COMPARATIVE MONITORING OF A 100% BIOFUEL-FIRED BUS AND A DIESEL BUS IN THE CITY OF VITORIA

(Old title: MONITORING OF 100% BIOFUEL-FIRED BUSES IN THE CITY OF VITORIA)

(Altener Contract No. XVII/4. 1030/93-05)

Summary report

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1.- INTRODUCTION

The project which forms the subject of this report was presented to the ALTENER programme of the EU in 1993, and was proposed by three different organisms: *Ente Vasco de la Energía (EVE)*, the organization responsible for the implementation of the energy policy of the Basque Government; the *Vitoria-Gasteiz City Council* (the Town Planning and Environmental Department and the Vitoria Municipal Urban Transport Company (TUVISA)); and *Biocombustibles Vascos S.A (BIVA)*, a Basque Country based company which manufactures biofuel.

The immediate objective of the project was to evaluate the performance of urban transport buses using rapeseed oil-based biofuel as fuel. Various aspects of the performance of the buses were monitored (energy consumption, gas emission, engine performance, noise and bus driver and users' reaction), and the resulting series of data taken from two practically identical buses operating on the same city route was analyzed. One of the buses was run on 100% conventional gas-oil whilst the other was run on 100% rapeseed biofuel.

2.- VEHICLES USED AND SELECTED

The performance of the buses was evaluated over a period of 13 months

Two brand new Mercedes-Benz buses were chosen to participate in the project.

Both vehicles covered the number 9 bus route (Armentia-Errakaleor) of the TUVISA Transport Company.

The conditions imposed by MERCEDES-BENZ to maintain the warranty on the biofuel-fired bus were met, namely to replace the existing fuel pipes with others resistant to RME (rapeseed methylester), to change the lubricating oil more frequently, and to comply with EC proposed specifications on fuel.

2.- FUEL: CONSUMPTION AND SUPPLY

The Biocombustibles Vascos S.A. (BIVA) company supplied for the project 39,000 litres of rapeseed methylester in six separate lots.

The fuel consumption rate of the buses is in the order of 50 l/100 km. The biofuel-fired bus consumes an average of 49 l/100 km, whilst the gas-oil bus consumes around 47 l/100 km, approximately 4% less.

3.- GAS EMISSION

The gas emission levels of the two buses are much the same, the balance slightly favouring biofuel with respect to regulated contaminants. However, it is important to emphasize the fact that the use of biofuel does not produce SO_2 emissions, though it does conversely produce higher atmospheric emission concentration levels of some non-regulated compounds.

Two types of on-road measurements were carried out; on an urban circuit of the city of Vitoria-Gasteiz covering the number 9 bus route (Armentia-Errekaleor), and on the Vitoria - Bilbao - Vitoria motorway trip.

For on-road measuring, CO, CO_2, NO_x, HC & SO_2 emissions were measured in g/km, whilst organic compounds emitted in gas or particle form were measured in mg/km.

Measurements were also taken on a roller-bed test site. In this case, the following simplified 6 mode cycle was used as the nearest and best possible alternative to the 13 mode European cycle: tick-over, 50% maximum power at 1,400 r.p.m., 100% maximum power at 1,400 r.p.m., tick-over, 50% maximum power at 2,100 r.p.m., and 100% maximum power at 2,100 r.p.m..

At the roller-bed test-site, CO, CO_2, NO_x, HC & SO_2 emissions were measured in g/kWh.

3.1. CO, CO_2, NO_x, HC & SO_2 EMISSIONS

Measurements taken on the motorway and on the urban circuit have shown a high repetition factor. The results obtained from both the biofuel bus and the gas-oil bus show the same trend on the motorway as on the urban circuit.

