



Driving renewable energy for transport

**NEXT GENERATION POLICY INSTRUMENTS FOR
RENEWABLE TRANSPORT (RES-T-NEXT)**

November 2015

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Project Steering Group

Konrad Pütz	Enova, Norway (PSG Chair)
Miguel Cruz	IREC, Spain
Mary-Rose de Valladares	IEA Hydrogen Implementing Agreement, USA
Aaron Berry	Department for Transport, UK
Pierpaolo Cazzola	IEA, France
Nils-Olof Nylund	VTT, Finland
Rune Holmen	Enova, Norway
Kristian Petrick	Acting for the Operating Agent, IEA-RETD
David de Jager	Operating Agent, IEA-RETD

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AUTHORS

Huib van Essen, Sanne Aarnink, Anouk van Grinsven, Arno Schroten, Matthijs Otten, Maarten 't Hoen, Bettina Kampman (CE Delft) and Tammy Klein, Paul Niznik, Lucky Nurafiatin, Maelle Soares-Pinto (Stratas Advisors).



GLOSSARY

Abbreviation	
AFV	Alternative Fuel Vehicle (includes biofuel vehicles and ZEVs)
AT PZEV	Advanced technology Partial Zero Emission Vehicle (defined for ZEV Mandates)
BEV	Battery Electric Vehicle (includes FEVs/EREVs/PHEVs)
CIC	Carbon Immission Certificates (CICs)
CNG	Compressed Natural Gas
CO ₂	Carbon dioxide
CPT	Clean Power for Transport
EREV	Extended Range Electric Vehicle
ETS	Emission Trading System
EV	Electric vehicle (includes BEVs/FCEVs)
FAME	Fatty acid methyl esters (form of biodiesel)
FCEV	Fuel Cell Electric Vehicle (running on hydrogen)
FEV	Full Electric Vehicle
FFV	Flex-Fuel Vehicles
FTC	Federal Trade Commission
FQD	Fuel Quality Directive
GGE	Gasoline Gallon Equivalent
GHG	GreenHouse Gas
GLE	Gasoline Litre Equivalent
GPP	Green Public Procurement
GVD	Greener Vehicle Discount
GVW	Gross Vehicle Weight
H ₂	Hydrogen
HDV	Heavy Duty Vehicle (HGV/bus)
HGV	Heavy Goods Vehicle
HOV lane	High Occupancy Vehicle Lane
HVO	Hydro-treated Vegetable Oil
ICE	Internal Combustion Engine
ICV	Internal Combustion Engine Vehicle
ILUC	Indirect Land Use Change
kWh	kilo-Watt-Hour
LCFS	Low Carbon Fuel Standard
LCV	Light Commercial Vehicle
LDV	Light Duty Vehicle (LCV/car)
LEV	Low Emission Vehicle (defined in Californian Standards)
LNG	Liquefied Natural Gas
LTZ	Limited Travel Zones
MJ	Mega-Joule
MS	Member State

Abbreviation	
Mt	Mega ton
NEV	Neighbourhood Electric Vehicle(defined for ZEV Mandates)
NGO	Non-Governmental Organisation
NO _x	Nitrogen Oxides
NREAP	National Renewable Energy Action Plans
OECD	Organisation for Economic Co-operation and Development
OEM	Original equipment manufacturer
OS	Obligated Subject
PHEV	Plug-in Hybrid Electric Vehicle
POI	Point of Interest
PPP	Public-Private Partnership
PZEV	Partial Zero Emission Vehicle (defined for ZEV Mandates)
RE	Renewable Energy
RED	Renewable Energy Directive
RES-E	Renewable Energy Sources for Electricity
RES-T	Renewable Energy Sources for Transport
RME	Rapeseed Methyl Ester (form of biodiesel)
TCO	Total Cost of Ownership
TEN-T	Trans-European Transport Networks
TTW	Tank-to-wheel
TZEV	Transitional Zero Emission Vehicle (defined for ZEV Mandates)
UCO	Used Cooking oil
ULED	Ultra Low Emission Discount
ULEV	Ultra Low Emission Vehicles (ZEVs and relatively fuel efficient ICVs)
VAT	Value Added Taxes
VRT	Vehicle Registration Taxes
WTO	World Trade Organisation
WTT	Well-to-tank
WTW	Well-to-wheel
ZEV	Zero Emission Vehicle (includes FEVs/EREVs/PHEVs/FCEVs)

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EXECUTIVE SUMMARY

Renewable energy sources in transport (RES-T) are crucial for avoiding climate change. As transport is currently almost fully dependent on conventional fuels and, as such, has a significant share in global emissions, the transition to RES-T is an important aspect in the broader climate policy. This transition requires changes in three dimensions: the vehicle fleet, energy infrastructure and energy carriers. The required changes depend on the technology pathway: battery-electric, hydrogen or biofuels. This study investigates the main barriers to each RES-T pathway and for all three dimensions, assesses individual policy instruments and defines an overall policy strategy to overcome these barriers. The main focus is on urban road transport.

There is a wide variety of policy instruments which can be implemented at different administrative levels to remove the barriers to RES-T. Roughly 40 policy instruments have been identified, ranging from financial instruments and regulations to PPPs, information provisioning, and spatial and transport policies. A selection of 17 policy instruments has been made with a broad geographical coverage, a mix of policies targeting each of the main dimensions and with policies that have been proven, or are expected, to be most effective in terms of increasing the share of RES-T. Each policy instrument on the short list has been assessed in detail on six criteria: increase of alternative powertrains in the vehicle fleet, increase in renewable energy use by transport, Greenhouse gas (GHG) emission reduction, coverage, cost-effectiveness (expressed as the net costs to society in €/tonne of CO₂ eq) and ease of implementation.

Most policy instruments increase the share of alternative powertrains, but few (also) directly target the share of renewable energy consumption. The most effective instruments for increasing the share of Alternative Fuel Vehicles (AFVs) are:

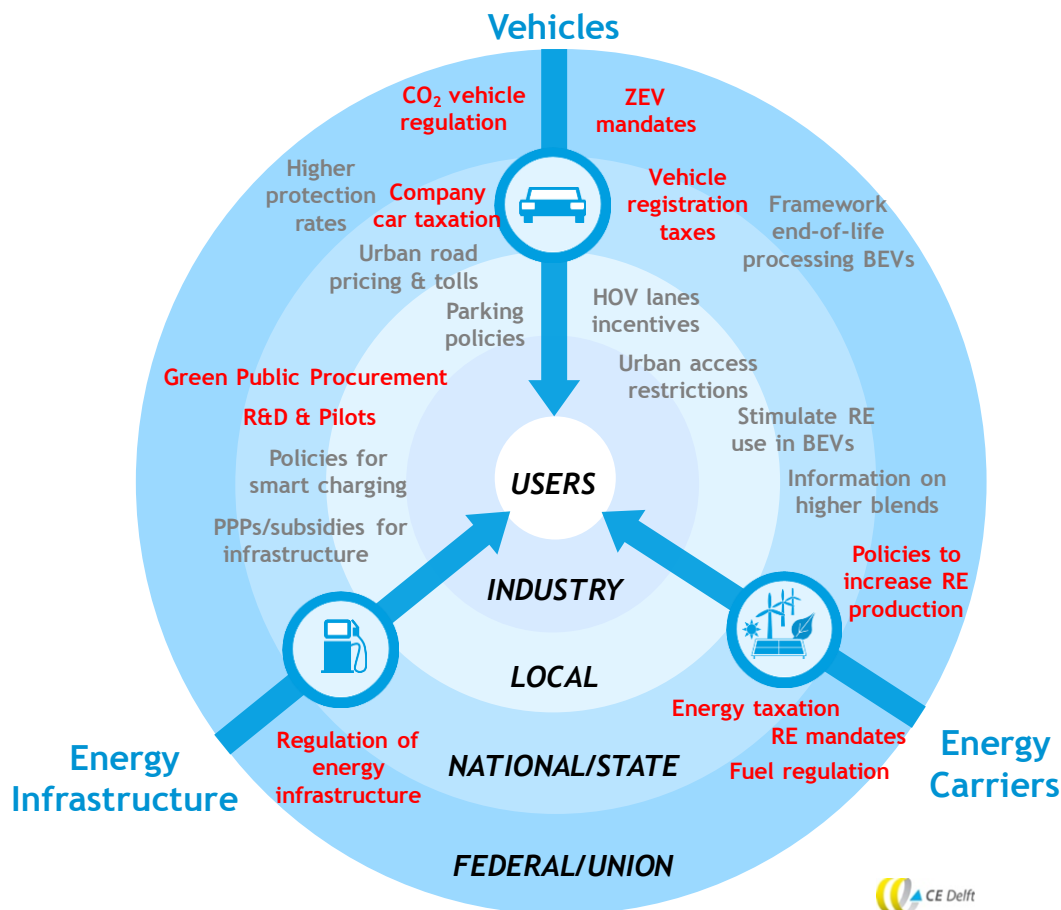
- Zero Emission Vehicle (ZEV) mandates (obliging OEMs to meet a minimum share of ZEVs in their sales);
- Financial incentives in vehicle registration taxes (VRT) and in company car taxation
- CO₂ regulations of road vehicles, particularly when CO₂ targets are sufficiently ambitious.
- Various local incentives for AFVs.

For effectively increasing the share of renewable energy in transport, there are fewer instruments available. Most effective are **Fuel regulations** and **renewable energy mandates**. Furthermore, the share of RES-T is also strongly dependent on a range of energy policies targeting renewables power generation.

All policies investigated reduce GHG emissions. Highest GHG emission reductions can be expected from instruments targeting both RES-T and fuel efficiency improvements of conventional vehicles, **most notably CO₂ regulations** for road vehicles and **most financial incentives**. These policy instruments are also likely to have a higher cost-effectiveness. Most other policies currently have a low cost-effectiveness, because fuel savings and other internal and external cost reductions do not outweigh the higher costs of Battery Electric Vehicles (BEVs), Fuel Cell Electric Vehicles (FCEVs) and biofuels. This situation is likely to change in the future when economies of scale result in cost reductions.

Figure 1 provides an overview of the recommended overall policy strategy for increasing the share of RES-T, including the main policy instruments as well as the supporting instruments per administrative level and dimension.

Figure 1 Overview of main (red) and supporting (grey) policies at the various administrative levels



Battery-electric is the most promising pathway for urban transport. Although this transition does face significant barriers, the benefits, e.g. in terms of potential GHG emission reduction, the relatively easy use of renewables in electric power generation, and improved air quality, are significant as well. In the short- to medium-term, semi-electric vehicles (Plug-in Hybrid Electric Vehicles (PHEVs) and Electric Vehicles with a Range Extender (EREVs)) play a role in the transition, as the current driving range of Full Electric Vehicles (FEVs) may not be attractive to all urban transport users. This can generate volume and as such drive the necessary improvements in batteries and charging infrastructure and so help the battery-electric technology to overcome the 'valley of death'. In the longer-term, a transition to Full Electric Vehicles (FEVs) is most desirable, as PHEVs/EREVs are a sub-optimal technology from a renewables, cost and GHG emission reduction point of view.

The battery-electric technology has already been commercialised; it now requires policy instruments which generate volume. This is true for both vehicle shares as well as the number of charging points. In the short to medium-term, strict **CO₂ Regulations for road vehicles** and **ZEV mandates** are very important. The demand side can best be stimulated by **financial incentives in VRTs** and **company car taxation**, supported by various **local incentives** (e.g. Green Public Procurement, preferential parking policies, access to High Occupancy Vehicle lanes, etc.), increasing the attractiveness of BEVs for transport users. Once BEVs become competitive with Internal Combustion Engine Vehicles (ICVs), financial and local incentives can be reduced and/or eliminated.

Increasing shares of BEVs improves the business case of charging points. However, up to the point where there is a positive business case, national and/or local governmental support in terms of **PPPs or grants** are necessary. Ideally, regulations for harmonisation and standardisation need to be further improved. **Policies are required to exploit synergies between BEVs and renewable energy production** (e.g. smart charging and vehicle-to-grid integration). This requires **regulations for on-board intelligence and for differentiating electricity prices**. Finally, the development of a policy **framework for battery end-of-life processing** deserves attention.

Hydrogen may provide a feasible alternative or complementing pathway for urban road transport, especially if necessary improvements in batteries are not realised. However, FCEVs face significant cost and technical barriers as well, which need to be resolved first.

The hydrogen technology is not yet fully commercialised and requires policies which primarily promote pilots, first market uptake and further product development. This is a necessary first step for most regions, as only very few vehicle models exist, production volumes are low, and hydrogen fuel stations are still scarce despite recent projects in for example California, Japan and Germany. Policies supporting pilots should focus on each of the three dimensions (i.e. on FCEVs, Hydrogen infrastructure and hydrogen production from renewables). To prepare for the potential mass adoption of FCEVs, **policies for standardising the technology** and for stimulating **information sharing** to achieve a more positive public perception for this pathway are necessary. Also, it is recommended to already adopt safety regulations hydrogen infrastructure.

In markets where hydrogen is ready to be fully commercialised and locations with sufficient hydrogen filling stations, roughly similar policies are needed as for the battery-electric pathway (i.e. **CO₂ Regulations, ZEV mandates, financial incentives and local incentives** for FCEVs, and **PPPs/Grants** for hydrogen infrastructure). In addition, sustainable hydrogen production (from renewable energy sources) requires additional policies, like **mandatory sustainability criteria**.

The role of biofuels in (urban) transport firstly depends on the availability of available and sustainable feedstock. The biofuel pathway represents the least radical pathway, with fewest barriers, but also results in smaller and more uncertain reductions of GHG emissions and air pollutants. Moreover, the availability of sustainable feedstock may be limited. The smaller the amount of available feedstock, the more likely this will be used by long-distance road and non-road transport modes (and/or other economic sectors). However, if sufficiently large amounts can be produced, biofuel can be used to increase the share of renewables in the urban transport fleet which has not (yet) been electrified.

There is a clear need for a long-term policy framework to guarantee investment security to biofuel producers, OEMs and the fuel industry.

Overall, this framework should be part of a broader, **multi-sectorial biomass policy**, to prevent competition between biofuel users (e.g. industry, power generation, built environment) and between transport modes (e.g. road transport, aviation, maritime shipping). Policy frameworks should therefore include **allocation principles**.

Elements of this policy framework could include several aspects to ensure a wider availability of sustainable biomass feedstock. First, the uptake of biofuels can be realised with **mandatory fuel standards**, which are based on the GHG impacts of different conventional and biofuels. These mandates should at least include sustainability criteria for ILUC effects. In addition, mandates can include **sub targets for minimal shares of advanced biofuels**.

Alternatively (or in addition to mandates), **financial instruments** (e.g. investment tax credit for biofuel production facilities, loan guarantees or fiscal incentives) can be used to increase the production and uptake of advanced biofuels. Finally, once volumes from sustainable feedstock are sufficiently high, **blending limits can be enlarged** (e.g. to E15-E25 and B10). To prepare for such blends, vehicle standards should already include requirements for covering high protection grades in vehicle warranties and a **system of fuel labelling** should be set up by federal/union governments.

This study identified some cross-cutting issues which are recommended to take into account when designing a policy package. First, where possible, **policies should be defined in generic terms, targeting all technology pathways and user groups**. There are exceptions, such as the very effective company car policies, policies targeting the pre-commercialisation phase, or policies stimulating a technology that specifically results in large benefit when applied in a particular niche market (e.g. taxis).

Second, **policies should be designed from a social cost-effectiveness** principle, but it should be kept in mind that there is a clear trade-off between (current) cost-effectiveness and robustness for meeting the long-term climate goals. Some policies may not be cost-effective now (e.g. ZEV mandates or subsidies for hydrogen charging infrastructure), but may be crucial in ensuring alternative powertrains are brought to the market.

Third, **policies should be defined early on** and be as continuous as possible to provide (investment) certainty to the market.

Fourth, **the design of policy instruments should be harmonised where possible**, both between and within regions and economic sectors. Ideally, incentives are defined in similar terms/criteria and target levels harmonised.

Finally, in choosing the mix of policy instruments, **specific local or national circumstances should be taken into account**, as these influence the size of the required financial incentives and/or can result in a different ideal pathway for a region.

1. INTRODUCTION

1.1. BACKGROUND

The transition from conventional fuels to renewable energy sources in transport is crucial for meeting long-term climate targets. At the same time diversification of energy sources within the sector can increase energy security.

Although the decarbonisation goals for 2050 seem to be far away, the size and complexity of changes needed require early action.

The large-scale uptake of alternative energy carriers requires changes in three main dimensions:

- **Vehicles:**

The vehicle fleet should consist of a sufficient amount of compatible vehicles to enable high market shares of renewable energy sources. This requires a broad shift from Internal Combustion Engines Vehicles (ICEVs) to Alternative Fuel Vehicles (AFVs) such as Battery-Electric Vehicles (BEVs), Fuel Cell Electric Vehicles (FCEVs), Flex-fuel vehicles (FFVs), and so on.

- **Energy infrastructure/fuel distribution:**

A well-developed energy infrastructure should enable transport users to fuel or charge their vehicles with alternative energy carriers within reasonable distances and time availability. This requires a significant increase in the number of available charging points for BEVs, hydrogen filling stations for FCEVs and/or biofuel or biogas filling stations.

- **Availability of alternative energy carriers, produced from renewable sources:**

A shift from ICVs to AFVs in the fleet does not necessarily translate in a higher share of RES-T (renewable energy sources for transport) as the latter demands an increase in the share of renewable electricity in the national mix and an increase in sustainable biofuel production and hydrogen produced with renewable sources.

A large variety of actors has a role to play in this transition, including governments (local, (Member) States and Federal governments), the vehicle industry (vehicle and component OEMs), transport users (private consumers and businesses), and energy companies (oil companies and biofuel producers, utility companies, grid operators, power producers, etc.).

However, at the moment various barriers impede the transition to RES-T in one or several of the above-mentioned dimensions. Well-known examples are the immaturity of technologies, high costs, lack of energy infrastructure, adverse indirect effects such as indirect land-use change (ILUC) and low user acceptance. Hence, policy interventions are required to overcome these barriers, which can target the vehicle fleet, energy infrastructure and/or the availability of alternative energy carriers. To ensure a successful transition to RES-T, simultaneous change is needed in each of these three dimensions. Therefore, an integrated approach is required.

The interventions needed are likely to differ between the different alternative energy carriers (electricity, hydrogen and biofuels) and can change over time. This is due to differences in maturity levels on the one hand and energy carrier-specific barriers and needs on the other.

Various regions have developed policies to increase the share of renewables in their transport sector, which has resulted in a wide variety of policy instruments that are currently in force. However, while this has resulted in a rapid uptake of some alternative energy carriers in some regions, such as biofuels in Sweden and BEVs in Norway, California and the Netherlands, others were less successful. Hence, to ensure a transition to RES-T in all regions, it is important to consider the lessons learned from the approaches taken so far. However, considering the scale of the required transition and the future challenges with increasing shares of renewables, innovative policy instruments may be needed as well.

Within this context, the IEA-RETD has commissioned CE Delft and Stratas Advisors to carry out a study on next generation policy instruments for RES-T. This study complements two other studies on next generation policy instruments for renewable energy in the electricity sector (RES-E-NEXT) and for heating and cooling in commercial buildings (RES-H-NEXT).

1.2. OBJECTIVE & SCOPE

The main aim of this study is **to provide recommendations for next generation policy instruments and strategies to increase the share of renewable energy in transport.**

More specifically, the objectives are to review and assess existing policy approaches and strategies implemented worldwide, with the main focus on IEA-RETD member countries, and to explore new and innovative approaches. Policies will be assessed on various criteria, including their effectiveness and costs.

This study should inspire and stimulate countries in developing and implementing successful RES-T policies and should enable policy makers to identify the best policy strategy for their own country or region without presenting detailed policy solutions for every situation.

The study focuses on transport modes in urban areas, so mainly passenger cars, light commercial vehicles, public transport and heavy goods vehicles. Long-haul freight transport, maritime shipping and aviation are beyond the scope of this study.

The main focus of this project will be on policy instruments for increasing the uptake of renewable energy sources and AFV technology in the transport sector. However, there is a clear link with broader sustainable transport policy strategies, which may also include measures aimed at improving transport efficiency, modal shift or demand management, as well as energy system related issues and policies, such as smart grids, storage of renewable energy, and developments in renewable energy production. Where relevant such links will be mentioned in this study, without going into too much detail on these adjacent policy areas. More details on the scope of the study are depicted in Table 1.

Table 1 *Scope of work*

Aspect	Included in scope
Renewable energy sources for transport (RES-T)	<ul style="list-style-type: none"> • Renewable electricity • Biofuels (both liquid and gaseous) • Hydrogen
Sector	Transport sector including the dependencies between the transport sector, the energy sector, and industry
Transport modes	<ul style="list-style-type: none"> • Passenger transport (cars, two wheelers and buses) • Urban freight transport (light commercial vehicles and light trucks)
Policy measures	Main focus on <ul style="list-style-type: none"> • Financial incentives • Regulations • Awareness/information related policies • Public procurement and PPPs • Transport and Spatial policies
Geographical scope	IEA-RETD member countries (Canada, Denmark, France, Germany, Ireland, Japan, Norway, and United Kingdom) and other relevant countries (e.g. USA, Japan)
Time horizon	<ul style="list-style-type: none"> • Short term: up to the next 5 years • Mid-term: 10-15 years • Long-term: 30-40 years

1.3. OUTLINE OF THE REPORT

The remainder of this report is structured as follows. First, an overview of the main technology and energy carrier pathways and their key advantages and barriers is provided in Chapter 2. Hereafter, a summary of the main policy options available to promote RES-T is given in Chapter 3. In Chapter 4, the overall policy strategy is described for each of the three pathways (biofuels, electricity, hydrogen). Finally, in chapter 5 considerations for the overall policy strategy are discussed.

Annex A provides a brief overview of the main current policies in the US, Canada, the EU, Japan and China. Annex B contains a long list of policy instruments of which 17 selected instruments are assessed in more detail in Annex C, illustrated by several case studies. Finally, Annex D lists the persons that were interviewed for this study.

2. TECHNOLOGY PATHWAYS

2.1. INTRODUCTION

There are different pathways to realise a transition to renewable energy in transport. Some pathways are relatively incremental while others are more radical, this in turn impacts the size of the advantages and barriers each pathway faces. The text box below shortly describes the main pathways distinguished in this study.

Pathways to RES-T

Three main technology pathways are distinguished in this study: battery-electric, hydrogen and biofuels. Some key characteristics of each pathway are summarised below:

Battery-electric: This is a relatively radical pathway because the performance and usage of the vehicles and energy infrastructure are inherently different from ICVs: vehicles need to be charged not fuelled and the driving range is significantly smaller (for now) compared to ICVs. A distinction is made between Full Electric Vehicles (FEVs) and semi-electric vehicles: Plug-in Hybrid Electric Vehicles (PHEVs) and Electric Range Extended Vehicles (EREVs). The semi-electric technologies are less radical compared to FEVs, as the driving range is comparable to ICVs.

Hydrogen: This is also a radical pathway because the vehicle technology (Fuel Cell Electric Vehicles (FCEVs)) and energy infrastructure are inherently different from ICVs. It could well be combined with battery-electric with fuel cells as range extender. Only the application of hydrogen by means of FCEVs is explored in this study¹.

Biofuel: This is a more moderate pathway, especially for low blends, which can be used by conventional vehicles and distributed by existing infrastructure. High blends and biogas do require some adjustments in vehicles (dedicated biofuel or flex-fuel vehicles) and infrastructure and therefore more adaptations. However, compared to hydrogen and electric vehicles in particular, this pathway can be considered less radical as the required vehicle technology is already pretty mature and the vehicle performance and usage is similar to those of ICVs.

This chapter will outline the key advantages (Section 2.2) and barriers (Section 2.3) to increasing the share of renewables in transport while taking into account all relevant differences between the energy carrier pathways. Section 2.4 summarises the implications hereof for the short and long-term and for the different road vehicle modes distinguished in this study.

2.2. KEY ADVANTAGES OF RES-T

A transition to RES-T has several advantages, which are summarised in Table 2. This table also includes an indication of the size of the potential benefits. However, this strongly depends on the energy carrier (e.g. the feedstock used for biofuel and energy sources used for electricity/hydrogen production) and technology used (mainly semi- vs. full BEVs) and therefore should be regarded as indicative.

¹ Other technology pathways for applying hydrogen in transport, e.g. using it in a combustion engine, are not considered relevant options.

Table 2 Key advantages of renewable energy in transport

Advantage	Energy carrier		
	Battery-electric	Hydrogen	Biofuel
Preventing climate change – Decarbonisation	High**	High**	Medium-high*
Reducing local air pollution and noise	High	High	Low
Reducing the dependency on imports – Security of energy supply	High**	High**	Medium
Exploiting market opportunities – employment, trading balance and GDP benefits	High	High	Medium-high
Buffering - Electricity storage	Low/Medium***	High***	N/a

* Applies to advanced biofuel and biofuels without significant ILUC or other adverse GHG impacts.

** If consumed electricity/hydrogen has been produced with renewable sources.

*** The magnitude of these advantages and their (economic) value is very uncertain.

Table 2 indicates that several advantages can be obtained when a transition is made from conventional fuels to (a mix of) biofuels, (renewable) electricity and/or hydrogen. The battery-electric and hydrogen pathways have the highest number of potential advantages, comparison to biofuels.

First, **the adoption of electric and hydrogen vehicles can result in a significant GHG emission reduction.** The GHG emission reduction of FEVs is currently in the order of 35%² for a passenger car, but emissions can be reduced to a near zero level in case the FEV is powered with electricity produced with renewable sources (TNO & CE Delft, 2014; CE Delft et al., 2013). Semi-electric vehicles (PHEVs/EREVs) share these emission benefits, but only when driven in the electric mode. Hence, the size of the emission reduction is directly related to the share of electric kilometres driven. Not charging the PHEV/EREV at all, can result in much lower GHG emission reductions or even in a net increase of WTW (well-to-wheel) GHG emissions (TNO & CE Delft, 2014). Emission benefits from FCEVs depend strongly on hydrogen production methods, but are generally smaller than for BEVs if using the same primary energy source.

Biofuels can result in a GHG emission reduction as well, but the size of the emission reduction depends significantly on the type and feedstock used and on whether the uncertain impact of Indirect Land Use Change (ILUC) is taken into account. When ILUC is taken into account, some biofuels like the ones from waste and residues or sugar cane can result in high emission savings, while other biofuels from crops can in some cases even result in a net increase of GHG emissions.

² This comparison includes emissions from fuel production, power generation (average power mix in the Netherlands, 467 g/kWh) and emissions from vehicle production and materials used.

Second, when looking at other emissions, the reduction potential of **electric and hydrogen vehicles** is significant as well. These vehicles have **close to zero air pollutants (NO_x, PM₃) and noise emissions**, even with current electricity mixes (CE Delft et al., 2010). Renewable electricity and hydrogen can reduce (most notably NO_x) air pollutants even further. Biofuels on the other hand, generally do not provide benefits regarding air pollutants or noise compared to conventional vehicles⁴. It should be noted that vehicle standards have already significantly reduced pollutant emission of all conventional vehicles.

For improving local air pollution, banning older vehicles is generally much more effective than replacing new ICVs by ZEVs. However, there is increasing evidence that also very low emissions of ultrafine particles and soot from modern ICVs can still be very harmful for human health.

Third, **a transition to renewable energy sources can positively impact a region's energy security**. As most renewable energy can be generated with local sources (sun, wind, hydro and domestic biomass), a transition to alternative energy carriers (including electricity, hydrogen and biofuels) could improve the energy security of countries as they become less dependent on oil imports and hence, also less dependent on oil price fluctuations. Furthermore, the WTW energy efficiency of a battery-electric drivetrain is better than that of an ICV, resulting in a lower primary energy use. Also this can contribute to the energy security.

Positive macro-economic impacts are the fourth possible advantage of a shift to renewable energy carriers in transport. Such impacts vary significantly between regions though. A shift from oil products to locally produced energy for transport may improve the trade balance and GDP of a country, as a larger part of the supply chain becomes domestic. This effect is even larger when the AFVs are produced locally as well, as the proportion spent on fuel costs decreases (electricity is cheaper than petrol/diesel for example), while capital costs increase (an electric or hydrogen vehicle is more expensive than a conventional vehicle).

Hence, a larger proportion of the value chain would become domestic. Such increases in domestic activity will also positively impact employment (Cambridge Econometrics, 2012). Biofuels can have similar advantages in terms of GDP (especially in rural areas), trade balance and employment (in the agricultural sector in particular, but also in vehicle production, e.g. of Flex-Fuel Vehicles, FFVs), but this advantage will vary with type of feedstock (land-based vs. waste). Moreover, ILUC debates may reduce demand for land-based feedstock and hence, advantages for agriculture may well be lower in the long-term (European Parliament, 2015a).

³ It concerns PM emissions from the engine. PM emissions from wear and tear (e.g. brakes and tires, which are less harmful than emissions from the engine) are likely to be comparable or could even be higher compared to those of ICVs.

⁴ They can result in a decrease or increase of some pollutant emissions, but impacts are generally limited compared to conventional vehicles equipped with state of the art emission reducing technology.

A final advantage of a transition to renewable energy in transport is the potential to create **buffer capacity for storing electric energy**. With increasing shares of renewables in electricity generation, the supply of electricity will become more variable, which could require adjustments in the electricity grids and investments in back-up capacity. Large-scale adoption of electric cars could provide a buffer, by storing surplus energy in the batteries of these vehicles. Likewise, the combination with smart grids (e.g. time-specific charging) could result in a better match between demand and supply. Hydrogen could provide even larger benefits; in case there is a surplus of renewable energy in the grid, this could be converted into hydrogen, which can be stored much easier than electric power (however, this comes with energy losses in the conversion and new infrastructure needs). Such innovations could thus prevent (part of the) investments in grids and back-up capacity. However, the size and potential of these benefits are still uncertain, as well as how they compare to the costs of the additional energy and charging infrastructure that is required.

2.3. KEY BARRIERS TO RES-T

Several barriers impede the transition to RES-T and as such harvesting the full potential of the advantages described in the previous section. In this sub-section, the main barriers are described, which are summarised in Table 3 and grouped by the three main dimensions in Figure 2. As was the case for the advantages, the significance of the listed barriers shown in the right hand side of the table should be interpreted as a rough indication.

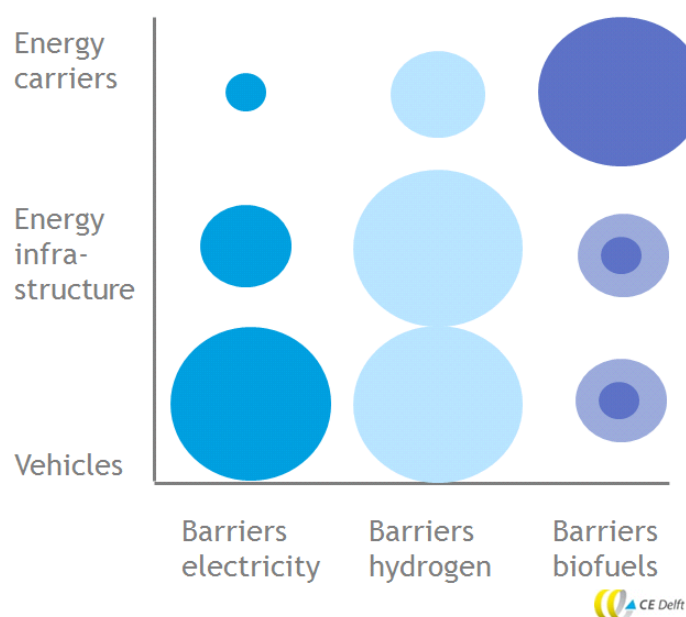
Table 3 Barriers to renewable energy in transport

Barrier	Dimension	Energy carrier		
		Battery-electric	Hydrogen	Biofuel
Financial barriers* –	Energy carrier	Low	Low	High
	Energy infrastructure	Medium	High	Low-medium**
	Vehicle	High	High	Low
Technical barriers vehicle technology & compatibility	Vehicle	Medium-High	Medium-high	Low-medium** Low-medium**
	Energy carrier	Low	Low	
Low acceptance by transport users	All	Medium-High	High	Low-medium**
Lack of sufficient energy infrastructure	Energy infrastructure	Medium	High	Low-medium*
Vested interests	All	High	High	Medium
Competition for the use of available renewable energy sources	Energy carrier	Low	Low	Medium
Investment risks*	All	High	High	High

* Financial barriers are from a demand/consumer perspective; investment risks rather from the supply/industry perspective.

** Medium mainly applies to high blends. These barriers are low for low blends, as these can be used with existing infrastructure and vehicles.

Figure 2 Relevance of barriers in the main dimensions for each energy carrier



Note: For biofuels there are no large barriers with respect to energy infrastructure (filling stations and fuel distribution) and vehicles (small dot), unless mid- and high blends are used (larger dot). Energy supply includes power, hydrogen and biomass production as well as biofuel plants and refineries.

Table 3 indicates that each energy carrier pathway faces several barriers, although most barriers are relatively smaller for biofuels. This could be expected as biofuels are a less radical alternative to conventional fuels than electricity and hydrogen.

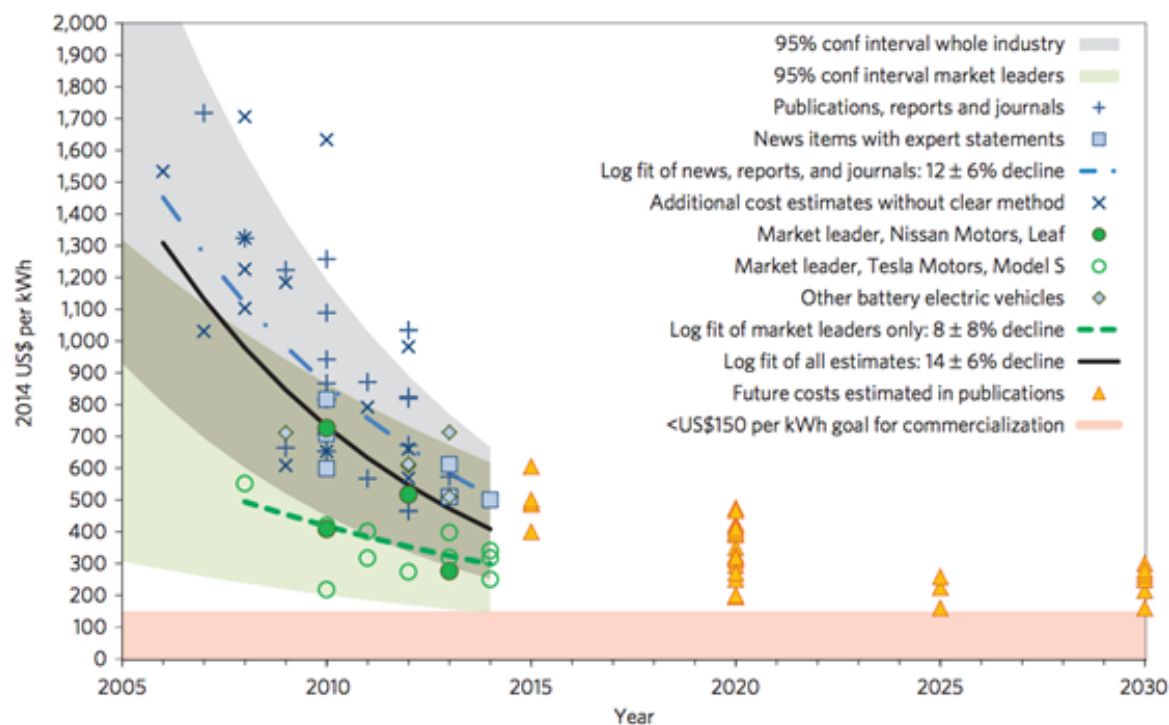
Each energy carrier pathway has **financial and economic barriers** impeding its uptake. The main **financial barriers to biofuels are related to the production of (sustainable) biofuel** (i.e. related to the energy carrier itself). The price difference between producing biofuel and conventional fuel is uncertain and depends strongly on oil price developments and a potential price increase for biofuel with a shift to the more advanced generation biofuels. Likewise, if blending percentages continue to increase up to a point where adjustments in vehicles and energy infrastructure are needed, financial barriers will remain high or even increase further. However, as dedicated biofuel vehicles are largely based on similar technologies as those used for ICVs and energy infrastructure adjustments can take place within the existing energy infrastructure of petrol and diesel stations, the barriers with respect to the vehicles are expected to remain relatively small.

Electricity and hydrogen need to be produced with sustainable renewable energy sources (e.g. biomass, wind), which may result in problems if no criteria are set and volumes become larger. However, at the moment, the financial barriers to the battery-electric and hydrogen pathways are mainly related to the vehicles and energy infrastructure. Both require a complete transition from the current vehicle fleet and energy infrastructure, although battery-electric vehicles have the advantage that they can also make use of the existing electricity grid. **Both battery-electric and FCEVs have significantly higher production and purchase costs compared to a conventional vehicle.** For cars, the price differences in 2010 were estimated at +100% for a FEV and +60 to 70% for a PHEV/EREV (CE Delft & AEA-Ricardo, 2013; AEA, 2012). More recent data from TNO and CE Delft (2014) show similar ratios. For FCEVs the price difference is even larger, e.g. a hydrogen distribution truck was three times more expensive than a conventional one in 2012 (CE Delft & DLR, 2013).

The price differences are decreasing and are expected to decrease further in the future due to economies of scale and learning effects. A recent study by Nykvist & Nilsson (2015) shows that the battery costs of BEVs are rapidly decreasing and that this is likely to result in price levels that allow full commercialisation within a decade, see Figure 3.

In addition to the battery cost, there are also issues to be solved with respect to the environmental and social problems related battery production and mining of raw materials (e.g. lithium and rare earth metals).

Figure 3 Cost estimates and future projections for electric vehicle battery packs.



Measured in \$US per kilowatt hour of capacity. Each mark on the chart represents a documented estimate reviewed by the study. Source: Nykvist et al Nilsson (2015).

Another financial barrier is related to the energy infrastructure for BEVs and FCEVs, which will require large investments. Literature is divided about the range of the investments required (e.g. due to the number of charging points necessary per BEV), but it is likely to be in the order of several hundreds of billions of euros (McKinsey, 2010) up to 2 trillion of euros (IEA, 2012) in Europe alone. IEA (2012) has defined these costs on a per kilometre basis and concludes that the required investments would add 1.8 eurocents per kilometre for an FCEV and 0.36 eurocents for a BEV.

The high financial investments required in the energy infrastructure cause, amongst other aspects, a **lack of sufficient infrastructure**. This is a barrier for consumers, as they are not willing to buy a vehicle that they cannot refuel/-charge easily. At the same time, infrastructure providers are reluctant to make large investments in refuel/-charge facilities before there is a sufficient amount of vehicles on the road (Melaina & Bremson, 2008).

This risk is probably largest for hydrogen as both vehicles and energy infrastructure need to start from scratch, while in the case of battery-electric, the existing power grid provides already a basic charging infrastructure. Furthermore, hydrogen vehicles are generally expected to be used for longer distances. Hence, even with small numbers of vehicles on the road, hydrogen vehicles will need a network of completely new filling stations with sufficient coverage over a wide geographical area (TNO et al., 2012).

Although BEVs require sufficient charging infrastructure in smaller geographical areas, charging times are generally long (except for fast charging facilities), and hence, sufficient overnight parking places need to be dedicated to BEVs (RAND Europe, 2012). Large numbers of BEVs do not solely require the roll out of a charging network, but also adaptations with respect to the grid and building intelligence in vehicles, charging points and the grid to allow smart charging.

Mid and high⁵ blend biofuels require engine modifications and adjustments in the service stations as well. Currently, the capacity of service stations to offer multiple blends is limited to two or three blends for petrol and two or three blends for diesel. In case of fungible (drop-in) biofuels, like HVO, there is no need for alternative fuel infrastructure. Either way, the adjustments in infrastructure are relatively smaller compared to electricity and hydrogen, as adjustments can be made within the existing energy infrastructure. Biogas can be an alternative, too. It can be used as feedstock for producing CNG or LPG, but will require additional energy infrastructure in those countries which do not have CNG/LPG distribution networks.

Each pathway also faces some technical challenges as regards vehicle technology (BEVs and FCEVs) and compatibility (biofuels). For BEVs, technical challenges are related to the limited energy density of batteries, which results in limited (electric) driving ranges (CE Delft, 2013), and to the long times required to charge the battery (RAND Europe, 2012). For FCEVs, the two main technical issues to improve are the on-board storage system of hydrogen, which is relatively heavy, large and costly at the moment, in particular for heavy duty vehicles, and the durability of the fuel cell system (i.e. the operating hours) (CE Delft & DLR, 2013). For biofuels the main technical hurdle to overcome is the compatibility of the vehicle fleet and fuel distribution with higher blends. The current car fleet in the EU can run on a mix containing around 7% biodiesel or 5-10% bioethanol without any engine modifications.

⁵ Mid blends are blends higher than what can be blended within current protection grades, e.g. B10/B30 and E15/E20/E25. High blends are for example E85 and B100.

In case of fungible (drop-in) biofuels, like HVO, there is no need to modify vehicles (although also until a certain maximum blend). Bio-CNG and bio-LPG can be used in conventional CNG or LPG vehicles and does not face significant technological hurdles with respect to vehicle technology.

The financial and technical barriers and lack of infrastructure negatively impact consumer acceptance.

In addition, consumers have limited choice in vehicle models (especially for FCEVs and FEVs) (McKinsey & Company, 2014), they may experience range anxiety (only for FEVs) and consumers may lack sufficient knowledge or confidence to determine the costs and benefits of BEVs and FCEVs (RAND Europe, 2012). Biofuels have also experienced some issues with consumer acceptance, especially with increasing blends. The majority of the fleet is capable to run on E10 for example, but consumers are afraid of engine damage, which partly results from the reluctance of OEMs to give warranties for higher blends.

Suppliers of fuel and vehicles may also be reluctant to accept new technology pathways, as they have vested interests in the existing transport systems in which they have invested billions of euros/dollars (Sovacool & Hirsh, 2009). Resistance to (low blends of) biofuels may be somewhat lower than for electricity and hydrogen at least in terms of infrastructure and vehicles, as they still need conventional oil refineries and conventional powertrain technology. Resistance to higher blends may be more problematic due to uncertainty in future policies for example. Moreover, vested interests hamper the switch from first to more advanced biofuels. Prior to the debates about ILUC, most biofuel production facilities built made use of conversion of food crops. These facilities are not yet depreciated and do not run at full capacity, which may reduce the ability and interest of the industry to move next generation biofuels. Also within governments there are some vested interests associated with the current energy technology. A major one consists of the tax revenues from fuel excise duties. A quick shift to AFVs would diminish these revenues and require some fiscal reforms to compensate for this.

Biofuel producers have to compete for the use of sustainably produced biomass. The availability of sustainable biomass needed to produce biofuels is limited. First, there are several other applications of biomass feedstocks in addition to transport, such as the food industry, electricity sector and chemical industry. Second, the production of biomass is limited to the availability of land that can be sustainably harvested. Advanced biofuels produced with waste and residues could also be limited by the availability of feedstocks and competition with other applications (Ecofys, 2013). In the case of biogas, there are various feedstocks possible like corn, vegetable waste and manure fermentation. Overall this barrier is therefore expected to be most problematic for biofuels.

While renewable electricity is also limitedly available at the moment, this is mostly related to the installed capacity and less to the general availability of the source. Moreover, due to existing policies, the share of renewables in power production is increasing rapidly in most parts of the world. In case of a fast uptake of FCEVs, hydrogen production from renewable sources needs to take off as well. This requires additional policies, but as hydrogen can be produced from various renewables (wind, hydro, solar and biofuels), the availability of sufficient renewable energy sources itself is not expected to be a main constraint.

A final barrier which can hinder each of the technology pathways are investment risks. A shift to alternative fuels/vehicles requires large investments in R&D and production facilities, while the return on investment is highly uncertain. This uncertainty is mainly related to the development of market shares, which in turn results from uncertainty in consumer preferences, in energy prices, in policy developments, and so on. Hence, investing in the ‘wrong’ technology can result in significant future losses and therefore transitioning to alternative fuels is risky.

2.4. CONCLUSIONS ON TECHNOLOGY PATHWAYS FOR ROAD TRANSPORT MODES

The previous sections have shown that each technical pathway has advantages and barriers and that there are some key differences between these pathways.

Biofuels represent a pathway where the transition is relatively incremental. Low blends can be introduced in the existing transport system by using conventional energy infrastructure and vehicles. With incremental steps the switch can be made to higher blends in which adjustments to the engines and infrastructure (but still within the existing system) may be required. Hence, biofuels (especially low blends) have relatively fewer barriers, but the advantages (especially in terms of GHG emission reduction) are smaller and more uncertain as well. Moreover, a switch to advanced biofuels from waste and residues is difficult but necessary in the long-term. The main challenge and uncertainty is related to the energy supply: the availability of sustainable feedstocks and competition with other sectors. Another main challenge is that investing in production facilities of next generation biofuels is associated with high risks.

When the availability of sustainable biomass increases and mid and high blends can be produced, barriers related to energy infrastructure and vehicles need to be overcome as well.

Battery-electric and hydrogen require a much more radical transition in which conventional vehicles and energy infrastructure need to be completely replaced by a new framework. Both pathways face significant financial and technical barriers and currently lack sufficient infrastructure. However, the benefits in terms of GHG emissions reduction, improvement of air quality and of energy security can be significant as well.

For cars, vans, buses and urban trucks, **battery-electric** are a promising pathway. However, the limited driving ranges and high costs of BEVs in comparison to conventional vehicles suggest that batteries need to improve significantly in the coming years to close this gap. This could either happen through gradual steps over the years and/or through a significant breakthrough in battery technology. From a cost and GHG emission performance point of view, PHEVs/EREVs are sub-optimal technology compared to FEVs. Nonetheless, they may play a role in the short- and medium-term, as they do not have range limitations and as such are acceptable to a larger share of the market. Hence, although FEVs are preferable in the long-term, PHEVs/EREVs can drive the necessary improvements in batteries and charging infrastructure first.

If breakthroughs in batteries are realised, battery-electric vehicles may sufficiently meet consumer demands in the long-term. However, if not realised, range limitations would remain an issue. **Hydrogen** could then provide a feasible option for these segments as well. However, the costs of FCEVs and the lack of hydrogen fuelling and distribution infrastructure are significant barriers that would need to be overcome first.

Overall, it can be concluded that **in the long-term, the role of biofuels is expected to be limited for light duty vehicles and road transport modes with relatively short driving ranges** as electric drivetrains are expected to become dominant. There are fewer emission reduction possibilities though for long-haul trucks, maritime, domestic navigation and aviation and electrification for these transport modes is less likely than it is for cars and vans. Hence, taking into account the uncertainty and limitations in sustainable biofuel availability, it seems more likely that the available biofuel is used by these other transport modes. However, the transition to electricity and/or hydrogen may take several decades. In the short to medium-term, a significant part of the car, van, bus and light truck fleets will still be comprised of ICVs. Hence, in the short to medium-term, biofuels provide a feasible option to reduce the climate impacts of ICVs.

3. AVAILABLE POLICY OPTIONS

3.1. INTRODUCTION

The transition to RES-T will result in significant changes for transport users and transport industries, including vehicle and component OEMs, oil companies, fuel suppliers and other energy suppliers (in particular power producers and grid operators).

In general, it is up to the market to deliver the required technology. The main changes with respect to vehicle and energy technology and infrastructure should therefore come from the industry. It should develop and produce goods and services needed for the transition to a transport sector that relies on renewable energy instead of fossil fuels.

However, without policy intervention, this transition is unlikely to take place. The main role of the public sector is to set the right framework conditions by strong, consistent and stable policies. Because the various actors, like auto manufacturers and energy companies (incl. oil companies), do not share the same beliefs on the winner powertrain technology, the public sector should also play a role in aligning the beliefs and preferences of various actors. The public sector, at all administrative levels can also play an important role through green public procurement and so contribute to the market uptake of a technology.

