MOBILITY & VEHICLE MECHANICS

https://doi.org/10.24874/mvm.2022.48.02.01
UDC: 62.838

EUROPEAN POLICY ON FUTURE ROAD MOBILITY - TECHNOLOGY NEUTRALITY RIGHT OF WAY OR HEADED IN THE WRONG DIRECTION?

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Received in August 2022 *Revised in September 2022* *Accepted in October 2022*

RESEARCH ARTICLE

ABSTRACT: The EU policy with the compulsion towards electromobility in the road and off-road vehicle sector and with an exclusive focus on driving operation (Tank-to-Wheel) and neglecting of the relevant processes of vehicle production (Cradle-to-Gate), energy supply (Well-to-Tank) as well as recycling (End-of-Life) leads to an ideological ecological distortion ignoring the boundary conditions of a free market economy. Parallel options for propulsion and fuel/energy systems have to be admissible. A return of the policy towards technology openness and scientific facts is essential.

KEY WORDS: *E-vehicle, technology-neutrality, EU policy*

EVROPSKA POLITIKA O BUDUĆOJ MOBILNOSTI NA PUTEVIMA - TEHNOLOŠKA NEUTRALNOST ISPRAVAN PUT ILI SE KRENULO U POGREŠNOM PRAVCU?

REZIME: Politika EU isforsirano okrenuta ka elektromobilnosti u sektoru drumskih i terenskih vozila i sa isključivim fokusom na vožnju (Tank-to-Wheel) i zanemarivanje relevantnih procesa proizvodnje vozila (Cradle-to-Gate), energije snabdevanje (Well-to-Tank) kao i reciklaže (End-of-Life) dovode do ideološke ekološke distorzije koja ignoriše granične uslove slobodne tržišne ekonomije. Paralelne opcije za pogon i sisteme za snabdevanje gorivom/energijom moraju biti prihvatljive. Povratak politike ka tehnološkoj otvorenosti i naučnim činjenicama je od suštinskog značaja.

KLJUČNE REČI: *E-vozilo, tehnološka neutralnost, politika EU*

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INTRODUCTION

Climate change and environmental pollution are an existential threat to the world. A sustainable approach must examine the effects of the respective measures on all ecological fields of action - local and global emissions, energy efficiency and noise emissions (see Figure 1). The political and societal objective is to limit global warming to 1.5°C. The European Union (EU) set ambitious greenhouse gas (GHG) emission reduction targets in the wake of the climate change conferences in Paris in 2015, Marrakech in 2016, Bonn in 2017 and Katowice in 2018. To achieve this challenging global warming limit, the "European Green Deal" has been established by the EU on July, 14th 2021 to reduce global emissions (greenhouse gas emissions) compared to 1990 levels by 55% by 2030 and to ensure no net emissions of greenhouse gases (resp. CO2 equivalent) by 2050. Furthermore, economic growth shall be decoupled from resource use. On this path, every sector – so also the transport sector – has to achieve these challenging goals. By now, transport global emissions represent around 25% of the total greenhouse gas emissions in the EU (and 20% in Germany). In order to achieve climate-neutrality in the EU by 2050, ambitious targets in the transport sector are set by EU emission regulations. This means a 90% reduction (sic!) in transport-related greenhouse gas emissions by 2050.

Passenger cars and vans are respectively responsible for around 12% and 2.5%, trucks and heavy-duty vehicles for 5,4% of the total EU emissions of CO2, which is the main greenhouse gas, see Figure 2.

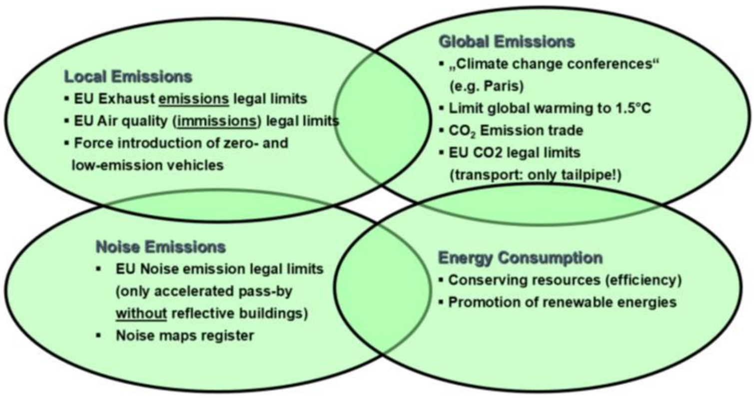

Figure 1. "Holistic" environmental protection as an overriding objective (Source: Pütz, R.)

Starting in the years 2025 and 2030, Regulation (EU) 2019/631 sets stricter EU fleet-wide CO2 emission targets for cars and vans, whereas Regulation (EU) 2019/1242 introduced stricter CO2 fleet targets for heavy-duty vehicles. All these targets

are defined as a percentage reduction from the 2021 starting points:

•Cars: 15% reduction from 2025 on and 37.5% reduction from 2030 on

•Vans: 15% reduction from 2025 on and 31% reduction from 2030 on

•Trucks: 15% reduction from 2025 on and 30% reduction from 2030 on

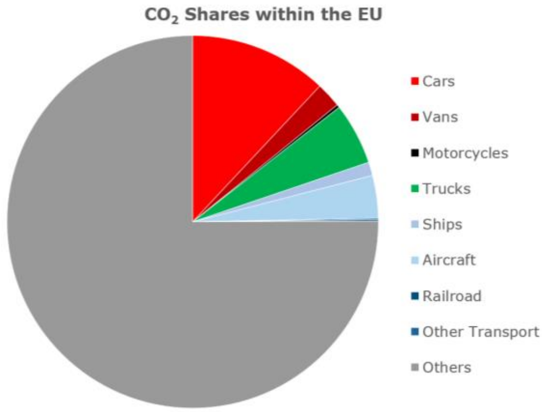

Figure 2. Contribution of the EU Transport Sector to the EU global Emissions in 2022 (Source: Statista)

The annual specific emission targets of each manufacturer will be based on these EU fleet-wide targets, taking into account the average test mass of its newly registered vehicles. If the average CO2 emissions of a manufacturer's fleet exceed its specific emission target in a given year, the manufacturer has to pay – for each of its vehicles newly registered in that year – an excess emissions premium of €95 per g/km of target exceedance. Besides, manufacturers are required to ensure correspondence between the CO2 emissions recorded in the certificates of conformity of their vehicles and the CO2 emissions of vehicles in service.

