Urban Pathways

The Barriers to Low-carbon Land-transport and Policies to overcome them

New Urban Agenda

Wuppertal Institut
UN HABITAT FOR A BETTER URBAN FUTURE
UN environment

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About this policy paper

Shifting to a low-carbon development pathway requires substantial efforts for the transport sector. Electric mobility provides the opportunity to lower harmful emissions, improve energy security and increase economic productivity (Greene 2009). There is an immediate need to move towards low-carbon modes and energy carriers in the transport sector from an economic, societal and environmental perspective.

Doing so harbours considerable potential for co-benefits if the technology is advanced enough to be introduced cost-effectively (Leinert et al. 2013; Viguié and Hallegatte 2012). Emobility technologies are, however, substantially underutilised; while some countries have made noticeable progress in this area, others have largely failed to do so (IEA 2015). There are split incentives between societal and individual benefits that create a collective action problem, which inhibits optimal outcomes in this area. This paper will explore those barriers and emphasise the need for policy intervention.

1. Introduction

The transport sector is a vital part of global climate change mitigation strategies, as it accounts for 23% of the energy related greenhouse gas emissions (IEA 2013). All available mitigation options are required to bring the transport sector on a 2 Degree Celsius stabilisation pathway (IPCC 2014). This includes vehicle fuel efficiency, modal choice and compact urban design among others, covering all transport modes and national as well as local levels of government.

There is a wealth of experience with local and national sustainable transport policy measures (Santos, Behrendt, and Teytelboym 2010; IEA 2009). However, beyond the design and implementation of single policies, a combination of measures is vital for their success in avoiding rebound effects and to foster the contribution of low-carbon mobility to sustainable development. This requires a mutually enforcing set of policy and infrastructure measures at the national and local level. This paper will highlight the key barriers for energy efficiency in the transport sector and outline the key elements of a policy package to overcome those barriers.

2. Barriers to low-carbon transport

Shifting to a low-carbon development pathway requires substantial efforts for the transport sector. One could argue, however, that fuel economy improvements are no-regret options to lower CO2 and harmful emissions, improve energy security and increase economic productivity (Greene 2009). There is an immediate need to improve vehicle fuel efficiency from an economic, societal and environmental perspective. Doing so harbours considerable potential for co-benefits if the efficiency technology is advanced enough to be introduced cost-effectively (Leinert et al. 2013; Viguié and Hallegatte 2012). Vehicle fuel efficiency technologies are, however, substantially underutilised; while some countries have made noticeable progress in this area, others have largely failed to do so (IEA 2013). There are split incentives between societal and individual benefits that create a collective action problem, which inhibits optimal outcomes in this area. The following section will explore those barriers and emphasise the need for policy intervention.

2.1 Split incentives

The initial-cost barrier is a major problem, in particular for individuals and despite available information on the relevant payback periods (Lescaroux 2010; Giblin, S., McNabola 2009). The key factor inhibiting improvement of the vehicle fleet's efficiency is the split incentive between individual-cost and economy-wide benefits, which is very strong in the transport sector. Vehicle purchases are made by individuals who apply discount rates as high as 20%, while most car buyers do not account for cost-savings from fuel efficiency beyond 2-3 years (ITF 2010). As such, only a fraction of the economy-wide benefits are considered by individuals when making a purchase decisions, with negative consequences on the economy-wide benefits/costs over the roughly 15 year lifetime of the vehicle.

The investment barrier is still the most prevalent obstacle to the widespread market penetration of energy efficient products (Sorell et al. 2009). A number of studies show that GHG reduction measures in transport have quite favourable abatement costs but require higher capital intensity than many measures in other sectors (McKinsey and Company 2009; Shalizi and Lecocq 2009). While these investments result in considerable economy-wide benefits over the lifetime of a vehicle, they may not create sufficient payback rates for the particular individuals responsible for vehicle purchasing decisions. Rebound effects may, however, undermine some of the efficiency gains, further complicating the collective action problem. These are examined in the following section.

2.2 Rebound effects

An additional issue affecting energy efficiency measures is the rebound or take-back effect. The effect refers to the tendency for total demand for energy decrease less than expected after energy efficiency improvements are introduced, due to the resultant decrease in the cost of energy services (Sorrell 2010; Gillingham et al. 2013). Ignoring or underestimating this effect whilst planning policies may lead to inaccurate forecasts and unrealistic expectations of the outcomes, which, in turn, lead to significant errors in the calculations of policies' payback periods (WEC 2008). One of the most typical examples in the transport sector is improved vehicle efficiency failing to lead to the desired reduction in energy consumption, as efficiency gains are 'taken back' by increased travel.
Some authors even suggest that energy efficiency improvements can result in an increase of energy consumption: the rebound effect is larger than the original efficiency gain (Khazzoom 1987; Inhaber 1997; Brookes 2000). This claim has yet to be proven, but a number of studies show that the rebound effect is indeed an issue which should be addressed when developing effective energy efficiency policies (S. Sorrell 2009), but should not serve as an excuse for not implementing efficiency policies (Gillingham et al. 2013). The expected rebound effect is around 0-12% for household appliances such as fridges and washing machines and lighting, while it is up to 20% in industrial processes and 10-30% for road transport (IEA 1998). The higher the potential rebound effect and also the wider the range of possible take-back, the greater the uncertainty of a policy's cost effectiveness and its effect upon energy efficiency (Ruzzenenti and Basosi 2008).

