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MUTUAL INFLUENCE OF INNOVATIVE CHOICES MADE BY INDUSTRIALISTS (CASE STUDY OF THE DIESEL TECHNOLOGY) AND COMMUNITY ENVIRONMENTAL STANDARDS

Our paper is focussing on the diffusion of the diesel technology and the way it was sustained by the Community environmental legislation. How can we analyse the mutual shaping of the aspiration towards cleaner cars (implemented by Community environmental standards) and the general trend in Europe in favour of the diesel technology? We study the collective elaboration of the environmental standards in the framework of the European Union over the long term. This seems to us an illuminative case of a collective choice which is gaining ground in countries which were reticent at the beginning (in Europe and outside, for instance the United States) and relies on societal expectations (a society which is not always sufficiently and fully informed), interests of car makers and gasoline industry, and public action (in particular through fiscal tools). Consequently, we would like to examine carefully this trend towards dieselisation in France, and more broadly in Europe (while connecting it with other International strategic choices for the transport sector, in particular in the United States and Japan), and highlight the interaction between public authorities – in particular the national states and the European Commission – and automakers and gasoline industry (especially through regulatory and fiscal tools considering economy, public health and defence of the environment issues).

The stakes are to place road transport in the framework of a sustainable development. Some tools appear very efficient for reaching this goal, in particular innovations and technological improvements for motorisation systems.

I - Context

Since 1960s, the impression is gaining ground in the United States and in European countries of a deterioration of the environment and a waste of natural and non renewable resources. The sensibility towards nuisances is getting stronger. Car makers, in particular, are

largely considered as responsible of the atmospheric pollution. In this framework, Community environmental standards aim at producing cleaner cars, less noisy cars, and cars more easy to recycle (end-of-life Community regulation). Since 1973, pollution and consumption issues became essential in Europe in the context of the petrol crises. Difficulties for obtaining petrol and price increases highlighted the necessity for a rationale transport policy: priority is given to consumption reduction and reflections about less polluting vehicles. But choices are not easy to make. Less polluting vehicles are more expensive to build and can see their petrol consumption deeply rise. Consequently, efforts for reducing exhaust emissions can go against efforts for reducing petrol consumption. For instance, it is generally admitted that the adoption of catalytic converters implies a rise of petrol consumption of about 15%.

II – Generalisation of diesel vehicles

In parallel, since the beginning of the 1970s, it exists a general trend in Europe towards the generalization of diesel vehicles for trucks as well as, what is really new, for personal vehicles.

A/ Trucks and light commercial vehicles

For trucks, the European situation is very simple since the dieselisation is total. Historically, the choice of the diesel technology has made road transport competitive compared to rail transport. For trucks, the choice of this technology began at the beginning of XXth century and its use is now general. How this evolution did occur? Diesel engine was a German invention. It was diffusing among some French truck makers during the 1930s: Peugeot produced engines under a Junkers license in Lille since 1928 and Renault, Panhard, Berliet (initially) made trucks with a Bosch injection. But sometimes the French are inspired by technical improvements made on the engine conception by an Englishman, Ricardo. Nevertheless, the technological advance of German truck makers, in particular Daimler-Benz and MAN Nutfahrzeuge, seemed very strong despite the quick improvements of their French counterparts[1].

Technical innovations from the end of the 1920s to the beginning of the 1930s (diesel engine, tires) allow trucks competing on long distances with rail. (…) The conjunction of a long economical crisis and a policy of coordination of rail and road, developed since April 1934, destroyed a promising rise and implemented new rules of the game: the State

[1] Patrick Fridenson, « Les relations entre les industries automobiles françaises et allemandes des années 1880 aux années 1960 », Yves Cohen und Klaus Manfrass (ed.), *Frankreich und Deutschland. Forschung, Technologie und industrielle Entwicklung im 19. und 20. Jahrhundert*, München, 1990.

intervention tried to limit competitions between different modes of transport through a Malthusian legislation which aimed at penalizing truck development[2].

For several decades, road traffic of exchange of goods by trucks is increasing rapidly. This activity increased from 800 billion tons/km in 1985 to 1500 billion tons/km in 2004. At the beginning of 2000s, trucks represented more than two-thirds of Diesel road consumption in Europe.