Heavy-duty vehicles, as trucks, buses and coaches, are responsible for about a quarter of CO2 emissions from road transport in the EU and for about 6% of total EU greenhouse-gas emissions. Due to increasing road freight traffic, these emissions are still rising.

The EU-wide CO2 emission standards mentioned above also include a mechanism to force the introduction of zero- and low-emission vehicles. The explicit weak point of these regulations is that only the operation part (tank-to-wheel) of the several options is covered, whereas a holistic analysis covering also the energy supply (well-to-tank), vehicle production (cradle-to-gate) and recycling/disposal (gate-to-end-of-life) is indispensable for a truly resilient evaluation of environmental impacts of different propulsion options and to hence ensure a technology-neutral way. For a comprehensive ecological and economic evaluation of vehicle fleets of different power drives and fuel types all stations of the lifecycle of transport systems must be included in the analysis, namely:

•Vehicle production (Cradle-to-Gate; CtG) and, if applicable, recovery/disposal,
•Fuel availability (Well-to-Tank; WtT),
•Driving mode (Tank-to-Wheel; TtW) and
•Maintenance

Since the isolated view of only looking at the actual driving operation can lead to completely false conclusions. Only in this way can targeted solutions be identified for transport systems with both low local and global emissions and increased energy efficiency and reduced noise in the context of a holistic ecological integrity (see Figure 2 for example PT bus). The subsystems highlighted in green form the PT system, which allows a comprehensive ecological and economic analysis. In the analysis of emissions, the main locally effective criteria are particulate and nitrogen oxide emissions and the main globally effective criteria are CO2 emissions (CO2 equivalent), the effects of which can be summarised as the ecological profile of a propulsion technology by determining their external costs.

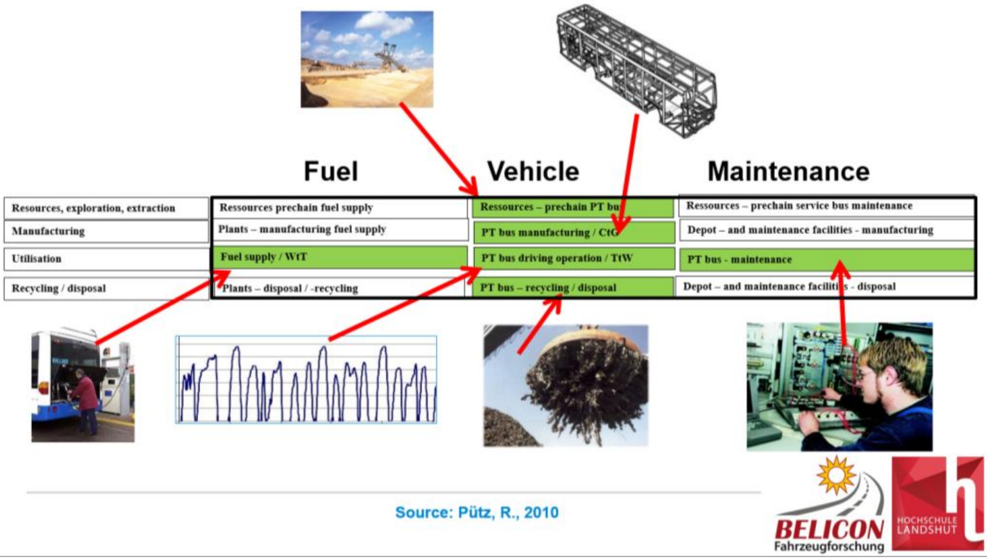

Figure 3. Ecological Systems Approach with Subsystems (example: PT Bus)

In fact, the actual regulations intend to exclusively promote electro-mobility with batteries and/or fuel cells. A further downfall of technology-neutrality is the compulsion to buy quotas of electric buses as laid down in the so-called “Clean Vehicles Directive” (Regulation (EU) 2019/1161). After the amended directive came into force, 45 percent of procurements are initially to consist of "clean vehicles" by 2026, half of which are to be "zero-emission vehicles", and by 2030 as much as 65 percent of procurements are to consist of "clean vehicles". Emission-free vehicles" are defined in the directive as vehicles with no local emissions and no direct emissions of CO2 (see Figure 3). What should be understood by "clean" fuels in connection with this is listed in the EU Directive 2014/94/EU v. 22.10.2014 (Directive on the Development of Alternative Fuels Infrastructure, so-called "DAFI Directive"). In addition, the "Renewable Energy Directive" defines targets for renewable energy quotas in the EU, according to which these should amount to at least 30 per cent at EU level in 2030 and at least 14 per cent in the transport sector.

The same political intention is to be identified in the proposals for EU Regulations on local emissions. A final legislative proposal for Euro 7 (cars) and Euro VII (trucks and buses) is expected in 2022, with introduction targeted for 2025 at the earliest, according to the current status. The aim is to maintain the lowest possible emission values in all conceivable driving situations in real-world operation over a driving distance of 1.2 million km and a lifetime of 15 years. Lowest cold-start emissions of e.g. 100-150 mg NOx/kWh in the WHTC engine type test cycle and permanent on-board emission monitoring supplement these extremely high requirements. In addition, new limit values for nano-particles PN10 and nitrous oxide N_2O will be introduced.

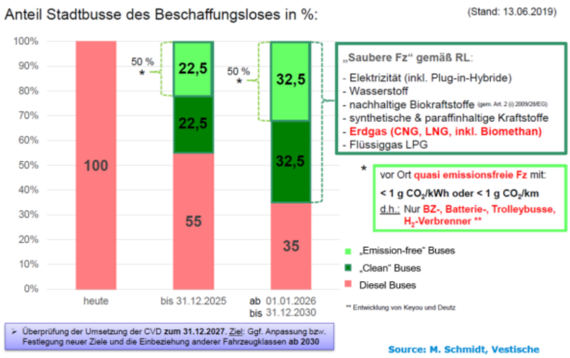

Figure 4. Fixed Quotas for the tendering of new PT buses over time acc. to EU "Clean Vehicles Directive".