2.3 The collective action problem

Personal motivation and political will to achieve collective action are aligned in many ways (Olson 1965). Individuals tend to be driven by rational behaviour and therefore favour the most cost effective choice, even though it may be morally objectionable (Diamond 2005). In the case of global climate change, individual perpetrators can be relatively certain of getting away with bad behaviour (e.g. driving a large instead of a small car) if there is no policy framework influencing individual behaviour. This represents the typical social dilemma situation, which discourages individuals from cooperating, as they can free-ride on the contributions of others. Atmospheric pollution is a reverse tragedy-of-the-commons. It is not the situation of removing something from the commons but putting something into it (the atmosphere), namely carbon dioxide. The overuse of the atmosphere as dumping ground for greenhouse gases is the result of individuals making the rational decision to maximise their gain (wealth, comfort, status etc.) by increasing their carbon footprint or at least by not to reducing it (Stern 2006). This encourages bad behaviour, as good behaviour would be punished (e.g. higher travel time by taking the bus, or higher prices through flight emissions offsetting). Energy consumers are generally rational, however each individual acts differently. Governing the commons means also coping with the different habits of its users (Dietz 2003, Stern et al. 2002).

3. Co-benefits as cornerstone to overcome barriers and link policy objectives

While from a climate change mitigation perspective vehicle efficiency and low-carbon fuels may provide the biggest potential, this does not fully reflect a broader sustainable transport perspective. A multimodal and integrated policy approach can minimise rebound effects, overcome split-incentives and achieve a higher level of socio-economic co-benefits (Givoni 2014). Energy efficiency and low-carbon fuels have a key role to play in decarbonizing the transport sector. However, the strategies, in particular avoiding travel through compact city design and shifting to low-carbon modes (Avoid, Shift) are the measures that yield substantial opportunities to contribute to sustainable development (Table 1).

Air quality, safety, energy efficiency, access to mobility services and other factors that are considered to be co-benefits of sustainable transport measures from a climate change perspective are in fact the driving factors for policy intervention, in particular on the local level (Jacobsen 2003; Goodwin 2004; Hultkrantz, Lindberg, and Andersson 2006; Rojas-Rueda et al. 2011). As transport relies almost entirely on petroleum products, energy security is a major issue for the sector products (Steve Sorrell and Speirs 2009) Costantini et al., 2009; Cherp et al. 2012). There is a direct link between energy security and climate change mitigation actions that focus on fuel switch options, such as biofuels and electrification (Shakya and Sh-

Table 1. Greenhouse gas mitigation potential and co-benefits potential

Approach	Area of focus	Potential Impact	Potential synergies
Avoid	**Activity** (reduction and management: short distances, compact cities and mixed use)	Potential to reduce energy consumption by 10 to 30% (TFL 2007; Marshall 2011)	Reduced travel times; improved air quality, public health, safety and more equitable access
Shift	**Structure** (shift to more energy efficient modes)	Potential for energy efficiency gains varies greatly, 10- 30% reductions (IEA 2012, Fulton et al. 2013)	Reduced urban congestion and more equitable access Freight… reduced maintenance costs for road
Improve	**Intensity** (vehicle fuel efficiency)	Efficiency improvement of 40-60% by 2030 feasible at low or negative costs (IEA 2012; GEA 2012)	Improved energy security, productivity and affordability
	Fuel (switch to electricity, hydrogen, CNG, biofuels and other fuels)	Changing the structure of the energy consumption. Mitigation and efficiency potential uncertain.	Diversification of the fuels used contributes to climate, air quality and/or energy security objectives

Adapted from IPCC 2014 and Figueroa Meza et al. 2014 restha 2011; Leiby 2007; Jewell, Cherp, and Riahi 2013) and demand side measures, such fuel efficiency, shift to more efficient transport modes and compact urban design (Leung 2011; Cherp et al. 2012; Sovacool and Brown 2010). These strategies are also likely to improve access to mobility services and reduce transport costs, which affects positively productivity and social inclusion (Banister 2008; Miranda and Rodrigues da Silva 2012) and provides better access to jobs, markets and social services (Boschmann 2011; Sietchiping, Permezel, and Ngomsi 2012; Banister 2011). Improved access is likely to have a positive impact on employment. A major cost factor generated by inefficient transport systems is congestion. Time lost in traffic was valued at 1.2% of GDP in the UK (Goodwin 2004); 3.4% in Dakar, Senegal; 4% in Manila, Philippines (Carisma and Lowder 2007); 3.3% to 5.3% in Beijing, China (Creutzig and He 2009); 1% to 6% in Bangkok, Thailand (World Bank 2002) and up to 10% in Lima, Peru with daily travel times of almost four hours (JICA 2005; Kunieda and Gauthier 2007).

