Chapter 1
Introduction

The need to reduce negative environmental impacts has become the key factor in the development of techniques and technologies in all industries. The use and development of advanced technologies involve constant verification of the existing conditions of human and machine labor and the consequences of its environmental impacts. Transport is considered to be one of the most rapidly changing industries, first and foremost because of reducing hazardous emissions.

Apart from improving the classic propulsion (internal combustion engine), research works are underway to develop alternative power train systems. However, on the basis of the existing analyses one can assume that internal combustion engines will continue to prevail until 2030 (Fig. 1.1). There are currently around 700 million vehicles owned throughout the world, which is predicted to increase to approximately 2.0 billion by 2050 (Fig. 1.2). The developed markets such as Europe, North America and Japan are expected to reach saturation in the near future, because these countries enter a period of population decline.

However, the global vehicle fleet is expected to increase through the rapid economic growth with the progress of automotive industry in emerging markets, such

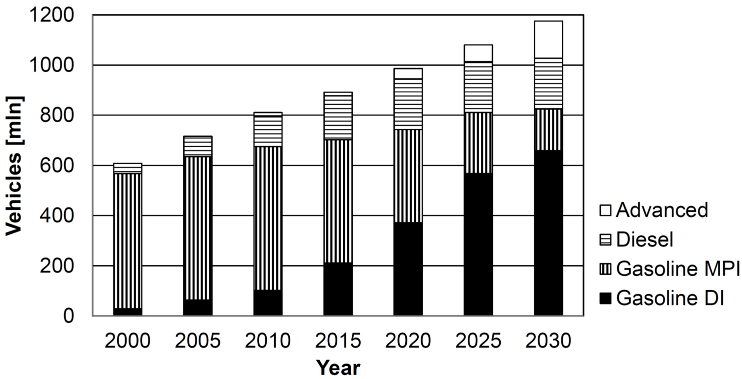

Fig. 1.1 Expected global passenger car structure by 2030, according to Obsidian Energy Company [2]

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as China, India, Brazil, etc. In 2030, the total vehicle ownership in these nations is predicted to exceed that in the developed nations [3].

The emission of (gaseous) toxic compounds and carbon dioxide as well as particulate matter continues to be a major threat, constituting an obstacle to the development of contemporary internal combustion engines, especially compression and spark ignition engines with direct injection. Euro 6 standard is a major change for vehicle manufacturers, as it requires reducing gaseous compounds and particulate matter emissions to levels far below the current ones (Fig. 1.3). Newly implemented technical and operating regulations may cause both positive and negative consequences. Well designed regulations should affect the natural environment in a positive way, but the nature of that influence also depends on the perspective taken when the influence is assessed. Positive effects of the regulations are particularly well visible in terms of the change in pollution limits.

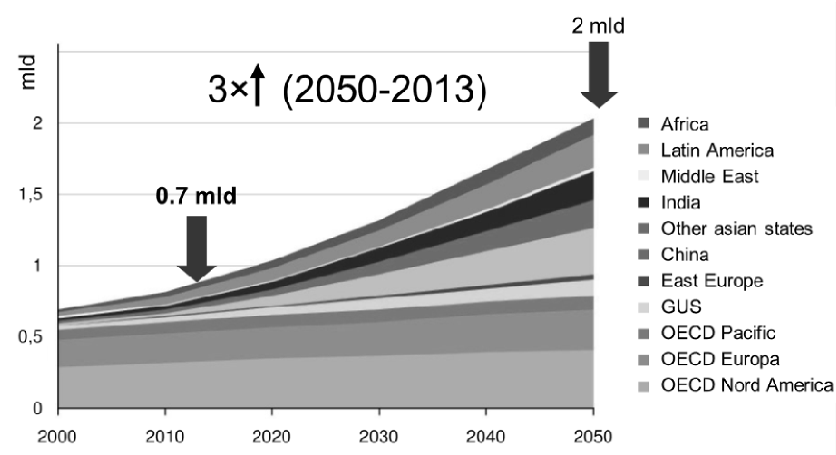

Fig. 1.2 Expected global number of vehicles by 2050 [8]

The main issues faced by the internal combustion engine in the future include reducing atmospheric pollution and adapting to the diversification of fuels. Partially due to stringent regulations, vehicle emissions are already cleaner than the surrounding air in some urban environments. However, further efforts are planned to reduce the emissions (that including the reduction of gases that contribute to the greenhouse effect). Toyota intends to improve the thermal efficiency of engines as much as possible to reduce CO_2 emissions to the same level as current HVs (Fig. 1.4). This technology can then be combined with hybrid technology to achieve both excellent dynamic performance and fuel efficiency.