There are also concrete plans in the EU to no longer allow new cars with combustion engines from 2035. The latest decisions do fortunately provide for an exemption for internal combustion engines that run on synthetically produced regenerative fuels, so-called e-fuels (or respective e-gases). But in general, a rather tendentious EU transport policy focusing explicitly on e-mobility seems to neglect the propagated and necessary technology-neutrality in the form of effective regulations and instead reveals a technology dictate which is not appropriate and not acceptable for a free market economy.

In order to achieve its ecological objectives, the EU policy provides for coupled political measures as so-called "transitions", which, in addition to the necessary "energy transition" towards the exclusive use of renewable energy, also considers a "mobility transition" (avoidance of traffic, shifting individual transport to public transport) and a "propulsion transition" (exclusive use of electric mobility) to be necessary (see Figure 4). But is a propulsion transition objectively really necessary? In the following, the actual status of local and global emissions from combustion engines in real driving cycles are discussed against the background of the EU´s emission policy. In line with the author's research focus, the emphasis here is on heavy-duty commercial vehicles and mobile machinery.

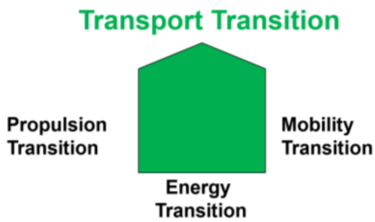

Figure 5. Derived coupled policy measures: "Drive, Energy and Mobility Transitions"

1. ANALYSIS OF THE FIELDS OF ACTION FOR LOCAL EMISSIONS

The EU political focus just on local tailpipe emissions ignores the provision of raw materials and energies for vehicle production including propulsion systems and storages (cradle-to-gate), the production of final energy including distribution – that means provision of fuel and electricity (well-to-tank) – and recycling and disposal (gate-to-end of life), but these subsystems are also very relevant and must be taken into account for a resilient holistic ecological (and economical) balancing. Whereas the intended elimination of pollutants like particles (particulate mass PM and particulate numbers PN) and nitrogen oxides (NO, NO_2, N_2O) is absolutely reasonable, the elimination of CO_2 from the tailpipe is completely irrelevant because global emissions work globally and it´s merely irrelevant if CO_2 is emitted tank-to-wheel or well-to-tank or cradle-to-gate and gate-to-end of life (see Figures 2 and 5). Furthermore, it is indispensable to consider and compare all technical measures within a holistic view because any ecological improvement must also be reflected in the required costs and its social influences – that means every technological measure must also be affordable (see Figure 6).

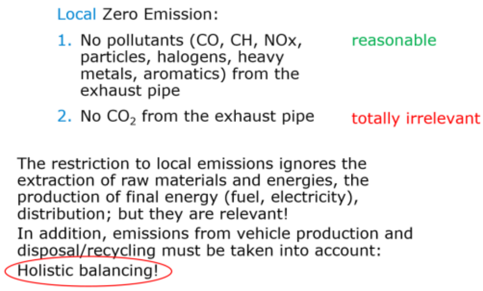

Figure 6. Target: Tailpipe emission-free driving only for pollutants reasonable.

Figure 7. Indispensable: All measures require a holistic view (Source: Bosch)

Concerning particulate emissions, Figure 7 shows for a PT Diesel bus of stage Euro VI with DPF that the intake air (here dirty ambient air) contains significantly more particles than the exhaust gas. Ambient air is thus actually cleaned in the process, a. positive effect which is not possible with battery or fuel cell propulsion.

Figure 8 shows the measured values from the real operation of articulated PT buses in urban traffic with ‘stop-and-go operation’ for a line with demanding topography. On the left, the emission ratio of a Euro V and, on the right, a Euro VI articulated bus are shown respectively. The rise in the exhaust gas temperatures profiles (in green) after about 20 minutes of operation reveal a steep incline of the road. The Euro V articulated bus shown on the left generates high NO emissions after the cold start, which settle down after less than 10 minutes. The Euro VI articulated bus shown on the right emits lower emissions than the operation-ready Euro V articulated bus even at cold start. With the Euro VI articulated bus shown on the right, nitrogen oxide emissions are already at ambient air level after just 10 minutes due to effective SCR exhaust gas after-treatment. Incidentally, the same also applies to Diesel engines in heavy tractors, see Figure 9.

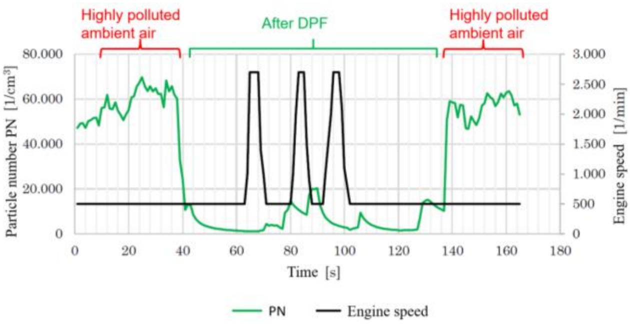

Figure 8. Particulate Emission of a Euro VI Diesel bus before/after Diesel Particulate Filter (DPF) (Source: Löw, J./Pütz, R.)

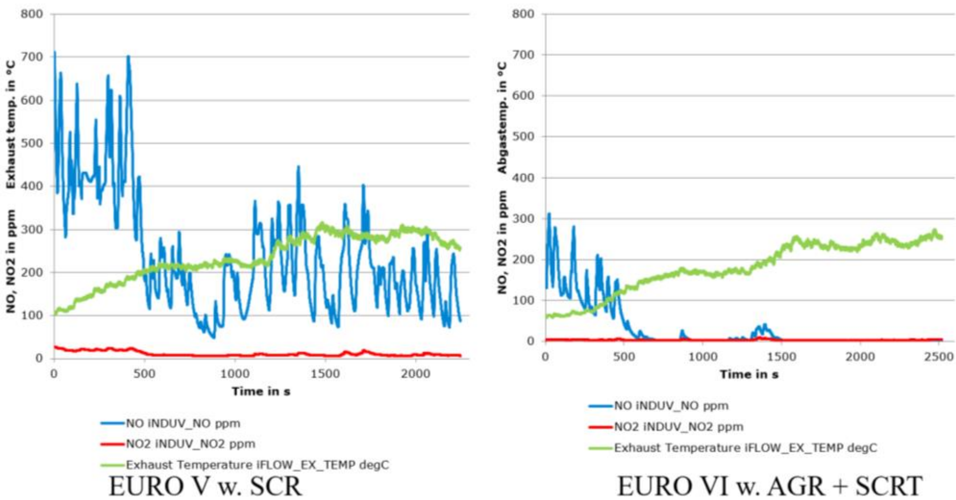

Figure 9. Comparison of NOx Emissions in Euro V/EEV and Euro VI articulated Diesel Buses after cold start on a very demanding city route with steep inclination (Source: BELICON/Pütz, R.)