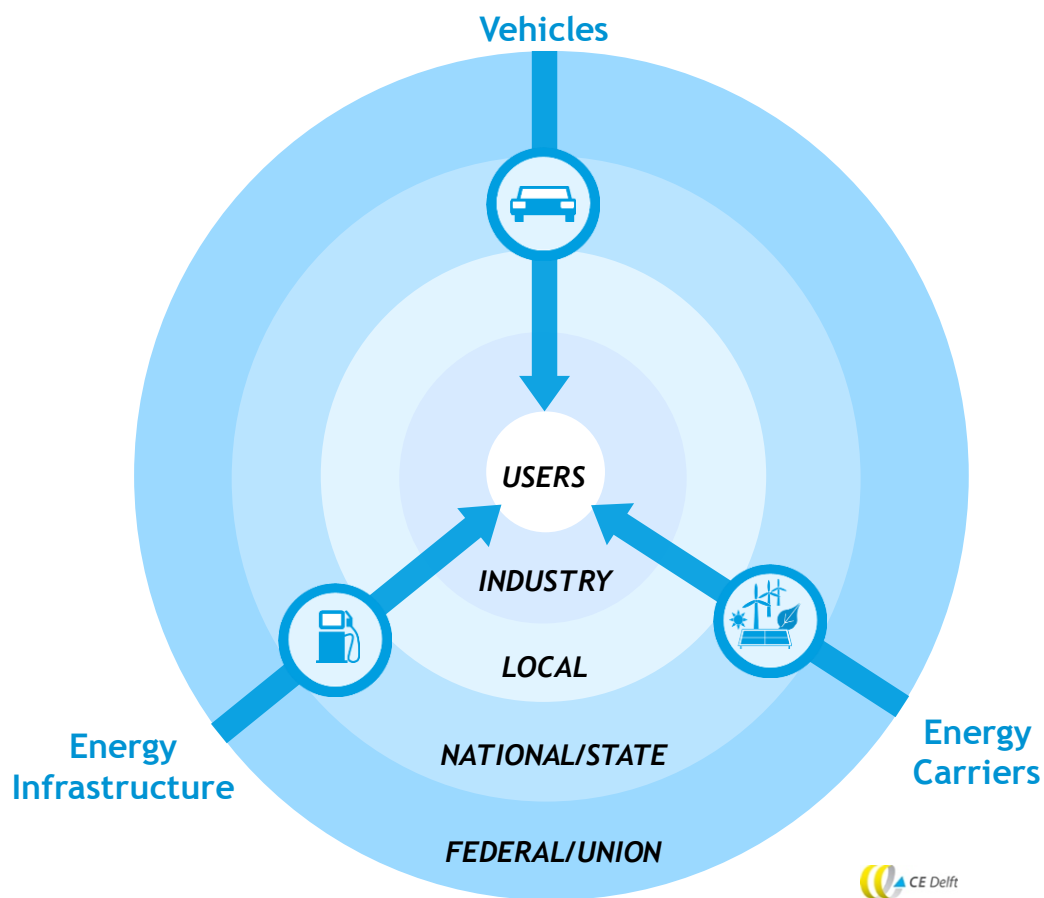
This chapter starts with a description of the key policies currently in place (Section 3.2). Hereafter, the full range of policy options is explored in Section 3.3. Finally, in Section 3.4 the results of the assessment of selected key policy instruments are summarised.

3.2. CURRENT KEY POLICIES TO PROMOTE RES-T AND MAIN DEFICIENCIES

Many governments have implemented a wide range of policy instruments to eliminate some of the barriers described in the previous chapter and to promote renewable energy uptake in transport. This is the case at both the national and local level. Furthermore, in the US and the EU, some policies are set at the national/union level. So, overall, three administrative levels can be distinguished.

As stated before, policy instruments can make changes with respect to vehicles, energy infrastructure, energy carriers or a combination of these dimensions. Figure 4 provides an overview of the three administrative levels and these three dimensions. In addition, the transport market players are included: transport users and transport industries, as they are ultimately targeted and making the required changes, stimulated or enforced by policies.








Figure 4 Three dimensions of RES-T policies in relation to the different administrative levels



When analysing the existing policy approaches, many differences between regions can be identified, but some similarities as well. Annex A contains a summary of the key policies implemented by the EU, US/Canada, Japan and China, with respect to the three dimensions distinguished in this study (vehicles, energy infrastructure and energy carriers). This section summarises some of the key differences and similarities between these regions.

Figure 5 summarizes the main policy approaches per region.

Figure 5 Key differences and similarities between RES-T policies in US/Canada, EU, China and Japan

	 US/Canada	 EU	 China	 Japan
 Energy carrier	<ul style="list-style-type: none"> Mandate on the volume of renewables in fuel 	<ul style="list-style-type: none"> Mandate for RES-T Mandate for renewables in fuels 	<ul style="list-style-type: none"> Targets for renewables in fuel 	<ul style="list-style-type: none"> Mandate for volumes of ethanol
 Energy Infrastructure	<ul style="list-style-type: none"> No federal policies on alternative infrastructure, but States have grants/loans 	<ul style="list-style-type: none"> Directive requiring MS to implement policy for alternative energy infrastructure 	<ul style="list-style-type: none"> Large scale roll-out of EV charging points in 20 pilot cities 	<ul style="list-style-type: none"> Subsidies for H2 filling stations and charging points
 Vehicle	<ul style="list-style-type: none"> LDV/HDV standards Some US states have ZEV Mandates 	<ul style="list-style-type: none"> LDV standards with specific incentive for EVs Many fiscal incentives for AFVs by MS 	<ul style="list-style-type: none"> LDV/HDV standards Min. shares of AFVs in public fleets AFV subsidy scheme 	<ul style="list-style-type: none"> LDV/HDV standards National targets for AFV sales



Mandates for the share of renewables in fuel exist in the US, Canada, Japan and the EU; China sets voluntary targets.

The rollout of alternative fuelling or charging infrastructure is heavily subsidised in China and Japans. In the EU and North America, this is rather a responsibility of (Member) States, also mainly by subsidies and PPPs.

All regions have vehicle standards for Light Duty Vehicles (LDVs) and except for the EU, also for Heavy Duty Vehicles (HDVs). In the EU, many Member States have fiscal incentives for AFVs; in the US many states have Zero Emission Vehicle Mandates. In China green public procurement is an important driver for RES-T.

3.3. RANGE OF POLICY OPTIONS TO TACKLE BARRIERS AND PROMOTE RES-T

A wide range of policy options is available to remove barriers and to promote alternative energy carriers, vehicles, and/or energy infrastructure. These policy options can be implemented by different administrative levels (i.e. federal level of the US/EU, (Member) State level and/or local levels). In this study, five key types of policy instruments are distinguished. Table 4 summarises these categories and also provides an indication of which barriers are most likely to be tackled with each type of policy instrument.

Table 4 Relation between barriers and key types of policy instruments (per pillar)

Barrier	Pillar	Main type of policy instrument				
		Financial instruments	Regulation	Information provision	Public procurement & PPPs	Transport & Spatial policies
Financial barriers*	Vehicle	X	X		X	X
	Energy carrier	X	X		X	
	Energy infrastructure	X			X	
Technical barriers	Vehicle	X	X		X	
	Energy carrier	X				
Low acceptance by transport users	All	X		X	X	X
Lack of sufficient energy infrastructure	Energy infrastructure	X	X		X	
Vested interests	All	X	X		X	X
Competition for the use of renewable energy	Energy carrier	X	X			
Investment risks	All	X	X		X	X

* Financial barriers and investment risks are related as many instruments that can help to reduce investment risks, also result in higher economies of scale and so in lower cost.

As shown in the table above, most barriers can be overcome with multiple types of policy instruments. Moreover, each main type of policy instrument can be designed in various ways. Financial instruments can for example be implemented as differentiated taxes, tax exemptions, subsidies, and so on.

Annex B contains a long list of policy options, structured by the five main types of policy instruments mentioned above.

A short list containing 17 policy options and 17 cases has been defined. The main selection criteria for the short list were to ensure:

- sufficient geographical coverage both in terms of countries and of administrative levels covered;
- proven or expected effectiveness of the policy option in terms of increasing the share of RES-T;
- a good mix of policies in terms of the three main dimensions targeted (vehicles, energy carriers and energy infrastructure) and of the main type of instruments.

Table 5 shows the short list that resulted from this selection process. Those types of policy instruments and case studies have been assessed in detail and the results of that are discussed in section 3.4 and chapter 4.

Table 5 Short list of policy options and case studies

#	Type of instruments	Case
Financial instruments		
1	Incentives in energy taxation	-
2	Incentives in vehicle registration taxes	Norway
3	Incentives in company car taxation	The Netherlands
4	PPPs and subsidies for energy infrastructure	Japan California (hydrogen)
5	Incentives in (urban) road pricing and tolls	UK (London)
Regulation		
6	Fuel regulation	EU: FQD implementation in Germany California: LCFS
7	Renewable energy mandates	EU: RED implementation in Italy
8	Regulation of charging/fuelling infrastructure	Sweden (for biofuels)
9	CO ₂ regulation for road vehicles	EU: CO ₂ & cars regulation
10	ZEV mandates	California
Traffic management and land-use policies		
11	Incentives in parking policies	Graz (Austria)
12	High Occupancy Vehicle (HOV) Lanes Incentives	-
13	Urban access restrictions	China
Other policies		
14	Information provision (on locations of alternative energy infrastructure, payment services and CO ₂ footprint of fuels offered)	-
15	Green public procurement	Japan
16	Pilots / demonstration projects	-
17	Policies to increase RE consumption	-
Overall policy strategy		Brazil: ethanol program Proálcool

In Table 6 the instruments not included in the short list are summarized. They were in general not selected for one or several of the following reasons (see Annex B for more details). Note that some of these instruments, although not assessed in detail in this study, can still be relevant and worth to be implemented in some cases or for other purposes.:

- **Low cost-effectiveness:** some instruments are not seen as a cost-effective means to increase the share of RES-T.
- **Too indirect incentive:** not all instruments are targeting an increase share of RES-T, but rather other policy objectives. This might result in too indirect incentives and consequently small impacts on RES-T.
- **Low effectiveness:** instruments not strong enough/not effective enough.
- **Limited scale of impact** is related to the share of the transport sector covered by the policy instrument. Some instruments have been preferred over others due to differences in the scale of impact.
- **Low transferability:** some policy instruments are too dependent on local circumstances and therefore lessons to be learned are hard to transfer elsewhere.

Table 6 Instruments not included on the short list including reasons for exclusion

Number*	Type of instruments	Main reasons for exclusion
Financial instruments		
6	Emission trading	Cross-sectoral emission trading schemes have small impacts on transport prices and emissions. System only covering transport is similar to fuel taxation. See also text box on the next page.
7	Tax breaks for biofuels	Tax breaks helped launch industries but are expensive and many countries have therefore shifted away from it, to mandates.
8	Incentives in annual circulation tax	Not very effective as car users are relatively incentive for circulation taxes.
9	Exemption from VAT	Implemented in only one country and works similar to vehicle taxes.
10	Direct subsidies for vehicle consumers	There are less costly and more effective policies available, such as incentives in vehicle taxes.
11	Subsidies for car manufacturers	There are less costly and more effective policies available, such as the vehicle standards. It is partly covered by Factsheet 4 and 16
12	Incentive for renewable energy production	Too general, not specifically targeting transport. Partly covered by Factsheet 17.
13	Support for R&D and pilots with vehicles	This study focusses mainly on instruments increasing the use of renewable energy in transport, while this instrument is more focused on innovation. It is partly covered by Factsheet 16.
Regulation		
20	CO ₂ standards LCVs	Instrument is very similar to the CO ₂ Regulation for cars. However, as there are many more cars than LCVs worldwide, the car policy is included in the short list instead of the LCV standard.
21	CO ₂ standards trucks and buses	Instrument is rather similar to the CO ₂ Regulation for cars. Furthermore, existing CO ₂ standards for trucks and buses do not provide specific incentives for AFVs.
Information provision		
23	Certificates (e.g. for renewable electricity) and bio-tickets	This is mainly a means to administrative handle the trade in renewable energy rather than related to information provision.

Number*	Type of instruments	Main reasons for exclusion
25	CO ₂ or energy labelling of cars	CO ₂ emissions of cars are also regulated, which is much more effective.
26	CO ₂ or energy labelling of vans	Not very effective for increasing the share of renewable energy in transport, as it provides weak incentives.
27	CO ₂ or energy labelling of trucks and buses	Not very effective for increasing the share of renewable energy in transport, as it provides weak incentives.
28	CO ₂ or energy labelling of vehicle components	Labelling components provides no specific incentive to AFVs and is therefore not included in the short list.
29	Carbon footprinting of transport services	Provides too weak incentives for increasing RE in transport or AFVs and has only been implemented in France.
Public procurement and PPPs		
31	PPPs for Innovative city distribution	This is not included in a separate factsheet, but innovative city distribution is discussed in a text box on page 55 and partly covered by Factsheet 4.
32	PPPs for investing in ZEVs (e.g. taxis)	Expensive to implement at larger scales and partly covered by Factsheet 4.
Traffic management and land-use policies		
36	RE production in or along transport infrastructure	Does not explicitly stimulate the increased application of renewable energy in transport although it is closely related.
37	Land use planning w.r.t. filling and charging infrastructure	Land use policy differs between countries and regions and appropriate rules depend on specific circumstances. Therefore, it would be difficult to investigate what would be a 'good' design of this instrument for the promotion of an alternative infrastructure. Furthermore, impact on RE use or AFV uptake expected to be small.
38	The right for a charging point	Not much variation in design and also very dependent on local circumstances. Therefore it has not been included.

* Numbers corresponds to the numbering in Annex B.

Emissions Trading System

A relevant policy instrument for the industry and power sector is the EU Emissions Trading System (ETS). The ETS concerns a 'cap and trade' principle, where a maximum (cap) is set on the total amount of GHG emissions that can be emitted by all participating installations. 'Allowances' for emissions are then auctioned off or allocated for free, and can subsequently be traded. The ETS system provides an incentive to reduce emissions via the most cost-effective means and therefore leads to relatively cost-effective reduction of GHG emissions.

The EU ETS affects the WTT GHG emissions of transport as it also includes the refining and power sectors. Therefore the ETS provides some incentives for RES-E and by affecting the power mix indirectly also provides incentives for RES-T. However, it should be noted that the allowance prices in the ETS are currently much too low for having significant impacts on the share of renewables and are expected to remain low for several years.

The transport sector is currently not included in the EU ETS (except for aviation). Inclusion of road transport is feasible as recently studied by CE Delft (2014). However, the impact on the transport sector in general and the share of RES-T in particular is under the current regime negligible. The current level of 5 euro per ton of CO₂ translates into a fuel price increase of only 1 eurocent per litre of gasoline. This is less than the daily fluctuations in fuel prices and thereby much too low to be noticeable to most customers (ICCT 2014). FiFo-Köln (2005) also estimated the effect on fuel prices to be low (1.3 eurocent to a maximum of 8 eurocent per litre for a CO₂ price

per tonne between 5 and 30 euro). Apart from the specific case of **the EU ETS**, emission trading could at least in theory be an effective instrument for reducing transport emissions. It results in higher fuel prices and the impacts are similar to raising fuel taxes with the same rate.

3.4. METHODOLOGY FOR ASSESSMENT OF SHORT-LISTED POLICIES

Each type of policy instrument on the short-list has been assessed and scored on six criteria. In addition, the **key lessons learned and other considerations were assessed**. This resulted in a **fact sheet for each policy option which can be found in Annex C**, while the results of the scoring assessment are summarised in (Table 8) in section 3.5.

The six criteria are:

- **Increase in alternative powertrains** (electric, fuel-cell, high blend biofuel vehicles, including gas powered and flex-fuel vehicles): the strength of the incentives provided to stimulate alternative powertrains, and where possible the results (i.e. share of alternative powertrains).
- **Increase in renewable energy**: the impact of the policy instrument on ensuring that the alternative energy carriers used in transport are based on renewable energy sources.
- **GHG emissions reduction**: the GHG emission reduction (TTW and WTW) realised by the instrument in relative (e.g. % reduction in the region) and absolute terms (e.g. in g/km).
- **Coverage**: the coverage of the instrument; instruments which influence a large share of the supplied energy, infrastructure, or vehicle fleet of a particular region can have a potentially larger effect on RES-T/GHG emission reduction.
- **Cost-effectiveness**: the net costs to society in terms of euro per tonne of CO₂ eq. The following cost components are taken into account:
 - Investment costs, e.g. higher purchase prices (excluding taxes) of electric vehicles.
 - Operational costs, e.g. energy cost savings (excluding taxes) by a shift to electric vehicles.
 - Regulation costs, e.g. costs for local governments to implement an urban road charging scheme.
 - Non-monetary welfare costs, e.g. loss in individual welfare due to a decrease in kilometres travelled. This effect may be relevant for policy options which discourage travel demand (e.g. road charging schemes, increased energy taxes, etc.).
 - External costs, e.g. air pollution, accidents, noise, congestion.

It should be noted that many of the cost components are very case-specific, as they depend on factors such as the fuel price. The scores of the policy options on cost-effectiveness are preferably based on specific evaluation studies. If these are not available, the likely direction (net cost or net savings) is indicated based on expert judgement.

- **Ease of implementation**: the difficulty of implementing the policy instrument.

Each instrument has been scored with a ++, +, 0, - or --. The legend of the scoring used can be found in Table 7. The scoring on these criteria reflects the current situation with respect to the state-of-the-art and cost of technology.

It should be noted that **scores could change over time** (this will also be discussed later on in this chapter) and also depend to some extent on the way the policy instrument is designed and implemented.

Some instruments on the short-list have not been scored. These are the instruments not focussed on *market uptake* but on stimulating *technology development, pilots, demonstration and/or market introduction*; the goals of these instruments are inherently different and scoring on the assessment criteria is less relevant. Furthermore, some instruments have not been scored on cost effectiveness when this is too dependent on the exact design of those policies.

For some of the policy instruments, **specific case studies** have been drafted as well. In these case studies the design and impacts of an instrument actually implemented are described. These instruments have been assessed on the following five criteria:

- **increase in alternative powertrains** (electricity, hydrogen and biofuels): same criteria as used in the factsheets;
- **increase in renewable energy**: same criteria as used in the factsheets;
- **GHG emissions reduction**: same criteria as used in the factsheets;
- **cost impacts**: the various cost elements for the different players (end-users, government, industry, etc.) are identified and assessed;
- **cost-effectiveness**: same criteria as used in the factsheets.

The case studies can be found in Annex C as well.

The results of the assessment of individual policy instruments have been used to define overall policy strategies. This will be the topic of the next chapter. As the barriers differ per pathway, the mix of policy instruments included in the overall policy strategy also differs.

Note that the scores below represent the *overall score* for all pathways (battery-electric, hydrogen or biofuel): an instrument could score high on ‘increase in renewable energy’, while not contributing to an increase of all three types of renewable energy. Therefore an instrument with high scores might not be the preferred choice for each of the three individual pathways.

3.5. RESULTS OF THE ASSESSMENT OF POLICIES ON THE SHORT LIST

Table 7 Legend of assessment scoring

	Increase alternative powertrains*	Increase renewable energy*	GHG reduction**	Coverage***	Cost- effectiveness* ***	Ease Implementation ****	of
--	Strong decrease in alternative powertrains	Strong decrease in renewable energy consumption	Strong increase in relative GHG emissions	Very small coverage (very small share of the market)	Very high net costs to society	Very difficult	
-	Decrease in alternative powertrains	Decrease in renewable energy consumption	Increase in relative GHG emissions	Small coverage (small share of the market)	Modest to high net costs to society	Difficult	
o	Neutral impact on alternative powertrains (i.e. no change)	Neutral impact on renewable energy consumption	Neutral impact on relative GHG emissions	Medium coverage (significant share of the market)	(close to) neutral costs to society	Modest	
+	Increase in alternative powertrains	Increase in renewable energy consumption	Decrease in relative GHG emissions	Large coverage (large share of the market)	Modest to high net benefit to society	Easy	
++	Strong Increase in alternative powertrains	Strong increase in renewable energy consumption	Strong decrease in relative GHG emissions	Very large coverage (entire market)	Very large net benefit to society	Very easy	
#	Unclear or too dependent on design	Unclear or too dependent on design	Unclear or too dependent on design	Unclear or too dependent on design	Unclear or too dependent on design	Unclear or too dependent on design	

* Increase or decrease in the total share of alternative energy carriers or renewables in the respective market segment (for the segments that were indicated in the box 'main impacts on').

** This criterion is related to the relative GHG emission reduction, such as the relative improvement in an average vehicle's efficiency, the relative reduction in CO₂ emissions per MJ, etc. (for the segments that were indicated in the box 'main impacts on').

*** Coverage of the instrument in the respective market, e.g. share of the vehicles covered, share of the electricity used in transport, etc. (for the segments that were indicated in the box 'main impacts on').

**** From a societal perspective.

***** From a government perspective

		Effectiveness			Other criteria		
Assessment criteria*		Increase alternative powertrains	Increase renewable energy	GHG reduction	Coverage	Cost-effectiveness	Ease of implementation
Policy instrument							
Financial instruments (Annex C.1)							
1	Incentives in energy taxation	o/+	+	++	++	+	+
2	Incentives in vehicle registration taxes	++	o	++	++	#	+
3	Incentives in company car taxation	++	o	++	+	#	+
4	PPP and subsidies for energy infrastructure	o/+	o/+	o/+	+	o	o
5	Incentives in (urban) road pricing and tolls	+	o	o/+	o	-	o
Regulation (Annex 0)							
6	Fuel regulation	o	+ / ++	+	++	-	o
7	Renewable energy mandates	o	++	+	++	-	+
8	Regulation of charging/fuelling infrastructure	+	+	+	++	o	+
9	CO ₂ regulation for road vehicles	+	o	++	++	++	o/+
10	ZEV mandates	++	o	+ / ++	+	--	-
Traffic management and land-use policies (Annex C3 C.3)							
11	Incentives in parking policies	+	o	o/+	o	-	o/+
12	High Occupancy Vehicle (HOV) lane incentives	+	o	o/+	o/-	+	o/+
13	Urban access restrictions	o/+	o	o/+	o	#	o
Other policies (Annex 0)							
14	Information provision	o/+	o/+	o/+	+	#	+
15	Green public procurement	+	o	+	-	#	+
16	Pilot/demonstration projects**	n/a	n/a	n/a	n/a	n/a	n/a
17	Policies to increase RE consumption **	n/a	n/a	n/a	n/a	n/a	n/a

* Note that these scores should be regarded as averages. The scores can vary significantly and depend on the way an instrument is implemented.

** These two policy instruments have not been scored because they are not focussed on market uptake but on stimulating pilots, demonstration and/or market introduction; the goals of these instruments are inherently different and scoring on the assessment criteria used here is therefore less relevant.

In the following the results are briefly discussed by assessment criteria highlighting the most effective and useful policies (which scored ++ or +). **Based on this analysis and the more detailed underlying assessment in Annex C, the overall policy strategies are further elaborated in chapter 4.**

3.5.1. Policies for effectively stimulating alternative powertrains

Table 8 shows that there are many policies that can effectively increase the share of alternative powertrains in the vehicle fleet. As this touches upon the main barrier for the electric and hydrogen pathways, these policies are particularly relevant for these two pathways. The most effective instruments are:

- ZEV mandates;
- incentives in vehicle registration taxes; and
- incentives in company car taxation schemes.

The reason is that these policies can directly target vehicles with alternative powertrains. ZEV mandates provide the most direct and strongest incentives to vehicle OEMs for developing, offering and marketing such AFVs. The two types of tax incentives have proven to be the most effective for stimulating consumers to purchase AFVs. This is among others related to the relatively high price elasticity of the behavioural response to those instruments and reflected by the large AFV sales in Norway and the Netherlands.

CO₂ regulation for road vehicles can also stimulate AFVs, but this depends on the design and on the target level. Current regulations provide modest incentives, but once target levels are sufficiently low and approach values that cannot be achieved anymore with ICVs the incentive for AFVs can be strong.

However, also many other policies can contribute: both generic instruments like energy taxation (by improving the TCO of AFVs compared to ICVs), instruments targeting charging and fuel infrastructure as well as incentives by local instruments like parking policies, HOV lanes, urban access restrictions and urban road pricing schemes. Also Green Public Procurement can help to create sufficient demand for AFVs, allowing OEMs to build and scale up production capacity.

3.5.2. Policies for effectively increasing the share of renewable energy use in transport

The range of instruments directly contributing to higher shares of renewable energy use in transport is much smaller. The most effective instruments are:

- Fuel regulation; and
- Energy regulation (renewable energy mandates).

These two instruments do directly target renewable energy use in transport, while most other instruments just indirectly affect renewable energy use. Particularly for the biofuel pathway, main barriers are related to energy supply, so for this pathway these are key policy instruments.

With respect to the other two pathways, it should be noted that the share of renewable energy sources in power and hydrogen production is not significantly affected by transport policies, but mainly by overall (renewable) energy policies.

Most policy instruments stimulating alternative powertrains can also result in higher shares of renewables in transport, but as long as the share of renewables in power and hydrogen production is low or modest, this effect is not very significant. In the medium to long term and in specific countries with already high shares of renewables in power (or hydrogen) production, such as Norway, policies stimulating AFVs will also result in higher shares of renewables in transport.

3.5.3. Policies for achieving the largest GHG emission reduction

All policy instruments that have been assessed in detail can contribute significantly to GHG emission reduction. Highest GHG emission reductions can be expected from instruments targeting both RES-T and fuel efficiency improvements of conventional vehicles:

- CO₂ regulation of road vehicles;
- incentives for AFVs and fuel-efficient vehicles in vehicle registration taxes;
- incentives in company car taxation;
- energy taxes (e.g. CO₂-based fuel excise duties and electricity taxes) will affect all types of energy use in transport and also trigger behavioural change like modal shift.
- ZEV mandates can result in high GHG-emission reductions when significant shares of AFVs are mandated. The reason is that, even with current power generation mix, AFVs do usually result in large GHG emission reductions. The impact of a ZEV mandate may however interfere with that of vehicle regulations.

The reason for this is that for the short to medium term, a large share of vehicle sales will still be conventional. There is a large potential for GHG emissions reduction by making those vehicles more fuel efficient. Therefore instruments that improve the energy efficiency of those vehicles are generally more effective in terms of GHG emission reduction than instruments just targeting AFVs.

3.5.4. Policies with the largest coverage

Financial instruments and regulation have the largest coverage as they often affect all or a very large share of all (new) vehicles in a country. Traffic and land-use policies and in particular green public procurement usually have much lower coverage as the share of the fleet that is affected is relatively small.

3.5.5. Policies with the highest cost-effectiveness

Most policies for stimulating RES-T currently score low on cost-effectiveness. The reason for this is that cost-effectiveness is strongly dependent on the total social cost of alternative AFVs and biofuels. In the current situation, the fuel savings and other internal and external cost reductions do not outweigh the much higher costs of BEVs, FCEVs or costs of biofuel production.

It should be emphasized that the cost-effectiveness may improve in the coming years when costs of AFVs go down due to economies of scale. For all three technology pathways, the development of fossil energy prices is also an important factor for the development of the cost-effectiveness of the various alternatives.

CO₂ regulation for cars and other road vehicles is the most cost-effective instrument on the list. The reason is that these instruments, apart from stimulating AFVs, also provide incentives for improving the fuel efficiency of conventional vehicles (ICVs). Those technologies are among the most cost effective GHG emission reduction measures in transport, which makes that vehicle regulations are very cost-effective too. Instruments mainly stimulating more expensive reduction options (like AFVs or biofuels) are, at least at the short to medium term, generally less cost effective.

For the longer term it should be noted that when vehicle standards are further tightened, their cost-effectiveness will probably decrease, as the social cost of additional GHG emission reduction will increase. This can be (partly) off-set by economies of scale and innovations. When vehicle standards push large shares of AFVs to the market this also worsens the cost-effectiveness, unless production costs of these vehicles have sufficiently gone down and their overall social cost have become competitive. Apart from the cost development of AFVs, also the development of fossil fuels prices and the cost renewable energy generation are an important factors that determine the overall cost effectiveness in the long term.

3.5.6. Policies that can easily be implemented

The ease of implementation depends on both the complexity of the development of the policy and the implementation and/or enforcement. From all instruments assessed, experiences in California have shown that implementing an effective and workable ZEV mandate is relatively complicated. However, also various other instruments can be difficult to implement often related to strong resistance by stakeholder groups and/or technical challenges in the implementation and enforcement.

4. POLICY STRATEGY PER PATHWAY

4.1. INTRODUCTION

This chapter proposes an overall policy strategy for increasing the share of RES-T. It explains how the various policy instruments and administrative levels could work together effectively and help the market to overcome the barriers identified in Section 2.3.

The most suitable policy strategy for increasing the share of RES-T cannot be designed as a ‘one-size-fits-all’ approach, but should take account of:

- differences in the main barriers for various technology pathways;
- differences in the maturity of technologies and market phases (innovation, market introduction, commercialisation);
- specific challenges or opportunities in different regions/countries.

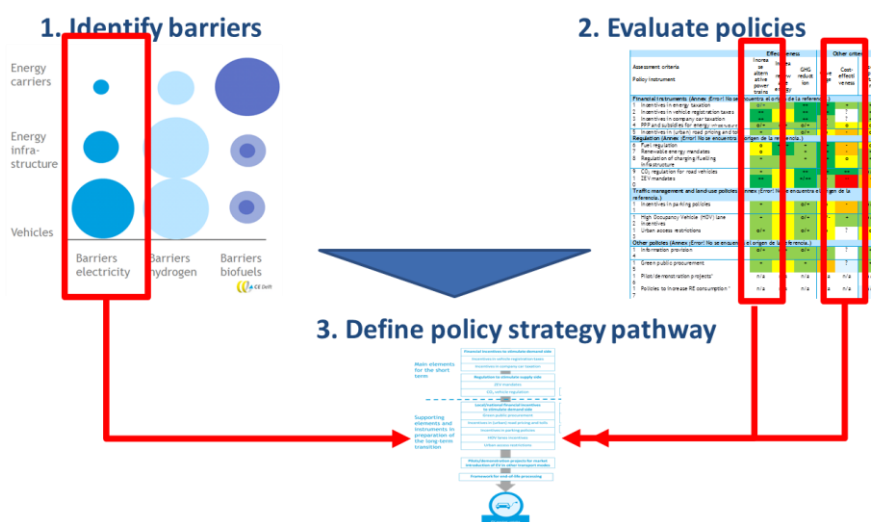
Due to the differences in the barriers that need to be overcome, the policy strategy differs between pathways. Therefore, **the policy strategy is elaborated for each technology pathway separately:**

- Section 4.2 for battery-electric.
- Section 4.3 for hydrogen.
- Section 4.4 for biofuels.

Figure 2 showed in which dimensions the main barriers exist for each renewable energy pathway. Taking these barriers into account in combination with the scores of different policy options (see Table 8), a short list of main policy instruments has been made for each pathway. This is schematically shown in Figure 6 for the battery-electric pathway.

Figure 6 Schematic overview of the methodology for selecting main policy instruments per pathway (for the battery-electric pathway)

Deriving the strategic policy mix for the electric pathway



In the policy strategy we distinguish main instruments and supporting instruments:

- The **main instruments** are the cornerstones of the policy strategy and are needed to overcome the most important barriers. They should preferably be developed in the short term.
- The **supporting instruments** can either be instruments supporting the main instruments, (e.g. focusing on a specific vehicle segment) or needed for preparing for the long-term transition and future challenges (e.g. policies aimed at preparing the power grid for very high share of BEVs).

After presenting the main policy instruments per pathway, this chapter continues with various cross cutting issues (Section 4.5), including the link with broader transport policies, broader energy policies, targeting specific user groups, cost-effectiveness, technology neutrality, dealing with uncertainties and specific challenges or opportunities in different regions/countries.

Finally, in Section 4.5 the overall policy strategy for all three technology pathways together is summarised, also indicating the roles of different actors and administrative levels.

This chapter builds on Chapter 2 and 3, interviews with some key players and experts in this field (see Annex D), a literature review, and on the assessment of individual policy instruments, which can be found in Annex C.

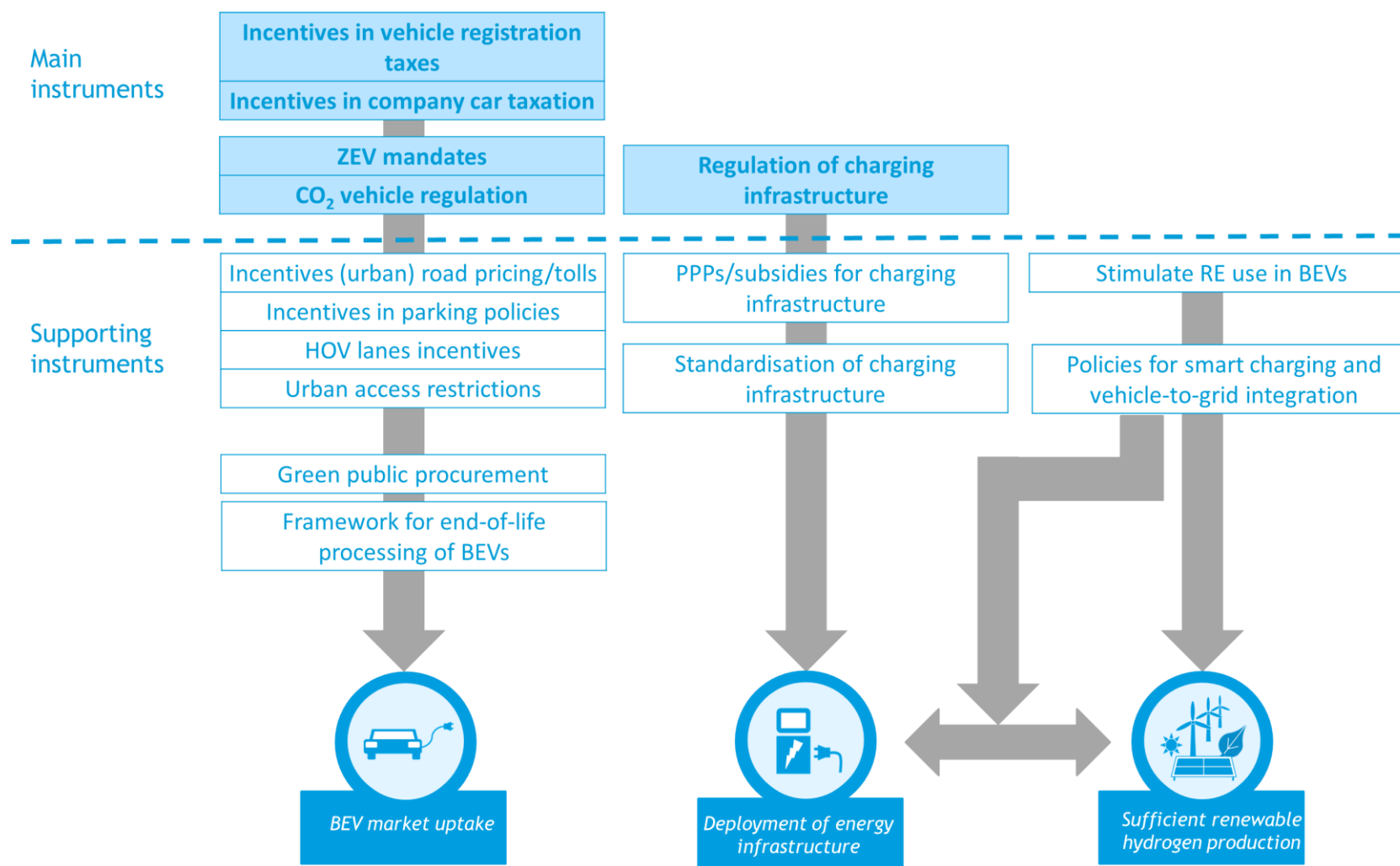
4.2. OVERALL POLICY STRATEGY FOR THE BATTERY-ELECTRIC PATHWAY

Figure 7 summarizes the *main* policy instruments and *supporting* policy instruments for the battery-electric pathway and shows which of the three main dimensions are targeted with each instrument. Note that in the case of battery-electric, there is a linkage between charging infrastructure and renewable energy production. Therefore, there is also a group of policies which targets this interaction and renewable energy production at the same time.

As concluded in 2.3, the main policy instruments within the battery-electric pathway should mainly target the uptake of BEVs in the overall vehicle fleet. **For this reason, policy instruments scoring high on ‘increase in alternative powertrains’ in Table 8 are selected as main instruments.** Four policy instruments can be regarded as the most important ones: two regulatory instruments to stimulate the demand side and two financial instruments to stimulate the demand side. In addition to the vehicle dimension, also the charging infrastructure requires policy support. Regulation of charging infrastructure (as part of a broader regulation of energy infrastructure) is the main instrument for that.

These main instruments and the reasons for selecting them are explained below. In section 4.2.6, the supporting policies for this pathway are summarized.

Figure 7 Overview of main policy instruments for stimulating the battery-electric pathway



4.2.1. Incentives in vehicle registration taxes (Factsheet 2 in Annex C.1)

Without financial incentives, the Total Cost of Ownership (TCO) of BEVs is currently not competitive with that of conventional vehicles. This is one of the main barriers for high shares of BEVs in new vehicle sales. Financial incentives in vehicle registration taxes can stimulate the demand side and provide strong incentives to all car buyers and scores therefore high on ‘coverage’. **Financial incentives help to improve the TCO of BEVs and have proven to be effective for stimulating BEV sales** (high score on increase alternative powertrains in Table 8). As car buyers are much more sensitive for registration taxes than for annual circulation taxes, the first are more suitable for providing incentives than the latter.

Incentives in vehicle registration taxes cannot just boost BEV sales but also result in significant GHG emission reductions, particularly when they do also provide incentives for other low carbon vehicles (e.g. fuel efficient ICVs; see high score on GHG reduction in Table 8).

The impact of vehicle registration taxes (and company car taxes) strongly depends on the level and design of tax benefits. As described in Factsheet 2 in Annex C.1 the share of FEVs is far higher in Norway compared to the Netherlands, because the Dutch tax benefit for FEVs was not sufficient to compensate for the higher purchase prices (ICCT, 2014d).

Also the cost effectiveness of this type of instrument depends strongly on its design. **Combining incentives for BEVs with incentives for fuel efficient ICVs will generally improve its cost effectiveness.** There can however be a trade-off with the effectiveness for increasing the share of BEVs. To avoid a decrease in tax revenues, incentives should be off-set by higher rates for relatively inefficient vehicles and **rates should be reviewed regularly** to take account of the autonomous fuel efficiency improvements and improvements resulting from CO₂ standards.

Technology development, learning curves and economies of scale are expected to improve the electric range of light duty BEVs while reducing their cost. In the long run, this is likely to result in a competitive TCO for BEVs compared to ICVs. Therefore in the medium to long term (5-10 years), the tax incentives can be built down.

For the medium to long-term, FEVs should be able to gain a large market share, but for the short to medium-term PHEVs and EREVs are considered to be important bridging technologies and can be stimulated too (e.g. with financial incentives). They are an important means to ensure consumers are getting used to BEVs, reduce range anxiety and support the roll-out of charging infrastructure.

4.2.2. Incentives in company car taxation (Factsheet 3 in Annex C.1)

Like in vehicle registration taxes, incentives in company car taxes can also lower the purchase price of BEVs. The coverage of this instrument is assessed lower due to the fact that incentives in company car taxation only affect company cars and consequently a smaller part of the fleet. At the other hand, **this instrument can boost BEV sales as least as much as incentives in registration taxes**, because corporate fleets have high annual mileages which improves the TCO of BEVs and the share of company cars in new vehicle sales is in most countries very significant (in the EU on average around 50%, (Roy, 2014)).

The considerations on design, impacts and cost effectiveness that were mentioned above for incentives in vehicle registration taxes also apply to company car taxes.

4.2.3. ZEV mandates (Factsheet 10 in Annex C.2)

The ZEV mandate is a regulatory measure setting binding targets for minimal shares of ZEVs sold in a particular Region. It has been implemented first by California and currently exists in several other US States. Where the financial incentives discussed in the previous sections address the demand side, ZEV mandates target the supply side. **ZEV mandates provide obligations for OEMs to supply ZEVs (like BEVs) to the market and are therefore a key policy for the battery-electric pathway, particularly at the short term.** They can be well combined with CO₂ vehicle standards (see below). Once the target levels of vehicle standards are set so low that they can not be met without large shares of ZEVs, the need for a ZEV mandate diminishes.

ZEV mandates are, however, seen as relatively difficult to implement compared to vehicle standards, as they leave less flexibility to the market (Bedsworth & Taylor, 2007).

4.2.4. CO₂ vehicle regulations (Factsheet 9 in Annex C.2)

With the current CO₂ standards for cars and vans, BEVs are not needed for meeting the targets, as targets can be met against much lower costs by applying fuel efficiency improvements on conventional vehicles (ICVs). However, when targets go down, more expensive GHG emission reduction options will be needed and then also BEVs can be pushed to the market. Therefore **a continuous decrease of the CO₂ targets of vehicle standards stimulates OEMs to develop BEV technology** and brings BEVs to the market. This way, CO₂ vehicle regulations can step by step take over the role of ZEV mandates and provide the incentives for BEVs.

The existing CO₂ standard in the EU provides additional incentives for BEVs by the so-called super credits. With this scheme, cars with emission factors of less than 50 grams per kilometre are counted more than once to meeting the target and so OEMs have additional incentives for bringing them to the market. However, super credits are often criticised for reducing the stringency of the overall CO₂ target (EC, 2012). In theory super credits could be combined with lower targets. However in practice they rather resulted in lowering the overall level of ambition. Furthermore, super credits always carry the risk that increasing numbers of BEVs or FCEVs hamper innovation in ICVs. For stimulating OEMs to increase the share of BEV in their fleet offerings in the short to medium term, ZEV mandates are therefore preferred.

4.2.5. Regulation of charging infrastructure (Factsheet 8 in Annex C.2)

An increase in the number of BEVs in the fleet requires the development of charging infrastructure. The preferred policy instrument for this is regulation of charging infrastructure. When actors like energy suppliers (including oil companies) or local governments are obliged to develop a minimum level of charging facilities, this provides certainty to car buyers. For instance, gas stations may be obliged to install a few fast charging stations plus a number of regular charging points (costs would have to be borne by the oil companies, not necessarily the owner of the concession); or charging points would have to be made available at every public building or public parking lot. This approach can have a large coverage (nationwide). An example is the approach taken by the Japanese car manufacturers, including Toyota Motor Corporation, Nissan Motor Co. Ltd., Honda Motor Co. Ltd. and Mitsubishi Motors Corporation. These companies jointly established a new company, Nippon Charge Service LLC. (NCS). The NCS' goal is to help build a charging network across Japan and it planned to widen the charging station network from 700 in 2014 to 5,500 in 2015.

As investments may be significant and the business case is not yet positive when numbers of BEVs are low, **this instrument may be combined with financial incentives or PPP type of arrangements** (see below under the supporting instruments). However, preferably industries (possibly including oil companies, power suppliers and vehicle manufacturers) should bear the largest part of the investments.

4.2.6. Supporting policy instruments for the battery-electric pathway

Besides the main policy instruments discussed above, various supporting policies are required for the further development of the battery-electric pathway. More details and assessment of these policies, their pros and cons, and case studies can all be found in Annex C.

Vehicle dimension

Incentives at the local level: in road pricing, tolls, parking policies, HOV-lanes and urban access restrictions

Financial incentives at the national and/or federal level can be complemented by various local incentives, such as preferential treatment in parking policies, HOV-lanes, congestion charging, or toll schemes which have proven to be effective, especially when combined with tax incentives (e.g. see the case study of Norway in Annex C.1). Many of these instruments score lower than mandates, standard or financial incentives at the national level, because the scope of these instruments is often limited to a certain city or region, do not have an obligatory elements and provide rather low incentives (the height of the incentive is relatively low compared to the purchase price of BEVs).

As is the case for financial incentives, it is recommended to design clear criteria as to when these local measures are eliminated.

A framework at the federal or national level is needed to harmonise the criteria applied in local policies (e.g. what vehicles are exempted) and so avoid a patchwork of many different types of local incentives, which is expected to be much less effective than a more harmonised approach. When all local incentive schemes use the same categorisation of vehicles, incentives are stronger and easier to understand for consumers. To what extent buying a BEV becomes more attractive by these incentives depends on the amount of incentives applied in a specific region and the level of the benefits. The types of instruments that are introduced and whether or not including incentives for ZEVs, may differ from region to region or municipality to municipality and can depend on local priorities or challenges (e.g. air pollution, congestion, lack of parking space, etc.)

Green public procurement

Green public procurement can include binding requirements or incentives for BEVs in public transport or public car fleets. This in turn can contribute to the roll-out of a charging infrastructure. National and local governments can also provide incentives for BEVs in taxi fleets, service vehicle fleets, and/or to delivery vans and light trucks, e.g. in access restriction schemes or in the requirements for permits.

By doing so the government sets an example for other stakeholders, provides an investment incentive for the industry and contributes to the market uptake of BEVs. For LDVs, the market share of governments is relatively small, but in markets like public transport buses, public procurement has a large market share.

It should be noted that when green public procurement criteria stimulating BEVs (or other AFVs) are also incorporated in other types of public procurement such as of construction works (e.g. road construction) or postal services, the impact can be significantly larger.

Framework for end-of-life processing of BEVs

Another policy area is a framework for battery end-of-life processing, including re-use and recycling. This innovative type of policy was mentioned by several interviewees but was not elaborated in a factsheet in Annex C. Without a well-developed approach, which can include both financial incentives and regulation, high numbers of BEVs may lead to serious environmental and social problems later on. To prevent this, a framework should be developed, preferably at the federal/union level that stimulates re-use (like for stationary applications) and recycling of batteries of BEVs at their end-of-life. Furthermore, the environmental and social issues with respect to battery production require policy attention (e.g. mining of lithium and rare earth metals), for instance by developing sustainability criteria in regulation or industry standards.

Charging infrastructure dimension

Financial incentives to improve the business case of charging infrastructure: PPPs or subsidies

In most countries and regions the number of BEVs is still too low to realise a positive business case for the charging infrastructure. Therefore, some governmental support in terms of PPPs, grants, subsidies or innovative financial instruments such as guarantees will be necessary, mainly at the national or local level. This requires coordinated planning of the optimal locations of public charging stations, which takes into account both user-friendliness (e.g. charge convenience and coverage), and costs (e.g. of grid reinforcement). Doing so ensures an effective and efficient use of public funds.

When the number of BEVs grows, the business case for owning charging infrastructure can become positive and public support can be scaled down. For PHEVs and EREVs some specific (financial) incentives are needed to stimulate that these vehicles are frequently charged and mainly driven in the electric mode. This requires policy action at the national level.

Standardisation of charging infrastructure

Harmonisation and standardisation of charging infrastructure requires action at the federal policy. There are various competing standards for fast DC charging (CHAdeMO, CCS, Tesla) and the interoperability between these technologies has not been completely solved yet and requires further policy action. Another element that deserves attention is the public accessibility of charging points. Note that this type of policy was not elaborated in a factsheet in Annex C.

Renewable energy production dimension

Smart charging and vehicle-to-grid integration: regulation of differentiated energy prices, on-board intelligence and accessibility of ancillary services

There are some opportunities for linking BEVs, large-scale charging infrastructure and (local) **renewable power production**, e.g. by simultaneously promoting BEVs and solar energy. However, as mentioned below, the overall development of the share of renewables in power production is unlikely to be significantly affected by transport policies.

In the short term, the use of renewable energy in BEVs can be increased by adding requirements to fiscal incentives for stimulating PHEVs or by introducing a ‘hard coupling’ between the BEV market share and RES-E targets (see Factsheet 17 on Policies to increase BEVs’/FCEVs’ renewable energy consumption).

Important elements that need to be set up in order to prepare for the medium to longer-term are concepts like **smart charging (e.g. demand management)** and **vehicle-to-grid integration**. With the uptake of local power generation (particular solar and wind), there is a challenge with respect to balancing power supply and demand and stabilising the grid. Large numbers of BEVs can partly increase those challenges but can also be part of the solution when BEVs are used to generate a flatter energy demand profile (by demand management). Another solution would be to use BEVs for temporarily storing an oversupply of electric power or providing short-term power in case of undersupply (by vehicle-to-grid concepts). Such concepts could reduce the operational costs of BEVs, if owners are rewarded for the flexibility their cars provide.

Both require timely development and deployment of smart charging concepts and technology. In this context, **regulating on-board intelligence** (e.g. enabling smart charging of BEVs or returning electricity to the grid by applying ‘vehicle-to-grid’ concepts) was mentioned by some interviewees. This could typically be done at the federal level and is important for a smooth and efficient integration of BEVs in the overall electricity system. Furthermore, this could also prevent potential loss of revenues from fuel excise duties, as on-board intelligence can help to prepare for electricity taxation and/or kilometre charging.

Other policies that are important for a proper integration of BEVs in the electricity system are accessibility for ancillary services, adjusting power system regulations, and the (de-)regulation of electricity prices (allowing electricity price differentiation in particular, so smart charging can benefit from lower electricity prices).

Policies to increase the use of renewable electricity in BEVs

The increase of the share of renewables in power production is mainly driven by overall electricity policies (such as subsidies for renewable power generation, emission trading and energy regulation) and not strongly dependent on specific policies for increasing the share of renewable in transport. Therefore, the stimulation of BEVs should be accompanied by a strong policy strategy for decarbonising power production. This is particularly important in regions with low shares of renewables in their power production and high GHG intensities of electricity.

