Reduction of CO_2-emissions from new passenger cars: will Switzerland achieve the EU's targets?

Term paper

Energy Economics and Policy

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Abbreviations

EU	European Union
GHG	Greenhouse gas
DETEC	Federal Department of the Environment, Transport, Energy and Communications

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1. Introduction

The transport sector is one of the main sectors responsible of final energy consumption and at the same time a major source of CO_2-emissions worldwide. In Switzerland, this sector accounts for 35% of total energy consumption (Figure 1) and for 31% of CO_2-emissions (Figure 2). In order to meet the requirements of the Kyoto protocol (reduction of GHG-emissions by 8% below 1990 levels between 2008 and 2012) and to implement the target of the CO_2 law (reduction of CO_2-emission by 10% below 1990 levels between 2008 and 2012), Switzerland is asked to considerably reduce the emission from the transportation sector, reducing the energy consumption and increasing the energy efficiency of passenger cars (FederalOfficeofEnvironment 2010). Figure 3 shows that the CO_2-emissions from transportation fuels are not attaining the target line imposed from the CO_2 law.

The reduction of energy consumption and CO_2-emissions from the transport sector is a big challenge. A lot of research is done in developing and optimizing highly efficient drive systems for passenger cars such as fuel cells, hybridization of IC-engines and electrification of electric vehicles. Nevertheless, until new technologies are competitive from a technological, environmental and economical point of view, it is worth concentrating on the improvement of existing technologies, in order to optimize, in the short run, the behaviour of consumers and exploit the available potential of energy consumption reduction.

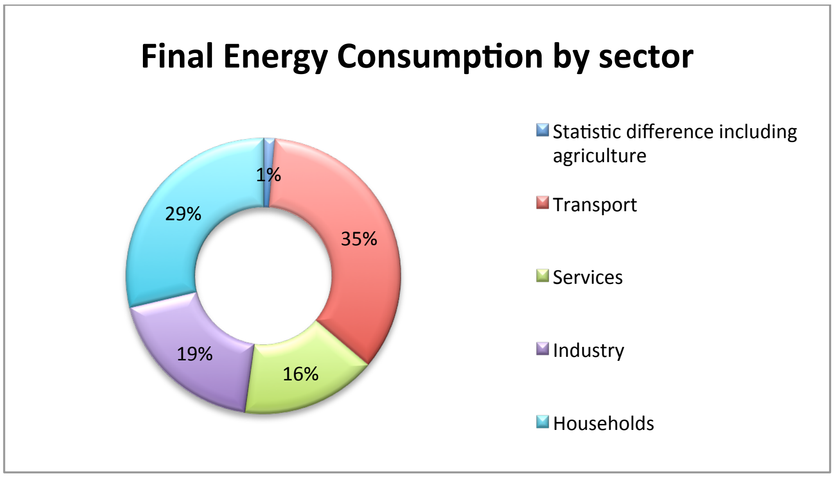

Figure 1: Final Energy consumption of Switzerland by sector, 2009 (SwissEnergyCouncil 2011).

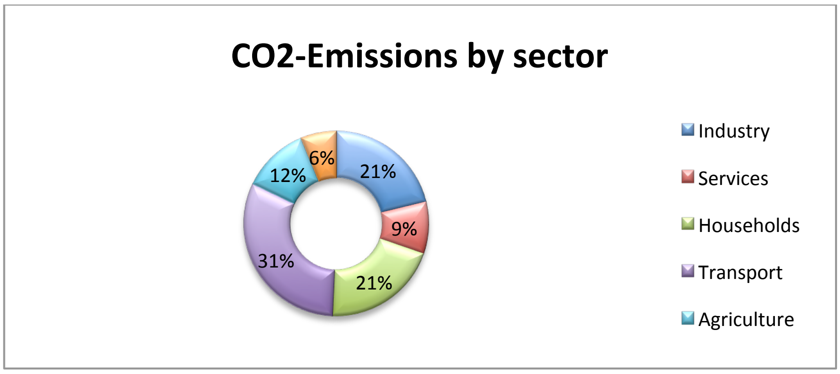

Figure 2: CO_2-emissions of Switzerland by sector, 2008 (FederalOfficeofEnvironment 2010).

