Decarbonizing Europe – Will the Transportation Sector Undermine This Policy?

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Abstract

In the European Union, 90 per cent of all transport activities continue to rely on petroleum products, and the transportation sector currently accounts for about 25 per cent of total CO_2 emissions. The EU's climate policy has set itself the target to reduce overall greenhouse gas emissions by 80 to 95 per cent in 2050. For the transport sector, the European Commission has already mandated a sector-specific reduction target of 60 per cent of $C0_2$ emissions by 2050.

Our paper discusses the challenges resulting from this ambitious target. It addresses the question whether the envisaged transformation of the transport sector can be successfully implemented. Our analysis focuses on e-mobility and fuel economy standards as preferred policy measures as well as the potential contribution of the existing EU emission trading system (ETS) in achieving the decarbonization goal effectively and efficiently.

1. Introduction

The transport systems of the EU member states has been changing fundamentally since the first oil crisis in the seventies. Technical progress, new organizational models and a comprehensive deregulation of the transport markets improved the efficiency of all transport modes. An efficient transport sector enables production and distribution solutions for industry and retail companies which increase the economic welfare of society as a whole and create new mobility options for all strata of the population. Energy efficiency has also improved significantly ever since. However, 90 % of transport activities in the EU still depend on the use of fossil fuels (European Commission 2011, p. 3). Globally, more than 50 % of oil consumption is accounted to the transport sector. Together with an increasing number of vehicles used in developing countries transport's share in global oil consumption will be soaring (Engerer and Kunert 2015, S. 779), because the potential for the substitution of fossil fuels seems to be limited compared to other sectors given the state of alternative technologies.

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Overall transport has improved its eco-friendliness significantly, but the strong growth of transport activities during the last decades compensated a significant portion of the achieved specific emission reductions. This is especially true with regard to the carbon footprint of transport; accordingly, the EU's climate policy addresses the transport sectors as one of the big challenges for its success, because transport is the only sector of the economy that was not able to reduce its greenhouse gas emissions since 1990.

The following paper therefore focusses on the question whether energy transition and the reduction of its carbon footprint can be successful achieved in the transport sector. It also deals with the role of transport for the use of fossil resources and the resulting emissions of greenhouse gases.

2. Transport, Environment, Energy: An Inventory

In 2010, the global transport sector consumed 2.200 megatons of oil equivalents (mtoe). This corresponds to about 19 % of the global energy supply. About three quarters of the energy consumed is used for road transportation (including 52 % for car traffic and 17% for freight traffic). The shares of aviation and shipping traffic are 10 % each, whereas the energy demand for railways only adds up to 3 %. Looking at the growth rates during the last few decades, energy demand related to transport since 1990 in the OECD member states has grown significantly faster than it has in the non-OECD countries, whereby the dynamics in the first group have accelerated. The largest growth rates are currently recorded for international shipping and aviation (World Energy Council 2011).

The worldwide fuel consumption in road transport has risen from 1.4 million kilotons in the year 2000 to 1.8 million kilotons today. The growth mainly took place in the non-OECD and BRIC countries. With regard to the shares of individual fuel types, an uneven picture emerges. Whereas regular fuel consumption (especially unleaded fuel) has declined in the most OECD countries, it has strongly increased in the rest of the world. By contrast, the demand for diesel fuel has risen worldwide in this period. Thus diesel fuel holds a share of 45 % of total fuel turnover worldwide, but over 70 % in the EU (Engerer and Kunert 2015, p. 779).

The shares of the different transport sectors to the global greenhouse gas emissions vary accordingly. The transport sector was responsible for 23 % of the global greenhouse gas emissions with 7 Gt of CO_2-equivalents and has experienced higher emission growth rates than any other sector in the last few years. 72 % of the emissions are produced by the road sector, 9 % by international shipping and around 10 % by aviation (Sims et al. 2014). Under status quo conditions, it is to be expected that the greenhouse gas emissions of the transport sector will double up to 2050 (International Energy Agency 2013).

The final energy demand in the EU in the year 2010 amounted to about 365 Mtoe. This amounted to 20 % of the global gross energy consumption of about 1,760 Mtoe or 31 % of the final energy consumption of 1.160 Mtoe. The sector-specific energy demand of the EU's transport industry stood at 17 % of the global transport-related energy demand; it also represented around 3 % of the total energy demand worldwide.

