Transport Policy and Programme Evaluation: Energy Efficiency in The Transpotation Sector for France from 1973 to 1991

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1. SYNOPSIS

The evaluation of the French transport energy conservation policy clearly shows that non-price measures are absolutely necessary to control theenergy demand trend, particularly after the 1986 counter-oil shock.

2. ABSTRACT

In 1991, transportation energy consumption in France accounts for 70 % of total oil demand. Its contribution to the greenhouse effect is around 25 %. The transportation sector is the key sector to control the energy demand and environment changes. Since 1973, France has sep-up a vast energy conservation programme covering a large set of actions and tools from regulation, R & D, incentives training and sensibilisation... towards all the users. In order to assess the overall impact of such energy policy, we have used the "technico-economic" approach that explains variations in energy demand through a combination of economic, socio-économic and technical factors. This approach allows for considerable disaggregation according to homogeneous consumer "modules". Results show that between 1973 and 1991, the trend in the transport sector (+ 13,5 Mtoe) can be explained by an activity effect accounting for + 19,5 Mtoe, and a unit consumption effect of - 6 Mtoe, of which -11,3 Mtoe due to technological improvments in vehicles. Analysis of the record of annual incremental energy savings yields two important general conclusions :

- High and very volatile short-term price sensitivity to variation in vehicle fuel prices.
- A general trend towards technology-led energy saving clearly apparent in periods of price stability or erosion.

From the analysis, it prevails that technological improvements have been partly offset by the worsening of user behaviour, particularly visible after the counter-oil shock. Market forces seem not sufficient themselves to control the energy demand evolution. Action towards user behaviour must reunforced. Thus, Ademe is launching an energy conservation and environmental programme where support to transport demand control become primordial.

3. INTRODUCTION

3.1. Background

Since 1974, France has set-up a vast programme of rational use of energy in order to reduce its energy dependence. Absorbing 70 % (1991) of the total imports of petroleum products, and depending on 96 % of oil, the transport sector is the key to France's energy independence. It represents an important stake difficult to manage. In 1982, with the creation of the french Agency for Energy Management (A.F.M.E.) conceived by the government to design, implement and disseminate the policy for rational use of energy, actions initiated towards transport user's became more important and decisive to cut the energy consumption of this sector.

Changes in the energy context and environmental constraints have recently led the french government to renew the institutional framework in this domain. With the creation of ADEME (french Agency for

Environment and Energy Management), in 1991, France disposes of an original tool to tackle with these new objectives, redesigning new programmes, more oriented towards transport demand and environmental controls.

3.2. Scope

Topics of this paper is to present the actions implemented, the problems met, and the results of this French experience. It will particularly indicate and comment the following points :

- The various ways, means and procedures set-up by AFME to cover the large field of actions from research to investments.
- The necessarly continuing adjustment process of the energy conservation policy, taking into account the past experience and the national context changes.
- The assessment of the overall impact of such energy policies showing particularly the 1986 counter - oil shock effect.

The evolution of energy consumption is subject to three major influences :

(1) growth economic and demographic which spurs expansion -or recession of production and of the needs of society which that production seeks to satisfy;

(2) modification of individuals' behaviour in response to economic changes (prices, income) and sociological changes (values, incentives);

(3) technological changes due to changes in price conditions (the relative cost of elements used in production) and R & D results, or instigated by measures of the institutional sort (regulations, standards).

In order to assess the overall impact of energy conservation and management policies, it is necessary first to measure the respective effects of these three major influences on energy consumption, and then to attempt to identify within each category that part which can be attributed more specifically to action taken within the framework of energy management policy.

While the first phase of this assessment can be carried out with a high degree of objectivity and rigor -as long as the relevant analytical tools are used- the second phase is much more delicate, and it is impossible to avoid the constant intrusion of value judgments. Indeed, this investigation contains all the ingredients of the debate about market and the virtues of laissez-faire economics !