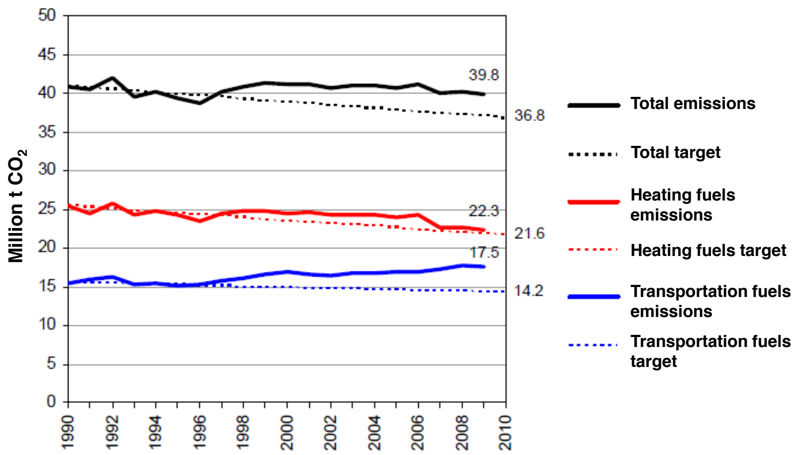

Figure 3: Development of CO_2-emissions according to the CO_2 law targets (1990-2010) (FederalOfficeofEnvironment 2010).

In Switzerland, different policy measures such as energy labelling and feebates[1] have been promoted in the last years in order to improve the energy efficiency of new passenger cars. The purpose of this paper is to give an overview of different tools used to shift the purchase of new cars towards more efficient vehicles and to assess if it will be realistic to achieve the EU's (European Union) emission targets for Switzerland (130 gCO_2/km for 2015 respectively 95 gCO_2/km for 2020). In order to do this, three scenarios with different assumptions on the sales mix of new cars in Switzerland are developed.

[1] Feebates is a combined incentive scheme consisting of fees for inefficient cars and rebates for efficient cars (de Haan

2. Emission Targets and Policy Instruments in EU and Switzerland

2.1 EU's Target for CO_2-Emissions from Passenger Cars

The European Parliament defined on April 23, 2009 a regulation with new targets for CO_2-emissions from light-duty vehicles. The target value for 2015 is an average of 130 g CO_2/km for the new car fleet, while for 2020 onwards, this value should decrease to 95 g CO_2/km[2] (EuropeanCommission 2009). Moreover, an excess emissions premium will be imposed on the manufacturers that exceed the average emissions target with their fleet. This regulation is derived from a wider EU Community strategy to mitigate CO_2-emissions from light-duty vehicles, which has been developed since 1995 and consists of three main pillars: voluntary reduction of CO_2-emissions from the car manufacturers, fiscal measures to promote energy efficient cars and better consumer information through a compulsory energy label for all new cars (EuropeanParliament 2008).

2.2 Switzerland's Policy for Reducing CO_2-Emissions from Passenger Cars

Following the EU line, Switzerland developed a strategy consisting of these 3 pillars (de Haan 2011):

1. Voluntary agreement of Federal Department of the Environment, Transport, Energy and Communications (DETEC) with "auto-schweiz" with the aim of reducing fuel consumption of new cars.
2. Creation of a Swiss energy label for new passenger cars.
3. Fiscal instruments at cantonal level.

These measures have been implemented in the following steps described below.

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[2] This corresponds to approximately to an average consumption of 4.06 litres gasoline resp. 3.64 litres diesel each 100 km, considering that burning 1 litre of gasoline produces 2.34 kg of CO_2 resp. 2.61 kg of CO_2 for 1 litre of diesel (SwissEnergy 2011).

In 2002, the association “auto-schweiz” and the DETEC agreed on voluntary commitments in order to decrease the fuel consumption of new passenger cars from 8.4l/100km (average in 2000) to 6.4l/100km in 2008, which was actually not reached (average in 2008 was 7.14l/100km (auto-schweiz 2010)). During the same year, the Swiss Federal Office of Energy decided to introduce an energy label on new passenger cars with effect from March 2003 (Figure 4), with the intent of increasing the transparency and the awareness of consumers. According to SwissEnergy (2011), the goal of this information tool is to reduce the energy consumption and therefore the related CO_2-emission of passenger cars. The information depicted on the label is fuel consumption in l/100 km, CO_2-emission in g/km and category of energy efficiency related to the car’s curb weight (relative energy-efficiency).