The energy consumption of the EU's transport sector was based for more than 95 % on fossil resources. 52 % of the energy consumption came from passenger road transport, 31 % from road freight transport, while the rail transport only claimed 2 % of the energy. In addition, 14 % of the energy demand in the transport sector was used for aviation and 2 % for inland navigation (European Commission 2014). However, in assessing these percentages one should bear in mind the respective modal shares of the different modes of transport. Therefore, in the reference year, the road transport ratio for goods transport came up to 72.4 % ton kilometers in the EU, while the rail share only amounted to 16.2 %. In the passenger transport market 73.4 % of the transport volumes were realized by road vehicles while a mere 6.2 % were produced by the railways. Aviation represented 8.2 % of the passenger kilometers in 2010 (European Commission 2014a).

For the future, the European Commission expects in their scenario report 2050 a further strong traffic growth at least until 2030. According to their analysis, road transport will retain its dominating role in the transport market, even when the car's market share will decline to 76 % by 2050 and the share of road freight will decrease to 70 %. Vice versa, the rail should reach market shares of 10 % in passenger transport in the year 2050 due to higher presumed growth rates– especially because of expansion of high-speed train traffic – and of 18% in freight traffic. The modal share of passenger aviation should increase from 8 to 12% (European Commission 2014).

While transport activities and the demand for energy were relatively closely linked in the past, the EU Commission expects a gradual decoupling over the next 40 years. This forecast is based on implemented and proposed political measures to increase the energy efficiency of cars and light utility vehicles (in particular regulation through fuel economy standards) as well as on the assumption of future technological and organizational measures to increase energy efficiency (i.e. in aviation or with respect to heavy goods road vehicles). The Commission further assumes (strongly) rising prices for fossil fuels as an essential driver of this development; in total, it expects the energy demand of transport sector, despite an average growth of traffic activities by 40% across all modes until 2050, to remain approximately constant. In this status quo scenario the greenhouse gas emissions of the traffic sector would be reduced by 8% despite considerably higher traffic performance. Obviously however, this scenario is only consistent with the propagated 2 degrees goal in climate policy if all other sectors bear the burden of adjustment by accomplishing a correspondingly higher absolute greenhouse gas reduction (European Commission 2014).

Therefore the European Commission has set the demanding target of reducing EU-wide greenhouse gas emissions by 80 to 95 % until 2050. To reach this target a nearly complete decarbonization of the economy would be necessary. First and foremost, the energy industry in particular, but also the transport sector would have to be restructured fundamentally. For transport the specific targets of the European Commission are a reduction of greenhouse emissions by 20 % until 2030 and by 60 % until 2050. This means a reduction by 70 % compared to 2008 because transport is the only sector of the economy which did not achieve decreasing emissions since 1990 (European Commission 2011).

3. Policy Measures

3.1. General Options

With respect to decarbonization of the transport sector, the pertinent literature focuses on three general concepts:

- The most obvious and often named possibility to reduce the use of resources and greenhouse gas emissions stemming from transport activities is simply the avoidance of (unnecessary) traffic. Despite social skepticism towards transport and its environmental effects, the avoidance of traffic is not feasible viewed objectively, as the economic and utility losses of traffic avoidance would be economically significant. From an economical point of view it is a given that all relevant externalities should be correctly internalized; once achieved, any additional normatively-affirmatively motivated limitation of traffic (“unnecessary” traffic) cannot be justified economically. In other words, this variety of traffic restrictions and interventionistic limitations in general does not withstand an economic cost-benefit analysis (Eisenkopf 2006).
- A commonly addressed aim in transport policy is the shift of traffic to more energy efficient and more eco-friendly modes of transport, i.e. the “improvement of the modal split” in terms of sustainability (as a way to internalize environmental externalities). To realize this aim, push and pull factors are at the disposal of policymakers. Push strategies are based on regulatory and pricing measures that reduce the attractiveness of a resource-intensive mode of transport for the user. Pricing measures would include tolls or the additional taxation of input factors of those traffic activities; regulatory measures could be designed as guidelines for mode-specific shifting or energy reducing goals. In contrast, push strategies should enhance the attractiveness of resource extensive modes of transport: Mutatis mutandis policymakers would make use of subsidies from public funds (or maybe use charges from the users of competitive carriers) to reach the desired modal shift by politically reducing prices of their preferred traffic alternatives. A central element of the pull strategy will be the infrastructure policy; the idea is an expansion of the infrastructure for the relatively more eco-friendly transport modes.