4. METHODOLOGY

Standard (economic) analysis of energy efficiency (final consumption per unit of 1980 GDP or transport A.V) has a relatively limited range of interpretation because it is highly aggregated and accounts poorly for structural effects (dematerialisazion of G.D.P.) that occured over the period. In other words , the energy intensity ratio daes not allow us to properly distinguish between the reduction in energy efficiency strito sensu (energy savings) and structural effects. It assesses the overall energy productivity.

In order to meet the objectives mentionned above (the overall impact assessment of rational use of energy), we have used the "technico-economic" approach. This methodology is now widely known (T. Morovic et al. 1989); L. Shipper et al. 1990, D. Bosseboeuf and B. Lapillonne 1989, B. Chateau 1988). It aims at explaining variations in energy demand through a combination of economic, socio-economic and technical factors. This approach allows us for considerable disaggregation according to homogeneous "consumer modules".

Two main indicators are defined by common agreement :

(1) The activity effect (or quantity), which measures the impact of the variation in economic growth on the variation in energy demand. This effect is measured assuming constant unit consumption.

(2) The unit consumption effect, which assesess the impact of variations in unit consumption on variation in energy demand. This effect has been assimilated as energy savings. Unit consumption figures have been calculated here in toe per physical unit (number of cars, number of ton - kilometer, etc.). It is also possible to identify technological and behavioural elements within this unit consumption effect. The content of behavioural elements covers modification of user behaviour in response to price signals, effects of management behaviour (better adaptation of truck fleet to the economic context), maintenance behaviour ; the impact of traffic congestion, for instance.

It should also remembered that inso far as possible, inter-module structural effects are by agreement integrated into the activity effect. Thus, the unit consumption effect (energy savings) presented here is exempt of structural effects. Inversaly, certain intra-module effects may subsist. The most notable is the broad penetration of diesel automobile.

With this method it is possible to offer precise "explanations" for the evolution of consumption figures. By definition, energy savings thus defined and measured do not include gains or reductions in energy efficiency that are induced by structural changes ; for exemple the long-term shift in passenger-miles from railroad transport to road transport is not counted as a non-saving in energy.

These structural effects appear to be quite significant over the long term, but the problem lies in the fact that there no longer exists any reference point for the identification of energy "savings" : should the evolution of leisure travel towards long-distance trips be taken as a non-saving in energy ?

The application of such methodology supposes a set of conventions and results depend on :

(1) The definition of the technico-economics effects, (what is the best indicator to assess transport activity ? number of vehicles, traffics...),

(2) The calculating process (the variation in activity is weighted by the reference unit consumption, the unit consumption variation is weighted by the activity of the final year),

(3) The selection of the reference year (1973 is the best compromise between a normal year where the system is at the equilibrium from an energy saving point of view and a proximate year),

(4) The level of disaggregation (depending of the data avability and the objectives),

(5) The selected data.

Taking into consideration these elements, unit consumption for road transport is calculated in toe per vehicle per year, except for road merchandise haulage, which is calculated in goe per ton-kilometer and goe/veh-km for cars. For other modes of transport we have used the indicators that are specific to each mode. We would like to point out that it is difficult to choose a pertinent explanatory determinant for international air traffic and marine bunkers.

5. RESULTS

To properly interpret the changes in transport energy consumption, we have to briefly present the major trends in consumption from 1973 to 1991, the evolution of energy pricing, and the energy management policies.

5.1. Major trends in transport energy demand from 1973 to 1991: the impact of the 1986 counter-oil shock.

After two decades of strong sustained growth, transport energy consumption in France has experienced an uneven evolution.

- After the first oil shock, growth in energy consumption was strong in the period between the two oil crisises (+ 4,5 Mtoe), stable from 1981 to 1986, and has once again been rising strongly since the 1985 counter shock in oil prices (+ 9 Mtoe from 1985 to 1991).

- As many industrialised countries, the rapid growth is due to road transport particularly the spread of automobile and recently of the boom of light trucks linked with the urban activity growth.

