The effect of the oil price countershock on energy efficiency in transport

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Synopsis

The recent come back of energy savings in the transport sector in France is surprising. Analysis of the transport energy demand and related policies since the counter oil shock shows that the pursuit of technological improvments, fuel substitution and road traffic conditions have counteracted the energy price signal effect.

Abstract

The oil price countershock has accelerated the trend towards higher energy demand for transport in France, which since 1986 has grown at an annual rate of 2.5%. Nevertheless, since 1993, we have observed a significant slowing down of energy demand growth, down to an average of 0.7% per year, a trend which seems to be confirmed in 1996. This recent phenomenon has occurred despite an annual 2.5% increase in passenger transport (pkm) and 5.5% per year for freight (tkm). To interpret this shift in the trend, we have used at a disaggregated level, a battery of technico-economic energy efficiency indicators, both descriptive and explanatory. Over the 1986-1995 period, the incremental increase in energy demand is close to 9.9 Mtoe. This can mainly be explained, first by an "activity effect" of 9.1 Mtoe due to growth in traffic and secondly by loss of savings of 0.8 Mtoe due to the worsening of unit consumption. Further disaggregation shows that behavioural changes as a response to lower prices have more than offset continuous technological improvement. Nevertheless, historical analysis of recorded incremental energy savings shows that energy efficiency reappeared in this sector after 1993, at a level of magnitude which had prevailed during the period of high fuel prices. During 1994 and 1995, two-thirds of the loss of savings recorded since the oil price countershock were offset. Keys to the interpretation of this new improvement can be found in the pursuit of technical improvements, fuel substitution and some improvement in road traffic conditions. In addition, the hypothesis of improvement in user behaviour due to the anticipation of future increases in fuel prices should not be neglected.

1. Introduction

On a long-term basis, over the period 1973-1995, consumption trends in the transport sector are due to the rapid growth in passenger mobility (more than tripling), and of freight transport (+60%). Parallel to fuel price changes, energy management policies, mainly through technological improvement of vehicles, were able to slightly counterbalance this trend, but with little success compared to other energy-consuming sectors (Bosseboeuf, Richard 1997).

Whatever the level of analysis (by fuel type, mode or vehicle type), the oil price countershock has indubitably introduced a rupture in transport energy demand consumption and in the energy efficiency trends that had prevailed before in France. More questionable is the recent and remarkable slowing down of consumption. Many factors have interacted during the last decade which can explain this observation:

1) Changes in the energy context with a trend to lower fuel prices in real terms and the retreat of public energy efficiency policies.

2) Uneven economic growth (a period of sustained GDP growth , 3.4% per year 1986-1990, followed by an unfavourable period (1.1% per year, including 1993 which was a year of recession). Household income fell slightly from 1990 to 1995.

3) Changes in the socio-economic context (life style, urbanisation etc.).

4) Impact of sectoral transport policies (single market, road infrastructure development etc.).
5) Incidental phenomena such as transport strikes by both truckers and railway employees, public policies to encourage renewal of the vehicle fleet (The so called "Balladurettes", "Jupettes" etc.[1]).

All these medium and short-term factors have variously shaped energy efficiency, and it is certainly difficult to assign responsibility for the overall situation, the result of all these factors, to the drop in oil prices alone.
The objective of this article is to interpret the role of the oil price countershock on energy efficiency trends in the transportation sector, and particularly on recent trends. Why has energy efficiency reappeared in this sector despite the continuous drop in fuel prices and the public authorities' progressive disengagement from energy management policy? Do we expect this trend to become structural due to the saturation of the level of car ownership in the country, or is it merely an ephemeral phenomenon?

These questions are of primordial importance for policymakers thinking about the relevancy of economic or non-economic instruments for controlling energy demand or combating greenhouse gas emissions in a context of low energy prices.

Using observed trends in consumption data (part 1), we will use a technico-economic approach (part 2) to assess energy efficiency trends (part 3) and their explanatory factors. A more detailed approach will be applied to cars and trucks.

2. Major trends in transport energy demand from 1973 to 1995

2.1. The oil price countershock first spurred energy demand and then a slowing down occurred.

After two decades of strong sustained growth before the first oil price shock, transport energy demand in France has experienced an uneven evolution. Total consumption for transport grew at an annual rate of 1.8% from 1973 up to 1995, corresponding to an incremental increase in consumption of 16 Mtoe. Four main periods can be distinguished: 1) between the two oil crises, growth in energy consumption was sustained (3% per year); 2), stable consumption from 1981 to 1986; 3) as a response to the price drop, energy demand once again rose substantially to 3.7% per year for the following four years; 4) a significant slow-down of the increase in consumption from 1993 (0.9% per year). Along with this evolution, two major structural changes can be identified:

By fuel type, market share has shifted greatly, to the benefit of diesel fuel which since 1991 is the most heavily used type of fuel. Two fuel types were the winners in the 1973-1995 period. Firstly diesel fuel, with consumption that has more than tripled, growing at 5.8% per year since 1973, and a huge acceleration after the oil price countershock (9.6%) due to massive fuel substitution, light vehicles shifting from gasoline to diesel, and the boom in road haulage of freight. However, it can be seen that from 1991 onwards, annual growth fell to 5%. Secondly, aviation fuel sales were still oriented towards a positive trend, excepting certain years (1991). At the opposite end of the spectrum, after 15 years of relatively stable but limited growth, gasoline consumption has experienced a negative trend from 1988 onwards. Particularly during the last three years, the drop in gasoline sales has been remarkable (-3.3% per year). More spectacular, but with less impact on the overall balance, marine bunkers were halved over the first part of this period, but they have remain stable since the end of the 1970s. No significant changes are observed for electricity consumption in transport, which has followed rail traffic trends.