CO_2 reduction becomes increasingly important. When CO_2 emission is calculated per passenger, couches buses generate the lowest amount, while passenger planes generate the highest one (Fig. 1.5). CO_2 emission from passenger cars at a

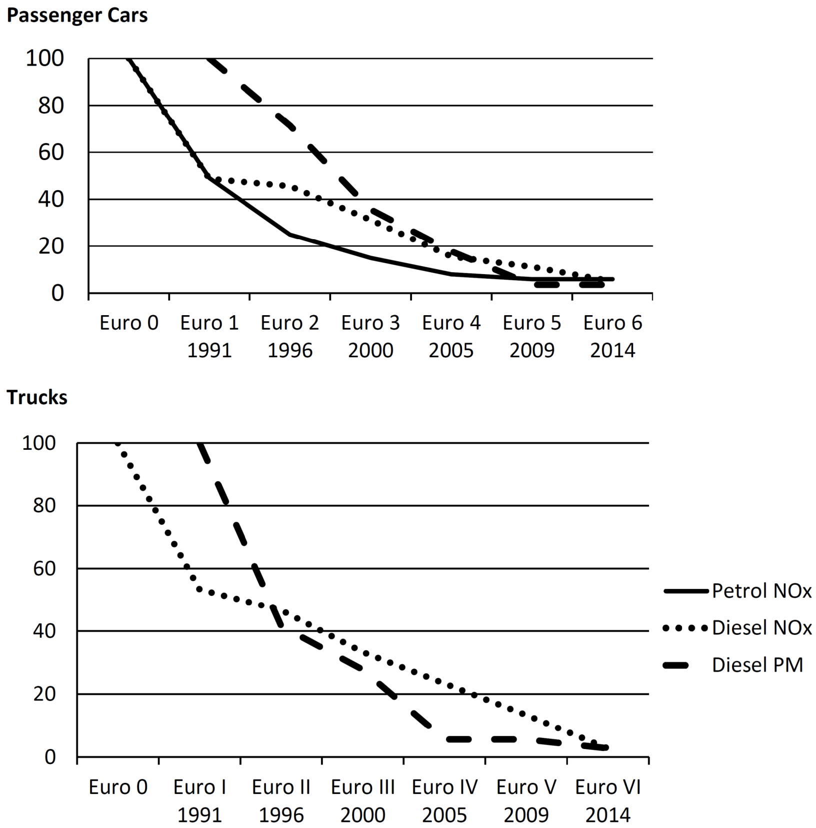

Fig. 1.3 Reduction of emission limits 1990 to 2014 [9]

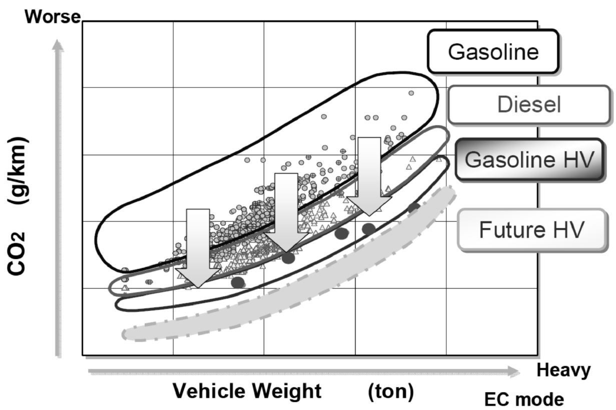

Fig. 1.4 Plan for reducing CO_2 emission for future vehicle [3]

level of 140 g/km corresponds to fuel consumption in the area of 6 dm^3/100 km, while 120 g CO_2 per km reduces fuel consumption down to 5.2 dm^3/100 km [1]. The introduction of CO_2 limits in the perspective of 2015 translates into an average fuel consumption reduction by 30% in a decade (Fig. 1.6) The Commission believes that the reduction of this factor by 25% as compared to the current value will be possible owing to new engine constructions as well as new tire, air conditioning and biofuel technologies.

German manufacturers (specializing in the production of large vehicles) proposed that much higher limits should be in place for heavier vehicles. An alternative view was presented by Italian and French car makers, who insisted on minimum deviations from the adopted limit and on significant penalties for exceeding it.

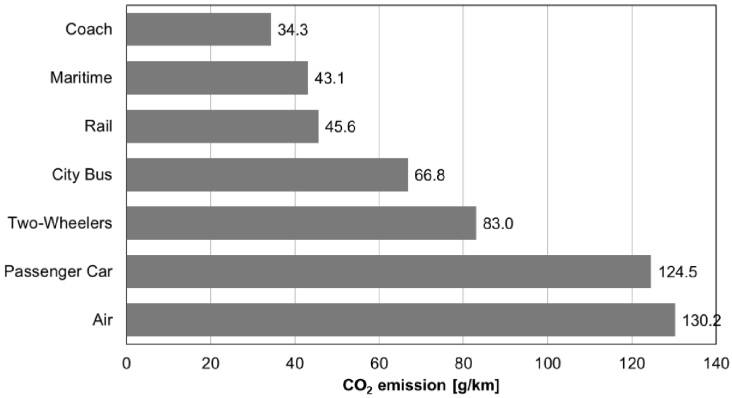

Fig. 1.5 CO_2 emission for various transport modalities (per passenger)

