Technology Options to Increase Fuel Efficiency and Reduce CO_2 Emissions from Passenger Cars
An Overview

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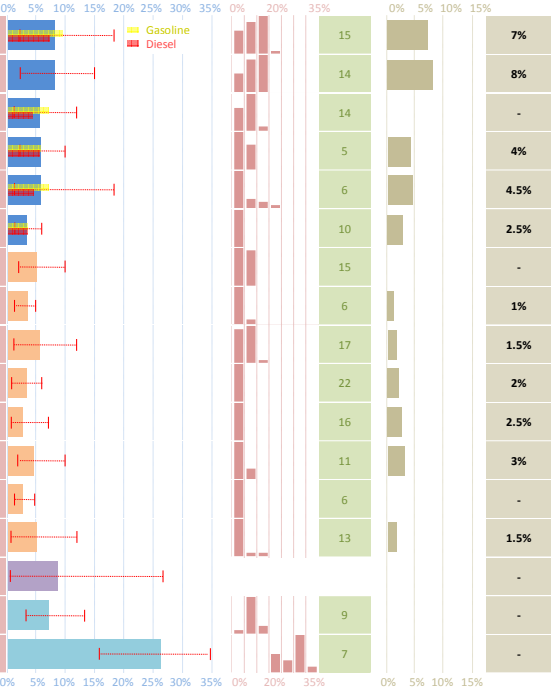
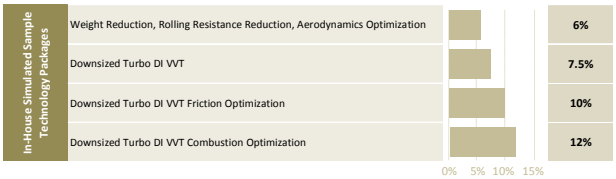
Introduction

Achieving the overall 2020 target of 95 g CO_2/km set for Europe calls for technical developments in different areas, where energy efficiency increase and CO_2 emission reduction could be exploited. Several studies have tried to deal with this topic, assessing the potential of the available technologies.

In the present work, an attempt to summarize the outcomes of the different studies is carried out. As a result, an overview of both technology specific and technology packages potential is portrayed. This will facilitate the identification of the technological paths towards achieving the target.

	Technology	Description	Literature Fuel Efficiency Increase [1] Median	St. Dev.	Average	Retrieved Values Distr.	Sources No [2]	In-House Simulation Fuel Efficiency Increase [3]
ENGINE TECHNOLOGIES	Downsizing / Displacement Difference	Replacing a larger engine with a smaller (cylinder content reduction or fewer cylinders), more efficient engine while matching performance through turbocharging	9.5%	3.9%	8%		15	7%
	Direct Injection	Injection of fuel directly in combustion chamber leading to more efficient fuel utilization, in stoichiometric or lean burn, naturaly aspired or turbocharged	9%	4%	8%		14	8%
	Variable Valve Timing & Lift	Varied timing and lift of engine valves depending on engine load to optimize air intake and exhaust, fully variable, wide range, variable compression	6%	3.2%	6%		14	-
	Cylinder Deactivation	Reduced engine losses through partial deactivation of engine cylinders depending on load	5%	1.6%	6%		5	4%
	Combustion Efficiency	Increased combustion efficiency via variable compression ratio, combustion period optimization, closed loop controls and combustion improvements	4%	5%	6%		6	4.5%
	Engine Friction Reduction	Reduced engine friction through multiple levers such as use of roller bearings, low viscocity lubricants, components with low friction, design and materials	3%	1.2%	3%		10	2.5%
NON ENGINE TECHNOLOGIES	Automatic / Automated Transmission	Improved control of automatic transmissions, automated manual transmissions, continuously variable transmissions, dual clutch, alternative technologies	4.5%	1.6%	5%		15	-
	Manual Transmission	Increased number of gears and optimized gear ratios (downspeeding) allow the engine to operate in a narrow range closer to its optimal speed	3.5%	1.2%	3.5%		6	1%
	Weight	Use of lightweight materials and structural redesign for weight reduction, lightweight components, new manufacturing technologies	5%	3%	5.5%		17	1.5%
	Rolling Resistance	Reduction in tire rolling resistance toward minimizing rolling friction losses, tire pressure monitoring systems, energy efficient tires	2.5%	1%	2.5%		22	2%
	Aerodynamics	Streamlined vehicle body design to minimize energy losses due to air drag, aerodynamic designe and optimization	2%	1%	2.5%		16	2.5%
	Accessories & Loads	Reduction in power consumption in auxiliaries and load systems, electrification of current mechanical systems, optimization of electrical systems and electronic controls	4%	1.7%	4.5%		11	3%
	Thermal Management	Heat energy recovery, heat storage, thermo-electric conversion	2%	1.2%	2.5%		6	-
	Start Stop	Reduced idle fuel consumption through engine shutdown	4%	2%	5%		13	1.5%
	Others	2-stroke / 4-stroke switching, alternative fuels, emmisions control systems, eco-innovations, destruptive innovations, systems optimization	4%	9.3%	8.5%			-
HYBRID TECHS	Energy Recuperation / Mild Hybrid	E-motor assists engine in acceleration, regenerative braking charges a small battery, start stop system, no all-electric propulsion possible	7%	1.7%	7.5%		9	-
	Full Hybrid	Combines e-motor and engine power that optimizes output to the wheels throught the operating range, parallel hybrid, series electrical, input power split, two mode power split	27.5%	4.8%	26%		7	-





[1] Fuel Efficiency Increase summarizes results given in the literature on fuel consumption efficiency increase, fuel economy increase, fuel consumption reduction and CO_2 emissions reduction. Aggregate results are given for a typical medium sized vehicle, gasoline or diesel. Presented ranges include a span of approximately ~10 to 15% coming from the different reporting tactics in the literature, typically for stardard cycle referring results (mainly NEDC) or estimations for real consumption efficiency and emissions. Errors bars indicate the minimum and maximum values found in the literature.

[2] Sources include papers, reports and presentations, originated from EU, US and Asia, ranging from 2003 to 2014 with an average age of ~4 years

[3] Preliminary and indicative results coming from a simplified physical model based on standard vehicle longitudinal dynamics and energy consumption simulation, developed from JRC under the scopes of the WLTP/NEDC correlation exercise. Several technologies are not simulated due to the fact that not all of the appropriate necessary data was available on the current moment

Results & Conclusions

The indicative aggregate results presented here, demonstrate that among the different technologies, the highest potential stands on the downsizing, the direct fuel injection and the combustion efficiency improvement. Nonetheless, alternative technologies like hybrids and other non-conventional innovations can also offer very important benefits. In the latter case issues regarding the cost effectiveness of such technologies need to be consider.

Our current projection, based on in-house simulations, is that the combination of engine and non-engine technologies will be able to reduce CO_2 emissions by approximately ~10-15%, in the medium term, for a conventional medium class passenger vehicle.

Follow Up

Further to the effectiveness analysis of the available technological options, in order to correctly support policy-making and R&D strategies, an analysis of the costs associated with the different technologies is crucial. A relevant study is ongoing at the JRC.

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