Road transport energy consumption largely dominates the sector, sharing 77 % of the overall transport consumption. From the first oil shock, road energy consumption has rapidly increased (+ 61 % from 1973 to 1991), explaining quasi-totaly the energy consumption growth of the whole sector. Cars consumption represents roughly half of the total consumption (13,5 Mtoe and 21 Mtoe respectively in 1973 and 1991). Important inter-fuel substitution from gasoline to diesel has occured, particularly impressive since 1982. Currently, diesel fueled cars represent 27 % of car's consumption. Parrallely and particularly after the counter oil shock, the spread of light trucks (of which 65 % are diesel fueled) and the recent rapid growth of trucks traffic have also contributed to the impressive increase of diesel consumption. From the first oil shock, diesel consumption has more than doubled, experienced an 9 % annual growth rate since 1985.

On a long term basis, consumption trend is due to the rapid growth in passenger mobility (more than doubling during the 20 last years, et goods transport (60 % over the period 1973 - 1991). This sliding of consumption, particularly visible after the counter-oil shock was due to multiple phenomena of which urbanisation leading to multimotorization, increase of short trips, urban activity development, road congestion, is becoming the most disturbing factor. We constated that energy consumption in urban areas (40 % of the total) has grown four times more rapidily than interurban transport over the 15 last years. As a consequence, the responsability of transport sector in greenhouse gaz emissions is growing from 20 % to 25 % becoming the major polluting sector, before industriel and domestic activities. In 1990, transport accounts for 75 % of total CO, HC, NOx emissions of which cars represent 63 %, 61 % and 34 % respectively.

5.2. Transport fuel princing evolution

The transport sector is the sector where oil prices increases are the most highly cushioned (in real terms), primarly due to the weight of taxes. 75 % for gasoline, 61,5 % for diesel (1991).

A brief presentation of the gasoline and diesel prices in real terms over the period 1973 - 1991, shows clearly that the effect of the 1985 oil price countershock partly offset earlier increases. Thus in 1991, prices for premnium gasoline and for diesel fuels were respectively only 8 % and 12,5 % higher than in 1973.

5.3. Rational use of energy policy for transport in France.

The various measures implemented since 1974 can be presented making a distinction bet-ween three main periods : (1974 - 1982), (1982 - 1987),(1987....) corresponding roughly to different priorities and types of actions.

5.3.1. Actions on the user's behaviour (1974 - 1982)

First answer to the oil crisis (1973), in addition to some measures of regulation (speed limitation), actions were mainly focused on the improvment of the user's behaviour through national advertising compaigns (ANTI-GASPI). Corresponding to a vigourous energy awareness of the users, facilited by the economical environment, these campaings were certainly efficient. Nevertheless, their real impact is difficult to assess, and non-durable. With recent experience in this field, we can add that it is necessary to focus these

compaigns on selected targets of user's (woman, young drivers), and the slogan must based on a multi-criteria approach (pollution, total running costs, safety, confort...). Contrarly to other consumming sectors, regulations (speed limit, standard consumption publication) did not lead to the anticipated results. We believe that new regulations on emissions would be more efficient. It's also at the end of this period that first research programmes with vehicle manufacturers were initiated Eve (RNUR) and Vera (P.S.A.)

5.3.2. The investment policy (1982 - 1987)

With the creation of AFME, efforts and actions have considerably increased, which were traduced in financial terms. A large set of actions was initiated, characterized by an emphasis on the subidizes allocated generating high investment levels, and research programmes. This new policy was implement throught three main fields : 1) actions towards new vehicles (R & D), 2) actions towards transports companies and cars drivers in operation, 3) Measures in favour of the rationalization of transports systems.

R & D for fuel efficient vehicles : actions towards new vehicles. At the beginning of the 1980's, AFME has supported several research programms to vehicle-manufacturers. The 3 liters programmes : initiated in 1981, the objective was to conceive a low - range vehicle of synthesis, using all technological improvments, consuming 3 l/100 Km (standart). Performances of these prototypes, Vesta (Renault) et ECO 2000 (PSA), went beyond the assignated objectives : 2,8 l/100 km for the gasoline option, 2,4 l/100 km for the diesel option. Industrial products resulting from these programmes (Ax, 205...) experienced a sharp drop in their fuel consumption, since over the 16 last years, the standart consumption of new vehicles drop of 26 %. (fig. 1)

The "Virages" programme for trucks. Results of this programme show a reduction of 1 l/100 Km per annum for a 38 tons truck. Other programmes concerning bus, train, metros were also implemented during this period.