Light commercial vehicles (under 3,5 tons) represented 20 million units in 2003 (at the same period, personal vehicles reached 190 million units). 60% of these vehicles were equipped with a diesel motorisation.

B/ Personal vehicles

Since the beginning of the 1970s, a trend, for which France is well present, took shape in Europe towards a generalization of diesel technology for personal vehicles. Diesel vehicles represented 15% of European personal vehicles in 1985, 32% in 2000. In 2003, they represented 45%. In 2006, one European vehicle produced out of two vehicles was a diesel one, a part which more than doubled over the last ten years. The success of the diesel technology in Europe is sustained by technological improvements and more specifically by the direct injection “common rail” or particle filters. These efforts are made by car makers for limiting pollution of diesel and rise performances of the engine.

Is it a French specificity? If this country became since 1987 the first world market of diesel vehicle producers, we have to highlight the fact that other European producers, i.e. German and Italian, used to be in a strong position on this market. Nevertheless, the production of diesel vehicles in these countries began to be reduced since 1985-86. This was mainly due to a strengthening of taxation on diesel vehicles. This change in orientation of public strategy in Germany and Italy stimulates several questions: why did this change occur? Is it a European orientation? Why did French authorities remain outside this movement?

The dieselisation is a characteristic of the European market of personal vehicles, but is differentiated from one country to another. Several reasons could explain this disparity: fiscal situations, on fuel as well as on vehicles, different and not linear; but also, differentiated perceptions of environmental performances of the diesel technology. (Cf. particles)

In 1992, France was the first market in the world for diesel personal vehicles. Diesel demand reached 39% of the entire national market. Even more significant, the production of

[2] Jean-François Grevet, Au cœur de la révolution automobile : l’industrie du poids lourd du plan Pons au regroupement Berliet-Saviem. Marchés, industries et Etat en France 1944-1974, PhD defended in Lille on 13 December 2005, p. 27.

diesel personal vehicles was 991 000 units. This amount represented 30% of French production. It was still rising (from 22%). This trend was the result of the explosion of a foreign demand for this kind of vehicles. Diesel vehicles' exports rose from 78%. This kind of motorization was more and more considered as convenient by consumers, in terms of prices, solidity and quality. Reciprocally, automakers realized that it was important for them to be present on this market. Therefore, meanwhile in 1970 Peugeot was the only brand which proposed diesel vehicles; every brand was present on this market less than fifteen years later. For a long time, this movement concerned the most expensive vehicles, but it generalized afterwards to the whole range of production. Additionally, the diesel technology benefited from a price gap between fuel and diesel and from a favourable tax (for the "vignette", the French annual tax on the use of vehicles from 1956 to 2001, and the "carte grise", the administrative document issued when the vehicle is bought). Then, the diesel proportion of the automobile market in France was reduced (40%) on 1996-1998. This movement can be explained by a campaign on polluting aspects of the diesel technology and the possible change of the favourable tax on diesel. But since 2000, the sales of diesel vehicles rose steep again from 50% to 70% (in particular thanks to the particles filter developed by PSA Peugeot Citroën).

For other European recent trends are the following:

Spain: explosion of the diesel market with a rate progressing from 16,6% in 1992 to more than 60% in 2004.

Italy: Diesel vehicles sales are increasing (22% in 1998) after the definitive suppression of the "Super Bollo", the tax on diesel vehicles. The market represented 34% of all vehicles sales in 2000 and more than 50% in 2004.

Germany: After a stabile period around 16-17% during the 1990s, the first part of the 2000s shows an increase of the diesel market with a penetration superior to 40% in 2004.

