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Potentials and Costs for GHG Mitigation in the Transport Sector

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Mitigation pledge of the European Union

Scientific analysis suggests that effective mitigation of climate change requires industrialised countries combined (Annex-I) to reduce their GHG emissions by 25% to 40% in 2020 as a first step towards a reduction by 80% to 95% in 2050, each relative to emissions in 1990. This target was endorsed by the G8 at their L'Aquila Summit. Prior to the UN-Summit on Climate Change in Copenhagen, the European Union indeed suggested to reduce its GHG emissions (all sectors combined) by 20% to 30% in 2020 relative to 1990.

What would such a reduction target imply for the transport sector in the EU? What additional measures would be needed in the transport sector? How much would its realisation costs extra? To answer such questions the GAINS model was adapted to determine cost-efficient reduction potentials for greenhouse gases and air pollutants covering all emission sectors (Amann et al. 2009). The projection of the World Energy Outlook 2009 including the implications of the economic crisis is taken as trend baseline (IEA 2009). In this baseline, total CO_2-eq emissions in EU27 would reduce already by 15% until 2020 and 2030 from 5468 Mt CO_2-eq emitted in 1990 (Figure 1)[1].

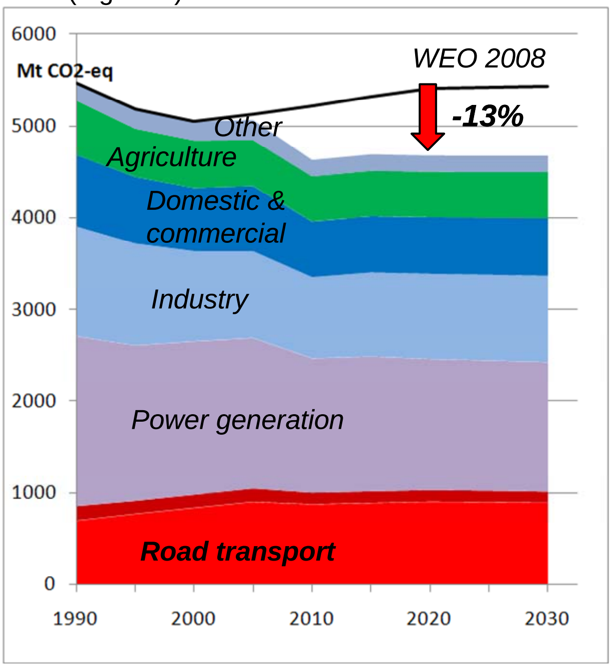

Figure 1: Development of greenhouse gas emissions from major sectors in EU27 from 1990 to 2030 according to the latest World Economic Outlook (IEA 2009). The effect of the financial and economic crisis and further policy measures leads to an assumed stagnation of GHG emissions that is 13% less than projected in the previous World Economic Outlook 2008. [IIASA GAINS, following IEA WEO 2009 for baseline].

Here we determine what additional technical potentials exist in all sectors to reduce an extra 5% to 15% below this baseline projection by 2020. We determine the marginal technical reduction potential as a function of marginal abatement costs for CO_2eq emissions. Costs and potentials are not distributed evenly across sectors, quite on the contrary. Therefore the portfolio with least

[1] This projection (IEA 2009) accounts for effects of the financial and economic crisis. Emissions are lower by 13% in 2020 relative to the pre-crisis projection (IEA 2008).

overall economic costs is determined, meaning that different sectors will contribute above or below average to the total mitigation target. This paper focuses on the technical mitigation potential for the road transport sector and the related costs in the years 2020 and 2030. Measures for non-road sectors are not considered. New technologies may result in higher investment and/or operation & maintenance costs on the one hand. On the other hand, higher vehicle efficiency results in fuel savings. The value of these fuel savings depends on the fuel price and a potential carbon charge. When extra costs discounted at a social interest rate of 4% are less than savings over the lifetime of the technology, then the technology is considered economical. New technologies and vehicles are assumed to penetrate the fleet in a business-as-usual rate; also if their introduction would be fostered, the uptake will be constrained by economic, physical, technical and cultural factors. This is taken into account in the modelling. For details on the approach, cf. Amann et al. (2009) and Borken-Kleefeld et al. (2009); all input data can be accessed under http://gains.iiasa.ac.at/index.php/gains-annex-1.