The combination of various policy objectives that can be addressed by an integrated multi-level policy and governance approach provides a solid basis for durable polcies that can have long-lasting impacts. Climate change, air quality, noise prevention, safety, energy security and productivity are key policy objectives for policy makers at the local and national level, even though to varying degrees (de Hartog et al. 2010; Rabl and de Nazelle 2012; Tiwari and Jain 2012; Jewell, Cherp, and Riahi 2013). The polices described in the following section provide a framework in which synergies between thee policy objectives can be generated to foster the contribution of low-carbon mobility to sustainable development.

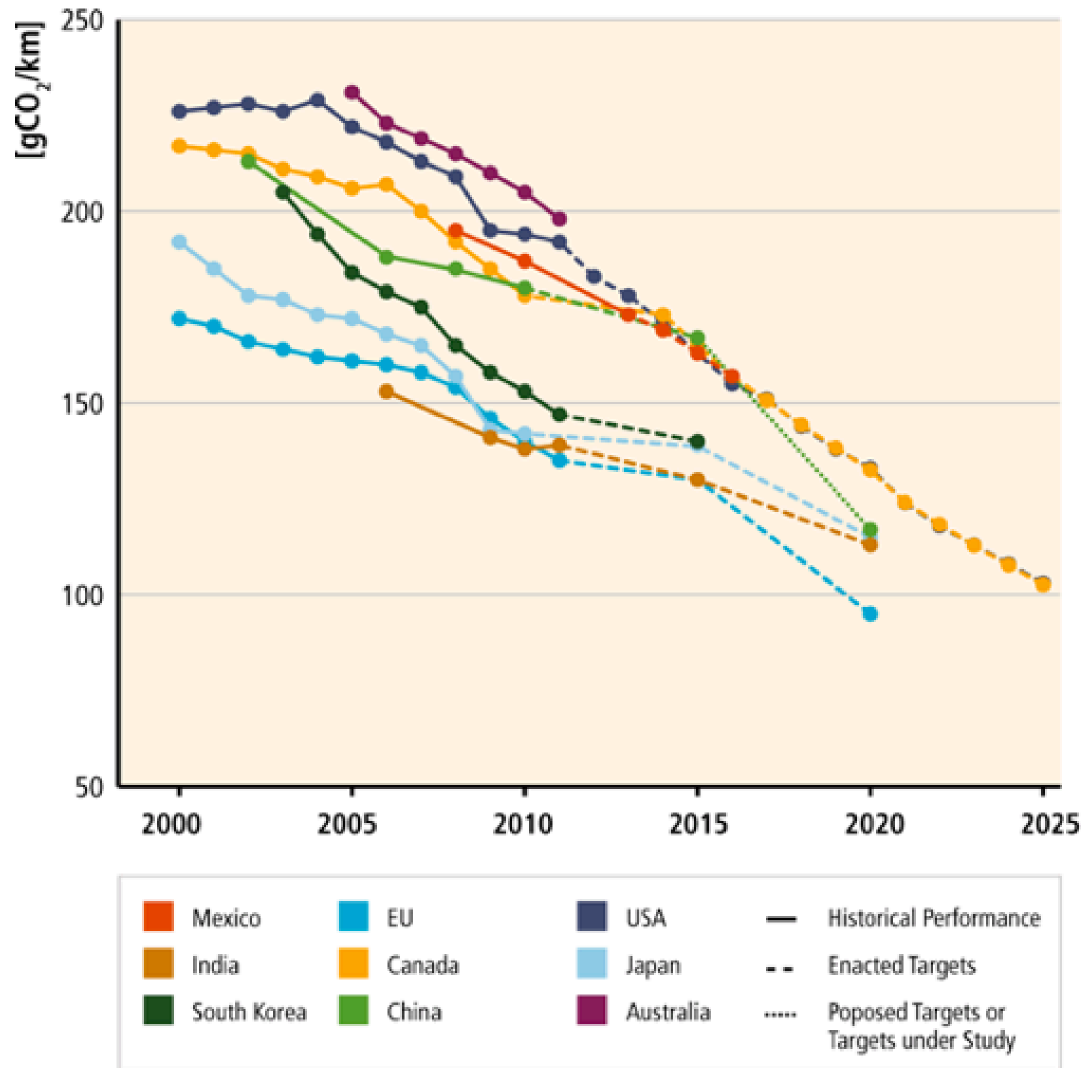
4. Policies to overcome the barriers to fuel efficiency

There are manifold policy options to increase the efficiency of the vehicle fleet (UKERC, 2009, ITF 2010, IEA 2013, IPCC 2014). This section outlines some of the main aspects of policies that are considered in this paper to be vital for a low-carbon vehicle fleet: vehicle efficiency standards, fuel tax, differentiated vehicle taxes. These measures together with the provision of modal choices and compact city design are considered to reduce transport activity, shift towards a more efficient transport structure, improve the energy intensity of fuels and foster the uptake of low-carbon fuels. Only this integrated approach can generate the co-benefits needed to create coalitions among national and local stakeholders, which is necessary to overcome the barriers described before.