Broken down by modes, road transport energy consumption more and more largely dominates the sector, accounting for 80% of overall transport consumption in 1995, compared to a 70% market share in 1973. Since the first oil crisis, road transport energy consumption has rapidly increased (2.5% a year), more rapidly than overall consumption, and alone almost fully accounts for the energy consumption growth of the whole sector. After the oil price countershock, two major ruptures occurred: an impressive and rapid response (3.7% per year) to the price change, and more interesting, a remarkable falling back to a 1.2% growth rate over the last four years. As in many industrialised countries, this rapid growth was due to the spread of the automobile, and more recently to the boom in the use of light trucks linked with growth in urban activity and freight transport.

Since 1986 growth in consumption for Air transport (including international bunkers) has accelerated to a 5.5% annual rate, compared to an average of 3.7% from 1973 to 1986. No remarkable shift in this trend has been seen in recent years.

Regarding rail, the decrease in consumption observed from 1980 to 1986 (-0.1% per year), widened to -0.8% for the period 1986-1991, and since 1991 has continued and amplified, attaining an annual rate of -3.2% over the last four years.

2.2. Fuel price trends: 1995 prices remain lower than in 1986

Transport is the sector where oil price increases are the most highly cushioned (in real terms), primarily due to the weight of taxes (82% for gasoline, 72% for diesel in 1996).

A brief presentation of gasoline and diesel prices in real terms over the period 1973-1995, (figure 1) shows clearly that the effect of the 1985 oil price countershock partly offset earlier increases. Thus in 1995, prices for premium gasoline and for diesel fuels were respectively only 15% and 17% higher than in 1973 and lower than in 1974. If we look at the recent trends, we can see that despite a return to rising fuel prices, they still stand at a lower level that in 1986. Due to the high price gap between gasoline and diesel, one of the highest in the OECD countries, large-scale fuel substitution occurred in France. For this reason, the average weighted price of automotive fuels sales is a better indicator for following the price situation in France. It is clear from figure 1 that the pressure of automotive fuel prices has diminished for the average French driver since 1986. Nevertheless, one could think that the recent slight increase might lead users to anticipate a rise in fuel prices.

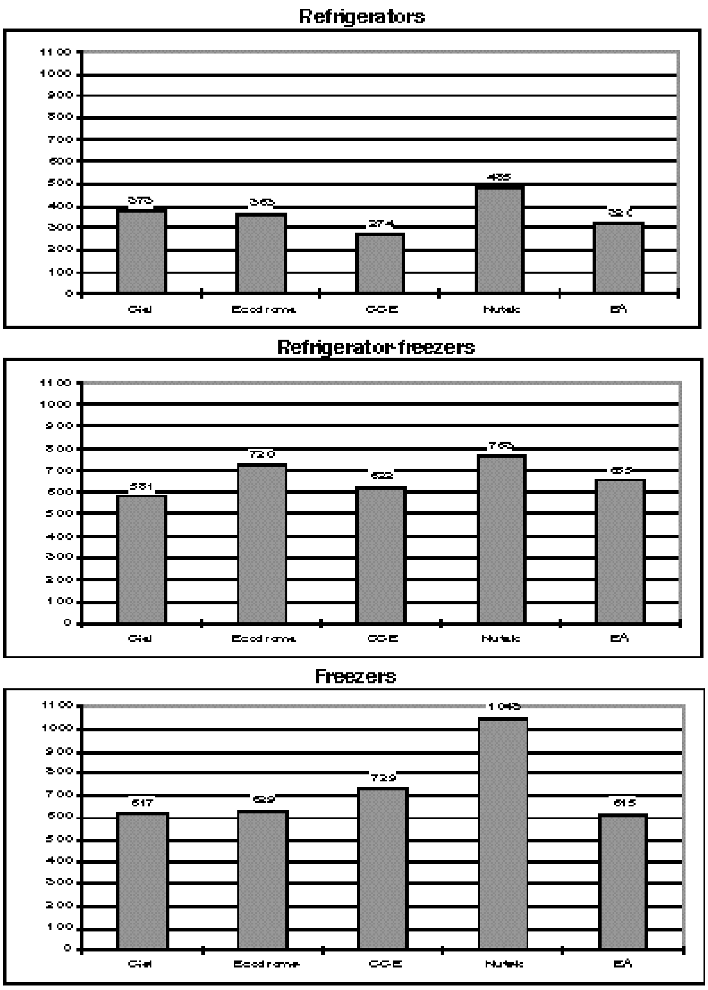

Figure 1. Fuel prices evolution in France (FF 1995)