Even if the ecological assessment with the systems approach shown in Figure 2 reveals for only the locally effective emissions in driving operation for the time horizon "today" advantages in favour of the alternative electric drive options due to the local zero emissions onsite, however, this advantage must be put into perspective in view of the "near-zero emissions" achieved with the Euro VI level for conventional internal combustion engine drives. The local emissions from driving operations today only account for around 4 to 5 percent of the total environmental profile for a Euro VI bus fleet under the above-mentioned boundary conditions, see Figure 10. To sum up, the local pollutant emissions of modern, exhaust-gas after-treated Euro VI (CV) and 6d (cars) combustion engines are already uncritical and negligible even in very demanding driving situations.

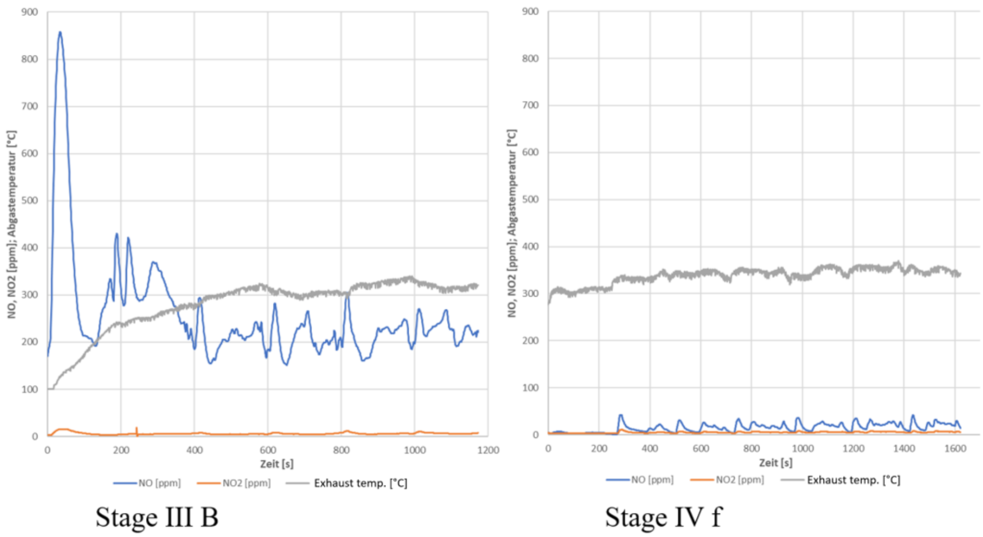

Figure 10. Comparison of Stage III B and Stage IV f tractors: Nitrogen oxide emissions in heavy arable farming (Source: Strixner, M./Pütz, R.)

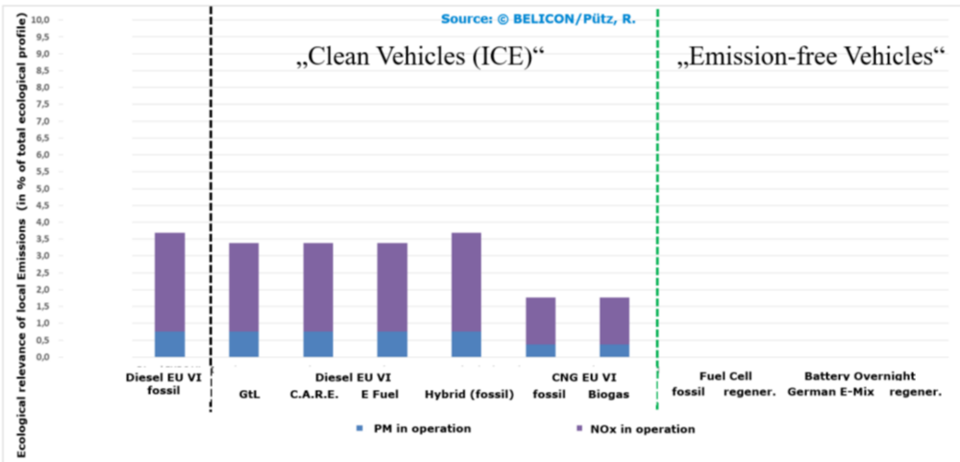

Figure 11. Local environmental relevance in the operation of a real bus fleet (time horizon "today") (Source: BELICON/Pütz, R.)

2. ANALYSIS OF THE FIELD OF ACTION FOR GLOBAL EMISSIONS

Global net anthropogenic GHG emissions have continued to rise during the last decades. Encouragingly, the global CO_2 intensity decreased by 0.3% per year between 2010 and 2019 which is a positive sign. The latest report of the political organization IPCC (International Panel on Climate Change) leaves no doubt about the urgent necessity to dramatically cut GHG emissions. To limit earth's warming to 1.5°C GHG emissions need to be cut by 45% by 2030, compared to 2019 levels. The EU´s "New Green Deal" even goes beyond this recommendation and set the goal to reduce its global emission levels by 55% by 2030. Against the background of the intended ban on highly clean combustion engines, it makes sense to first analyze the global share of anthropogenic CO_2 emissions and hereby those from the transport sector, which is done in Figure 11. In 2020 the contribution of the transport sector has been about 0,6 % of the worldwide CO_2 equivalent which amounts to 14% of the total anthropogenic contribution which itself accounts for only 4.2% of total global CO_2 emission equivalent. Since the EU sees itself as a pioneer in global climate protection it is necessary to quantify the EU´s "leverage effect". This requires a look at the world's largest CO_2 emitters, see figure 12. It can be seen that the largest CO_2 emitter within the EU – Germany – contributes only 1,85% of global CO_2 emissions (the second largest CO2 emitter within the EU is Italy with 0,93% of global CO_2 emissions. Against this background, the EU's ideological goals on climate change seem to be almost ineffective.