4.1 National level policies

4.1.1 Vehicle fuel efficiency standards

Fuel efficiency standards aim to ensure a supply of efficient vehicles and, even more importantly, aim to limit the level of fuel consumption throughout the vehicle fleet. For policy-makers, the key benefit of this measure compared with other mechanisms is the need to deal with only a re-



latively small number of car manufacturers, whereas other policies usually target a vast number of individuals.
The provision of long-term efficiency targets offers certainty to vehicle manufacturers; crucial to them in order to make investments in new technologies (Schipper, 2007). To ensure equal conditions for all manufacturers, standards should apply to all vehicles entering the fleet, whether locally produced or imported. Moreover, efficiency targets should be combined with demand-side polices in order to ensure the supply of more efficient vehicles matches consumer demand. Together, the resultant changes have the potential to deliver the largest share of CO2 mitigation in the transport sector (Figure 1).

However, there is also a debate about whether fuel economy standards alone are the most effective way of reducing transport fuel consumption and GHG emissions. While the major manufacturing countries have standards in place, they have failed to create substantive progress in lowering vehicle fleet carbon emissions, particularly in Canada, Australia and the USA. This is consistent with the observation that only integrated policy packages, including standards and fiscal measures, will achieve substantial results.

One of the key shortfalls of standards as the sole policy measure to reduce fuel consumption is related to the rebound effects they can initiate (Skinner et al. 2010; Van Dender 2009; IEA 2009; Santos, Behrendt, and Teytelboym 2010). Vehicle efficiency standards reduce the cost of driving and hence promote increased travel (Plotkin, 2009). However, increased travel associated with more stringent standards is not considered a strong argument against them, because the increased travel decreases as income grows (Small and Van Dender, 2004). Furthermore, the rebound effect can be minimised by appropriate fuel pricing, as discussed below. From a societal perspective, individuals do not act responsibly when making purchasing decisions. Consumers rarely evaluate the trade-off between higher initial cost for efficient vehicles and the benefit of fuel saved as previously mentioned. The gap between private and societal discount rates can be mitigated to some extent by policies, one of which can be vehicle standards.

The USA was the first country to introduce vehicle fuel economy standards, in 1975, just two years after the first oil crisis, in form of the US CAFE standard. This requires car manufacturers to meet sales-weighted average fuel economy standards for light vehicles sold domestically. This mandatory standard was effective in improving fuel vehicle fuel efficiency for around a decade, with fleet-average fuel economy of passenger cars rising from approximately 15 miles per gallon (15.68 L/100km) in 1975 to approximately 28 mpg by 1989 (8.4 L/100km). After oil prices recovered in the 1980s and policy-makers' attention in this area decreased, so did the effectiveness of the CAFE standards (Schipper 2008). A number of factors contributed to this, most notably that CAFE standards remained unchanged for more than two decades and failed to include light trucks (SUVs) (UK ERC, 2009).
In an analysis of the policy which aimed to advance the attainment of the 2020 target (35 mpg) to 2016, the US Environmental Protection Agency (EPA) came to the conclusion that the average price increase for model year 2015 cars and light trucks would be paid back from reduced fuel costs in 56 and 50 months, respectively (assuming manufacturers pass on costs to consumers, and fuel prices of US$2.26 in 2016 and $2.51 in 2030). Economy-wide net benefits (using a 7% discount rate) from lower fuel costs, reduced oil dependence and avoided external costs are estimated by NHTSA to be US$15.2b for cars and $26.4b for light trucks (NHTSA, 2008; Sharpe B 2011).

The EU has moved from voluntary arrangements with the automobile industry to regulation. The Regulation EC 443/2009 is based on a target of 120 g CO2/km for the European car industry by 2015. A target of 130 g/km of CO2 is to be reached by improvements in vehicle motor technology. A further 10 g/km can be reduced by using other technological improvements such as the use of biofuels or more efficient ancillaries and tyres. The regulation also includes a medium-term target of 95 g/km of CO2 by 2022. While there is evidence suggesting that vehicle efficiency standards improve average vehicle efficiency over the medium to long-term (Sharpe B 2011), this measure appears to deliver only modest system-wide efficiency improvements. For example, the EU voluntary agreement improved average light vehicle fleet fuel economy, using to the standard European test cycle (NEDC), by about 10% between 1996 and 2008 (DfT 2009). However, in the same period, total passenger car CO2 emissions fell by only ≈4% (ibd.), indicating a substantial rebound effect. Hence technology improvement focused measures require policies that can influence consumer behaviour (differentiated vehicle taxes) and can manage vehicles use (fuel tax). In addition, the provision of modal choices is vital, not only for the efficiency of the transport system, but also for its ability to contribute to sustainable (urban) development.