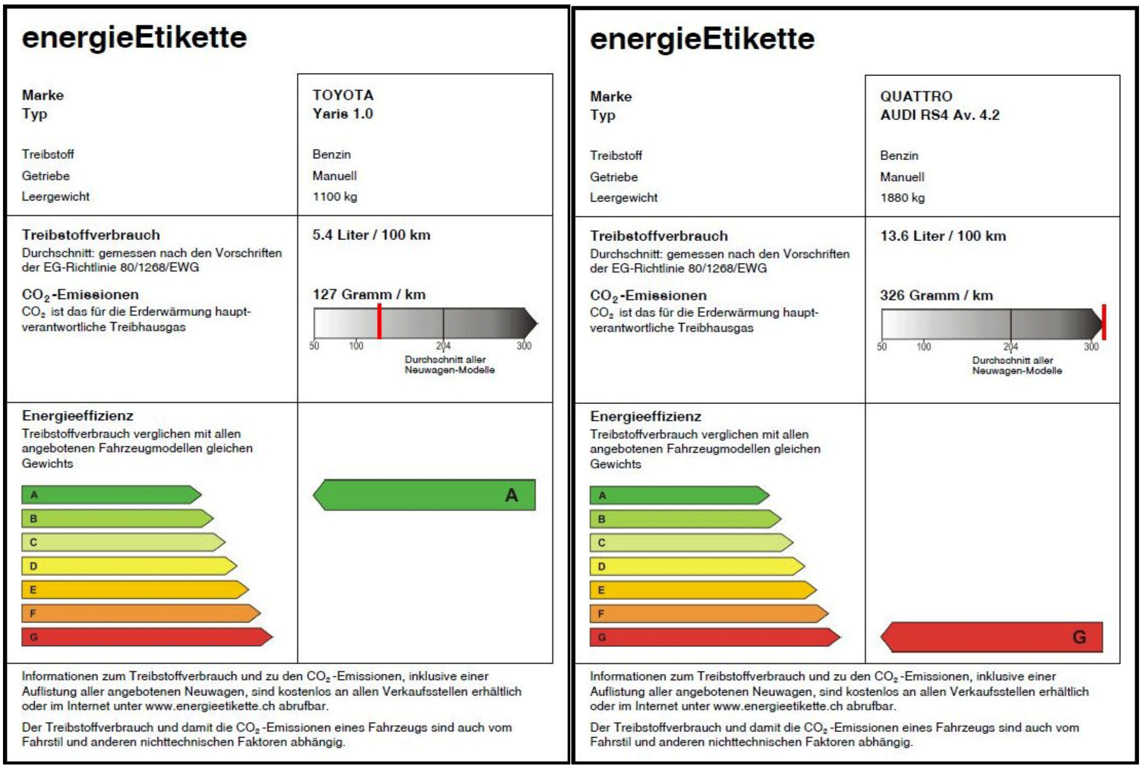

Figure 4: Examples of energy labels for Toyota Yaris 1.0 (Energy-efficiency category A) and Audi RS4 Av. 4.2 (Energy-efficiency category G) (comparis.ch 2011).

The purpose of such measure is to achieve in the long-term a reduction of fuel consumption of 4-5%, according to the goal of the European Union (EU) (Energieverwertungsagentur 1999).

As the third pillar, Swiss cantons promote energy-efficient vehicles offering tax rebates or penalize energy-inefficient vehicles through supplementary taxes (e-mobile 2010).

2.3 Swiss Market for New Passenger Cars

At the end of 2010, the Swiss parliament adopted an emission target of 130g CO_2/km for 2015 but not a further decrease to 95g CO_2/km for 2020 (SchweizerFernsehen 2010). Now, to achieve the same target of the EU will be more ambitious for Switzerland, because new cars sold in Switzerland have on average higher capacity (+260 ccm) and more power (+24 Kw resp. 33 PS) in comparison to bordering countries (de Haan 2007). Furthermore, the average weight of new cars is higher in Switzerland than in EU (1448 kg in Switzerland as opposed 1328 kg in the EU) (auto-schweiz 2010). As depicted in Figure 5, the weight of passenger cars increased continuously from 1989 to 2007 due to increased security and comfort of vehicles, while a change of trend has been noticed in the last few years. The same consideration can be applied to the capacity of vehicles. According to SwissEnergy (2011), an increase of 100kg leads approximately to an increase of 0.5l/100km in fuel consumption.