Dieselisation rate in European markets from 1985 to 2004 (% of personal vehicles' registrations)

	1985	1990	1995	1999	2000	2001	2002	2003	2004
France	15	33	46,5	44,1	49	56,2	63,2	67,4	70
Germany	22,1	9,8	14,6	22,4	30,3	34,5	37,9	39,9	43
Italy	25,1	7,8	10,3	29,4	33,6	36,5	43,5	48,7	51
Spain	21,7	14,2	33	50,6	53,1	52,5	57,3	60,9	62
UK	3,6	6,4	20,2	13,8	14,1	17,8	23,5	27,3	29

Europe (17 countries)	15,6	13,9	22,1	28,4	32,1	36	40,3	43,7	46

Source: CCFA

The evolution of road fuels in Europe followed the same pattern. In 1985, the consumption in occidental Europe reached 180 Mt (60% for fuel and 40% for diesel). In 2004, the consumption reached 270 Mt with an inversion of trend (60% for diesel and 40% for fuel)[3]. This increase of diesel consumption during the two last decades aggravated the misbalance of fuel supply in Europe. Fuel exports could reach 40 million tons in 2010; meanwhile diesel imports could reach 30 to 40 million tons in 2010[4].

III – Articulation of the Community public policy and the choices made by market players

How can we articulate this trend in favour of diesel vehicles with the general aspiration in Europe towards clean cars? Until recently, diesel vehicles had a very bad image of polluters even if they were considered as more economical to use than their gasoline counterparts. Now, diesel production is considered as the best answer in the transport sector to the danger of climate change. Indeed, it is usually presented as fitting actual stakes of automobile sustainable development, in terms of local pollution[5] as well as CO^2 emissions. Therefore we can develop the hypothesis that this infatuation for diesel vehicles, which can be characterized as a European specificity, could be connected with their new image, more environment-friendly, communicated by media and car producers. But does this new image correspond with a reality?

If it is the case, how were these great improvements achieved by automakers over a few decades? Why did they attribute so many funds to researches on the improvement of exhaust emissions of their vehicles? Is it a new strategy of automakers or an efficient synergy with other actors (public authorities, gasoline industry, etc.)?

If this new image corresponds only partially to reality, how did the supporters of this technology succeed in offering an improved image?

[3] Bernard Bensäid, Les carburants routiers en Europe : l'explosion de la demande en gazole, Institut français du pétrole, Panorama 2005.

[4] Michel Bénézit (General Director Refining/Marketing, Total), "Les biocarburants chez Total", IFP Panorama, 1st February 2007.

[5] Local pollution concerns CO, HC, NOx, particles, O 3 pollutants, meanwhile global pollution is exhaust emissions with greenhouse effects.

Could not we insist on the risk through this infatuation for the diesel technology to put apart at first sight all other technological choices for automobiles which could be environment friendly (would it be hybrid motors, hydrogen motor, biofuels for transport, and so on) for consumers as well as for research ?

The convergence between the generalization of diesel vehicles and technological improvements made by automakers in favour of this technology relied in particular on a long-term postponement of Community legislation on diesel vehicles and a focus on exhaust emissions for a long time (a Community legislation on particles came much later).

A/ Diesel vehicles out of the field of Community legislation during initial negotiations

European Community was attached, since 1970, in reducing the pollution of motor vehicles in Europe. In this perspective, it has made some proposals whose aim was to reduce noise, gas substances, smokes and particles and was preparing another proposal whose aim was to introduce speed limits. Nevertheless, Community preoccupations in terms of environment are not rapidly transferred into legal requirements. Until 1986, the directive concerning the noise provoked by engines is the only text to be implemented (in 1970). The directive concerning exhaust emissions and lead in gasoline, on which the Council has had some difficulties to reach an agreement, was not adopted formally, because of the Danish opposition. Denmark was in favour of the adoption of stricter standards. Nevertheless, other member countries already applied the orientations of the directive and automobile manufacturers prepared the engine production which fit the standards implemented by the European Commission. During all these years, diesel vehicles were not addressed by Community regulation, through representing a growing part of European automobiles.

Nevertheless, future diesel vehicles' standards were being discussed. The German government wanted first to introduce American standards of 1983 for diesel vehicles. Later on, it rapidly considered implementing American standards of 1987 (particles emissions) which would have raised various problems, notably a rise of vehicle prices. German car makers asked their government to keep the 1983 standards, pointing out the fact that these standards do not have any connections with the problems encountered by the German forests damaged, which was the focus point of German authorities at that time.