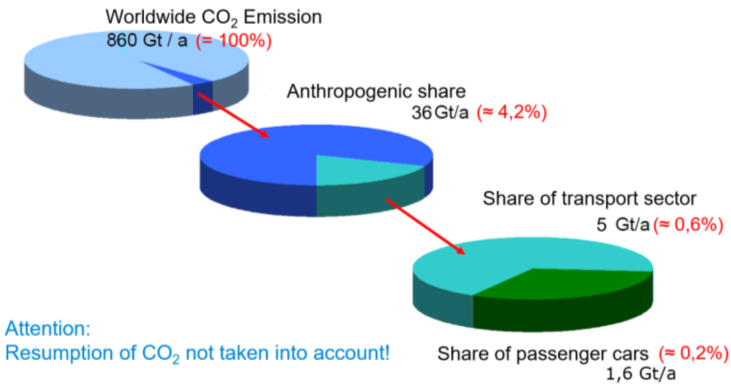

Figure 12. Worldwide annual CO2 emissions in 2020 (Source: UNEP)

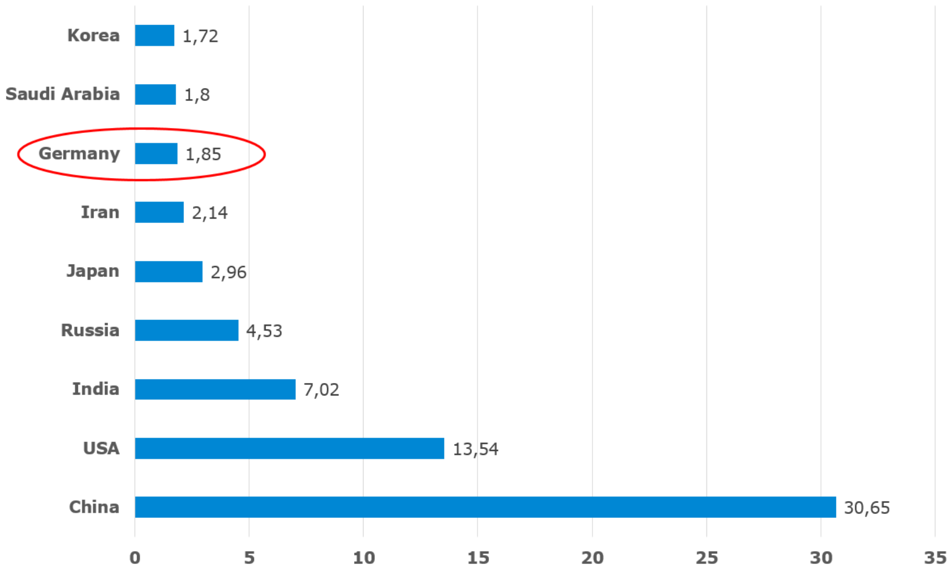

Figure 13. The world's largest CO2 emitters in 2021 (share in %; Source: GCP, Statista)

Today the only need for action is with regard to the use of renewable fuels to significantly reduce globally effective emissions (GHG) and to conserve fossil resources. The ecological assessment of only the globally effective emissions for the time horizon “today” shows a significant dominance of global emissions in the overall ecological profile (external costs) according to the systems approach shown in Figure 2. In terms of global emissions, highly significant improvements compared to the fossil Diesel Euro VI PT bus would be achievable through the use of HVO (C.A.R.E. Diesel), E-Fuels (PtL; Power-to-Liquids) and biogas from waste. With these regenerative fuels in ICE (internal combustion engines) already today also the same GHG emission level as with the alternative drive variants of the spectrum electro-mobility with exclusively renewable energy is achievable, see Figure 13. So the EU political ideology exclusively towards the options of electro-mobility with the elimination of combustion engines is neither comprehensible nor reflects the technology-neutrality which is indispensable in a free market economy.

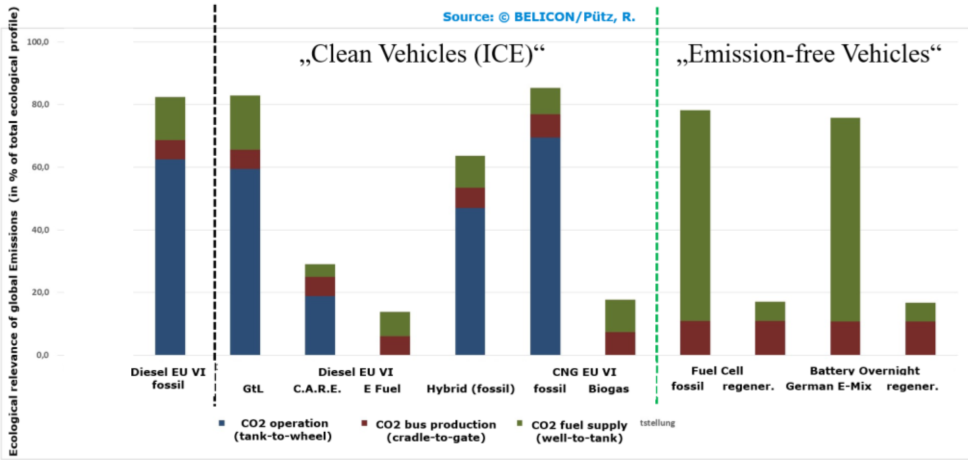

Figure 14. Global environmental relevance of a real bus fleet (time horizon "today") (Source: BELICON/Pütz, R.)