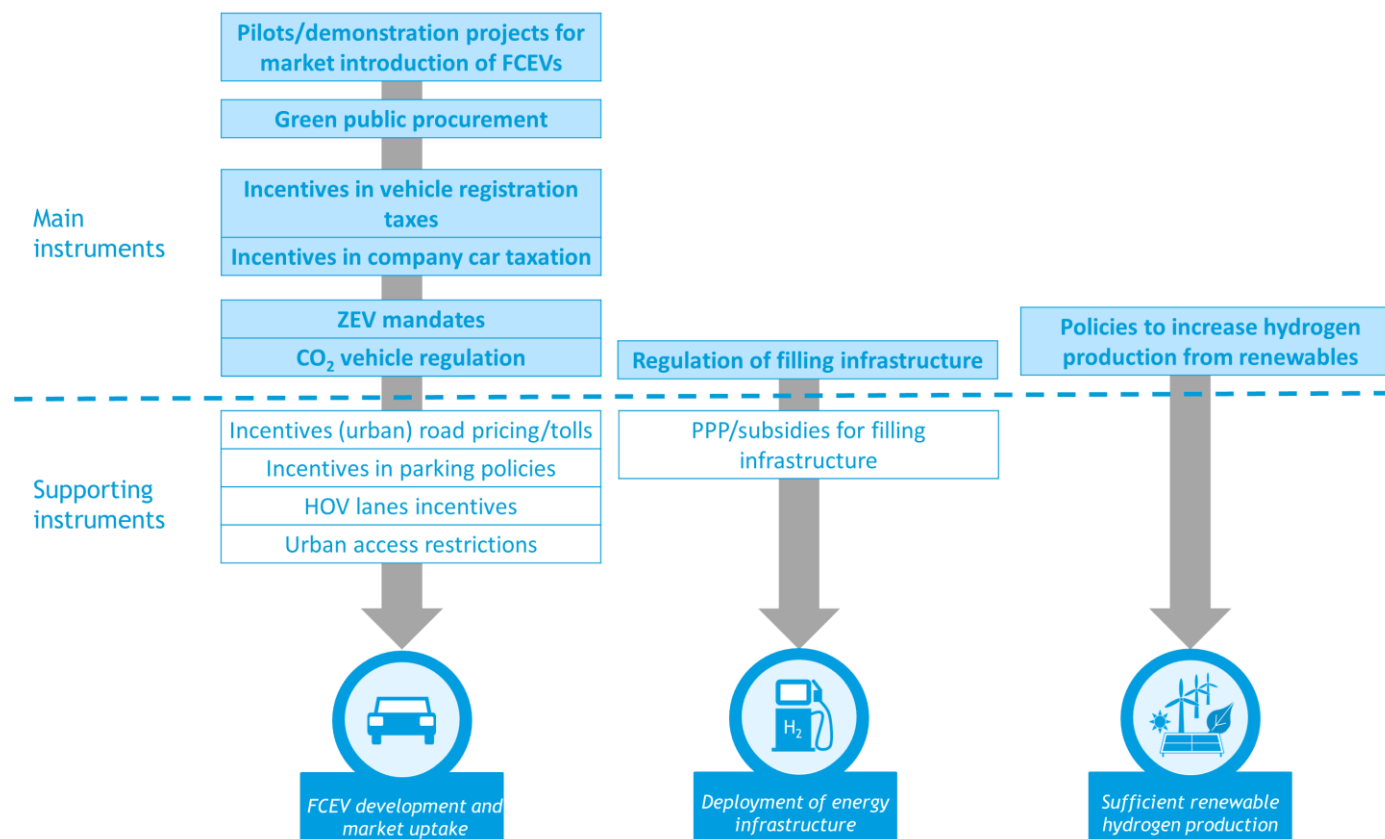
There are some market initiatives that stimulate combining the purchase of a BEV with purchasing solar panels. This may also be supported by specific policy arrangements, e.g. for companies or households. It is expected that this type of innovative policy will be further developed.

4.3. OVERALL POLICY STRATEGY FOR THE HYDROGEN PATHWAY

Figure 8 summarizes the *main* policy instruments and *supporting* policy instruments for the hydrogen pathway and shows which of the three main dimensions are targeted with each instrument. **Note that both the main and supporting instruments are for a large part similar to the ones recommended for the battery-electric pathway.** Eight policy instruments have been identified and selected as main policies. This includes the four policies for stimulating the market uptake of AFVs and regulation of energy infrastructure, as also needed for the battery-electric pathway.

As the supply side of the vehicle market of FCEVs is much less developed, pilots/demonstration projects for market introduction of FCEVs and green public procurement are included in the main policies. Furthermore also policies for increasing the share of renewables in hydrogen production has been selected as main policy. All main instruments and the reasons for selecting them are summarized below. In section 4.3.6, the supporting policies for this pathway are summarized.

Figure 8 Overview of main policy instruments for stimulating the hydrogen pathway⁶



⁶ Local incentives are not included here, but could help to stimulate FCEV sales as well, once the supply of FCEV models takes off.

4.3.1. Pilots/demonstration projects for market introduction of FCEVs (Factsheet 16 in Annex C.4)

Compared to battery-electric, the hydrogen pathway for LDVs is still less mature. The first fuel-cell powered mass-produced car models have entered the market only very recently (e.g. in 2013 the Hyundai ix35 Fuel Cell, in 2015 the Toyota Mirai) and the production volumes are still very low. Also with respect to energy infrastructure the pathway is in a very early development phase. In almost all countries, hydrogen infrastructure, if yet existing, is much less dense compared to the electric charging infrastructure. Furthermore, renewable hydrogen production is much less developed compared to renewable electricity production which is a challenge for sustainable FCEV uptake.

Therefore, **policies for hydrogen in transport should for the short term primarily focus on supporting the market introduction.** Pilots or demonstration projects are a main policy for this pathway. This gives various actors the possibility to get used to new technology and to test it in real world circumstances, providing useful information on performance, costs, reliability and user acceptance in normal daily operation. The degree of public sector involvement in such projects should not be limited to providing guidelines for private companies as an active role of the government through heavy investment and setting up public private partnerships (PPPs) are needed, at least in the short to medium term. An example of such an approach is Iceland that is aiming to become a world leading Hydrogen vehicle demonstration facility, is investing in a hydrogen infrastructure for cars and has hydrogen vehicles demonstration projects (IEA 2012). More recent examples of such public-private partnerships are the H2 Mobility efforts in Germany and the United Kingdom.

This type of instrument can well be combined with green public procurement and PPPs, e.g. for setting up hydrogen filling stations.

4.3.2. Green public procurement (Factsheet 15 in Annex C.4)

Green public procurement can also play a key role in the market uptake of FCEVs. **Public fleets like public transport buses or municipality car and LCV fleets are very suitable as launching niche markets.** In Japan the launch of FCEVs by Toyota in November 2014 has been very effective, as of mid January 2015 60% of the 1,500 vehicles ordered were purchased by government agencies and 40% by private actors (see case study ‘Green Purchasing Law–Japan’).

As mentioned above, such a GPP approach can well be combined with PPPs for developing hydrogen filling stations, and, preferable, hydrogen production facilities from renewable sources.

4.3.3. ZEV mandates, CO₂ vehicle regulation, incentives in vehicle registration taxes, and company car taxation (Factsheet 10,9, 2 and 3 in Annex C)

Once the fuel cell technology is ready for larger market uptake (which is in some vehicle segments possibly to be the case in the next few years), the hydrogen pathway could benefit from some of the policies for stimulating battery-electric (see section 4.2), in particular with respect to the **vehicle** dimension. CO₂ vehicle Regulation, ZEV mandates, fiscal incentives and local measures can all be designed in such a way that both BEVs and FCEVs are promoted.

Until today, these policy instruments have mainly resulted in an increase in BEVs and not in FCEVs, because the first FCEVs have entered the market just very recently and are available in very low numbers; and without a hydrogen filling station nearby, a FCEV is no option. This is likely to change in the short to medium term (at least in some countries), so these instruments that now mainly stimulate BEV sales can also support the market uptake of FCEVs.

4.3.4. Regulation of filling infrastructure (Factsheet 8 in Annex C.2)

To make FCEVs a true option for business or private users, a basic network of filling stations is imperative. As also the number of vehicles is still very low, there is no positive business case yet for setting up this basic network.

Like for the battery-electric pathway, regulation of energy infrastructure is the preferred option for this. When actors like energy suppliers (including oil companies) or local governments are obliged to develop a very basic network of hydrogen filling stations, e.g. in few urban areas or along main corridors, this provides certainty to car buyers. This approach can have a large coverage (nationwide). Like for the battery-electric pathway, this instrument can best be combined with financial incentives or PPP type of arrangements to turn the business positive (see below under the supporting instruments).

A topic that deserves particular attention in the regulation for energy infrastructures are safety standards for hydrogen filling infrastructure.

4.3.5. Policies to increase hydrogen production from RE (Factsheet 1, 4 and 17 in Annex C)

Pilot hydrogen production may use existing industrial production facilities, although this will not directly result in a direct increase in RES-T as the hydrogen is produced from fossil fuels. Therefore, also **pilots where hydrogen is produced with renewable energy sources should be set up**. PPPs have been able to attach stipulations on renewable content (e.g. 30% renewable hydrogen requirements in hydrogen infrastructure PPP grants from the California Energy Commission), which should provide an incentive to the increase of RES-T (see factsheet 4 on PPP & subsidies for energy infrastructure in Annex C.1). Once ready for scaling-up, policies should be implemented that require both the hydrogen feedstock (e.g. biogas) and the process energy be renewable.

For the near term, building hydrogen fuelling infrastructure will be capital-intensive compared to other fuelling infrastructure, so infrastructure development will be at least partially funded by a governmental financial instrument, which can attach renewable stipulations. In the long-term, consideration for renewable content in hydrogen fuel should be integrated into fuels and carbon policies that reward renewable content enough to overcome the relative difference in price between renewable v. non-renewable hydrogen feedstocks (e.g. California's LCFS effect on biogas vs. fossil natural gas use in transportation).

Similar to the battery-electric pathway, this may also be combined with innovative policies that stimulate the combination of driving an FCEV and using hydrogen produced from renewable sources.

4.3.6. Supporting policy instruments for the hydrogen pathway

Besides the main policy instruments discussed above, a few supporting policies are required for the further development of the hydrogen pathway. They are grouped by the three main dimensions (vehicles, energy infrastructure, energy carriers). More details and assessment of these policies, their pros and cons, and case studies can be found in Annex C.

Vehicle dimension

Incentives at the local level: in road pricing, tolls, parking policies, HOV-lanes and urban access restrictions

As mentioned above, once the fuel cell technology and network of filling stations allow for a larger market uptake, the hydrogen pathway could benefit from some of the policies for stimulating battery-electric (see section 4.2). This is also true for the local incentives discussed in section 4.2.6: preferential treatment in parking policies, HOV-lanes, congestion charging, or toll schemes. In the short to medium term, these instruments that now mainly stimulate BEV sales can also support the market uptake of FCEVs, particularly in countries that have sufficient hydrogen filling stations.

Energy infrastructure dimension

Financial incentives to improve the business case of hydrogen filling infrastructure: PPPs or subsidies

As result of the immaturity of hydrogen as RES-T technology, stakeholders would like to reduce or share the risk associated with investing in it. Public Private Partnerships are currently the most popular model for risk sharing. For hydrogen filling stations, the government usually initiates the PPP in the form of a grant for a portion of the capital costs (see factsheet PPP & subsidies for energy infrastructure).

PPPs and subsidies are expensive but also effective ways of quickly developing a basic hydrogen infrastructure. Examples at the federal level are the HIT-TENT project that stimulates the deployment of hydrogen refuelling infrastructure along key Trans-European Transport Network (TEN-T) corridors within the EU. In a next phase this could be further developed to realise a minimally required coverage of filling stations.

There are some countries which already plan to roll out a significant network of filling stations in the near future. The Japanese government has set aside a budget of more than JPY 21 billion in 2012-2015 to subsidize the construction and operation of 100 hydrogen filling stations by March 2016. As of April 2015 there were five hydrogen filling stations. The government set a target of 100 filling stations by end of 2015 and the Tokyo government plans to build 35 filling stations in Tokyo by 2020 (see case study: PPP and Subsidies for Infrastructure – Japan). In Germany, the H2 mobility initiative (consortium created by Air Liquide, Daimler, Linde, OMV, Shell and Total) agreed to expand the hydrogen infrastructure from the current 15 stations to 100 filling stations by 2017 and 400 stations by 2023.

4.4. OVERALL POLICY STRATEGY FOR THE BIOFUELS PATHWAY

As identified in Section 2.3, the main challenge for the biofuels pathway for the short- to medium-term is the availability of sustainable biomass feedstock and the competition for this with other sectors (e.g. industry, power generation, built environment) and other (non-road) transport modes (e.g. aviation, maritime shipping). Therefore **the policy strategy for this pathway should be well integrated in a broader multi-sectorial approach**. Such an approach should include allocation principles like cascading of biomass⁷ and a level playing field for all types of biomass in electricity, heating and cooling, and transport.

Biofuel demand is strongly policy driven and this situation is likely to remain so for a long time. The experience in Brazil (see case study in Annex C.5) shows that even in a situation with higher shares of biofuel use, the market remains largely policy driven, particularly in times of low fossil fuel prices and high prices of bio-commodities. Also the E85 infrastructure grants in the US state of Minnesota illustrate the strong policy dependency of biofuels. When the Minnesota infrastructure grants expired in 2014, the number of E85 stations immediately decreased.

Therefore **the long-term policy framework should give investment security for both biofuel producers, OEMs and the fuel industry**; the biofuel industry depends on policy driven biofuel demand, hence, policy measures should at least cover the depreciation period of installations.

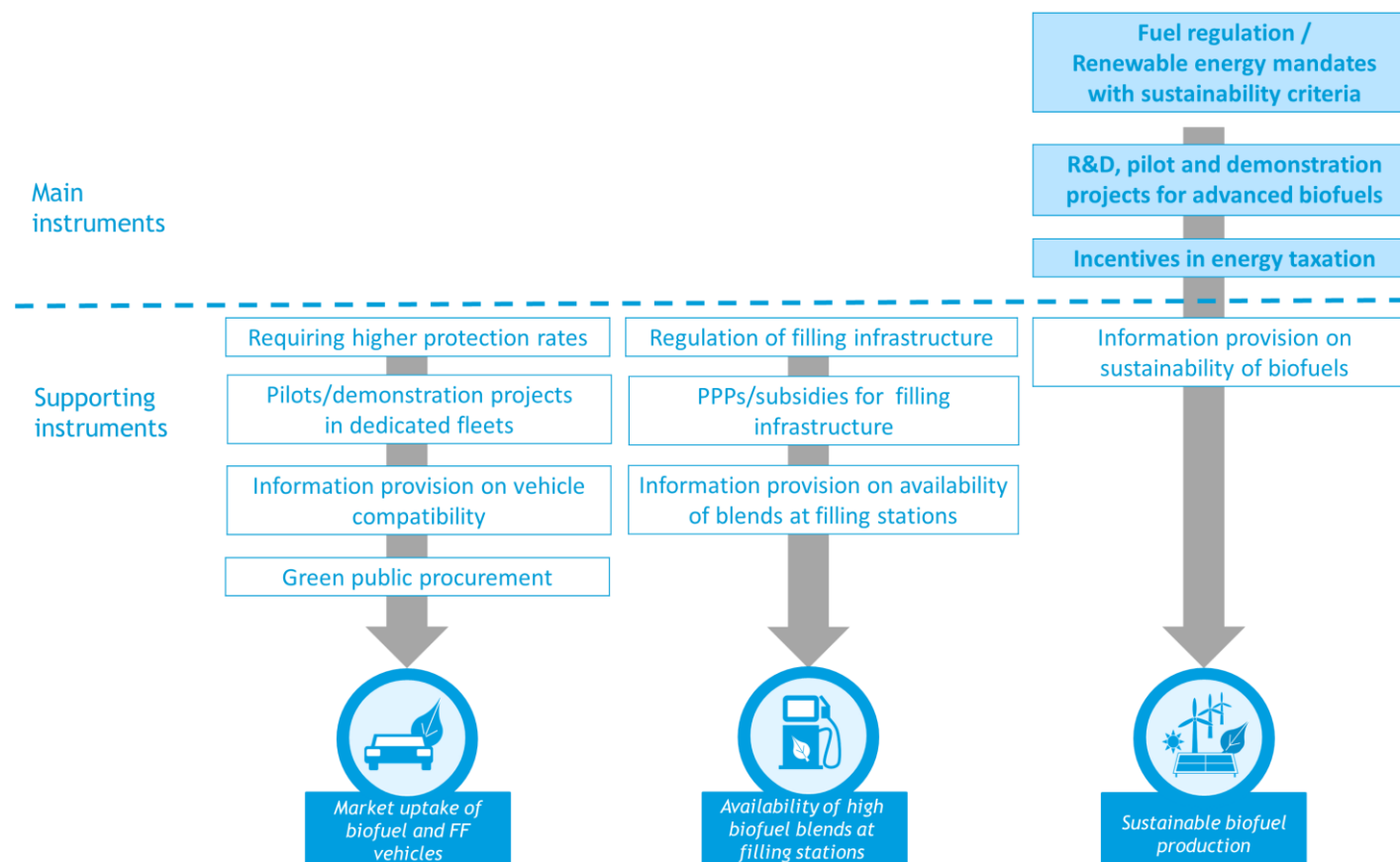
Figure 9 summarizes the *main* policy instruments and *supporting* policy instruments for the biofuels pathway and shows which of the three main dimensions are targeted with each instrument.

Four policy instruments have been identified and selected as main policies, all related to the energy carrier dimension: Renewable energy mandates and Fuel regulation (including Sustainability criteria) Incentives in energy taxation and Pilot and demonstration projects (for advanced biofuel production).

All main instruments and the reasons for selecting them are summarized below. As the Renewable energy mandates and Fuel regulation are highly related they are highly discussed together in section 4.4.1. The other main instruments are discussed in section 4.4.2 and 4.4.3. In section 4.4.4, the supporting policies for this pathway are summarized.

⁷ Cascading of biomass is a method to achieve a more efficient use of biomass by using the biomass subsequently for different purposes, starting with application with the highest possible value. An example is the use of biomass to produce bio-plastics which can be recycled after use and incinerated with energy recovery when recycling is no longer an option.

Figure 9 Overview of main policy instruments for stimulating the biofuels pathway⁸



⁸ Local incentives as mentioned in the overview for battery-electric (Figure 7) are not included here, but could help to stimulate FCEV sales as well, once the supply of FCEV models takes off.

4.4.1. Fuel regulation / Renewable energy mandates (Factsheet 6 and 7 in Annex C.2)

Fuel regulation is important for increasing the share of biofuels in two ways:

- **Blending limits** regulate the maximum content of biofuels in fuels brought on the market and so harmonising the market.
- By setting **targets for the GHG intensity of fuels**, incentives are given for blending biofuels. This second element of fuel regulation is closely related to renewable energy mandates for transport.

Blending limits for conventional fuels should be well aligned with the warranty of existing fleets (B7, E5 and E10 in the EU). Increasing the blending limits allows for larger volumes of biofuel use. However, in many countries the current blending limits are not fully utilised yet. Once biofuel production volumes from feedstocks meeting the minimum sustainability criteria allow for higher volumes, the first approach would be to look at mid blends that can be used by all new vehicles (e.g. E15/E20/E25 and B10). In this case, standardisation and prioritisation of a limited number of blends is recommended at federal levels to avoid a patchwork of blends. This also requires that the use of higher biofuel blends are soon included in the warranty for new vehicles (see also supporting policies in section 4.4.4).

Besides blending limits, also incentives are needed for the uptake of biofuels. Without such incentives, there will be hardly any demand. **The preferred instruments for giving such incentives are targets for the GHG intensity of fuels (in fuel standards) and renewable energy mandates.**

Targets for the GHG intensity of fuels in fuel standards can best be set at the federal level and are mandates for fuel suppliers. This type of instrument has a large coverage (all fuels sold) and a very effective way to increase the share of biofuels. By including the GHG impacts of different fossil fuel sources as well, the effectiveness of this approach is improved, as it will also discourage the use of high carbon fossil fuels (e.g. tar sand oils).

Renewable energy mandates for transport can provide similar incentives for increasing the share of biofuels, but without the possibility for giving incentives for reducing the carbon intensity of fossil fuels. In comparison to a GHG emission target in fuel regulation, renewable energy mandates provide more direct incentives for increasing the share of renewables and are therefore slightly more effective for increasing the share of RES-T.

It should be noted that there are strong interactions between renewable energy mandates and GHG intensity targets as part of fuel regulation because an increasing share of renewable energy in transport directly impacts the overall GHG intensity of transport fuels. Therefore, when the two instruments are implemented together, the targets should be well aligned.

An advantage of renewable energy mandates is that they do not require assumptions on the GHG intensity of all energy carriers which has turned out to be a complex and sensitive topic, making it more difficult to implement fuel regulation.

Fuel standards and in particular renewable energy mandates can also provide incentives to support the development and uptake of advanced biofuels. This can be done by sub-targets for advanced biofuels could, like implemented in the RED in the EU. Sub-targets can provide long-term investment security for new advanced biofuel plants.

Furthermore, both instruments are only effective if combined with tight sustainability criteria, including ILUC to make sure that biofuels used in the short to medium-term meet at least minimum sustainability criteria and reduce GHG emissions over their entire life cycle. Particularly the inclusion of ILUC impacts is important for a proper GHG reporting and accounting. The sustainability criteria applied in these instruments should be well aligned with the criteria that apply to biomass used in other economic sectors.

4.4.2. Incentives in energy taxation (Factsheet 1 in Annex C.1)

The regulation mentioned in the previous section could be complemented by **financial incentives to stimulate the commercialisation of advanced biofuels that are ready for market introduction**. These incentives should be strong enough to realise their uptake and should include a long-term perspective to guarantee a boost for innovation in currently immature technologies and to guarantee sufficient capacity growth. Energy taxation is the preferred instrument for this as it has the largest coverage and GHG emission reduction potential. Specifically for the commercialisation of advanced biofuels, this could be well combined with other incentives like investment tax credit for biofuel production facilities, loan guarantees or other fiscal incentives.

4.4.3. R&D, pilot and demonstration projects for advanced biofuels (Factsheet 17 in Annex C.4)

For exploiting the long term potential of biofuels, advanced biofuels are extremely important. Therefore there is a need for policies supporting the development and testing of such fuels and the set-up of pilot plants. Without such support, the development and uptake of such biofuels is not likely to take place.⁹

The most suitable instruments for this are (financial) support of R&D on advanced biofuels, production facilities and pilot plants. **This support could for example consist of grants or loan guarantees.**

4.4.4. Supporting policy instruments for the biofuels pathway

Besides the main policy instruments discussed above, various supporting policies are required for the further development of the biofuels pathway. They are listed below, grouped by the three main dimensions (vehicles, energy infrastructure, energy carriers). More details and assessment of these policies, their pros and cons, and case studies can all be found in Annex C.

Vehicle dimension

Requiring vehicle warranties to cover vehicle compatibility with higher biofuel blends

In order to prepare for a possible shift to the future use of higher blends, it is recommended to already require vehicle warranties to cover vehicle compatibility with higher biofuel blends (e.g. E15/E20/E25 and B10). Such requirements could be included in vehicle regulations. The additional costs for vehicle OEMs are relatively low, while the long term benefits can be significant by preventing a lock-in in low blends, in a case when the biomass availability increases quickly and allows also higher blends.

⁹ IEA-RETD will discuss the conversion of first generation biofuel sites to second generation sites in its scoping study RES-T-BIOPLANT (forthcoming).

Pilots/demonstration projects in dedicated fleets and green public procurement

Where appropriate, policies should prepare for high blends in niche markets. Particularly in countries with a high availability of sustainable biomass, introducing high blends for niche markets can be effective for increasing RES-T and reducing GHG emissions. Because of the various other alternatives in urban areas (BEVs and FCEVs), it seems appropriate to use high blends mainly for long-haul freight transport, maritime and inland shipping and aviation. The same is true for biogas applications in transport.

The use of high blend biofuels (e.g. B100, E85, biogas) is particularly interesting for captive fleets (e.g. coach companies or hauliers with their own fuel depot). By setting up pilots/demonstration project, the vehicle technology can be tested and filling infrastructure be set up, similar as this is recommended for hydrogen.

Such pilots or demonstration projects can well be combined with or result in green public procurement to stimulate the market uptake of higher blend biofuel vehicles. Public fleets are very suitable as launching niche markets. This could well be combined with PPPs for developing filling stations for high-blend biofuels and/or production facilities for advanced biofuels.

Information provision on vehicle compatibility

When the number of available fuel blends increases, the need for proper information to consumers is something that needs to be taken care of. Without proper information provision there is a risk that consumers become reluctant for using higher blends as they are afraid that it damages their cars (as happened in Germany with the introduction of E10). This is not likely to be solved by the market and therefore this requires policy support.

Energy infrastructure dimension

Regulation of filling infrastructure

Higher blends will only be used if these blends are sufficiently available.

Therefore, in order to prepare for a possible shift to higher blends, there is a need for regulation of filling infrastructure. Fuel suppliers can be required to offer certain higher blends at a certain minimum share of their fuel stations. The blends should of course match with the protection grades in vehicle standards (e.g. E15/E20/E25 and B10). This is particularly important when the biomass availability increases quickly and allows also higher blends. This approach can have a large coverage (nationwide).

Financial incentives to improve the business case of hydrogen filling infrastructure: PPPs or subsidies

Like for the hydrogen pathway, stakeholders would like to reduce or share the risk associated with investing in high blend biofuel facilities. Public Private Partnerships are currently the most popular model for risk sharing. For filling stations, the government usually initiates the PPP in the form of a grant for a portion of the capital costs (see fact sheet PPP & subsidies for energy infrastructure). This instrument could well be combined with pilots or demonstration projects in dedicated fleets and/or green public procurement.

Information provision on availability of blends at filling stations

When the number of available fuel blends increases, the need for proper information to consumers is something that needs to be taken care of. This is not likely to be solved by the market and therefore this requires policy support. Main elements in such an approach would be to set up a system of fuel labelling with respect to vehicle compatibility and to enable price comparisons that are based on energy content.

Energy carrier dimension

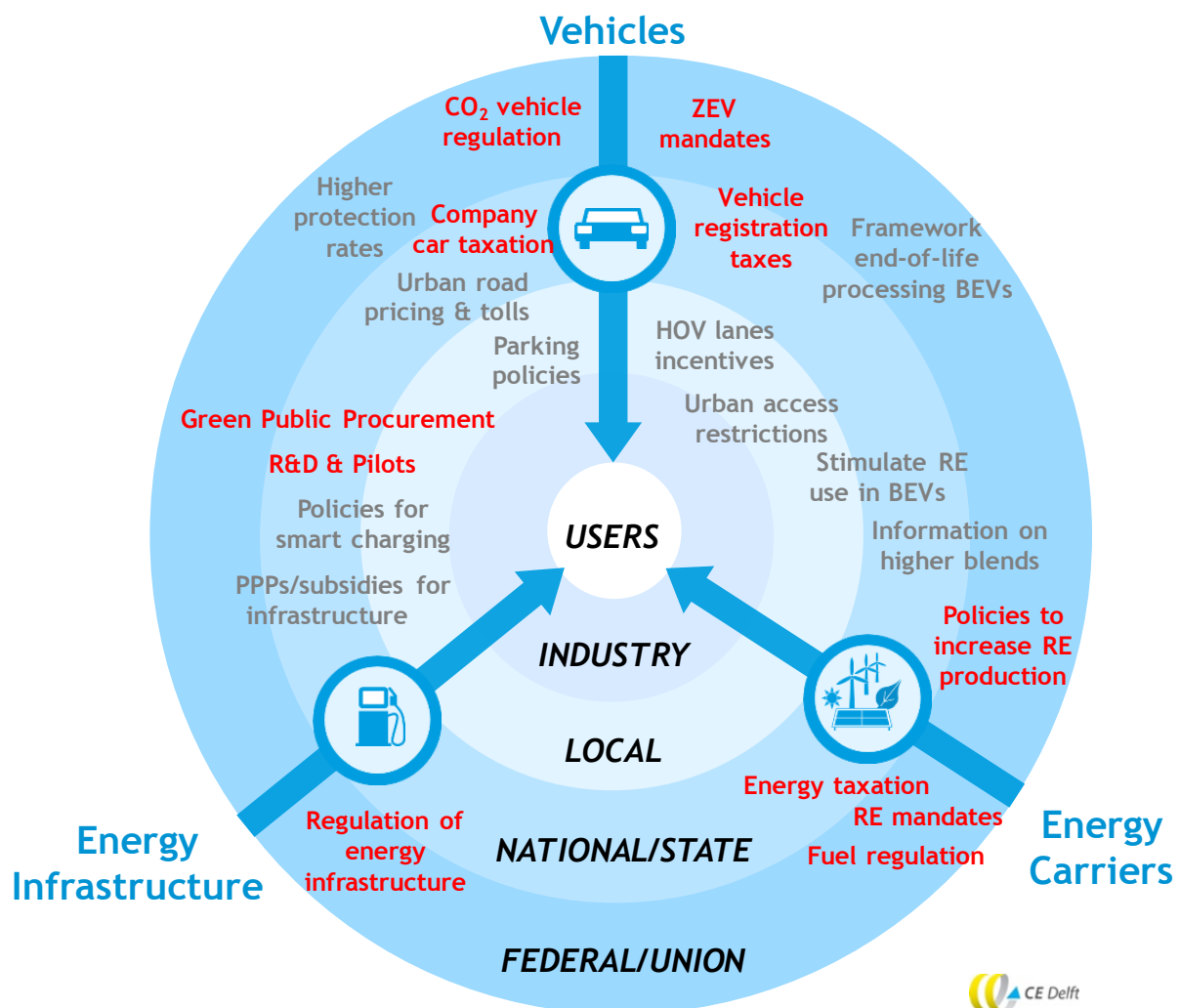
Information provision on sustainability of biofuels

The need for proper information provision when the number of available fuel blends increases has been explained above. In addition to vehicles and filling stations, this also covers the energy carriers themselves, in particular their sustainability and data on their overall GHG emissions reduction.

4.5. SUMMARY OF POLICY STRATEGY PER PATHWAY AND ADMINISTRATIVE LEVEL

Figure 10 provides a summary of the key policy instruments for stimulating RES-T. It shows the policy instruments discussed in section 4.2 to 4.4, at which administrative level each instrument should be considered and whether they mainly affect the vehicles, energy infrastructure or energy carriers. Policies that were identified as *main* policies are printed red, the *supporting* policies are printed grey.

Figure 10 Overview of main (red) and supporting (grey) policies at the various administrative levels



Most of the policies in this figure are primarily targeting the uptake and commercialisation of technology that is sufficiently mature. Pilots are the only exception, which focus on the phase before market readiness. All policies ultimately target the new technology development by transport industries and changing behaviour of transport users.

For developing new technology, governments can also provide financial support for R&D, either for universities and other public research organisations or in cooperation with commercial R&D institutes or departments. Examples are the Horizon 2020 R&D programme of the EU and various national programmes. Such policy instruments can target each of the three dimensions (i.e. vehicles, energy infrastructure and energy carriers).

4.5.1. Conclusion for pathways

Due to the different barriers, the policy strategy differs significantly between pathways.

The **battery-electric** technology has already been commercialised and now requires policy instruments which generate volume, both in terms of vehicle shares as well as in the number of charging points. In the short to medium-term, strict CO₂ regulations for road vehicles and ZEV mandates are very important. To stimulate the demand for BEVs, financial incentives in VRTs and company car taxation are needed, supported by various local incentives (e.g. Green Public Procurement (GPP), preferential parking policies, access to HOV lanes, etc.). Once BEVs become competitive with ICVs, financial and local incentives can be reduced and/or eliminated.

Increasing shares of BEVs improves the business case of charging points. However, up to the point where there is a positive business case, national and/or local governmental support in terms of PPPs or grants are necessary. Ideally, regulations for harmonisation and standardisation need to be further improved. Policies are required to exploit synergies between BEVs and renewable energy production (e.g. smart charging and vehicle-to-grid integration). This requires regulations for on-board intelligence and for differentiating electricity prices. Finally, the development of a policy framework for battery end-of-life processing deserves attention.

The **hydrogen** pathway is yet less developed than the battery-electric pathway. It is not yet fully commercialised and requires policies which primarily promote pilots and further product development. These should focus on each of the three dimensions (i.e. on FCEVs, hydrogen infrastructure and hydrogen production from RES). To prepare for the potential mass adoption of FCEVs, policies for standardising the technology and for stimulating information sharing to achieve a more positive public perception for this pathway are necessary. Also, it is recommended to already adopt safety regulations for vehicles and hydrogen infrastructure.

In the longer-term, when hydrogen technologies are ready to be fully commercialised, roughly similar policies are needed as for the battery-electric pathway (i.e. CO₂ regulations, ZEV mandates, financial incentives and local incentives for FCEVs, and PPPs/Grants for hydrogen infrastructure).

In addition, sustainable hydrogen production requires additional policies. Mandatory criteria can ensure the sustainable production and harvesting of renewable energy (e.g. biomass).

For **biofuels**, there is a clear need for a long-term policy framework to guarantee investment security to biofuel producers, OEMs and the fuel industry. Overall, this framework should be part of a broader, multi-sectorial biomass policy, to prevent competition between biofuel users (e.g. industry, power generation, built environment) and between transport modes (e.g. road transport, aviation, maritime shipping). Policy frameworks should therefore include allocation principles.

Key elements of such a policy framework include mechanisms to ensure a wider availability of sustainable biomass feedstock. First, the uptake of biofuels can be realised with mandatory fuel standards, which are based on the GHG impacts of different conventional and biofuels. These mandates should at least include sustainability criteria for ILUC effects. In addition, mandates can include sub-targets for minimal shares of advanced biofuels. Alternatively (or in addition to mandates), financial instruments (e.g. investment tax credit for biofuel production facilities, loan guarantees or fiscal incentives) can be used to increase the production and uptake of advanced biofuels. Finally, once volumes from sustainable feedstock are sufficiently high, blending limits can be enlarged (e.g. to E15-E25 and B10).

To prepare for such blends, vehicle standards should already include requirements for high protection grades and a system of fuel labelling should be set up by federal/union governments.

4.5.2. Policy strategy per administrative level

Overall, **the federal/union level is the most important as most barriers require action at a high administrative level to avoid market distortions and adverse effects**, as was stressed by many interviewees. This includes mandatory policies for getting AFVs and energy carriers on the market but also making sure the market prepares for changes that will be needed later on, such as on-board intelligence or higher protection grades regarding biofuels.

Vehicle OEMs and fuel suppliers operating in supranational markets have the highest impact on vehicle technology and the share of renewable energy in fuel supply. Therefore, policies at the federal/union level are more in line with the operational level of these main actors than policies at the national/state level. Vehicle standards are a good example of an effective regulatory measure at the federal/union level in terms of GHG emission reduction potential and cost-effectiveness and able to reach large coverage: according to ICCT (2015) 80% of the new car sales worldwide are now subject to a standard (see factsheet ‘Vehicle standards’), see Table 8.

The federal level is also important for setting and coordinating frameworks for lower administrative levels, e.g. with respect to charging infrastructure and filling stations, green public procurement or incentives in parking policies and tolls. This can also include standardisation of components, like sockets etc. in order to ensure cross-border mobility and to ensure a certain level of harmonisation.

In case of the Renewable Energy Directive and the Fuel Quality Directive, the EU clearly has fulfilled a framework setting role because Member States had to translate these Directives into national legislation. In most Member States this has resulted in national governments imposing blending obligations or fuel mandates on fuel suppliers. Because there are differences in implementation of Member States, the level of harmonisation is affected. A similar approach as applied in case of the vehicle standards (the EU Directly imposing obligations on fuel suppliers) could have been more effective (see for example the factsheet Fuel regulation).

Policies at federal levels can also be introduced at the (Member) State level, but in general this increases the risk of market distortions. For example, differences in tax incentives for stimulating AFVs and in energy taxes between EU Member States reduce the effectiveness of these policies.

The distinction between federal and state level is particularly relevant in the US and EU where some of the policies that ideally should be set at the federal level are the responsibility of individual (Member) States. Example are fiscal policies in the EU. This touches upon the autonomy of (Member) States and the mandate at the federal/union level. An example in the US is the Clean Air Act, granting California special legal status to set vehicle emissions and fuel standards to reduce air pollution – the only state with such status. It has been proactive in setting cutting-edge stringent standards for both fuels and vehicles, which the federal government tends to follow. However, this causes uncertainty to OEMs and fuel producers which must comply with two sets of standards until they are harmonised..

Although implementation at the federal level can enhance harmonisation, it could also be a barrier for countries/states with more advanced policy goals. An example are the sustainability criteria for biofuels as included in the Renewable Energy Directive (see case study Renewable Energy Directive), where EU Member States are not allowed to go beyond the sustainability criteria as laid down in the

Directive. Consequently, this slows down Member States with higher ambitions. Another example would be California in the United States, which has been a frontrunner in various environmental policies: overall US policies implemented some years after the introduction in California are often less ambitious.

Local governments, such as provinces, municipalities and cities can provide additional incentives by implementing flanking instruments. This can be realised by giving AFVs a preferential treatment in various local policies, such as in High Occupancy Vehicle (HOV) lanes, parking policies and access restrictions. Besides climate change and energy supply, in particular reducing air pollution and noise are key arguments for local authorities to stimulate AFVs. Local governments also play a role in choosing locations for charging points and other land-use related local issues.

5. CONSIDERATIONS FOR AN OVERALL POLICY STRATEGY

Complementing the overall policy strategy per pathway summarised in the previous chapter, this chapter discusses some cross-cutting issues that are relevant for all technology pathways and deserve particular attention when elaborating policy strategies for increasing the share of RES-T.

5.1. THE CONTEXT OF BROADER SUSTAINABLE TRANSPORT POLICIES

Increasing the share of RES-T can contribute to climate mitigation, energy security and local air pollution, and can provide economic opportunities (sometimes referred to as ‘green growth’). However, a transition to RES-T is not the only option how the transport sector can meet these policy objectives and should always be considered together with other options, such as more fuel efficient ICVs, lower speeds, eco-driving, modal shift, cycling, car sharing, teleworking or innovative logistics (see text box). Moreover, many other policy objectives are to be met by a broader transport policy as well, such as improving traffic safety, reducing road congestion, reducing local noise and improving accessibility.

Some policies that stimulate RES-T can also contribute to these other policy objectives, like reducing air pollution, noise and congestion and improving road safety. This is particularly the case for policies at the local level, like urban road pricing, HOV lanes and parking policies. Such policies are usually primarily aimed at reducing road congestion, stimulating modal shift and/or reducing car use in urban areas in order to improve the urban environment. Urban access restrictions are usually primarily aimed at improving local air quality.

Including specific incentives in these instruments for increasing the share of RES-T can either increase their effectiveness or decrease it. Particularly exemptions for AFVs reduce the effectiveness of schemes which target congestion reduction and/or modal shift. E.g. allocating parking spaces to electric vehicles or allowing AFVs on HOV lanes cannot be continued anymore when the share of AFVs becomes too high. Therefore such incentives should be seen as temporary measures, which mainly work for lower market shares of AFVs. Timely adaptations prevent negative side effects which some cities are now experiencing with high BEV numbers (e.g. bus lane congestion).

Innovative city distribution

The characteristics of many city logistics operations, such as a relatively limited number of vehicle-kilometres per trip and multi drops (and collections) per trip, make these operations perfectly eligible for BEVs (FREVIEW 2013). However, to enable the use of Electric Freight Vehicles (EFVs) in city logistics operations, new logistics concepts that overcome range and load concerns are needed.

Many city distribution experiments have already taken place, mainly in the EU. However, the technology is not mature yet and there are still some barriers to overcome.

The first (modern) trials/demonstrations were undertaken more than 20 years ago. Currently, the leading programme is FREVIEW (**F**reight **E**lectric **V**ehicles in **U**rban **E**urope). The FREVIEW project brings together cities and companies that are introducing Electric Freight Vehicles for their city logistics. The aim is to reduce or even eliminate CO₂ emissions and other harmful pollutants in city centres, such as Amsterdam, Lisbon, London,

Madrid, Milan, Oslo, Rotterdam and Stockholm.

The Netherlands has, within the Dutch Green Deal programme, closed a Green Deal on zero-emission city distribution. Unique about the Green Deal concept is that councils, transporters, shippers, vehicle manufacturers, suppliers, business and branch organisations, and interest groups have all signed the agreement. The cities signing up to the Green Deal give businesses the opportunity to test new technologies and smart logistics in practice. The purpose of the experiments is to learn at a small scale and to share successes with other councils and businesses where possible.

The main challenges faced by operators with the implementation of EFVs in city logistics are: high procurement costs, limited choice of vehicle models, little or no after-sales support and long waiting times for spare parts, low performance of battery technologies, limited mileage range, low vehicle speed and limited payload.

Pilot programmes with innovative city distribution show the potential of this concept. Although today's EFVs have greater range and improved loading capacity, the actual implementation of EFVs in city logistics operations is still limited and many barriers have to be overcome.

At the national/federal level, there is particularly a trade-off between stimulating RES-T and fuel efficiency improvements in ICVs. The super credits implemented in the design of the EU CO₂ standards for cars for example, clearly promote EVs but also result in higher wheel-to-wheel GHG emissions and a lower (cost-)effectiveness of the regulation, as ICVs are allowed to emit more than without super credits. This trade-off, however, does not exist between biofuels and fuel efficiency improvements. Although there are some biofuel policies providing some (low) incentives for fuel efficiency gains, no specific policy incentives to OEMs are provided to sell vehicles for high blends of biofuel.

In order to choose the right balance between RES-T and other objectives, it should be clear what the main objective of each policy instrument is (e.g. reducing GHG emissions, increasing RES-T, improving air quality) as well as the (cost-)effectiveness of each instrument. Policy instruments should be complementary, i.e. not every instrument needs to target vehicles, energy carriers and energy infrastructure simultaneously or contribute to all objectives at the same time. The overall consistency and alignment of policy instruments therefore deserves attention.

5.2. THE CONTEXT OF BROADER SUSTAINABLE OVERALL ENERGY SUPPLY

There is strong interaction between RES-T and broader (renewable) energy supply of the entire economy. An increasing share of RES-T can affect other sectors and vice-versa. For an effective overall policy strategy, account should be taken of those interactions.

Policies for developing a BEV charging infrastructure and smart charging should be well aligned with developments in the power sector, the development of smart grids, and other changes in power demand and supply (e.g., heat pumps, solar energy), for example. The co-evolution of the transport and energy sector is crucial to reap synergies (IEA-RETD RETRANS).

In the case of biofuels, it is important to ensure that the demand for scarce biomass from various sectors (e.g. chemical industry, energy sector, transport) is managed well. Biofuel policies should not result in unintended market distortions or competition with other sectors. Principles like bio-cascading could be useful for developing such an economy-wide biomass policy. The availability or absence of alternative pathways for decarbonising various economic sectors can be an argument in the overall biomass strategy, to ensure long-term climate targets are met. Also sustainability criteria for biomass should preferably be harmonised across all sectors.

Finally, there is a strong link between increasing RES-T and the overall energy policy. While the shift to alternative powertrains is driven by transport policy, the actual renewable energy consumption is dependent on renewable power and hydrogen production, which in turn is strongly driven by other policies, such as incentives for renewable power generation, emission trading (see text box) and energy regulation. The RE mandates for transport are usually linked to RE mandates for other sectors or for the economy as a whole.

5.3. GENERIC POLICIES OR TARGETING SPECIFIC USER GROUPS?

Many of the policies at the federal and (member) state level are generic, targeting all user groups. Examples are vehicle and fuel regulations, vehicle registration taxes, renewable energy mandates and fuel taxes. An exception are company cars which are an interesting target group because in many countries they have a large share in new car sales, can be targeted with specific fiscal policies (i.e. company car taxation schemes), are relatively sensitive to environmental arguments (e.g. as part of corporate sustainability programmes), and have relatively high annual mileage which improves the business case of AFVs.

Other policies that could target specific user groups are R&D, pilot projects, and the stimulation of high blend biofuels in niche markets. Some policies at lower administrative levels (e.g. municipalities) could target specific user groups as well (e.g. with respect to public transport, taxis, urban delivery, etc.). Considerations for doing so can be potential synergies with regional/local objectives such as air quality, economic opportunities for local companies, etc. Main policy instruments that could target these groups are GPP, PPPs, subsidies and urban access restrictions (see Factsheet 4, 13 and 15).

5.4. TECHNOLOGY NEUTRALITY

Technology neutrality means that incentives are defined in general terms (e.g. all vehicles with less than $x \text{ gCO}_2/\text{km}$), rather than specifying technologies. Defining policy instruments in such a way that they are technology neutral has important advantages and is often taken as starting point by policy makers. The reason is that for governments it is hard to predict which technology will be the most (cost-)effective one; technology neutral instruments leave it to the market to choose. Therefore policies targeting vehicles and/or energy carriers can and are often defined in a technology neutral way (e.g. CO_2 standards). However, policies aimed at energy infrastructure have to be in most cases technology specific, as each pathway requires its own type of energy infrastructure.

It should be noted that a technology neutral policy can still stimulate specific technologies, e.g. vehicles standards based on tailpipe emissions stimulate ZEVs and FCEVs, but provide no incentive to vehicles that are compatible with mid- or high-biofuel blends. In a similar way, the choice of sustainability criteria in fuel regulation can strongly influence the type of feedstock stimulated by the policy. Therefore, technology neutrality is in itself a good guiding principle, but it cannot be applied to all policies.

5.5. COSTS-EFFECTIVENESS VS PREPARING FOR LONG-TERM TRANSITION

The transition to RES-T will require large investments, but will also provide large benefits to society in the long run. In order to minimise costs to society, cost-effectiveness (from an overall societal perspective) is an important guiding principle for developing policy instruments.

However, there can be a trade-off between cost-effectiveness and robustness with respect to meeting long-term GHG emission reductions. This is linked to the issue of technology neutrality. In general, a higher level of technology neutrality results in a higher cost-effectiveness as it leaves it to the market to select the most cost-effective solution.

It is important to distinguish between policies clearly targeting mass market uptake and policies targeting R&D, innovation and new product development. For the latter, cost-effectiveness is generally hard to quantify and not suitable as a guiding principle. This means that policy instruments like vehicle standards, fuel standards or taxation schemes should be assessed on their overall cost effectiveness (e.g. in euro per tonnes of CO₂). This should also include co-benefits like impacts on air pollution. Instruments like PPPs, pilot projects and green public procurement usually mainly target innovation and provide support to market introduction. Assessing such policies on their cost effectiveness for reducing CO₂ emissions is less useful.

5.6. DEALING WITH UNCERTAINTY AND PREVENTING LOCK-INS

The overall policy approach should be determined well in advance and should be as continuous as possible, to provide certainty to stakeholders that are making investments. Investors need a long-term, stable policy to see the return on investment in capitalisation of projects. For example: the regulatory uncertainty related to the inclusion of ILUC and the post-2020 policy framework in the EU has to a large extent been responsible for a drop in the increase of RES-T in the period 2010-2011 and has resulted in a decrease of investments in new biofuel production facilities (see factsheet EU Renewable Energy Directive (RED)).

At the same time, policy makers face some significant uncertainties with respect to the potential, costs, rebound effects and indirect effects of various technologies and their overall market developments (including emerging new technologies). Therefore, there is a need to adjust policies with new insights regularly. Examples are tax incentives that, if not updated regularly to take account of the fuel-efficiency improvements induced by other policies (e.g. CO₂ standards), become less effective and can result in a significant loss of tax revenues for governments. Another risk is getting locked in suboptimal technology paths and lower adoption rates (Bedsworth & Taylor, 2007).

For example, the previous ineffective Californian ZEV mandate resulted in a spill-over to hybrid vehicles (ibid.) instead of the uptake of ZEVs (see factsheet ‘Zero Emission Vehicle (ZEV) Regulations in California’).

Another example of policy instruments that may require regular interventions are regulations designed as a market based instrument. Systems with credits and deficits (like the Low Carbon Fuel Standard in California) can result in a surplus of credits if the interim targets in the early years of implementation are not stringent enough. Because credits might be used in future years, such surpluses could threaten the realisation of the targets, like projected shares of renewable energy or projected GHG emission savings (see factsheet ‘Fuel Regulation’).

The same is valid for the ZEV mandate in California, where many OEMs currently possess banked credits, which, if used, result in 25% less ZEVs and a 1% lower share in sales by 2025 (ARB, 2012) (see case study Zero Emission Vehicle (ZEV) Regulations in California).

Although public interventions are not the preferred option for market-based mechanism, public authorities might want to introduce corrective actions to safeguard the realisation of policy goals.

The balance between interventions and predictability is tricky and can best be managed by defining and monitoring some indicators (e.g. cost of battery prices of BEVs). The policies can then be adapted to the level of these indicators making it to some extent predictable but also providing sufficient freedom for policy makers to adapt to changing developments.

Note that the assessment of individual policy instruments (fact sheets as well as case studies in Annex C) has shown that there is broad lack of data on the (cost) effectiveness of policy instruments. The monitoring and evaluation of policy instruments by the responsible authorities could be improved to gain more insight in the effectiveness of the various instruments.

5.7. CONSISTENCY AND ALIGNMENT OF POLICY INSTRUMENTS

An important aspect of an effective overall policy strategy is that the various policy instruments are well aligned and harmonised. This requires, amongst other aspects, that targets are well aligned. In the US this is currently not the case with the CAFE standard and RFS. The CAFE standard will fade out compliance incentives for E85 compatible vehicles, while increasing E85 sales would, at least theoretically, be one of the pathways toward meeting current RFS compliance goals.

Using the same definitions and categorisations in various policies improves the overall effectiveness, e.g. using the same definition of ZEVs and CO₂ values for cars that are used for vehicle labels, fiscal policies, and all types of local incentives.

Another way of improving consistency is by setting policies at the federal level rather than by (Member) State. This reduces adverse cross-border effects, such as the high number of vehicle imports/exports between EU Member States currently caused by differences in vehicle taxation, or the fuel tourism in border regions due to differences in fuel excise duties. As mentioned before, this could however, result in less ambitious policies, because the policy goals will be a compromise between the frontrunners and the countries/states lagging behind.