- Generally, a reduction of resources used by the transport sector is possible when its efficiency can be improved. Increases in efficiency take place especially by continuous or disruptive innovations, which can be of technological, as well as of organizational nature. To be addressed are, for example, fuel economy standards of cars, improved traffic management systems or a better integration of the different modes of transport. In addition, the replacement of fossil fuel consuming engines in vehicles through electric motors (electric mobility) is especially relevant in this context. Depending on the market situation a more intensive inter- or intramodal competition could enhance the efficiency of transport. Political instruments to reinforce such efficiency improvements can be design and/or emission standards (e.g. greenhouse gas emission standards for vehicle fleets) as well as specific technological support measures. However, the efficiency of governmental regulated efficiency enhancement programs has to be critically verified.

Yet furthermore, general economic and structural limitations also influence the efficiency of a society’s transport system. For example settlement patterns and spatial structure of the economy – which, in turn, are influenced by policymakers through a variety of regional and structural policies - are as relevant in this context as the incentive effects of the tax system.

3.2. Options for Modal Shift

3.2.1. Modal Shift in the European Freight Transport

The tension between continuous transport growth and the strain on natural resources will become particularly relevant in freight transport because this segment has grown above average in the course of the completion of the Single European Market (since it was formally established in 1986) and the globalization process, with a further large increase being expected for the foreseeable future (OECD/ITF 2015). According to the EU’s current transport policy the main contribution to designing a sustainable transport system should be provided from the shift from road transport to the railways and inland waterways. Accordingly, the political target is to shift 30 % of road transport over distance in excess of 300 km (186.4 statute miles) to these alternative modes by 2030, and over 50 % until 2050. Efficient and eco-friendly freight transport corridors are discussed to facilitate this transition.

At first glance, such a shifting scenario could be interpreted as a regulatory interference in the free choice among competing transport modes. However, there are no corresponding indications in the EU Commission’s White Paper for such plans (European Commission 2011). Nevertheless, it makes no mention at all what specific measures are to be taken to implement the intended modal shift change. Although the redesign of the transport-related taxes and duties, and the charging for external costs, are routinely and vaguely addressed as potential levers, in view of the past experiences with the effects of certain newly introduced price signals (i.e. the introduction of truck road tolls in Germany) only a prohibitive tax increase (i.e. accordingly high greenhouse gas emissions charge) or intervening regulatory political measures appear to be effective in achieving such a large-scale modal shift.

Comparing the external costs of road traffic and the railways in the freight sector, all pertinent studies show that rail freight transport produces substantially less emissions per transport unit. This also holds for the greenhouse gas emissions that are directly related to the usage of fossil energy sources (Ricardo-AEA 2012). However, the means of transport with the lowest external costs or least greenhouse gas emissions is not necessarily the most favorable instrument to solve a specific transport task. A transport, which has to be handled several times due to the usage of the railway generally, ceteris paribus means higher overall costs for the customer. In most cases, also transport duration is typically substantially longer. Moreover, cargo shippers often complain about the bad quality and the lack of punctuality of railway transports, especially for cross-border intra-EU links. An isolated shifting strategy from the road to the railway would therefore possibly lead to significant utility losses for the economy as a whole (Eisenkopf 2006).

Economically and politically viable sustainability concepts for freight transport have additionally to take note of the influence of general political restrictions. A large amount of the transport increase in the last 15 years is based on the completion of the single market in general and on the integration of the 10 new Eastern European member states in 2005-07. If the deepening and widening of economic integration among current member states (even after the Brexit decision in the UK) and the further expansion of the EU (e.g. towards the Balkans) remain politically desirable, additional traffic will be hardly avoidable. The key question therefore arises how the unchanged integration objectives of the EU should be accommodated in a resource-efficient way in the transport sector.