3. ANALYSIS OF THE FIELDS OF ACTION FOR ENERGY CONSUMPTION AND RANGE

A typical Diesel PT bus with a relatively small 350 litre tank has a range of over 1.000 km and only needs to be refuelled every two to three days. In contrast, solo battery buses with a 350 kWh battery and a usable capacity of 300 kWh only reach about 300 km in the best case at around 21°C ambient temperature. In winter times when both battery and passenger compartment have to be heated the range is reduced significantly, see Figure 14. The majority of today's battery buses only manage a range of 160-180 km at best anyway. If the limited passenger capacity due to the high battery weight is also considered, at least two – and in extreme cases four (!) – electrical overnight-charger buses are needed to replace one diesel bus. Figure 15 shows the operational profile of a typical optimized German PT bus fleet. About two thirds of the buses have daily operational ranges of more than 200 km and hardly any stopping time at the terminal stops of the lines. This proves the cost-intensive necessity of additional buses and of course their drivers (the latter amount to half of km cost). These extra cost in the loss-making public transport sector must be provided from public funds. Rhetorical question: Did EU policy take this fact into account in the decisive EU Clean Bus Directive which demands mandatory quotas for E-buses?

Comparable conditions apply to long-haul trucks. While typical long-haul trucks have a range of 3.000 km on one tank of fuel, prototype battery trucks actually have a ranges of only around 500 km and fuel cell trucks reach 1.000 km - with the potential for a 1.500 km range. What is missing today is a sufficient, nationwide energy distribution and refuelling infrastructure for electricity and hydrogen. The cost for their establishment are likely to be immense. In contrast, E-fuels as liquid fuels and methanised E-gases can be used in the existing infrastructure.

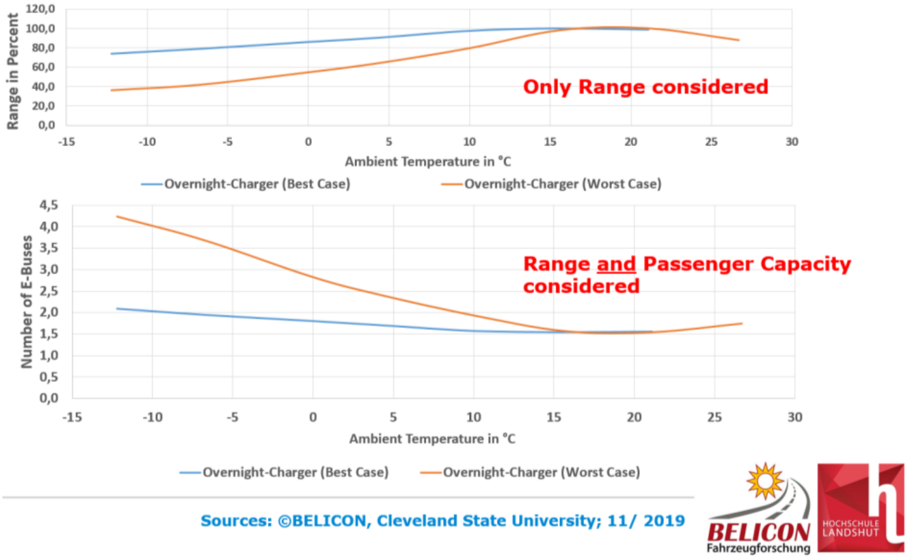

Figure 15. Range depending on ambient Temperature and Passenger Capacity of Overnight-Charger E-Buses (Sources: BELICON/Pütz, R., Cleveland State University)

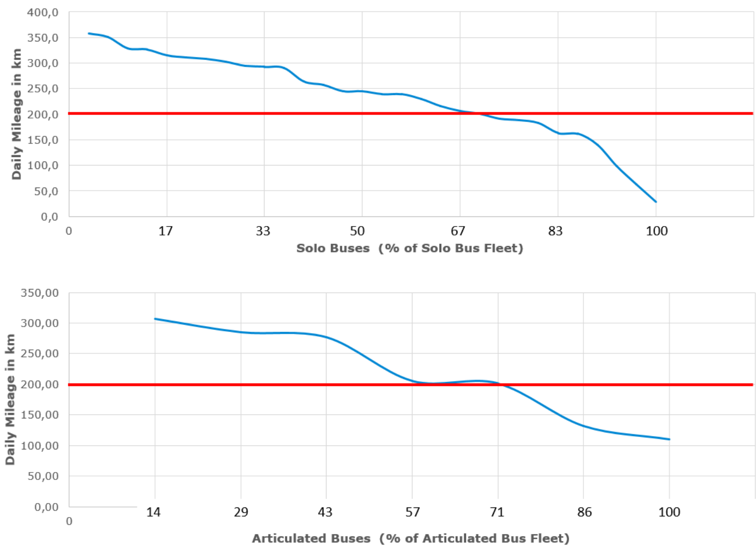

Figure 16. Daily milage on a typical day in school time for a typical German PT bus operator (Source: BELICON/Pütz)

4. ANALYSIS OF THE TOTAL ECOLOGICAL AND ECONOMICAL PROFILES AND OUTLOOK

The overall ecological assessment for the time horizon "today" according the model in Figure 2 shows that for comprehensive sustainability – taking into account local and global emissions as well as energy consumption – the modern Euro VI Diesel fleet is already adequately positioned and today, with the German electricity mix, hardly any to no improvements are achieved through the procurement of alternative electric drive variants, although according to the EU Clean Vehicles Directive all electric vehicles are even declared as "emission-free" regardless of the electricity mix. In the near future and also in the long term, therefore, there would be de facto no ecological need to abandon ICE technology, especially since further ecological potential can be tapped with E-Fuels, see Figure 16. The use of E-fuels (via water electrolysis with regenerative electricity and CO_2 from the air or from power plants; produced in areas with sufficient regenerative primary energy such as North Africa, Southern Europe, etc.) would offer the ecological optimum from today's perspective.

However, the calculation with the average power plant electricity mix, as applied here and in other studies, is merely a whitewash, because the fluctuating residual load must mainly be covered by controllable power plants. In concrete terms, this means that if the demand for charging power increases, only fossil-fuel power plants are ramped up, so that instead of the average power mix, a fossil-fuel power mix is more likely to be used. This worsens the eco-balance of electro-mobility. Figure 17 shows this effect using a typical passenger car as example.