Finally, also harmonization of local policies deserves attention. According to Windisch (2013) the effectiveness of local policies, like parking policies, can be improved if the same policies are applied in different cities. Norway developed therefore a national framework for parking policies for stimulating AFVs and Germany is planning to do so (see also Factsheet 11). In addition, local policies can strongly reinforce each other.

The effectiveness of incentives in parking policies in stimulating AFVs can be strengthened by harmonising these policies with incentives given by other policy instruments, like urban congestion schemes, incentives in registration taxes, company car taxes, etc.

5.8. DIFFERENCES BETWEEN REGIONS

Another cross-cutting issue is to take specific local or national circumstances into account. An example is the availability of domestic sustainable biomass. For countries with high amounts of waste and residues or other types of sustainable feedstock, it may be more (cost) effective to use high-biofuels blends than for countries that do not have domestic biomass availability. At the same time, biomass is traded worldwide and also between various sectors, so local biomass use in transport may need to compete with other sectors and/or regions elsewhere demanding biomass. Similarly, countries which already have a high share of RES-E, a quick shift to BEVs is much more beneficial (in terms of GHG emission reduction) than for countries that mainly rely on fossil power generation or have a slow uptake of renewables.

Also the demographic and geographic structure may be important to take into account when designing policies. For example, the business case of BEVs is much better in densely populated regions or cities with rather short commuting distances than in rural areas.

Finally, also the governance structures are important to consider. In the EU, fiscal policies at the Union level may in theory be more effective, yet the current governance structures do not allow this, as fiscal policies are a national mandate.

5.9. MAIN CONCLUSIONS ON THE POLICY FOR INCREASING RES-T WITHIN ITS BROADER CONTEXT

Policy strategy for increasing the share of RES-T should be considered within the broader policy strategies for a transition to sustainable transport and sustainable overall energy supply.

Policies for stimulating RES-T can contribute to other policy objectives, like reducing air pollution, noise and congestion and improving road safety. Particularly at the local level, these are often the main objectives of the (local) policy instruments discussed in this study. Including specific incentives in these instruments for increasing the share of RES-T can either increase their effectiveness or decrease it. Particularly the exemptions for AFVs (e.g. in parking policies, HOV lanes or pricing schemes) reduce the effectiveness of those schemes with respect to congestion reduction and/or modal shift. Therefore such incentives should be seen as temporary measures and adapted in time. At the national/federal level, there is particularly a trade-off between stimulating RES-T and fuel efficiency improvements in ICVs, e.g. in the case of super-credits in CO₂ standards for road vehicles.

In order to choose the right balance between RES-T and other objectives, **policy instruments should be complementary**, i.e. not every instrument needs to target vehicles, energy carriers and energy

infrastructure simultaneously or contribute to all objectives at the same time. Therefore overall consistency and alignment of policy instruments deserves attention.

This is also true across sectors. There is a strong link between renewable transport and the overall energy policy. While the shift to alternative powertrains is driven by transport policy, the actual renewable power and hydrogen production is strongly driven by other policies, such as incentives for renewable power generation, emission trading and energy regulation and subsidies. IEA-RETD RETRANS has therefore called for a **co-evolution of the energy and transport sector**.

Furthermore, policies for developing an BEV charging infrastructure and smart charging should be well aligned with developments in the power sector, the development of smart grids, and other changes in power demand and supply (e.g., heat pumps, solar energy).

In the case of biofuels, it is important to ensure that the demand for scarce biomass from various sectors (e.g. chemical industry, energy sector, transport) is managed well. Therefore, the biofuel policy mentioned above should be integrated in a broader biomass policy framework.

When further developing policies for increasing the share of RES-T, the following cross cutting issues are recommended to be considered.

1. Policies can best be defined in generic terms, targeting all technology pathways and user groups. There are exceptions, such as the very effective company car policies, policies targeting the pre-commercialisation phase, or policies stimulating a technology that specifically results in large benefit when applied in a particular niche market (e.g. taxis).
2. Policies should be designed from a social cost-effectiveness principle, but it should be kept in mind that there is a clear trade-off between (current) cost-effectiveness and robustness for meeting the long-term climate goals. Some policies may not be cost-effective now (e.g. ZEV mandates or subsidies for hydrogen or charging infrastructure), but may be crucial in ensuring alternative powertrains are brought to the market.
3. Policies should be defined well in advance and be as continuous as possible to provide (investment) certainty to the market.
4. Policy instruments should be harmonised where possible, both between and within regions. Ideally, incentives are defined in similar terms/criteria and target levels harmonised.
5. Policies should take specific local or national circumstances into account, as these influence the size of the required financial incentives and/or can result in a different ideal pathway for a region.
6. The assessment of individual policy instruments has shown that there is broad lack of data on the (cost) effectiveness of policy instruments. Therefore it is recommended to better evaluate policy instruments and so gain more insight in the effectiveness of the various instruments.

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ANNEX A OVERVIEW OF CURRENT POLICIES

A.1 OVERVIEW OF KEY POLICIES IN THE EU

Dimension	Description of key policies
Energy carrier	<p>The Renewable Energy Directive (RED). The RED sets a binding target of 10% renewable energy in transport by 2020 to be reached by each individual Member State. In practice, this target will mainly be met with biofuels. The RED defined sustainability criteria for biofuels and biofuels from waste and residues count twice towards the target. Therefore, the actual share of RET-T can be lower than 10%. In autumn 2014 agreement has been reached on the EU Energy and Climate package 2030, which also impacts the RED targets for 2030. Most notably, the new policy framework will not include a binding target for the share of renewable energy in the transport sector.</p> <p>The Fuel Quality Directive (FQD) targets the average carbon emission intensity of road transport fuels over their entire lifetime (in gCO₂/MJ) and sets a target of a 6% reduction by 2020 compared to 2010. In practice, this target will mainly be achieved by blending biofuels, as is the case for the RED. The same sustainability criteria apply.</p> <p>Both the RED and FQD have been implemented at the Member State level. Member States differ significantly in the policy instruments they have implemented to reach their target. This has not resulted in a high level of harmonisation across the EU. In general, most Member States have shifted away from financial instruments, like differentiated fuel excise duties/energy taxations, tax exemptions and subsidies, towards obligations for fuel suppliers to bring a certain share of biofuels on the market.</p> <p>The Energy Taxation Directive (ETD) (2003/96/EC) sets minimal taxation rates for energy carriers. However, its design provides a <i>disincentive</i> for renewables. Currently, the tax rate of fuels is determined by volume, so renewables with lower energy contents, such as biodiesel, have a relatively heavier tax burden than the conventional fuel they replace. The European Commission submitted a proposal to adjust the ETD from a volume-based to a CO₂ and energy based taxation of energy carriers. Renewables would benefit from this change (European Commission 2011), but up to now the proposal is subject to heavy discussion and has not yet been adopted.</p>
Energy infrastructure	<p>Clean Power for Transport (CPT) Directive - as adopted in September 2014 - requires Member States to develop national policy frameworks for the market development of alternative fuels, especially in relation to alternative infrastructure requirements. The Directive covers electricity, CNG, LNG, and hydrogen and prescribes Member States to provide an appropriate number of publicly accessible points, but also contains some provisions on the promotion of biofuels through better information provision and also addresses the use of biogas (like local refuelling points utilising locally produced biomethane and the injection of biomethane into the natural gas grid. To harmonise</p>

Dimension	Description of key policies
	<p>energy infrastructure across the EU, the CPT Directive also foresees the use of technical specifications for recharging and refuelling stations and covers consumer information on alternative energy carriers. This Directive has not yet been implemented by Member States.</p> <p>In addition to the CPT Directive, there are several financial support schemes, e.g. the Connecting Europe Facility (Trans-European Networks).</p>
Vehicles	<p>The CO₂ Regulations for cars and vans set CO₂ targets for the fleet average CO₂ emissions of Light Duty Vehicles (LDVs). This Regulation implicitly promotes alternative energy carriers as OEMs' targets are based on tank-to-Wheel (TTW) emissions. Consequently, FEVs and FCEVs count as zero towards the target. In addition, the existing Regulations contain so-called 'super credits', which explicitly promote alternative powertrains by counting LDVs with <50 gCO₂/km multiple times when determining the OEM's fleet average emissions.</p> <p>The Regulations beyond 2020 are still in the design phase, and hence, it is uncertain what kind of incentives will be given to alternative powertrains in this period</p> <p>A wide variety of Member States have implemented financial incentives to stimulate the uptake of AFVs. Most Member States of the EU levy purchase and/or ownership taxes on vehicles, which increasingly contain a CO₂-based element (European Commission, 2012). Moreover, many Member States exempt (semi-)electric vehicles from these taxes (ACEA, 2014).</p>

A.2 OVERVIEW OF KEY POLICIES IN THE US

Dimension	Description of key policies
Energy carrier	<p>The Renewable Fuels Standard (RFS) requires a specific amount of different types of renewable fuel to be used in gasoline, increasing on an annual basis through 2022. The types of renewable fuel include renewable fuel (generally, corn ethanol), cellulosic biofuel, advanced biofuel and biomass-based diesel (generally, biodiesel) and are specifically defined in the regulation. The amount of renewable fuel is based on the volume percentage of gasoline sold or introduced into US commerce and consists of a single applicable percentage (renewable volume obligation) that applies to all categories of refineries, blenders and importers. The renewable volume obligations are based on estimates that the Energy Information Administration (EIA) provides to EPA on the volumes of gasoline it expects will be sold or introduced into commerce. The minimum qualifying 'Renewable Fuels' for the RFS2 must have a 20% GHG reduction over their petroleum counterpart and the specialized 'Advanced Biofuels' must reduce GHG production by at least 50%.</p> <p>The Renewable Fuels Standard (RFS) currently applies in California, but the state has also put into place the Low Carbon Fuels Standard (LCFS). The LCFS requires a 10% reduction in the carbon intensity (CI) of transportation fuels by 2020 over the baseline year of 2010. CI is measured on a life-cycle basis expressed as grams of carbon dioxide equivalent per unit energy of fuel (gCO₂e/MJ). The program is part of a larger state effort to reduce GHG emissions to 1990 levels by 2020, which would mean the reduction of 15 million metric tons of CO₂. In addition to mitigating climate change, the LCFS program was designed to facilitate the entry of other alternative fuels in the state and thus enhance energy diversity or security as well. The program has been implemented and enforced since 2011 and has thus far survived legal challenges by the refining and ethanol industries. The LCFS has been implemented using credits and deficits, with each credit denoting one metric ton of CO₂ reduction based on the life-cycle CI of the fuel. Compliance is achieved by offsetting deficits against credits; credits can be banked and traded, similar to other new fuel programs that have been implemented in the US over the years. The credits do not expire and can be used anytime for compliance.</p>
Energy infrastructure	<p>There is no overarching federal-level policy currently enacted to require or encourage the development of energy infrastructure at this time. However, some US states do have policies in place to encourage the development of infrastructure for biofuels and alternative fuels and rely on such measures as grants, loans, loan guarantees and revolving loans projects to facilitate infrastructure development.</p> <p>The California Energy Commission oversees the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP), which provides funds for investing in clean transportation projects, as much as \$ 100 million annually. The Commission may use grants, loans, loan guarantees, revolving loans, and other appropriate measures for projects. Eligible recipients include: public agencies, private</p>

Dimension	Description of key policies
	<p>businesses, public-private partnerships, vehicle and technology consortia, workforce training partnerships and collaborations, fleet owners, consumers, recreational boaters, and academic institutions. Infrastructure development and expansion is covered under the program, and through a competitive grant process, a team comprised of an equipment provider and property owner apply for co-funding. Following grant approval, a project plan is developed and submitted for permitting. The Commission has provided \$ 26.8 million in ARFVT Program funding for charging infrastructure, supporting multiple types of charging infrastructure. The state now possesses the largest network of nonresidential charging stations in the nation.</p>
Vehicles	<p>While not linked to the RFS program, the US has implemented new corporate average fuel economy standards (CAFE) in several phases. First, model year (MY) 2011-2020 CAFE were set high enough to ensure that the industry-wide average of all new passenger cars and light trucks combined would not be less than 35 miles per gallon (mpg) by MY 2020.</p> <p>In 2009, the National Fuel Efficiency Program was announced; it was intended to regulate GHG emissions and fuel economy from on-road light-duty vehicles (LDVs) for MY 2012-2016. Based on the National Program, NHTSA has set fuel economy standards for light duty vehicles (LDVs) to achieve fleet-wide average of 34.1 mpg. Following that, new CAFE standards were set for the years 2017-2025 that included a GHG reduction component. Similar to CAFE, each manufacturer has a GHG target unique to its fleet, depending on the footprints of the vehicle models produced by that manufacturer. A manufacturer has separate footprint-based standards for cars and for light-duty trucks. These standards require the national LDV fleet to meet an estimated combined average GHG emissions level of 163 grams per mile (g/mile) of CO₂ in MY 2025. A new regulation is under development that would require GHG emissions reduction and improved fuel economy from medium- and heavy-duty vehicles.</p> <p>California implements federal regulations respecting fuel economy and GHG reduction, described above. However, the state has also implemented the Zero Emission Vehicle (ZEV) program, which requires manufacturers to offer for sale specific numbers of the cleanest cars available, including battery, electric, fuel cell and plug-in hybrid (known as a transitional ZEV) vehicles. Amendments approved in 2012 would require ZEVs and plug-in hybrids to more than 15% of sales in the state by 2025.</p>

A.3 OVERVIEW OF KEY POLICIES IN CANADA

Dimension	Description of key policies
Energy carrier	Environment Canada published the final federal Renewable Fuel Regulation (RFR) on Sept. 1, 2010. The RFR took effect on Dec. 15, 2010, and requires an average 5 vol% renewable fuel content in gasoline across Canada. The RFR program represents the government's key strategy in its commitment to reduce Canada's total GHG emissions by 17% from 2005 levels by 2020. Compliance with the 5 vol% requirement is calculated based on the volume of gasoline sold by the obligated party. The obligated party would generate compliance units based on the volume of renewable fuel used. The 5 vol% requirement and provisions for compliance units came into force on Sept. 1, 2010. The provisions requiring an average 2 vol% renewable fuel content in diesel fuel and heating distillate oil started in 2011, with permanent exemptions for the provinces of Newfoundland and Labrador and, as of November 2013, all heating oil.
Energy infrastructure	There is no federal-level policy currently enacted to require or encourage the development of energy infrastructure at this time.
Vehicles	To significantly curb GHG emissions and align them with the US, Canada has established mandatory GHG emissions limits on light-duty vehicles starting with MY 2011. The new goal is to achieve a 17% reduction in GHG emissions by 2020 (relative to 2005 levels). The established GHG standard closely follows the US automotive GHG standard and would help align automotive GHG emissions limits from new LDVs in North America by MY 2016. Environment Canada is currently developing a new regulation for fuel economy and GHG emissions for the years 2017-2025 that would align with the US standards. The proposed regulations would improve upon MY 2011-2016 fuel economy and GHG standards, reducing passenger automobile GHG emissions by 5% per year on average between 2017 and 2025, leading to a total estimated reduction of 162 megatons. Canada also intends to follow the US and implement standards for medium- and heavy-duty vehicles.

A.4 OVERVIEW OF KEY POLICIES IN JAPAN

Dimension	Description of key policies
Energy carrier	<p>In June 2009, the Act on the Promotion of the Use of Non-Fossil Energy Sources and Effective Use of Fossil Energy Source Materials by Energy Suppliers was enacted; it requires energy suppliers, particularly oil distributors, to use biofuels. In particular for ethanol, the act double-counts the usage of cellulosic ethanol and requires GHG emissions of fuel ethanol to be less than 50% of gasoline on a life-cycle analysis (LCA) basis. Although it is not mandatory to blend ethanol with gasoline at designated levels, mandatory volumetric targets have been set for ethanol, increasing from the 2010-2011 target of 346,000 kilolitres (344 million litres) to 824,000 kilolitres (825 million litres) by 2017. Therefore, the policy target for 2015 stands at 626,000 kilolitres (625 million litres); for 2020 and 2025, the policy targets are assumed to remain the same (at 3 vol%) from 2017.</p>
Energy infrastructure	<p>The government does not set a separate policy concerning alternative fuel infrastructure. Instead, it set up several strategies pertaining to development and deployment of next-generation vehicles (FEVs, PHEVs, FCEVs and clean diesel vehicles).</p> <p>The Next-Generation Vehicle Strategy in April 2010 covering three basic initiatives i.e.: creation of initial demand of the vehicles; support the R&D to improve the vehicles performance and efficient development of infrastructure. The development of charging infrastructure is mainly based on visions drawn up by local governments. These visions are based on FEV and PHEV Town Concept that is used for demonstration experiment to diffuse FEVs and PHEVs on a full scale. While FEV and PHEV Town Concept was started from several prefectures and town including the Prefecture of Okinawa, Tottori, Gifu, Fukui, Saga, Nagasaki, Kumamoto, Okayama, Osaka, Kyoto, Aichi, Niigata, Aomori, Tochigi, Saitama, Kanagawa and Shizuoka and Tokyo. As of September 2013, the whole 47 Prefectures nationwide have drawn up ‘a vision for the installation of chargers’ aiming for electric vehicles.</p> <p>In June 2014, the government set the Strategic Road Map for Hydrogen and Fuel Cells aiming to realize a hydrogen society. Under this road map, plans to create a hydrogen infrastructure to power FCV are included. A budget of JPY21.38 billion is set aside in FY 2012-2015 to subsidize the construction and operation of 100 hydrogen filling stations by end of FY2015. Furthermore, the government plans to convey the ‘hydrogen society message’ to the whole world by leveraging the 2020 Summer Olympics in Tokyo.</p> <p>In March 2015, the government announced a budget of JPY30 billion to facilitate the development of charging infrastructure. This budget will be used to subsidize (up to 50%) the purchase price and installation costs of battery chargers and to survey how such vehicles are used on expressways. Under this project, the Ministry of Economy, Trade and Industry (METI) aims to double the number of installed charges by end of FY2015.</p>
Vehicles	<p>In 1979, the Act on the Rational Use of Energy (Energy Conservation Act) was enacted. The Act has been upgraded and improved responding to social needs. In 1998, the government amended the Act adding the Top Runner Program for automobiles and household electrical appliances. Specific for automobiles, the Top</p>

Dimension	Description of key policies
	<p>Runner Program set standards for fuel efficiency concerning small freight vehicles including passenger cars, van and trucks. In March 2015, the government amended the fuel efficiency standards under the Top Runner Program. The new fuel efficiency standard for passenger car is increased from 12.7-23.2 km/l in FY2015 to 16.9-28.1 km/l in FY2020 and for van and truck from 7.9-18.2 km/l to 10.2-21.0 km/l.</p> <p>Under the Next-Generation Vehicle Strategy 2010, the government set a target of 20-50% of new vehicles sales in 2020 should be next-generation vehicles. This next-generation vehicle target comprises of 20-30% hybrid vehicles; 15-20% FEVs and PHEVs; ~1% FCEVs and ~5% clean diesel vehicles. The target is further increased in 2030 to reach 30-40% hybrid vehicles; 20-30% FEVs and PHEVs; ~3% FCEVs and 5-10% clean diesel vehicles.</p>

A.5 OVERVIEW OF KEY POLICIES IN CHINA

Dimension	Description of key policies
Energy carrier	<p>It is important to note that usage of each alternative fuel and vehicle is not harmonized throughout the country except for new energy vehicles (i.e. FEVs, PHEVs). Each alternative fuel is used in different cities and provinces depending on the availability and accessibility of reserves and necessary infrastructure.</p> <p>Currently, there is no national mandate to blend biofuels. However, there is a full E10 mandate in the six provinces of Jilin, Heilongjiang, Henan, Anhui, Liaoning and Guangxi, and a partial E10 mandate in the four provinces of Hebei, Hubei, Shandong and Jiangsu. Only voluntary volumetric targets stand for 2010 and 2020 under the Medium- and Long-Term Renewable Energy Development Plan released by the National Development and Reform Commission (NDRC) in August 2007, where the 2020 target stands at 10 million tons. Note that this target has yet to be revised until now. Further in the National Energy Administration's 12th Five-Year Bioenergy Development Plan (2011-2015), a target has been set for 4 million tons of ethanol production by 2015.</p> <p>In October 2012, NDRC announced a new Natural Gas Utilization Policy (2012 Gas Policy) which came into effect on Dec. 1, 2012. Under this policy, the government encourage the use of natural gas in various sectors including transportation (in particular dual-fuel and LNG vehicles). However there is no specific target mentioned in this policy.</p>
Energy infrastructure	<p>With regard to natural gas, under the Qingyuan Special Plan (2013-2020) the Qingyuan city announced its plan to build 22 natural gas refuelling stations.</p> <p>Under the 12th Five-Year Development of EV Technology Plan (2011-2015), the government aims for 2,000 electric charging stations and 40,000 electric charging poles in more than 20 pilot cities by the end of 2015. To increase the number of charging stations in Beijing, the Beijing Municipality has required new residential communities to install charging stations in 18% of their parking units in 2014.</p> <p>To speed up the uptake of new energy vehicles, in December 2014 the Ministry of Finance announced the State Council on Accelerating Guidance to Promote the Application of New Energy Vehicles. Under the guideline, the government set up a reward system for cities which met the target number of new energy vehicles on their roads.</p>
Vehicles	<p>China is currently the only country where methanol blend is commercially available. The use of methanol is led by Shanxi province. 20 other provinces and cities are also testing methanol blends include Shaanxi, Heilongjiang, Sichuan,</p>

Guizhou, Shandong, Jiangsu, Henan, Zhejiang, Ningxia and Xinjiang.

The Shanxi government set a target for new energy vehicles (methanol vehicles included) to account for a minimum of 40% of Taiyuan's government agencies and public institutions' purchase in 2014-2016. New energy vehicles shall account for a minimum of 30% of new purchase by the government agencies and public institutions in Datong, Jinzhong, Changzhi and Yuncheng cities with other cities set a minimum target of 10%. It is important to note that only in Shanxi and Shaanxi provinces methanol vehicles are included in the definition of new energy vehicles.

In 1996, the Communist Party of China Central Committee included EVs project in **9th Five-Year Plan (1995-2000)** to establish EVs as a key state project. In January 2009 the Ministry of Science and Technology (MOST) launched a project of '**Electric Vehicles for Ten Cities**' from 2009 to 2012 to run demonstration of 1,000 new energy vehicles in each city each year. To implement the strategy and road map to develop the EV market in China, the MOST launched the '**Development of EVs Technology Plan (2011-2013)**' in 2012. Under the plan the government set a target of 50,000 alternative fuels vehicles by 2012 and 39,700 units by March 2013. In the same year, the Ministry of Industry and Information Technology launched the '**Energy Efficiency and New Energy Vehicle Industry Development Plan (2012-2020)**' which set a target of 500,000 FEVs and PHEVs by 2015 and 5 million FEVs and PHEVs by 2020. The government reduced the 2015 target to 336,000 units.

To speed up the deployment of new energy vehicles, the government released a subsidy scheme (up to CNY500,000 depending on the model) to purchase selected models of FEVs, PHEVs and FCEVs applicable in 2016-2020.

To help reduce energy consumption, the government launched the **Energy Conservation Law** enacted on April 1, 2008. Since then the government has been active in implementing new and revised vehicle fuel economy standards. While the first fuel economy standards implemented in China dated back to 1984 for trucks and passenger vehicles in operation and to 1996 for new motorcycles and mopeds, the third phase of fuel consumption standards enacted on Jan. 1, 2012. From 2012 to 2015, corporate average fuel consumption (CAFC) levels for all passenger vehicles and for fuel-efficient vehicles are required to meet the 2015 targets of 6.9 l/100 km and 5.9 l/100 km respectively. By 2020 CAFC levels for all passenger vehicles and for fuel-efficient vehicles are required to meet 5.0 l/100 km and 4.5 l/100 km respectively. Fuel-efficient passenger cars include conventional fuel vehicles, conventional hybrid vehicles and dual fuel passenger cars.

ANNEX B LONG LIST OF POLICY INSTRUMENTS

#	Instrument	Cases	Energy carrier				Infrastructure	Vehicles			Adm. level				Main reason for in- or excluding instrument		
			Conventional fuels	Biofuels	Electricity	Hydrogen		Cars	LCVs	Light trucks (urban)	Buses	Federal (US)/Union (EU)	(Member) State/Country	Local		Included on short list?	
Financial instruments																	
1	Incentives in energy taxation (fuel excise duties, electricity tax)	Many EU countries (e.g. in DK, FR, IE, SE, FI); CN	X	X	X	X			X	X	X	X		X		Y	Instrument has been implemented in many countries. A CO ₂ -based energy taxation contributes to a level playing field for all types of renewable energy in transport and provides an incentive to optimize CO ₂ reduction. Because it doesn't prescribe specific technologies stakeholders are also free to choose for the most cost-efficient option. No case study.
2	Incentives in one-time vehicle registration/purchase taxes	Many EU countries (e.g. ES, FI, FR, NL, DK, NO); US; JP; CN	X	X	X	X			X					X		Y	Instrument has been implemented in many countries worldwide. CPB (2015) estimates this has on average reduced emissions of new cars with 1.3% in Europe. Furthermore, it reduces the financial barriers to EV adoption. Case study: Norway , as it is known as one of the EU countries with the strongest incentives for ZEVs at the purchase moment.

#	Instrument	Cases	Energy carrier				Infrastructure	Vehicles			Adm. level				Included on short list?	Main reason for in- or excluding instrument	
			Conventional fuels	Biofuels	Electricity	Hydrogen		Cars	LCVs	Light trucks (urban)	Buses	Federal (US)/Union (EU)	(Member) State/Country	Local			
3	Incentives in company car tax	Many EU countries (e.g. BE, FR, UK, NL); JP	X		X	X			X				X	X		Y	Company cars have a large share in the total vehicle sales. These financial incentives have had a large impact on new company car fleets in some countries. Case study: Netherlands , design has been proven effective.
4	Incentives in (urban) road pricing and tolls	Some EU countries (e.g. UK, FR, NO)	X		X				X	X					X	Y	Financial incentives are generally effective but mostly directed at vehicles. This financial incentive is directed specifically at urban situations which is where BEVs have most potential/are most attractive. Case study: London (UK) , as London’s congestion charging scheme is well-known and well-documented.
5	Subsidies and PPPs for alternative energy infrastructure (e.g. filling stations and charging points)	EU, NL, JP, CN, US		X	X	X	X		X	X	X	X	X			Y	May help tackle the chicken and egg problem. In general, subsidies are expensive, but most policies are directed at vehicles while infrastructure is equally important. Case study: Japan , as Japan has many BEVs and to ensure sufficient geographical coverage.
6	Emission trading	EU ETS			X								X			N	The impact of cross-sectoral emission trading schemes (like the EU ETS) on transport emissions are very small due the small price impacts on transport. The impacts of including road transport in such a scheme are expected to be very small too, for the same reason. An alternative could be to introduce a separate emission trading scheme for road transport.

#	Instrument	Cases	Energy carrier				Infrastructure	Vehicles				Adm. level				Included on short list?	Main reason for in- or excluding instrument
			Conventional fuels	Biofuels	Electricity	Hydrogen		Cars	LCVs	Light trucks (urban)	Buses	Federal (US)/Union (EU)	(Member) State/Country	Local			
7	Tax breaks for biofuels	Many EU countries (e.g. AT, CZ, IE, RO, SK, SE); NO, JP	X					X	X	X	X	X	X	X	N	Tax breaks, even local, helped launch industries but are expensive. The inclusion of sustainability aspects in tax breaks is very complicated. Many Member States have already shifted away from financial instruments, like tax breaks, to biofuel mandates. Although not further assessed in this study, it may be a useful options in specific cases.	
8	Incentives in annual circulation tax	Many EU countries (e.g. DE, GR, FI, NL, UK); JP; US	X		X	X		X	X	X	X	X	X	X	N	CPB (2015) found that differentiations in annual road taxes had no or even an adverse effect in the EU.	
9	Exemption from VAT	NO			X			X					X		N	Only implemented in one country (NO) and quite similar to tax incentives. The latter is chosen for the short list as it has been implemented in many more countries.	
10	Direct subsidies for vehicle consumers	Many EU countries (e.g. ES, FR, NL, UK, SE); US; JP; CN	X	X	X	X		X	X	X	X		X		N	Subsidies are generally an expensive policy option for governments and may therefore be difficult to implement in the long-term and more broadly (CE Delft, 2010). There are less costly and more effective policies available, such as incentives in vehicle taxes. Therefore, these types of subsidies are not included.	

#	Instrument	Cases	Energy carrier				Infrastructure	Vehicles				Adm. level				Included on short list?	Main reason for in- or excluding instrument
			Conventional fuels	Biofuels	Electricity	Hydrogen		Cars	LCVs	Light trucks (urban)	Buses	Federal (US)/Union (EU)	(Member) State/Country	Local			
11	Subsidies for car manufacturers	UK			X				X							N	Subsidies are generally an expensive policy option to for governments and may therefore be difficult to implement in the long-term and more broadly (CE Delft, 2010). There are less costly and more effective policies available, such as the vehicle standards. Moreover, this instrument is partly covered by the assessment of instrument 5 and 40 (Factsheet 4 and 16).
12	Incentives for renewable energy production	Many EU countries; CA, US; JP	X	X								X	X	X		N	Not specifically directed to increase renewable energy use in transport. Partly covered by Factsheet 17.
13	Support for R&D and pilots with vehicles	EU; JP; CN; US	X	X	X	X	X		X	X	X	X		X		N	This study focusses mainly on instruments increasing the use of renewable energy in transport, while this instrument is more focused on innovation. This instrument partly overlaps with number 40 which is elaborated in Factsheet 16.
Regulation																	

#	Instrument	Cases	Energy carrier				Infrastructure	Vehicles			Adm. level			Included on short list?	Main reason for in- or excluding instrument
			Conventional fuels	Biofuels	Electricity	Hydrogen		Cars	LCVs	Light trucks (urban)	Buses	Federal (US)/Union (EU)	(Member) State/Country		
14	Fuel regulation	EU: FQD implementation in EU countries; US/CA: RFS; California (LCFS)	+ X	X	X	X					X		X	Y	Fuel regulation can provide strong and direct incentives for higher shares of renewables in transport. Two cases: 1) EU (FQD) + DE. At the national level the current introduction of a FQD-like CO ₂ reduction target in Germany replacing the blending obligation is an interesting case. 2) US: California The LCFS in California has been the first fuel standard in the world and has therefore always be seen as a frontrunner.
15	Renewable mandates	energy EU: RED + national implementations		X	X	X					X	X		Y	This is a very powerful and direct instrument for increasing the share of renewable energy in transport. Case study: EU (RED) + Italy: The RED is the cornerstone of the EU renewable energy policy and Italy is the first EU country which has announced a target for advanced biofuels.
16	Regulation of charging/fuelling infrastructure	EU: CPT					X				X			Y	The CPT needs to be implemented, but it would be interesting to investigate to what extent minimum numbers for filling stations and charging points could enable the transition towards alternative means of transport or that simply increasing the energy infrastructure will not automatically result in more alternative vehicles. Case study: EU

#	Instrument	Cases	Energy carrier				Infrastructure		Vehicles			Adm. level				Included on short list?	Main reason for in- or excluding instrument
			Conventional fuels	Biofuels	Electricity	Hydrogen			Cars	LCVs	Light trucks (urban)	Buses	Federal (US)/Union (EU)	(Member) State/Country	Local		
17	Obligation to offer certain higher biofuel blends at filling stations	Many EU member states (e.g. SE)	X				X							X		Y	Several countries have introduced the obligation to offer specific biofuel blends. For example, several Member States have introduced E10 as mandatory blend. Some countries have been more successful than others as result of different levels of consumer acceptance. Especially these differences between countries are interesting to study. Case study Sweden: The Pump Act in Sweden is an interesting example of the introduction of E85.
18	Minimum share of alternative powertrains in vehicle sales	US: California (ZEV mandate)		X	X				X	X	X			X		Y	Regulation is generally very effective and this mandate could be easily implemented in other countries. Moreover, this Regulation is specifically directed at realising a particular share of ZEVs in the vehicle sales and is therefore very relevant. Case Study: California, as this is the only state where it has been implemented.
19	CO ₂ standards cars	EU, US, JP; CN; KR	X	X	X	X			X				X			Y	An important cornerstone in the CO ₂ policies of many main regions and proven to be very effective, in some cases also providing strong incentives for ZEV-sales. Case study: EU, as this Regulation includes specific incentives for ZEVs (super credits) in addition to the overall targets that have been set.

#	Instrument	Cases	Energy carrier				Infrastructure	Vehicles		Adm. level				Included on short list?	Main reason for in- or excluding instrument	
			Conventional fuels	Biofuels	Electricity	Hydrogen		Cars	LCVs	Light trucks (urban)	Buses	Federal (US)/Union (EU)	(Member) State/Country			Local
20	CO ₂ standards LCVs	EU, US, JP; CN	X	X	X	X			X		X			N	Instrument is very similar to the CO ₂ Regulation for cars. However, as there are many more cars than LCVs worldwide, the car policy is included in the short list instead of the LCV standard.	
21	CO ₂ standards trucks and buses	CN; JP; US; CA	X							X	X	X		N	Instrument is very similar to the CO ₂ Regulation for cars. Furthermore, existing CO ₂ standards for trucks and buses do not provide specific incentives for AFVs.	
Information provision																
22	Information services on locations of alternative energy infrastructure	n/a					X					X		X	Y	Innovative services are increasingly being marketed and are included on the short list as promoting such services can be a very inexpensive instrument which is targeted at energy infrastructure. No case study is included as it has not yet been implemented as a policy instrument.
23	Certificates (e.g. for renewable electricity) and bio-tickets	NL		X	X										N	It is mainly a means to administrative handle the trade in renewable energy and can therefore be seen more as an administrative instrument rather than related to information provision.

#	Instrument	Cases	Energy carrier				Infrastructure	Vehicles			Adm. level				Included on short list?	Main reason for in- or excluding instrument
			Conventional fuels	Biofuels	Electricity	Hydrogen		Cars	LCVs	Light trucks (urban)	Buses	Federal (US)/Union (EU)	(Member) State/Country	Local		
24	CO ₂ labelling of energy carriers	-	X	X	X	X									Y	Due to the complex supply chain and fuel distribution practices It is complicated to label energy carriers at service stations. However, similar information is needed for fuel regulation. This is elaborated in factsheet 14, together with policy instrument 22. No case study is included as it has not yet been implemented as a policy instrument.
25	CO ₂ or energy labelling of cars	EU; JP; CN; US	X	X	X	X			X				X		N	CO ₂ emissions of cars are also Regulated, which is much more effective compared to labelling and therefore included in the short list.
26	CO ₂ or energy labelling of vans	JP; US	X	X	X	X			X						N	Not very effective for increasing the share of renewable energy in transport, as it provides weak incentives e.g. compared to vehicle standards or financial incentives.
27	CO ₂ or energy labelling of trucks and buses	JP								X	X				N	Not very effective for increasing the share of renewable energy in transport, as it provides weak incentives e.g. compared to vehicle standards or financial incentives.
28	CO ₂ or energy labelling of vehicle components	EU	X	X	X	X			X	X	X	X	X		N	Labelling components provides no specific incentive to ZEVs and is therefore not included in the short list.
29	Carbon footprinting of transport services	FR	X	X	X	X				X			X		N	Provides too weak incentives for increasing RE in transport or AFVs and has only been implemented in France.

#	Instrument	Cases	Energy carrier				Infrastructure	Vehicles			Adm. level				Included on short list?	Main reason for in- or excluding instrument
			Conventional fuels	Biofuels	Electricity	Hydrogen		Cars	LCVs	Light trucks (urban)	Buses	Federal (US)/Union (EU)	(Member) State/Country	Local		
Public procurement and PPPs																
30	Green procurement of public transport	Many EU countries (e.g. NL); US; CN; JP	X	X	X			X	X		X	X	X		Y	Green public procurement can be very effective in improving the sustainability of public transport and public services (e.g. police, cleaning, etc.). Therefore, it has been included in the short list. Case study: Japan as they have implemented this policy and to ensure geographical coverage.
31	PPPs for Innovative city distribution	Some pilots in EU, e.g. NL		X	X					X				X	N	This is not included in a separate fact sheet , but innovative city distribution is discussed in a text box on Page 55 and partly covered by Factsheet 4.
32	PPPs for investing in ZEVs (e.g. taxis)	China		X											N	Expensive to implement at larger scales and partly covered by Factsheet 4.
Traffic and spatial policies																
33	Parking policies (e.g. dedicated parking places, differentiated parking fees)	Many EU countries (e.g. NL, UK, NO, FR, AT)		X				X						X	Y	Parking is increasingly problematic in many larger cities, especially in the EU. Therefore, an incentive in the parking policies of local governments can provide a strong motivation to buy an alternative car and is included in the short list. Case study: Austria (Graz) , where several incentives have been implemented in the parking policies.

#	Instrument	Cases	Energy carrier				Infrastructure	Vehicles				Adm. level				Included on short list?	Main reason for in- or excluding instrument	
			Conventional fuels	Biofuels	Electricity	Hydrogen		Cars	LCVs	Light trucks (urban)	Buses	Federal (US)/Union (EU)	(Member) State/Country	Local				
34	Environmental zoning (urban access restrictions)	Many EU countries (e.g. UK, FR, NL, IT); CN	X	X	X	X			X	X	X	X				X	Y	Environmental zoning is currently often targeted at air pollutants. However, it can potentially provide a strong incentive for ZEVs. In some (parts of) cities in China there are (plans for) restricting access to ZEVs only. Case study: China.
35	High-occupancy vehicle (HOV)lanes for all ZEVs	CA; NO; US		X	X	X			X	X	X			X		X	Y	Provides a non-financial incentives to ZEVs, and is a relatively new policy instrument to promote renewable energy in transport.
36	RE production in or - along transport infrastructure						X						X	X		X	N	Does not explicitly stimulate the increased application of renewable energy in transport although it is closely related.
37	Land use planning w.r.t filling and charging infrastructure	Varies per country					X										N	Land use policy differs between countries and regions and appropriate rules depend on specific circumstances. Therefore, it would be difficult to investigate what would be a ‘good’ design of this instrument for the promotion of an alternative infrastructure. Furthermore, impact on RE use or AFV uptake expected to be small.
38	The right for a - charging point						X										N	Not much variation in design and also very dependent on local circumstances. Therefore it has not been included.

#	Instrument	Cases	Energy carrier				Infrastructure	Vehicles				Adm. level				Included on short list?	Main reason for in- or excluding instrument
			Conventional fuels	Biofuels	Electricity	Hydrogen		Cars	LCVs	Light trucks (urban)	Buses	Federal (US)/Union (EU)	(Member) State/Country	Local			
Other policies																	
39	Policies to increase - EVs' and FCEVs' renewable energy consumption			X	X	X			X	X	X	X				Y	Innovative policies could ensure that new BEVs and FCEVs in the fleet also consume renewable electricity. It is important that this link is made more explicit in the future, to prevent the creation of a business case for conventional power generation. Therefore, it is included in the short list. No case study
40	Setting up pilot/ - demonstration projects for new energy technology in transport			X	X											Y	Most policies target market uptake of proven technologies, while it is equally relevant to look at pilots and demonstrations of technologies in earlier stages of development. Therefore, this instrument is included on the short list. No case study

ANNEX C FACTSHEETS & CASE STUDIES

C.1 FINANCIAL INSTRUMENTS

Factsheet 1 - INCENTIVES IN ENERGY TAXATION						
Description of the instrument						
Several incentives in energy taxation can be used to stimulate alternative fuel vehicles (AFVs):						
<ul style="list-style-type: none">– changes in overall energy taxation levels: an overall increase in tax levels for fuels or a reduction in overall tax levels for electricity or hydrogen;– providing discounts on specific energy taxes: e.g. fuel taxes on biofuels are reduced;– CO₂ differentiated energy taxes or CO₂ taxes: differentiating energy taxes by the CO₂ content of energy carriers or implementing specific CO₂ taxes can reduce the (relative) tax burden of fuels with a low CO₂ intensity.						
In Europe and Asia, (incentives in) energy taxes are currently implemented at country levels , although in Europe minimum energy taxation levels are set at the Union level. In the US, fuel taxes are set at federal and state levels .						
Main impacts on						
	Energy carriers	Energy infrastructure	Vehicles			
			Car	LCV	Light truck	Bus
Electricity			X	X	X	X
Hydrogen			X	X	X	X
Biofuels	x		X	X	X	X
Results of the assessment						
Increase alternative powertrains (o/+)	Increase renewable energy (+)	GHG reduction (++)	Coverage (++)	Cost-effectiveness (+)	Ease of implementation (+)	
Country coverage						
Implemented <ul style="list-style-type: none">– energy taxes are implemented in almost all countries;– discounts on energy taxes for AFVs: several countries/states, e.g. Austria, Finland, Romania, Slovakia, British Columbia;– CO₂ differentiated energy taxes: several countries, e.g. Denmark, France, Ireland, Sweden.			Implementation being considered Unknown			
Design options						
Some key design elements with respect to (incentives in) energy taxation are:						
<ul style="list-style-type: none">– tax levels: the impact of incentives in energy taxation depends on the difference in tax rates that apply to fossil fuels and to renewable energy carries;– metric for differentiation: energy taxes can be differentiated by energy and/or CO₂ content of the energy carrier, or discounts can be applied to specific types of fuels (e.g. biofuels).						
Key lessons learned with respect to renewable energy in transport						
<ul style="list-style-type: none">– Rebound effects: discounts on energy taxes for renewable energy carriers may stimulate the uptake of AFVs and/or the use of biofuels, but it may also result in an increase in transport demand (as driving an additional kilometre becomes cheaper) (CE Delft, 2010). This may partly reduce the environmental effectiveness of this measure. Such rebound effects can also result from other policy measures which make vehicles more efficient (e.g. vehicle standards). Increasing overall energy taxation levels can be an option for minimising these rebound effects.– Harmonising (incentives in) energy taxation between countries/states may simplify the introduction of the design options introduced above, by removing potential competitiveness impacts or unfair completion near national/state borders. In Europe, minimum tax rates are set by the Energy Taxation Directive (2003/96/EC) in						

<p>order to arrange such a harmonisation, but Member States are free in determining the tax level (above the minimum). Hence, differences between Member States still result.</p> <ul style="list-style-type: none"> – Wrong design of the metric for differentiation can provide a disincentive for renewable energy. If energy taxation is fully based on energy content, renewables with lower energy contents, such as biofuels, have a relatively heavier tax burden than the conventional fuel they replace (European Commission, 2011). – An often mentioned complaint about energy/carbon taxes is their regressive nature; the relative tax burden is higher for low-income households (Bureau of National Affairs, 2013). However, this adverse impact can be addressed by lowering other taxes (e.g. income taxes). 	
Interaction with other types of policy instruments	
<p>Energy taxation can interact with other types of policy instruments in various ways (CE Delft, 2010). Firstly, incentives in energy taxation can strengthen the incentives given by other instruments, e.g. to purchase an AFV. Secondly, higher fuel taxes can compensate for the reduction in fuel cost that results from using more fuel-efficient cars and hence, they can limit the rebound effects described above.</p>	
Assessment	
Increase in alternative powertrains	+
<p>Incentives in energy taxation may stimulate the uptake of alternative powertrains because they make conventional fuels more expensive. An increase of fuel taxes (or decrease of taxes of electricity/hydrogen) provides consumers an effective financial incentive to purchase an electric or hydrogen vehicle, as illustrated by many studies (e.g. Alhualal and Takeuchi, 2014; Diamond, 2009; Gallagher and Muehlegger, 2011). Alhualal and Takeuchi (2014), find that a 1% fuel price increase results in a 0.4% increase in eco-friendly vehicle purchases for example. Likewise, implementing fuel taxes that are differentiated by the carbon content of fuels or providing tax exemptions for biofuels, can provide an effective incentive to choose for biofuels (Wiesenthal et al., 2009). However, there is evidence that incentives in energy taxation are less effective than incentives in vehicle taxation (i.e. company car taxes, registration taxes) (Alhualal and Takeuchi, 2014). This can be explained by consumer myopia (i.e. future cost savings are only partly taken into account by consumers at the point of vehicle purchase), but also uncertainty of future fuel prices plays a role.</p>	
Increase in renewable energy	+
<p>Energy taxation can influence the use of renewable directly, e.g. PHEVs and The impact of this policy instrument on the share of renewable electricity and hydrogen consumed in transport is strongly dependent on the shares of renewables in electricity and hydrogen production. These shares are not directly influenced by this policy. However, a shift to AFVs does result in some increase in RES-T and in energy savings. Additionally, this policy instruments can provide a direct incentive to use more biofuels.</p>	
GHG emissions reduction	++
<p>In contrast to most other instruments, energy taxation provide incentives for basically <i>all</i> technical and non-technical options for reducing CO₂ emissions, including the purchase of fuel-efficient vehicles, applying fuel-efficient driving and reducing the number of kilometres travelled (CE Delft, 2010). Additionally, by differentiating energy taxes by the carbon content of the energy carrier, incentives are given to shift to low carbon fuels. Therefore, incentives in fuel taxation is a very effective instrument to reduce the CO₂ emissions of transport.</p> <p>PBL and CE Delft (2010) performed an extensive literature study and concluded that - in general - a 10% increase in fuel prices results in an emission reduction of 6-8% for passenger cars. This is mainly due to a decrease in travelled kilometres, but also a shift to more fuel-efficient cars significantly contributed.</p>	
Coverage	++
<p>(Incentives in) Energy taxation covers all road transport modes and the entire vehicle fleet (both new and existing), hence, coverage is very large.</p>	
Cost-effectiveness	+
<p>Based on a literature review, CE Delft and TNO (2010) conclude that increasing fuel taxes is a cost-effective way to reduce CO₂ emissions of transport. This measure results in significant fuel savings (++) and reductions of external costs like congestion (+/++), accidents (++) , air pollution (+) and noise (+). In most cases, these benefits are larger than the costs of welfare losses due to a decrease in travelled kilometres (-/-) and higher purchase costs of fuel-efficient vehicles (-). However, some of the social benefits of fuel taxation (i.e. reduction in congestion and traffic accidents), depend heavily on local circumstances and hence, the cost-effectiveness of this measure is likely to vary widely between countries/states.</p> <p>The application of a revenue neutral CO₂-based differentiation of energy taxation is probably cost-effective as well (CE Delft and TNO, 2010), as this instrument stimulates both AFVs and fuel-efficient conventional vehicles. Incentives in energy taxation only stimulating the uptake of AFVs/biofuels (e.g. tax exemptions) are probably not cost-effective, as the reduction options stimulated by these incentives are not cost-effective (see CE Delft and</p>	

TNO, 2010). However, this option is likely to become more cost-effective, as the purchase costs of BEVs and FCEVs are expected to decrease in the future.	
Ease of implementation	+
This policy option only requires adjustments to existing instruments and is therefore relatively easy to implement (CE Delft, 2010).	
Other considerations	
A shift to RES-T in general and many other policy instruments stimulating AFVs or improved fuel efficiency in particular (e.g. vehicle taxation, vehicle standards) will result in lower revenues from fuel taxes, as the average vehicle becomes more fuel-efficient. Increasing the overall fuel tax level can be used to avoid significant losses in governmental tax revenues, but in the long-term there may be a need to look for alternatives, e.g. electricity taxation for BEVs or kilometre charging.	

Factsheet 2 - INCENTIVES IN VEHICLE REGISTRATION TAXES (VRT)						
Description of the instrument						
This policy instrument provides financial incentives in vehicle registration taxes to stimulate the purchase vehicles with low and/or zero CO ₂ emissions. It is currently implemented at country and state levels .						
Main impacts on						
	Energy carriers	Energy infrastructure	Vehicles			
			Car	LCV	Light truck	Bus
Electricity			X			
Hydrogen			X			
Biofuels						
Results of the assessment						
Increase alternative powertrains (++)	Increase renewable energy (o)	GHG reduction (++)	Coverage (++)	Cost-effectiveness (?)	Ease of implementation (+)	
Country coverage						
Implemented Cars: EU (multiple countries, incl. NO), US (multiple States), Japan				Implementation being considered Unknown		
Design options						
<p>Many countries worldwide levy vehicle registration tax (VRT) when a new car is registered. Increasingly, countries differentiate their VRT by CO₂ emissions (or fuel consumption/economy). Consequently, alternative fuel vehicles (AFVs) can benefit from lower tax levels (ICCT, 2014d). Note that some countries also levy VRT for other vehicle types, e.g. motor cycles or vans, but these are often not (yet) differentiated by CO₂. Key differences in design are:</p> <ul style="list-style-type: none">– The metric: differentiation of the financial incentive can be based on CO₂ emissions (g/km), fuel consumption (l/100km), fuel economy (km/l), weight, horsepower, fuel type or a combination (T&E, 2014).– The Steepness of CO₂ differentiation (if any): Some countries have made the VRT fully dependent on CO₂ emissions (or fuel consumption) (e.g. The Netherlands, UK), while others have made it only partially dependent on CO₂ emissions in addition to another metric (e.g. Finland, Denmark). Moreover, those countries which have fully based their VRT on CO₂ emissions differ in steepness of the differentiation (T&E, 2014). The UK has a step-based differentiation with pre-defined classes and tax rates, while the Netherlands has a continuous scheme in which the CO₂ emission factors are multiplied with a fee per g/km for example.– Exemption of alternative powertrains: Many countries which levy VRT have exempted FEVs and FCEVs and few countries exempt PHEVs/EREVs as well (e.g. Greece) (ACEA, 2014).– Fee-only vs. Feebates: Feebates impose a fee on vehicles with a low fuel economy/high CO₂ emissions per km and provide a rebate to vehicles with a high fuel economy/low CO₂ emissions per km. Fee-only systems have differentiated tax rates based on CO₂ or fuel economy but do not provide rebates (T&E, 2014).						