A complete shift of freight transport in the EU to the railways probably cannot realistically be put into practice given the currently existing and planned future infrastructure capacities. In the year 2012, rail freight services in the EU provided 407 billion tkm, and road transport stood at 1,693 billion tkm. This corresponds to a modal-split-share for the rail of about 17 % (European Commission 2014a). If only a quarter of the current performance of the public road transport was to be shifted to the rail, the volume of the rail freight services would double, and the required extra infrastructure capacities would have to be designed, financed and built accordingly (US-style operational measure such as longer trains and the use of double-stack container wagons cannot be implemented in the EU due to insurmountable technical limitations of the existing infrastructure, e.g. i.a. the limited light height of tunnels). Furthermore, the predicted increase of transport activities would have to be added up as well. Whether and how the required expansion of the rail infrastructure could be realized remains doubtful given the overall negative track records as regards the implementation of Trans-European Networks Transport (TEN-T) projects since they were formally established in 1993. The reasons lie in insufficient funding on EU level and the conflicts between national and EU interests with respect to the selection and co-financing of existing TEN-T projects.

The proposed change of the modal split in freight services pursued by the EU also requires massive regulatory and pricing policy interventions in the road transport to render it economically less attractive and to provide for the required massive expansion of the railroad infrastructure. It is questionable whether such expansion scenarios are realistic in terms of the proposed timeframe and the budgetary implications of funding the expenses; it is also doubtful, that this policy can be enforced socially vis-à-vis the electorate as it would require hugely complex planning and decision-making processes with substantial public participation in the majority of the EU’s member states (as most large-scale infrastructure projects in the EU are met with legal challenges by locals, it is not unrealistic to assume a 20 year implementation period per project in most cases). In addition, it is doubtful whether the expansion scenarios with the obvious emphasis on railways, the necessary regulations or road transport and the modal-split-shares of railroads envisaged are useful from a regulatory policy point of view.

The dominant railway infrastructure operators who produce the largest share of the value added of the EU’s railway transport system are hardly replaceable and are able to act as a monopolist towards their users and politicians and to skim economic rents as a result. In addition, on the level of the rail transport companies, state-owned companies still by and large control the market, as entry barriers remain exceedingly high. In addition, in the most European countries the market dominating railway enterprises are vertically integrated companies. In comparison, intensive competition and easy market entry characterize the road transport sector.

Therefore, it would be economically unfavorable to enforce a shift to rail by means of drastic regulatory and pricing measures. If the goals of the EU – to shift 50% of the freight transport and the majority of passenger transport over 300 km to the railways – would in fact be successfully realized through transport policy instruments, ceteris paribus, significant market segments of passenger and freight transport would see customers being dependent on a partially monopolistic market and a (partially) inefficient railway sector. This cannot be the aim of transport policy. Therefore, such ambitious shifting goals – which would substantially reduce intramodal competition - should be pursued only at after the implementation of an effectively liberalized and competitive EU market for freight and passenger rail services.

3.2.2. Modal Shift in the EU’s Passenger Transport Markets

Even if the future growth of passenger transport in Europe will be fairly small in light of key sociodemographic factors such as income levels and demography, the measures to shift the passenger transport especially from the car or airplane to different modes of transport are being discussed intensively in the Commission and amongst policymakers of the member states. Again, rail transport is in the focus, but long-distance bus traffic should also be assessed as an environmentally friendly alternative to cars and planes. The traffic in metropolitan areas is increasingly characterized by a strained overload during rush hours and environmental problems (particularly excessing fine dust and nitrogen oxide limit values), so that also here a switch to non-motorized means of transport (i.e. bicycle) and public transport seems to be economically and ecologically sensible. Abstracting from the traffic jam problems, a massive increase in the usage of electric cars is frequently proposed to contribute strongly to the solution of the specific environmental problems in metropolitan areas (e.g. noise pollution, particle emissions, greenhouse gas emissions) and to the conservation of fossil energy resources. Under resource aspects, also organizational innovations like car-sharing are being politically supported.

A modal shift in the passenger transport sector can, in turn, be incentivized by push and pull factors. Thus there is the option on the one hand to reduce the price and quality profile of the resource intensive modes transport by regulatory and pricing measures and on the other hand to increase the attractiveness of the resource extensive transport sectors. In line with a push strategy, a kilometer-based road user charge, higher fuel taxes or the taxation of aviation fuel are possible options. As pull measures, for example, subsidized transport services in rail passenger transport would be applicable.