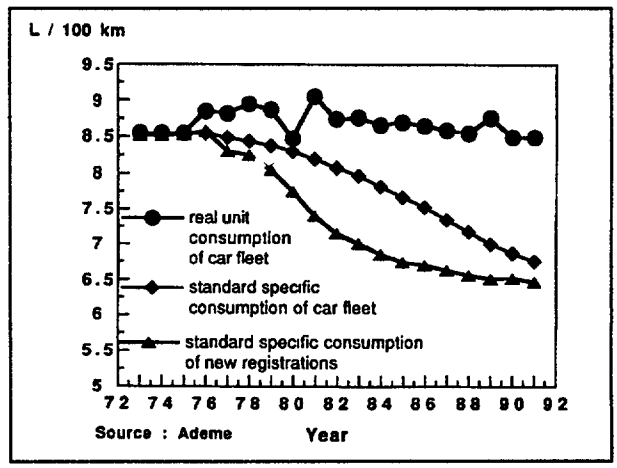

Figure 1. ***Evolution of the specific consumption for cars***

Actions on the existing fleet : towards road transport companies. In spite of diverse situation of road transport companies, to reduce the energy consumption, a similar approach was adopted : Accounting and analysis of the energy situation of the fleet ; implementation of adapted investments.

Taking into consideration these two steps and the differencied nature of the transport companies, three procedures were implemented of which two investment aid procedures. 1) Energy audits (800 were carried out, 50 % of the total study costs were subsidized), 2) companies contracts for companies consumming more than 300 toe/year. Subsidies warying in a range of 20 % to 50 %, were allowed for the completion of a global plan. 400 energy savings plans were implemented, reducing the energy consumption after plan completion of 15 % to 18 %, whith a reasonable energy saving pay-back times of 2 years and half.3) the equipment aid. Offering easier access to the small and medium size road transport indertakings, automatic subsidies were allocated from a selected list of energy saving equipments.

Actions on the existing fleet : toward car users. Actions were mainly made through information compaigns via driving sheet edited by the manufacturers and systematic information on standart consumption. Establishment of some 350 "diagnosis centers" for the control of carburation and ignition completed the programme.

5.3.3. The reorientation of the French policy (1987..)

Parrallely to the counter-oil shock, on the one hand, the french energy policy has been reoriented towards an increased liberalism, letting therefore the market forces to play more freely. It was traduced by drastic reduction of financial support to the users conducting to the forsaking of investment aid. Nevertheless, support to R & D was maintened at a significant level. The emergence of environmental issues and the single EEC market has also contributed to this necessarly reorientation. On the second hand, shown is figure 1, we constated that the technological gains were partly offseted by other phenomena particularly, the sliding of user behaviour. Three main strategic drives haves thus been identified :

- improvement of road vehicles and of the drive's behaviour, though far from being sufficient to revert the increasing trend of energy consumption in the transport sector, it is confirmed that such actions are necessarly and effective ; (programme fuel efficiency and friendly environmental vehicle, velvet touch programme...).

- improvement of traffic management and control, through measures such as traffic lights synchronization and crossroad tuning, guiding (programme CARMINAT and PROMETHEUS..).

- improvement of the attractivity of other modes of transport than personnal, in order to encourage the modal shift towards non road modes both for passenger and goods traffics (T.G.V. du futur, programme COMMUTOR)...

5.4. Energy savings assessment[1]

5.4.1. Global observation.

Between 1973 and 1991 the trend in the transport sector (+ 13,5 Mtoe) can be explained by an activity effect accounting for + 19,5 Mtoe, and a unit consumption effect of - 6 Mtoe. In other words, if the technical caracteristics of vehicles had remained unchanged since 1973, and if user behaviour had likewise stayed the same, transport energy consumption in France would have been higher by 19,5 Mtoe in 1991. It corresponds to the pressure exerted by demographic and economic growth alone. Technical and sociological factors of energy demand has conducted to reduce the consumption of 6 Mtoe.