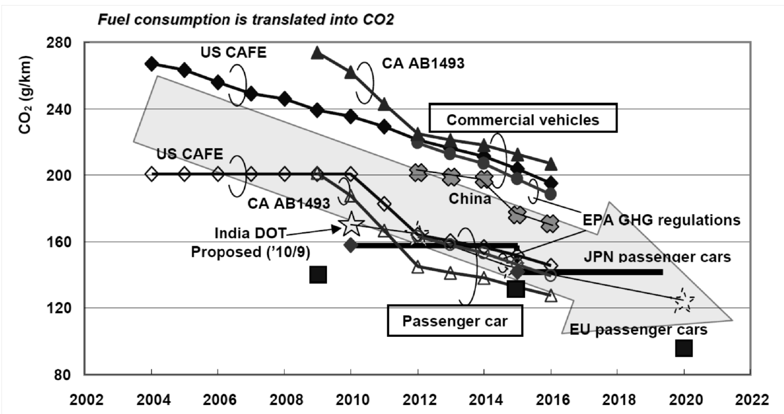

Fig. 1.6 Carbon dioxide emission trend

Eventually the Commission proposed that the new emission limit should be an average value for the entire car fleet. Heavier vehicles will be subject to higher limits (e.g. 150 g CO_2/km for vehicles heavier than 2,000 kg). Car makers will also be allowed to pool their emissions, so that e.g. Porsche could calculate its average CO_2 emission together with a manufacturer of small vehicles. In 2012, the penalty for 1 g of excess emission will be EUR 35 per vehicle. In 2015 the penalty will grow to EUR 95. Manufacturers with an annual production below 10 thousand vehicles will be subject to a separate set of regulations.

Efforts are taken not only to reduce CO_2 emissions in vehicle exhaust gases, but also in the vehicle's entire lifecycle ("from well to wheel"). It is hoped that adequate legislation policy will allow cutting overall vehicle CO_2 emissions by 3- to 5-fold over the next 20 years [4]. It will be possible through implementing increasingly strict emission standards and regulatory alignment in all countries.

By extending the study over the whole vehicle lifecycle (including the production of the vehicle itself, its use, the production of the fuel or electricity and the production of the first and spare batteries), a lifespan of 15 years and an overall traffic performance of 250,000 km can be assumed with modern vehicles. As the conversion of 1 dm^3 of gasoline generates 2.25 kg CO_2, a range of 250,000 km leads with a fuel consumption of 8.5 dm^3/100 km gasoline to 47,800 kg CO_2. Similarly, the conversion of 1 dm^3 of diesel fuel generates 2.55 kg CO_2, thus leading to the emission of 39,500 kg CO_2 over the whole driving range with a fuel consumption of 6.2 dm^3/100 km. By taking the 10% of energy lost during the fuel production into account, the CO_2 emission caused by the reference vehicle reaches 53,100 kg with a gasoline engine and 43,900 kg with a diesel engine.

The production of a vehicle such as Volkswagen Golf, including its powertrain generates 4,400 kg CO_2 according to [6] and to the data provided by Volkswagen AG. As the reference vehicle considered in this study belongs to a higher vehicle class (C-class for the reference vehicle and B-class for Volkswagen Golf), a higher effort for its production (including the more elaborate exhaust gas after-treatment) is necessary. Therefore, it is assumed that the production of the reference vehicle with combustion engine or with electric powertrain (yet, without battery) generates 5,000 kg CO_2. Thereby, the CO_2 emission of the reference vehicle increases to 58,100 kg with a gasoline engine and to 48,900 kg with a diesel engine, as shown in Fig. 1.7.

The reference vehicle with electric powertrain requires the same amount of energy for its production as the one fitted with an internal combustion engine, thus generating the same CO_2 emission (5,000 kg). Over the whole driving distance of 250,000 km and with an energy input of 140 kWh for 300 km (modern lithium ion batteries), a total amount of 62,500 kg CO_2 is released into the atmosphere. In addition, the energy required for the battery production has to be taken into account. According to [40], the production of the energy storage system requires the same amount of energy and thus causes the same CO_2 emission as the production of the reference vehicle (5,000 kg). Moreover, it is assumed that the battery has to be replaced at least once during the vehicle lifecycle, thus adding 5,000 kg CO_2 to the balance. As a result, the production of the reference vehicle with an electric powertrain and its use over 15 years and 250,000 km generates 77,500 kg CO_2. This means that a vehicle with electric powertrain causes CO_2 emission that are 1.33 times higher than the same vehicle with a gasoline engine and 1.58 higher than with a diesel engine (Fig. 1.7).

