Electromobility: More than just replacing a combustion engine with an electric engine

A sensible component in turning to ecological transport policy – given the right framework conditions


Photo: NABU/Rieger

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The transport sector is still accountable for around one quarter of European greenhouse gas emissions. This proportion has remained constant for years, despite of all the developments in the field of vehicle efficiency. At the same time, the contracting states of the UN Climate Negotiations agreed in Paris to keep global warming well below degrees Celsius, ideally 1.5°C. For the transport sector this obligation represents a CO_2 reduction of 95-100% by 2050[1]*. This means that our mobility needs must be met with practically no emissions in the future. This can only be achieved by ceasing to use fossil energy sources. Electromobility can make an essential contribution to such an almost complete decarbonisation of the transport sector but only if the regulatory framework conditions are set in a sustainable and favourable way.*

German environmental NGO NABU has been involved in the public discussion regarding electromobility for many years. This paper summarises NABU's assessment of technological achievements and assesses this complex policy field from an environmental, health and climate protection point of view.

Electromobility – What are we talking about?

In the public discourse, unfortunately, the term "electromobility" has been equated with electric cars from the very outset. This terminological constriction means that other reasonable, mature and available emobility solutions such as rail transport or pedelecs have been ignored by political decision makers to a great extent. Yet, precisely these areas have already proven to be successful fields of application of emobility and which demonstrate considerable climate protection potential in the short term. In principle, NABU advocates a reinforcement of green transport modes, consisting of public transport, cycling and walking, and promotes not only traffic prevention, but also a shift to these environmentally friendly means of transport in first place. In contrast, private motorised transport, primarily by car, comes at a price of higher external costs for the environment and should therefore be reduced as much as possible. The use of materials and thus of valuable resources, the energy requirements, the land use

[1] Öko-Institut (2014): Klimafreundlicher Verkehr in Deutschland. Weichenstellungen bis 2050.

for parked cars as well as the destruction of landscapes for the purpose of building motorways or bypasses are all disproportionately high due to car use, especially in relation to the duration of use and the occupancy level[2] of the vehicles. This is true even in cases where the combustion engine is replaced by an electric engine.

However, since the public – and above all political – debate is currently focussed primarily on electric cars, this paper shall highlight electric cars, taking also into account the importance of road transport and its respective emissions as well as the urgent need of sustainable solutions for future mobility.

Where do we stand? Technological potential

In 2009 the federal government committed to the goal of putting one million electric cars on Germany's roads by 2020. Measured against this aim, the mid-term results are sobering: According to the Federal Motor Transport Authority (Kraftfahrtbundesamt), 11,000 battery powered and 33,000 hybrid vehicles, which have both an electric and a combustion engine, were registered in 2015[3]. Of these latter, one-third were plug-in hybrids (PHEV), in other words, vehicles that have smaller electric engines and batteries (which can be charged externally), but also a combustion engine. While annual sales figures have increased since 2010 on average by at least 60%[4] compared to each previous year, the current fleet of around 50,000 electric cars[5] (25,000 battery electric plus plug-ins) and 130,000 hybrids means that these drive types continue to play a minor role in light of a total vehicle inventory of 45 million in Germany[6]. At the beginning of 2016, 29 different models by German manufacturers with (partial) electric engines were available on the market.[7] Yet in terms of global turnover, German brands currently lie well behind the sales figures of Nissan, Renault, Citroen, Mitsubishi or new market entries such as BYD from China and Tesla from the US.[8]

According to German law electromobility is defined as "vehicles that are powered by an electric engine and which derive their energy mainly from the power grid, in other words, they can be charged externally."[9] Thus the regulations only cover battery powered, plug-in hybrid and electric cars with range extenders[10] (REEV), as well as fuel cell vehicles. The Electromobility Act defines the parameters of a 40-kilometer range with the exclusive use of an electric engine, and a cap of 50g/CO_2 emissions per km according to the official European driving cycle.[11] This definition is problematic for a number of reasons: The official manufacturers' information on both the range and fuel consumption is calculated using specially prepared vehicles under laboratory conditions, with an ever diminishing correlation between official numbers and actual values under real world driving conditions. The International Council on Clean Transportation (ICCT) recently calculated an average of 40% higher fuel consumption for new vehi-