4.2 Fuel taxes

Fuel taxes and excise duty rates should be set at a level, which internalises external costs (e.g. from GHG emissions) (Barker et al., 2007; Litman 2008). Doing so directly affects both travel demand and the vehicle technologies used and, in turn, fleet fuel consumption and CO2 emissions. Also, fuel prices can have a significant impact on vehicle ownership rates. The impact of fuel price changes on consumption is defined as its price-elasticity. In the short-term, there is little change in demand in response to price changes (WEC, 2009), e.g. a 10% fuel-price increase results in only 0.11%-0.6% lower demand (Goodwin et al., 2004; Graham/Glaister, 2004; Small/Van Dender, 2007), i.e. fuel demand is inelastic in the short term. However, more sustained fuel price increases, e.g. from taxation, result in considerable energy demand reductions: a 10%

fuel price increase will result in a 2.5% to 3% energy use decrease in the first year and up to 6% after 5 years (Goodwin et al., 2004).

Fuel prices not only affect energy demand, but also vehicle choice. A 10% petrol price increase would lead to a fleet-average CO2 emissions reduction of ≈0.5 g/km ithe first year, and up to ≈2.8 g/km in the longer term (Ryan et al., 2008). Goodwin et al. (2004) estimate the vehicle efficiency improvement generated by a 10% fuel price increase to be 11% over the long-term. Despite this evidence, there are remarkable differences in fuel taxation across OECD countries (Figure 2).

Figure 2 Taxes on unleaded petrol in OECD countries from 1998-2009 (OECD Tax Database 2013)

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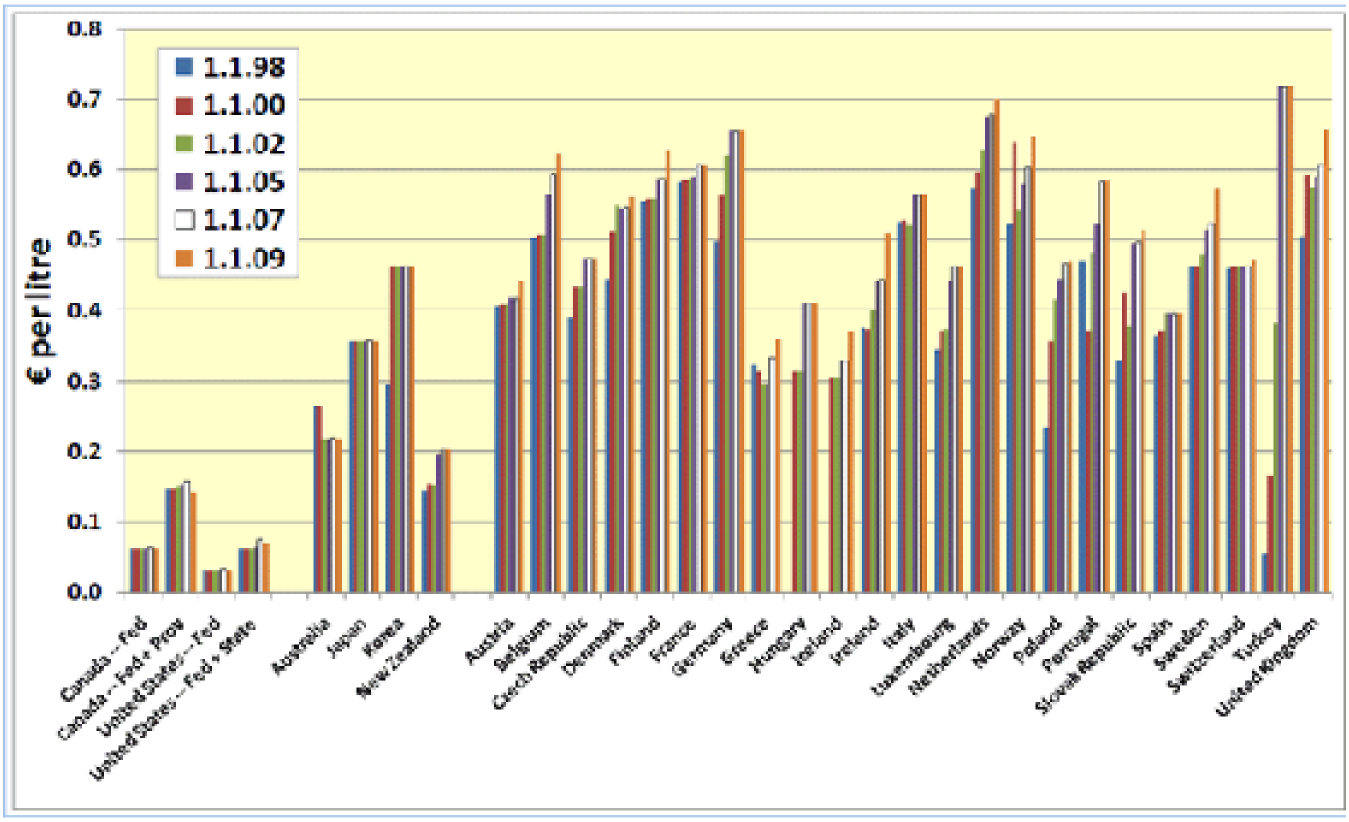
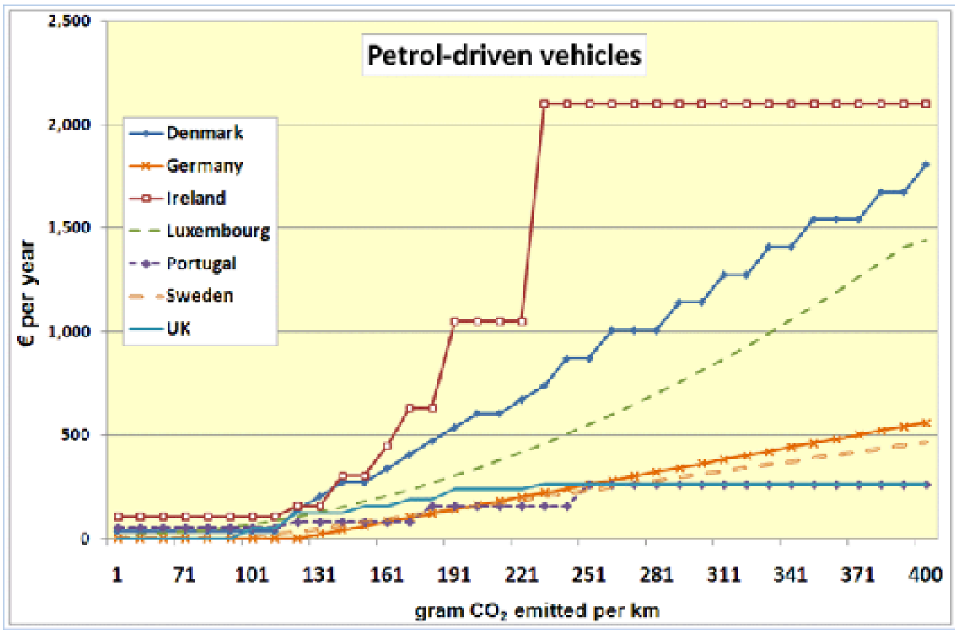


