The Environmental Impact Of Reduced Fuel Consumption In Road Vehicles.

Presented by Ogab®

Table of Contents

1. Road transport fuel consumption

Fuel is consumed by a vehicle's engine as it travels on the road, with engine power output contributing to five primary factors: Drivetrain, Inertia/braking/grade, Rolling resistance, Auxiliary loads and Aerodynamics losses.

In an urban environment the power dissipated through acceleration and braking of the vehicle is the dominant loss, whereas on the highway the aerodynamic losses are dominant.

In this section the fuel consumption and its impact of various vehicles is analysed. In the next table the assumed fuel consumption is presented per type of vehicle.

Table 1 Fuel consumption per year and vehicle lifespan of various road vehicles. Source: Ministerio de Fomento, 2017

Type of vehicle	Yearly km considered	Vehicle lifespan (total km)	Average vehicle fuel consumption (litres/100 km)	Annual fuel consumption (litres)	Vehicle lifespan fuel consumption (litres)
Lorry. Articulated lorry	120,000	1,200,000	38.5	46,200	462,000
Lorry. 3 axle truck	95,000	950,000	30	28,500	285,000
Lorry. 3 axle truck	90,000	900,000	26	23,400	234,000
Average lorry	**101,667**	**1,016,667**	**31.5**	**32,025**	**320,250**
Van	50,000	400,000	12	6,000	48,000
Car	-	240,000	7	-	16,800

The related environmental impacts of current average fuel consumption per vehicle is presented below.

Table 2 Environmental impacts of fuel consumption (fuel production and combustion) during each vehicle lifespan.

Environmental impact category	Units	One vehicle lifespan		
		Average lorry	Van	Car
Climate change	kg CO_2 eq	982,882	145,467	49,874
Stratospheric ozone depletion	Kg CFC11 eq	0.53	0.09	0.02
Ionizing radiation	kBq Co-60 eq	7,279	1,062	366
Ozone formation, human health	kg NOx eq	4,665	683	91
Fine particulate matter formation	kg $PM_{2.5}$ eq	914	183	33
Ozone formation, terrestrial ecosystems	kg NOx eq	4,709	701	94
Terrestrial acidification	kg SO_2 eq	2,698	405	89
Freshwater eutrophication	kg P eq	1.05	0.17	0.07
Terrestrial ecotoxicity	kg 1.4-DBC e	228,091	512,409	38,666
Freshwater ecotoxicity	kg 1.4-DBC e	292	73	15
Marine ecotoxicity	kg 1.4-DBC e	579	330	41
Human carcinogenic toxicity	kg 1.4-DBC e	740	919	36
Human non-carcinogenic toxicity	kg 1.4-DBC e	39,415	4,979	1,977
Land use	m^2a crop eq	499	58	33
Mineral resources scarcity	kg Cu eq	7.0	2.6	1.9
Fossil resource scarcity	kg oil eq	327,199	48,507	16,485
Water consumption	m^3	1,438	211	75
Cumulative energy demand	MJ	14,195,199	2,100,882	716,678

For the worldwide vehicle fleet, 947 million cars, 279 million vans and 56 million lorries, the results for the carbon footprint and energy demand is shown.

Table 3 Carbon footprint and energy demand during worldwide vehicles lifespan.

Impact category	Units per type of vehicle worldwide	Lorries	Vans	Cars
Climate change	tons CO_2eq	54,632,799,006	40,673,327,063	47,234,240,002
Cumulative energy demand	MWh	219,174,945,635	163,171,808,963	188,542,095,383

2. Aerodynamic drag reduction benefits

With the proposed vehicle aerodynamic drag reduction solution, with 40.98% improvement on drag coefficient, it is possible to reduce 20.49% fuel consumption. So:

- 65,619 litres of diesel can be saved during a lorry service life
- 9,835 litres of fuel can be saved during a van lifespan
- 3,442 litres of fuel can be saved during a car service life

This potential fuel consumption reduction can be translated into emissions savings. In the following table, the potential impacts saved are presented:

Table 4 Environmental impacts saved due to 20.49% fuel reduction during each vehicle lifespan.

Environmental impact category	Units	One vehicle lifespan savings due to 20.49% fuel reduction		
		Average lorry	Van	Car
Climate change	kg CO_2 eq	201,393	29,806	10,219
Stratospheric ozone depletion	Kg CFC11 eq	0.11	0.018	0.005
Ionizing radiation	kBq Co-60 eq	1,492	218	75
Ozone formation, human health	kg NOx eq	956	140	19
Fine particulate matter formation	kg $PM_{2.5}$ eq	187	38	7
Ozone formation, terrestrial ecosystems	kg NOx eq	965	144	19
Terrestrial acidification	kg SO_2 eq	553	83	18
Freshwater eutrophication	kg P eq	0.21	0.036	0.015
Terrestrial ecotoxicity	kg 1.4-DBC e	46,736	104,993	7,923
Freshwater ecotoxicity	kg 1.4-DBC e	60	15	3
Marine ecotoxicity	kg 1.4-DBC e	119	68	8
Human carcinogenic toxicity	kg 1.4-DBC e	152	188	7
Human non-carcinogenic toxicity	kg 1.4-DBC e	8,076	1,020	405
Land use	m^2a crop eq	102	12	7
Mineral resources scarcity	kg Cu eq	1.4	0.5	0.4
Fossil resource scarcity	kg oil eq	67,043	9,939	3,378
Water consumption	m^3	295	43	15
Cumulative energy demand	MJ	2,908,596	430,471	146,847

Worldwide, this 20.49% fuel reduction can be translated to avoiding the following greenhouse gas emissions and energy used:

Table 5 Avoided impact due to 20.49% fuel reduction worldwide

Impact category	Units per type of vehicle worldwide	Lorries	Vans	Cars
Climate change	Avoided tons CO_2eq	11,194,260,516	8,333,964,715	9,678,295,777
Cumulative energy demand	Avoided MWh	44,908,946,361	33,433,903,656	38,632,275,344

References

Ministerio de Fomento (2017) Observatorio de Costes del Transporte de Mercancías por Carretera. Spanish Government.