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[2] The current avarage occupancy level of cars in Germany is 1.5 persons per car. Source: „Mobilität in Deutschland" (2008).
[3] Kraftfahrtbundesamt (2016): Jahresbilanz – Fahrzeugzulassungen im Dezember 2015. http://docs.dpaq.de/10185-pm-2016-01_fahrzeugzulassungen_im_dezember_2015.pdf
[4] Zentrum für Sonnenenergie- und Wasserstoffforschung Baden-Württemberg (ZEW, 2016): http://www.zsw-bw.de/infoportal/presseinformationen/presse-detail/zahl-der-elektroautos-weltweit-auf-13-millionen-gestiegen.html
[5] https://www.vda.de/de/themen/innovation-und-technik/elektromobilitaet/elektromobilitaet-in-deutschland.html
[6] http://www.kba.de/DE/Statistik/Fahrzeuge/Bestand/b_jahresbilanz.html;jsessionid=93A83CCA651286CF352C6DD1FCD05DAA.live2052?nn=644526
[7] https://www.vda.de/de/presse/Pressemeldungen/20150117-elektromobilitaet-braucht-nachhaltige-marktanreize.html
[8] http://www.automobilwoche.de/article/20151128/AGENTURMELDUNGEN/311289995/cam-studie-china-neuer-leitmarkt-der-elektromobilitat
[9] http://www.bmub.bund.de/themen/luft-laerm-verkehr/verkehr/elektromobilitaet/fahrzeugkonzepte-fuer-elektroautos/
[10] Range Extender decirbes a concept where cars are generally driven in a electric mode but where the limited range is extended by an additional combustion engine which provides extra electric energy for driving or charging purposes.
[11] https://www.gesetze-im-internet.de/bundesrecht/emog/gesamt.pdf

cles.[12] In the case of hybrid cars, the deviation is generally even greater, because the current test cycle takes the (theoretical) maximum electric range as a basis, which trims down the fuel consumption even of large SUVs such as the Mitsubishi Outlander PHEV or Porsche Panamera S E-Hybrid with more than 400 PS (on paper) to an incredible 1.8, or 3 litres. As a result official consumption data of battery powered cars and especially of plug-in hybrids is massively airbrushed and has little relation to reality. As well as the theoretical maximum for electric range, it is also important to know if drivers actually do strive to drive their hybrids in electric mode and charge the batteries of their vehicles with green energy. In the case of pure hybrids, without the option of external charging, this is simply not possible at all. Moreover, initial investigations show that also plug-in hybrids are driven in combustion modus disproportionately more often – especially with increasing travel distance[13]. Yet the electric range stated by the manufacturers, currently 30-50 km, is sufficient to cover most of the distance travelled daily[14]. However, the vehicles that have been sold so far were often heavy, inefficient SUVs, mid-sized or saloon cars, which were mostly used as company cars and therefore tended to cover longer distances in combustion engine mode. If, in addition, the employer donates a fuel card with the car, there are additional incentives to continue filling up with diesel and petrol instead of electricity from a private power source. Nevertheless, an increasing share of electricity as fuel is also connected with the risk of a rebound effect, where electricity – which is cheaper than petrol and diesel – makes car driving cheaper and thus leads to increasing car use. This development must be considered and prevented by the legislators when setting the political framework. It must be ensured that plug-in hybrids do only profit from financial subsidies to a much lower extend than all-electric vehicles and accordingly to their electric range. Moreover, vehicles with a very low electric range are not used as a ploy to meet European fleet targets on paper, without any potential CO_2 savings being achieved in reality. This mechanism could be counteracted by dismissing supercredits for electric cars as a way for manufacturers to meet their individual CO_2 targets and by setting a binding quota for new electric vehicle registrations instead. The current CO_2 standards for passenger cars and vans allow multiple accounting of EVs to a manufacturer's annual CO_2 targets (so called "supercredits"), a regulation that undermines CO_2 emission reduction by artificially overrating EV sales[15]. More electric vehicles being supplied to the market, a more impactful market acceleration scheme such as quotas should be considered.

