trend comes as a serious challenge, undermining France's commitments to stabilise CO₂ emissions by 2000. In light of the current energy outlook it seems that it will be impossible to meet this goal without an interventionist energy management and conservation policy based on incentives and fiscal and regulatory instruments. The issue of untapped potential for efficiency gains is often at the heart of the debate, and two opposing points of view are heard.

- One, the most cost-effective efficiency gains have been implemented since 1973, and we are now entering a new period in which GDP and energy consumption are tightly linked.

- Two, technical progress has replenished potential sources of energy efficiency, and great new "pockets" of energy inefficiency and "wells" for energy conservation investment can still be discovered.

The truth undoubtedly lies somewhere between these two extremes. While potential for greater energy efficiency may still exist, it has to be admitted that it is not spontaneously exploited in a context of low energy prices, even if the associated investments are *a priori* cost-effective. Rather than presenting an assessment of these potential sources in terms of their simple cost-effectiveness, this analysis focuses on policies and energy-efficiency measures capable of

triggering investment decisions. But the untapped potential must necessarily be expressed with reference to an unavoidably conventional benchmark and a given time horizon.

This prospective analysis differentiates between the various consuming sectors in order to closely follow the real-life decisions made by different actors in the economy (households, businesses). It does not claim to be an exhaustive inventory of all the potential efficiency gains for each use, but rather an assessment of a certain number of examples for which solid data is available.

- In the residential building sector the assessment covers efficiency gains related to heating in existing buildings. Gains induced by a possible reinforcement of thermal regulations for new construction are therefore not included, nor those related to other energy uses (notably specific electricity consumption). The approach used was to simulate a certain number of measures that could be applied in existing buildings; taking the present situation into account, the goal would be to exploit 75% of the technically available efficiency improvements by 2015.

- In the industrial sector, existing and emerging technologies have been identified that are already partially implemented and could be more widely disseminated, given energy prices and corporate cost-effectiveness criteria. The untapped potential identified here does not depend upon technologies that are still being developed, but the economic gains that these techniques could furnish in the medium term have been taken into account. Thus the exploitation of the untapped potential induced by a change in energy costs (for instance a carbon-energy fiscal measure) can be evaluated.

This description of potential sources of energy efficiency gains is intended to provide a clearer view of the political and economic conditions for a return to an energy efficiency trajectory.

4. RESIDENTIAL SECTOR

Considering the increasing importance of the residential sector among the consuming sectors (and that space heating represents over 70% of the total consumption for domestic uses) and the numerous actions from the Public bodies in this area, Ademe has asked the consulting firm Inestene to develop the Model for the Rational Use of Energy (MURE, in French).

MURE

The two main objectives of the model are first to measure the energetical impact of different energy efficiency programmes and second, to follow the heating consumption of the French dwellings at a very accurate level and to get forecasts towards 2015.

MURE is a techno-economic model structured on 4 detailed databases

- 1) the housing stock database (14 families, 13 energies, 5 qualities, 5 years time-space, giving the number of dwellings, the G coefficient, the area, the unit consumption);
- 2) the scenarios database (evolution of the housing stock every 5 years up to 2015);
- 3) the energy efficiency measures database (11 measures concerning the envelope and the system of the dwelling, energy efficiency rate, cost);
- 4) the "ratio" database discounted cost of the measures / saved kWh

The energy conservation programme identified here proposes several energy-saving measures concerning the building envelope (roof, wall and floor insulation, double-glazed windows) and heating systems and controls (energy management, high-efficiency furnaces) (Angioletti and Richard 1994). This programme can be modulated in terms of quality by combining the different measures, and in quantity, depending on the various goals set for equipment installation for each type of measure in the reference time frame.

Scenarios for trends in primary residence housing stock and their heating installations are derived from work regarding energy consumption up to 2010 done by the energy forecasting team of the French planning ministry. They integrate changes in new construction, withdrawal of old and dilapidated housing, energy substitution, changes in types of heating, etc.

Potential energy savings are calculated as the difference between benchmark consumption levels and the levels derived from the implementation of energy management programmes.