Figure 5: Development of curb weight (orange [kg]) and capacity (green [ccm]) new passenger cars(de Haan 2011).

3. Assessment of EU's Targets for Switzerland

In the first part, the main policy instruments to reduce CO_2-emissions and energy consumption of passenger cars to meet the requirements of the emissions target have been discussed. Now, a closer look at the effects of such measures and at possible future average emissions of new cars in Switzerland will be given.

3.1 First Scenario: Constant CO_2-Reduction Rate for Switzerland

In this first scenario, the achievement of EU's CO_2-emission targets in Switzerland is investigated. The assumptions consider a constant reduction rate for the two timeframes 2010-2015 and 2016-2020 of 1.52%, which is actually the average reduction rate per year in the period between 1996 and 2009 in Switzerland. Figure 6 illustrates the historic development of CO_2-emissions until today and the predicted reduction lines, using a constant sales mix with today's market shares. Furthermore, the two targets of 130 g CO_2/km for 2015 and 95 g CO_2/km for 2020 are showed in the graph. One can see that, assuming this constant reduction rate, the targets will not be achieved. For the 2015 rate, a value of 151.41 g CO_2/km is reached, while in 2020 the value decreases to 140.27 g CO_2/km.

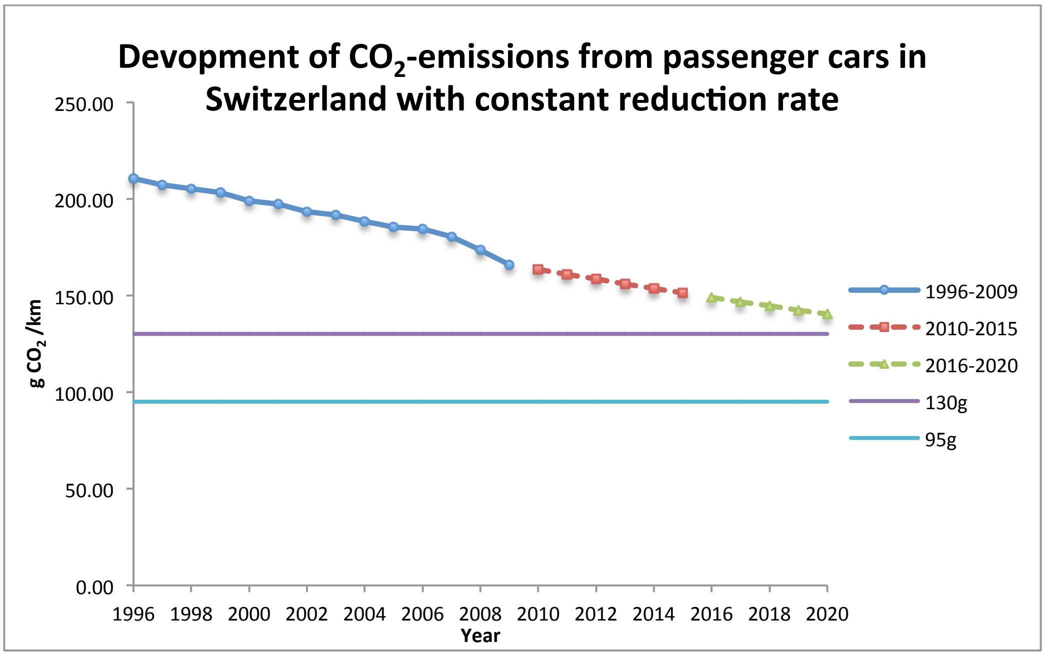

Figure 6: CO_2-emissions from passenger cars in Switzerland until 2020.

This result is not really surprising, because the sales mix of Switzerland presents car with large engines and high weight, which corresponds to larger fuel consumption. In 2009, the emission by new passenger cars accounted for 146 g CO_2/km in EU and 167 g CO_2/km in Switzerland (auto-schweiz 2010; Eurostat 2011). Due to this condition of the market, one can conclude that, in order to achieve the EU's goal, the sales mixes in Switzerland should quickly experience a shift towards high-efficiency IC-engines as well as hybridized and electrified cars.