Mitigation through technical efficiency

Compared to other sectors, transportation has higher marginal abatement costs (Figure 2). The biggest extra mitigation potentials for a given carbon price (in percent change relative to the baseline development) are in the domestic & commercial and the power plant sectors. Extra mitigation measures in the agricultural, industrial and transport sectors are below average. Nonetheless, sizeable potentials for efficiency improvements and emission reductions exist also for the transport sector. This is analysed in detail in the following.

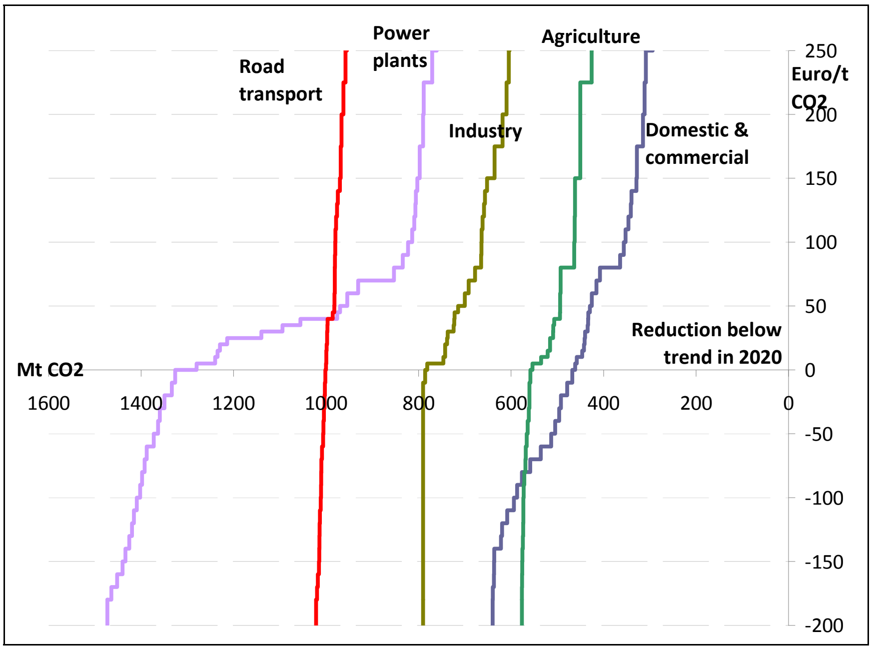

Figure 2: Marginal GHG abatement potential vs. costs for all major sectors relative to baseline emission in 2020 in EU27. [Baseline: IEA WEO2009, lifetime cost accounting, 4% discount rate].

In the trend scenario (IEA WEO 2009) the emissions of the long-lived greenhouse gases from all sectors *except* transport would go down by more than 20% until 2020 and 2030 relative to 1990 levels (Table 1). By contrast, emissions from road transportation in EU27 would stagnate at about 900 Mt CO_2-eq in 2020 to 2030, almost 30% higher than in 1990. Their growth has been driven by strongly increased emissions from trucks (+60% in 2005 vs. 1990) that more than offset efficiency improvements from cars. In the same period transport volumes from cars are projected to increase by 70% and from trucks by 90% in EU27 combined.

Mt CO_2-eq	1990	1995	2000	2005	2010	2020	2030
Road transport	700	772	838	903	878	905	894
Non-road transport (dom.)	155	140	140	143	123	124	117
All other sectors	4614	4270	4072	4017	3632	3651	3665
TOTAL EU27	**5468**	**5181**	**5051**	**5063**	**4632**	**4680**	**4676**
Share road in total	*13%*	*15%*	*17%*	*18%*	*19%*	*19%*	*19%*
Share transport in total	*16%*	*18%*	*19%*	*21%*	*22%*	*22%*	*22%*

Table 1 Greenhouse gas emissions in EU27 [1990 to 2005] and trend projection until 2030, accounting already for economic crisis, for road transport and other sectors (IIASA GAINS, following IEA WEO 2009 for baseline).