2. Methodology

The statistical analysis of annual energy balance differences or "technico-economic effects" leads us into the area of explanatory energy efficiency indicators (EEI). The basic principle (see box 1) (Bosseboeuf and al., 1995; Bosseboeuf and Richard 1997) consists in breaking down the incremental demand into essentially two effects: the variation in activity due to socio-economic trends (activity effect) and the variation in unit consumption expressing improved or worsened energy efficiency (unit consumption effect). The latter can be in turn broken down into technological, behavioural and substitution effects. One advantage is that they can be directly linked to an energy technology (i.e. vehicle) or service, as they are calculated in terms of physical units.
This assessment is based on technico-economic indicators derived from the DATAMED database managed by Enerdata for ADEME. The results and interpretation of this method are dependent on the following elements:

- The definition of technico-economic effects. The definition can continue to evolve along with the goals, as long as the statistical data is available and supplementary causes of variation in EEI can be identified and quantified.
- The method of decomposition of energy demand variation: In the literature, two different approaches are used to explain the variation in energy consumption between two years, using explanatory effects (Schipper 1992 applied in DOE 1995 and NRC Canada 1996, and ENERDATA 1995). They are, however, quite different, in terms of types of effects measured, how these effects are calculated, and the questions addressed.
- The level of disaggregation. There is a consensus that the level of disaggregation used has an effect on the results obtained. However this consensus does not extend to two further issues: how far should disaggregation by end uses be carried to be relevant, and what structural effects are under consideration (e.g. modal split, increasing use of diesel engines, higher-powered cars)?
- The reference period: The assessment presented here is based on a single reference year, 1986, taken to be the starting point of a period of low prices. The results of energy conservation presented as annual differentials are also calculated with reference to 1986 (1995-1994; base year 1986) and not as a "sliding" calculation (1995-1994); base year 1994).
- The sources used.

Despite precautionary measures, theoretical and operational difficulties persist in our analysis. The conditions of independence of the explanatory "technico-economic" effects are not preserved across the board. The effects of energy efficiency policy per se and of sectoral transport policies cannot be properly allocated, due to the increasingly necessary interconnection between energy efficiency policy, and environmental, industrial or transport policies. In the same way, energy substitution effects may be integrated into energy efficiency policy or be accounted separately.

3. Results. Since the oil price countershock, the transport sector has recorded loss of savings, but they have been partly offset since 1994.

Between 1986 and 1995, the trend of the energy consumption in the transport sector (+9.9 Mtoe) can be explained by an activity effect accounting for +9.1 Mtoe, and a unit consumption effect of +0.8 Mtoe (figure 2) [2].
Growth in traffic explains for the most part the increase in consumption (activity effect +9.1 Mtoe). In other terms, if technology and user behaviour were similar to those of 1986, France would have consumed an additional 9.1 Mtoe due to increased traffic. Particularly, car traffic growth (+3.4 Mtoe), trucks (+2.7 Mtoe) and air traffic (+2.1 Mtoe) are the main factors responsible for activity growth.

Few energy savings have been achieved in transport of passengers (-0.22 Mtoe), including -0.3 Mtoe for cars and -0.23 Mtoe for air. Loss of efficiency of freight transport has led to higher consumption (+1 Mtoe) attributable to light trucks (+0.9 Mtoe), while large trucks have contributed to improvement in the energy balance (-0.15 Mtoe). Further breakdown of energy savings shows that their components have evolved differently. Technological improvement in vehicles, reflecting the impact of R&D programs on vehicle products, has been very significant (- 4.3 Mtoe), but is the sole factor which has contributed to reducing the energy balance. The “mileage effect ” has boosted consumption by +2.1 Mtoe. Change in behaviour has also generated important significant loss of savings (+2.9 Mtoe consumed) due to a worsening of user practices (driving style, maintenance, company operating conditions, adaptation of fleets to economic conditions, conditions of use, shorter trips, more congestion). From what it has been said, it is clear that the negative effect of the oil price countershock on energy efficiency is still present.

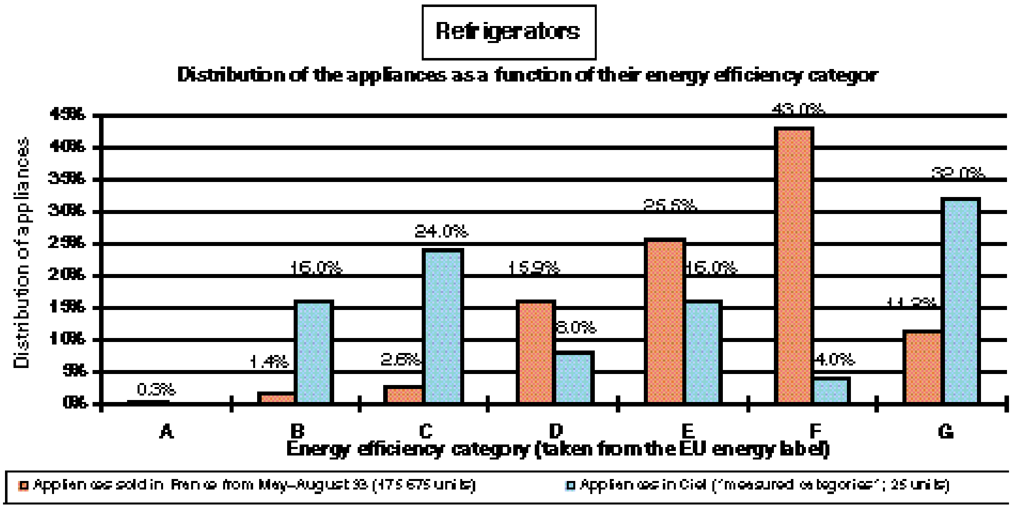

Figure 2 : Explanatory factors of energy demand changes in transport (France 1986-1995)

Nevertheless, analysis of the recorded incremental energy savings yields new indications. (figure 3).