Figure 7 illustrates the market share for 2009 in Switzerland referred to the energy efficiency categories and related CO_2-emissions. One can see that the 23.80% of the total new vehicles already meet the requirement for the 130g EU's target (auto-schweiz 2010). Furthermore, the energy label in Switzerland in defined in a relative value, which means that also larger cars can achieve the A level. This means, that a large range of high-efficient vehicles are already available on the Swiss market and that further efforts should be done in order to shift the purchase of new vehicles towards more efficient models.

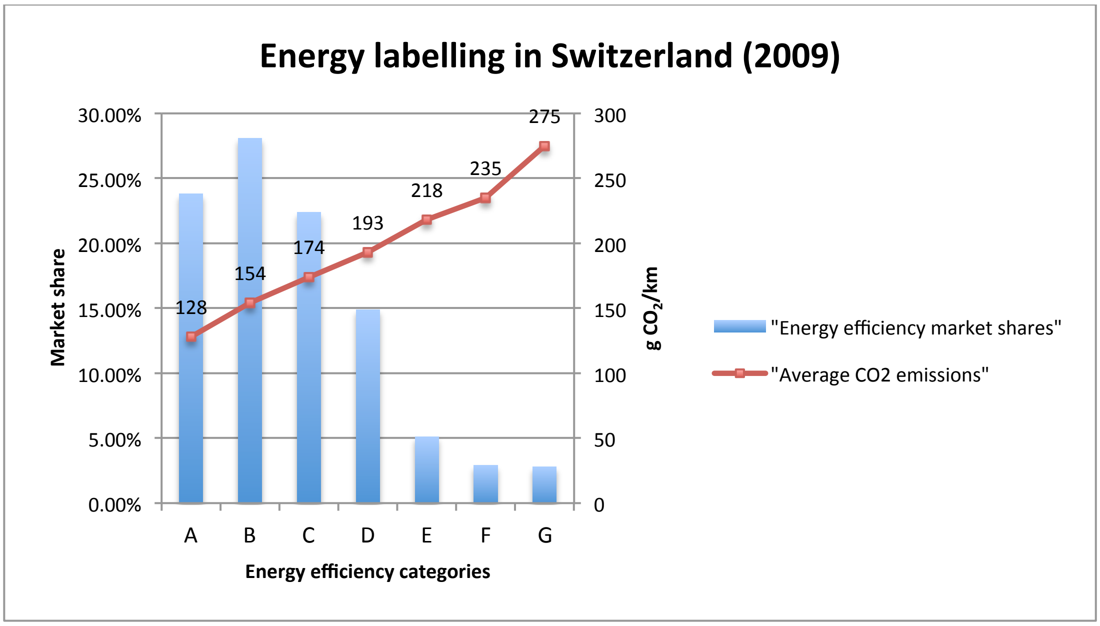

Figure 7: Energy labelling in Switzerland: share for different energy efficiency categories and average g CO_2/km for new cars in 2009 (auto-schweiz 2010).

In the next section, two scenarios are developed. Different sales mixes for Switzerland are assumed in order to check the achievement of the EU's emission targets.

3.2 Optimistic and Realistic Sales Mix Scenarios for Switzerland

3.2.1 Assumptions

The purpose of this section is to predict average CO_2-emissions of new cars in Switzerland for 2015 and 2020 using different assumptions for the sales mixes. Two different scenarios are developed: The first adopting optimistic and the second with more realistic assumptions from the literature. Table 1 shows the actual sales mix in Switzerland, where gasoline and diesel together account for 98% of market. Diffusion of cleaner technologies such as hybrid and electric cars is included in the assumed sales mixes as well as reduction of curb weight for new cars and consumption reduction due to technological improvements.

Table 1: New cars sales mix in Switzerland 2010 (SwissStatistics 2011).

Type	Share
gasoline	67.79%
hybrid	1.43%
diesel	30.60%
gas (CNGL/LPG)-gasoline	0.11%
electric vehicles	0.07%

In the following sections, different assumptions for the development of the sales mix, penetration of new technologies and CO_2-emission of new cars are presented.

Gasoline and diesel vehicles

For gasoline and diesel engines a constant average reduction rate[3] of emission is assumed as defined in Chapter 3.1 for both optimistic and realistic scenarios. This leads to the following average emissions (Table 2):

Table 2: Predicted emissions for 2015 and 2020.