4.3. Differentiated vehicle taxation

Differentiated vehicle registration, purchase taxes and/or feebate schemes can guide consumer demand and help mitigate split incentives between individuals and society. Figure 3 provides an overview on a selection of countries and their approach to differentiation in circulation tax.

Figure 3 Differentiated circulation vehicle taxation in selected European countries (OECD Tax Database 2013)



These schemes have to respond to changes in the vehicle fleet to ensure sufficient demand for more efficient vehicles and to maximise cost-effectiveness (TIS, 2002; Nemry, et al., 2009). Circulation/ownership taxes are a recurring charge (typically yearly), which can be used to encourage purchasing more efficient cars by setting the charge according to cars' fuel economy, either directly or by proxy (CO2 emissions, engine size or power-to-weight ratio). Linking taxes to greenhouse gas and harmful emissions in this way is a well established and studied policy measure, and has proven to be more cost-effective than enforcing direct controls (Baumol and Oates, 1971; Baumol, 1972; Parry,2007).

Ryan et al. (2008) analyse fiscal instruments' influence on individual purchasing decisions, finding that vehicle and fuel taxes have a considerable influence on the efficiency of vehicles entering the fleet. A 10% increase in vehicle circulation taxes could result in a short-term fleet CO2 emissions decrease of 0.3 g/km, increasing to 1.4 g/km in the long term (Ryan et al., 2008). The European Commission considers it essential to differentiate taxes, rewarding energy efficient cars with significantly lower taxes and imposing considerable taxes on cars with poor fuel efficiency. COWI (2002) found that replacing existing vehicle taxes with taxes dependant on only CO2 emissions, with sufficient differentiation, led to the largest reductions. Where differentiated taxes already exist, adding a CO2 emissions dependant element provides smaller, but still significant reductions. For example, the Irish CO2 emissions-differentiated vehicle tax is estimated to have resulted in a 3.6–3.8% emissions intensity reduction and an annual reduction of transport CO2 emissions of 3% (Giblin, McNabola 2008). Under a feebate system, the rate of progression is being increased over time, and thus lead to even greater CO2 emissions reduction, but significant savings also could be achieved by increasing the differentiation of existing taxes.