The results obtained with this simulation should be used with precaution. They do, however, represent orders of magnitude that are reliable enough to be used in an initial assessment of overall potential savings related to home heating.

4.1. Methodology

Baseline Scenario

This scenario is based on the scenario outlined by the energy forecasting team of the French planning ministry. It posits low economic growth (+1,6% per year) and low energy prices (22 \$89/bl in 2010), and includes the following assumptions:

- 1.44 million housing units will be withdrawn between 1990 and 2015.
- The proportion of homes equipped with central heating will rise from 83% in 1990 to 94% in 2015.
- The main energy substitutions are falling shares for fuel-oil and coal, a rising share for electricity and above all for gas.

Energy Management Programme

The potential savings presented here cover only heating in housing units that existed in 1990, that are equipped with central heating and use just one form of energy for heating, for a total of 16.2 dwellings (75% of primary residences representing 68% of the heating consumption). The results therefore essentially survey all the potential energy savings to be achieved in existing buildings.

The simulated energy improvements to be applied to housing not yet equipped in 1990 are: roof, wall and floor insulation, double-glazing, and high-efficiency furnaces and controls. The different equipment rate are presented in table 1.

Table 1. *Equipment rates of the measures (%)*

	Single family houses		Multy family flats			
	Individual central heating		Individual central heating		Collective central heating	
	< 75	> 75	< 75	> 75	< 75	> 75
Roof insulation	71	93	100	100	100	100
Walls insulation	45	85	21	60	24	34
Floor insulation	35	46	54	100	62	100
Double-glazing	48	82	33	70	25	35
Regulation	18	51	24	46	40	39
Efficient boiler	0	0	0	0	100	100

This is a "normative" (standardized) scenario which assumes that on average each measure will be applied in 75% of cases by 2015. This penetration rate represents a reasonable estimate of market saturation, and makes allowances for the non-application situations likely to be encountered in the field. It is assumed that market penetration for the measures will be linear over the period considered.

4.2. Results

Housing Stock

The trend in centrally-heated housing units is characterised by a strong progression in gas-fired and electric installations, for the most part replacing fuel-oil equipment (table 2). These results are to a large degree determined by the hypotheses of the French planning ministry scenario describing the evolution of market share for different forms of energy (Ministère de l'Industrie 1989).

Table 2. *Central heating in housing stock (thousands of housing units)*

	Electricity	Gaz	Fuel-oils	Other	Total
1990	4152	6247	4300	1537	16236
2000	4796	7234	2898	1697	16624
2015	5762	8716	804	1944	17222

Energy consumed for heating

Baseline scenario

This scenario shows an annual drop of 0.5% in total annual energy consumption for heating, despite an increase in central heating (table 3). This drop is essentially explained by a major decline of fuel-oil (-6.9% per year) shifting to gas (+0.9%/year) and electricity (+1.9%/year), leading to lower unit consumption due to higher efficiency.

Table 3. *Energy consumption trends, baseline scenario (Mtoe)*

	Electricity	Gaz	Fuel-oils	Other	Total
1990	2,7	8,3	6,8	3,1	20,9
2000	3,2	9,2	4,4	3,2	20,1
2015	4	10,3	1,1	3,5	18,9