	2015	2020	Reduction rate
gasoline	148.7	135.73	1.58%
diesel	157.76	148.29	1.12%

[3] The reduction rates of CO2-emission are quite low because the technological improvements were partially compensated from increasing engine power and weight of cars (de Haan 2011)

Diesel cars have known a rapid increase in the last years and they passed from a market share of 5.2% in 1996 to 33% in the 2008 (auto-schweiz 2010). In 2009, this share decreased for the first time. According to J.D.Power (2008a), the increase of diesel vehicle market share in Western Europe has passed its peak. Therefore, it is assumed that the actual ratio between gasoline and diesel cars (7 to 3) will stay constant until 2020.

Weight loss

In addition to the constant reduction of fuel consumption, a weight loss of new cars is predicted for the next year, as showed previously in Figure 5. The assumed weight losses are illustrated in Table 3, according to the findings of Bhatt (2010) and Heywood (2010):

Table 3: Weight loss predictions.

	2015	2020
Realistic	10%	5%
Optimistic	5%	3%

A weight loss of 100kg leads in average to a decrease of 0.5 l/km in fuel consumption (auto-schweiz 2010). Using this formula and the average weight of 1448 kg for 2009 the emissions for gasoline and diesel cars are obtained:

Table 4: Emissions for gasoline and diesel.

	Optimistic	Realistic
2015	5%	3%
gasoline	140.22	143.62
diesel	148.31	152.10
2020	10%	5%
gasoline	118.78	127.25
diesel	129.49	138.84

Mild/Full Hybrid

In order to simplify our assumptions, micro hybrids are neglected and considered as part of the technological improvements of IC-engines, according to Bhatt (2010). In the literature, several scenarios forecasting the future marker penetration of hybrid technologies can be found and sometimes the results can be constrasting. Using the forecasts from J.D. Power (2008b), the following share are assumed: 10% for (optimistic) and 4% (realistic) for 2015 and 20% (optimistic) respectively 8% (realistic) for 2020 for mild/full Hybrid.

According to Heywood (2010), the relative fuel consumption of full hybrid referred to actual gasoline cars will be 0.56 for 2020. We further assume a factor 0.60 for 2015. This assumption is derived in order to forecast future CO_2-emissions from full hybrid.

Electric vehicles: BEV and PHEV

Eurelectric (2010) predicts a substantial reduction of the carbon intensity of the EU electricity mix mainly due to renewables and carbon capture and storages technologies. This will reduce the emission of electric vehicles from the actual 80 g CO_2/km to 52 g CO_2/km in 2015 respectively 38 g CO_2/km in 2020. These values using the EU electricity mix development are assumed in our scenarios. In order to keep the assumptions simple, it will not be distinguished between BEV and PHEV.

The market share forecast follow the assumption of Bhatt (2010) and are the following: 4% (optimistic) and 2% (realistic) for 2015 respectively 8% (optimistic) and 3% (realistic) for 2020.

Gas-gasoline

Because this category plays only a marginal role in the market today and the projections of increase are not high (Bhatt 2010), gas-gasoline cars will be neglected in our assumptions.

3.2.2 Results

Using the assumptions derived in the previous section, two sales mixes for the Swiss market are developed for the timeframes 2010-2015 and 2016-2020. The purpose of this calculation is to see if the EU's emissions target can be reached with the assumed sales mix and penetrations of new technologies. The first scenario utilizes optimistic assumptions, where a rapid penetration of new technologies like hybrid and electric vehicles is considered, while the second presents forecasts that appear more feasible under today's market situation in Switzerland. Optimistic and realistic scenarios are developed for 2015 and 2020 (Table 5 and 6).

Table 5: Swiss sales mix for 2015.

	Optimistic		Realistic	
	Share	g CO_2/km	Share	g CO_2/km
Gasoline	59.99%	140.22	65.90%	143.62
Diesel	26.01%	148.31	28.10%	152.10
Hybrid	10.00%	84.14	4.00%	84.14
Electric	4.00%	52.00	2.00%	52.00
Average emissions	100.00%	133.18	100.0%	141.79

Table 6: Swiss sales mix for 2020.