Registration taxes

By imposing higher taxes on the purchase of less efficient vehicles, registration taxes influence consumer behaviour directly at the point of vehicle sale. Denmark's purchase-tax system led to an average fuel efficiency increase of 4.1 l/100km for diesel light vehicles and 0.6 l/100km for petrol (Smokers et al., 2006). Purchase or registration taxes are highly visible, which is very helpful in steering buyers' decisions towards more efficient vehicles and may also result in lower car ownership rates (Anable/Bitrow, 2007): a 10% increase in car registration taxes would reduce car ownership in European cities by about 1.4% (Smokers et al., 2006), which would, in turn, result in lower overall car use and a higher share of more efficient modes in urban areas. However, there may be negative welfare or equity implications (UK ERC, 2009). Taxes imposed at the time of the first registration may also delay the renewal of the vehicle fleet, as car owners may keep their vehicles longer and may prefer to replace current vehicle with other used rather than new ones (Kageson, 2003). An ex-post assessment of the Netherland's feebates estimated the scheme saved approximately 0.6-1m tonnes of CO_2 per annum (Harmsen et al. 2003), approximately 2-3% of the Netherland's total transport sector CO_2 emissions. The Dutch system's provision of direct incentives to buy very efficient cars has had a measurable effect on purchasing decisions, with the market share of cars from the highest efficiency class increasing from 0.3% to 3.2%, and that for the second highest class increasing from 9.5% to 16.1% in 2002 (VROM; 2003). Following the government's decision to discontinue the feebates, efficient cars' market share dropped almost instantly, although it stayed higher than before the scheme's introduction (Smokers et al. 2006).

In December 2007, France established a feebate scheme. The scheme rewards a rebate of up to €5,000 for vehicles with CO_2 emissions below 60 g/km (e.g. electric vehicles and plug-in hybrids), through to a charging a fee of €2,600 for cars with CO_2 emissions above 250g/km. According to official figures, the scheme has been very successful, with sales of vehicles with CO_2 emissions lower than 130 g/km increasing 45% in the scheme's first eight months. A number of ex-ante estimates have been made of the policy potential of feebate schemes. A feebate scheme of US$ 1,000 for every 0.01 gallon per mile improvement, if introduced in the United States for one year and then ceased, would increase the efficiency of the light vehicle fleet by 24% over the following 10 to 15 years (Greene et al. 2005). Langer (2005) estimated that a feebate of US$1,825/gallon/100mi (4.25 L/km) would reduce the average fuel consumption of vehicles entering the fleet 16% by 2010 and 28% by 2020.

4.2 Local level policies and measures

4.2.1 Compact city design and integrated planning

Compact cities provide the opportunity for shorter travel distances and can avoid unnecessary travel. Higher population densities provides the basis for mass-transportation modes and can enable the integration of public transport and non-motorised transport infrastructure (Hymel, K.M., Small, K.A., Dender 2010). Combined with mixed use, these factors can reduce travel distances, and improve accessibility and efficiency of public transport (UN-Habitat 2013). While the development of urban form and transport infrastructure are long-term processes, there is a large potential that sustainable urban planning can influence cities that are small to medium size and rapidly growing as is the case today in many developing countries (United Nations 2010; Amekudzi et al. 2011).

4.2.2 Public transport, walking and cycling

Another vital aspect for low-carbon and accessible transport is the provision of high-quality public transport infrastructure and services as well as walking and cycling facilities (Small and Verhoef 2007). Cities that invest considerably in public transport and in walking and cycling infrastructure tend to achieve higher shares of these modes, which increases the economic efficiency of transport and reduces public health and environmental impacts as well as congestion (UN-Habitat 2013).
Metro system (MRT), Lightrail (LRT) and Bus Rapid Transit (BRT), provide options for high capacity and high average speed mass transit options, which can provide highly cost-effective alternatives to individual motirised transport, at least over the long-term. Fulton et al. (2014) suggests that doubling the market share of public transport, walking and cycling could yield cumulative savings of over US$100 trillion over a 40 year period.
Walking any cycling infrastrcuture along with measures such as bikesharing schemes and bike parking facilities provide modal alternatives and also act as feeder to the public transport system. Long-term master plans for the promotion of walking cycling and public transport, such as those developed by the cities of Freiburg (Germany) and Odense (Denmark) that led to an increase of cycling in the modal share to 26% (1999 Freiburg) and 35% (2001 Odense) (Figueroa et al. 2014).

4.2.3 Urban logistics

Urban freight transport creates a disproportionate level of negative impacts, such as greenhouse gas and harmful emissions, noise and congestion. For some time now, authorities at the national and local level in Europe have tried to address this challenge and manage freight in urban areas more effectively to foster sustainable development in cities. Key freight policies include logistics, supply china management. By integrating transport modes, warehousing and inventory, logistics enables more efficient and seamless flows of goods in a globalised economy (Hesse and Rodrigue 2004). Integrated supply chain management concepts can optimise vehicle utilization, energy efficiency and modal choice (McKinnon 2010). Just-in-time delivery reduces the need for warehousing and increases supply chain efficiencies, but also increases the need for packaging hence increasing volume rather than weight, which limits load factor (Kamakaté and Schipper 2009).