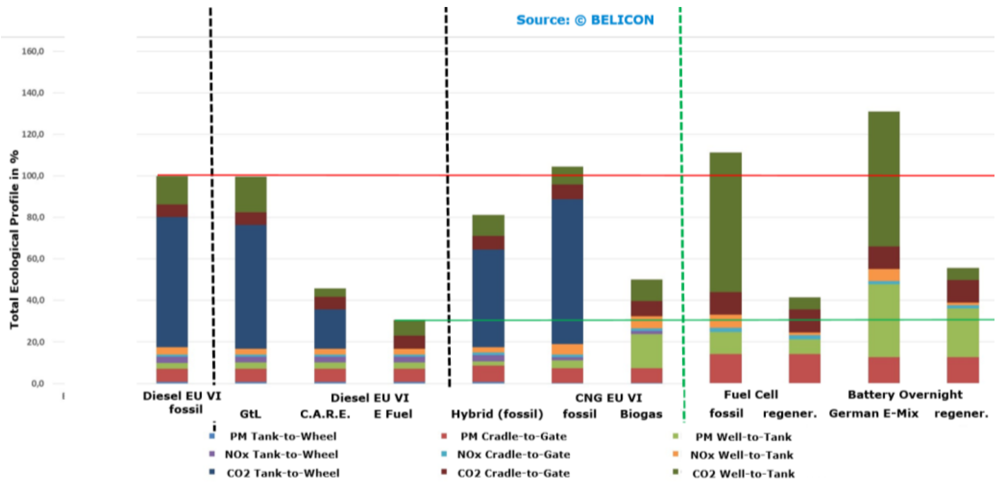

Figure 17. System-related total environmental relevance of a real German PT bus fleet for the time horizon "today" (Source: BELICON/Pütz)

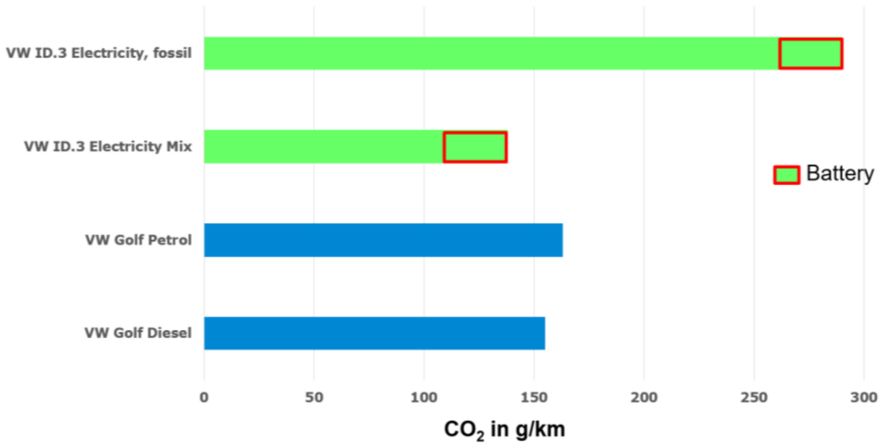

Figure 18. Comparison of CO2 emissions of electric cars using electricity mix and electricity from fossil power plants; electric cars in green (Source: Ruhsert, K.)

In order to objectify the "real" additional cost of the alternative electric options forced by the EU, any vehicle and infrastructure subsidies are disregarded here, as these funding only brings initial relief anyway. The overall economic evaluation of the pure vehicle costs (including infrastructure) depending on the drive technology for the time horizon "today" with an usual depreciation period of 10 years is shown in Figure 18.

It is initially assumed here – against the realities shown in Figures 14 and 15 – that no additional vehicles will be required for battery electric mobility (here: overnight chargers), as it is assumed to be possible to overplan the timetable with possibly lower timetable efficiency. Nevertheless, today the vehicle cost for overnight-charger battery buses have at least to be doubled if not rather tripled, compare with Figure 14. So for overnight-charger buses this means vehicle cost of three to more than five times compared to Diesel buses. Not included here are additional costs due to today in general still lower availability of the electric mobility options (FC hybrid and battery technologies), since according to statements by the German vehicle manufacturers, the same availability as for buses with ICE can be expected in the short term. Also not included are the opefigure 19

rational costs for the necessary transition to daily "refuelling" in the case of FC hybrid and overnight charger battery buses as well as possible additional vehicles when using overnight charging due to the lower passenger capacity (due to the still heavy battery technology) and obligatory electric heating, which can significantly reduce the range in winter as already described.

If among the variety of options only the ecologically targeted options are considered, the use of HVO Diesel fuel (C.A.R.E. Diesel) today requires only slightly more than 3 percent higher vehicle costs, while the use of E-fuels would increase vehicle costs by more than 85 percent. The use of natural gas engines with biogas from waste would increase vehicle cost by more than 22 percent. In contrast, the electromobility options today would require for an overnight charger fleet a significant increase in cost by almost 67 percent. In economic terms, the fuel cell hybrid bus is still far behind, with additional cost of over 140 percent. These "real" market costs make it necessary to massively fund electromobility, which should definitely be continued in the coming procurement years. The use of E-fuels in Diesel engines is already at the cost level of the electromobility options today – regardless of the significant industrialisation potential.

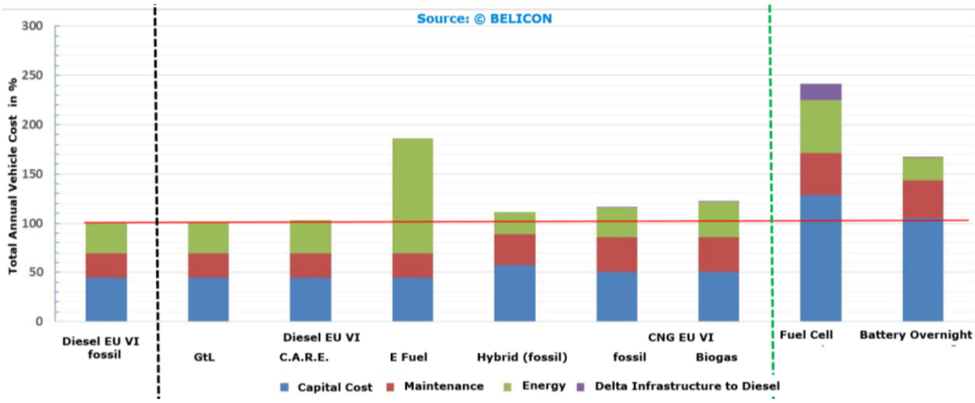

Figure 19. Relative vehicle cost of a real German PT bus fleet "today" - without subsidies (Source: BELICON/Pütz)