This last factor is the result of three components. The first one covers technological improvements in vehicles (-11,3 Mtoe), corresponding to the fleet penetration of more energy efficiency vehicles resulting from research programmes. The second one expresses the influence of the distance - traveled on the unit consumption. It is here only assessed for cars and corresponds to a reduction of - 0,6 Mtoe. The third factor in the unit consumption effect covers non-savings (+ 5,9 Mtoe) due to changes in behaviour corresponding to a worsening of user practices (driving style, maintenance), of traffic conditions (more short trips, increased congestion), and companies' operating conditions (adaptation of fleets to economic conditions). It is noticiable that the worsening of user-behaviour has conducted to generate "non-saving", offsetting part of the technological gains.[2] Figure 2 shows the results.

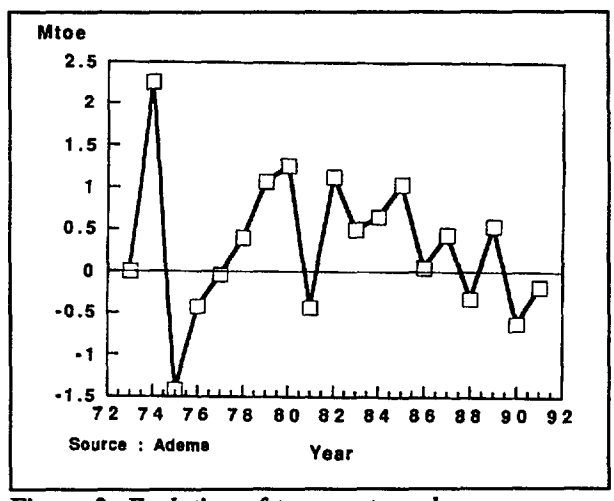

Figure 2. ***Evolution of transport yearly energy savings***

The evolution of annual incremental energy savings (Fig. 3) gives a better idea of the multiple phenomena

which over time reinforce or offset each other : technical progress, behavioural changes, substitutions of energy forms with vastly different user efficiency rates. It is necessarly to assess these phenomena correctly if our global evaluation of energy savings is to have operational and decision-marking value. How "durable" are these energy saving ? How do they affect untapped potential savings that technical know-how has made feasible ? How sensitive are they to prevailing economic conditions ? What temporal correlation can be established between programs in support of energy efficiency, and the results achieved ?

Analysis of the record of annual incremental energy savings yields two important general indications :

- high and very volatile short-term price sensitivity to variations in vehicle fuel prices (major but highly transient behavior-led savings).

- a general trend towards technology-led energy savings, clearly apparent in periods of price stability or erosion (1975 - 1979, 1985,1986-1987).

  (i) the 1974 price effect had been two-thirds canceled out by 1977.

  (ii) As early as 1986 a rising trend towards supplementary annual energy savings can be detected, largely corresponding to the readjustment of consumer demand towards less powerful and less fuel-consuming vehicles.

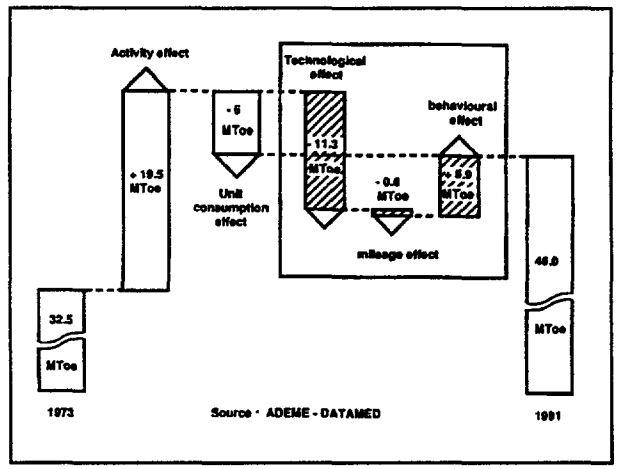

Figure 3. ***Explanatory factors of transport energy demand changes: 1973-1991***

(iii) This phenomenon was accentuated in 1979-1980, under pressure exerted by the second oil crisis (renewed price effect, new behavior-led savings), which was however weakened by rapid inflation.