It is also misleading to speak of battery electric vehicles as "zero emission vehicles". Even if we ignore the CO_2 emissions that occur during the production of a vehicle, and consider only – and somewhat pointlessly – greenhouse gases which are emitted solely during driving, still around 600 g CO_2/kWh have to be estimated due to the current German energy mix.[16] An electric powered compact car currently needs between 12 and 25 kWh for a range of 100 km[17], which represents in the best case 72 g CO_2/km,

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[12] ICCT (2015): From Laboratory to Road. http://www.theicct.org/news/real-world-vehicle-fuel-economy-gap-continues-widen-europe-press-release

[13] Fraunhofer ISI (2015): Real-world fuel economy and CO2 emissions of plug-in hybrid vehicles. http://www.isi.fraunhofer.de/isi-wAssets/docs/e-x/working-papers-sustainability-and-innovation/WP01-2015_Real-world-fuel-economy-and-CO2-emissions-of-PHEV_Ploetz-Funke-Jochem-Patrick.pdf as well as TNO (2014): Update analysis of real-world fuel consumption of business passenger cars based on Travelcard Nederland fuelpass data. http://repository.tudelft.nl/search/tno/?q=title%3A%22Update%20analysis%20of%20real-world%20fuel%20consumption%20of%20business%20passenger%20cars%20based%20on%20Travelcard%20Nederland%20fuelpass%20data%22 und IFEU (2015): IFEU (2015): Weiterentwicklung und vertiefte Analyse der Umweltbilanz von Elektrofahrzeugen. http://www.bmub.bund.de/fileadmin/Daten_BMU/Pools/Forschungsdatenbank/fkz_3711_96_113_elektrofahrzeuge_umweltbilanz_bf.pdf

[14] According to the European Commission 80% of today's car fleet is driven less than 65 km per day. https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/individual-mobility-conventional-electric-cars

[15] Regulation 333/2014, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2014.103.01.0015.01.ENG

[16] Umweltbundesamt (2014):, Entwicklung der spezifischen Kohlendioxid-Emissionen des deutschen Strommix in den Jahren 1990 bis 2013.

[17] ADAC (2014): Autotest: VW E-Golf. http://www.adac.de/_ext/itr/tests/Autotest/AT5134_VW_e_Golf/VW_e_Golf.pdf

but can also quickly exceed the current European fleet target for new vehicles of 130 g/km. Thus electric cars are emission-free in operation only when they are powered by green electricity. The same applies to air pollution emissions of the vehicles which, though generally absent locally, can be considerable elsewhere due to the production of coal-fired power. To reduce traffic-induced greenhouse gas emissions, therefore, it is not sufficient to look at direct emissions alone, but also to correctly balance energy sources, production, and upstream chain of all raw materials used. For this lifecycle observation the German Environment Ministry assumes an additional 63 g CO_2/km for a present-day electric car, compared to 42 g CO_2/km for a car with a combustion engine.[18] Overall, however, in a lifecycle assessment electric cars do already have a slight environmental benefit compared to conventional vehicles, and will show an even better balance in the coming years given an accelerated uptake of renewable energy.[19] While significantly higher amounts of greenhouse gases are emitted during the production of electric cars, especially due to the energy-intense battery production, a battery electric vehicle nevertheless rates almost 25% more climate efficient over its whole lifespan than a combustion engine car , even when considering the German energy mix. It is obvious: The greater the green power share in the energy mix, the fewer CO_2 emissions are released per kilometre travelled. Climate-friendly emobility and the associated increasing demand for green power therefore once more underline the necessity of a rapid expansion of renewable energy capacities. Nevertheless, energy efficiency must also be maintained here, which is why the early and timely introduction of respective regulations in parallel with the further development of CO_2 limit values are necessary. These could inter alia provide the required impulse for the engines' further down-sizing and lightweight construction, for it is also true of electromobility: The lighter and less motorised the vehicle, the less battery performance is necessary in order to reach a reasonable range.

The public discourse is also dominated by aspects such as range anxiety, potential customers' fear to be limited by an electric car's lower autonomy compared to conventional cars due to limited battery capacity. Further market obstacles are a higher purchase price at a time when oil prices are at a historic low as well as lacking charging infrastructure. Indeed, the battery technology must still make considerable advances in order to increase power density and thus also enable potentially longer distance rides, but above all to significantly reduce vehicle weight. Such developments can also be used for industrial policy purposes by manufacturing the next battery and cell generation in Germany or Europe.[20] The current distribution of charging infrastructure is also currently regarded as insufficient: in its third report in 2014, the National Platform for Electromobility – an industry platform set up by the government to accelerate EV market roll-out – assumed that up to 150,000 charging stations would be necessary in Germany; at present there are 4,800 charging points in the country at around 2,400 locations, as well as some 150 super chargers.[21] The following is noted with a view to the further development of the sector: in principle it does not appear advisable to develop expensive infrastructure without the necessary demand – especially if these are public funds that could be spent more effectively for the reinforcement of more sustainable modes of transport. Rather, the main priority should be to create the prerequisites for barrier-free charging, for example by means of increased interoperability