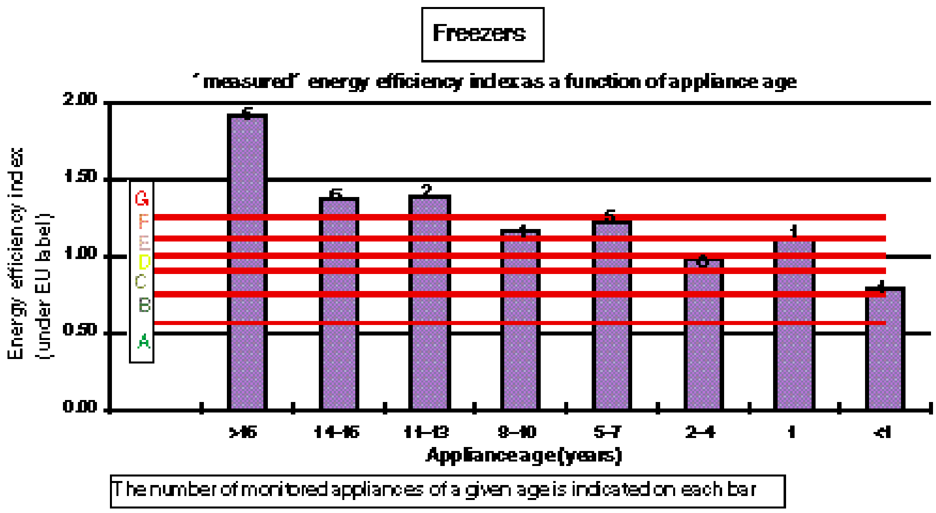

Figure 3 : Incremental energy savings in transport sector (France 1986-1995)

Particularly visible after 1988, the oil price countershock has year by year generated additional loss of savings at an annual rate of 300,000 toe. Cumulative loss of energy savings reached a maximum in 1993 (+2 Mtoe). But additional energy savings reappeared in the sector in 1994 (-0.7 Mtoe), confirmed again in 1995, with an order of magnitude comparable to that observed in the 1980s. In two years, two-thirds of the energy efficiency losses which had occurred since the oil price countershock were offset. Preliminary results for 1996 show that this trend will continue.

3.2. Cars: Improvement in traffic conditions explains the comeback of energy efficiency

Cars consume half of the energy consumed for transport (23 Mtoe in 1995) and account for one-third (3.1 Mtoe) of the incremental increase in transport consumption of the last decade.

If unit consumption had remained at the 1986 level, automobile consumption would have increased by 3.4 Mtoe, due to the growth in the number of vehicles (activity effect). The impact of the greater number of cars on automobile energy demand has been reduced over the period because signs of market saturation, particularly for the first-car ownership ratio, have become perceptible. If between 1973 and 1995, the car fleet increased by 60%, since 1986 the growth rate for the car fleet has slowed down to an annual rate of 1.8%, compared to 2.5% over the period 1973-1986. Particularly visible in 1991 and 1992, this very slow fleet growth (1% per year), partly related to the regression of household income, continued in the following years, despite public incentives encouraging the renewal of the fleet from 1993 to mid-1995. As a consequence, the ageing of the automobile fleet continues, even if these public policies have temporarily affected the trend. In other words, without speaking of a causal effect of the drop in oil prices, explanatory factors relating to car fleet structure take precedence over those relating to the total number of vehicles, due to market saturation. In the recent past, public policies have indeed oriented the structure of the car fleet towards less powerful cars. But this effect cannot be detected at the level of disaggregation used in our analysis.

In the meantime, the average energy consumption per car has dropped slightly, generating 0.3 Mtoe of energy savings. Nevertheless, the three selected components of energy efficiency have evolved differently over the period as revealed by the analysis of incremental energy savings:

- a technological improvement due to the penetration of fuel-efficient cars which has decreased consumption by 3.3 Mtoe. Nevertheless, it should be noticed that the average tested specific consumption of new cars improved only from 6.74 to 6.51 litres/100 km from 1986, even though it has fallen by 22% since 1973 (figure 4). More worrying, this small improvement was only due to the dieselisation of the car fleet (Morcheoine 1994), since specific consumption has increased for both technologies (gasoline and diesel) in the recent yeras. On average 1995-model diesel cars consume 2% (in l/100 km) more than 1986 diesel cars. This effect is due to French drivers' preference for safer and more comfortable cars (CCAF 1995).