(iv) The sharp drop in real fuel prices in 1981 (inflation once again) triggered a highly tangible reverse price effect (loss of behavior-led savings) which led to a net balance incremental energy savings close to zero, or even negative.

(v) After 1982 (excluding the oil countershock year of 1986) new technical energy savings appear year by year, as a result of progress in vehicle energy efficency acquired through R & D programs, and, for a while, due to the continued effect of the shift to vehicles in a lower power range. It should nonetheless be noted that the 1986 countershock clearly altered the trend towards technical progress ; this is essentially a manisfestation of the return to a race for higher-powered vehicles which had been subdued for several years. From 1986, the overall balance of fuel saving decreases, in real terms, under pressure from falling fuel prices show the irresistible increase of behavioral unsavings "eating" part of the technological gains. Figure 4 shows this phenomenum in dynamic.

5.4.2. Energy savings, breakdown by means of transport

Cars. Individual cars make up the largest category of means of transport in terms of energy consumption, with 21 Mtoe consumed in 1991 (47% of the total in 1991). From 1973 to 1991, the automobile fleet grew by 60 % ; if unit consumption had remained unchanged, fuel demand would have grown by 8,9 Mtoe. In the same times mileage changes have decreased the consumption of 0,6 Mtoe. This decrease is attributable at certain times to behavioral effects (price effect) which are later abandoned, but above all it is attributable to a significant shift in the structure of automobile use towards short-distance city trips (party linked to increases in two - (or more) (car households drive more, but cars drive less). The drop in average unit

consumption (- 1 Mtoe) can be explained by two main factors :

- a worsening trend in average conditions of car use, measured by the comparison between real specific fuel consumption per kilometer traveled and the theoretical figures given by automobile manufacturers. This degradation is the inevitable result of the increased weight of short (city) car trips : + 3.2 Mtoe.
- a steady improvement in specific vehicle consumption (that is to say, in energy efficiency), due to the shift in power range effect initially, and later due to technical progress made in all pwoer ranges: -4,4 Mtoe.

It can be seen that the light amount of energy saved reflect the fact that technological gains in vehicles have been offset by the worsening of conditions in which they are used. A prononced movement towards the use of diesel fuel in the automobile fleet can also be observed, starting in 1983. This switch to diesel fuel has several note worthy consequences : The move from gasoline to diesel fuel implicates primarily cars with high annual distances traveled ; the progressively rising proportion of diesel-fueled cars entails an automatic and simultaneous decrease in the average distance traveled by both gasoline - and diesel-powererd cars. The result is to slow down the growth in both gasoline and diesel fuel consumption, an effect which can be interpreted in terms of a "distance traveled effect" of a structural nature (and not behavioral). In the same way, by automatic effect, the shift to diesel fuel helps to increase the weight of short trips for both kinds of vehicles, therefore bringing down the average real efficiency and consequently pushing up gasoline and diesel fuel consumption.

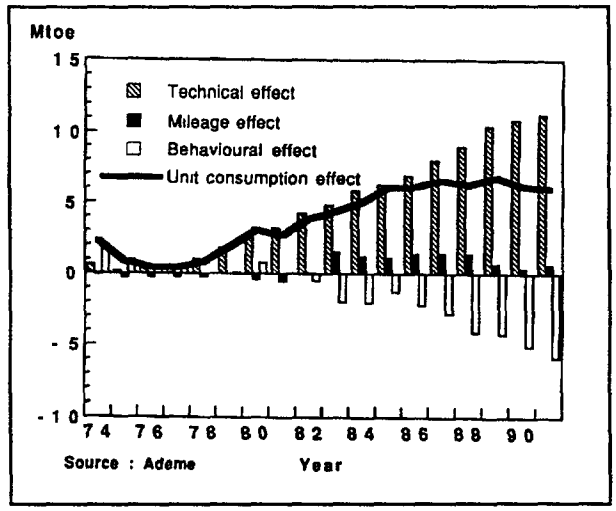

Figure 4. ***Evolution of unit consumption effect components***

Lastly, as diesel car has a higher average energy efficiency than gasoline-fueled cars, the shift to diesel contributes to falling average specific consumption in the automobile fleet. At least, the impact of shift to diesel cars on energy demand is impressive. It can be assessed to 5 Mtoe.