Available: https://www.fomento.gob.es/CVP/handlers/pdfhandler.ashx?idpub=TTW103

Spielmann, M., Bauer, C., Dones, R., Tuchschmid, M. (2007) Transport Services. Ecoinvent report No. 14. Swiss Center for Life Cycle Inventories, Dübendorf, 2007

Annex. Impact categories description

<table>
<tr><th>Environmental impact category</th><th>Unit</th><th>Description</th></tr>
<tr><td>Climate change</td><td>kg CO_2 eq</td><td>An increased atmospheric concentration of greenhouse gases will increase the radiative forcing capacity leading to an increase in the global mean temperature (°C). Increased temperature ultimately results in damage to human health and ecosystems.</td></tr>
<tr><td>Stratospheric ozone depletion</td><td>Kg CFC11 eq</td><td>Emissions of Ozone Depleting Substances ultimately lead to damage to human health because of the resultant increase in UVB radiation. Chemicals that deplete ozone are relatively persistent and have chlorine or bromine groups in their molecules that interact with ozone (mainly) in the stratosphere. This increased radiation negatively affects human health, thus increasing the incidence of skin cancer and cataracts.</td></tr>
<tr><td>Ionizing radiation</td><td>kBq Co-60 eq</td><td>Anthropogenic emissions of radionuclides are generated in the nuclear fuel cycle (mining, processing and waste disposal), as well as during other human activities, such as the burning of coal and the extraction of phosphate rock. Exposure to the ionizing radiation caused by these radionuclides can lead to damaged DNA molecules and thus affect human health.</td></tr>
<tr><td>Ozone formation, human health</td><td>kg NOx eq</td><td>Ozone is not directly emitted into the atmosphere, but it is formed as a result of photochemical reactions of NOx and Non Methane Volatile Organic Compounds (NMVOCs). This formation process is more intense in summer. Ozone is a health hazard to humans because it can inflame airways and damage lungs.</td></tr>
<tr><td>Fine particulate matter formation</td><td>kg $PM_{2.5}$ eq</td><td>Air pollution that causes primary and secondary aerosols in the atmosphere can have a substantial negative impact on human health, affecting the upper part of the airways and lungs when inhaled.</td></tr>
<tr><td>Ozone formation, terrestrial ecosystems</td><td>kg NOx eq</td><td>Ozone is not directly emitted into the atmosphere, but it is formed as a result of photochemical reactions of NOx and Non Methane Volatile Organic Compounds (NMVOCs). Ozone can have a negative impact on vegetation, including a reduction of growth and seed production, an acceleration of leaf senescence and a reduced ability to withstand stressors.</td></tr>
<tr><td>Terrestrial acidification</td><td>kg SO_2 eq</td><td>Atmospheric deposition of inorganic substances, such as sulphates, nitrates and phosphates, cause a change in acidity in the soil. This change in acidity can affect the plant species living in the soil, causing them to disappear</td></tr>
<tr><td>Freshwater eutrophication</td><td>kg P eq</td><td>Freshwater eutrophication occurs due to the discharge of nutrients into soil or into freshwater bodies and the subsequent rise in nutrient levels, i.e. phosphorus and nitrogen. Environmental impacts related to freshwater eutrophication are numerous. They follow a sequence of ecological impacts offset by increasing nutrient emissions into fresh water, thereby increasing nutrient uptake by autotrophic organisms such as cyanobacteria and algae, and heterotrophic species such as fish and invertebrates. This ultimately leads to relative loss of species.</td></tr>
<tr><td>Terrestrial ecotoxicity</td><td>kg 1.4-DBC e</td><td rowspan="5">Human toxicity and ecotoxicity accounts for the environmental persistence (fate), accumulation in the human food chain (exposure), and toxicity (effect) of a chemical. This can result in affected species and disease incidences, leading finally to damage to ecosystems and human health.</td></tr>
<tr><td>Freshwater ecotoxicity</td><td>kg 1.4-DBC e</td></tr>
<tr><td>Marine ecotoxicity</td><td>kg 1.4-DBC e</td></tr>
<tr><td>Human carcinogenic toxicity</td><td>kg 1.4-DBC e</td></tr>
<tr><td>Human non-carcinogenic toxicity</td><td>kg 1.4-DBC e</td></tr>
<tr><td>Land use</td><td>m^2a crop eq</td><td>Land use includes the direct, local impact of land use on terrestrial species via change of land cover and the actual use of the new land. Change of land cover directly affects the original habitat and the original species composition accordingly.</td></tr>
<tr><td>Mineral resources scarcity</td><td>kg Cu eq</td><td rowspan="2">Assessment of consumption of natural resources (distinguished in two indicators depending on whether the resources are energy or non-energy) including a weighting of these resources according to their scarcity and the speed of their exploitation. The more the resource is considered as scarce and exploited, the more the value of the indicator increases and the more the product contributes to the depletion of resources.</td></tr>
<tr><td>Fossil resource scarcity</td><td>kg oil eq</td></tr>
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Water consumption	m^3	Water consumption is the use of water in such a way that the water is evaporated, incorporated into products, transferred to other watersheds or disposed into the sea. Water that has been consumed is thus not available anymore in the watershed of origin for humans nor for ecosystems