Energy management programme

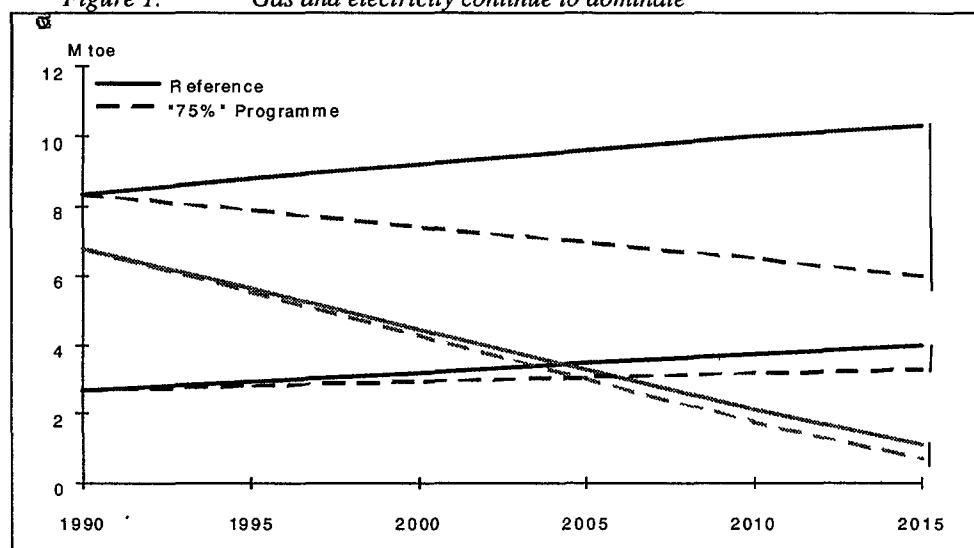
Total technically available energy savings can be estimated at 7 Mtoe up to the year 2015, for savings projected in the framework of an energy management programme targeting 75% penetration of efficiency measures in existing centrally heated housing (table 4). The gain represents a reduction of 37% compared to overall consumption projected in the baseline scenario.

Table 4. *Energy savings trends, "75%" programme (Mtoe)*

	Electricity	Gaz	Fuel-oils	Other	Total
2000	0,3	1,8	0,2	0,6	2,8
2015	0,7	4,4	0,4	1,5	7

The largest share of energy savings is achieved with gas (63% of total savings), amounting to a 42% reduction in gas consumption compared to the baseline scenario (figure 1). Gas has both the highest penetration rate in housing stock, and the greatest potential for savings per unit of equipment. Savings on central electric heating are considerably lower (10%). This is due to the initial performance of the generator (yield close to 1) and to the fact that they are generally installed in well insulated housing. The potential for savings in fuel-oil is dropping simply due to loss of many units replaced by gas-fired or electric equipment.

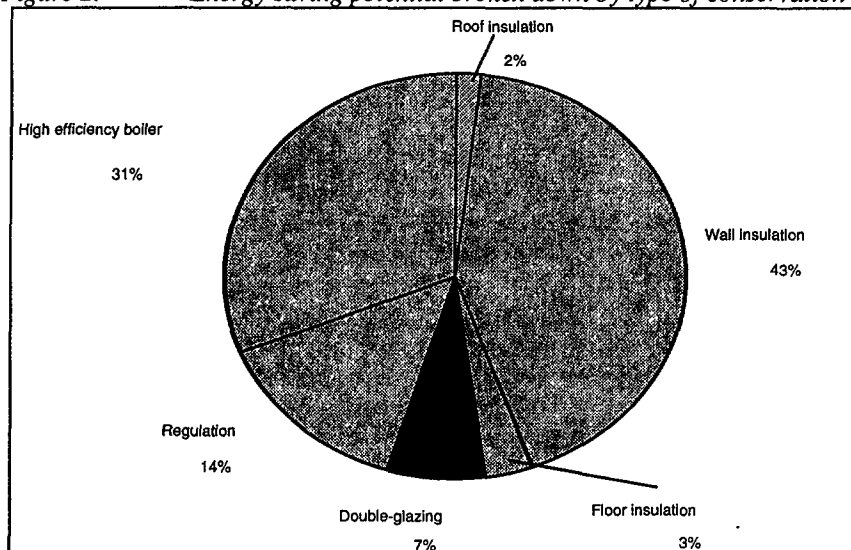
Figure 1. *Gas and electricity continue to dominate*



The savings potential is greatest, of course, in housing units built before 1975 (91%), and among these in single-family homes (51%) and multi-family buildings equipped with building-wide central heating systems (23%).

Three measures constitute over 85% of the energy saving potential. These are wall insulation, controls and high-efficiency furnaces (figure 2).