[18] BMUB (2015): Wie klimafreundlich sind Elektroautos? http://www.bmub.bund.de/fileadmin/Daten_BMU/Download_PDF/Verkehr/emob_klimabilanz_2015_bf.pdf

[19] IFEU (2015): Weiterentwicklung und vertiefte Analyse der Umweltbilanz von Elektrofahrzeugen. http://www.bmub.bund.de/fileadmin/Daten_BMU/Pools/Forschungsdatenbank/fkz_3711_96_113_elektrofahrzeuge_umweltbilanz_bf.pdf

[20] For requirements needed in order tos et up next-gen battery cell production in Germany e.g. see: Nationale Plattform Elektromobilität (2016): Roadmap integrierte Zell- und Batterieproduktion Deutschland. http://nationale-plattform-elektromobilitaet.de/fileadmin/user_upload/Redaktion/NPE_AG2_Roadmap_Zellfertigung.pdf

[21] https://www.bundesregierung.de/Content/DE/Artikel/2015/03/2015-03-27-elektromobilitaetsgesetz-bundesrat-beschluss.html

and harmonisation of the charging and billing systems. In addition, the question should be addressed as to when and where a certain number of public charging points will be needed, in line with the actual determined requirements. Initial user studies show that both private and commercial users mainly use the charging points that are available in their own garages or on company property, which indicates that there is only moderate need for an additional public charging infrastructure. If, in addition, car-sharing providers, supermarket chains or other service providers also offered charging infrastructure in the context of customer service and loyalty, sufficient supply can be ensured without any major public investment. Moreover, we can assume that the increased range and coverage of electric cars will further limit the need for additional charging infrastructure. Take a look at filling stations: while in 1970 there were some 46,000 filling stations throughout the Germany, the network has now been consolidated to only around 14,000. This is due to the increased range of petrol and diesel vehicles and thus a decreased need to fill up frequently.

Policy context: Transport sector needs to reduce emissions

International, European and national climate protection obligations and targets form the policy framework on climate policy to which all of Germany's transport and mobility policies must be directed.

As well as Germany's commitment to aim to limit global warming preferably to 1.5°C, the energy concept of the federal government foresees a reduction in greenhouse gas emissions by 2050 of 80-95% compared to 1990 levels. The transport sector is responsible for almost 20% of German greenhouse gas emissions, however, to date there is no specific CO_2 target, but merely a target with regard to the reduction of energy needs by 40% by 2050, compared with the base year 2005.[22] In fact, the transport sector has not only been unable to reduce its emissions since 1990; instead they even rose slightly, by 0.6%.[23] According to a study in 2014 by Öko-Institut, the 95% reduction in emissions that is necessary in the transport sector can be achieved only if political framework conditions are laid out at an early stage aimed at traffic avoidance and shift, increased efficiency and alternative motors and decarbonised fuels.[24] Based on current knowledge, therefore, mostly electromobility in combination with renewable energy seems a realistic and promising way when it comes to road transport. In the automotive country Germany electromobility is being discussed not only with regard to climate change, but also industrial policy. NABU does not see this as a contradiction, but rather as a chance to set the right agenda with sustainable technologies.

As early as 2009, the government adopted a national development plan for electromobility, and in 2011, the national programme for electromobility, which foresaw in particular investment in research and development for market preparation. The participating departments are, in the first instance, the ministries for transport (BMVI), research (BMBF), economic affairs (BMWi) and environment (BMUB), but also individual federal states and municipalities by means of funding projects and display-case regions. As a consequence, by mid-2015, around 1.5 billion Euro in state subventions had been given to emobility projects.[25] In parallel, in 2015 an Electromobility Act was passed, which aims to allow municipalities to create privileges for electric cars by mean of