URBAN CIRCUIT	SPEED km/h	CONSUMPTION g/km	HC g/km	CO g/km	NO_x g/km	CO_2 g/km	SO_2 g/km
Biofuel	18.7	358	0.25	2.7	20.0	981	-
Gas-oil	18.6	318	0.29	3.1	24.7	1012	1.1

MOTORWAY VI-BI	SPEED km/h	CONSUMPTION g/km	HC g/km	CO g/km	NO_x g/km	CO_2 g/km	SO_2 g/km
Biofuel	62.8	248	0.44	3.7	11.7	685	-
Gas-oil	60.7	227	0.40	4.1	12.4	723	0.8

MOTORWAY BI-VI (*)	SPEED km/h	CONSUMPTION g/km	HC g/km	CO g/km	NO_x g/km	CO_2 g/km	SO_2 g/km
Biofuel	60.6	310	0.12	1.1	18.1	854	-
Gas-oil	62.2	284	0.16	2.0	18.7	902	0.9

(*) Upnill journey

The roller-bed testing sessions showed an unexpectedly and excessively high variation of results. This would seem to indicate a malfunctioning of the roller-bed itself, and therefore no conclusions have been drawn from these tests.

ROLLER BED BIOFUELE	POWER (kW)	CONSUMPTION g/kWh	HC g/kWh	CO g/kWh	NO_x g/kWh
Session 1	45.32	408	0.73	6.7	24.3
Session 2	45.44	462	0.05	1.8	24.5
Session 3	47.78	339	0.06	1.6	21.7
Session 4	--	-	-	-	-

ROLLER BED GAS-OIL	POWER (kW)	CONSUMPTION g/kWh	HC g/kWh	CO g/kWh	NO_x g/kWh
Session 1	49.4	423	0.09	4.1	30.0
Session 2	53.55	356	0.11	4.2	27.3
Session 3	49.4	302	0.11	3.2	18.8
Session 4		-	-	-	-

3.2. ORGANIC COMPOUND EMISSIONS

Measurements were taken on the urban circuit bus route.

It can be deduced from the results obtained that the use of biofuel reduces the level of atmospheric emission of solid particles, toluene and ethylbenzene and xylene, but produces a higher level of benzene and formaldehyde emission. PAH emission levels seem higher when biofuel is used.

4.- LUBRICATING OIL

The lubricating oil used in both vehicles has been CESPA Turbo SHPD 15W40.

Preventive analysis was carried out periodically on both vehicles to determine the optimum time to change the oil.

The viscosity of the oil in the biofuel bus decreases at a faster rate than in the case of the gas-oil bus. After 12,000 km, the oil in the biofuel bus shows a viscosity level which warrants a change of oil, whereas this oil change is only seen as necessary in the gas-oil bus after 21,000 km.

With respect to the concentration of metallic particles in the lubricating oil, the levels of aluminium (Al), chrome (Cr), nickel (Ni) and vanadium (V) remain practically constant in the oil in both buses. It can also be seen that the concentration levels of lead (Pb) and silicon (Si) are subject to very little variation; no clear tendency is observed. With respect to the level of tin (Sn), after the first oil change in the biofuel bus, the trend of an increase in the concentration level was not confirmed, and the level remained practically constant. The concentration of copper (Cu) is more or less constant at the beginning but begins to increase as the oil gets older. The level of iron (Fe) increases progressively in the oil in both buses, although greater concentration levels are observed in the oil of the gas-oil bus.

5.- ENGINE PERFORMANCE

Two boroscopic inspections were carried out on the engines of both buses participating in the experiment. In the light of the results, it can be deduced that the gas-oil engine produces a superior combustion (less and more uniform type deposits).

The engine of the biofuel bus was inspected at the end of the experiment. The corresponding report showed that the engine had not been significantly affected by the use of biofuel.

6.- NOISE

The results obtained show that there are no appreciable differences between the biofuel bus and the gas-oil bus. The noise level is in the order of 80 dB.

7.- BUS DRIVER AND PUBLIC REACTION

Both the bus drivers and the users of the service have expressed opinions clearly in favour of this experiment and, in general terms, in favour of using alternative fuels in place of conventional fuels.

8.- CONCLUSIONS

The organizations and companies which have participated in this project consider the experiment to be positive in that it has contributed to the promotion of the use of renewable energy in the transport sector, an area in which the consumption of oil derivatives represents practically 99% of total energy consumption. The following conclusions have been drawn:

1. The use of rapeseed biofuel represents no significant differences in performance when compared to the use of conventional gas-oil;

2. From a technical and environmental viewpoint, no disadvantages have been observed in the use of rapeseed biofuel for a fleet of public transport vehicles. Perhaps the only drawback is the price of the fuel; the pre-tax price is almost double what transport companies pay for gas-oil.