Assuming neither a change in transport demand nor a significant reduction of vehicle sizes nor consumer behavior, a quicker introduction of more efficient vehicles and a higher use of biofuels can moderately bring down emissions below these baseline developments. Extra savings of 3% by 2020 and of 4.5% by 2030 could be achieved at no extra costs. Extra emission reductions of 5% and 6% by 2020 and 2030 respectively could become economical for marginal abatement costs of 50 € per ton CO_2-eq abated. Only little extra measures become economical at 100 € per ton CO_2-eq abated. The maximal technically feasible reduction potential is estimated at 8% and 10% below baseline by 2020 and 2030 respectively. The economic mitigation potential becomes larger with time as additional measures starting in 2010 have more time to penetrate the fleet. The potential for improvement is also much larger e.g. in the US where the fleet of passenger cars and light duty vehicles has only recently become more fuel efficient (e.g. An et al., 2007).

The economic reduction potential is lowest for cars with 1% and 3% at marginal abatement costs of 0 and 50 € per ton CO_2-eq abated in 2020 (Figure 3). These reflect the fact that many efficiency measures have already been introduced and are part of the baseline development. Trucks have a technical reduction potential with 4% and 6% emission reduction below baseline at marginal abatement costs of 0 and 50 € per ton CO_2-eq abated in 2020. That cost-efficient abatement measures exist for trucks may surprise at first sight. However, truck holders decide on investments based on a requested payback period of not more than 18 months. This effectively allows only cheap investments and precludes major efficiency gains that are economical over the lifetime of the vehicle. This difference between private and social investment perspectives is an important example where markets do not deliver possible efficiency improvements. In this respect the mitigation potential presented here is an upper (most economic) limit, while the costs are a lower limit, assuming optimal planning and investments. Markets without a different policy framing are more than unlikely to deliver this.

Improvements of the conventional combustion engine and the power train for cars and light duty vehicles are both cheapest and biggest in terms of potential. Better aerodynamics and low-friction tyres are important and cheap measures for trucks. A higher use of biofuels (above mandatory requirements) becomes economical at about 45 € per ton CO_2-eq abated. Hybrid and electric cars would certainly provide a sizeable extra reduction potential. However, with projected high costs notably of the battery their marginal abatement costs are above 200 € per ton CO2-eq. abated[2].

[2] Caveat: If battery and vehicle costs however would come down quicker and/or stronger than assumed here, the reduction potential would increase at lower marginal abatement costs.

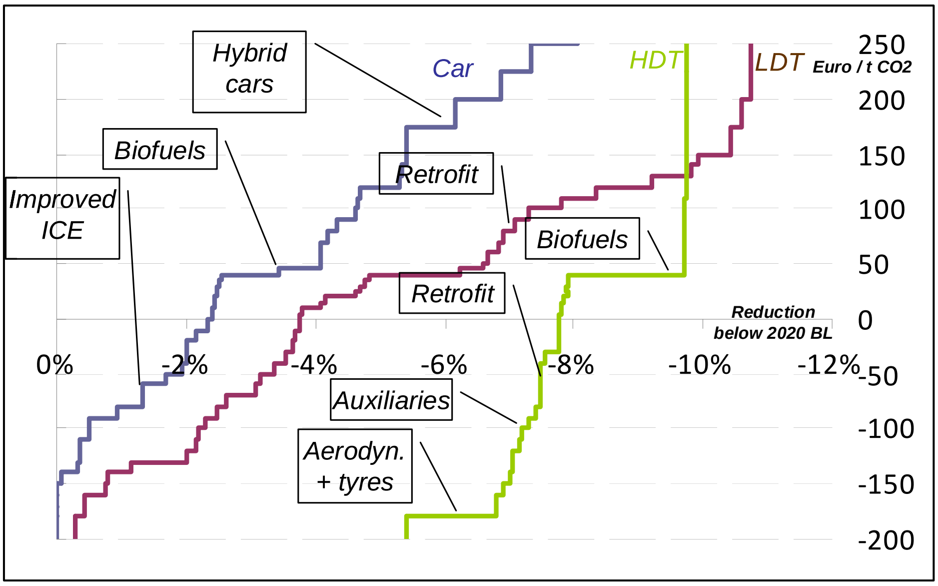

Figure 3: Marginal GHG abatement potential vs. abatement costs for road vehicles in EU27 by 2020. Each step represents one additional technology becoming cost-effective at the respective carbon abatement costs in one of the European Member States. Indicated are major technology packages for cars, light (LDT) and heavy trucks (HDT). [GAINS, with baseline development after IEA WEO2009, lifetime cost accounting, 4% discount rate].