Finally, a modal shift policy would only then be successful, if the users were, in fact, to make use of these alternative modes of transport. Therefore, for the long distance passenger services market the substitutability between motorized individual traffic (MIT), air transport, railroad passenger services and long-distance bus services is relevant. An analysis of the substitutability between these transport alternatives shows that intermodal competition plays a smaller role than often presumed because the substitution gaps to be overcome by the travelers in holiday/leisure traffic as well as in the business traffic are relatively large (Eisenkopf, Hahn and Schnöbel 2008). This is valid in leisure time transport especially for the substitution of car rides by train, while in business traffic the replacement of the train over long distances by the car is problematic. An argument for significant substitution gaps between the modes of transport can be found in the empirically measured cross-price elasticities between railway transport and automotive transport, or air transport.

While cross-price elasticities describe the shift for example from the car to the rail due to the increase of the operating costs, the direct price elasticity of demand only addresses the change of transport activities because of a change of price. In the following we primarily refer to the direct price elasticity as, on the one hand, a suitable data basis for the cross-price elasticity is currently inexistent and, on the other hand, the pricing strategy of rail passenger service operators often adapts to the development of the user costs of the car. This means especially that the rail passenger services tend to emulate any operating cost increase for the car and hike up their own fares accordingly.

In relevant literature, higher taxes for mineral oil, vehicle taxes, specific registration taxes and infrastructure charges are considered as suitable instruments to avoid traffic and to induce modal shift. In respect of the substantial substitution gaps outlined above and the pretty low price elasticities, this notion is rather wishful thinking, however. So, for a long time, the literature implied a thumb rule of a presumed direct price elasticity of -0.2 with respect to the demand of car transport; accordingly, a fuel price increase of 100 % would be necessary to reduce the mileage by 20 % (Aberle 2009, p. 12).

However, more recent estimates for Germany show higher elasticities today, which currently range between -0.42 for diesel fuel and -0.51 for regular gasoline (Frondel und Vance 2014). This would mean that a duplication of the diesel prices would lead to a decline of driving performance of 42 %. Such hypothetic calculations are however to be treated with some reservation, however. On the one hand, we must realize that with a diesel price of about one Euro, the mineral oil tax (which currently is a fix amount of 47.04 cents per liter diesel fuel and of 65.45 cents per liter gasoline in Germany) has to be raised by 1 Euro and 1.30 Euro respectively to double the final price. This would lead to significant macroeconomic distortions – quite apart from the massive political unrest this would create among the electorate. Furthermore, in regard to this claim it has to be noted that elasticities always are defined for very small changes of the independent variable and therefore the empirical validity of the aforementioned estimates remains highly questionable for such massive, non-incremental changes. Moreover, it may be observed that price elasticities of the demand for transport services decline with increasing income (Fouquet 2012).

3.3. Fleet Emission Standards

The most important instrument of European climate policy with respect to passenger transport is fleet emission standards. Fleet emission standards could be interpreted as fuel economy standards because of the direct and fixed relation between emissions and fuel consumption. Vehicle emission standards potentially constitute a powerful lever for emission reduction because about half of the energy consumption in the transport sector accounts to private cars (both worldwide and on the EU-level.)

Already in 1995, European heads of state and government agreed to a reduction of CO_2-emissions of first registered cars to 120 g/km by 2012 (this corresponds to 4.5 liters of diesel fuel and 5 liters of gasoline per 100 km). Actually, a limit of 130 g/km is mandatory since 2015. The difference of 10 grams is compensated by additional internal measures (e.g. use of biofuels, credits for electric vehicles). The current legal framework defines an additional reduction goal down to 95 g/km by 2021, whereby a lot of “supercredits” (especially for electric cars) make it easier to achieve this goal.

Their general potential to reduce greenhouse emissions from private cars notwithstanding, fleet emission standards should by critically assessed with respect to their economic efficiency, however. Most of the (Western) European countries raise rather high mineral oil taxes which can be interpreted as an internalization measure for the negative externalities of greenhouse gas emissions. In Germany, for example, tax rate is 65.45 cent per liter gasoline (47.04 cent per liter diesel). The increase of tax rates in Germany after 1999 was explicitly justified with the argument that higher tax rates for mineral oil products could help to reduce greenhouse emissions from the transport sector (so-called "ecological tax reform"). Looking at the fuel tax as a levy on greenhouse gas emissions from using fuel in combustion engines, one ton CO_2(-equivalent) is implicitly taxed with 280 Euro for gasoline and 180 Euro for diesel (1 liter gasoline corresponds to 2.32 kg of CO_2; 1 liter diesel corresponds to 2.62 kg of CO_2).