[22] Bundesverkehrsministerium: Mobilitäts- und Kraftstoffstrategie. https://www.bmvi.de/SharedDocs/DE/Anlage/UI-MKS/mks-strategie-final.pdf?__blob=publicationFile
[23] Umweltbundesamt (2015): Daten zur Umwelt 2015. https://www.umweltbundesamt.de/presse/presseinformationen/daten-zur-umwelt-zeigen-verkehr-beim-klimaschutz
[24] Öko-Institut (2014): Klimafreundlicher Verkehr in Deutschland. Weichenstellungen bis 2050.
[25] https://www.tagesschau.de/wirtschaft/elektroautos-105.html

changes to traffic regulations, for example with regard to preferential parking and fees, exemptions from restricted access or the permitted use of bus lanes. Electric cars are already exempt from car tax in the years 2016 – 2020. The annual counter value of this tax cut represents around 50 Euro per vehicle. Furthermore, an adjustment of the taxable monetary advantage for electric commercial vehicles has also been passed.[26] Whether these regulatory and fiscal measures represent a serious incentive to purchase the more expensive electric cars is questionable. NABU estimates that they may even be counterproductive with regard to their effect on the climate, as can be seen from the example of the opening of bus lanes to electric cars. It is already the case today that buses, taxis and cyclists compete for limited space in the bus lanes. Allowing access to electric cars too will negatively impact traffic and thus to the lower attractiveness of public transport and bicycles. The social acceptance of electric cars is likely to suffer, for example when highly motorised SUVs with plug-in technology block up bus lanes of the cities and towns. Municipalities should therefore refrain from allowing electric cars to use bus lanes, providing free parking.

Elements to expand electromobility are also anchored in the National Mobility and Fuel Strategy (MKS), which foresees, among other things, a stronger dovetailing of the transport and energy sectors and the diversification of energy providers, e.g. by expanding electromobility. However, except for a reference to insufficient public charging infrastructure and procurement, it remains unclear how this will be driven concretely.[27] In addition, the EU directive "Clean Power for Transport" foresees such a massive expansion of alternative filling and charging infrastructure[28]. It has been implemented at national level due to the charging station regulation[29]. Last but not least, the federal government's Climate Protection Action Plan 2020, from 2014, also refers to the necessary decarbonisation of the transport sector, however without explicitly mentioning electromobility. The continuation of the action programme as Climate Protection Plan 2050 should introduce the necessary precision on this point.

Potential of electro-mobility

Electromobility combines the possibilities of environmental and climate protection that cannot be achieved with cars running on combustion engines, despite all actual increases in efficiency, consumption and noise protection regulations and European emissions standards. This is especially true when it comes to efficiency. The conventional combustion engine can use only 30 percent of the energy consumed to drive the car. Electric engines, in contrast, reach more than 90 percent. While road traffic in Europe now causes around one-third of total national energy consumptions, this share could be lowered to 14% due to increased efficiency, if all vehicles were powered electrically. However, the technology can unfold its potential only if the right incentives are provided from the very outset. Fitting heavy and high-horsepower vehicles with an additional electric engine does not make them eco-friendly. These vehicles remain energy inefficient. Since humanity is currently a long way from covering its energy needs solely from renewable sources, every single extra kilowatt hours used in traffic damages the environment. Potential benefits to the climate arise only if a mostly electricity-based energy supply of the transport sector was interlinked closely to the expan-

[26] FÖS (2015): Schaffung von Kaufanreizen für besonders emissionsarme Pkw. http://www.foes.de/pdf/2015-02-Kaufanreize-Emissionsarme-Fahrzeuge.pdf
[27] Bundesverkehrsministerium: Mobilitäts- und Kraftstoffstrategie. https://www.bmvi.de/SharedDocs/DE/Anlage/UI-MKS/mks-strategie-final.pdf?__blob=publicationFile
[28] Directive 2014/94/EU on the deployment of alternative fuels infrastructure. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0094&from=EN
[29] "Ladesäulenverordnung I and II". http://www.bgbl.de/xaver/bgbl/start.xav?startbk=Bundesanzeiger_BGBl&jumpTo=bgbl116s0457.pdf#__bgbl__%2F%2F*[%40attr_id%3D%27bgbl116s0457.pdf%27]__1460705979128

sion of renewable energy capacities. Specifically, the share of renewable energies has to be increased rapidly, and strategies to integrate cars into an intelligent power network must be developed and supported with the necessary infrastructure. At the same time, energy efficiency targets must be passed for all vehicles, in order to ensure an appropriate vehicle design, weight and engine performance, also in the area of electromobility. Electric cars must therefore also be as efficient as possible and have low energy consumption, in order to limit the additionally required capacity of renewable energy. The implementation of an environmentally sound energy transition already is a great challenge these days, the expansion of wind energy plants and the necessary power network infrastructure is fighting for acceptance today in many regions. For this reason, we cannot build an additional and random amount of capacity or plants on top to cater for transport policy.