The economic evaluation for the time horizon "medium term" (2030) is hardly possible at present, as the Russia-Ukraine war makes a development of fuel prices hardly resilient. For this reason, no outlook can be given here. With regard to the investment costs for electromobility, however, a highly significant cost degression of the energy storage system (batteries) can be assumed, but still a replacement battery over the (up to 18-year) operational service life of the (first) operator in Western Europe is very likely because today, it can be assumed that the service life of batteries in average public transport use is hardly more than "half the life of a bus". A significant cost degression can also be expected for the fuel cell (FC) technology and for E-Fuels. For the latter, production cost of less than one €/l are expected in the medium term. Although electromobility has advantages in terms of energy efficiency compared to the "ICE + e-fuel" approach, this does not play a single role if the excessive availability of renewable energy in regions as North Africa, Patagonia, Australia, Asia etc. is used, see Figure 19. Whereas an on-shore windmill in Germany in average only achieves 1.500 full load hours per year (at maximum 2.500 hours) a windmill in Patagonia achieves up to 5.200 hours per year. The same applies to photovoltaic systems: While in Germany only around 970 full load hours per year can be achieved, in Morocco around 2.350 full load hours can be expected.

In the context of being technology-neutral, the German Energy Agency (dena) anticipates in the long term for Germany a parallel, equal existence of electrical and non-electrical final energy applications within the framework of scenarios for combined energy and power transitions, whose proportional representation in this respect is still completely open (see Figure 20). It is undisputed that the predominant use of regenerative energy must replace the fossil fuel economy soon, but the propulsion technology does not have to be an electric motor. Locally highly clean, reliable and robust ICE have an equal existence – if professional expertise unmasks pure political ideology, see Figure 21. By the way: The increasing share of electricity from fluctuating renewable energies endangers grid stability without countermeasures. Load management should synchronize the load peaks with the regenerative electricity production peaks and make a larger share of the producible green electricity usable. Electric cars do not really help here, they in fact destabilize the grid even more. An example: In order to charge only 3 % of the approximately 50 million cars in Germany simultaneously with only 50 kW charging power, twice of the grid power capacity would be required, which is not feasible in the foreseeable future. With electro-mobility, there is less of an energy problem than a grid problem - and additionally a storage problem. In this context, 50 kW charging power is rather moderate, because most fast-charging stations for cars, e.g. from Tesla, have charging powers between 150 and 250 kW. In the commercial vehicle sector, even charging powers of 500 kW are currently being tested. The grid capacity required for the latter increases the grid problem significantly.

The fossil energy demand in Europe before the start of the Corona pandemic was around 17.100 TWh. In order to be able to replace this demand with renewable energies, more than 2,9 million (sic!) new wind turbines would have to be installed in Europe in addition to the 82.000 already existing. With regard to photovoltaics, the calculation would look similar: The current photovoltaic area of just under 2.100 km^2 would have to be increased to around 230.000 km^2. The decision-makers in the EU should be aware that this would require a fundamentally new electricity grid capacity – as well as the utopia that these figures reflect.

To sum up, the old wisdom that "many roads lead to Rome" should definitely as well be accepted by the EU policy – for the sake of neutrality to technology and a free market economy!

The author as a neutral and for decades experienced scientist takes the perhaps impudent liberty of addressing the following note to the persons responsible for EU transport policy: Quidquid agis, prudenter agas et respice finem!.

Figure 20. Targeted production regions for E-fuels (Source: frontier)

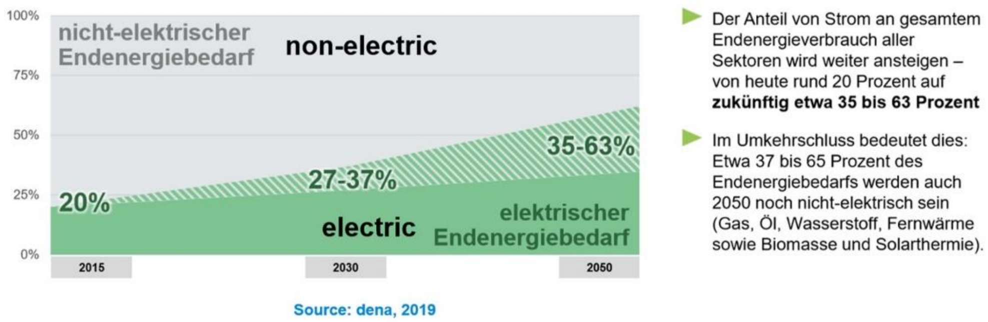

Figure 21. Use of renewable Energies @ end-user over Time (Source: dena)

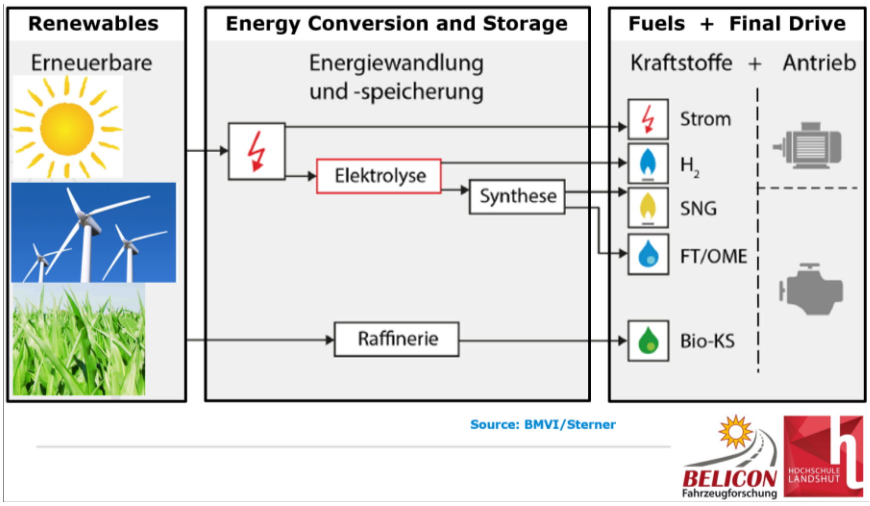

Figure 22. Renewable Energies are the key, but the final drive is still open (Source: BMVI/Sterner)

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