Therefore, from an economical point of view, drivers already pay a high shadow price for their CO_2-emissions. Any measure to reduce fuel consumption with marginal CO_2 avoidance costs of less than 280 Euros for cars run with gasoline and 180 for diesel cars respectively would be economically interesting from the customer's point of view. Accordingly, demand for such measures should exist, and automobile manufacturers should have strong incentives to adapt because of the competitive industry structure. Additional measures to reduce CO_2-emissions will therefore have marginal avoidance costs higher than 180 Euros per ton CO_2 and have to be assessed as economically inefficient considering current market prices for CO_2-emission allowances in the European Emission Trading System (ETS). Against this background, any further tightening of fleet emission standards as being discussed in the EU is inefficient and unreasonable. The money spent on the reduction of fuel consumption of cars could instead be earmarked for more efficient CO_2-reduction measures in other sectors of the economy.

Fuel economy standards have also been criticized because of the so-called rebound effect, resulting in limited net emission reductions only (Lah 2015**).** The rebound effect indicates the fact that a reduction of user costs of cars by the decrease of specific fuel consumption results in additional travel activities and/or a less energy efficient driving style. In older studies, the rebound effect is estimated at 10 to 30 % for road traffic (International Energy Agency 1998). Recent studies report a large scattering of results from 5 to 66 % (International Risk Governance Council 2013). For Great Britain e.g. the rebound effect because of tightened emission standards is estimated to range between 20 and 60 %. A 10 per cent saving of specific fuel consumption therefore would cause an additional driving performance of approximately 2 to 6 % (Fouquet 2012).

Furthermore, CO_2-emission standards are counterproductive because measuring devices will be adjusted to comply with the theoretically defined and politically set conditions. Therefore the results obtained from test benches in perfect driving conditions do not normally correspond well to real driving emissions. As we have learned from Volkswagen's notorious "Dieselgate" affair, there is already a massive distortion of incentives and a lack of appropriate regulatory oversight with respect to enforcing these standards. Therefore, simply tightening fleet emission standards will not automatically lead to better regulation unless a critical analysis and restructuring of the current institutional framework are undertaken beforehand.

3.4. Promotion of Electric Mobility

The use of electric vehicles for road transport is supposed to constitute a significant step towards a reduction of the use of fossil resources and the emission of greenhouse gases. The EU's White Paper on Transport policy from 2011 postulates to halve the use of conventional vehicles in city logistics until 2030 in the EU, but electric mobility is not supported by legal acts at the moment except a directive concerning the extension of charging infrastructure.

On the other hand there are numerous initiatives on a national level of different European, not just EU, countries. Norway is known as the country where the fleet of plug-in electric vehicles is the largest per capita in the world, but the country has never been a member of the EU. As of September 2016, 92.813 all electric cars and 26.225 plug-in hybrids were registered in Norway (Cobb 2016). The market share of plug-in electric vehicles has been the highest in world during the last years (22.4 % in 2015, up from 13.8 %). From an environmental economics perspective, the comprehensive Norwegian political initiatives promoting electric cars can be assessed as successfully because 98% of the electricity generated in the country is based on hydropower. Therefore, Norway's fleet of electric cars clearly is the ecologically cleanest worldwide (Figenbaum, and Kolbenstvedt 2016).

Compared to Norway, the diffusion of electric mobility in the countries of the EU is rather modest. As of January 1st 2016, in Germany about 23,500 electric cars were registered; the figures for Great Britain and France were 28.000 and 27.000 respectively. To understand the economic relevance of these numbers you have to put them in a relation to total number of registered cars. In Germany, for example, the total stock of registered cars is about 44 Million units (Kraftfahrtbundesamt 2016).