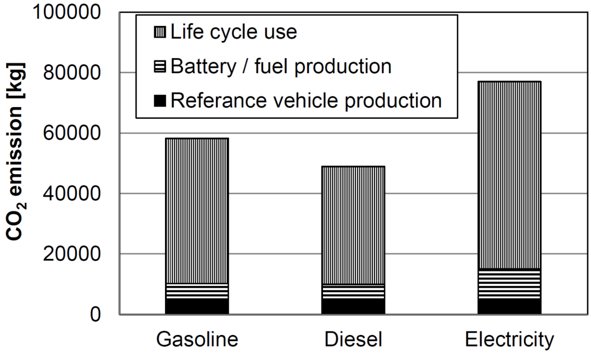

Fig. 1.7 CO_2 emission over the whole vehicle lifecycle (in each case 15 years; 250,000 km)

In tandem with its global architecture strategy, GM has an advanced propulsion technology strategy that enables it to address common powertrain concerns that are important across every vehicle segment. Since fuel economy and rising energy prices are the principal challenges in this area, GM strategy is to pursue both energy diversity and fuel-efficient technologies that are relevant to customers.

GM focus is to dramatically improve the efficiency of powertrains and ultimately reduce tailpipe emissions to zero. In line with this approach, it is leveraging efficiency improvements in advanced engines and conventional and hybrid transmissions, aggressively pursuing alternative fuels such as ethanol and electricity and developing new technology solutions such as the extended range Chevrolet Volt electric vehicle, battery electric vehicles, and hydrogen fuel cell vehicles (Fig. 1.8).

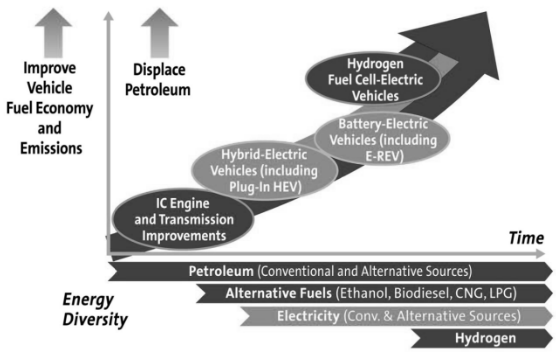

Fig. 1.8 General Motors Advanced Propulsion Technology Strategy [7]

Currently, no single energy source or propulsion alternative offers a complete solution. Therefore, GM is applying advanced technology where it makes the most sense in terms of fuel efficiency, performance, and cost. It is working to improve the efficiency of conventional gasoline engines, using new technologies such as direct injection, lower displacements, turbocharging, advanced fuel systems, reduced friction, and many others. For instance, by the end of this year, GM will offer start-stop technology on all major Opel models, significantly improving fuel economy and decreasing emissions in urban driving [7].

The vehicle and engine technologies to realize higher performance, lower emissions are getting more complex and sophisticated and it makes the engine increasingly sensitive to the market fuel qualities and properties (Fig. 1.9). For example, precise engine control with the combination of various devices, such as exhaust gas recirculation (EGR), after treatment catalyst, and particulate filters, is required to further reduce diesel emissions.

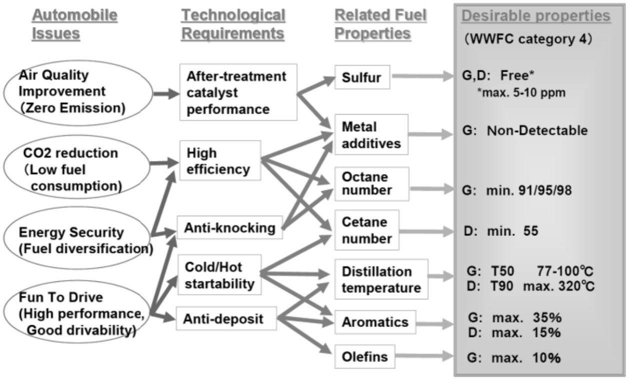

Fig. 1.9 Automobile issues and fuel qualities [3]

The EU has lately lunched a package of new regulations regarding the emission of pollutants from vehicles classified as M (carriage of passengers) and N (carriage of goods) categories. The package includes:

- Euro 5 and Euro 6 regulations for light-duty vehicles (tested for emissions on a chassis dynamometer), thus replacing the earlier Euro 4 regulations,
- Euro VI regulations for heavy-duty vehicles (with engine bench testing), thus replacing the earlier Euro V regulations.

The new regulations introduce a great number of changes. The most important ones are related to:

- the structure and form of regulations,
- the rules for classifying vehicles as light and heavy, and the scope of application,

- testing,
- requirements regarding the emission of pollutants.

The new EU regulations have been discussed as of 31.12.2012.

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