Factsheet 2 - INCENTIVES IN VEHICLE REGISTRATION TAXES (VRT)

Innovative design elements: to ensure the full GHG emission reduction benefit from AFVs, exemptions/beneficial tax rates could only be issued if the car buyer has an agreement on renewable electricity.

Key lessons learned with respect to renewable energy in transport

- **The design of the financial incentives has a strong influence on the type of alternative powertrains stimulated.**
For example, in the Netherlands and Norway, BEVs have a market share of 6.6 and 12.7% respectively, but in Norway these are mainly FEVs (see also the case study) and in the Netherlands mainly PHEVs/EREVs (ICCT, 2014d). In the Netherlands, the incentives in VRT (and ownership taxes) for private owners resulted in a situation where the absolute tax benefits for some PHEVs were much higher than those for FEVs (e.g. the difference in VRT between a conventional V60 and a V60 plug-in hybrid was € 20,900 and between a conventional Renault Clio and a battery-electric Renault Zoe only € 1,800). Consequently, the tax benefit for FEVs was not sufficient to compensate for higher purchase prices. In Norway, this situation is reversed (ICCT, 2014d).
- **Tax rates need to be frequently revised to prevent unintended loss of tax revenues;** if tax rates are differentiated by CO₂, the improved efficiency of vehicles automatically translates in lower tax revenues.

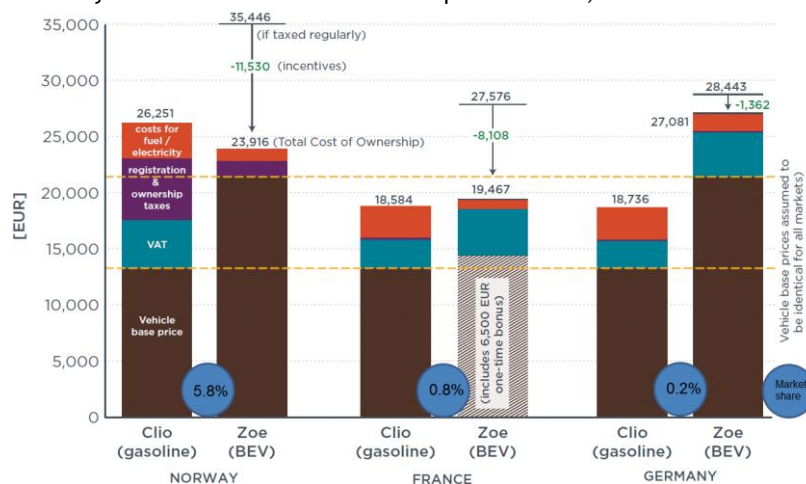
Interaction with other types of policy instruments

The provision of financial incentives in registration taxes supports OEMs to meet their vehicle GHG standard (Factsheet 9) and/or ZEV mandate (Factsheet 10) (strong link).

Assessment**Increase in alternative powertrains**

++

The inclusion of CO₂ differentiation in VRTs directly stimulates AFVs (mainly electric and hydrogen vehicles) through providing a financial incentive for purchasing these vehicles. This financial incentive improves the TCO of AFVs and as such improves the attractiveness of these vehicles. It is difficult to conclude on the effectiveness hereof in terms of increasing alternative energy carriers, as this is strongly dependent on the design (and hence size) of the financial incentive, as is shown in the figure below for a Renault Zoe (FEVs). As shown, the total fiscal incentives provided to private car owners (incl. ownership taxes) results in benefits ranging from € 11,500 to € 1,400. In Norway, the TCO of a FEV is lower compared to the conventional alternative as a result. Unsurprisingly, the market share is relatively largest here as well. However, fiscal incentives are unlikely to be the only explanatory factor; in Denmark for example, the fiscal incentives are even larger than in Norway (roughly € 16,000 euro) and the difference in TCO even larger. However, the market share is only 0.3%. There are likely to be other barriers to the adoption of AFVs, such as a lack of infrastructure or consumer acceptance



Source: ICCT, 2014d.

Increase in renewable energy

o

The impact of this policy instrument on the share of renewable energy in transport is strongly dependent on the shares of renewables in electricity and hydrogen production. These shares are not influenced by the policy, but depend on other policy instruments, such as policies for increasing renewable energy production, which has a large potential. However, a shift to AFVs does result in some increase in RES-T and in energy savings.

GHG emissions reduction

++

This instrument can result in reduced CO₂ emissions by increasing the share of alternative powertrains, but also by stimulating a shift towards more efficient conventional cars (T&E, 2014). The effectiveness depends on the

Factsheet 2 - INCENTIVES IN VEHICLE REGISTRATION TAXES (VRT)	
<p>design of the scheme; incentives based on pre-determined categories will be less effective compared to continuous schemes (ICCT, 2010).</p> <p>(CPB, 2015) has performed an empirical investigation and concludes that the average effect of increased CO₂ differentiation in registration taxes between 2001 and 2010 in the EU15 has reduced the CO₂ emissions of an average new car with 1,3 percent, partially through a shift from petrol to diesel cars. This modest GHG emission reduction can be explained by the fact the EU countries with large domestic car industries (e.g. FR, DE, IT, UK) have not applied strong CO₂ differentiation in their VRT. Hence, (CPB, 2015) still concludes that this fiscal vehicle policies can significantly affect the average CO₂ emissions of new cars. This is in line with findings of T&E (2014), which conclude that the Member states with strongly differentiated VRTs (and company car taxes) achieved the highest annual improvement in average CO₂ emissions of new cars in 2012.</p>	
Coverage	++
<p>In principle, registration taxes impact all new vehicle sales of a country or state once implemented, and hence, coverage of the market has large potential. Currently, not all countries/states have differentiated their VRT by CO₂ (T&E, 2014; ICCT, 2014c).</p>	
Cost-effectiveness	?
<p>The cost-effectiveness of incentives in registration taxes for society are heavily dependent on the design of the scheme. Schemes which are not differentiated by CO₂ emissions, but which do exempt alternative powertrains from paying this tax, are likely not to be cost-effective, as the higher purchase price of these vehicles (-) cannot be fully compensated by fuel cost savings and external cost savings. The cost-effectiveness of these schemes will improve when the purchase prices of AFVs decrease in the future. Schemes which also focus on improving the fuel efficiency of conventional vehicles on the other hand, may well be cost-effective. The higher price (-) can be compensated by fuel cost savings (+) (e.g. up to 95g/km (CE Delft ; TNO, 2012).</p>	
Ease of implementation	+
<p>This policy is relatively easy to implement, especially fee-only systems. Feebates are more complex as a wrong design can result in large net costs to governments (i.e. more rebates given than fees received) (ICCT, 2010).</p>	
Other considerations	
<ul style="list-style-type: none"> Financial incentives in VRTs usually result in higher shares of diesel cars, as diesel cars have lower TTW CO₂ emissions compared their petrol variant. This can negatively impact air quality (T&E, 2014; (CPB, 2015) and may result in some other rebound effects, such as higher transport volumes and larger sizes. Increased diesel shares can be prevented by implementing diesel surcharges that discourage purchase (ibid.). Incentives in VRTs can negatively impact governmental balances (-) as the revenues from the VRT may decrease (e.g. exempting certain vehicles). 	

CASE STUDY: Electric Vehicle Incentive Scheme in Norway
<p>Summary of the policy instrument and objective</p> <p>The Electric Vehicle Incentive Scheme was gradually introduced from 1989 onwards. The financial incentives in Norway's registration tax was implemented temporarily in 1990 and permanently in 1996 (EV Norway, 2015). FEVs are completely exempted from this tax. The incentive scheme was expanded with several other financial incentives (e.g. exemption from VAT and circulation taxes) and user incentives (e.g. access to bus lanes) (ibid.). For PHEVs/EREVs the incentives are less pronounced, although registration taxes have been differentiated by CO₂ emissions since 2007. Since then, it is a stepwise proportional function of CO₂, weight and power, which also results in financial incentives for choosing cars with low CO₂ emissions (Ciccone, 2014).</p> <p>The financial incentives in registration taxes (and other incentives for FEVs) provided by the Norwegian government are the result of the ambitious climate policy of the country. Part of this commitment is to reach a target of 85 g/km for new cars by 2020 as defined in a cross-political agreement in 2012. FEVs and PHEVs/EREVs are seen as the key to reaching this target, combined with a shift to more efficient conventional vehicles (EV Norway, 2015). More specifically, the goal of the EV incentive scheme is to ensure FEVs are competitive with comparable ICVs, from an economic as well as from a functional point of view (Malvik, et al., 2013).</p>

CASE STUDY: Electric Vehicle Incentive Scheme in Norway**Impacts and costs**

- **Increase in alternative powertrains:** The total package of FEV incentives provided in Norway initially did not result in a significant increase in FEV sales. However, by increasingly adding more and more incentives, the sales volume started to increase rapidly. With this total package of incentives, Norway has obtained a front runner position in the share of ZEVs in total sales (12.7% in 2014). The growth rate between 2012 and 2013 was 90%. According to the qualitative analysis of (TOI, 2013) the VAT exemption, access to bus lanes and free toll roads were relatively most important (++) followed by some other incentives, including the exemption from registration tax (+).
- **Increase in renewable energy in transport:** As the share of RE in electric power production in Norway is very high, the instruments results in an increase in the share of RES-T.
- **GHG emission reduction:** Ciccone (2014) has investigated the impact of the CO₂ differentiation in the Norwegian registration tax. According to this study, the financial incentives that were implemented in 2007 resulted in a 6 to 8 g/km reduction in the average CO₂ emission level of new cars in the year of implementation, which is about half of the total emission reduction observed. The emission reduction resulted partially from a shift towards greener vehicles (including EVs) and partially due to a shift towards diesel cars; the market share of diesel cars increased with 22-24 percentage points.
- **Cost impacts:** The financial incentives provided to FEV in Norway are significant. In total, buyers of a Renault Zoe FEV receives a benefit of roughly € 11,500 compared to a comparable conventional car (ICCT, 2014d). Together with lower fuel costs (about one third of the fuel costs of a conventional car due to the relatively high gasoline price and relatively low electricity price in Norway), the higher purchase costs (+61%) for consumers are fully compensated by these financial benefits. The FEV has a 9% lower TCO than the conventional alternative as a result (for 10,000km per year, 4 years).
This however, is the combination of incentives in VAT and registration tax. The Renault Clio is charged €4,100 registration tax and € 3,320 VAT, the FEV Renault Zoe is exempt from these taxes. Likewise, a Plug-in Hybrid Volvo V60 is charged € 2,000 euro less compared to a conventional V60, but both cars pay the same VAT rate of 25%. As the price of the Plug-in model is higher than that of the conventional model, the benefit in registration tax is mostly off-set by the higher VAT amount. Hence, the TCO of this PHEV is higher compared to the conventional alternative (ICCT, 2014d). The governmental cost of exempting electric vehicles from the registration tax is estimated at € 233 million (EFTA Surveillance Authority (2015), which makes it the main measure to stimulate electric vehicles in Norway in terms of governmental costs (see the following table).

Measure	Annual costs in NOK	Annual cost in Euro
Exemption from registration tax	2,000 million	233 million
Reduced annual vehicle tax	100 million	12 million
Free parking at public parking places	100 million	12 million
Exemption of road tolls	200 million	24 million
Free access to national ferries	5 million	0.6 million
Authorisation to drive on bus lanes	n/a	n/a
Free use of public charging stations	140 million	16 million
Favourable income tax calculation (company car tax)	140 million	16 million
Total	2,685 million	313.6 million

- **Cost-effectiveness:** No estimations have been found on the cost-effectiveness of the CO₂ incentives in the registration tax.
From a social perspective, the switch to FEVs and PHEVs is unlikely to be cost-effective on its own, as the purchase cost (excl. taxes) cannot be compensated fully by fuel cost savings. However, the incentives also target all conventional vehicles. Purchase cost increases due to Improvements in ICVs are generally off-set by fuel cost savings (EC, 2012).
Hence, overall, the scheme may well be cost-effective.

Future plans

- the Norwegian Parliament has agreed to keep the financial incentives for the purchase and use of ZEVs until

CASE STUDY: Electric Vehicle Incentive Scheme in Norway

- 2017, as long as the number of ZEV does not exceed 50,000 (EV Norway, 2015);
- the CO₂ differentiation in registration taxes is expected to become gradually stronger, as it is the main measure to reach the 85 g/km target that has been set in the cross-political agreement of 2012 (Toi, 2013).
- References used:** Ciccone, 2014; EV Norway, 2015; Malvik et al., 2013; ICCT, 2014d; Toi, 2013; EC, 2012.

Factsheet 3 - INCENTIVES IN COMPANY CAR TAXATION**Description of the instrument**

By providing incentives in the company car taxation fuel-efficient and alternative fuel vehicles can be stimulated.

This **financial measure** targets company cars and is implemented at **country level**.

Main impacts on

	Energy carriers	Energy infrastructure	Vehicles			
			Car	LCV	Light truck	Bus
Electricity			X			
Hydrogen			X			
Biofuels						

Results of the assessment

Increase alternative powertrains (++)	Increase renewable energy (o)	GHG reduction (++)	Coverage (+)	Cost-effectiveness (?)	Ease of implementation (+)
---------------------------------------	-------------------------------	--------------------	--------------	------------------------	----------------------------

Country coverage

<i>Implemented</i>	<i>Implementation being considered</i>
Cars: Belgium, France, Norway, The Netherlands, UK	Not publicly known

Design options

Company car taxation schemes are primarily used to tax employees' benefits from personal use of their company car.

Four primary methods to determine the taxable benefit can be distinguished: it can be based on the price of the vehicle, distance travelled, direct costs of personal use, or it can be a fixed amount (Harding, 2014).

Although the primary method chosen can affect the CO₂ emissions of these vehicles, this factsheet focuses on elements of company car taxation schemes that directly target the average fuel efficiency of company cars and/or stimulate the purchase of AFVs. Several countries differentiate the primary tax treatment (e.g. % of price of the vehicle) by the CO₂ level of the car:

- Norway applies lower rates to electric vehicles.
- Belgium bases the percentage of the list price that is treated as taxable on the CO₂ rating of the car; a continuous scheme is applied ranging from 4% to 18%, meaning that the tax rate charged increases with every g/km.
- France, the Netherlands and the UK also base the percentage of the list price treated as taxable on the CO₂ rating of the car, but in these countries a stepwise approach is applied. The tax rate is determined by cross referencing the CO₂ emissions of the car to fixed CO₂ categories.

Factsheet 3 - INCENTIVES IN COMPANY CAR TAXATION

Key lessons learned with respect to renewable energy in transport

- Implementing CO₂ incentives in the company car taxation can be **effective in stimulating alternative fuel vehicles** (see also below), but this depends heavily on its design. An important precondition is that the difference in tax rates applied to alternative fuel vehicles and comparable conventional vehicles is sufficiently large to provide an effective incentive to employees to choose for the former type of car.
- **Regular adjustments to the schemes** (lowering CO₂ limits and/or raising tax rates) are necessary to avoid significant tax revenue losses. Due to technological improvements (partly initiated by the implementation of vehicle standards, see factsheet 9) the fuel efficiency of new cars continuously improves. Without any adjustment to the CO₂ differentiated company car taxes, cars increasingly qualify for lower tax rates and hence governmental tax revenues decrease (PRC & TNO, 2014).
- Since **most company car taxation schemes do not provide any incentive to charge PHEVs**, the actual CO₂ emission reduction resulting from these vehicles is lower than initially expected (CE Delft, 2013). Employees often do not have to pay for fuel and hence do not have any incentive to increase their electric kilometres. Specific arrangements could be added to the scheme to increase its CO₂ effectiveness.
- Applying a stepwise approach with a limited number of CO₂ categories - as is done in the Netherlands - can result in **distortive effects** in the market for new cars. As is illustrated by Polk (2013), employees are incentivised to choose cars just falling below the CO₂ limits of the defined categories, while vehicles with CO₂ emission ratings just above these limits are not often chosen.

Interaction with other types of policy instruments

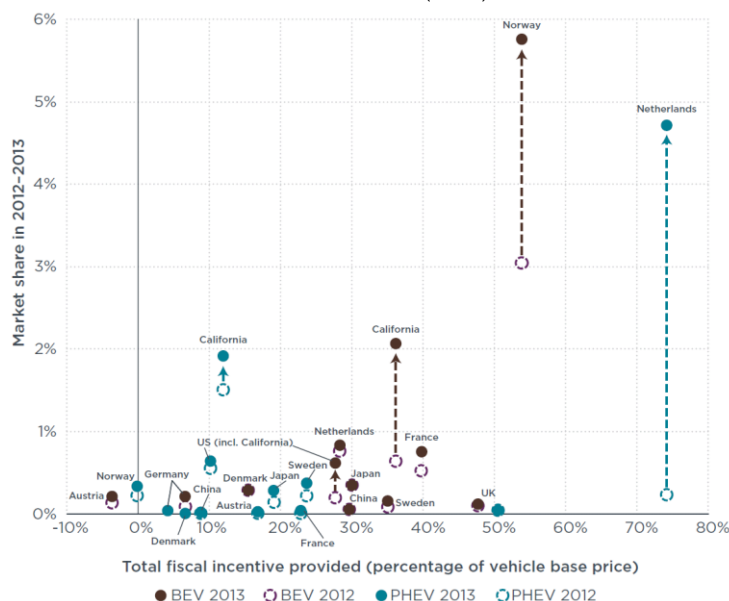
There is a clear link with other financial instruments (e.g. vehicle registration taxes, fuel taxes), since these instruments can reinforce each other. To maximise this effect the instruments should be carefully tuned. Additionally, as discussed above, there is also a strong link with the implementation of vehicle standards.

Assessment

Increase in alternative powertrains

++

This instrument directly stimulates AFVs (mainly electric and hydrogen vehicles) by improving the TCO of AFVs and hence improving the attractiveness of these vehicles. This is illustrated in the figure below. The results for Norway and the Netherlands provide clear evidence about the fact that financial incentives can have a significant impact (ICCT, 2014d; T&E, 2014a,b). However, it is unlikely to be the only explanatory factor: for example, California has relatively weaker financial incentives compared to the UK and France, but much higher market shares. Hence, other incentives (e.g. Mandates, HOV lanes, differentiated parking fees, etc.) are likely to explain some of the differences between countries as well (ibid.).



Source: ICCT, 2014d.

Increase in renewable energy

o

Factsheet 3 - INCENTIVES IN COMPANY CAR TAXATION	
The impact of this policy instrument on the share of renewable energy in transport is strongly dependent on the shares of renewables in electricity and hydrogen production. These shares are not influenced by the policy, but depend on other policy instruments, such as policies for increasing renewable energy production, which has a large potential. However, a shift to AFVs does result in some increase in RES-T and in energy savings.	
GHG emissions reduction	++
Providing incentives in company car taxation can effectively reduce GHG emissions of company cars. Evidence from the Netherlands (see also the case study below) and the UK shows that fiscal incentives have reduced the CO ₂ emission ratings of new cars sold by 5 to 10% (based on PRC & TNO, 2014; HM Revenue & Customs, 2006).	
Coverage	+
In many countries, company cars have a large share in new vehicle sales. In the EU for example, they are 50% of new car registrations (Roy, 2014). In the long-term, incentives in company car taxation can therefore cover roughly 50% of the total car fleet and hence the coverage of this instrument is large.	
Cost-effectiveness	?
The cost-effectiveness of implementing CO ₂ incentives in company car taxation schemes depends heavily on their design. If the scheme only/mainly covers zero-emission or near zero-emission vehicles (e.g. semi-electric) vehicles, it will probably not be cost-effective from a social perspective. The higher purchase price of these vehicles (--) can often not be compensated by fuel cost savings (+) and external cost reductions (+) that can be realised over the lifetime of the vehicle (CE Delft and TNO, 2012). The cost-effectiveness of these schemes will improve when the purchase prices of AFVs decrease in the future. However, if the scheme also covers (a large range of) fuel-efficient conventional cars, this instrument may already be cost-effective, as the higher purchase prices (-) are likely to be offset by fuel cost savings (++) and external cost reductions (+) (CE Delft and TNO, 2012).	
Ease of implementation	+
This policy instrument can be implemented relatively easy. An important precondition is that the tax authority has access to the CO ₂ emission ratings of new cars, in order to determine the correct tax level (or in case the company car tax is charged indirectly via the employer to monitor the taxing process).	
Other considerations	
Several studies (e.g. Copenhagen Economics, 2010; Harding, 2014) show that company cars are currently under-taxed in most countries, which is likely to result in a disproportionately large increase in total distance driven by company cars. This in turn is caused by an increase in the number of company cars in use and an increase in distance driven per car (Roy, 2014). This is likely to result in significant negative environmental impacts. By abolishing these 'hidden subsidies', these adverse environmental impacts of company cars can be reduced (CE Delft, 2010).	

CASE STUDY: CO₂ differentiated company car tax in the Netherlands
<p>Summary of the policy instrument and objective</p> <p>In the Netherlands, the taxable benefit to the employee from personal use of a company car is primarily based on the list price of the car; the employee is charged income taxes on a certain percentage of the list price. Since 2008 the rate to determine the tax base depends on the CO₂ emission rating of the car. Over the years this scheme has been adjusted regularly, particularly by adding additional CO₂ categories to the scheme. In 2015 five categories are distinguished: 4% (zero-emission vehicles), 7% (1-50 g/km), 14% (51-82 g/km), 21% (83-110 g/km) and 25% (> 110 g/km). In 2016 the number of CO₂ categories will be reduced from five to four and at the same time the CO₂ limits of the categories will be adjusted.</p> <p>Due to continuous improvements of the fuel efficiency of new vehicles (partly due to the vehicle standards implemented) the share of company cars qualifying for a lower rate increases automatically, resulting in lower tax revenues for the government. In order to (partly) avoid this the CO₂ limits of the various categories are regularly lowered.</p> <p>The main aim of the CO₂ differentiation of the Dutch company car tax was to stimulate the purchase of the most fuel-efficient cars available (Dutch Ministry of Finance, 2011). Additionally, innovative vehicles (e.g. electric vehicles) are supported by this policy instrument.</p>
<p>Impacts and costs</p> <ul style="list-style-type: none"> – Increase in alternative powertrains: over the last years, the number of (semi)-electric cars in the Netherlands has increased significantly: from about 6,000 in 2012 to 50,000 in February 2015 (RVO, 2015).

CASE STUDY: CO₂ differentiated company car tax in the Netherlands

The majority of these cars are company cars. According to PRC & TNO (2014), the sharp increase in (semi-)electric cars sold in the Netherlands depends heavily on the CO₂ differentiated company car tax. This is illustrated by the fact that a drop in the number of newly registered (semi-)electric cars in the Netherlands from about 22,000 in 2013 to about 13,000 in 2014 (ACEA, 2015) coincided with the increase of the tax rate on electric/semi-electric cars from 0% of the list price in 2013 to 4/7% in 2014.

- **Increase in renewable energy in transport:** this impact is unclear but probably small, as the measure does not explicitly stimulate renewable electricity to be consumed by the FEVs/PHEVs that entered the market.
- **GHG emission reduction:** according to PRC & TNO (2014) CO₂ differentiated vehicle taxes (both registration tax and company car tax) have resulted in a decrease of the CO₂ emissions of new cars in the Netherlands in 2013 of about 10% (on top of the decrease due to other policy instruments like the EU CO₂ standards for cars). The CO₂ differentiation of the company car taxation is expected to have made a large contribution to this reduction.
- **Cost impacts:** electric vehicles are significantly incentivised by the Dutch company car taxation scheme. Buyers of a Renault Zoe FEV receive an annual benefit of about € 2,000, while for a Volvo V60 Plug-in hybrid they receive an annual benefit of about € 4,000 (own calculations, based on ICCT, 2014d). Together with all other fiscal benefits for electric vehicles (e.g. discounts on the registration and circulation tax), the total incentive for consumers to choose for a Renault Zoe FEV as a company car instead of a conventional Renault Clio is about € 6,000 (for 10,000km per year, 4 years) (ICCT, 2014d). This relatively small incentive is the result of the fact that most of the vehicle taxes in the Netherlands are based on CO₂ emissions and hence the tax level for the conventional Renault Clio (CO₂ rating is 99 g/km) is not too high anyway. Therefore, the tax break for the Renault Zoe is insufficient to compensate the higher purchase price. The situation is different for the Volvo V60; the total incentive to choose for a plug-in hybrid Volvo V60 instead of the conventional one is about € 38,000, which is sufficient to compensate for the higher purchase price (ICCT, 2014d).
- Since the improvement of the fuel efficiency of passenger cars went faster than expected, the lowering of the CO₂ limits of the various categories in the taxation scheme was not in line with the decline in average CO₂ emission figures of new cars. As a consequence the tax revenues for the government decreased. PRC and TNO (2014) estimate that in 2013 this lack of tax revenues was about € 765 million.
- **Cost-effectiveness:** no empirical evidence is available on the cost-effectiveness of this policy instrument. However, since the majority of the vehicles stimulated by this instrument are fuel-efficient fossil fuel vehicles and since a switch to these vehicles is expected to be cost-effective (see CE Delft and TNO, 2012), the CO₂ reduction over the last years has probably been cost-effectively realised (from a social perspective) by this policy instrument.

Future plans

The future of the Dutch company car taxation scheme is currently heavily discussed in the Netherlands. The design of the future scheme is still undecided, but adjustments are expected to make the revenues better predictable, reduce the amount of market distortions and to make the scheme less complex (PRC & TNO, 2014).

References used

ACEA (2015), CE Delft and TNO (2012), Dutch Ministry of Finance (2011), ICCT (2014d), PRC & TNO (2014).

Factsheet 4 - PPP & SUBSIDIES FOR ENERGY INFRASTRUCTURE**Description of the instrument**

This financial instrument aims to expand charging infrastructure networks by supplementing the initial capital expenses or discounting operating expenses. The aim is to increase the network of filling stations and charging points to boost the adoption of AFVs. Alternative energy infrastructure is often desired by countries before the business case is economical, and subsidies instruments are generally designed to defray some portion of the capital expense for building infrastructure to improve the return on investment. The instrument is implemented at federal (EU), country or local level.

Main impacts on

	Energy carriers	Energy infrastructure	Vehicles			
			Car	LCV	Light truck	Bus

Factsheet 4 - PPP & SUBSIDIES FOR ENERGY INFRASTRUCTURE						
Electricity		X				
Hydrogen		X				
Biofuels		X				
Results of the assessment						
Increase alternative powertrains (o/+)	Increase renewable energy (o/+)	GHG reduction (o/+)	Coverage (+)	Cost-effectiveness (o)	Ease of implementation (o)	
Country coverage						
Implemented: EU, many EU Member States, US, China, Japan, India			Implementation being considered: -			
Design options						
<p>There are many actors or stakeholders in this development of infrastructure. In the case of BEVs, the stakeholders include electricity generators, electricity distributors, battery manufacturers, recharging equipment manufacturers, municipalities, vehicles manufacturers and OEM, refuelling stations, mobile charging service, IT companies and regulators. Similarly, in the case of hydrogen, the stakeholders include electricity generators, electricity distributors, hydrogen suppliers, refuelling equipment manufacturers, municipalities, vehicle manufacturers and OEMs and IT companies.</p> <p>In the case of biofuels, investment in infrastructure will involve feedstock supplier, biofuels producers, auto manufacturers, transportation company or pipeline operators, wholesale liquid fuel traders or dealers, refuelling station owners and regulators.</p> <p>In general, formats for subsidies can include: tax credits, tax reductions, loans, grants and public private partnerships (PPPs). Depending on the economic risks, there are several options to reduce the risks involved in establishing energy infrastructure for AFVs:</p> <p>a Risk reduction: Long-term strategies on development of AFVs (e.g. in the form of detailed road maps) created by the government with input from the industry may help easing some doubts and increasing the private sector's commitment to develop the infrastructure. The governments can also help reducing the risk indirectly by creating incentives to stimulate market demand. For example: the Japanese government provides subsidy for BEVs purchase and up to 60% subsidy for purchasing and installation cost of charging stations. Also the Chinese government uses fixed amount of rewards depending on the number of BEVs deployed in the cities to be used for establishing charging infrastructure. The US uses tax incentives at the country level.</p> <p>b Risk sharing: the most popular model of this risk sharing is Public Private Partnerships. This scheme allows governments to initiate businesses run by private companies that serve the public without exposing the government to the long-term management and costs of the business. For infrastructure businesses, like hydrogen filling stations, the government usually initiates the PPP in the form of a grant for a portion of the capital costs. Several examples can be drawn. In Japan, the consortium of four major auto manufacturers has agreed to provide the remaining 40% of installation and purchase costs to build charging stations (provided the applications met the requirements). In Germany, the National Innovation Programme provides a common framework for a number of hydrogen and fuel cell research projects conducted by academic institutions and industry. This PPP is scheduled to run for 10 years. The States in the US uses grants and PPPs to establish infrastructure network. In France, the 'Ville de demain' project run by the French environmental and energy agency ADEME covers 50% of the costs for normal and fast charging points and 30% of cost for rapid charging points.</p> <p>c Risk transfer: This strategy is usually transferring the economic risk of AFV infrastructure development to a third party. This involves medium- to long-term expectations. For example, the H2 mobility initiative (consortium created by Air Liquide, Daimler, Linde, OMV, Shell and Total) in Germany which agreed to expand the hydrogen infrastructure from the current 15 stations to 100 filling stations by 2017 and 400 stations by 2023.</p> <p>d Risk retention: This strategy to keep the economic risks of energy infrastructure development for AFVs is usually taken by the industrial players. For example: Tesla builds its charging stations network; Air Liquide offers the entire hydrogen supply chain from production and storage to distribution and applications; etc.</p>						

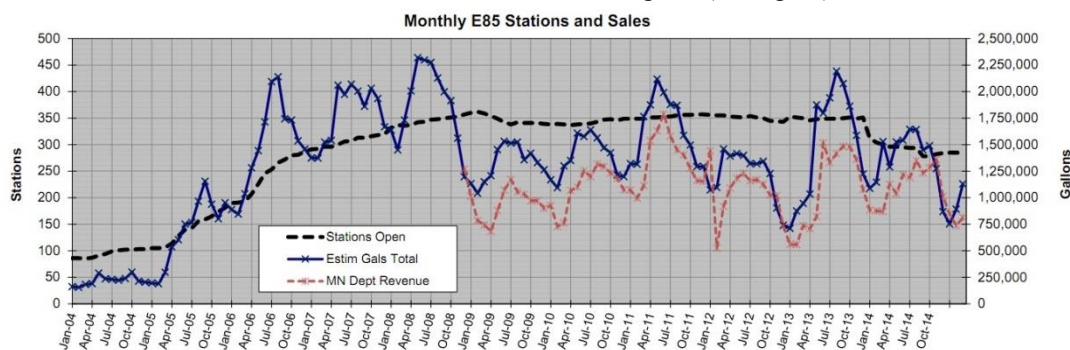
Factsheet 4 - PPP & SUBSIDIES FOR ENERGY INFRASTRUCTURE

While most governments set up road maps or strategy to develop the AFV infrastructure, some create policy instruments which have a stronger effect. For example: EU adopts Directive 2014/94/EU on the deployment of alternative fuels infrastructure in October 2014. European Commission announces the creation of the Sustainable Transport Forum (STF) to facilitate the implementation of the Directive. It shall assist the EC in implementing the programmes aimed at fostering the deployment of alternative fuels infrastructure.

Many EU Member States including Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Ireland, Netherlands, Norway, Portugal, Spain, Sweden and UK set up different subsidy schemes on alternative fuels or charging infrastructure. Other countries such as Japan do not set a separate instrument solely for AFV infrastructure development.

Key lessons learned with respect to renewable energy in transport

- Subsidies for infrastructure that provide specific incentives for establishing filling stations (E85/fuel cell/hydrogen) and charging points are one of the most common and effective methods for expanding infrastructure (behind state-run fuel businesses e.g. Brazil). Grants solve the chicken-an-egg problem by initiating RE infrastructure before RE growth has reached a point where RE fuelling infrastructure can make a solid business case. For example: E85 infrastructure grants in the US state of Minnesota (The Twin Cities Clean Cities Coalition) were in part responsible for the rise of E85 stations (along with federal tax credits). The Minnesota infrastructure grants expired in 2014, and the immediate reduction in the number of E85 stations can be linked to the end of the grant (see figure).



- Aligning the beliefs or preference of actors is also important. Till date, neither auto manufacturers nor energy companies (including oil companies) share the same beliefs on the winner powertrain technology. As such, more funds will be needed to develop many types of alternative fuel infrastructure network compared to one or two agreed type(s) of fuel.
- With regard to public private partnerships, this may be the way to bring the project forward, but until the risks are shared or transferred between the partners, the project will stall.
- Regulatory uncertainty has significant impact across all factors of AFV development. It affects manufacturers' decision to produce and commercialize the vehicles, consumer acceptance, and the development of infrastructure. As such the governments are expected to create a detail road map together with the industry.

Interaction with other types of policy instruments

Generally, infrastructure subsidies do not interact with other policy instruments, though the large cost can detract from common budgets. However, increasing number of vehicles through purchase incentives and/or tax reduction/exemptions will improve the business case of AFV infrastructure. Similarly, a wide AFV infrastructure network will make AFVs a more attractive option to the customers.

Assessment

Increase in alternative powertrains

o/+

This instrument facilitates adoption of alternative fuel vehicles (in this case hydrogen, electric vehicles and high blend biofuels) through wider charging facilities penetration. However, this effect is likely to provide a relatively smaller push for AFVs compared to financial incentives at the time of purchase. Furthermore, it depends on the scale of the subsidies provided.

It is expected that the use of hydrogen vehicles is more correlated to increases in the number of charging/refuelling stations than the use of electric vehicles, as there are no alternatives for refuelling the former vehicles.

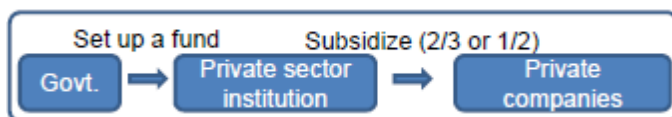
Factsheet 4 - PPP & SUBSIDIES FOR ENERGY INFRASTRUCTURE	
<i>Increase in renewable energy</i>	o/+
The impact of this instrument on the share of renewable energy is highly dependent on the share of renewable energy in the production of hydrogen and electricity. The portion dispensed that is renewable is generally not governed by the instrument. PPPs have been able to attach stipulations on renewable content (e.g. 30% renewable hydrogen requirements in hydrogen infrastructure PPP grants from the California Energy Commission).	
<i>GHG emissions reduction</i>	o/+
The instrument has an indirect impact on GHG emissions reduction. The reduction will mainly because this instrument will increase the number of fuelling and charging stations that in turn will affect the number of AFVs, as well as expectations on increased renewable content in all alternative fuels.	
<i>Coverage</i>	o
Subsidies for alternative fuelling infrastructure are widespread. These policies generally cover the whole country with addition to the states. However, as subsidy budgets are limited, the additionally placed infrastructure will also be relatively limited.	
<i>Cost-effectiveness</i>	o
The investment (and operational) cost of dedicated charging/refuelling points for hydrogen and electric vehicles will be very high (--), while the costs for liquid renewable fuels infrastructure is relatively less (-). However, it should be noted that these investments are done for a long time period, given the long depreciation period of these types of infrastructure and hence the annual costs will probably be moderate. Given the limited direct effectiveness of this measure, this measures will probably be moderately cost-effective.	
<i>Ease of implementation</i>	+
Good implementation of this instrument requires a good knowledge of issues that may be faced by all actors. It also needs alignments between all actors and factors influencing the value chain the fuels. In addition, since the cost is mostly borne by the government, this policy may be difficult to be implemented in every country.	
<i>Other considerations</i>	
Subsidies for infrastructure will be more effective if jointly arranged with the auto manufacturers in addition to the alternative energy suppliers. By involving in infrastructure development, the auto manufacturers can ensure the uptake of their products and the government can save some of the budget.	

CASE STUDY: PPP and Subsidies for Infrastructure - Japan**Electric Vehicles:**

After the launch of the Next-Generation Vehicle Strategy (2010) in June 2010, the Japanese government started from the state governments which were selected as model regions, known as EV & PHEV Towns, in the Prefecture of Okinawa, Tottori, Gifu, Fukui, Saga, Nagasaki, Kumamoto, Okayama, Osaka, Kyoto, Aichi, Niigata, Aomori, Tochigi, Saitama, Kanagawa and Shizuoka and Tokyo to create initial demand for electric vehicles. In each EV & PHEV town, intensive development of charging network was done in collaboration with local enterprises. Then, penetration models taking into account regional characteristics were established and applied to the whole countries.

Each EV & PHEV town set up objectives behind their efforts to promote electric vehicles including:

1. Improvement in the environment.
2. Development in the regional manufacturing sector.
3. Development in regional tourism using electric taxis and rental cars. And
4. Service for local residents, facilitate purchase and use of electric vehicles.

Subsidy Scheme and Methods:

Source: Ministry of Economy, Trade and Industry.

1. 2/3 of purchasing cost and installation cost will be borne by the government for development of infrastructure based on “Deployment Plans” made by local governments with the public nature.
2. 1/2 of purchasing cost and installation cost will be borne by the government for establishing public charging facilities but not based on “Deployment Plans” but with the public nature.
3. 1/2 of purchasing cost and installation cost will be borne by the government for establishing charging facilities in parking area of multi-unit buildings.
4. 1/2 of purchasing cost will be borne by the government for other deployment.

The aim of this regulation is to achieve “a country without running out of electricity.” In September 2013, 47 prefectures throughout the country have drawn up “a vision for the installation of charges.”

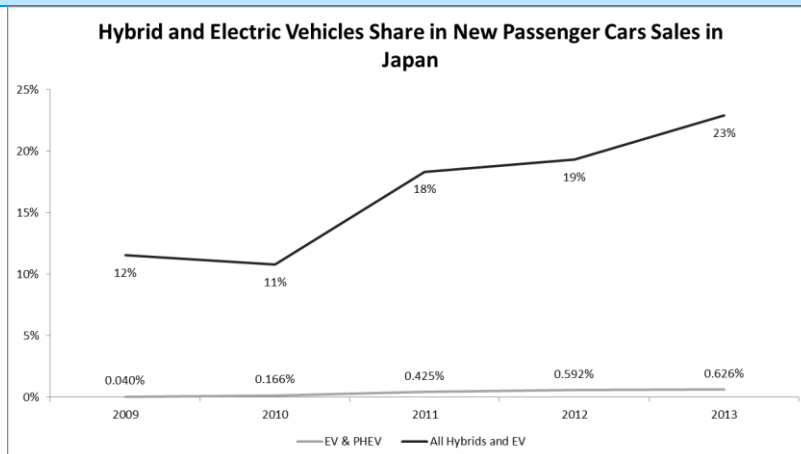
Hydrogen Vehicles:

Aiming to lead the world in setting up a hydrogen-based society, the government set aside a budget of JPY21.38 billion in 2012-2015 to subsidize the construction and operation of 100 hydrogen filling stations by March 2016.

Impacts and costs

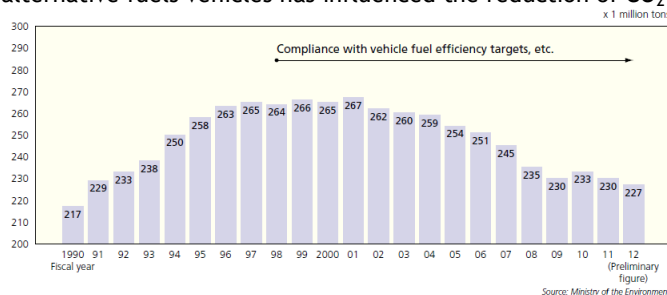
- **Increase in alternative powertrains and infrastructure:** The increase in the number of charging stations (from 1,900 quick charging stations and about 3,000 standard charging stations in mid-2013 to 3,087 quick and 11,000 standard charging stations as of March 2015 and December 2014 respectively. The latter equals 38% of the number of gasoline filling stations) and other fiscal incentives targeting electric vehicles, stimulate the increase of the share of electric vehicles in new passenger cars sales in Japan from 0.04% in 2009 to 0.63% in 2013. The government set a target of 15-20% of electric vehicles shares in passenger vehicles market by 2020 and 20-30% in 2030. This target may only be achieved with a further significant increase in the number of charging stations.

CASE STUDY: PPP and Subsidies for Infrastructure - Japan



Source: Stratas Advisors citing JAMA data.

- **Increase in renewable energy in transport:** Direct impact of this policy to increase in renewable energy in the transportation sector is unclear. Indirect impact depends on the source of electricity. Currently about 11% of electricity is generated from renewable energy. The government set a tentative target of 30% electricity comes from renewable sources by 2030 (the final target is currently under discussion).
- **GHG emission reduction:** According to the Ministry of Environment, the transportation sector accounts for about 20% of Japan's total CO₂ emissions. Compliance with vehicle fuel efficiency targets along with shift to alternative fuels vehicles has influenced the reduction of CO₂ from its peak in 2001.



Source: JAMA.

- **Cost impacts:** The government set aside budget of JPY 100 billion (EUR 747 million) in FY2012 Supplementary Budget for development of BEV charging stations; JPY 4.59 billion (EUR 34.3 million) in FY2013 Budget for development of hydrogen filling stations and JPY 39.59 billion (EUR296 million) in FY 2014 Supplementary Budget for development in hydrogen and BEVs filling/charging stations. For FY2015, METI requested a total fund of JPY 187.4 billion (EUR 1.4 billion) to promote FCEVs, develop hydrogen filling stations and R&D in hydrogen. No figures are available on the investments done by private parties.
- **Cost-effectiveness:** There is no data on societal cost-effectiveness of this case study. According to the industry it is difficult to create a positive business case for both electricity and hydrogen infrastructure, e.g. due to uncertainty on future market shares of these vehicles. However, it is uncertain to what extent these business cases are based on the whole depreciation period of the infrastructure (notice that the cost-effectiveness of this measure will be higher if a longer time period is taken into account, as the annual cost of the infrastructure become smaller).

Future plans

- As of February 2015, there were 3,000 quick charging stations. As of December 2014, there were 11,000 standard charging stations.
- The government aims to increase the number of BEVs charging stations to reach 5,000 quick and 2,000,000 standard stations by 2020.
- As of April 2015 there were 5 hydrogen filling stations. The government set a target of 100 filling stations by end of 2015 and the Tokyo government plan to build 35 filling stations in Tokyo by 2020.

References used

Ministry of Economy, Trade and Industry, Japan Automobile Manufacturer Association

CASE STUDY: PPPs for Hydrogen Stations in California**Summary of the policy instrument and objective**

In the case of California, the state used the PPP format with the primary objective to start hydrogen fuelling businesses in advance of the arrival of fuel cell vehicles expected from manufacturers to meet ZEV mandates. Besides overcoming the economic hurdles of launching a premature hydrogen fuelling business, the government was able to situate the businesses in areas to reach objectives to reduce local air-pollution in high-traffic areas. Recent PPP awards also included requirements for renewable energy content for the dispensed hydrogen, helping with objectives to reduce GHG.

Impacts and costs

- **Increase in alternative powertrains:** There is no data on hydrogen volumes dispensed at facilities in California. Fuel cell vehicles became commercially available in California in 2014, and 125 are currently registered in-state with almost double that number of out-of-state registered vehicles in demonstration fleets. The number of public hydrogen fuelling stations has decreased by 19% in the last 5 years. In 2010, California has awarded 12 PPP-type hydrogen fuelling projects and 7 in 2013, out of a total of 54 grants to-date. Of these recent PPP grants, only 3 are currently open. The state estimates that a total of 29 public hydrogen fuelling stations will be open by the end of 2015. There is no data correlating hydrogen volumes to PPP initiatives for hydrogen infrastructure in California. However, all currently operating public hydrogen stations have received an average of over \$3 million total from government initiatives, currently primarily in the PPP-type format, so PPPs are critical to hydrogen dispensing in CA. Currently announced plans call for 100 public hydrogen fuelling stations by 2017, with ambitious targets discussed for following years.
- **Increase in renewable energy in transport:** Only 1 of the 3 operating public California PPP-type hydrogen stations is using renewable hydrogen, and all future CEC awarded stations (above) will be providing at least 30% renewable hydrogen. This is however a better portion than the other 11 California, non PPP public hydrogen stations (18%).
The ability to add operational stipulations, such as renewable energy contents requirements in recent California hydrogen infrastructure grants, is not unique to PPP instruments but seems to be more easily implemented in this instrument structure.
- **GHG emission reduction:** The lack of data on the amount and type of hydrogen dispensed does not allow analysis of the GHG reductions from the any hydrogen infrastructure initiative.
- **Cost impacts:** California initiated \$ 11.9 million in PPP-type grants in 2013 for hydrogen infrastructure, with private partners expected to contribute \$ 9.9 million to complete the 9 projects. Public contribution on these PPP-type hydrogen projects (54%) is relatively high compared to other government incentives (e.g. 30% for the federal alternative infrastructure tax credit) applicable to hydrogen infrastructure.
- **Cost-effectiveness:** The relative effectiveness of the policy instrument for hydrogen infrastructure in California is not quantifiable with the limited data available.

References used

FCHEA, CFCP, CEC 2010, CEC 2013, GIAWGZEV 2015.