Utilitarian vehicles. With a consumption level of 14,6 Mtoe in 1991, utilitarian road vehicles (city buses, coaches, trucks, lihgt-trucks vehicles) represent the other large fraction of transport energy consumption (32 %). If fuel consumption levels for these vehicles had closely followed the growth in the number of vehicles, they would have risen by 7,3 Mtoe between 1973 and 1991. The difference between this extrapolation and the actual observed trends (1,3 Mtoe) is dues to the drop in unit, consumption levels of all vehicles types of which -3,1 Mtoe are due to technological improvments. This fall in unit consumption is caused by three prime forces :

- variation in annual use modes, corresponding to modification of vehicle management practices (more or less distance traveled for the same service rendered).
- more or less efficient driving practices (temporary behavior effect).
- technical improvements to vehicles.

Taking behavioral effects into consideration, energy savings of a technical nature in the utilitarian vehicle fleet can be estimated at 2,8 Mtoe for 1991.

6. CONCLUSION

The technico-economic approach is a powerfull tool for analysing the respective contribution of the explanatory factors of transport energy demand changes. It allows us to interprete the energy policy impact. From such evaluation covering 17 years of french experience, on energy conservation, the followings findings can be drawn :

- It is possible to save energy in the sector. A considerable amount has been saved (6 Mtoe) in 17 years.

- Princing policy is not sufficient to reduce energy consumption. A volontarist energy conservation programme is necessary.

- The important role of an institutional framework aimed at beeing a pole of reflexion and designing procedures has been put in evidence.

- Actions are more and more often multricriteria, and their nature must be various covering all modes and vehicles types.

- Technical improvment and investment policy have been the key components of a durable effect on consumption. Nevertheless, from the recent past, its prevails that technological improvments, have been partly offset by the worsening of user behaviour, particularly visible after the counter-oil shock. Market forces seem not sufficient themselves to control the energy demand evolution. From this statment, Ademe is lauching an energy conservation and enviromental programme where support to transport demand control, action towards user's behaviour and urban planning become primordial.

It is possible to organize action in favour of a more energy efficient and less polluting transport sector according to the main following axes :

- The evolution of the organisation, planning and managment of cities in order to control the urban mobility must be supported. It concerns issues such as management of public space scarcity (traffic regulation, street sharing, tarification), the attractivity of public transports, urban freight transport (distribution and collection), and interaction urban planning /transport demand/transport system.

- Concerning interurban freight transport, to refrain the road traffic leardership due to the under estimation of real cost in transport pricing. The developments of performant alternative technics (combined transport, roll of roll on train) and the application of the polluter's -payor's principle to the freighters related to their modal choice will be the basis of the action.

- To encourage diversification of energy forms in transport in order to reduce the oil dependence. The possibilities offered by the three fuel cycles, electricity, bio-fuels, gaz, from the sources avaibility view point, the adapted technics, the impact on the economical and ecological balances must be developped.

- The development of the technologies to be put on the market, fuel efficiency and friendly environmental vehicles must be pursuing. The real use of personal vehicles must be taken into account by manufacturers.

- Actions on user's behaviour must be developped. It concerns informations issues towards different concerned targets, driving trainning and education which are the privilegied means to stabilize efficient behaviour on a long term basis.

ENDNOTES

1. Results come from DATAMED, a technico-economic database of ADEME, developped by ENERDATA S.A. using SPIDIAL Software.

2. Since, comparison between californian context and europeen context has to be made with cautions, it would be interesting to compare behavioural aspects of study findings from studies of californian Clean Air Act initiatives. (e.g. : Cameron w 1991 "Transportation efficiency : Southern californian Air Pollution and Congestion" : Regional Institute of Southern California).

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