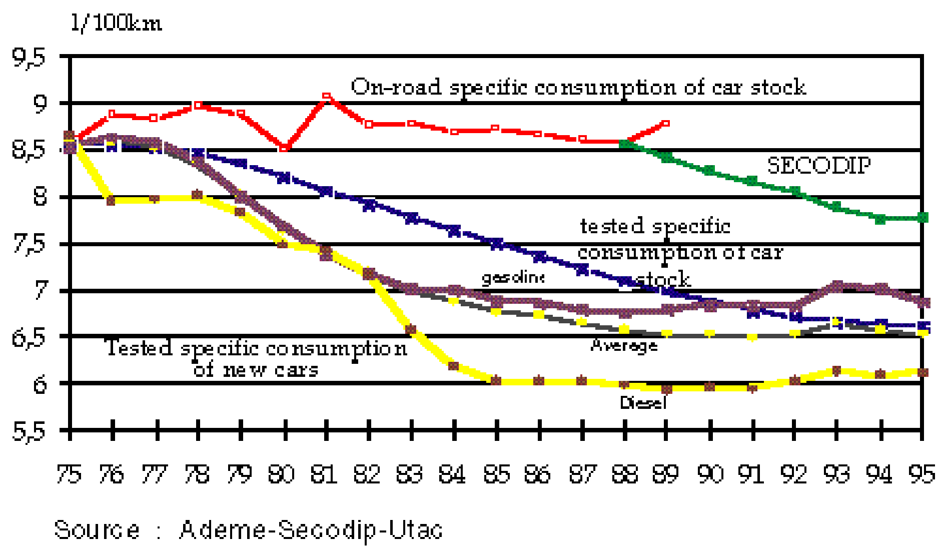

Figure 4 : Evolution of specific consumption (l/100 km) for cars (France 1976-1995)

- The most visible effect of the oil price countershock can be seen in the average yearly mileage per car which has had a great impact on energy consumption (2.1 Mtoe) (figure 5). On average a French car driver logged 1,600 km more in 1995 than in 1986 (+23%), taking all fuel types together. Due to the recent fallback in household income and its structure, the explanation for this increase in distance travelled is to be found in falling operating costs as a consequence of less pressure on fuel prices (figure 1) and fuel substitution towards diesel-fuelled cars. For instance, in 1995 diesel cars run 19740 km/year compared to 11490 km/year for a gasoline fueled car. Ten years ago, the diesel cars runned 23200 km compared to 11500 km for gasoline cars.

- a trend to deterioration in the average conditions of car use which can be detected by comparing specific consumption and on-road consumption (see figure 4). This behavioural effect has increased consumption by +0.86 Mtoe. This gap encompasses the effects of traffic conditions, driving and maintenance behaviour. Nevertheless, this gap has narrowed recently.

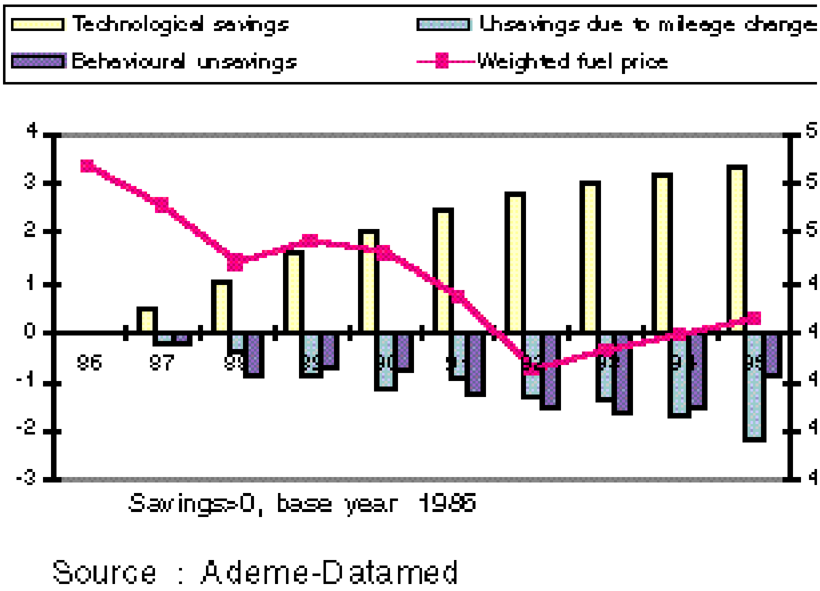

Figure 5 : Evolution of the componants of energy savings for cars (1986-1995)

However, we do not feel comfortable with this observation which reveals opposing trends in the two components of unit consumption, i.e. mileage and driver behaviour in the recent past. These two effects interact more or less together, or at least should evolve in the same way in response to price signals. Consequently, the explanation must be found in action not directly linked to oil prices. Results from transport surveys indicate that traffic conditions were improving over the period. Comparison of national transport surveys (Madre, Maffre 1995) shows that the average speed of traffic increased between 1982 and 1994 (30 km/h and 35 km/h respectively). This improvement in road driving conditions can be explained by the fact that traffic growth has occurred in less congested areas, i.e. intercity traffic. This phenomenon can be observed from traffic data derived from surveys by type of road network (Ministry of Transport 1995 in INSEE 1996). In accordance with past trends (3% per year), highway traffic in 1994 and 1995 increased (+4.9% and 4.5% in vkm) as did traffic on trunk roads (3.7% and 2.8%).. At the opposite end of the spectrum, urban and local traffic stagnated at 2%, a figure confirmed by a local survey in the Paris region (Gallez 1996).