To promote electric cars, almost every EU member state has set up some kind of political initiative. In Germany, the government holds on to their early, eye-catching, goal of achieving 1 million registered electric cars in 2020. In light of the obviously rather weak demand for electric cars, the government decided in May 2016 to introduce additional political measures for the promotion of electric cars. Core of this initiative is a buyer's premium for electric cars and plug-in hybrids cheaper than 60.000 Euro (4,000 Euro and 3,000 Euro per vehicle, respectively). The subsidy is split 50:50 between public funds and contributions by the car manufacturers themselves. Public funds are limited to 600 Million Euro and are only available until the end of the year 2020 at the very latest. Additionally the government supports the development of a nationwide network of charging stations for an amount of 300 Million Euro (Bundesregierung 2016).

Subsidies for the promotion of electric cars should be critically assessed because of governance issues. In general, such subsidies violate the idea of a non-distorted free market mechanism (assuming no externalities exist). Subsidizing car purchases, including electric cars, also give rise to regressive distributional effects and create a technology bias which may result in sunk costs due to barely reversible lock-in effects, should a more efficient alternative emerge in the future.

Besides this criticism from a pure free market perspective, it also has to be stated that electric vehicles do not offer any ecological advantages compared with vehicles using a traditional internal combustion engine. This assessment is especially true for the so called plug-in hybrids. Independent research agencies confirm that battery-electric cars create a very similar climate footprint compared to conventional cars when the analysis takes in account the whole life cycle of the vehicle types and is based on the existing electricity mix in Germany (ifeu 2011, p. 1).

In a dynamic perspective, so as to provide sufficient clean electricity for about 5 million electric cars, the expansion of renewable energies has to be intensified far beyond the current – already very ambitious - political goals. At present, consumption of electricity in Germany amounts to about 600 terawatt hours yearly. To provide this electrical energy, a power generation capacity of about 70 gigawatt per year is in place. 5 million additional electrical cars would require about 20 terawatt additional hours electrical energy (assuming current usage patterns).

By the end of 2015, 26.800 wind power plants were installed in Germany. They produced about 88 terawatt hours of electrical energy (subject due to substantial supply swings dependent on wind patterns and wind intensity). To accommodate only 5 million additional electrical cars, about 6,000 additional wind power plants would have to be installed. To completely replace cars with internal combustion engine by electric cars, at least 85.000 additional wind power plants would be required; some expert assessments see even a need for around 240.000 wind power plants. To build these extra wind power plants, a surface area of about 17,763 sqm would be occupied – which is slightly than the federal state of Thuringia, which represents some 4.5 % of Germany's total land territory. Much more difficult would be the use of solar energy because of the typically adverse weather conditions in Germany for this source of renewable energy. An area at least twice as large as the size of the state of Saarland – slightly more than 5.000 sqm – would be required to produce the necessary electrical power (Douglas 2016).

Given the fact that the production of electrical power from renewable sources in Germany (wind and solar energy) is currently subsidized – essentially by means of minimum feed-in tariffs – to the tune of about Euro 26 bn per year, with the amount of subsidies still increasing year by year, a complete switch to electrical cars powered by clean energy alone is a monstrous waste of economic resources. .What is more, a completely new charging infrastructure would have to be installed at enormous expenses as well. Last not least, a further crucial impediment to successful implementation is the unresolved issue of how to prevent charging patterns which would give rise to peak load problems which, might, in turn, heavily affect the systemic stability of the electricity power network (Schill, Gerbaulet and Kasten 2015, p. 211f.). At the moment only a centrally controlled user charging system offers a way out of this problem – but would add an additional element of a command-and-control economy to the energy sector – and, newly, to a key segment of the transport sector.

Besides the question of possible ecological advantages of electric mobility we would like to discuss the economic competitiveness of electrical cars now. Simulating an ideal market without distortions caused by subsidies and taxes the user costs of 1 kilowatt hour of driving power is quite similar for electric cars and cars with an combustion engine (Heller 2016). Regardless of this general finding electrical cars will not be competitive compared to vehicles with internal combustion engines for the years to come, however. Given prevailing market conditions this sounds true also on an international level. For the U.S., a recent paper (Covert, Greenstone and Knittel 2016, p. 126) calculated that at currently realistic battery costs of 325 USD per kilowatt hour, electric mobility needs an oil price of about 350 USD per barrel to become competitive. A target price of 125 USD per kilowatt hour, as assumed by the U.S. Department of Energy for the year 2022, requires a minimum oil price of 110 USD to achieve competitiveness. Assuming that electric power is generated in a climate-neutral manner and the social costs of greenhouse gas emissions are covered by conventional cars, the cost-efficiency threshold will move to 90 USD. For the foreseeable future, it is therefore impossible for electric mobility to deliver a relevant contribution for the reduction of the use of fossil resources in the transport sector.