Factsheet 5 - INCENTIVES IN (URBAN) ROAD PRICING AND TOLLS						
Description of the instrument						
Several cities have implemented urban road pricing schemes to manage the traffic flows to and within the city. Some of these schemes also include incentives to use fuel-efficient or alternative fuel vehicles (AFVs), e.g. by charging a lower fee to these vehicles. This financial measure can cover all modes (although buses are usually exempt) and is implemented at local level .						
Main impacts on						
	Energy carriers	Energy infrastructure	Vehicles			
			Car	LCV	Light truck	Bus
Electricity			X	X	X	
Hydrogen			X	X	X	
Biofuels			X	X	X	
Results of the assessment						
Increase alternative powertrains (+)	Increase renewable energy (o)	GHG reduction (o/+)	Coverage (o)	Cost-effectiveness (-)	Ease of implementation (o)	
Country coverage						
Implemented London, Bergen, Trondheim, Oslo, Milan			Implementation being considered Unknown			
Design options						
Incentives in urban road pricing schemes to stimulate AFVs have been designed in several ways, particularly differing in the scope applied: <ul style="list-style-type: none">– In London, the Ultra Low Emission Discount (ULED) went into effect on 1 July 2013, providing electric cars and plug-in hybrids that are on a specific Government’s list free access to the congestion charge zone . Furthermore, any car or van that emits less than or equal to 75 g/km of CO₂ and meets the Euro 5 standard, also qualifies for a 100% discount on the congestion charge (www.tfl.gov.uk).– In Milan, EVs are exempt from the congestion charge. Hybrid vehicles, CNG, LPG and bi-fuel natural gas vehicles are exempt from this charge until the end of 2016 (www.comune.milano.it).– In Norwegian cities, EVs are exempt from urban road charges (Valoen, 2012).						
Key lessons learned with respect to renewable energy in transport						
<ul style="list-style-type: none">– With urban road charging schemes there is a trade-off between reducing congestion levels and stimulating AFVs. If AFVs are exempted from congestion charges, the scheme covers a smaller part of the total traffic and hence is less effective in reducing congestion. For the city councils of Milan and London this was reason to reform the congestion charging scheme and to define more ambitious criteria to qualify for an exemption (Danielis et al., 2011; TfL, 2012). In Stockholm, it was the main reason to stop with exemptions for AFVs (Whitehead et al., 2014). This trade-off can be mitigated by regularly checking whether adjustments should be made in the type of vehicles that qualify for the exemption (as was done in Milan) or to continue but reduce the discount given to AFVs. The latter option provides both an incentive to purchase more AFVs and to drive less kilometres in the city.– The effectiveness of incentives in urban road charging schemes to stimulate AFVs can be strengthened by harmonising the scheme with incentives given by other policy instruments, such as parking policies, incentives in the registration taxes, company car taxes, etc. In this case, the same criteria for eligible vehicles could be applied in all instruments.– There may be a lack of public support for the schemes if so-called eco-friendly vehicles are provided discounts while these vehicles are less environmental friendly under real-world conditions than during type approval. For example, CO₂ emissions of PHEVs have much higher real world than type approval emissions, as owners of these vehicles make more use of their combustion engine than is assumed for determining type approval emissions. The resulting decline in public support for stimulating such vehicles was a second reason for Stockholm to discontinue all exemptions given to AFVs in the Stockholm congestion charge (Energy Foundation, 2014).						
Interaction with other types of policy instruments						

Factsheet 5 - INCENTIVES IN (URBAN) ROAD PRICING AND TOLLS	
This instrument is closely linked to other local instruments, such as parking policies. If these instruments target the same vehicles they can strongly reinforce each other. Additionally, strong linkages exist with incentives in vehicle taxes (vehicle registration taxes, company car taxes).	
Assessment	
Increase in alternative powertrains	+
Evidence from several implemented urban road charging schemes shows that incentives to stimulate the use of AFVs can be quite effective. For example, several evaluation studies of the Stockholm congestion tax conclude that this instrument significantly affected the purchase of AFVs between 2006-2008 (from 2009 onwards, the exemption of these vehicles was phased out). Padam et al. (2009) and Lindforms and Roland (2009) find a total increase of about 24% in newly sold AFVs due to the congestion charge. The increase in the purchase of private AFVs due to this instrument is estimated at about 11% (Whitehead et al., 2014), indicating that the congestion tax had a larger impact on company vehicle purchases compared to private vehicle purchases. Evidence of the effectiveness of incentives in urban road charging schemes for increasing market shares of AFVs was also found for the schemes of Milan and Norwegian cities (see Danielis et al, 2011; Hannisdahl et al., 2013). However, these studies did not quantify the size of these impacts.	
Increase in renewable energy	o
The impact of this policy instrument on the share of renewables in transport is strongly dependent on the shares of renewables in electricity and hydrogen production. These shares are not influenced by the policy, but depend on other policy instruments, like policies for increasing renewable power production. Only in Milan discounts exist for bi-fuel vehicles, stimulating the use of biofuels. However, whether this actually results in an increase of biofuel consumption is dependent on whether users buy biofuel or conventional fuel.	
GHG emissions reduction	o/+
Based on a thorough review of various urban road charging schemes, Ecorys and CE Delft (2012) conclude that these schemes can significantly reduce the CO ₂ emissions emitted in the respective cities. For example, the congestion charge in Milan resulted in a CO ₂ reduction of 11% and the scheme in London has resulted in a CO ₂ reduction of approximately 16% (Danielis et al., 2011; TfL, 2008). These CO ₂ impacts are the result of several effects: a reduction in traffic flows, more fuel-efficient driving conditions due to less congestion and a shift to the use of more fuel-efficient vehicles (TfL, 2012). However, rebound effect may have resulted if people started travelling to other cities. Although there is no evidence about the size of this effect, TfL (2008) estimates that this rebound effect is smaller than other effects, and hence, urban road charging schemes result in a net CO ₂ reduction.	
Coverage	o
This instrument only covers vehicles that regularly visit the city in which the urban road charging scheme has been implemented and hence, compared to EU-wide or nation-wide instruments - such as vehicle standards or vehicle registration taxes - this instrument covers a significantly smaller part of the vehicle fleet.	
Cost-effectiveness	-
In general, urban road charging schemes as a whole are found to be cost-effective (from a social perspective). Cost-benefit analyses of the schemes in London, Stockholm and Milan show that they result in net social benefits (Eliasson, 2008; Rotaris et al., 2009; TfL, 2007). The investment and operational costs can be high, but are more than compensated by social benefits, of which reduced travel times is the largest one. There is no specific evidence available on the cost-effectiveness of incentives in urban road charging schemes to stimulate AFVs. However, it may be expected that these specific incentives are - in contrast to urban road charging schemes as a whole - currently not cost-effective from a social perspective, as vehicles are incentivised for which higher purchase prices (--) cannot be fully compensated by fuel cost savings (+) and external cost savings (+) that can be realised over the lifetime of the vehicle (CE Delft and TNO, 2012). Furthermore, the investment and operational costs of implementing differentiated schemes are considerably higher compared to schemes with a flat rate (ITS, 2006).	
Ease of implementation	o
Implementing urban road charging schemes is rather complex, due to several barriers (CE Delft, 2010):	
<ul style="list-style-type: none"> – relatively high implementation cost (both investment and operational costs), e.g. due to technical devices needed to monitor the vehicles entering/leaving the charging zone; – lack of social support; 	

Factsheet 5 - INCENTIVES IN (URBAN) ROAD PRICING AND TOLLS
– fear for adverse impacts on the local economy (although there is no evidence that urban road charging schemes actually harm the local economy (Ecorys and CE Delft, 2012)).
Other considerations
n/a

CASE STUDY: Incentives in the London congestion charging scheme
<p>Summary of the policy instrument and objective</p> <p>In 2003 the London Congestion Charging Scheme (LCCS) was implemented in the city centre of London. An extension to Western parts of the city was implemented in 2007, but withdrawn as of January 2011. The main objective of the congestion charging scheme was to reduce congestion. The scheme is an area licensing scheme: users pay a daily charge to enter or be within the charging zone, after which they can enter and exit the area as often as they want during the charging period. Currently the fee is set at £ 11.50 per day. Discount rates apply to residents (90% discount) and specific vehicle categories (e.g. public transport, two-wheelers, etc.). Since its introduction, the congestion charging scheme also provided environmental discounts to encourage drivers to switch to more environmentally friendly vehicles. Three types of incentives have been applied:</p> <ul style="list-style-type: none"> – The <i>Alternative Fuel Discount</i> ran from 2003 until December 2010 and provided a 100% discount for all vehicles (partly) running on alternative fuels (bi-fuel, natural gas, hybrids, PHEVs, FEVs, etc.) – The technology neutral <i>Greener Vehicle Discount (GVD)</i> ran from January 2011 until June 2013, and provided a 100% discount for cars with CO₂ emissions of 100 g/km or less that also met the Euro 5 emission standard. The GVD was combined with the <i>Electric Vehicle Discount</i>, which provided a 100% discount for full electric and plug-in hybrid cars. – In July 2013, the <i>Ultra Low Emission Discount (ULED)</i> was introduced, replacing the GVD and Electric Vehicle Discount. <p>A 100% discount from the congestion charge is provided to all EVs as well as to cars and vans with a CO₂ emission level of or below 75 g/km and also meet the Euro 5 emission standard.</p>

CASE STUDY: Incentives in the London congestion charging scheme**Impacts and costs**

- **Increase in alternative powertrains:** the London congestion charging scheme has significantly contributed to the uptake of AFVs. In 2012 about 2,500 GVD eligible cars (≤ 100 g/km and Euro 5) were observed during charging hours in the charging zones on a typical weekday, while only half the amount enters these zones on weekend days (when charges do not apply); this indicates the effect of the GVD on car purchasing decisions. No empirical evidence of the ULED is available yet, but TfL (2012) expects that it will have a significant impact on the purchase of EVs as well.
- **Increase in renewable energy in transport:** this impact is unclear but probably small, as the current design of the scheme does not explicitly stimulate biofuels or renewable electricity to be consumed by EVs.
- **GHG emission reduction:** the overall CO₂ emission reduction of traffic in the charging zone is estimated to be roughly 16% (TfL, 2008). Half of this reduction resulted from a reduction in the number of vehicles entering the zone and the other half due to more fuel-efficient driving conditions resulting from less congestion. No evidence is available about the CO₂ impact of the shift in the vehicle fleet composition incentivised by the scheme. Although part of the reduction in CO₂ emissions of traffic in the charging zone is offset by increases in emissions elsewhere due to traffic which deterred from entering the zone, a net overall CO₂ reduction is expected.
- **Cost impacts:** in the first of the scheme, the (social) costs and benefits are thoroughly studied (TfL, 2007). According to this study, travellers (individuals and business) have profited by the introduction of the scheme (net benefits of M€ 45 in 2005), mainly due to significant travel time and reliability benefits (M€ 303). These travel time benefits were partly compensated by, among other things, expenditures on the congestion charge (M€ 236) and welfare losses due to deterred trips (M€ 31). There was also a net benefit for the government (M€ 47), mainly due to the net charging revenues. Finally, the reduction in external effects (accidents, CO₂, air pollution) was estimated at M€ 17.
- **Cost-effectiveness:** The evidence on the costs and benefits described above indicates that the London Congestion Charging Scheme in general is cost-effective.

Future plans

There is no publicly available information on any future plans for the London congestion charging scheme.

References used

TfL (2007; 2008; 2012).

C.2 REGULATION

Factsheet 6 - FUEL REGULATION						
Description of the instrument						
Fuel standards are a regulatory measure which set fuel specifications for fuels to be placed on the market in order to guarantee lower emissions through e.g. blending fuels with biofuels. As being part of a GHG reduction strategy, fuel standards can impose reduction targets for the average GHG intensity of fuels . It is implemented at union/federal and country levels .						
Note that fuel standard cannot only be used to set a target for the reduction of the average GHG intensity of fuels: fuel standards can also regulate the maximum content of biofuels in fuels brought on the market, also known as blending limits . These blending limits can contribute to harmonisation of the market.						
Main impacts on						
	Energy carriers	Energy infrastructure	Vehicles			
			Car	LCV	Light truck	Bus
Electricity	X					
Hydrogen	X					
Biofuels	X					
Results of the assessment						
Increase alternative powertrains (o)	Increase renewable energy (+/++)	GHG reduction (+)	Coverage (++)	Cost-effectiveness (-)	Ease of implementation (o)	
Country coverage						
Implemented EU (FQD) US California (LCFS) British Columbia (Renewable and Low-Carbon Fuel Requirement Regulation)		Implementation being considered According to Fuelling California (year unknown) twenty-two other US states are in the process of considering or developing similar low carbon fuel standards policy standards, including states in the Midwest, the Northeast/Mid-Atlantic region, and the states of Oregon and Washington.				
Design options						
According to Holland et al. (2009), there are several design options to regulate the GHG intensity of fuels, including: <ul style="list-style-type: none">– Definition of the target: energy-based fuel standard or fuel economy fuel standard (based on carbon per transportation mile. Because this is very similar to vehicle standards, this type is rarely used, because it does not provide any additional incentive.)– A market-based instrument with credits and deficits (like the LCFS in California) or a non-economic instrument.– Baseline: a historical baseline or ‘rolling average and fixed proportion LCFs’ (Holland et al., 2009). Other design options are related to: <ul style="list-style-type: none">– a binding or non-binding target;– scope of emissions: TTW versus WTW, in- or excluding ILUC emissions;– scope of fuels included: only road transport fuels or also non-road mobile machinery and other non-road sectors;– GHG values used: level of the GHG intensity values and differentiation of these values, especially in relation to the aggregation level of values and the use of default values;– compliance options allowed.						
Key lessons learned with respect to renewable energy in transport						
<ul style="list-style-type: none">– In the EU the implementation of the FQD has led to a long discussion on the calculation methodology due to the interests at stake and the potential trade impact the choice of default values could cause. Sufficient time should therefore be foreseen for establishing a new fuel standard or redesigning existing standards. Otherwise the realisation of targets might be at stake due to delays in implementation.– Like renewable energy targets, fuel standards are a main driver for biofuel consumption. As result of the concerns on the environmental performance of biofuels sustainability criteria should also be part of fuel						

Factsheet 6 - FUEL REGULATION	
<p>standards. Because biofuels often contribute to both targets alignment of sustainability requirements results in harmonisation and would limit administrative cost.</p> <ul style="list-style-type: none"> – In California the credit system in combination with the level of the interim target has resulted in a surplus of credits. These credits might be used in the coming years and therefore might lower actual GHG emission reduction. A good functioning of a market based instrument is therefore required to meet projected GHG emissions savings. 	
Interaction with other types of policy instruments	
<ul style="list-style-type: none"> – Fuel regulation instruments interact with renewable energy targets: the share of renewable energy as result of renewable energy targets directly contribute to the reduction of the average GHG intensity of fuels on the market. However, renewable energy targets are not defined in such a way that these maximize GHG reduction, like fuel standards do. – Policy instruments aimed at reducing the demand for energy in transport also contribute to the realisation of fuel standards: if less energy is consumed the same amount of alternative energy will result in a higher reduction of GHG intensity and thus will benefit the realisation of the target. 	
Assessment	
Increase in alternative powertrains	0
Most targets are likely to be met by the use of biofuels. Therefore this instrument is not likely to result in a significant increase of alternative drive trains like electric vehicles and/or hydrogen powered vehicles.	
Increase in renewable energy	+ / ++
Compared to other policy instruments fuel regulations provide a strong and direct incentive for an increase in renewable energy. Fuel regulations designed based on a reduction target for the GHG intensity of fuels provide, however, a less strong incentive than renewable energy mandates, because of the following mechanism: in case of fuel regulation the increase in renewable energy depends on the GHG potential of available alternative energy carriers: less alternative fuels are required when their GHG emission savings are very high, but because these fuels are often also more expensive, fuel suppliers will probably prefer more fuels with lower GHG potential to limit compliance cost. Besides this, the average GHG intensity of fuels could also be reduced by reducing the GHG intensity of fossil fuels. If this pathway is preferred less alternative fuels will be placed on the market. Again, this will depend on compliance cost.	
GHG emissions reduction	(+)
<p>Because the target of fuel regulation instruments is mostly defined as a GHG intensity to reach by a certain year or by a reduction target in GHG intensity that should be met, these instruments directly steer at GHG reduction and are therefore assessed to have a high impact on GHG emissions reduction. In contrast to market instruments, this instrument does not provide a continuous incentive to reduce the GHG intensity of fuels (Holland et al., 2009). Once the standard is met, no additional incentive exists to improve the GHG intensity of the fuels.</p> <p>In absolute terms, Holland et al. (2009) however argues carbon emissions can still increase under a low carbon fuel standard, because compliance can be reached by either reducing the production of high-carbon fuels either by increasing production of low carbon fuels. The production of high carbon fuels can still grow if it sufficiently compensated by an increase in renewable energy.</p>	
Coverage	(++)
Fuel standards could be imposed on fuel suppliers at any administrative level and therefore could reach high coverage. Because different fuel standards only exclude small fuel suppliers and because only a few big oil companies cover the majority of the fuel market, fuel standards are likely to reach the majority of the fuel market as well.	
Cost-effectiveness	(-)
According to Holland et al. (2009) the abatement costs of a national LCFS in the US are far higher compared to the average abatement costs: \$ 307-2,272 per CO ₂ metric ton compared to \$ 60-868. If the damage per ton CO ₂ eq. is less than these \$ 307 a LCFS reduces welfare and in fact most damage estimates are less. Hence, from a social perspective fuel standards are not cost-effective to reduce CO ₂ emissions of transport.	
Ease of implementation	0
As stated earlier, calculation methodologies for the WTW GHG intensity of fuels are complicated and difficult to design and to reach agreement on. Although the start up of reporting system might increase administrative efforts of actors involved these efforts might reduce again after the first years of implementation.	
Other considerations	
In the EU Member States implement the FQD and thus oblige fuel suppliers to reduce emissions. It could	

Factsheet 6 - FUEL REGULATION

however, be questioned to what extent it would be more effective if the EC would directly oblige fuel suppliers to reduce the

GHG intensity of their fuels, like the EC also directly imposes vehicle standards on vehicle manufactures. This would require a Fuel Quality Regulation rather than a Fuel Quality Directive. (based on interview outcomes).

References

Holland et al (2009); Fuelling California (year unknown).

CASE STUDY: EU (FQD) + implementation in Germany**Summary of the policy instrument and objective**

The Fuel Quality Directive on the one hand regulates the maximum content of bio-components in transport fuels by means of fuel specifications as laid down in Article 3 and 4 (and the Annexes). Petrol should not contain more than 10% ethanol (E10) and diesel not more than 7% non-fungible biodiesel (B7).

On the other hand, the FQD obliges fuel suppliers to reduce the average GHG emission factor of transport fuels by 6% by 2020 on a life-cycle basis (Article 7a). This 6% reduction target could be achieved by biofuels and the use of less carbon intensive liquid fossil fuels or gaseous fuels or by reducing the emissions from flaring and venting. Two indicative additional steps of 2% reduction can be reached by the use of electricity in vehicles and carbon capture and storage and secondly, by clean development mechanism credits. With respect to electricity in vehicle use, suppliers can choose to contribute to the reduction obligation if they can adequately measure and monitor electricity supplied for vehicle use. Although the target has been set in 2009, the EC still had to work out the calculation methodology and the exact implementation. The proposal of the EC, as published in 2012, has been heavily debated for five years until a final agreement was reached in December 2014. As result of this discussion many Member States have not yet implemented Article 7a in national legislation. The same sustainability criteria for biofuels as laid down in the Renewable Energy Directive (RED) are included in the FQD. The (direct) fossil fuel greenhouse gas intensity of 2010 is taken as a baseline and includes the emissions from extraction, processing and distribution of the fuels.

National implementation Germany:

EU Member States have to implement the FQD at the national level. Most Member States have blending obligations in place to meet both the RED and FQD. Since 1 January 2015 Germany is the first EU country shifting from an energy quota to a

GHG reduction quota, making the FQD leading instead of the RED. Because the GHG reduction quota only have been implemented recently, the impacts are not known yet.

CASE STUDY: EU (FQD) + implementation in Germany**Impacts and costs**– **Increase in alternative powertrains:**

Because the target is mainly fulfilled with biofuels, the FQD does not significantly contribute to the transition to alternative drive trains, like electric vehicles.

– **Increase in renewable energy in transport:**

The FQD will increase the share of RE in transport, but it can be questioned to what extent this increase is additional to the increase in RE as result of the RED. Because only actual emission savings count towards the target (double counting is not allowed) the FQD is likely to result in additional biofuels.

The exact increase of biofuels depends on the GHG intensity of the biofuels: less biofuels are required in case of the consumption of biofuels with high emission reductions.

– **GHG emission reduction:**

The FQD provides higher incentives for best performing biofuels compared to the RED, because the target is defined in terms of GHG emission reduction. Due to the higher cost of biofuels it is unlikely that fuel suppliers will go beyond the 6% emission reduction target.

– **Cost impacts:**

According to CE Delft (2012) the administrative cost for EU fuel suppliers related to reporting amounts to a total of about

M€ 40-80 on an annual basis. This equals €ct 0.8-1.6 per barrel of imported oil or one quarter to half a Eurocent per full tank

(50 litre of fuel). According to the impact assessment of the European Commission the overall impacts on pump prices have estimated to be between 0.02 and 0.03 eurocents per litre (between 59 to 79 million euros in total). This increase reflects the additional efforts needed once the RED target has been met. The total price increase related to the entire 6% reduction is estimated to be about 0.3 eurocents per litre.

– **Cost-effectiveness:** not known yet (due to delay of implementation).**Future plans**

The fuel specifications of the FQD will probably stay in place, although adjustments might be adopted to increase the current blending limits, enabling higher volumes of biofuels to be placed on the market. Due to new Energy and Climate Package for the period 2020-2030 it is, however, unsure to what extent the GHG intensity reduction target will be in place after 2020. However, MEP Nils Torvalde, biofuels rapporteur of the European Parliament, stressed the importance of the continuation of the FQD after 2020 (Vieuws, 2015).

References used: EC (2009), EC (2014), CE Delft (2012), Vieuws (2015); FuelsEurope (2014).

CASE STUDY: US California Low Carbon Fuel Standard

CASE STUDY: US California Low Carbon Fuel Standard

Summary of the policy instrument and objective

The Low Carbon Fuel Standard (LCFS) has been established by Executive Order S-1-07)) on 18 January 2007 by former Governor Arnold Schwarzenegger. The law requires fuel suppliers to realise a ten percent reduction in the carbon intensity of transport fuels by 2020. The carbon intensity is expressed in gCO₂ eq per MJ and covers well-to-wheel (WTW) emissions (including producing, transporting, distributing, and use of the fuel). The California Air Resources Board (CARB), responsible for the implementation of the LCFS, adopted regulations in 2009. Since the beginning of 2011 these regulations have been implemented and enforced. The carbon intensity as provided in the compliance schedule ranges from 98 gCO₂ eq/MJ in 2013 to 89 gCO₂eq/MJ in 2020. Deficits, measured in metric tons of CO₂, are accrued from users of fuels, like gasoline and diesel, which have carbon intensities above the scheduled annual intensity. Credits can be earned by users of fuels with carbon intensities below the scheduled annual intensity, such as ethanol, biodiesel, natural gas, electricity and hydrogen. The total fuel use of regulated parties, which can include both users and producers of all types of fuels, must reach a net zero balance against the carbon intensity scheduled for that year's compliance, and any credits from over-compliance can be traded or banked indefinitely. The valuation of the credit can provide a price incentive for the purchase and use of low-carbon fuels and energy in transportation (ICF International, 2013; CERES, 2014).

Impacts and costs– **Increase in alternative powertrains:**

The LCFS does not directly provide an incentive for alternative drive trains, although hydrogen and electricity are identified as alternative fuels under the LCFS and thus can be used to generate credits. However, the LCFS interacts with the ZEV requirements as part of the ZEV program: the LCFS is facilitating the fuels, while the vehicles are increasingly available as result of the ZEV program.

– **Increase in renewable energy in transport:**

According to the April 2015 status review report (Yeh and Witcover, 2015) the share of alternative fuels increased from

6.2% to 7.2 of total energy consumption in transport between 2011 and 2014. In the review period (2011-2014), ethanol represented 57% of credits, biodiesel (BD) and renewable diesel about 30% each, CNG and LNG 8%, biogas 3% and electricity 2%. Although overall biofuel volumes have remained at a constant level since 2011, the role of ethanol decreased from 90% of all credits in 2011 to 5% in the 2014, while biodiesel (mostly from waste) and renewable diesel increased from 9% in 2011 to 42% in 2014.. The use of electricity increased from 0.35 million gasoline gallon equivalent (gge) in 2011, to 1.22 million gge in 2012 and 3.95 million gge in 2014 (Yeh and Witcover, 2014 and 2015).

– **GHG emission reduction:**

The LCFS aims to cut statewide emissions by 16 million metric tons CO₂ equivalent (CO₂e) by 2020 (Lueders et al. 2015).

Weak interim targets in earlier years of the LCFS have allowed suppliers to save credits for later use and due to this effect only around 88% of projected GHG emission savings have been realised. Still, the reported average fuel carbon intensity (AFCI) of all alternative fuels included in the program declined 15 percent from 86.4 gCO₂e/MJ the first year of the program (2011), to 73.5 gCO₂e/MJ in 2014 (Yeh and Witcover, 2015).

– **Cost impacts:**

The cost of compliance are directly linked to the price and availability of alternative fuels compared to conventional fossil fuels. An increasing difference between the marginal costs of both fuel types increases compliance costs (Lade and Lin, 2013). According to Yeh and Witcover (2015), the LCFS credit price provides an indication of expected compliance cost. It remained around \$20-25 per credit from the second half of 2014 through early 2015. This price translates to roughly one-third of one cent per gallon of gasoline used for blending in 2014. Prices in 2014-2015 have been under \$ 25 and very stable. This is because the credits do not expire and the system has not been advancing the annually decreasing carbon intensity compliance schedule because of a revision process and legal entanglements, so credit banks are very high.

– **Cost-effectiveness:**

No information is available on the cost-effectiveness of this instrument.

Future plans

As result of a California state court case (POET) on procedural flaws in the LCFS ARB is considering revisions to the LCFS, which will take effect in 2016. The California Air Resources Board is expected to vote on re-adoption of the LCFS in July 2015 and will likely involve a new compliance schedule to 2020, a credit price cap plus provisions for limited deficit rollover under special circumstances, adjustments in carbon intensity ratings including indirect land use change (ILUC), and a streamlining of fuel pathway certification (Lueders et al., 2015; Yeah and Witcover, 2015).

References used: CERES, (2014); ICF International, (2013); Yeh and Witcover,(2014, 2015); Lade and Lin,

CASE STUDY: US California Low Carbon Fuel Standard

(2013), ARB, (2014), Fuelling California (year unknown), Lueders et al. (2015).

Factsheet - 7 RENEWABLE ENERGY MANDATES

Description of the instrument

Min. shares for renewable energy in transport or blending obligations for biofuels are a **regulatory measure** which sets binding targets for the share of renewable energy, or biofuels, in transport (based on energy content or based on volume). It is implemented at **union/federal and country levels**.

Main impacts on

	Energy carriers	Energy infrastructure	Vehicles			
			Car	LCV	Light truck	Bus
Electricity	X					
Hydrogen	X					
Biofuels	X					

Results of the assessment

Increase alternative powertrains (o)	Increase renewable energy (++)	GHG reduction (+)	Coverage (++)	Cost-effectiveness (-)	Ease of implementation (+)
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Country coverage

Implemented

The most well-known examples are: The Renewable Energy Directive (RED) in the EU and the related blending obligations/mandates at individual Member State level and the Renewable Fuel Standard in the US

In the Renewables 2014 - Global Status Report (REN21, 2014) an overview can be found of national and State/Provincial Biofuel Blend Mandates (Table R18) and other renewable energy targets (Table R15). According to this study 10 countries had a biofuel mandate in place as of early 2005, 52 countries at the end of 2012 and 63 at the end of 2013. This includes countries from all continents (EU, Asia, South America, North America, Africa, etc.

Implementation being considered
Not known

Design options

Key differences in design are related to:

- The **metric**: Renewable energy targets can be defined as share of total energy consumed in transport based on energy content or based on volumes consumed in the sector. Targets can apply to road transport alone or can include non-road modes as well. With respect to the time scope some targets set a target for the long-term (for example 2020) (EU) or define targets annually (short term)(mostly at country level). Overall renewable energy targets are technology neutral, while biofuel mandates specifically aim to increase the share of biofuels.
- **Differentiation of the target**: subtargets for petrol and diesel might be in place. In relation to ILUC subtargets for advanced (and/or double counting) biofuels (see case study Italy, and cellulosic standard in the US) and caps on land-based biofuels, like the cap on corn starch derived ethanol are being considered more often nowadays (Schnepf and Yacobucci, 2013).
- Implementation of **additional incentives**: additional incentives can be provided for better performing biofuels by means of for example double counting mechanisms.
- **Innovative design elements**: sustainability criteria, especially in relation to the accounting for indirect emissions, which have not been applied in legislation before the introduction of the RED in the EU.

Key lessons learned with respect to renewable energy in transport

- **Sustainability criteria and indirect emissions**: although early biofuel policies did not include sustainability criteria to guarantee a minimum level of GHG reduction and to limit other negative environmental impacts, extensive (academic) research has learned that the environmental performance of biofuel vary so widely that sustainability criteria are required to guarantee actual GHG reduction rather than increase in emissions. This also includes the inclusion of indirect emissions as result of indirect land use change (ILUC) in GHG emission reduction calculations.

<ul style="list-style-type: none"> – Certification schemes management of chain of custody: many lessons have been learned from the different certification schemes developed by government and private actors. – Trade impacts: difference between schemes applied in different countries can significantly impact trade flows of feedstocks. For example: countries with strong incentives for biofuels from waste and residues might attract these waste flows from other countries. Although this might result in high GHG emission savings in the country with high incentives in place, the GHG emission savings in the country of origin might turn out lower due to a lack of waste and residues. – Long-term investment security: renewable energy production capacity, like biofuel production facilities, do need long-term investment security due to the high investment cost. This requires a long-term policy framework. 	
Interaction with other types of policy instruments	
<ul style="list-style-type: none"> – Fuel regulations linked to the GHG intensity of fuels: an increasing share of renewable energy in transport also directly impacts the overall GHG intensity of transport fuels. Therefore there interactions exist between renewable energy targets and fuel regulations. However, the incentives might be slightly different, because renewable energy targets do aim at the highest share of RE in transport rather than maximisation of GHG reduction. – Biobased economy: because the use of biomass is also increasingly being used and stimulated in other sectors (electricity sector, chemical sector, construction work) besides the already existing applications (food and feed) biofuels might compete with other applications of biomass and might result in higher sustainability risks as result of a higher overall demand. Availability problems, especially in relation to available sustainable biomass, might therefore arise. – Energy efficiency: the share of renewable energy in total energy consumption in transport is strongly linked to energy efficiency: on the one hand, higher efficiency results in a lower absolute demand for renewable energy to fulfil the target. On the other hand, Harmsen et al. (2011) state that renewable energy targets (in general, not just for transport) contribute to energy savings targets, because renewable energy production is often more efficient: the same final energy can be produced using less primary energy and thus results in a contribution to energy savings targets. (Harmsen et al., 2011). – Waste hierarchy: advanced biofuels from waste and residues might interact with the waste hierarchy in waste handling policies. Renewable energy targets provide an incentive for the use of these advanced biofuels due to no ILUC impacts (like the double-counting in the RED), while the waste hierarchy prescribes other applications of biomass over burning biomass in fuel tanks. – excise duties and import tariffs: because renewable energy targets might attract cheaper renewable energy sources from abroad, excise duties and import tariffs might be changed to protect national markets (to the extent allowed under WTO agreements). 	
Assessment	
Increase in alternative powertrains	0
Because most targets are met by an increasing market share of biofuels, often applied in low blends, this instrument does not provide a strong incentive for the transition to alternative drive trains, like electric and hydrogen vehicles.	
Increase in renewable energy	++
The main aim of these targets is to increase the share of renewable energy. Therefore the impact is estimated to be very high, especially in comparison to other less direct instruments. The exact impact and the exact effectiveness of the obligations are however, difficult to quantify, as many countries also apply subsidies and tax exemptions for biofuels (between EUR 5.5 and 6.9 billion in 2011, which equals a subsidy between 15 and 21 eurocents per litre bioethanol and between 32 and 39 eurocents per litre biodiesel (IISD, 2013). Therefore, it is difficult to isolate the impact of the obligations. On the other hand: many countries have shifted away from subsidies and tax exemptions in latest years without affecting the trend in increase of renewable energy. This suggests the obligatory aspect of blending obligations to have a strong impact on the share of renewable energy.	
GHG emissions reduction	+
Most blending obligations and renewable energy targets require minimum GHG reduction savings for biofuels in order to count towards the target. These targets do not exist for other types of renewable energy. Because these measures aim to maximise the share of renewable energy rather than GHG emission reduction the actual emission reductions can vary strongly. In addition to this, there is a large difference between direct and indirect emissions: including indirect emissions in case of biodiesel from oil crops, like rapeseed, might even result in an increase of GHG emissions.	
Coverage	++
In general, national fuel suppliers have to fulfil the blending obligations or meet the renewable energy targets. Nowadays most blending mandates are met by using low blends (within the blending limits of applicable fuel regulations). This results in a wide, but low, penetration of biofuels in the overall passenger vehicle fleet.	

Cost-effectiveness	-
<p>Biofuels have higher costs compared to fossil fuels, caused by higher production cost in combination with lower energy contents of biofuels. Compared to other types of renewable energy, the purchase cost for vehicles related to biofuel consumption are very low, because most vehicles are compatible with low blends of biofuels. The cost of Flex-Fuel Vehicles (FFVs), being able to run on 85% ethanol are comparable to the purchase cost of regular gasoline vehicles. Due to the high production costs of biofuels, they are considered not to be cost-effective in reducing CO₂ emissions of transport (CE Delft and TNO, 2010) and hence blending obligations are not cost-effective as well. As the future production costs of biofuels are uncertain (cost could decrease due to efficiency improvements, but they could also increase due to higher demand or stricter sustainability criteria for biofuels), the future developments in the cost-effectiveness of this policy instrument are uncertain.</p>	
Ease of implementation	+
<p>Implementation efforts are mainly linked to:</p> <ul style="list-style-type: none"> – the administrative systems that are required to verify compliance with both the fulfilment of the obligations as well as compliance with the sustainability requirements; – reaching consumer acceptance, mainly in case of higher blends, like E10 and E15, in relation to price differences and information on vehicle compatibility. 	
Other considerations	
<ul style="list-style-type: none"> – Because of higher prices and the policy-driven demand for renewable energy in transport the share of renewable energy might drop after termination of obligation schemes. Obligated parties also have a strong incentive to go for the cheapest options in order to meet the targets at least cost. Therefore it can be questioned to what extent renewable energy targets, as currently being implemented, provide sufficient incentives for innovation and thus long-term transition. – The impact on energy security is directly linked to the share of fossil fuels replaced by biofuels. However, it should be noted that many feedstocks for biofuel production also have to be imported and hence may contribute to energy dependency of countries, although feedstocks are derived from other regions than conventional oil and feedstock sources are more diversified. – A disadvantage of financial instruments to stimulate biofuels, like tax exemptions, is that they result in lower tax revenues. For that reason many countries have chosen to stimulate biofuels by mandatory targets instead of financial instruments. 	
References	
EC, 2009; Pelkmans et al., 2014; REN21, 2014; CE Delft & TNO (2012); Schnepf and Yavobucci (2013); IISD (2013).	

CASE STUDY: EU Renewable Energy Directive (RED)

Summary of the policy instrument and objective

The Renewable Energy Directive RED (EC, 2009) sets an overall target for renewable energy use in the EU (20% in 2020), and individual targets for each Member State. The overall target results in an increasing share of renewable energy in energy production and consequently results in higher GHG emissions reductions for electricity consumption in transport. The RED obliges Member States to ensure that the share of energy from renewable sources in all forms of transport in 2020 is at least 10% of the final consumption of energy in transport in that Member State. This 10% should come from all types of renewable energy: biofuels, renewable energy in electricity and hydrogen used by transport, but in practice mainly biofuels are used to meet the target. Only biofuels that meet the minimum sustainability criteria as laid down in Article 17-21 can count towards the target. The criteria define the methodology to calculate the GHG emissions of biofuels, set minimum GHG reduction levels, exclude biofuels from biomass that is cultivated in areas with high biodiversity or high carbon content of the soil, etc. Approved certification schemes are used to prove compliance.

The contribution made by biofuels produced from wastes, residues, non-food cellulosic material, and ligno-cellulosic material shall be considered to be twice that made by other biofuels in order to stimulate the use of these biofuels with on average higher GHG emission reductions. Also a correction factor of 2.5 is in place to correct for the higher efficiency of electric vehicles. Member States are free in their choice of policy instruments to reach this 10%, although they can not demand stricter sustainability criteria. The most preferred options are biofuel mandates for fuel suppliers and subsidies and tax exemptions for biofuels.

Impacts and costs

CASE STUDY: EU Renewable Energy Directive (RED)**– Increase in alternative powertrains:**

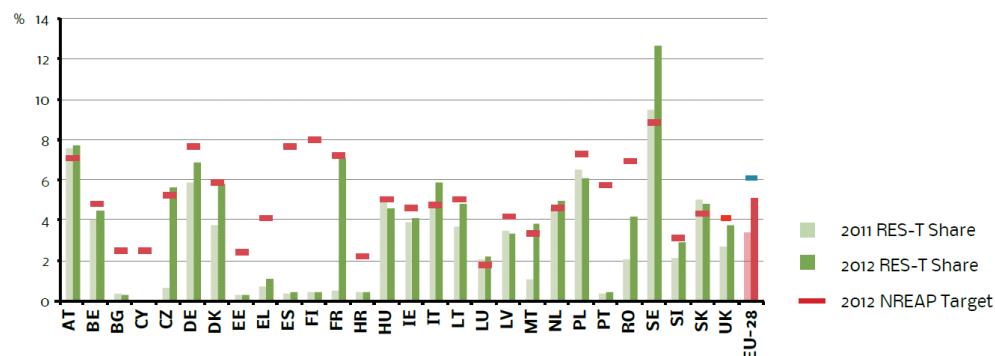
Many Member States have chosen to have blending mandates in place to meet the 10% target of the RED. Therefore, the increase in alternative drive trains can mainly be attributed to other policy instruments. For example: in 2013 renewable electricity in road transport only covered 75 ktoe of 15,427 ktoe total RES-T, which equals 0.5% of total RES-T. (Eurostat, 2015)

– Increase in renewable energy in transport:

The share of renewable energy in transport increased from 1.0% in 2004 to 5.4% in 2013 (in line with the calculation methodology as laid down in Article 3(4) of the RED (including double counting). (Eurostat, 2015) With the minimum share of 3% double counting biofuels, the minimum share of RES-T to be achieved in 2020 is 8.5% for countries that just meet this 3%; with higher share of double counting biofuels the actual share can even be lower.

The increase in RES-T showed a drop during the years of implementation of the RED in 2010-2011 and current growth is less steep compared to the period up to 2010 due to regulatory uncertainty related to the inclusion of ILUC and the post-2020 policy framework. According to EUFORES (2012) the growth in the last two years has been actually lower than the necessary annual growth rate, which might cause problems in the future, because the trajectory foreseen for the coming years is more ambitious. Some Member States are more successful than others: the figure below shows the shares realised in the various Member States in 2012 compared to the trajectories foreseen in the National Renewable Energy Action Plans (NREAPs).

The contribution of different type of biofuels in 2005, 2010 and 2020 is depicted in the figure below (JRC, 2013).

Actual versus planned RES-T shares (EUFORES, 2014)**ACTUAL VERSUS PLANNED RES-T SHARES****– GHG emission reduction:**

Because biofuels are produced from different feedstocks the average GHG emission reduction varies. According to Article 17(2) of the RED, the GHG emission savings of biofuels counting towards the target should at least be 35%. With effect from

1 January 2017, the GHG emission savings should be at least 50 %. From 1 January 2018, GHG emission savings from biofuels from installations which came in operation after 1 January 2017, should be at least 60% (EC, 2009). This emission reduction only covers the direct emissions and not the indirect emissions associated with indirect land use change (ILUC). If the ILUC-factors as published in the ILUC proposal of 2012 are taken into account mainly biodiesel from food crops might result in an increase of GHG emissions rather than a decrease, while biofuels from waste and residues, and thus without any ILUC-emissions, might have a net emission reduction of 80%. Due to this wide range in reduction potential it is hard to predict the overall GHG emission reductions as result of the RED. According to the progress report of the EC, the 4.7% share of biofuels (in 2011) is estimated to have generated 25.5 Mt CO₂ eq savings, based on information submitted by Member States in their progress reports. The application of global default values results in an estimate of 22.6 Mt CO₂ eq. (EC, 2013) This represents a saving of 53-60% compared to the consumption of only fossil fuels (Ecofys et al., 2012). Based on these numbers this equals about 2.4-2.8% GHG emission reduction in transport in 2011.

– Cost impacts:

The costs and administrative burden related to compliance with the sustainability criteria in the RED are mainly related to the development of a mass balance chain of custody. Because this system did not exist yet, the administrative burden has been high for all actors in the first years of implementation of the RED. However, the recognised voluntary schemes and the default values limit the administrative burden and cost for economic

CASE STUDY: EU Renewable Energy Directive (RED)

operators and the cost and administrative burdens related to the mass balance system are seen as proportional. Differences in implementation between MS (such as reporting requirements) and between the RED and FQD might result in higher compliance cost for fuel suppliers operating in different Member States (partly as result of higher administrative efforts) (CE Delft et al., to be published). According to IISD (2013), additional cost per litre for motorist as result of biofuels in the fuel mix range from 16 eurocents per litre (2013) to 6 eurocents per litre (2020) for ethanol and from 37 eurocents per litre in 2013 to 34 eurocents per litre in 2020 for biodiesel.

– **Cost-effectiveness:**

In Table 8 the social abatement cost of biofuels and hence EU biofuel policies are depicted. These abatement costs show a wide range depending on how indirect emissions are accounted for.

Table 8 Abatement cost biofuels in € per tonne CO₂ eq incl. and excl. ILUC (IISD, 2013)

	Biodiesel	Bioethanol
No ILUC	285-325	350-400
Low ILUC	780-900	385-440
Moderate ILUC	5,200-6,000	415-475
High ILUC	Net emission increase of more than 2 million tonnes of CO ₂ eq, therefore no abatement cost	432-493

Future plans

- On 17 October 2012 the EC published the **ILUC-proposal** on how to amend the RED and FQD to take into account indirect land use change emissions. This proposal includes a cap on land based biofuels, a non-binding target for advanced biofuels and reporting of indirect emissions by fuel suppliers. A final vote was taken on April 28 and includes a cap on first-generation biofuels of no more than 7% of energy consumption in transport by 2020 and reporting on ILUC emissions.
The EC should report and publish data on indirect emissions and should report back to the European Parliament and the Council the option to include ILUC emission in the existing sustainability criteria. Member States must enact this new piece of legislation by 2017 at the latest (European Parliament, 2015a).
- In January 2014 the European Commission proposed the **2030 Energy and Climate Package** and on 23 October 2014 EU leaders agreed on a GHG reduction target of at least 40% (by 2030 compared to 1990), a share of renewable energy of at least 27% by 2030. The increase in energy efficiency should also be at least 27%. It is still unclear whether there will be a subtarget for renewable energy in transport in place.

References used: EC (2009, 2013, 2014), Eurostat, (2015), EUFORES, (2014); JRC, (2013); CE Delft, (to be published); Ecofys et al (2012); IISD, (2013); EESC (2015).

CASE STUDY: National implementation of the RED in Italy**Summary of the policy instrument and objective**

Italy has a quota obligation system in place since 2007. Obligated subjects (OSs), which bring gasoline and diesel for motor transport on the Italian market, are obliged to mix conventional fuels with a share of all types of sustainable biofuels. For the year 2014 this obligation was 4.5% (based on the calorific values of the fossil fuels released in 2014). Another means of compliance is buying biofuel immission certificates (CICs). In general one CIC equals 10Gcal of biofuels.

Additional incentives

Until July 2014 biofuels produced in the EU from EU food crops received one CIC every 8 Gcal instead of 10 Gcal. This so-called ‘8 Gcal bonus’ was also valid for biofuels applied in mixtures containing more than 25% v/v biofuels. Italian law n. 134/2012 prescribes that biofuels produced from waste and residues including non-food cellulosic and ligno-cellulosic material **count double** towards the target. Until the beginning of 2014 waste and residues counting towards the target should originate from and should be produced in the EU. Also until the beginning of 2014 max. 20% of the obligation could be met by waste and residues. Not all residues could be double counted: the Italian law lists the residues that are allowed for the double counting. As result of the double counting, Italy, together with the Netherlands and UK, has become one of the countries dominating the consumption of double-counting biofuels in the EU.

Impacts and costs

- **Increase in alternative powertrains:** because of the quota obligation system for biofuels in place, the realisation of the RES-T target in Italy is unlikely to result in a significant increase of alternative drive trains;
- **Increase in renewable energy in transport:** the share of RES-T increased from 0.8% in 2007 to 5.0% in 2013 and is mainly the result of an increase in biofuel consumption up to 1,169 ktoe biodiesel and 56 ktoe bioethanol in 2013 (Eurostat; 2015; EurObserver, 2014).

Table 9 Share of renewable energy in transport (RES-T) in Italy in period 2004-2013 (Eurostat, 2015)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Italy	1.0%	0.8%	0.9%	0.8%	2.3%	3.7%	4.6%	4.7%	5.8%	5.0%

Italy, together with the Netherlands and UK, dominate the consumption of double-counting biofuels in the EU: consumption of double counting biofuels increased from 38 ktoe in 2009 to 340 ktoe in 2012 with a strong increase from 2011-2012 (from 64 to 340 ktoe). Due to a lack of domestic waste and residues, Italy is a net import of waste and residues: about 98% of UCO biofuels were imported from mainly Spain and the Netherlands in 2012. However, import dependency decreased in the last years, because an increase in local production of UCO and animal fat (Pelkmans et al., 2014).

- **GHG emission reduction:** According to OECD (2013) the reduction in GHG emissions as result of biofuels was estimated to be 2 Mt CO₂ eq in 2010 and 3 Mt CO₂ eq in 2020, which equals 6% of total GHG reduction potential in both EU ETS as non-ETS sectors (OECD, 2013).
- **Cost impacts:** CICs could be bought for about € 400-450 in 2013. In general one CIC equals 10Gcal of biofuels. Non-compliance cost vary between € 600-900 per CIC. These costs are for the obligated subjects (OSs). Although the price for Used Cooking Oil (UCO) has double from 2004-2011, there is no evidence that the implementation of the double counting in 2012 has had an impact on the market prices. This is also valid for animal fat, although biodiesel producers stated double counting to be responsible for a larger price difference between the ‘best’ quality animal fat and animal fat of less quality (Pelkmans et al., 2014).
- **Cost-effectiveness:** Based on the ENEA’s marginal abatement cost curve referred to in OECD (2013) the GHG emission reduction as result of the promotion of biofuels in Italy results in a cost-effectiveness of € 100 per tonne of CO₂ saved. This seems low, which might be caused by the scope of GHG emissions taken into account (limited to direct emissions).

Future plans

In October 2014, in anticipation of a decision to be taken on ILUC, Italy adopted a subtarget for advanced biofuels of 0.6% of all petrol and diesel as of 2018, increasing up to 1% in 2022. Italy is the first Member State to introduce a subtarget (European Parliament, 2015a; Ministero Dello Sviluppo Economico, 2014).

References used: EurObserver (2014); Eurostat (2015); Ministero dello Sviluppo Economico (2014); Pelkmans et al. (2014); European Parliament (2015), OECD (2013).

Factsheet 8 - REGULATION OF CHARGING/FUELLING INFRASTRUCTURE						
Description of the instrument						
The obligation to realise the energy infrastructure for alternative energy carriers in terms of a binding number of filling stations and charging stations are a regulatory measure which aims to stimulate the market penetration of alternative vehicles in the vehicle fleet by ensuring a minimum energy infrastructure. In order to reach this minimum level implementing bodies can oblige stakeholders, like fuel suppliers or fuel stations to realise infrastructure. A option would, for example, be to oblige fuel stations to offer a certain number of alternative energy carriers or prescribed alternative energy carriers. It is implemented at union/federal and country levels and the stakeholder being the regulated party depends on design choices made.						
Main impacts on						
	Energy carriers	Energy infrastructure	Vehicles			
			Car	LCV	Light truck	Bus
Electricity		X				
Hydrogen		X				
Biofuels		X				
Results of the assessment						
Increase alternative powertrains (+)	Increase renewable energy (+)	GHG reduction (+)	Coverage (++)	Cost-effectiveness (o)	Ease of implementation (+)	
Country coverage						
Implemented EU: Clean Power for Transport Directive (Directive adopted, but Member States have two years to submit their national policy frameworks Sweden (Pump Act) California (requirements in Buildings Code)			Implementation being considered Not known			
Design options						
In principle, the instrument functions roughly the same throughout countries. Key differences in design are related to:						
<ul style="list-style-type: none">– The metric: number of filling stations or charging points. This is a crucial aspects, because you would like to reach the minimum number of charging points required to provide a sufficient incentive for vehicle sales. Indicators, like motorisation and urbanisation rates, level of car ownership and the share of population in densely populated areas are al useful indicators to determine the required number and type of infrastructure.– Differentiation of the target: targets for different energy carriers, type of alternative energy carriers included, requirements for the location (TEN-T network for example).– Technology neutral or prescribed technologies (including prescribed standard for sockets for example).– Standardisation and technical specifications included in any requirements are relevant for the level of interoperability.						
Key lessons learned with respect to renewable energy in transport						
<ul style="list-style-type: none">– Minimum numbers to be achieved should be realistic and should represent the real minimum required for the market to pick up a new technology and should not represent the numbers required to set up a complete network. In this light, the first numbers proposed in the CPT were not realistic (interview Jos Dings).– The Pump Acts in Sweden has resulted in mainly E85 pumps and cars. It should be kept in mind that technology neutral instruments can result in lock-in effects if the market has a strong preference for one option. Governments should consider to what extent this hinders any long-term objectives, because long-term benefits are not included in the decision making process of the obligated parties.						
Interaction with other types of policy instruments						
Minimum requirements for energy infrastructure support the realisation of policy goals, like renewable energy targets and/or GHG reduction targets or provisions related to the market penetration of alternative drive trains. Besides this, minimum requirements for energy infrastructure, especially in relation to LNG and CNG, also contribute to air quality policy objectives (NO _x and particulate matter).						

Factsheet 8 - REGULATION OF CHARGING/FUELLING INFRASTRUCTURE	
Assessment	
<i>Increase in alternative powertrains</i>	+
A guaranteed minimum infrastructure network for alternative energy carriers should increase consumers' trust to such extent that consumers no longer perceive the lack of infrastructure as barrier for the purchase of AFVs. Different sources mention that this instrument should not be seen as stand-alone policy: this kind of infrastructure policy is unlikely to result in large increase in vehicle sales, but interacts with other measures targeted at energy carriers and vehicles.	
<i>Increase in renewable energy</i>	+
The impact of this policy instrument on the share of renewables in transport is strongly dependent on the shares of renewables in electricity and hydrogen production and the shares of bio-CNG and bio-LNG.	
<i>GHG emissions reduction</i>	+
The GHG emission reduction depends on the type of infrastructure and to what extent transport users will make use of this alternative energy infrastructure. According to the impact assessment of the Clean Power for Transport Directive GHG emissions will decrease up to 0.3% by 2020 as a result of increased deployment of electric and fuel cell vehicles.	
<i>Coverage</i>	++
Depending on the administrative level at which this instrument is implemented and on how targets are defined this policy instrument can cover a wide area. Especially by the inclusion of criteria for the location of infrastructure the coverage can be guaranteed in an efficient way. It can also contribute to cross-border mobility in case standardisation is regulated as well.	
<i>Cost-effectiveness</i>	0
The realisation of alternative energy infrastructure requires high investment costs. Depending on how this instrument is implemented costs will be paid by industry (in case of obligations) or (partly) by the government (in case of a subsidy system). These investment cost can be depreciated over the economic lifetime of the infrastructure, such that the annual capital cost will probably be moderate. Hence, also the cost-effectiveness of this measure will probably be moderate.	
The cost-effectiveness can be influenced by strategic choices in and planning of the design process in relation to transport networks (for example TEN-T in EU) and the distance between locations. Number of filling stations/charging points as chosen as an appropriate number to provide sufficient incentives for a higher uptake of alternative drive trains can also be seen as a critical factor: too many filling stations/charging points unnecessarily increase the price, while the impact does not increase. Too few do not result in the desired impacts.	
<i>Ease of implementation</i>	+
Implementation efforts are mainly linked to: <ul style="list-style-type: none"> – What extent governmental bodies choose to have mandates or prefer to realise the minimum level of infrastructure through soft incentives (although this makes the realisation of the minimum level of alternative energy infrastructure more uncertain). Depending on the approach other efforts are required. Examples of policy measures which can contribute to the realisation of a minimum infrastructure network without public spending are: min. requirements in building codes, obligation for Distribution System Operators (DSOs), and conditions of parking lot permits. – Changes and adaptations to land use policy to allow and/or to give priority to these new types of refuelling infrastructure – Information provision to consumers: by information provision on number and location of alternative energy infrastructure consumers' trust should increase to such extent that consumers no longer perceive a lack of infrastructure as barrier for the purchase of AFVs. – A challenge in the implementation would be to reach a good geographical distribution matching demand for infrastructure. 	
Other considerations	
A point of consideration is how to incorporate ongoing innovation in refuelling and charging technology (like smart charging) in policy in order to, on the hand stimulate this innovation and on the other hand, to ensure state of the art technology in infrastructure developments.	
References	
EC (2013); Plugincars (2013).	