The doubling of road infrastructure expenditures (to stimulate civil engineering works), truly visible after 1988 (FF 50 billion per year) has been particularly materialised to the benefit of the hyhway network development which have increased of one thirdIt has certainly enabled French drivers to travel in better conditions. The negative impact of this road infrastructure development due to "induced effects" does not seem to have been felt yet. Large-scale fuel substitution has occurred in France and has had an impact on energy efficiency trends. Factors which explain the "success story" of dieselisation in France are numerous and cannot be interpreted only by the fuel price gap (Hivert 1996). If performance differences (certainly in terms of l/100 km, less so in terms of koe/100 km) had an obvious and direct impact on energy efficiency trends, this inter-fuel substitution has also helped modify the size and the structure of the car fleet and mileage, indirectly playing a role in energy efficiency results. Fuel substitution leads to two opposing tendencies: a year-by-year decrease in the absolute number of gasoline-fuelled cars from 1991 at an average rate of -1.7%; and a large rise in the number of diesel cars, +14% on average from 1986 to 1995, a rate which has slowed to 12% these last few years. This recent trend can be explained by customer anticipation of future increases in the price of diesel fuel. Results show that inter-fuel substitution has led to a reduction in consumption of 0.48 Mtoe from 1986 onwards.

3.3. Trucks:

The road haulage activity performed by trucks is the second item which merits to be analysed in detail, for two main reasons: 1) Its growing importance in the transport energy balance, 2) rapid changes which have occurred in trucking operations due to deregulation of transport and internalisation of markets. Road freight traffic is very dependent on the level and the structure of the economy and for some markets, elasticities of transport demand to GDP can attain a factor greater than three (Enerdata 1997). To summarise the effects of the recent development of economic growth on trucking activity we can say that: 1) the increasing weight of the manufacturinged products and services sector in the economy increases the value of shipments and decreases their density, 2) the internationalisation of markets and greater distances between the place of production and area of consumption lead to a lengthening of distances travelled; 3) new logistics developments (just-in-time practices) leads to smaller and more frequent shipments, 4) the fall in transport utilisation costs due to deregulation and low energy prices for transport. All these factors have played a different role in the level and the structure of trucking activity and consequently on energy efficiency trends. Particularly, changes in the fleet structure, with more 40-tonne trucks for long-distance haulage (transit), and towards medium-sized and small trucks due to just-in-time logistics, and the decrease in load weights are the most visible consequences of the above-mentioned factors.

The challenge of interpreting energy efficiency trends in this sector stems from the interaction of these factors and their temporal coincidence with the drop in oil prices. Statistical limits also reinforce the difficulties of interpretation, particularly because there is no longer a direct link between the sale of diesel fuel to trucks and recorded traffic. We have partly resolved this problem by subtracting from total diesel sales allocated to trucks, the fuel consumed by foreign vehicles in transit through France [3].

If the diesel consumption of trucks had followed the evolution of traffic (tkm), consumption would have increased by 2.7 Mtoe over the 1986-1995 period. This renewed growth recorded in France became particularly visible after the oil price countershock. Growing at an annual rate of 8% since 1986, international traffic performed by french truks grew three times more rapidly than domestic truck traffic and explains the main growth in overall traffic on French infrastructures along side the transit. Figure 6 shows that after the 1993 economic recession when traffic decreased (-3.4%), the activity effect rose sharply, by 3.5% per year.

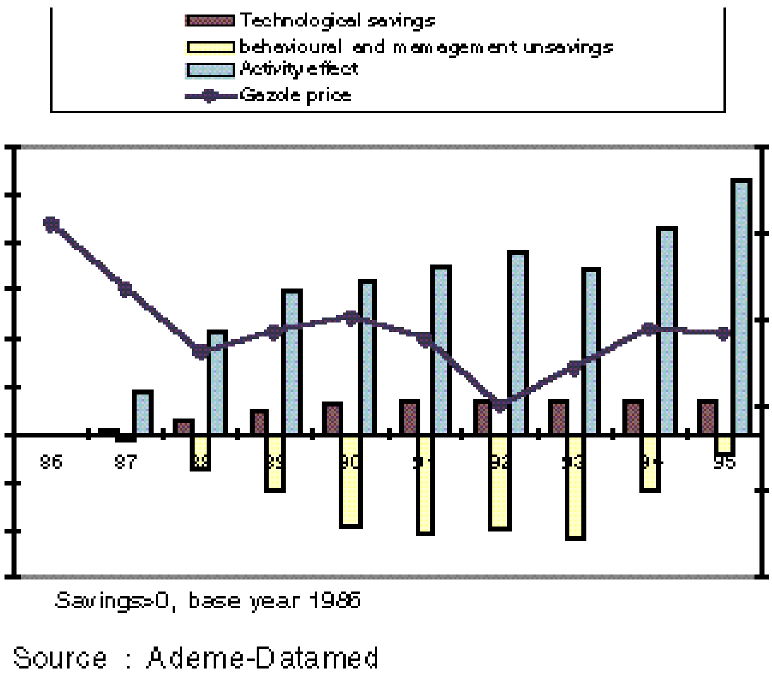

Figure 6 : Explanatory factors of energy demand changes for truks (1986-1995)

The "unit consumption effect" calculated here is the result of technological improvements and behavioural changes which helped reduce consumption by 0.2 Mtoe in 1995. This last factor encompasses the impact on unit consumption of changes in load weights, driving style and conditions of use.