Finally, Community decisions put an end to discussions which were acute for many months on clean cars. On 27 June 1985, the "Luxembourg Agreement" concerning European standards for reduction of exhaust emissions was signed. It foresaw two different steps: the

application of the first step led to a sensitive reduction of exhaust emissions compared to 1977. While applying a new reduction of 15% for small cars, the second step (foreseen for 1992/1993) aimed allowing European countries to reach an air quality similar to that of the United States as far as automobile exhaust emissions were concerned. This agreement was put in question as soon as in March 1989 by Italian Commissioner for Environment, Carlo Ripa di Meana (i.e. before the implementation of these measures). The Commissioner announced the adoption of stronger standards due to a growing sensibility of the European population to environmental issues. First of all, European standards (30 grams of carbon monoxide and 8 grams of nitrogen oxide) would be compulsory for all vehicles circulating in the Community, as soon as 1 January 1991. Then the Commission proposed that less than two years later, member countries would have to impose to European car makers the respect of "stricter" standards (i.e. between 19 and 21 grams of carbon monoxide by test and between 4.8 and 5.2 grams of non-burnt hydrocarbon and nitrogen oxide). These new standards would then be close from American standards 83 (20 grams of carbon and 5 grams of nitrogen). The European Commission wanted to go faster than the European Parliament which was on the point of rejecting European standards proposed in the Luxembourg Agreement, invoking the defence of the clearness of the atmosphere.

Finally, in June 1988, a document has been signed for diesel cars standards. Dispositions foresee the limitation of particles' emissions in exhaust emissions to 1.1 gram by test for new cars since October 1990 and to 1.4 gram by test for new cars (old models). This agreement has been signed without any difficulties.

B/ An original focus on exhaust emissions favoured the diesel technology

First attempts of various European countries during the last five years in favour of the implementation of clean vehicles did not reach their target. In most cases, the impact of national aids dealing with GPL or electrical vehicles was not high enough for orienting consumers' choice. Considering this result, governments decided to modify their approach. Their new aim was not anymore to raise the rate of penetration of clean vehicles, but rather to low the level of exhaust emissions. The EU aimed for 2008-2012 a reduction of exhaust emissions of 8% below the levels of 1990.

The implementation of ever stricter and ambitious European standards on exhaust emissions (Euro4 in 2005, then Euro5 in 2008) benefited to diesel vehicles, and in particular to those of them equipped with particle filters, whose CO2 emissions were inferior to fuel

vehicles[6]. Indeed, the development of the diesel technology for personal vehicles was an answer to the objectives of exhaust emissions of European car makers on their whole range of products (140 g CO2/km in 2008). The consumption and CO2 emissions of a diesel engine equipped with indirect injection are 30% below their non-diesel counterparts. The emissions of particles, which are produced only by diesel vehicles, and which are considered as a real danger for public health (in particular in the United States, which can explain a relative low level of implementation of diesel vehicles on the US market), were not considered until recently by Community legislation.

Following the regulatory framework, car makers realise great improvements in this field. Particle filters, first realized by PSA Peugeot Citroën[7], began to tackle this problem. Particle filters are efficient on any kind of particles whatever their size. This equipment implies a direct injection for the engine, or HDI (High Pressure Direct Injection). Coupled with the implementation of a turbo, this kind of engine allows also the reduction of the consumption by 20%, which raises the interest of diesel engine for the struggle against exhaust emissions. In 2006, PSA reached 140 g CO2/km (minus 5 grams compared to 2005) and Renault 144 g CO2/km. France is among the more performing European countries in this respect. In 2005, Citroën counted 144 g CO2/km, Renault 149 g CO2/km and Peugeot 151 g CO2/km ranged second, third and fifth on a European level. These good results are primarily due to the fact that their range of products counts small diesel vehicles with good CO2 emissions with some vehicles meeting a real commercial success (Citroën C1, C2, C3, Peugeot 107, 207, Renault Clio and Modus). On a more global scale, the European average of CO2 emissions was lowered from 25 g/km in ten years. South European countries realised the best results. There are also countries where traditionally the automobile market is oriented towards small vehicles and diesel vehicles. On the contrary, northern European countries have principally big non-diesel vehicles[8].

Nevertheless, it may be difficult to reach a valuable reduction of exhaust emissions on a short term because of the weights of vehicles and of new options proposed like air conditioning on cars which implies an increase of diesel consumption. According to a prospective study made by the European Commission in January 2003 untitled “European Energy and Transport Trends to 2030”, global consumption of personal vehicles in the EU may remain stable until 2030.