	Optimistic		Realistic	
	Share	g CO_2/km	Share	g CO_2/km
Gasoline	48.66%	118.78	60.20%	127.25
Diesel	23.34%	129.49	28.80%	138.84
Hybrid	20.00%	78.52	8.00%	78.52
Electric	8.00%	38.00	3.00%	38.00
Average emissions	100.00%	106.76	100.0%	124.01

The calculated average emissions for 2015 and 2020 are plotted in Figure 8. This graph shows how both EU's targets are not achieved even with optimistic assumptions. However, the 130g CO_2/km target for 2015 is almost reached by the optimistic scenario, where a value of 138.18 g CO_2/km is reached. Otherwise, the 95g CO_2/km target for 2020 seems to be too ambitious for Switzerland, since it will not be reached even with the optimistic assumptions.

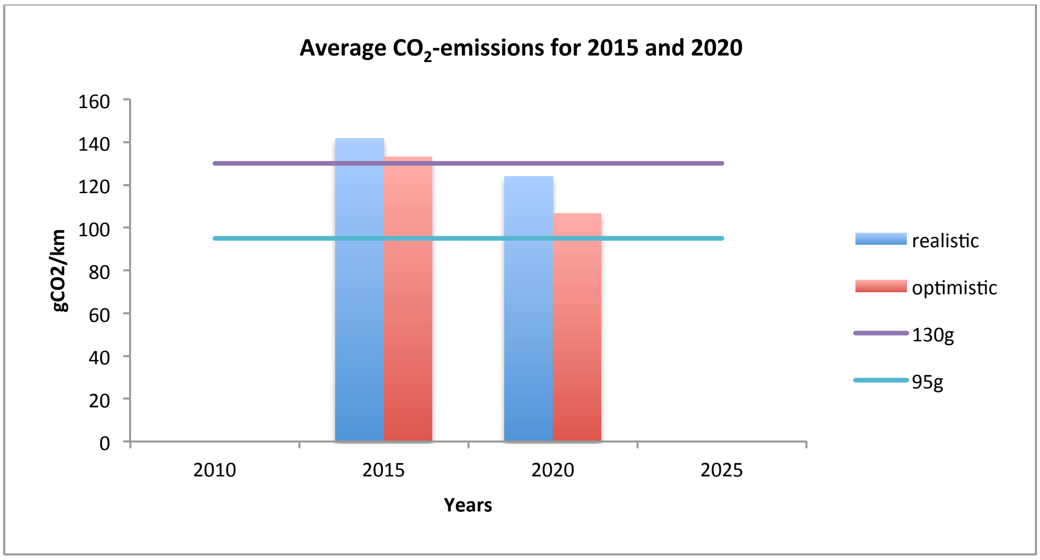

Figure 8: Average CO_2-emissions with two different sales mix scenarios for Switzerland.

4. Conclusion

The main findings of this paper can be summarized as follows: applying a constant reduction rate we found emissions values of 151 g CO_2/km for 2015 and 140 g CO_2/km for 2020. Using this simple assumption, it is clear that the EU's targets will not be reached in Switzerland. In a second step, two different scenarios for sales mix of new cars in Switzerland have been developed. The results show that the 130g CO_2/km target could be almost reached by the optimistic sales mix (133.18 g CO_2/km), while the 95g CO_2/km for 2020 appears to be too ambitious also under the best assumptions (106.76 g CO_2/km). Obviously, the assumptions of the scenarios were kept really simple. Further analysis considering additional aspects such as additional technology improvements for IC-engines is needed in order to achieve more realistic results with lower average emissions rate.

The difficulty in achieving EU's targets for the Swiss sales mix can be explained by the fact that Switzerland starts with a higher level of average emissions than EU in 2009 (+21 g CO_2/km, (auto-schweiz 2010; Eurostat 2011)). This value is mainly due to a higher per capita income, which results in the purchase of larger cars with more powerful engines. The recently approved 130g CO_2/km target for 2015 can be reached primarily through a change in purchasing behaviour of Swiss customers. As showed previously, a larger offer of highly efficient cars is already available on the market today. Furthermore, the choice of the engine plays a much more important role than the car model or size. A study shows that an average range of 94 g CO_2/km between the most and the least efficient engine of the same car model (de Haan, Mueller et al. 2009). This means that further the environmental awareness of buyers has to be improved through improvements of the labelling system. Other measures for achieving the emissions target could be a tax system on new cars that internalises the external costs of transport. These taxes can be applied on acquisition, ownership or car use (road-pricing, fuel tax) in order to help the market penetration of hybrid and electric vehicles. On the other side, further technological improvements such as a consistent weight reduction, decrease of rolling resistance of tyres, higher efficiency of internal combustion engines and so on have to be promoted.

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