Figure 2. Energy saving potential broken down by type of conservation measure



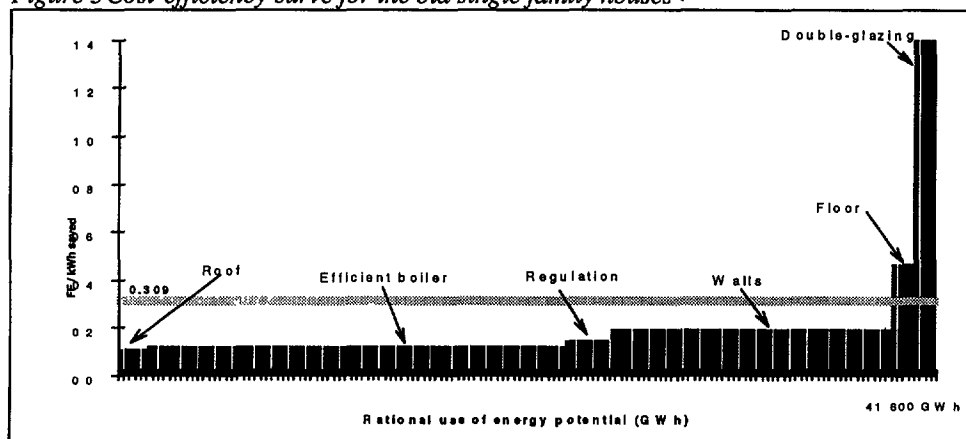
This ranking depends to a large degree on the initial equipment rate for different types of housing, that may be already heavily penetrated by one or more of the measures.

Programme costs and cost-effectiveness of efficiency measures

At 1990 cost levels, the "75%" programme entails a total investment of 950 billion ECUs (1 FF = 6,5 ECU) over the model period from 1990 to 2015, i.e. 38 billion ECUs per year. This level of investment is markedly lower than expenditures for building improvements declared by households in recent years; these expenditures are estimated at between 160 and 200 billion ECUs per year (annual surveys carried out by Ademe and SOFRES). These two sets of figures do not cover exactly the same improvements-- most notably, the replacement of old furnaces with identical equipment is included in the SOFRES survey but is not integrated into the energy management programme. However given the correlation of these orders of magnitude, it is not unrealistic to think that households could finance energy improvements under the "75%" programme.

In addition, the cost-effectiveness of the measures may vary with the type of housing in which they are implemented. For instance, the cost-effectiveness curve for the old single family houses (figure 3) shows that the cheapest measures are the roof, the efficient boiler, the regulation, the walls, the floor and the double-glazing; the largest potential being covered by the efficient boiler and the insulation of the walls. If we then take into account the average price of energy for this family (0,31 FF92/kWh), it appears that two of the measures are too expensive and are not economically efficient: the insulation of the floor and the double-glazing.

Figure 3 Cost-efficiency curve for the old single family houses .



It should be recalled for reference that energy savings achieved since 1973 in older buildings (pre-1975 construction) are estimated at 10.7 Mtoe per year, as of 1990. To conclude, a coherent incentives programme could be used to tap potential savings that are equal to two-thirds of the savings already realised since the first oil price shock. Furthermore, the amount of CO₂ emissions that could be avoided by implementing the "75%" programme in existing buildings is estimated at 2.3 Mt carbon-equivalent up to 2000, and 5.6 Mt carbon-equivalent up to 2015.

5. INDUSTRY

5.1. Methodology

Ademe has asked the Centre d'Etudes et de Recherches sur l'Energie (CEREN) to update the assessment of potential energy savings in industry for the period up to 2005 (Ceren 1993). This update was made necessary by the new energy price context, the retreat of energy management policy and the rise in environmental concerns. The analysis carried out by CEREN is highly detailed, breaking industrial consumption down into 23 sub-sectors and 18 end-uses 11 linked to manufacturing and 7 other than manufacturing. A total of **188 energy-saving opportunities** have been pinpointed, on the basis of opinions from industrialists, technical centers, professional associations and experts from Ademe. For each of the techniques involved, the main information gathered includes technical description of the conservation measure, identification of the field of application, degree of development (technical maturity and experienced penetration on to the market and speed of penetration, added investment cost and identification of the main barriers to dissemination.