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[6] “Evolution des politiques publiques de soutien aux véhicules propres”, DREE, Revue Stratégies, n°41, June-July 2004.
[7] Later on, particle filters were also adopted by Audi, BMW, Mercedes, Opel, Toyota and Volkswagen.
[8] 15 May 2007, Press Release, “Emissions de CO2 des voitures, les avancées 2007”, ADEME.

Perspectives concerning particles emissions appear clearer. According to a study realised by the French ministry of Equipment, diesel particles emissions of personal vehicles reached a high point in the mid-1990s. The growing severity of emission standards would largely compensate the rise of proportion of diesel vehicles in new registrations. Therefore, from 2000 to 2020, particles emissions for diesel vehicles would be divided by five.

In search of a low CO2 emissions level, car makers worked much on the efficiency of their engines, notably diesel ones. We have to notice that improvements on diesel carburetion were most important and numerous than on non-diesel carburetion. But, in consequence, car makers had to face a raise of nitrogen oxides emissions. The reinforcement of requirements for pollutant emissions implies some adaptations of engine carburetion which can lead to a raise of CO2 emissions. Until recently improvements on engines have allowed hindering this phenomenon. The implementation of Euro4 on 1st January 2006 has implied a slight deterioration of the engine carburetion of previous Euro3 models in order to fit the reduction by two of nitrogen oxides emissions. This is more noticeable on diesel than on non-diesel vehicles. Additionally the requirement of division by two of particles emissions in the framework of this standard has lead some car makers to equip some of their models with particles filters, which can also amplify the rise of CO2 emissions. Diesel vehicles equipped with particles filters met a noticeable increase (26% of models and 23% of sales in 2006, compared to 10% and 17% respectively in 2005). The future adoption of Euro6 may produce similar results.

The continuous policy of Community public authorities in the last years aiming at the reduction of road vehicles exhaust emissions – carbon monoxide, non-burnt hydrocarbons, and more recently nitrogen oxides and particles – implied a reinforcement of technical specifications on fuels. The reduction of sulphur levels in diesel is one of the most recent measures taken by the European Commission in this field. A generalization of diesel without sulphur could allow the implementation of “DeNOx” catalyses equipment on vehicles, which would allow the suppression of nitrogen oxide emissions.

In front of the strong development of road traffic for passengers as well as goods, the EU tries to promote alternative fuels, and more specifically biofuels. In the Green Paper of the European Commission “Towards a European strategy for the security of energy supply” (2001), it was foreseen to replace 20% of fuels by fuels of substitution by 2020. There are mainly biofuels, natural gas and hydrogen. The mixture of biofuels in fuels in Europe began in the 1980s with the adoption of the directive on oxygenated components (1987). It was

authorized to introduce 5% of ethanol and 15% of ETBE in fuels. The use of biodiesel is more recent. In France it is only authorized until 5% of EMHV in diesel.

Evolution of quality standards of products in Europe from 1996 to 2009

	1996	2000	2005	2009
Fuel				
Sulphur max	500 ppm	150 ppm	50 ppm	10 ppm
Benzene max	5%	1%	1%	?
Aromatics max	n.d.	42%	35%	?
Olefin max	n.d.	18%	18%	?
Diesel				
Sulphur max	500 ppm	350 ppm	50 ppm	10 ppm
Cetane[9] min	49	51	51	?
PAH (Polycyclic Aromatic Hydrocarbons)	n.d.	11%	11%	?
Density max	860	845	845	?

Source: IFP

IV – Concluding remarks

On this case study, there is an interesting convergence of actions from car and truck manufacturers and public authorities in favour of the diesel technology. Regulation and fiscal measures allowed this technological choice or even favoured it. Meanwhile car and truck manufacturers realized some great improvements on this technology. It resulted in a real advance of this technology on exhaust emissions. Consumers were growingly interested, not really because of environmental improvements of this technology, but rather because of additional advantages. The great increase of sales which followed was a further encouragement for car and truck manufacturers for developing this technology still a bit further.

[9] Cetane rates measure the aptitude to self-inflammation.