Mitigation costs

Here we calculated how much greenhouse gases could be abated by 2020 and 2030 in industrialised countries, if more efficient technology would be introduced earlier or more widespread than in the baseline development. Leaving transport demand, travel, driving and purchase behaviour unchanged, this means purchase of more efficient vehicles (than in the baseline). These vehicles would require an initial extra investment of about 40 billion Euro in EU27 combined by the year 2020, about 500 Euro extra per car, about 1200 Euro extra per light truck and about 9000 Euros extra per truck (Table 2). About two thirds of these extra costs would be invested in light and heavy duty trucks, the remainder mostly for passenger cars. However, through fuel savings over the lifetime of the vehicle, the initial extra capital investment would pay back. Indeed, most investments would already be cost-efficient at standard fuel prices; the higher the fuel price becomes, e.g. as a consequence of a carbon charge, the more or the earlier an investment in more efficient vehicles will pay back. For instance marginal abatement costs of 60 Euro per ton CO2-eq. abated would equate to a carbon charge of 0.15 Euro per litre gasoline. However, the total mitigation through vehicle technology is also limited by the turnover-time of the fleet. Abatement by vehicle technology either pays off itself through fuel savings or becomes much costlier than in other sectors with marginal abatement costs in the order of 200 Euros per ton CO_2-eq abated. Abatement costs are lower in 2030 than in 2020 as costs for more advanced components, notably the battery for hybrid vehicles, are assumed to decrease significantly[3].

[3] Caveat: If battery and vehicle costs however would come down quicker and/or stronger than assumed here, the reduction potential would increase at lower marginal abatement costs.

	2020				2030			
	Marginal abatement costs [€ per ton CO_2eq]				Marginal abatement costs [€ per ton CO_2eq]			
	0	50	100	Max	0	50	100	Max
Greenhouse gas emissions from transportation [Mt CO_2eq / % reduction below baseline]								
	1000/ -2%	982/ -4%	980/ -4%	955/ -7%	998/ -4%	953/ -8%	944/ -9%	879/ -15%
Number of vehicles that could be improved beyond baseline [mio. veh.]								
Cars	28.3	31.1	31.4	67.7	49.8	49.8	49.8	90.7
LDT	5.9	6.0	6.9	12.5	22	26.1	26.6	26.9
HDT	2.2	2.2	2.2	2.3	4.4	4.4	4.4	4.4
Extra investments for mitigation [bio. Euro]								
Cars	12.4	14.8	15.6	114	2	5	14	100
LDT	7.0	7.3	9.1	21.5	4.1	5.7	6.75	9
HDT	19.1	19.1	19.1	19.2	45	46	46	46
Extra investment per vehicle [Euro]								
Cars	438	476	497	1684	40	100	281	1103
LDT	1186	1217	1319	1720	186	218	254	335
HDT	8682	8682	8682	8348	10230	10455	10455	10455

Table 2 GHG emissions, number of vehicles that could be improved, the required capital investment as a function of the marginal abatement costs in EU27 in years 2020 and 2030. [baseline development: IEA WEO2009, lifetime cost accounting, 4% discount rate].

Discussion

These results are robust for a wide range of future fuel prices and investment costs. However, the cost break-even point critically depends on the payback period required for the initial investment. Therefore markets miss out on more than half the reduction potential as long as payback is required within a few years only. This is particularly pertinent for trucks where existing efficiency potentials are currently not realised by private operators under current market conditions.

Important differences exist between countries and vehicle categories. For instance, the relative reduction potential is larger for the USA and Australia, where light duty vehicles have not been so efficient, than for the EU or Japan (for details consult the GAINS online-database).

Compared to other sectors transportation seems to have higher costs per unit reduction. But given the size of the transport sector, reductions in total national emissions in the order of 20% or more can only be achieved with reductions in the transport sector. Technical measures beyond those assumed in the baseline development have in EU27 combined an extra mitigation potential of 4% by 2020 and 8% by 2030 at marginal abatement costs of up to 100 Euros per ton CO_2-eq abated. Further abatement needs to address travel demand, purchase decisions (notably car weight and engine power) and mode choice.

References

Access to all input data presented here: http://gains.iiasa.ac.at/index.php/gains-annex-1

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