CASE STUDY: Pump Act in Sweden**Summary of the policy instrument and objective**

The Act (2005:1248) on the Obligation to Supply Renewable Fuels of 1 April 2006, also known as the Pump Act, aims to regulate the supply and availability of biofuels throughout the country by requiring filling stations, selling more than 1,000 m³ petrol or diesel to also supply at least one renewable fuel per 1 March 2009. The act only covers liquid and gaseous biofuels, renewable electricity is not included. The Act is closely linked to fulfilment of the targets of the EU Biofuels Directive and the renewable energy targets as result of the RED and FQD.

Filling stations offering renewable fuel raised from 10% in 2005 to 62% in 2010. This growth is almost entirely due to the installation of E85 pumps, while the regulation itself is technology neutral. (Swedish Energy Agency, 2012) In 2009 90% of the filling stations offering renewable fuel offered E85 (Riksrevisionen, 2011). In Table 10 the increase in number of filling stations per renewable fuel is depicted. There are, however, large geographical differences and differences between urban and rural areas, caused by the fact that filling stations in these areas often do not exceed the 1,000 m³. The increase in methane gas filling stations is driven by municipalities and a few actors in the gas sector and can be found mainly in the south of Sweden. The decrease in RME points is caused by a lack of vehicles able to run on pure RME (Committee on Transport and Communication, 2010).

Table 10 Number of filling stations offering biofuels or biogas

Date	E85	Methane gas	RME (pure biodiesel)
September 2009	1493	103	14
December 2005	300	62	23
December 2003	92	31	

Impacts and costs

- **Increase in alternative powertrains:** Because the Pump Act has mainly resulted in E85 pumps, the shares of flex-fuel vehicles (FFVs) are most interesting to look at. These shares of FFVs in new sold vehicles increased significantly from 2006 reaching a maximum share of 25% in 2008. After 2008 the market share of FFVs in vehicle sales dropped again to 5% in 2011. According to Sprei (2013), several other factors other than the Pump Act are responsible for this decline, such as changes in the rebate structure and the removal of the exemption of the congestion charging (Sprei, 2013).
- **Increase in renewable energy in transport:** the overall share of renewable energy in transport in Sweden has increased to 6% in 2010 (Swedish Energy Agency, 2012). Methane gas for vehicles contained approximately 58% biogas in 2008. Price developments in petrol and E85 have shown that the market uptake of renewable energy in transport, such as bioethanol, is not guaranteed by the availability of biofuels at filling stations, but to large extent are driven by price differences: in autumn 2008 the price of petrol dropped, while the price of E85 went up, making consumers prefer petrol over E85. In summer 2009 the price of petrol went up again, while the price of E85 remained stable resulting in higher market shares of E85 again (Committee on Transport and Communication, 2010).
- **GHG emission reduction:** Because there are several other factors responsible for the share of renewable energy in transport and FFVs it is hard to say which GHG emission reduction can be attributed to the Pump Act alone. Besides this, the GHG emission reduction of biofuels can widely vary depending on the type of feedstock used.
- **Cost impacts:** the investment cost associated with the Pump Act vary between € 32,366 (SEK 300,000) and € 43,155 (SEK 400,000) for E85 filling points. For methane, cost are estimated to be SEK 4 million for methane filling points of which SEK 3.8 million is eligible for subsidies. Mostly the larger petrol companies have borne these costs, but also some individual owners. (Committee on Transport and Communication, 2010). Total cost for the distribution sector is estimated to be around € 1.1 million (SEK 1.2 billion) (Riksrevisionen, 2011).
- **Cost-effectiveness:** No information on the cost-effectiveness or on the net benefits to society were found.

Future plans

No information has been found with regards to the future plans for the Pump Act.

References used

Swedish Energy Agency (2012), Sprei (2013), Committee on Transport and Communication (2010), Riksrevisionen (2011).

Factsheet 9 - CO ₂ REGULATION FOR CARS AND OTHER ROAD VEHICLES						
Description of the instrument						
Vehicle standards are a regulatory measure which set binding targets for the maximum fleet average CO ₂ emissions or fuel consumption of new vehicles sales. It is implemented at Union and country levels .						
Main impacts on						
	Energy carriers	Energy infrastructure	Vehicles			
			Car	LCV	Light truck	Bus
Electricity			X	X	X	X
Hydrogen			X	X	X	X
Biofuels						
Results of the assessment						
Increase alternative powertrains (+)	Increase renewable energy (o)	GHG reduction (++)	Coverage (++)	Cost-effectiveness (++)	Ease of implementation o/(+)	
Country coverage						
Implemented Cars: Japan, EU (excl. NO), US, S. Korea, Mexico, Brazil, India Vans: US, Mexico, EU HDVs: US, Canada, Japan, China			Implementation being considered Cars: Canada, China Vans: Canada HDVs: Mexico			
Design options						
In principle, the instrument functions roughly the same throughout countries: a mandatory standard is set with targets OEMs must meet. Key differences in design are related to: <ul style="list-style-type: none">the metric: regulation of CO₂ emissions (g/km), fuel consumption (l/100km), or fuel economy (km/l);differentiation of the target: uniform targets (i.e. no differentiation between OEMs), mass-based, or footprint-based¹⁰ corporate averages;implementation of additional incentives (e.g. credits for CO₂ reductions not measured by the test procedure) and/or flexibilities (e.g. derogations for small OEMs). Innovative design elements : Measuring performance with real world instead of test data and a WTW and/or energy-based metric instead of a TTW CO ₂ -based metric are under discussion.						
Key lessons learned with respect to renewable energy in transport						
<ul style="list-style-type: none">Super credits provide a specific incentive for alternative powertrains, but are often criticised for reducing the stringency of the overall target and for not being technology neutral (EC, 2012).With increasing shares of alternative powertrains, the appropriateness of TTW CO₂-based metrics is increasingly being questioned, as emissions shift from the use phase to other phases of the vehicle's lifecycle (e.g. production of electricity, production/disposal of the vehicle and battery, etc.). Furthermore, it does not provide strong incentives for dedicated biofuel vehicles, nor does it promote improvements in the efficiency (MJ/km) of alternative vehicles (AEA et al., 2012).The gap between real world and test cycle emissions has increased significantly over the years (ICCT, 2014b), which reduces the effectiveness of the legislation and the incentive for alternative powertrain technology. For PHEVs the gap is even larger than for ICVs (in the EU legislation), due to the formula used for calculating the emissions, which assumes an unrealistically high share of electric kilometres.						
Interaction with other types of policy instruments						
The provision of financial incentives in registration taxes supports OEMs to meet their target (strong link).						
Assessment						
Increase in alternative powertrains					+	
This instrument stimulates alternative powertrains (mainly electric and hydrogen vehicles) through: The target itself (+) : alternatively powered vehicles generally have lower WTW and TTW emissions compared to conventional vehicles. Hence, sufficiently strict targets push vehicles with alternative powertrains, especially when the targets become too strict to be met with conventional vehicles alone						

¹⁰ 'Footprint' refers to the surface between the tyres of the vehicle.

Factsheet 9 - CO₂ REGULATION FOR CARS AND OTHER ROAD VEHICLES

- The adoption of **TTW based metrics (++)**, which implies that electric and hydrogen vehicles count as zero emission when determining the OEMs' fleet average. This provides a strong incentive for such vehicles. If future Regulations also cover WTT emissions or adopt an energy-based metric (MJ/km), this incentive would become weaker, as the difference between electric and conventional vehicles would be smaller. The implementation of **explicit incentives in the Regulation (++)**, such as the super credits which have been implemented in the EU (see case study). In the future, other options would be to set a minimum share of alternative powertrains in vehicle sales (i.e. integrate standards with ZEV mandates (see Factsheet 10)).

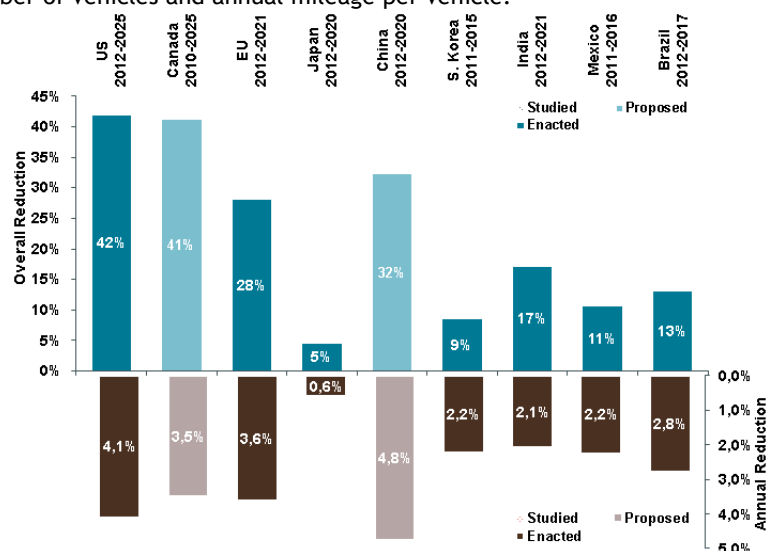
Increase in renewable energy**0**

The impact of this policy instrument on the share of renewable energy in transport is strongly dependent on the shares of renewables in electricity and hydrogen production. These shares are not influenced by the policy, but depend on other policy instruments, such as policies for increasing renewable power production. However, a shift to AFVs does result in some increase in RES-T and in energy savings.

GHG emissions reduction**++**

This instrument is known to be very effective in reducing CO₂ emissions from new passenger cars, at least with respect to the test cycle emissions. In the EU, prior to the standards several voluntary agreement were made, but this did not result in the emission reductions that were agreed upon. After implementation of the standards, a much steeper reduction can be seen

(EC, 2012). The total reduction potential differs between sectors, as it depends on aspects such as the baseline vehicle and target level. The figure below evidences that the total reduction in fuel consumption of the new passenger car fleet can be quite significant (up to 42%), with annual reductions ranging from 0.6 to 4.8%. The overall GHG emission reduction also depends on the coverage (see below) and the development of the total number of vehicles and annual mileage per vehicle.



Source: ICCT, 2014a.

Factsheet 9 - CO₂ REGULATION FOR CARS AND OTHER ROAD VEHICLES	
Coverage	++
As vehicle standards cover all new vehicle sales in a region, they have a relatively large coverage. Moreover, as many countries have already implemented this measure, 80% of the new car sales worldwide are now subject to a standard (ICCT, 2015).	
Cost-effectiveness	++
Vehicle standards improve the efficiency of new vehicles, which results in large fuel cost savings (++) . This is partially off-set by a higher purchase price (-). Whether the improved efficiency results in net cost savings depends on local circumstances, such as the target level (stricter targets require relatively more expensive technologies) and the fuel price (higher prices result in larger benefits), but as shown in the case study below, it might well be a large net saving. Incentives for increasing the share of electric and hydrogen vehicles (TTW metric and explicit incentives such as super credits) generally lead to higher overall GHG reduction costs (-) (EC, 2012).	
Ease of implementation	o/+
This policy is complex, but can be implemented relatively straightforward for cars and vans. For HDVs, this is more complex, as - amongst other reasons- the HDV market is much more complicated (e.g. a wider variety of vehicle designs) than that of LDVs, which makes the design of a standard more complex as well (CE Delft, 2013a).	
Other considerations	
<ul style="list-style-type: none"> – Vehicle standards do not necessarily decrease absolute GHG emissions, as they target fleet average efficiency. – Fuel cost savings can negatively impact the governmental balance, as it reduces income from excise duties (-). However, if cars become more expensive, increase income from registration taxes may increase (if taxes are based on purchase price) (EC, 2012). – Vehicle standards can also positively impact energy security (+), GDP (+), and employment (+). They can negatively impact social equity (-), as the price increase is unlikely to be equal across segments (EC, 2012). 	

CASE STUDY: Vehicle standards for new Cars: Regulation (EC) No 443/2009 - EU**Summary of the policy instrument and objective**

Vehicle standards for new cars (Regulation (EC) 443/2009 amended by (EU) 333/2014) sets binding emission targets (defined as g/km) for the new passenger car sales in the EU. Each OEM has a specific fleet average target to account for differences in vehicle weight between OEMs (i.e. mass-based corporate average). Combined, this results in an EU fleet wide TTW target of 130 g/km for 2015 and of 95 g/km for 2021 (EC, 2009). Those OEMs failing to comply with their targets have to pay an excess emission premium which is defined as the excess amount (in g/km) times a penalty per gram times the number of cars sold (ibid.).

The aim of the Regulation is to reduce the CO₂ emissions of LDVs while ensuring a proper functioning of the EU's internal market. Although not a specific objective, the design of the EU car standards provides incentives to vehicles with alternative powertrains, especially to electric and hydrogen vehicles. Firstly, the CO₂-based TTW metric provides a strong incentive for electric and hydrogen cars, as these vehicles count as zero emission with a TTW CO₂ metric. Secondly, the EU Regulation provides so-called 'super credits', causing that very low emission vehicles (≤ 50 g/km) are counted more than once (e.g. as 2.5 cars in 2014 and 1.5 in 2015) when determining the fleet average of the OEM. Finally, dedicated biofuel vehicles which can run on E85 receive a 5% discount in their TTW emissions, if 30% of the filling stations in the relevant MS supply this type of biofuel (EC, 2009).

Impacts and costs

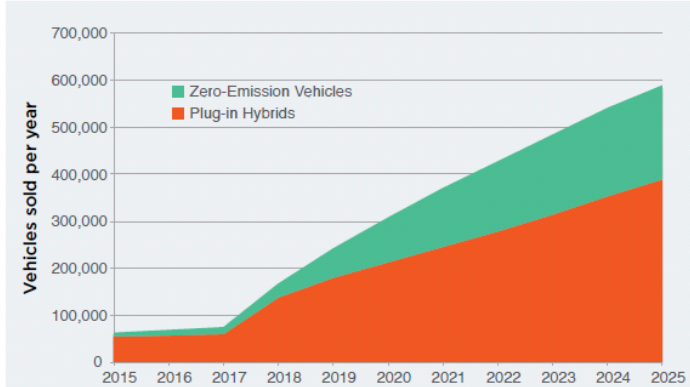
- **Increase in alternative powertrains:** Although the number of (semi-)electric cars has increased significantly during the period in which the standards have been in force (ranging from 0,1-0,7% of the EU27 new vehicle sales prior to implementation to 1,3-3,8% in the years after implementation (2008-2013)) (EEA, 2014), it is difficult to conclude which share hereof is the result of the standards and which is the result of incentives in registration and company car taxes.
- **Increase in renewable energy in transport:** This impact is unclear but probably small, as the standard does not explicitly stimulate renewable electricity to be consumed by the FEVs/PHEVs that entered the market).
- **GHG emission reduction:** The 2015 target represents a reduction of 18% in the TTW CO₂ emissions per kilometre of new cars compared to 2007 when the emission adopted the proposal. The 2020 target represents a further reduction of 27% in the TTW CO₂ emissions per kilometre compared to the 2015 target. This is expected to reduce total emissions between 2010 and 2030 by 24%.
- **Cost impacts:** Compared to the baseline, the 2020 target of 95 g/km is expected to result in a 25% reduction in oil consumption, saving fuel worth € 27bn per year from 2020-2025 and 36bn per year from 2025-2030 (incl. fuel cost savings from vans) (EC, 2012). Per vehicle (assuming equal mileages), this results in fuel savings from € 2,900-3,800 over the lifetime (ibid.). Part of these savings will be off-set by R&D costs and purchase price cost increases.
- **Cost-effectiveness:** The net benefits to society are expected to be significant (i.e. the costs of the policy (higher purchase prices) are fully offset by lower running costs (i.e. fuel cost savings). The net benefits to society are dependent on future oil prices, and are expected to range from € 80 (at \$ 90 per barrel) to €230 (at \$140 per barrel) per tonne of CO₂ (EC, 2012).

Future plans

- The Commission is currently in the process of designing a Regulation for the period beyond 2020 (i.e. 2025 and 2030), hence, future targets are likely to be adopted.
- However, the design of this Regulation is still undecided and under investigation. Ongoing research on this matter re-evaluates some of the main discussion points, such as the utility parameter, test vs. real world emission measurements, TTW vs. WTW CO₂ targets and the in- or exclusion of emissions from vehicle production.

References used: EC, 2009, 2012, 2014.

Factsheet 10 - ZERO EMISSION VEHICLE (ZEV) MANDATES						
Description of the instrument						
The ZEV mandate is a regulatory measure setting binding targets for minimal shares of ZEVs sold in a particular Region. It is currently implemented at the State level .						
Main impacts on						
	Energy carriers	Energy infrastructure	Vehicles			
			Car	LCV	Light truck	Bus
Electricity			X	X	X	
Hydrogen			X	X	X	
Biofuels						
Results of the assessment						
Increase alternative powertrains (++)	Increase renewable energy (o)	GHG reduction (+/++)	Coverage (++)	Cost-effectiveness (--)	Ease of implementation (-)	
Country coverage						
Implemented All vehicles up to 8,500 lbs (=3,850t): 10 States in the USA (California, Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, Vermont) (C2ES, 2015)			Implementation being considered Unknown			
Design options						
<p>This instrument sets a minimal share of ZEVs in OEMs' vehicle sales of a particular region. The mandate is defined as a 'minimum (credit) percentage' (ARB, no year). The key design elements in this Regulation are:</p> <ul style="list-style-type: none">– Scope: The Regulation can theoretically apply to any road vehicle type, but is currently applied to the cumulated sales of cars, vans and some light trucks (i.e. all vehicles with a GVW <8,500 lbs) (C2ES, 2015).– Definition of compatible vehicle technologies: The Regulation needs to define which vehicles can contribute to the mandate of an OEM, which can be broader than pure ZEVs (i.e. vehicles with zero tailpipe emissions) if e.g. also plug-in hybrids and regular hybrids are eligible (C2ES, 2015).– Differentiation of the mandate (between OEMs and compatible technologies): The mandate can be differentiated between compatible technologies by determining a minimum share to be met with pure ZEVs, but by allowing the remainder of the Mandate to be met by other vehicle technologies. In addition, the mandate can be differentiated between OEMs. In existing Regulations, differentiation is based on the sales volume of OEMs: smaller OEMs are exempted from the mandate, while for larger OEMs the mandate increases with size (iCET, 2014) (see the case study of California for an example).– Flexibility mechanisms: The Regulation can include several flexibility mechanisms, such as a penalty for OEMs not meeting their Mandate, cross-state credit pooling, and alternative compliance options. Most notably is the fact that existing Regulations implemented a credit banking and trading system: the mandate is defined as a minimum credit percentage to be obtained, which OEMs can obtain themselves by selling compatible vehicles or by buying credits from other OEMs (ZEV Program Implementation Task Force, 2014).						
Key lessons learned with respect to renewable energy in transport						
<ul style="list-style-type: none">– The design of the Mandate and level of ambition need to be well aligned with market developments (e.g. as regards cost developments and emerging new (near)ZEV technologies. If this is not the case, the Mandate risks to lock in a suboptimal technology path with respect to consumer demand and/or cost-effectiveness) (too strict) or to result in lower adoption rates of ZEVs than would otherwise have been the case (not stringent enough) (Bedsworth & Taylor, 2007).						
Interaction with other types of policy instruments						
<ul style="list-style-type: none">– the provision of financial incentives in registration taxes supports OEMs to meet their mandate (strong link);– the implementation of ZEV mandates assists OEMs to meet their nationwide vehicle standard (see Factsheet 9)						

Factsheet 10 - ZERO EMISSION VEHICLE (ZEV) MANDATES	
Assessment	
Increase in alternative powertrains	++
<p>This instrument directly stimulates the adoption of alternative powertrains (FEVs, PHEVs/EREVs and FCEVs) by setting minimum requirements with respect to the sales volume in the region where it is in force. Initially, the Californian Mandate failed to result in a large offering of EVs and the original goal of 10% ZEVs in new vehicle sales were not met. The program is argued to have resulted in an important technology spill-over to hybrid vehicles (Bedsworth & Taylor, 2007). Although initially ineffective, the Californian Mandate has been defined stricter from 2017 onwards and has been implemented in 10 other States of the USA by now. The figure below shows that this is estimated to result in yearly sales of 600,000 alternatively powered vehicles by 2025 (of which 400,000 PHEVs/EREVs and 200,000 ZEVs), which is roughly 15% of the total new vehicle sales. The cumulative total is roughly 3.5 million vehicles between 2018 and 2025. Hence, in the future, it may well be effective, if no additional flexibilities reducing the effectiveness are introduced.</p> <p>Projected ZEV Compliance Scenario for the MOU States</p>  <p>Source: Task force ZEV, 2014.</p>	
Increase in renewable energy	0
<p>The impact of this policy instrument on the share of renewable energy in transport is strongly dependent on the shares of renewables in electricity and hydrogen production. The mandate itself does not impact this increase in renewable electricity, as it only targets sales of alternative powertrains. However, a shift to AFVs does result in some increase in RES-T and in energy savings.</p>	
GHG emissions reduction	+ / ++
<p>Alternative powertrains (FEVs/FCEVs in particular) can drastically reduce the GHG emissions compared to a conventional vehicle. The reduction depends on many factors, including the reference vehicle, carbon intensity of the electricity mix and the frequency of charging it (only applies to semi-electric cars) (TNO & CE Delft, 2014). ARB (2012) estimates the WTW emission reduction per kilometre to range from 75% (FEV) to 45% (PHEV/EREV) (and FCEV 65%) compared to a conventional petrol car in 2020 in the US. The absolute emission reduction depends on the coverage (number of vehicles by main vehicle type) and lifetime mileage. Applying the expected vehicle numbers presented above with a lifetime mileage of 185,000 estimates the absolute GHG emission reduction to be in the order of 150 Mt. It should be kept in mind that these GHG emission benefits overlap with the GHG emission standards (see Factsheet 9) currently in force in the US.</p>	
Coverage	++
<p>The ZEV mandates covers all new vehicle sales in a State, once implemented and therefore can have a large coverage within the State. In theory, ZEV mandates can also be implemented at federal/Union levels, which would further increase coverage. Currently this instrument is implemented in 10 States of the USA, as a result, 28% of the new car sales in the USA is now subject to a mandate (ZEV Program Implementation Task Force, 2014). Within the USA, the Mandate did result in spill-overs in EV offerings from ZEV Mandate States to non-ZEV States. Whether such spill-overs may also result if some EU Member States would adopt Mandates is uncertain, as Member States may be perceived as less homogeneous than States.</p>	
Cost-effectiveness	--
<p>ZEV mandates result in the adoption of alternative powertrains, which result in significant fuel cost savings (+) and external cost savings (+) over the lifetime of the vehicle. However, these savings are probably eroded by higher purchase prices (--), resulting in a low cost-effectiveness of ZEV Mandates. However, as purchase prices are likely to decrease in the future, ZEV mandates are likely to become more cost-effective as well.</p>	
Ease of implementation	-

Factsheet 10 - ZERO EMISSION VEHICLE (ZEV) MANDATES

Mandates are considered more difficult to implement compared to more general vehicle standards, as it leaves less flexibility to the market (Bedsworth & Taylor, 2007). The fewer technologies contribute to the sales mandate, the larger the risks that Regulators choosing suboptimal technology pathways (e.g. technologies which cannot meet consumer demands or are not the most cost-effective) (ibid.). Hence, Regulators have to determine an appropriate level of strictness and choose the ‘right’ technologies.

Other considerations

- If the ZEV mandate is credit based, it can assist **small start-up companies** which specialise in ZEVs to reach market maturity. Tesla Motors for example, has earned roughly \$ 250 million from selling ZEV credits to mainstream OEMs, which can be invested in the business (iCET, 2014).
- Lower petrol and diesel consumption can negatively impact the **governmental balance (-)** if taxes on electricity consumed per kilometre are lower than taxes on fuel consumed per kilometre. On the other hand, the significantly higher purchase price of ZEVs can increase income from registration taxes (if taxes are based on purchase price).
- ZEV mandates have a relatively larger positive impact on **energy security (++)** compared to general vehicle standards as they result in higher alternatively powered vehicles than would be the case with general vehicle standards alone (ARB, 2012). They can also positively impact **GDP (+)** and **employment (+)** (ZEV Program Implementation Task Force, 2014).

CASE STUDY: Zero Emission Vehicle (ZEV) Regulations in California**Summary of the policy instrument and objective**

California designed and adopted the first ZEV Regulations in 1990 with the objective to drastically reduce air pollutants (Bedsworth & Taylor, 2007). The ZEV Regulations force a minimal share of ZEVs in OEMs’ vehicle sales and has been designed to overcome barriers to their widespread adoption by creating market volume (ibid.). By now, it is also an important instrument for meeting California’s GHG emission goals (-80% by 2050) (ARB, 2012).

The design of the ZEV Regulations has been amended many times since its implementation in 1990 mainly to ‘reflect the pace of ZEV development and the emergence of new ZEV and ZEV-like technologies’ (ARB, 2012, p. 1). Most notably, it is now broader than pure ZEVs and based on a credit system of banking and trading. The main design elements of the existing

(2012-2017) and future (2018-2025) Regulations are:

- The existing and future Regulations cover 5 and 3 **vehicle types**, respectively, as shown in the following table.
- The Mandate is defined as a **Minimum ZEV Requirement (%)** which OEMs must meet by obtaining **ZEV-credits**. They can earn credits by producing and selling a compatible vehicle type or buy credits from other OEMs. The amount of credits generated for each vehicle sold, depends on the type of the vehicle, as shown in the following table. OEMs which fail to comply have to pay a penalty (ARB, no year):
 - The Regulation defines a minimum ‘**floor level**’ of **pure ZEV-credits** (FEVs/FCEVs) which OEMs *must* obtain.
They *may* then choose to generate the remainder with other ZEV-credits (ibid.)
- The **Minimum ZEV Requirement (%)** **differs between OEMs**. Differentiation is based on OEMs’ sales volume: smaller OEMs are exempted and the Mandate increases with volume for larger OEMs (ibid).

Definition	Vehicle type(s)	Credits 2012-2017	Credits 2018-2025
ZEV: zero emission vehicle	FEV/FCEV	1-9	1-4
TZEV: Transitional ZEV	PHEV/EREV/hydrogen ICV	1-3	0.4-1.3
NEV: Neighbourhood Electric Vehicle	Low-speed FEV (short range)	0.3	0.15
PZEV: Partial ZEV	High performing conventional vehicle	0.2	n/a
AT PZEV: Advanced technology PZEV	Natural gas vehicle/Hybrid EV	0.2-0.3	n/a

CASE STUDY: Zero Emission Vehicle (ZEV) Regulations in California**Impacts and costs**

- **Increase in alternative powertrains:** The Mandate is directly linked to the deployment of alternative energy carriers. ZEVs/TZEVs had a combined share of 2.4% in 2013 Californian vehicle sales (ICCT, 2014c), which is expected to increase to 15.4% by 2025 with the Mandate. This is expected to result in a *cumulative total* of 530,200 ZEVs and 883,700 TZEVs between 2018 and 2025. However, many OEMs currently possess banked credits, which, if used, result in 25% less TZEVs and a 1% lower share in sales by 2025 (ARB, 2012).
- **Increase in renewable energy in transport:** this impact is unclear but probably small, as the Mandate does not explicitly stimulate renewable electricity to be consumed by the ZEVs/TZEVs that entered the market.
- **GHG emission reduction:** According to ARB (2012) the ZEV mandate does not result in any additional GHG emission reductions, as ZEVs contribute to OEMs' compliance with LEV III GHG vehicle standards. A rough indication of the lifetime GHG emission savings can be made though when assuming only a ZEV Mandate would have been implemented. WTW savings compared to a conventional 2020 baseline results in savings of 76% (FEV) and 45% (PHEV). With an average lifetime of 186,000 mile in California (ARB, 2012), the above presented cumulative totals result in a GHG emission saving of roughly 60 Mt.
- **Cost impacts:** ARB (2012) estimates compliance costs for OEMs to be in the order of \$(2009) 1,840 per vehicle (2018-2025 Regulations). However, as OEMs need to comply with LEV III standards as well, incremental compliance costs resulting from the ZEV Program are \$ 500 per vehicle, resulting in total additional compliance costs of \$ 4,6 billion. These costs will result in higher vehicle prices for consumers ranging from \$ 7,500 (PHEV20) to 14,500 (FEV) per vehicle compared to a 2016 gasoline baseline vehicle. Consumers' lifetime fuel cost savings (186,000 miles) vary from \$ 6,000 (FCEV) to 10,600 (PHEV40/FEV). Together with the federal tax credit of \$ 7,500, some PHEVs and FEVs are cost-effective to the end-user; in this case, the PHEV and FEV with smaller electric ranges (20 and 75 km, respectively) result in savings of \$ 750 to \$ 1,500 over the lifetime in 2025, while the PHEV and FEV models with larger electric ranges (40 and 100 km, respectively) and FCEV are expected to result in additional net costs of \$ 500 to \$ 3,000.
- **Cost-effectiveness:** Cost-effectiveness from a social perspective is only estimated in combination with the LEV III standard: resulting in savings of \$ 290 per tonne of CO₂ in 2025 (ARB, 2012). However, as there are net incremental costs from the ZEV program on the LEV III Standard (i.e. the cost-effectiveness of the LEV III standard is higher than the combined cost-effectiveness of both the LEV III and ZEV Mandate), the ZEV program itself is likely to have (significant) net costs to society. However, this instrument is likely to become more cost-effective in the future, as purchase costs of ZEVs are likely to decrease in the future as well.

Future plans

- the Mandate has been defined up to 2025 and it is unclear whether it will be continued hereafter;
- California (and other States) has (have) committed to expand supporting policies (e.g. financial incentives, HOV lanes) to ensure vehicle sales are consistent with the Mandate (ZEV Program Implementation Task Force, 2014).

References used: ARB, no year, 2012; ZEV Program Implementation Task Force, 2014; Bedsworth & Tayler, 2007; ICCT, 2014c.

C.3 TRAFFIC AND LAND-USE POLICIES**Factsheet 11 - INCENTIVES IN PARKING POLICIES****Description of the instrument**

Many **local authorities** have implemented parking policies to stimulate alternative fuel vehicles (AFVs) and/or environmentally friendly conventional cars. In general, three categories of measures can be distinguished (based on CROW, 2010):

- **parking fee measures;** exempting AFVs from parking fees incentivises people to use these vehicles (e.g. implemented in Barcelona, Copenhagen, Helsinki, London, Madrid, Oslo, Salt Lake City, San Jose);
- **parking capacity measures;** allocating parking spaces to AFVs and/or implementing preferential parking permits in dense urban areas, can stimulate AFVs (e.g. implemented in Amsterdam);
- **parking duration measures;** exempting AFVs from maximum parking times and/or providing them the opportunity to park for free for a specified time period, stimulates these vehicles (e.g. implemented in Malmö, Reykjavík).

Main impacts on

Factsheet 11 - INCENTIVES IN PARKING POLICIES						
	Energy carriers	Energy infrastructure	Vehicles			
			Car	LCV	Light truck	Bus
Electricity			X	X		
Hydrogen			X	X		
Biofuels			X	X		
Results of the assessment						
Increase alternative powertrains (+)	Increase renewable energy (o)	GHG reduction (o/+)	Coverage (o)	Cost-effectiveness (-)	Ease of implementation (o/+)	
Country coverage						
Implemented Many cities in Europe (e.g. Amsterdam, Barcelona, Graz, London, Malmo, Paris, Oslo) and the US (e.g. Sacramento, Salt Lake City, San Jose).			Implementation being considered Many cities (including Beijing , Los Angeles).			
Design options						
The three types of parking policies that can be implemented to stimulate AFVs share a number of key design elements:						
<ul style="list-style-type: none">– Target group: policies can be focussed on parking licensees (mainly inhabitants of the inner-cities) or people parking on-street (CROW, 2010). Policies targeting the former group are expected to be more effective in terms of stimulating the purchase of AFVs, since these people have less options to evade the scheme. Moreover, they are continuously confronted with the policies, while - in most cities - a large share of the people parking on-street visit the city incidentally (Ecorys and CE Delft, 2012).– Geographical scope: policies can be implemented in inner-city only, but implementation in the outskirts of the city is possible as well. The latter option increases the effectiveness of parking policies, not only because more vehicles are covered, but also because evading parking policies becomes less attractive (i.e. it becomes less attractive to evade the parking policy by parking just outside the parking zone) (CROW, 2010).– Conditions to qualify for benefits (e.g. discount on parking fees, preferential parking spaces); although in all schemes conditions are set which vehicles must meet to qualify for a preferential position, the definition of these conditions differs. In some schemes only EVs are targeted, while in other schemes also other AFVs or even fuel-efficient or clean conventional vehicles qualify for the defined benefits.– Incentive level; schemes differ in incentive levels set (e.g. 50 or 100% discount on parking fees for AFVs).						
Key lessons learned with respect to renewable energy in transport						
<ul style="list-style-type: none">– Parking policies can be used to achieve various objectives, such as financing parking facilities, parking and transportation demand management, to generate additional revenues, and to stimulate (the use of) environmentally friendly vehicles (VTPI, 2011). In order to find a good balance between these objectives, a trade-off between generating additional revenues and managing transport demand on the one hand and stimulating AFVs on the other hand should be made. E.g. by providing free parking to AFVs, the scheme generates less revenues.– By harmonising the parking policies applied in different cities, the effectiveness of the scheme can be improved. Therefore, in some countries (e.g. Norway, Germany (planned)) national frameworks for parking policies as regards to stimulating AFVs are implemented (Windisch, 2013).– The effectiveness of incentives in parking policies in stimulating AFVs can be strengthened by harmonising these policies with incentives given by other policy instruments, like urban congestion schemes, incentives in registration taxes, company car taxes, etc. For example, the same criteria for determining which vehicles qualify can be adopted.						
Interaction with other types of policy instruments						
This instrument is closely linked to other local instruments such as urban road pricing schemes. If these instruments target the same vehicles they can strongly reinforce each other. Additionally, strong linkages exist with incentives provided in vehicle taxes (vehicle registration taxes, company car taxes).						
Assessment						
Increase in alternative powertrains				+		

Factsheet 11 - INCENTIVES IN PARKING POLICIES

The empirical evidence about the impact of parking policies on the uptake of AFVs is scarce and fragmented. On the one hand, ICCT (2014c) found that free parking for FEVs has no strong impact on the amount registered. However, their results are based on a relatively small sample size and they have used early EV sales which were very small at the time. On the other hand, results from a pilot with free parking for AFVs in Malmö showed a significant increase of 10% in the number of AFVs sold (CIVITAS, 2008). Also the results of a pilot in Winchester (UK) provide some evidence that parking policies may significantly contribute to an increase of AFVs (MIRACLES, 2006), although these results are less clear than those of the Malmö pilot. To conclude, parking policies may have a small positive impact on the number of AFVs purchased.

Increase in renewable energy

0

The impact of this policy instrument on the share of renewable is strongly dependent on the shares of renewables in electricity and hydrogen production. These shares are not influenced by the policy, but depend on other policy instruments, like policies for increasing renewable power production. Some cities have implemented parking policies where bi-fuel vehicles are incentivised as well. In these cases there can be a (small) increase in the amount of biofuel consumed, but only if the user purchases biofuel instead of conventional fuel.

GHG emissions reduction

o/+

In general, parking policies can contribute to a CO₂ emission reduction in the parking zone (CROW, 2010; Ecorys and CE Delft, 2012). However, part of the reduced CO₂ emissions will leak away, as CO₂ emissions may increase as a result of additional transit use and car travel to other cities (CE Delft, 2010). The net benefits are expected to be positive.

Less evidence is available on the CO₂ impact of parking policies specifically stimulating AFVs. Given the fact that these policies are expected to have only a small impact on the number of AFVs (see above), the CO₂ reduction associated with these policies is probably small and in some cases insignificant. For example, the pilot in Malmö showed a CO₂ reduction of approximately 0.2 kton per year.

Coverage

0

This instrument only covers the vehicles that are owned by inhabitants of the city and/or vehicles owned by people regularly visiting the city in which the parking policy is implemented. Therefore, this instrument covers a significantly smaller part of the vehicle fleet than EU-wide or nation-wide instruments.

Cost-effectiveness

-

There is no evidence available on the cost-effectiveness of parking policies stimulating AFVs. On the one hand, parking policies focussed on stimulating AFVs result in higher vehicle costs, as the higher purchase costs of these vehicles (--) cannot be fully compensated by fuel cost savings (+) (CE Delft & TNO, 2012). Additionally, there are governmental costs to implement these schemes (-). On the other hand, the shift to AFVs may result in a reduction of GHG emissions, air pollutants and noise levels (+), which from a social perspective, can be seen as benefits. However, it may be expected that these benefits are not sufficient to compensate for the costs (based on CE Delft & TNO, 2012) and hence it is expected that these schemes are not cost-effective from a social perspective.

Ease of implementation

o/+

This policy is relatively easy to implement, particularly the capacity measures. Introducing differentiated parking fees (e.g. 100% discount for AFVs) is more complex, since it requires more advanced parking meters. However, the additional costs of these meters are low (CROW, 2010; Windisch, 2013).

Other considerations

n/a

CASE STUDY: Lower parking tariffs for low-emission cars in Graz**Summary of the policy instrument and objective**

The Austrian city of Graz has implemented a city-wide parking management scheme in order to reduce the travel flows to the city centre and to support the reduction of air pollutant emissions (CIVITAS, 2006). A parking fee system with 'blue zones' and 'green zones' was introduced in 2004 and over the years the scope of this scheme was enlarged. The blue zones are areas in and around the inner city with short-term parking regulation (a maximum of 3 hours), while the green zones allow to park for longer time periods.

In addition to the introduction of a city-wide parking fee system, Graz introduced reduced parking tariffs for low emission vehicles (eco tariff). In order to qualify for this reduced tariff, vehicle owners have to register their cars with the city of Graz and then they receive a special parking coin (Umweltjeton) - that can be used in ticket machines - and a parking badge identifying the car. The badge has to be placed visible on the dashboard behind the windshield. In the period 2004-2013 a car had to meet the following criteria to qualify for the reduced tariff:

- petrol powered vehicles had to achieve the Euro IV norm and emit less than 140 gram CO₂ per kilometre;
- diesel powered vehicles had to achieve the Euro IV norm, should be equipped with particle filters and emit less than 130 gram CO₂ per kilometre;
- gas powered vehicles have to achieve the Euro IV norm and emit less than 140 gram CO₂ per kilometre.

Since October 2013 the reduced parking fees for environmental friendly conventional cars are abolished, since advanced technology caused too many vehicles met the criteria (www.graz.at). Instead, a complete exemption of parking fees for (semi-)electric vehicles was introduced. However, in the 'blue zones', the maximum parking time of 3 hours also applies to these vehicles.

The main aim of the lower parking tariffs for low-emission cars was to increase the number of smaller and/or lower emission vehicles in the city centre, particularly to improve its air quality (CIVITAS, 2006). Additionally, it was meant to develop and implement a parking model system that was acceptable for citizens and feasible from a technical and organisational point of view.

Impacts and costs

- **Increase in alternative powertrains:** Lowering parking tariffs for AFVs (slightly) improves the TCO of these cars compared to conventional vehicles. For example, a regular visitor of Graz (e.g. three times a week, parking 2 hours per visit) can save approximately € 560 per year by using an AFV. Unfortunately, no evaluation studies on the exemption of parking fees for (semi-)electric vehicles have been carried out yet. The previous scheme with discounts for all low-emission cars has been evaluated in 2006 (Trendsetter, 2006). Although this evaluation study did not provide empirical evidence for an increase of environmentally friendly cars due to the parking measures, it showed that 30% of the interviewed visitors/inhabitants of Graz expect that car users will be influenced by the measure (buying environmentally friendly cars, parking outside the inner-city). However, it is unclear to what extent these expectations have been actually realised.
- **Increase in renewable energy in transport:** This impact is unclear but probably small, as the measure does not explicitly stimulate renewable electricity to be consumed by the FEVs/PHEVs in Graz.
- **GHG emission reduction:** The increase of (semi-)electric cars visiting Graz will probably result in a reduction of CO₂ emissions emitted in the inner-city of Graz. However, no empirical evidence is available on the size of this CO₂ reduction. For the previous (broader) scheme, a CO₂ reduction of 435 tonnes per year was estimated (Trendsetter, 2006). It should be noted that this measure could result in rebound effects (people parking more often outside the paid parking zones, people visiting other cities than Graz) which partly offset these positive CO₂ effects.
- **Cost impacts:** No empirical evidence is available on the costs of this measure. It may be expected that the main costs for the local authority are related to implementing, monitoring and enforcing the scheme. For users, there are higher purchase costs of EVs, but at the same time lower fuel costs.
- **Cost-effectiveness:** No estimates have been found on the cost-effectiveness of exempting EVs from parking fees. However, from a social perspective, the switch to FEVs and PHEVs is unlikely to be cost-effective on its own, as the purchase cost (excl. taxes) cannot be compensated fully by fuel cost savings. Therefore, we expect that this measure is currently not cost-effective.

Future plans

- No information is available on any future plans.

References used

CIVITAS (2006), Trendsetter (2006).

Factsheet 12 - HIGH OCCUPANCY VEHICLE (HOV) LANES INCENTIVES**Description of the instrument**

In certain states and municipalities, alternative fuels vehicles have been granted access to faster-moving highway lanes that are traditionally reserved for high occupancy vehicles (HOV lanes). The access has been granted to incentivize purchase and use of vehicles based on their technology, typically HEV, BEVs or FCEVs, but not typically alternative fuels like biofuels.

Main impacts on

	Energy carriers	Energy infrastructure	Vehicles			
			Car	LCV	Light truck	Bus
Electricity			X	X	X	
Hydrogen			X	X	X	
Biofuels						

Results of the assessment

Increase alternative powertrains (+)	Increase renewable energy (o)	GHG reduction (o/+)	Coverage (o/-)	Cost-effectiveness (+)	Ease of implementation (o/+)
--------------------------------------	-------------------------------	---------------------	----------------	------------------------	------------------------------

Country coverage

Implemented

US, Norway

Implementation being considered

Unknown

Design options

The policy provides incentives to selected vehicles by giving access into car-pool, “eco-lanes”, bus-lanes or high occupancy vehicle (HOV) roadways lanes, which are generally faster and less congested. The policy allows single-occupant AFV’s an exemption from the multi-person requirements for access.

- The policy is often tailored to encourage new “green” technology vehicles as they are being introduced commercially. For example, an unlimited number of non-plug-in hybrids were given HOV lane access in California in the early stages, but are now only part of a limited pool of 40,000 eligible vehicles. Currently, an unlimited number of PHEVs, FEVs, hydrogen and CNG powered vehicles are allowed in the HOV lanes.
- The policy can be technology and specific to fuel-type, depending on local and national goals.

Key lessons learned with respect to renewable energy in transport

- In the US, the policy is state specific and has not included high-blend biofuel vehicles traditionally included in the Federal definition of “Alternative Fuelled Vehicles”.
- Customers place a high value on HOV access at time of purchase of AFVs. In a 2009 study (Audetex 2009) comparing used Honda Civics prices (hybrid vs. non-hybrid) and normalizing across a multi-state baseline, hybrids achieved a \$ 1,200-1,500 premium for 4 year old vehicles which was attributed to the HOV stickers (see also Jin, 2014). California HOV sticker availability and eligibilities changes makes it impossible to calculate the current absolute value of the HOV sticker-premium for AFV’s, but OEMs anecdotally describe it as a major factor (Reeves, 2012; see also interviews section). In California, a 2013 survey (Tal 2014) found that HOV stickers were often the primary motivation to buy plug-in vehicles for the Nissan Leaf (38%), Chevrolet Volt (34%) and Toyota Prius Plug-in (57%).
- OEMs have reported anecdotally that early adopters of AFVs, currently PHEVs and FEVs, are affluent and value the time savings (offered by HOV access policies) over the price incentives. This is confirmed in the by a recent study of EV purchasers (Tal 2014): “We observed a significantly higher household income among owners with [HOV] stickers than among those without stickers (\$ 173,000 with a sticker vs. \$ 145,000 without a sticker). This difference may reflect the higher value of time of PEV owners who obtained the sticker and also the higher relative value of the state rebate to PEV owners who did not obtain the sticker.”

Interaction with other types of policy instruments

This instrument is closely linked to HOV initiatives aimed at reducing traffic and regional pollution. HOV lane development is almost always initiated by highway policy programs for traffic considerations, and renewable fuels or AFV policy have not been noted as a factor in HOV lane development.

Assessment

Increase in alternative powertrains

+

Factsheet 12 - HIGH OCCUPANCY VEHICLE (HOV) LANES INCENTIVES

There is no qualitative analysis on AFV sales volumes related to HOV lane access incentives. Anecdotal reports from AFV manufacturers (e.g. Reeves 2012) and preliminary sales analysis (Tal 2014) indicate that HOV access is a strong factor in AFV's sales. Jin (2014) place HOV lane access on par with price incentives and inspection incentives for the sales of PHEV and FEVs. Anecdotal inputs from discussions with OEMs (see also interviews section) suggest that, for current EV role-out in the US, OEMs feel this instrument has been at least as important to the introduction of EVs sales as price incentives, as they perceive first-adopters are more affluent and therefore more time sensitive than price sensitive. To conclude, this policy probably plays a significant role in the uptake of these vehicles.

Increase in renewable energy

0

The impact of this policy instrument on the share of renewables in transport is strongly dependent on the shares of renewables in electricity and hydrogen production. These shares are not influenced by the policy, but depend on other policy instruments, like policies for increasing renewable power production.

GHG emissions reduction

o/+

The GHG emissions reductions from this instrument are not strongly quantifiable. Some theoretical research for EU mid-sized cities (Fontes 2014) showed that the introduction of HOV lanes that encouraged AFVs (eco-lanes) would not reduce emissions if AFVs were already in the market. Emissions are highly dependent on the source energy. Single-occupancy AFVs that displace multi-passenger vehicles HOV lanes have a less favourable impact. Overcrowding in the HOV lane (possibly by AFV access in excess of lane capacity) makes the AFV HOV incentive less appealing. California used limits on permits for hybrids to prevent overcrowding.

Coverage

o/-

Currently, 12 states in US offer this incentive, as well as some EU Member States. However, maximum future theoretical usage in developed nations is limited to regions where existing or future road infrastructure improvements could accommodate dedicated lanes that produce time-saving through congestion avoidance. Growth of this policy in those regions is highly dependent on existing infrastructure and regional growth patterns. However, in developing countries, where vehicular infrastructure is expanding rapidly, dedicated lane growth may be faster.

Cost-effectiveness

+

Considering the relatively low cost of this instrument, the effect-to-cost ration is high even if the regions of potential implementation (e.g. areas with existing HOV lanes) is relatively small.

Ease of implementation

o/+

Implementation has been historically easy and inexpensive compared to other instruments (++), but execution is limited to areas where HOV and carpooling lanes exist or are planned. Overcrowding in HOV lanes is an issue (noted in earlier) for use of this instrument. Hybrid vehicles are being phased out of the HOV program in California for this reason. Since HOV lane access is finite, it is expected that long-term use of the policy for certain AFVs will not be possible or effective if vehicles with those technologies become commonplace (-).

Other considerations

Anecdotal input from OEM's imply that this instrument would not be as strong an instrument (e.g. vs. price incentives) as alternatively fuels vehicles; A), become less of a novelty; and B), reach modest vehicle price-points. However, these variables are not quantifiable within the scope of this study.

Factsheet 13 - URBAN ACCESS RESTRICTIONS**Description of the instrument**

Urban access restrictions are instruments to restrict the circulation in urban areas through access limitations in the form of environmental zones (low emission zones), limited travel zones (LTZ or ZTL (it)), road space rationing, city tolls and congestion charging. The financial restriction instruments (city tolls and congestion charging) are covered by Fact sheet 5 (Incentives in urban road pricing and tolls). The regulatory measures are covered in this fact sheet.

In an environmental zone, access for vehicles that do not meet the emission standard is forbidden. In limited travel zones, access is limited to certain periods, activities or groups (e.g. residents and local entrepreneurs). Road space rationing allows daily car usage which is based on the number plate (i.e. last digit even or odd). Urban access restrictions are implemented at **local level**. Implementation schemes are often arranged at country level.