Furthermore, the purposes for which electric cars are used is also relevant. Today's ranges have led to the fact that electric cars are used primarily in urban spaces, and not in the countryside. Yet cities tend to have a comparatively well-developed public transport system, with a much better climate balance, so that the car – with a few exceptions – is per se the worst option. Therefore, electric cars should be used primarily wherever public transport is poorly developed, rather than in competition with it. But where there is already a more or less well developed public transport system today, greater emphasis should be placed on electrifying the drivetrains. Particularly the buses of the communal transport services provide a considerable potential here, to be driven first as hybrid vehicles, and later increasingly fully electric. The possibility should also be examined here – depending on local factors – of using trolleybuses as an alternative to battery electric vehicles. Car-sharing is in any case a better alternative to private ownership, as this leads to a reduced number of vehicles and thus land use in public spaces by parked cars. The combination of electromobility and car-sharing makes sense especially when most shared cars are used for short journeys, where combustion engines have a disadvantage and the exhaust gas abatement technology often does not reach operating temperature, with the result that it does not work properly. For the area of inner-city delivery transport, electric-powered vehicles are preferable to conventional commercial vehicles with diesel engines. Particularly for urban areas there should be rigid emphasis on replacing mopeds with electric mopeds and e-bikes. Access restrictions should be introduced for small motorbikes with two-stroke combustions engines. There is also a considerable need for action regarding railways. Although 90 percent of the trains' transport performance is already being provided electrically in Germany, only 59 percent of the railway network is electrified. Germany is poor in this regard, when compared to the rest of Europe.[30]

Moreover, an honest review of the electric cars' environmental and climate lifecycle balance must also take into account the raw materials used and the resource intensity of the products. Electric engines and current battery technology, for example, require critical raw materials such as rare earths, whose extraction in their countries of origin – such as China – leads to considerable pollution and environmental devastation as well as radioactive pollution due to antiquated mining management. The violation of human rights at the extraction sites is also considerable. Other raw materials such as cobalt, lithium or copper can and must be recycled and reused, yet the energy required for this process can exceed that used for the production of primary copper. In order to truly achieve a positive environmental and climate balance with electric cars, the numbers of vehicles (and thus raw materials) within must be reduced significantly. In addition, obligatory usage cascades must be defined from the very beginning, where

[30] https://www.allianz-pro-schiene.de/themen/aktuell/elektromobilitaet-verkehrstraeger-uebergreifend-foerdern/

manufacturers are responsible for the receipt of returns, the reuse and ultimately the proper disposal of batteries e.g. in the sense of comprehensive product responsibility.

Instruments to promote low-emission cars

In principle, both financial and regulatory instruments are available to help electric cars prevail. Not only must existing competitive disadvantages for electric vehicles be reduced or removed, but the framework conditions must also be changed in such a way that electric cars are economically advantageous to both private and commercial customers from a total-cost-of-ownership perspective, when compared to a car with a combustion engine. In addition, the framework conditions for conventional vehicles must also be laid out in such a manner that they become increasingly unattractive due to financial considerations or restrictive measures such as access restrictions, and as a consequence their purchase is waived either completely or in favour of an electric vehicle.

Financial instruments

A successive adjustment of energy tax ("mineral oil tax") should make the consumption of fossil fuels much more expensive and thus create incentives for an increased use of renewable energies, also in the transport sector. Furthermore, car tax must take greater account of the factor of environmental pollution and thus disadvantage those vehicles with combustion engines, weighted in accordance with their CO_2 emissions, compared with electric cars. A car toll based on performance, time and pollutants[31], the so-called "intelligent toll", could also have a similar effect. A technology- and revenue-neutral purchase premium for low-emission vehicles, financed reciprocally by a special levy on high-consumption vehicles (bonus-malus regulation), could generate the desired effect. The same applies to special depreciation for commercial vehicles, which could also have a strong effect if, in parallel, depreciation models are adapted for climate-damaging vehicles and expanded by a malus. In both cases, the subsidy rates or tax benefits provided should be degressive, i.e. become less from year to year. The revenue-neutral financing via road transport, and a link with an ecological steering effect for the future car fleet, are essential for the success, respectively the environmental benefits of buying incentives.

At any event, financial incentives in the area of electric cars must not mean that public investment in more sustainable means of transport such as railways, buses or cycling is expanded to a lesser degree or even reduced.