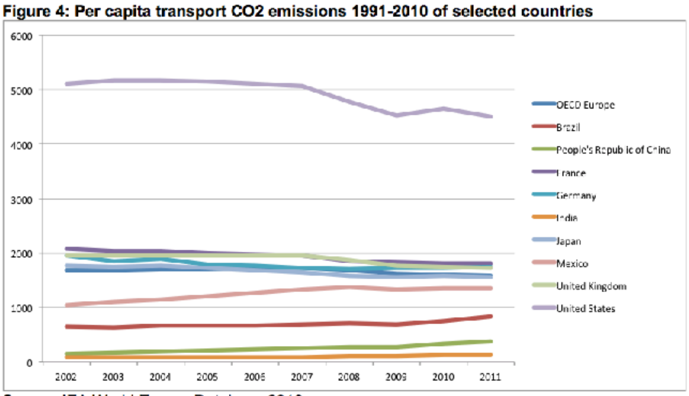
5. Policy packaging to overcome the barriers

It is often claimed that transport is the hardest sector to decarbonise (ECMT 2007; IEA 2011). However, some countries have managed to curb emissions in this sector, at least to some extent. While it is acknowledged that current measures in most, if not all, countries will not be sufficient to bring transport onto a 2°C pathway, some countries have shown reasonable progress (Figure 4).

France, Japan, the United Kingdom and Germany are among the few developed countries that have seen a policy-led decline in transport GHG emissions in recent years. These countries stand out as they have seen their road greenhouse gas emissions stabilise or even decrease, despite economic and road-freight growth over the same period (ITF 2010). What these countries have in common is that they all have the policies in place mentioned above and not just one of them (e.g. vehicles standards in the US), but all of them. In addition to that many cities in France, the UK, Germany and Japan have a compact design and provide modal choices (Sims at al. 2014). The US shows substantial improvements over the last years, but from a much higher level. Standards certainly made a contribution to this, but also the saturation of travel demand. It is doubtful if levels similar to France or Japan can be achieved with this policy approach. The emerging economies of India, China Brazil and Mexico show a clear upward trend, which can only be managed if the policies outlined in this paper are implemented on the national level and complemented with city planning and local policies.

A number of studies emphasize that vehicle fuel efficiency improvements are a key measure to cost-effectively reduce transport-sector energy consumption (and thus greenhouse gas emissions), in particular over the short- and medium term (IPCC 2014). While emissions reductions can be achieved through several means, such as modal shift, efficiency gains and reduced transport activity, it is apparent that vehicle efficiency has a key role to play. Fulton et al. (2013) state that significant cuts in overall travel and substantial modal shifts would be needed to make up for slightly reduced fuel efficiency improvement in OECD countries, and similarly, that travel demand growth would need to be curbed significantly if reasonable efficiency gains are not continued in developing countries. While in developing and emerging countries will be more on maintaining the currently still high share of low-carbon transport modes, fuel efficiency will play an important role to facilitate the growth in travel demand and still making a contribution to global climate change mitigation efforts. Vital element for this strategy is a policy package as outlined in the previous sections and summarised in the table below.

Figure 4: Per capita transport CO2 emissions 1991-2010 of selected countries



Source: IEA World Energy Database 2013

While this paper focuses on the ability of an integrated policy approach to overcome barriers, it is acknowledged that not only the policies themselves (content) are an important element in this equation, but also the policy environment (context) (Justen et al. 2014). This context includes not only socio-economic, but also political aspects, taking into account the institutional structures of countries. The combination of policies and policy objectives can help building coalitions, but can also increase the risk of the failure of the package if one measure faces strong opposition, which, however, can be overcome if the process is managed carefully (Sørensen et al. 2014). A vital element of success is the involvement at an early stage of potential veto players and the incorporation of their policy objectives in the agenda setting (Tsebelis and Garrett 1996).

Table 2: Elements of a multi-modal, multi-level sustainable transport package

Examples for national measures	Examples for local measures
Fuel tax	Compact city design and integrated planning
Vehicle tax based on fuel efficiency and/or CO2 emissions Vehicle fuel efficiency regulation and labelling	Provision of public transport, walking and cycling infrastructure and services Urban logistics Travel demand management, incl. Road User Charging, parking pricing, access restrictions
	Registration restrictions and number plate auctions
	Public awareness campaigns, eco-driving schemes

6. Conclusion

Reducing greenhouse gas emissions in the transport sector is a significant challenge. The situation is very disparate from country to country, but it is apparent, as explored in this paper, that policies are the vital element that can explain these differences. Policy packaging and integration is a vital element of the (relative) successes. Policies have to be designed to be part of a consistent framework, with the aim of improving vehicle fleet efficiency, but also of encouraging efficient vehicle use. If applied in isolation these measures are unlikely to achieve their stated goals of reducing overall emissions and increasing vehicle fuel efficiency. For example, vehicle standards alone are likely to increase the fleet's efficiency, but this improvement is likely to be offset by increased vehicle use (rebound effect). Similarly, increased fuel taxes, without the provision of modal alternatives and/or measures to ensure a supply of efficient vehicles, would impact negatively on mobility and transport affordability. Hence a balanced and integrated policy approach is needed that combines vehicle efficiency standards, fuel tax, differentiated vehicle taxes with the provision of modal choices and compact city design.

While the combination of measures is vital to the success of sustainable transport policies, the policy environment and the institutional structures are equally vital to make these policies a success. More research is needed to assess the ability of co-benefit strategies to create the basis for coalitions that can link local and national governments and other relevant veto players.

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