5.2. Results

Energy conservation potential

If industry had introduced in 1990 all of the most effective energy-saving measures, **19%** of energy consumption for 1990 could have been economised. This corresponds to potential energy savings of 9.4 Mtoe, 5.6 Mtoe in fuels, 3.2 Mtoe in electricity and 0.6 Mtoe in cogeneration.

Technical progress will broaden the range of cost-effective available technologies, adding another 1.5 Mtoe of potential energy savings. If increases in industrial production over the period are included, the increase in potential savings is 0.6% (this estimation is based on the assumptions used by the energy forecasting team at the French planning ministry, i.e.: GDP growth 1.6%, industrial production growth 1%, price of crude oil \$21/bbl in 2005). This assessment may seem conservative, for more optimistic hypotheses concerning economic growth would speed the penetration of new technologies. Taking into account a trend towards penetration of energy conservation between 1990 and 2005, estimated at 3.9 Mtoe (baseline scenario), the potential for energy savings remaining in 2005, called the residual potential, is estimated at 7.6 Mtoe. The following table sums up the dynamics of these fluctuations in potential energy savings.

Table 5. Potential energy savings, 1990-2005

	Mtoe
Potential in 1990	9,4
Production effect	+ 0,6
Additionnal potential of R&D	+ 1,5
Trends in energy savings	-3,9
Remaining potential in 2005	7,6

Source: Ademe-Ceren

A breakdown by sector (table 6) reveals that sizeable potential still exists in energy-intensive industries. In the steel industry, where operating costs are still relatively low, the potential for energy savings is high, as is also the case in the bulk chemicals industry, but at a much higher cost.

Table 6. Energy savings by industrial sector

	Cons 1990	Potential 1990	Potential / cons.	Invest Cost	Energy sav. 1990-2005	Remaining potential
	ktoe	ktoe	%	F/Toe	ktoe	ktoe
steel industry	9656	1394	14%	2300	11096	627
Non ferrous metals, cement	5756	1614	28%	2900	835	1161
Metals, metallurgy excluded	6868	1561	23%	3300	465	1347
consumption goods	12553	2060	15%	3500	744	2076
food industry	5618	1573	28%	4400	285	1516
chemical	10243	1198	12%	5100	492	913
Total industry	50394	9401	19%	3500	3917	7640

Source: Ademe-Ceren

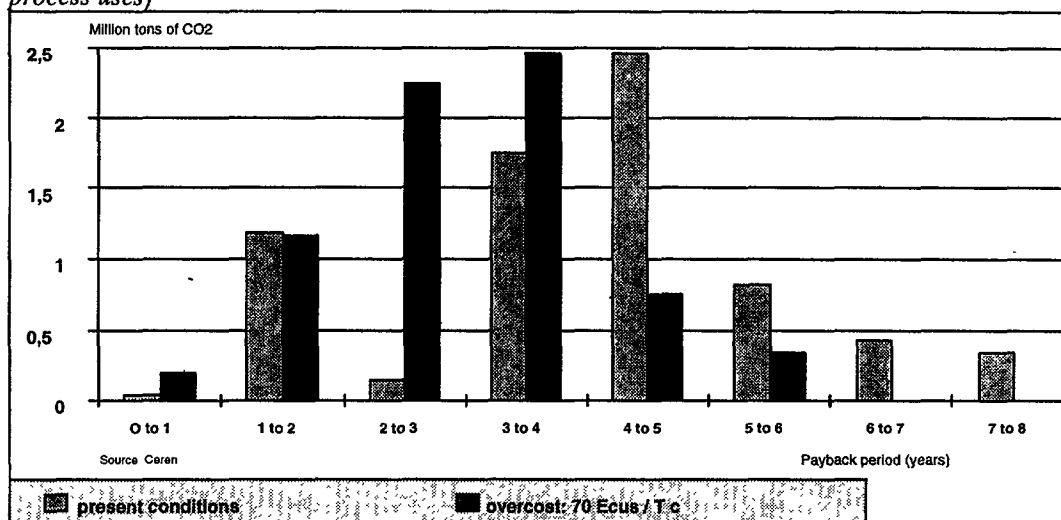
In this baseline scenario 36% of potential savings will be exploited, leaving a large share still untapped. Energy savings achieved over the reference period would equal 8% of industrial consumption. The investment cost involved would be **39 billion francs**.