A recent study for Germany forecasts a doubling of the power density of lithium-ion batteries to 200 watt hours per kg and a reduction of battery costs to less than 100 Euro per kilowatt hour until 2030 (Fraunhofer 2015). Talking a representative car like the Volkswagen e-Golf, the break-even point could then be reached at 100 USD per barrel of oil. A recent independent paper from Germany analysed the efficiency of electric cars for different classes of vehicle and applications from the perspective of different user groups (Bubeck, Tomaschek and Fahl 2016). The main result is that full electric cars and plug-in hybrids remain uncompetitive without subsides. Depending on vehicle size and user type, subsidies from 9,400 to 18,000 Euro are necessary to compensate for existing cost disadvantages. Eventually, the study concluded that full electric cars can reach economic viability from 2030 onwards for some vehicle sizes and user cases. For users with an annual mileage of more than 17,500 km battery electric cars are a least cost option in the categories medium and executive (e.g. BMW 320i, Mercedes E300 Blue Efficiency). For light users (7,500 km per year) petrol driven cars are the least cost option for any vehicle class. It should be kept in mind that the annual mileage driven in Germany is about 14,000 km.

4. Conclusion

Bearing in mind what we have discussed in the last chapter, it sounds rather unlikely that the policy instruments used or proposed to fight climate change in the EU's transport sector pass a strict economic assessment. Options for modal shift seem to be restricted without making use of dirigiste regulatory measures and the tightening of fleet emission standards have to be rejected on efficiency grounds. Electrification of traffic initially sounds promising, but we have shown that the potential to electrify road transport is very limited at least until the year 2030.

Talking seriously about the goals of the international climate policy, we have to accept that substantial emission reductions are required very quickly. So far, the European Commission has shied away from naming specific and sufficiently effective measures to reduce greenhouse gas emissions, however. Although the European Commission has defined very challenging modal shift targets, it has failed to operationalize the political measures to reach these goals. It seems that the necessary radical measures to reduce greenhouse gas emissions in the transport sector would give rise to inacceptable economic losses and social tensions.

From an economic point of view any specific policy measure to reduce the greenhouse gas emissions of transport activities (e.g. fleet emission standards) does not make sense unless Europe makes use of a greenhouse gas emission trading system in general. The full integration of the transport sector into the European ETS must therefore be considered the economic first best solution, compared to any sector-specific reduction regime. This relates in particular to road transport, whereas rail transport is already part of the emission trading system in the case of electrically powered trains. Intra-EU flights have to account for emission allowances as well. With an upstream solution charging for emission allowances at the level of fuel suppliers, road transport could be easily integrated into the ETS. Midstream or downstream solutions, on the other hand, would not be feasible because of prohibitive transaction costs, especially for the involvement of hundreds of millions of car users.

Calculating a target price of 30 Euro per ton (which represents the European Commission's own long-term target price) corresponds to surcharge of 7 cent per liter of gasoline and of 8 cent per liter of diesel. With such a climate surcharge used to purchase emission allowances the consumption of fuel for driving cars, buses and heavy goods vehicles would become an integral part of the European emission trading system. This would be an efficient solution from an environmental economics perspective because for any emission covered in the emission trading the equimarginal principle applies, ensuring economic efficiency.

On the other hand, we should not expect meaningful modal split changes or a significant reduction of transport activities below a target price of 30 Euro per ton of CO_2. Assuming a price elasticity of fuel consumption of about 0.4 to 0.5, a price increase of 7 or 8 cent would lead to a decline in volumes of a maximum of 2 %.

The integration of road transport in the ETS would also make plans of the European Commission obsolete to set up specific emission standards for heavy goods vehicles. Emission standards for trucks create a lot of serious problems, because specific vehicle configuration, operating conditions and the degree of loading of course make it almost impossible to set up and enforce an economically and ecologically sound regulation.

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