Since battery technology is one of the central factors for the success or failure of electromobility, the state should provide public research funds for research and development, in order to advance the development of the next battery generation.

Regulatory instruments

As well as monetary incentives, there is a whole series of regulatory levers that could act as positive triggers: The European CO_2 limits have proven to be effective means for reducing the CO_2 emissions of conventional vehicles, which is why an ambitious fleet target must also be set for 2025. There should be no crediting of electric cars with 0 g CO_2/km, nor should this factor be increased by so-called "supercredits", which credit the sale of one electric car a number of times, thus making a manufacturer's fleet appear greener than it actually is. In order to force manufacturers to maintain efficiency also in the area of (partially) electrified vehicles, binding energy efficiency targets must be imposed. It is also conceivable to introduce a quota that prescribes for manufacturers the proportion of electric engines in all new cars sold, in addition to fleet targets for CO_2 emissions which remain the most effective way to promote low-emission cars. Ambitious CO_2 fleet targets and energy efficiency requirements should also be established as binding procurement directives for vehicles in the area of public service fleets, and they should also be introduced into tender directives, in order to generate additional demand for low-emission vehicles.[32] This applies not only to electric cars, but also to buses. Here, ambitious consumption limits should encourage transport companies to carry out a successive conversion of their bus fleets towards electric engines, and trigger corresponding procurement by the state.

A speed limit on motorways would also have a positive effect, in that higher speeds with a disproportionately high energy consumption would be ruled out. The further development of environmental zones ("blue sticker" [33]), or access restrictions in cities for highly pollutant vehicles, would also be a step in the right direction, as electric vehicles would be categorised in principle in the best possible emissions class, and would therefore be allowed access.

NABU's policy recommendations

The politically motivated target of having one million electric cars on the road by 2020 is not an advance in itself, either in terms of transport, climate or environmental policy. Neither is it for Germany as an industrial location, nor for any kind of lead market or nature conservancy and climate protection. Rather, it is more important that the electrification of drivetrains is embedded in an integrated overall strategy for a mobility transition. In the area of private motorised transport, there is first the necessity to reduce the number of cars dramatically, to make vehicles much more efficient, and to convince motorists to switch to more sustainable modes of transport and to use car-sharing options.

Consequently, from an environmental perspective it may be better to reach the mark of one million vehicles as late as 2025 than to promote much too heavy, resource-intensive and high-consumption plug-in cars with public money. SUVs and sports cars weighing almost 2300 kg and with a performance of over 350 horsepower have nothing to do with a modern, sustainable transport policy – in spite of electric engines.

NABU demands

- the tightening of CO_2 limits for new vehicles (without supercredits for electric vehicles) and the introduction of energy efficiency targets for electric cars in 2025;
- a binding electric car quota for manufacturers, which can be an effective to CO_2 targets;
- an ecological tax reform, especially in the field of energy taxation e.g. by increasing the "mineral oil tax" and the abolition of subventions for diesel;
- technology-neutral purchase premiums for ultra-low-emission vehicles (decreasing over time and graded according to CO_2 emissions), as long as counter-

[32] The green public procurement directive's transport criteria are being reviewed this year on EU level http://ec.europa.eu/environment/gpp/pdf/tbr/transport_tbr.pdf

financing is foreseen with ecological steering elements (bonus-malus regulation)[34]; Plug-in Hybrid must not profit from subsidies to the same extend than all-electric cars.

- that public fleets must procure the most efficient vehicles possible. European CO_2 fleet target should be binding in nature for the average fuel consumption of the fleets;
- that transport companies electrify their bus fleets successively;
- an integrated concept from the government and the federal states, which dovetails electromobility with the expansion targets for renewable energy, network expansion and intelligent charging;
- an honest balancing of the raw materials and resources consumption of electric cars, as well as the anchoring of the principle of product responsibility for manufacturers (receipt of returns, recycling, second-life use);
- the promotion of research and development with public funds, especially in the area of battery technology ("2nd battery generation");
- urban entrance prohibition for vehicles with high pollutant emissions (further development of low emission zones); a general speed limit on motorways; the introduction of a car toll based on performance, time and pollutants/"intelligent toll" to finance the infrastructure;
- a general access restriction in city centres for small motorbikes with two-stroke engines;
- that municipalities do not avail of the option to allow electric cars to use bus lanes or to enjoy free parking;
- the clear expansion of electrification to existing railway lines and the use of hybrid locomotives; the expansion of tram networks in cities.

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