Roughly 40% of the potential can be tapped at a cost below 3,250 francs per toe saved. At today's energy prices this corresponds to a payback time of under three years. The range of conservation cost is wide as you can see below.

CO ₂ emissions potential	FF/toe	% of potential
	<2250	20%
CEREN has also estimated the reductions in CO ₂ emissions that would be associated with these potential energy savings. A more interventionist scenario has	from 2250 to 3250	20%
	from 3250 to 4250	13%
	from 4250 to 5250	12%
	from 5250 to 6250	25%
	from 6250 to 7250	10%

been used to assess the potential gains that would be tapped through a shift in energy prices. This includes a simulation of the economic conditions resulting from a carbon tax on the order of 70 ECUs per tonne of carbon; this tax would raise energy prices and thereby automatically reduce the payback times for energy conservation investments. The underlying hypothesis is that even if such a tax cannot be imposed on industry without a consensus within the OECD, negotiated agreements should encourage industrial companies to make investments that would have been cost-effective under the carbon-tax conditions. **Figure 3** shows CO₂ emission reductions for energy conservation investments linked to process energy uses (77 technologies identified), in relation to different payback times, depending on whether current energy prices are used or higher energy prices induced by the carbon tax. Even though it is difficult to evaluate the potential impact of the tax on the basis of payback times alone, it can be observed that the modification of energy costs can significantly increase the cost-effectiveness of investments. Thus a greater potential for energy savings and CO₂ emission reductions exists for the shorter payback times corresponding to higher energy prices, or to cost-effectiveness criteria closer to those applied to public investments.

Figure 4. Potential for CO₂ emission reduction in the industry (for 77 energy-conserving technologies for process uses)



6. CONCLUSION

This analysis of energy consumption in different sectors shows that potential energy savings are far from being exhausted. The estimations carried out here do not cover all energy uses, and other untapped potential gains will be added to this initial assessment (particularly savings that can be achieved in specific electricity consumption). All the conservation measures identified call for the penetration of technologies that are already on the market. The potential energy savings that may come from research and development activity have not been considered at this stage of the assessment.

Overall this untapped potential represents for the horizon 2010 energy savings on the order of 11 to 13 Mtoe-- 7 Mtoe in the residential sector, 4 to 6 in industry. Even if the high figure is undoubtedly an upper limit, the potential energy savings that could be achieved over the next fifteen years are on the same order of magnitude as the savings achieved since the first oil crisis.

This observation should not lead to optimism, however. Realising these savings, even at the low end of the spread, requires conservation measures and economic signals that are currently lacking. Energy efficiency has been regressing for the last three years: 3 Mtoe of savings have been lost per year since 1990. This reversal of the trend comes several years after the 1986 oil countershock, and is not limited to France. It calls into question the very notion of a baseline scenario. Just two years ago all energy economists had integrated a move to greater energy efficiency into their "business as usual" scenarios (see for example the work presented by the World Energy Council in Madrid in 1992).

If this recent trend continues the objectives identified above will become even harder to attain (although paradoxically, potential savings would grow as energy efficiency decreased!). Inversely, the energy management programmes identified in this work could help put society back on a trajectory towards greater efficiency, by combining and balancing the various instruments of public policy in favour of well thought-out energy management (fiscal measures, regulations, incentives). Above and beyond the commitments made in the framework of the Climate Convention, energy management is grounded in measures that contribute to other goals (industrial investment, construction activity, reducing the negative impacts of transport, etc.). But despite the current weakness of oil markets, the prime justification might still reside in the protection offered against vulnerability of energy supply.

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