Monitoring specific consumption of trucks (litres/100 km) through surveys is very difficult to set up. In the case of France, information on specific consumption is dependent on information supplied by drivers in surveys (Ministry of transport) every three years, and by an annual survey of a panel of firms for 40-tonne trucks (Direction des Transports Terrestres 1994). It appears that technological gains were substantial between the two oil crises (figure 7), but from 1986 onwards, specific consumption was stabilised at around 38 litres/100 km. Technological improvements have led to a reduction in consumption of 0.4 Mtoe.

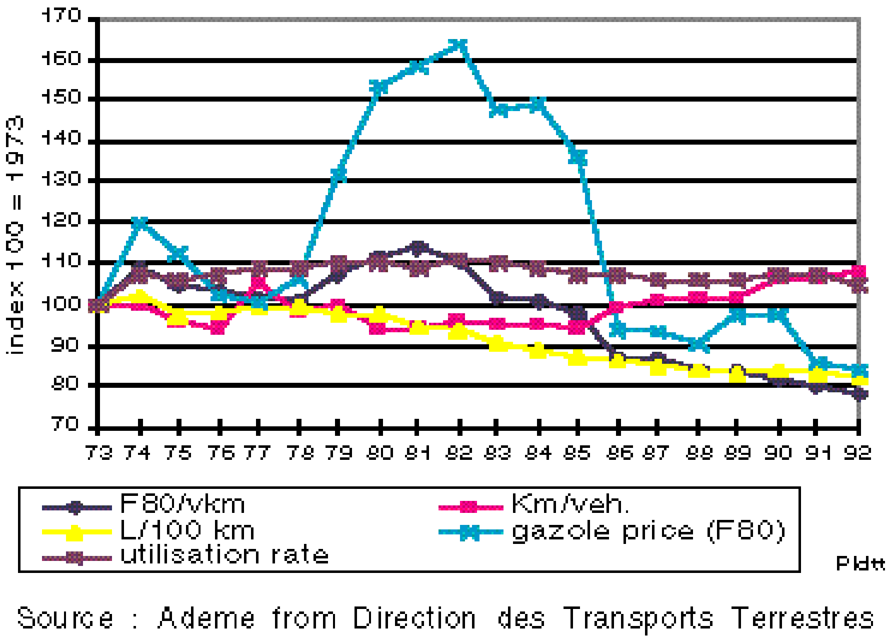

Figure 7 : Evolution of specific consumption for truks and its determinants.

Changes in trucking company management and their consequences on the load factor have been considerable, and starting in 1986 the fall in the utilisation rate (tkm/vkm) has led to an increase in consumption of 0.2 Mtoe. But since 1994, a break can be observed and improvement of the load factor has become the major factor in unit consumption improvement. Further works have to be carried out to confirm these results.

Conclusion

Historical analysis (Bosseboeuf 1997) reveals that energy efficiency in the transport sector is characterised by very little progress compared to other sectors. Freight haulage even shows a loss of efficiency. One explanation can be found in the narrower range of specific energy management instruments that have been implemented, compared to other sectors. Public energy management intervention (other than fuel taxation) has been relatively limited in this sector, and the measures taken have been juxtaposed alongside other very far-reaching policies focusing strictly on transport, with effects that indeed have thwarted energy management efforts, most notably in the form of support for road haulage. While investment subsidies can be effective when applied to vehicle fleets, they have a limited impact. Generally speaking, public transport policy, which favours road transport, is not favourable to energy management.

On a long-term basis, the various components of energy savings have evolved differently. On the one hand, there is a general upward tendency in energy conservation due to technology-derived energy savings, clearly apparent in periods of price stability or erosion. On the other hand, changes in behaviour generate strong but very volatile energy savings due to the short-term sensitivity to fluctuations in fuel prices.

These statements can be generalised to European countries, but are based on observations during a period of high fuel prices. Few results are available in a context of stabilised low energy prices and attempts to design new policy in this new context are still not convincing.

It is clear that the oil price countershock has introduced a rupture in energy efficiency trends in transport. But our disaggregated analysis partially challenges the hitherto accepted notion that technological energy savings are structural savings and that behaviourial savings are volatile and reversible. Particularly visible from 1990, technological gains were very limited and even worsened due to the slackening production of fuel-efficient vehicles by manufacturers. This phenomenon corresponds to their anticipation of continued low pressure on fuel prices and their intent to meet consumers' desires for greater comfort and safety. The oil price countershock has also enabled car drivers to drive more, and has lowered transport costs for trucks. Only the economic recession and the stabilisation of income household have, for certain years, introduced a slowing down of these trends. Ten years after the fuel price drop, unsavings are estimated at 0,4 Mtoe. Changes in behaviour are indeed affected by movements in fuel prices, but also correspond to structural modification in conditions of mobility–increased traffic congestion, short trips, and the management of trucking industry.

Since 1994, contrary to all expectations, energy efficiency is apparently once again on the rise in the transport sector, offsetting two-thirds of the recorded energy savings since 1986. Our first hypothesis was that users' behaviour was no longer affected by the negative effect of the oil price drop due their anticipation of future price increases. But this is in contradiction with the increasing distance travelled. Without a doubt, the public policies encouraging the renewal of the fleet have contributed to temporarily shift the fleet towards younger and smaller cars. But the main explanation can be found in a non oriented energy efficiency strategy, and the improvement of road traffic conditions due to huge and new development in road infrastructures. Today, the Frenchs drive more and get around better. If this diagnosis is correct, this recent energy efficiency improvement will be an avatar which will disappear as soon as the induced traffic creates congestion once again. Consequently, strategies in controlling energy demand cannot be implemented independently of general transport policies. Because technological options are not sufficient to counteract the downward spiral in user behaviour which is becoming increasingly a structural phenomenon, the priority now is management of transport organisation.

References

Bosseboeuf D. (1995): "L'analyse technico-économique dans les transports, application au PVD asiatiques", P.H.D., Grenoble University.

Bosseboeuf D., Richard C. (1997) : « Evolution de l'efficacité énergétique en France 1973-1993 », rapport pour le CIME, Ademe, Paris

Bosseboeuf D. Richard C. (1997) "The need to link energy efficiency indicators and related policies », ADEME, Paris.

Bosseboeuf D. Chateau B. Lapillone B. and al., (1996): "Cross country comparison on energy efficiency indicators phase 2", project DGXII ADEME-Save-Enr, Paris.

Comité des Constructeurs Autombiles Français (1996) : « L'industrie automobile en France : analyse et statistique 1995 »: Paris

Comité Professionnel Du Pétrole (1996) :« Pétrole 95, éléments statistiques », Rueil-malmaison

Direction des Transports Terrestres (Ministry of transport) (1994) : « Vingt ans d'enquête sur les prix de revient », la note d'information de la direction des transport terrestres n°135, Paris

DOE-EIA (1995): « Measuring energy efficiency in the US' Economy : A beginning », Washington DC

ENERDATA (1996) : « Handbook on methodology of energy efficiency indicators », report prepared for Ademe, Paris

ENERDATA (1997) : « Prospective des flux de transports internationaux en Europe, éléments de formalisation », report for Ademe, Paris

GALLEZ C.(1996) : « Bilan Energie-Pollution de la mobilité urbaine en Ile de France », report prepared for

Ademe, Arcueil
Hivert L.(1996) : « Le parc automobile des ménages, étude en fin d'année 1995 », rapport de l'INREST prepared for Ademe, Arcueil,
INSEE- (1996) : « Les transports en 1995 », séries INSEE résultats, 33éme rapport de la commission des comptes des transports de la nation, Paris.
Madre J.L., Maffre D (1995) :« Toujours plus loin, toujours plus vite », collection INSEE-première, Paris
Morcheoine A., Orfeuil J-P. (1994): "The challenge, 20 years of energy conservation policies in transport for France", ADEME, Paris
Natural Ressource Canada (1996) : « Energy efficiency trends in Canada », Ottawa
Secodip (1996) : « Panel Secodip, étude de la consommation aux 100 km de la consommation aux 100 km et du kilométrage », repoort prepared for Ademe, Paris
Ministry of Transport (1995) : « Mémento des statistiques de transports, résultats 1994 », Paris
Ministry of Transport (1996) : « L'utilisation des véhicules de transport routier de marchandise en 1995.

Box 1 : The technico-economic Effects methodologies

The methodology used in this article, is called « technico-economic effects » and is used to assess energy savings with a bottom-up approach. The basic principle is to explain the energy consumption variation with two main effects (B. Lapillonne, 1986, ADEME, 1996):

- a quantity effect: (Q U_o ;
- a unit consumption effect: Q (U.

All effects used to explain the variation of the energy consumption between two years are calculated at the level of homogeneous and relevant sub categories of energy consumption (sub-sectors, end-uses...) ;

The quantity effect measures the variation of consumption due to changes in activity of the module (tons produced, number of vehicles, of appliances...). It is calculated with the unit consumption of the reference year.

The unit consumption effect measures the influence of changes in the unit consumption at the module level (e.g kWh per appliance, l/100 km, toe or Gj/ton). This effect is calculated by difference between the actual consumption variation and the quantity effect, which means that there is no residual factor. The unit consumption effect is calculated with the quantity of the current year. This mode of calculation corresponds to a Laspeyres-Paasches method.

The objective of this method is not to measure the influence of structural changes. The concept of structure of a sector does not appear as such. This characteristic enables to use different units for the quantities and, thus, unit consumption within the same sector (e.g tons and value added in industry, number of vehicles-km, passenger-km and ton-km in transport). In each module, the most relevant unit can thus be used to grasp energy efficiency changes (e.g liters/100 km for road vehicles instead of GJ or toe/passenger-km).
At an aggregate level, the quantity effect is the aggregation of several individual quantity effect related to various modules composing the aggregate.

Endnotes

[1] The so called « balladurette and Jupette » procedures were initiated in 1995 and forwards by the ministry of industry. They aimed in accelerating the renewall of the fleet at reactivating the new car registrations on the French market. The basic principle of implementation was to provide a 5000 up to 7000 FF direct subsidiy to each

purshaser of new cars under the condition that he replaces its old 10 years car by the new one.

[2] . The error sensitivity of the energy savings assessment is highly linked with the data accuracy of the fuel use, because the activity effect is generaly more accurate (data on fleet are correct).

[3] . Consequently, foreign trucks represent more than 20% of total tkm and more than 16% of total vkm in 1995, compared to 13% and 10% in 1986