Main impacts on

Factsheet 13 - URBAN ACCESS RESTRICTIONS

	Energy carriers	Energy infrastructure	Vehicles			
			Car	LCV	Light truck	Bus
Electricity			X	X	X	X
Hydrogen			X	X	X	X
Biofuels						
Results of the assessment						
Increase alternative powertrains (o/+)	Increase renewable energy (o)	GHG reduction (o/+)	Coverage (o)	Cost-effectiveness (?)	Ease of implementation (o)	
Country coverage						
Implemented Cars vans and HDVs: Many cities in Europe (e.g. Berlin, Milan, Athens), Latin America (e.g. Mexico City, Santiago) and China (e.g. Beijing, Nanchang, Changchun). Other cities are Teheran and Singapore.			Implementation being considered Cars vans and HDVs: multiple cities, e.g. Antwerp (2016), Paris (july 1015/2016).			
Design options						
Many different design options are possible for the different urban access restrictions (PWC, 2010): <ul style="list-style-type: none">– Primary Objective (Congestion reduction/Environment/Other): In environmental zones (mainly in Europe) the primary objective is air quality. For road space rationing (mainly in China and Latin America) the objectives are mainly air quality and congestion reduction. In limited travel zones liveability (i.e. passenger zones) can be a goal in addition to air quality and congestion reduction.– Targeted Vehicles (Private cars/Freight/all).– Time of operation (e.g. 24h/Day time).– Type of enforcement (Manual/Stickers/Camera recognition/ Rising bollards).– Exemptions on the restriction: Exemptions of the restrictions can be made, for example for residents or special traffic. Environmental zones only allow vehicles that meet a certain emissions standard. Likewise, there are several schemes in which exemptions are made for EVs (e.g. Athens, Beijing). An overview of different access restriction schemes in the EU can be found via: http://urbanaccessregulations.eu/general-overview .						
Key lessons learned with respect to renewable energy in transport						
<ul style="list-style-type: none">– Environmental zones can be specifically effective in reducing air polluting emissions (EC, 2015). With the restrictions on air polluting emissions, the schemes, however, also discourage driving old vehicles and encourage the purchase of new vehicles that fulfil the requirements to enter the environmental zone. As an increasing, though still limited, share of the newly sold vehicles in many countries is alternatively fuelled, the contribution of environmental zones to fleet renewal indirectly positively impacts the limited growth in the number of AFVs. For example, a distribution company that is not allowed to use its euro 3 vans anymore in the city centre, might decide to replace these by new vans. These could be conventional euro 6 vans, but also electric vans might be considered, especially when they are subsidized. Depending on the share of (and goals for) renewable energy in a country this contributes to more renewable energy in transport.– Limited travel zones restrict the access of vehicles. In many cases EVs (e.g.. Perugia, Krakau) and/or natural gas (mainly in Italy, Parma, Imola) are exempted from these restrictions. For bi-fuel vehicles such exemptions are non-existent or unknown (PWC, 2010). This may stimulate consumers to buy an EV. Depending on the share of (and goals) for renewable electricity and bio-CNG this contributes to more renewable energy in transport.– Road space rationing restricts car use by assigning time frames in which cars may be used which is often based on licence plates (e.g. odd and even last digits of number plates assigned to certain days of the week) . In several cases exemptions are made for EVs (e.g.. Beijing, Mexico City, Athens), thereby stimulating the purchase of EVs and possibly renewable energy, depending on the electricity production. However, road space rationing has been found to have a negative impact on car possession in Mexico City (Davis, 2008).To be able to drive every day, people bought cheap, used second hand cars on conventional fuels (with a different last digit on the number plate), with higher than average emission profiles. In Mexico City no environmental benefits were found according to Davis. However, in Beijing, road space rationing led to an emission reduction of 9% (ACGSB/WISE 2013).						

Interaction with other types of policy instruments	
The instruments described above are often combined with charging schemes and tolls (e.g. Stockholm, Milan). Charging schemes can be very effective in stimulating alternative fuels. In general access restrictions promote the purchase of new vehicles. Therefore, access restriction schemes can support instruments that stimulate AFVs, such as subsidies for EVs or bi-fuel vehicles. Access restriction schemes are often supported by a (temporal) scrappage scheme.	
Assessment	
Increase in alternative powertrains	o/+
EVs are stimulated mainly due to their exemption from restriction schemes. The effectivity of this instrument has not yet been evaluated but is expected to be positive.	
Increase in renewable energy	o
The impact of this policy instrument on the share of renewable is strongly dependent on the shares of renewables in electricity and hydrogen production. These shares are not influenced by the policy, but depend on other policy instruments, like policies for increasing renewable power production. However, a shift to AFVs does result in some increase in RES-T and in energy savings.	
GHG emissions reduction	o/+
Most schemes aim at congestion reduction and air pollution reduction. Their impact on GHG reduction is indirect by promoting newer (often more efficient) vehicles. A stronger effect on GHG reduction is obtained in schemes where EVs are exempted from the restriction (e.g. Beijing, Mexico City) and/or when requirement are set on the CO ₂ emission standard of the vehicles for entrance (only very few examples, e.g. Athens). Most effective schemes to reduce CO ₂ involve tolls and road pricing (see Factsheet 5).	
Coverage	o
This instrument only covers the vehicles that want to enter a city. Therefore, this instrument covers a significantly smaller part of the vehicle fleet than Union-wide or nation-wide instruments.	
Cost-effectiveness	?
<p>The cost-effectiveness of the schemes depends on the design of the access restriction zones. The main costs of access restriction schemes are implementation and enforcement costs for the government and costs for the vehicle owners/users. The vehicle owners/users experience costs of not being able to use the vehicle in certain areas and/or for replacing the old vehicle by a new one. The main benefits of access restriction schemes are a reduction in air polluting (and climate) emissions and reduced congestion (reduced travel time). In case of restricted zones in historical city centres, liveability and tourist accessibility might be important benefits as well.</p> <p>From a social perspective, the cost-effectiveness of schemes will be higher when they are targeted at restricting vehicles with the highest emissions per kilometre. There are several examples of environmental zones schemes found to be cost-effective. (TML, 2012; APUR 2012). However, the more vehicles are restricted, the higher the costs imposed on vehicle owners/ users and the lower the cost-effectiveness will be (Goudappel/CE Delft, 2008). For road space rationing schemes, restrictions are not specifically targeted at polluting vehicles. The cost-effectiveness of road space rationing is expected to be much lower (Viuard and FU 2014; Davis 2008). However, the costs and benefits should be evaluated on a case-by-case basis. For governments, the costs of implementing an access restriction are relatively low compared to other measures for improving air quality (DIVV, 2011).</p> <p>There are no existing examples of access restriction zones solely allowing electric, H₂ or bi-fuel vehicles. However, such a zone is expected to impose very high costs to vehicle owners/users. In this case, the benefits need to be very high to ensure a cost-effective access restriction.</p> <p>For existing restriction schemes there are many examples that exclude electric vehicles from the restriction. Excluding electric, H₂ or bi-fuel vehicles from existing schemes makes it more beneficial for people to own these vehicles, which might increase the share in the vehicle fleet. Exclusion from existing schemes is therefore expected to be very cost-effective (not taking the cost effectivity of the scheme itself into account), as the costs of permitting these vehicles are very low (mainly congestion costs). Although the cost-effectiveness might be high, the total effect on the number of alternative energy vehicles might not be very high.</p>	
Ease of implementation	o
This policy is complex, but there are many examples around the world that can be adopted. Therefore, implementation is not considered to be complex.	
Other considerations	
n/a	

CASE STUDY: Environmental Zoning – China

In light of the Beijing Olympics 2008, the Beijing government set an access restricted zone for conventional vehicles entering the city's zones based on the plate numbers on alternative dates to reduce traffic congestions.

Vehicles with an even numbers on their last digit license plate i.e. 0, 2, 4, 6 and 8 can only enter the city's zone on Tuesdays, Thursdays and Saturdays while vehicles with odd numbers i.e. 1, 3, 5, 7 and 9 are only allowed to enter the city's zone on Mondays, Wednesdays, Fridays and Sundays.

On April 7, 2015 in addition to the “odd” and “even” days, the Beijing government issued a Notice on weekday rush hour limit line area (Beijing 2015) that is implemented within the Fifth Ring Road on Monday to Friday from April 11, 2015 to April 10, 2016. Exemptions apply to:

- police cars, fire engines and ambulances;
- public electric vehicles, long-distance passenger vehicles coming in from other provinces, taxis, mini public transportation vehicles, postal vehicles, tourist vehicles (with license from the city traffic bureau), public security vehicles and school buses;
- administrative vehicles including those with the purpose of clearing car wrecks;
- vehicles with environmental, gardening, road repair and maintenance purposes, casket vehicles;
- diplomatic vehicles; and
- **pure electric vehicles** (defined as a vehicle with its rechargeable battery as the sole power and has an electric drive engine).

In addition there are restrictions for cargo vehicles and vehicles not meeting emission standards (Beijing 2014):

- Every day from 6 AM to 11 PM, cargo vehicles are not allowed to enter the city starting with the Fourth Ring Road, and cargo vehicles with gross vehicle weight of 8 tons and above are not allowed to enter the city starting with the Fifth Ring Road.
- For all days at all times, gasoline vehicles not meeting Euro I and diesel vehicles not meeting Euro III standards (defined as yellow labelled vehicles) are not allowed to enter the city (including Sixth Ring Road) and its suburbs. Passes will not be given to these vehicles to operate in the city by the city government departments.
- Yellow labelled vehicles registered in the city are required to undergo emissions testing every 3 months. Vehicles that fail the testing are not allowed to run on the roads.

For vehicles coming into the city from other provinces other restrictions apply.

These regulations are often changing as and when needed.

Following the success of Beijing, other cities such as Nanchang, Changchun, Lanzhou, Guiyang, Hangzhou and Chengdu are also implementing access restriction zones in the city mainly at peak hours to ease traffic congestions and improve air quality.

Impacts and costs

- **Increase in alternative powertrains:** Even though these access restrictions aim to reduce the traffic congestions in the city centre, the exemption applied to electric vehicles is also used by the government to promote the use of electric vehicles. The impact of the exemptions on the number of electric vehicles is unknown.
- The combination of all measures to promote new energy vehicles, however, has increased the number of electric vehicles in major cities in China. Sales of new energy vehicles reached 38,163 units with 22,258 units are electric vehicles and the remaining 15,905 units are plug-in hybrid vehicles in from January to October 2014. A total of 74,763 units of new energy vehicles were sold in China in 2014. IEA estimates that about 83,198 electric cars and 36,500 electric buses run on Chinese roads at the end of 2014.
- **Increase in renewable energy in transport:** In the case of electric vehicles, the (indirect) impact on renewable energy depends on the source of electricity. In China 9% of the electricity is generated from renewable energy sources, the main source of electricity production in China (67%) is coal (BP 2014).
- With regard to biofuels, the volume of biofuels used in China will increase mainly because of increases in consumption of gasoline and diesel. However, these increases will not result in a higher share of biofuels in the total gasoline and diesel consumed by the transportation sector. Restriction zones do not directly influence the share of biofuels.

CASE STUDY: Environmental Zoning – China

- **GHG emission reduction:** The access restriction zone for conventional vehicles is expected to reduce CO₂ and traditional air pollutions in major cities during the restriction times.
- In addition, the shift to electric vehicles in China is expected to further improve air quality at the same time reduce GHG emissions from the transportation sector. However, because more than 50% of electricity is generated from coal, it is highly probable that this shift will increase GHG emissions from the electricity generation sector in the short term.
- In the long-term, the government is expected to reduce the share of coal and increase the share of renewables in its energy mix. The share of non-fossil fuel energy is projected to increase reaching 15% in 2020 and 24.5% in 2035. Thus, CO₂ emission is expected to reduce in line with reduction in coal consumption.
- **Cost impacts:** Direct costs of this policy are not reported. Most important costs for the government are expected to be the costs for monitoring and enforcement schemes. Cost for businesses may relate to the change in time of receiving goods supply in the city centre area and potential longer route as the vehicles need to detour during the restriction hours(--). Civilians experience (non-)monetary costs of not being able to travel into the city centre with their vehicle on the designated days. Indirect costs, related to the exemptions of electric vehicles, will mostly be in the form of infrastructure establishment (charging stations and increasing capacity of the grid) (--) and R&D on the shift of public transport from conventional vehicles to electric vehicles (--). The benefit will be in the form of reduction of fossil fuels consumption (less usage of vehicles) (++), air quality improvement (++) and congestion reduction (reduced travel time).
- **Cost-effectiveness:** The cost-effectiveness has not yet been fully studied but it is clear that large costs are involved (Viuard and FU 2014). Air pollution problems in Beijing, however, are also significant and reducing traffic can significantly reduce air polluting emissions. It is likely that the cost effectivity can be improved by targeting specifically at highly polluting vehicles as, is partly already done within the scheme.

Future plans

The future policy pertaining to this access restriction zone is unknown. The government is expected to revise/adjust/add the access restriction zones depending on the traffic and air quality situation.

References used

China Central Government, Beijing Municipality Government, Shanghai Municipality Government

C.4 OTHER POLICIES

Factsheet 14 - INFORMATION PROVISION

Description of the instrument

Information provision is a very broad instrument that can encompass many aspects of renewable energy in transport. In this fact sheet, three aspects of information provision are covered which are crucial to increase renewable energy with transport policy at this moment. The aspects are:

1. Transparency of fuel prices.
 2. Biofuel labelling (also CO₂ foot printing of fuels).
 3. Locations of filling stations for hydrogen and biofuels and charging points for BEVs.
- Information provision can take away barriers to the uptake of renewable energy in transport by increasing consumer acceptance.

1. Transparency on fuel prices

Understandable and comparable prices are an important factor for the successful market introduction of alternative fuels. The fuels offered at filling stations are priced in different units (e.g. petrol/diesel in litre/gallon, hydrogen in kg and electricity in kWh). It is therefore not possible to directly compare different fuel prices at filling stations. This is further complicated by the fact that fuel use per kilometre differs significantly.

To increase the share of alternative fuels, a reform of pricing would be helpful. The price-performance ratio of different fuels could be made comparable, which would enable consumers to make a better informed decision. Moreover, the attractiveness of alternative fuels could be made more visible, which would improve their position in the competitive market.

2. Biofuel labelling (also CO₂ foot printing of fuels)

When biofuel is blended with conventional fuels, confusing and inconsistent fuel labelling can cause transport users to make purchasing mistakes (i.e. buy fuel that may be incompatible with their vehicle). This can result in significant damage to vehicles. The introduction of standardised labelling provides more clarity to transport users and prevent errors being made at the fuel pump (AAA, 2011). Furthermore, adding CO₂ labelling would show the impact of different fuels (and electricity and hydrogen), which may stimulate consumers to buy fuels/electricity/hydrogen with lower CO₂ emissions. For both reasons, it is important to show relevant, consistent and clear information on the compatibility and CO₂ emissions of fuels and vehicles.

3. Locations of filling stations for hydrogen and biofuels and charging points for BEVs.

Range anxiety and locating charging points can be a major concern for BEV drivers. The limited driving range and limited availability of public charging infrastructure have been reported as barriers for BEV uptake. Range anxiety can be reduced by ensuring that BEV drivers have freely available online access to BEV charging point information, including live availability of the charge points and their locations (Lilley, Kotter and Evatt, 2013). Currently this is only applied to BEVs, however, in the future information services on locations of hydrogen and high blends biofuel can be developed.

EV telematics packages, containing a Point of Interest (POI) and navigation packages, could reduce range anxiety and range conservation and encourage mass adoption of BEVs (Frost and Sullivan, 2009). Currently, in-vehicle navigation systems provide the location of charging points to BEV drivers, as key destinations similar to POIs. The location of the charging points is collected and integrated into digital maps by the map provider of the in-vehicle navigation system. The charging point data could be improved by including information on location, private access, connector or power feed types, the number of connectors, and opening hours and payment methods (Lilley, Kotter and Evatt, 2013).

Main impacts on

	Energy carriers	Energy infrastructure	Vehicles			
			Car	LCV	Light truck	Bus
Electricity	X	X				
Hydrogen	X	X				
Biofuels	X	X				

Results of the assessment

Factsheet 14 - INFORMATION PROVISION

Increase alternative powertrains (o/+)	Increase renewable energy (o/+)	GHG reduction (o/+)	Coverage (+)	Cost-effectiveness ss (?)	Ease of implementation (+)
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Country coverage**1. Examples of transparent on fuel pricing**

- In the USA, natural gas is priced as fuel per gasoline gallon equivalent (GGE) or gasoline litre equivalent (GLE). This sales unit is used on the filling station totem, the pump and the cash register receipt.
- In addition, regulators in several countries use price comparison websites as a tool to increase price transparency (e.g. Greece, Spain, France, Cyprus, Austria, and Portugal and proposed in Germany). In these countries, regulatory rules have been enacted that require fuel retailers to notify their prices to a publicly administered database which in turn serves as the foundation for one or more comparison websites (CIVIC, 2014).
- The EU Clean Power Directive (Art 7) states that when fuel prices are displayed at a fuel station, in particular for natural gas and hydrogen, it should be possible to compare unit prices to conventional fuels, (e.g. '1 petrol litre equivalent'), by information disclosure. A common methodology will be developed.

2. Examples of biofuel labelling

- The EU has stated in the Clean Power for Transport (CPT) Directive that Member States shall ensure that relevant, consistent and clear information is made available on the compatibility of the fuels and vehicles. Such information has to be made available in motor vehicle manuals, at refuelling and charging points, and at motor vehicle dealerships. Graphical expressions (e.g. a colour coding scheme) have to be easy to understand, simple, clearly visible, on corresponding pumps and nozzles at all refuelling points, in immediate proximity of all fuel tanks' filling caps and in motor vehicle manuals (for new vehicles sold after November 2016).
- The European FQD and RED also require the provision of appropriate information to consumers about the biofuel content of petrol (and on the appropriate use of different blends of petrol) and diesel (FQD). If the percentages of biofuels exceed 10% by volume this should be noted at sales points (FQD). Likewise, information should be provided on the availability and environmental benefits of all different renewable energy sources for transport (RED).
- The US has introduced the E15 Misfuelling Mitigation Plan (EPA 2012). This plan prohibits the use of gasoline containing more than 10 vol% ethanol in vehicles, engines and equipment not covered by the partial waiver decisions (i.e., MY2000 and older LDVs, all gasoline HDVs and motorcycles). Furthermore the plan uses a label (see below) for fuel pumps that dispense E15 to alert consumers to the appropriate and lawful use of the fuel. Biofuel labelling is also required by the Federal Trade Commission which governs this aspect of fuel regulation in the US.

**3. Examples of locations of charging infrastructure for EVs (also FCEVs)**

- In the US, the focus is on developing and installing uniform signage on federal highways: through the West Coast Electric Highway initiative, the departments of transportation in Washington, Oregon, and California adopted a standardised symbol to identify publicly accessible BEV charging stations along major roadways.
- Washington state law (RCW 46.08.185) requires that BEV charging stations are clearly identified with the following: (1) an "EV Charging Station" sign; (2) a "No Parking Except for Electric Vehicles Charging" sign; and (3) green pavement markings (ZEV Program Implementation Task Force, 2014).
- The UK National Chargepoint Registry (UK Department for Transport 2011) is a real-time publicly-accessible database of public charging points across the UK, funded by the national government. The Registry allows businesses to innovate and provide supporting products, such as satnav and mobile apps, to make it easier for plug-in vehicle owners to access charging points.
- Some companies are leveraging/developing in-vehicle navigation systems and connected technologies to reduce range anxiety. For example, the Nissan LEAF's in-vehicle digital system (EV-IT) uses communication

Factsheet 14 - INFORMATION PROVISION

networks and a dashboard to keep the driver continuously updated about the range of the BEV and closest charging point.

- The EU Clean Power Directive specifies that Member States have to ensure information services on availability of recharging and refuelling points, which should be accessible to the public. Furthermore, recharging of BEVs should make use of intelligent metering systems, which provide accurate and transparent information on the cost and availability of recharging services.

Design options

As already indicated with the examples above, many different design options exist for the different information provision measures. The most important choices are elaborated on below.

1. Fuel price transparency

The design options for comparable transparent fuel pricing concern the included fuels (all fuels or only alternative fuels/some specific fuels), the sales unit (€ per kWh, 10kWh, m³, litre equivalent) and scope of the information (price specification at totems, bills or both).

2. Biofuel labelling

Design options are:

- scope of the information (availability in motor vehicle manuals, on motor vehicles, at refuelling and charging points and motor vehicle dealerships);
- the information provided (blending volume, compatibility, CO₂);
- inclusion of a colour coding scheme or other graphics.

3. Locations of charging infrastructure

There are many different design aspects for a publicly accessible database that are relevant, including: the level of detail of the site (type of connection of the charge point, addresses, owner contact, charger power), the type of map (interactive), live information, membership details, etc.

Key lessons learned with respect to renewable energy in transport

- Fuel price comparison can be difficult due to differences in energy content of fuels. Also the comparison has to be comprehensible for the general public.
- Consumer and stakeholder survey respondents indicated that fuel labelling at the pump is their primary source for general information about vehicle fuels and fuel-vehicle compatibility (CIVIC, 2014).

Interaction with other types of policy instruments

Information provision has a lot of interaction with other policy instruments, as it can support financial instruments by eliminating non-financial barriers to stimulate alternative vehicle and/or fuel purchase. Price transparency interacts with fuel tax taxations for example. The steering effect of the energy tax credit for alternative fuels can be maximised through transparent pricing (Dena, 2014).

Assessment**Increase in alternative powertrains**

o/+

These measures will increase the share of alternative carriers in different ways:

- Fuel price transparency (o): Fuel price transparency can support the uptake of alternative powertrains that are cost competitive. However, as BEVs/FCEVs have significantly higher purchase costs, it is unclear if this will increase the uptake of such vehicles. Moreover, fuel price transparency may result in a disincentive for alternative fuels if these fuels are not competitive, but this effect is unclear as well.
- Biofuel labelling (o/+): Labelling of biofuels improves transparency on the compatibility of (higher blends) biofuels and vehicles, which will make it easier to purchase biofuels. Therefore, it may result in more compatible vehicles for higher blends.
- Locations of charging infrastructure (0/+): Findability of charging points for BEVs will reduce the range anxiety for potential BEV users. Therefore, these services may be an important factor in reducing range anxiety. However, the additional push may be small, as price incentives are likely to be a larger influence on increased BEV sales.

Increase in renewable energy

o/+

The information provision may have a small positive impact on the share of renewable energy:

- Fuel price transparency (o/+): Fuel price transparency can increase the consumption of alternative fuels if they are cost-competitive with conventional fuel. For biofuels this is generally not the case, but electricity is cheaper than fuel. Clear information hereof may therefore stimulate PHEV owners to use less fuel and more electricity.
- Biofuel labelling (o/+): Consistent, simple, easy to understand fuel labelling reduce the risk of using the wrong fuel. Thereby, CO₂ labels clearly show the positive impact of biofuels on the environment. This may result in a higher demand for biofuels. However, only a small share of the consumers take environmental

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arguments in consideration in their purchase decisions, therefore, impacts of labelling are generally small

- Locations of charging infrastructure (o): Better findability of charging infrastructure will have no influence on the share of renewable energy, which depends on other policies in the power sector.

GHG emissions reduction

o/+

These measures can have an indirect impact on GHG emissions, through the increase of AFVs and RE consumption (see above).

Coverage

+

Information services that are publicly available can have a relatively large coverage, it depends on the level of implementation though. If fuel price transparency would be provided by all energy providers, coverage would be very large. Likewise, biofuel labelling and locations of charging infrastructure would be accessible to everyone who is interested as well. However, public would need to be made aware hereof.

Cost-effectiveness

?

Information provision is a relatively cheap measure to implement; it may require some subsidies for gathering information and developing standards. However, the costs and benefits of information services depend heavily on its design and the scope of implementation. No information has been found on the cost-effectiveness.

Ease of implementation

+

It is easy to implement a single measure, but more complex to make sure all information provision mentioned in this fact sheet is covered appropriately. In some cases international standardisation may be desirable which increases complexity.

Other considerations

N/a

Factsheet 15 - GREEN PUBLIC PROCUREMENT**Description of the instrument**

This instrument aims to promote eco-friendly goods and services by the state and other entities. It is generally originated by the Ministry of Environment (or Environmental Agency) and was implemented nationwide at the various administrative levels. According to the United Nations, green or environmentally responsible procurement is the selection of products and services that minimizes environment impacts. In simple terms, the law adds environmental attributes to the government's purchasing parameters i.e. **environmentally preferable purchasing or green procurement = environment + price + performance or quality**.

Green public purchasing schemes are designed for a wide range of products and services and not necessarily the same for every country. As such, not all countries include the transportation sector or government fleet in the scheme.

For the purpose of this study, the discussion below only highlights green procurement schemes applicable for the transportation sector.

Main impacts on

	Energy carriers	Energy infrastructure	Vehicles			
			Car	LCV	Light truck	Bus
Electricity	X	X	X	X		X
Hydrogen	X	X	X	X		X
Biofuels						

Results of the assessment

Increase alternative powertrains (+)	Increase renewable energy (o)	GHG reduction (+)	Coverage (-)	Cost-effectiveness (?)	Ease of implementation (+)
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Country coverage

Implemented (in general procurement) Argentina, Australia, Brazil, Canada, China, EU and most EU member States, Hong Kong, Japan, Korea (South), Malaysia, Mexico, New Zealand,

Implementation being considered: UAE, India

Factsheet 15 - GREEN PUBLIC PROCUREMENT

Norway, OECD, Singapore, Taiwan, Thailand, US

Design options

In principle, the basic policy of green procurement highlights the need to consider environmental attributes in addition to price and quality considerations. However, it requires the development of a list of purchasing criteria which can be either mandatory or voluntary. Meeting the voluntary criteria may give additional points for a tender. Furthermore both types of criteria can be based on input-output (e.g. stating a pilot project with fuel cell vehicles) or outcome (e.g. share of renewable energy in energy mix or CO₂ emissions).

While environmental attributes vary widely, most countries adopted common attributes such as the reduction of GHG emissions and air pollution, improved energy efficiency, use of renewable energy resources and support reuse and recycling.

Comparison of select countries' green procurement schemes for vehicles

United States	Japan	China	EU
<p>The Executive Order 13514 signed in 2009 requires reduction in fossil fuels consumptions by:</p> <p>Using low GHG emissions vehicles including alternative fuel vehicles i.e. FEV, HEV, PHEV, dedicated AFV, bi-fuel AFV, FCEV and using biodiesel amongst others.</p> <p>Reduction of fossil fuels consumption by a minimum rate of 2% per year until end of FY2020 relative to the baseline of FY2005.</p> <p>The State and Alternative Fuel Provider Fleet Program of EPAct, amended in April 2014: 75% of the new LDV that the state fleets acquire each year must be AFVs. For alternative fuels providers, the above requirement is 90% BEV, PHEV and FCV receive 0.5 credits per vehicle.</p> <p>The use of biodiesel can apply toward the requirement.</p>	<p>Green Purchasing Law enacted in 2000 requires the government agencies/institutions to implement green procurement. All government agencies and state ministries have to define an annual procurement targets and make the results of green procurement efforts publicly available.</p> <p>In the case of the government vehicle fleet, priorities are given to low emissions vehicles. Since 2004 all vehicles in the government fleet has been replaced by low emissions vehicles.</p> <p>The Green Purchasing Network has about 3000 members, of which 300 government agencies, 300 NGOs and the remaining 2,400 are private companies.</p>	<p>Starting 2007 the government are asked to give priority to environment-friendly products listed in a "green product inventory." The list has been approved by the China Certification Committee for Environmental Labelling and includes products ranging from cars to construction materials.</p> <p>In July 2014, the Central Government released a regulation requiring a minimum of 30% of new vehicles government fleet purchase each year from 2016 to 2020 must be new energy vehicles (EVs, PHEVs and FCVs).</p>	<p>Directive 2009/33/EC on the Promotion of clean and energy-efficient road transport vehicles stated that:</p> <p>From Dec. 4, 2010 the MS shall ensure that operational lifetime energy and environmental impacts are considered when purchasing new road transport vehicles. The environmental impacts include at least:</p> <p>(1) energy consumption; (2) CO₂ emissions; and (3) traditional air pollutants.</p>

Source: Stratas Advisors, compiled from various resources.

Key lessons learned with respect to renewable energy in transport

- **The Scheme** provides higher chance of AFVs including electric and fuel cell vehicles to penetrate the market and reach a non-negligible market size. Favouring AFVs purchases by the government over conventional vehicles should prompt more auto manufacturers to invest in the technology and the infrastructure, making them grow.
- **Reaching the CO₂ reduction target** becomes more manageable when part of the target is to be achieved by

Factsheet 15 - GREEN PUBLIC PROCUREMENT

- the government sector.
- The use of LEVs by government agencies will be seen as a **good example** for private sectors and citizens to follow.
 - Generally the retail prices of green products (including vehicles) are more expensive than non-green products of the same class. Thus, the purchase of green products will lead to higher costs. However, because the governments set a mandatory percentage of green purchase, the higher costs spent on buying items on the green procurement list may be compensated by the purchase of items which are not included in the list.
 - An intensive training on the environmental attributes of products for the purchasers is needed to ensure that the target is reached.

Interaction with other types of policy instruments

There is no direct interaction with other types of policy instruments. However, to sustain the uptake of AFVs, other instruments pertaining to infrastructure, purchase subsidy (if any), and research and development to improve the performance of such vehicles are also needed. Tax incentives can also improve the business case for governmental organizations for purchasing AFVs.

In the case of public transportation system running on alternative energy, this instrument may have a direct interaction with PPP instruments on fuel distribution network i.e. charging and refuelling facilities.

Assessment**Increase in alternative powertrains**

+

This instrument facilitates faster adoption of next generation vehicles through mandating the purchase of such vehicles by government agencies and institutions. This mandate will spur the development of other supporting items such as charging and filling stations and battery improvement.

Increase in renewable energy

o

The impact of this instrument on the share of renewable energy is highly dependent on the share of renewable energy in the production of the fuel (hydrogen and electricity). This is not influenced by this policy, but rather by other policies/target in the electricity generation sector. In the case of vehicles running on high blends of biofuels, e.g. CNG buses on biogas, the share of renewable energy in transport increases.

GHG emissions reduction

+

The instrument has a direct impact on GHG emissions reduction because of increasing the number of low-emissions vehicles on the road.

Coverage

-

This law covers the national/federal government with state/local governments encouraged to follow. In most cases, this is just a small share of the national fleets. However, when green public procurement criteria stimulating AFVs are also applied to services such as building works, postal and courier services or consultancy and ICT services, the impact can be considerably larger, but will still remain a relatively small share of the total vehicle fleet in a country (except for specific vehicle categories like public transport buses or waste collection trucks).

Cost-effectiveness

?

The cost-effectiveness of green public procurement is heavily dependent on the design of the scheme. If only AFVs meet the criteria for environmental friendly vehicles, the measure is likely not be cost-effective, as the higher purchase price of these vehicles (-) cannot be fully compensated by fuel cost savings and external cost savings. The cost-effectiveness of these schemes will improve when the purchase prices of AFVs decrease in the future. On the other hand, if also fuel-efficient conventional vehicles meet the criteria for environmental friendly vehicles, the measures may well be cost-effective. For these vehicles, the higher price (-) can be compensated by fuel cost savings (+) (e.g. up to 95g/km)(CE Delft & TNO, 2012).

Ease of implementation

+

This law is relatively straight forward to implement. However, it requires good knowledge of the options of green products available in the market. This also requires a thorough understanding of which options can be made mandatory for public procurements and which could be stimulated by award criteria (voluntary measures). Furthermore, in the case of AFVs, as the state of the art of technology develops over time, such criteria should be regularly updated.

Other considerations

-

CASE STUDY: Green Purchasing Law – Japan

Japan is considered one of the best models for green purchasing scheme. In Japan, the green purchasing law is a policy for promoting comprehensive and planned procurement of materials, components, products and services with low environmental impact (known as eco-friendly goods). The policy is applicable to the national government (i.e. the Diet, government ministries and agencies, and courts) and corporations defined by the government ordinance 556 of the year 2000. Although this policy is not binding for the local governments, the government encourages local governments, enterprises and citizens to also make a commitment to procure eco-friendly goods and service.

The government believes that prioritizing the purchase of eco-friendly goods and services will help build the market for such items. This initiative is expected to have a cascading effect; expanding this commitment to local governments and the private sector, promoting the shift in demand toward eco-friendly goods and services in the whole country.

The following principles are to be followed:

1. Purchase decisions must take into consideration the conservation of the environment in addition to price and quality.
2. To minimize the environmental impact, factors including global warming, air pollution, waste and decrease in biodiversity must be considered in a holistic manner.
3. The purchase of eco-friendly goods and services shall not increase the total amount of goods and services.

Specifically for vehicles, low-emissions vehicles are defined as:

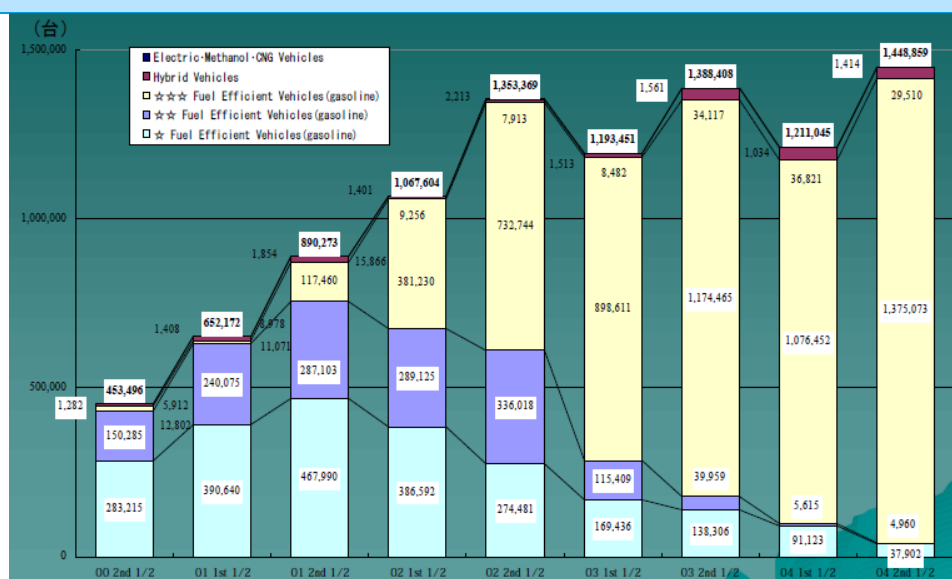
1. Electric vehicles
2. Natural gas vehicles
3. Hybrid vehicles
4. Plug-in hybrid vehicles
5. Fuel cell vehicles
6. Clean diesel vehicles (only for passenger cars).
7. Passenger vehicles and small buses run on gasoline and diesel complying with the applicable fuel efficiency standards.
8. Small freight vehicles run on gasoline and diesel complying with the applicable fuel efficiency standards.
9. Heavy vehicles include buses, trucks and tractors complying with the applicable fuel efficiency standards.
10. Vehicles run on LPG (passenger and small freight vehicles).

Furthermore, the implementation of green purchasing laws is not limited to the government agencies and institutions but also to private companies (voluntary).

Impacts and costs

- **Increase in alternative powertrains:** According to the Ministry of Environment's survey, the total sales of low-emission vehicles increased significantly since the mandatory implementation of the Green Purchasing Law. The figure below shows the growth of low-emissions vehicles sales in Japan because of the enforcement of the Green Purchasing Law.

CASE STUDY: Green Purchasing Law – Japan



Source: Green Purchasing Network.

The first Japanese car manufacturer to launch fuel cell vehicles was Toyota in November 2014. The sale of fuel cell vehicles started in mid-December 2014. As of mid-January 2015, there were 1,500 units ordered of which **60% were ordered by the government agencies** and institutions and the remaining 40% by individual customers in the country.

- **Increase in renewable energy in transport:** The direct impact of this policy on the increase in renewable energy in the transportation sector is unclear. The consumption of biofuels is expected to drop in line with the decline in gasoline consumption due to the shift to the next generation vehicles.

The indirect impact of this policy on the share of renewable energy in transport depends on the source of electricity and hydrogen. Currently only about 11% of electricity is generated from renewable energy. The government set a tentative target of 30% of electricity from renewable sources by 2030 (the final target is currently under discussion).

GHG emission reduction: According to the Ministry of Environment, the transportation sector accounts for about 20% of Japan's total CO₂ emissions. Compliance with vehicle fuel efficiency targets along with the shift to alternative fuel vehicles have been instrumental to the reduction of CO₂ from its peak in 2001. Although the shift to next-generation vehicles is not that significant yet, the reduction of CO₂ emissions from the transportation sector is expected to continue with a compounded annual rate of -1%.

Another way to reduce CO₂ emissions is by extending the use of electric engines to the public transportation sector such as buses. However, electric buses may only be effective in city centres because of the battery price. As such the automotive industry believes that biofuels and hydrogen are the most suitable fuels for buses and HDV at present. Mitsubishi is carrying out a pilot trial of electric city buses in Kitakyushu, Fukuoka Prefecture.

However it is important to note that the use of regular-route buses in public transportation service in Japan is decreasing and about 80% of the services operate at a loss. This is due to the increasing number of automobiles on the road that increase travel time by bus. Most Japanese travel by train.

As such, the CO₂ emission reduction in the transportation sector achieved because of this policy instrument is not significant.

- **Cost impacts:** The impact of this policy on costs has not been assessed.

CASE STUDY: Green Purchasing Law – Japan

- **Cost-effectiveness:** The benefits of this policy are mainly in the proven reduction of CO₂ emissions but the cost-effectiveness of the policy has not been established.

Future plans

In 2010, the Next Generation Vehicles Strategy Research Council has set targets by type of passenger vehicles in 2020 and 2030 (see the following table). This is the target in general; there is no specific target for the government fleet announced.

Type of Passenger Vehicles	Market Shares in 2020	Market Shares in 2030
Conventional Vehicles	50-80%	30-50%
Next-generation Vehicles	20-50%	50-70%
Hybrid vehicles	20-30%	30-40%
All electric vehicles including plug-in hybrid vehicles	15-20%	20-30%
Fuel cell vehicles	~ 1%	~ 3%
Clean diesel vehicles	~ 5%	5-10%

Source: Next-Generation Vehicle Strategy Research Council.

Though it is mandatory for the government agencies/institutions to purchase low-emission vehicles as defined in the green purchasing guideline, there is no specific target number of electric or hydrogen vehicles announced for the government agencies/institutions. In addition, there is no specific target pertaining to the penetration of BEVs or hydrogen vehicles in the public transportation sector announced by the government.

References used

Government of Japan, Ministry of Environment, <http://www.env.go.jp/en/laws/policy/green/>; Research Institute of Economy, Trade and Industry; Ministry of Economy, Trade and Industry.

Factsheet 16 - PILOT/DEMONSTRATION PROJECTS**Description of the instrument**

Pilot projects enable testing of a new energy technology on a small scale in order to evaluate feasibility, time, cost, benefits and adverse effects. The small scale of a pilot makes it possible to develop innovative vehicles, infrastructure, and energy carriers, with reasonable costs and acceptable risks.

Demonstration projects play three primary roles in supporting technologies to enter the market (DTU 2014):

- demonstrating the feasibility (technical, commercial and environmental) of the technologies;
- reduce costs (production, operating and maintenance);
- formation of knowledge networks, introduction of institutional embedding and improved public acceptance.

Main impacts on

	Energy carriers	Energy infrastructure	Vehicles			
			Car	LCV	Light truck	Bus
Electricity	X	X	X	X	X	X
Hydrogen	X	X	X	X	X	X
Biofuels	X	X	X	X	X	X

Country coverage

Almost every country worldwide that has set targets for RES-T has set up or participated in pilot programmes:

- In **China** the pilot projects and the first deployment today are mostly made up of public vehicles - especially buses and taxis. The pilot cities have invested in a large numbers of identical vehicles which all have the same requirements for charging infrastructure and result in economies of scale for OEMs (IEA, 2012). Another advantage of this uniform fleet is that is easy to implement standardisation of charging infrastructure.

Factsheet 16 - PILOT/DEMONSTRATION PROJECTS

- **Japan's** pilot projects are focusing on the development of smart grid networks (Ling, Kokichi and Masao, 2012).
- **Iceland** is aiming to become a world leading Hydrogen vehicle demonstration facility and is investing in a hydrogen infrastructure for cars and has hydrogen vehicles demonstration projects (IEA, 2012).
- Since 2011, Hyundai, Kia Motors and key hydrogen stakeholders from the Nordic countries (**Sweden, Denmark, Norway & Iceland**) are collaborating towards market deployment of FCEVs.
- Several advanced biofuel pilot and demonstration plants are already operating, and a considerable number have been announced for the next five years. The majority of these plants are in **North America** and the **European Union**, but an increasing number are operating or located outside the OECD.
- Pilot algae cultivation projects have been established in **Australia** during recent years; if successful, algae may become another biomass source in the longer-term (Geoscience Australia and ABARE, 2010).
- The first commercial advanced biofuel projects have been set up in the **United States and Europe**, as well as in **Brazil and China**, where several pilot and demonstration plants are already in operation. Once technologies are proven and feedstock supply concepts have been established, advanced biofuels will be set up in other emerging and developing countries (IEA 2011).

Design options

Pilot projects are mostly public-private-partnerships, diverse nationally / regionally funded projects, and in cooperation with local vehicle manufacturers. Key differences in design options are related to:

- type of energy carrier: Electric (infrastructure), Hydrogen (infrastructure), biofuel (infrastructure);
 - scope of the pilot project/scale;
 - funding: national government, regional government/municipalities, public private partnerships, or private funding;
 - usage models: car-sharing, public transport, postal vehicles, leased cars (Europe), public vehicles (China).
- Perdiguerro (2012) illustrates the wide variety of design options for pilot projects with examples of pilot projects.

The deployment of pilots with BEVs is aimed at industrialisation (Singapore), full network development (London) or recharging networks (Berlin). Likewise, the degree of public sector involvement varies from simple guidelines for private companies (Bangalore, Berlin) to an active role of the government in the market through heavy investment (Singapore, London).

Innovative design elements of different energy carriers**Key lessons learned with respect to renewable energy in transport**

- RETRANS (IEA-RETD, 2012) proposes a two-phase long-term policy approach for the large scale introduction of AFVs and Co-Evolution with RES-E. If the use of renewable energy in transport requires new technologies, e.g. FCEVs, BEV for heavy duty transport, pilot projects are necessary. Pilot projects result in the first infrastructure and vehicles and can as such stimulate **learning effects** (thus also **cost reductions**) in the production and maintenance of AFVs.
- Pilot projects are particularly suitable for projects that can be realised on a small scale.
- **Collaboration with market.** It is attractive for the market to have a contract with the government as is shown in the MoU construction of the Nordic countries with FCEV car manufacturers.
- For a country there are advantages and disadvantages in setting up pilot projects. It can be a lot cheaper to leave the demonstration phase to other countries. Once learning effects and cost reductions are achieved the technology can be implemented more cost-effectively. However, **setting up demonstration projects will push innovation.** The domestic industries will be able to establish a position as **leading industry** in the global markets.
- When a pilot project is conducted in different regions, it is important to ensure **co-ordination** and **information exchange** between the different regions to see what works out best/most efficiently.
- When evaluating pilot projects it is important to **measure** all effects, including **unintended effects** (e.g. ILUC emissions of biofuel pilot projects).

Interaction with other types of policy instruments

Pilot projects are very useful in the early stage of implementing innovative policy instruments. After successful pilots they should be followed up by policy instruments stimulating market uptake. Some pilot projects may interact with other policies, such as parking policies or urban access restrictions. For example, free parking for

Factsheet 16 - PILOT/DEMONSTRATION PROJECTS

(FC)EVs that are part of a demonstration project.

Assessment***Increase in alternative powertrains***

This instrument can stimulate alternative powertrains in the long-term through:

- identifying problems;
- solving technological barriers;
- demonstrating the feasibility of renewable energy technology;
- increasing public acceptance.

Increase in renewable energy

Pilot projects can increase the use renewable energy when they concern the supply of renewable energy, such as advanced biofuels plants or hydrogen plants. There are many pilots which target the so-called second- and third-generation biofuels (e.g. cellulosic-ethanol, HVO, BtL-diesel, Algae-biofuels, Bio-SNG, Pyrolysis oil). Each of the technologies has their own key R&D issues, which need to be tackled with pilot projects before being ready for market introduction.

GHG emissions reduction

In the short term, pilot projects will not result in large GHG emissions reduction due to the very small scale projects. However, pilot projects are essential for the implementation of RES-T. The early learning effect and cost reductions can provide a push towards market introduction and as such can contribute to large GHG emissions reductions in the long-term.

Coverage

As these are innovative policies, coverage is limited by definition. Each of these policies have the potential to result in significant coverage, if implemented by multiple countries/States or by Unions.

Cost-effectiveness

Pilot projects will generally not be cost-effective, as it requires high investments and/or operational costs (e.g. development of smart-grid infrastructure) while benefits are of limited size. However, as said above, they are crucial for the longer-term.

Ease of implementation

It is relatively easy to set up a pilot project as it only requires policy efforts on a small scale. However, if a maximum learning effect is to be acquired, a good approach is needed. This includes a monitoring and evaluation plan. Requirements to learn from pilot projects are detailed scientific support and modelling and monitoring.

Other considerations

N/a

Factsheet 17 - POLICIES TO INCREASE RE CONSUMPTION**Relevance of the instrument**

Many of the policies described in other fact sheets target the market share of AFVs. However, as most policies do not provide incentives to use electricity (or hydrogen) produced with renewables, the resulting shares of BEVs/FCEVs do not necessarily result in increased use of renewable energy in transport.

The share of renewable energy consumed by BEVs or FCEVs is by definition highly dependent on policies within the electricity sector which stimulate higher production levels (and hence supply) of renewable energy. Well-known examples are the wide variety of national subsidies compensating for the additional costs of producing a kWh with renewable sources and emission trading systems such as the EU ETS. However, there may be some **innovative policies** which could simultaneously stimulate increasing shares of both BEV/FCEV adoptions and the production/supply of renewable energy. Such innovative policies are the subject of this fact sheets. They could thus create synergies.

Main impacts on

	Energy carriers	Energy infrastructure	Vehicles			
			Car	LCV	Light truck	Bus
Electricity	X		X	X	X	X

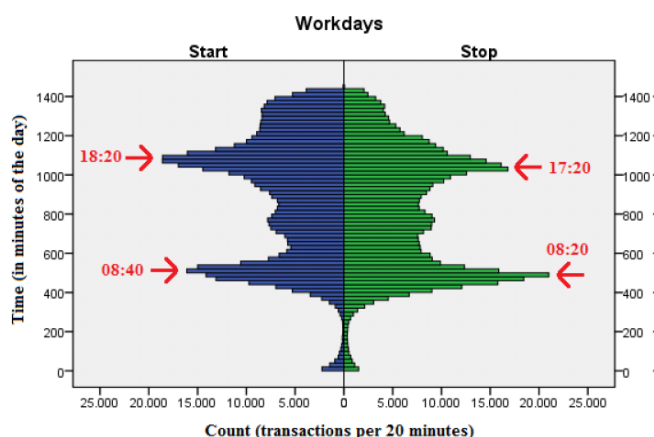
Factsheet 17 - POLICIES TO INCREASE RE CONSUMPTION

Hydrogen	X		X	X	X	X
Biofuels						

Policy options

Several innovative policies could increase the share of renewable energy consumed by BEVs/FCEVs:

1. **Stimulating smart charging of (PH)EVs:** Currently, electric vehicle charging patterns show a certain routine. Research from the Netherlands, based on data from nearly 1 million charging transactions, has shown that BEV owners mostly charge their vehicle when arriving at work and when arriving at home. Consequently, on workdays, there are significant peaks in electricity demand in the morning (around 9am) and evening (around 6pm) (Spoelstra, 2014), as shown in the figure below. “Start” means that a connection is made between the BEV and the charging point and “Stop” means that the connection to the charging point is disconnected. The number of transactions implies the number of vehicles being connected or disconnected at a particular point in time. This research has also shown that many vehicles are charged overnight.



Source: Spoelstra, 2014.

This charging routine has two consequences for the share of renewables in the electricity supplied to vehicles being charged. First, the peak demand of electricity may require back-up with conventional energy to meet demand, especially when the number of BEVs increases. Second, during nights production from renewable energy sources is relatively low, as there is no power generation from solar panels. Hence, the amount of renewable electricity consumed by electric cars could be increased by reducing peak demand and by better aligning charging times with renewable energy production. Innovative policies which could realise this are:

- a **Regulation for differentiated electricity prices:** At the moment, most countries allow limited room for differentiated energy price; there is usually a peak and off-peak tariff distinguished at predetermined times of the day. However, this is not necessarily aligned with the marginal price of electricity, which can become very low at certain times of the day when there is a large amount of renewable energy production. If electricity providers would be allowed to continuously differentiate their price with the marginal cost of production (e.g. charging a lower price at times where there is a large (renewable) energy production) consumers would have a financial incentive to use their appliances (incl. charging their electric car) at times of the day when prices are lowest (Andrey & Haurie, 2013).
 - b **Stimulating pilots on automatic demand-response solutions:** Through the application of smart meters, electricity providers could align decentralised production and consumption units to the grid. Hereafter, they can adjust some of the demand - the previously defined deferrable loads (e.g. washing machines, BEVs) - to the production of renewable energy. Ideally, this is combined with differentiated energy prices, to provide an incentive to consumers to give up some control over their energy using devices (Andry & Haurie, 2013). Note that this solution is something that should be up taken by the market, and hence the role of governments is limited.
2. **Incentives in existing vehicle policies:** Most vehicle policies (e.g. financial incentives in taxes, purchase subsidies) do not provide incentives to those purchasing an BEV to also consume renewable electricity. Hence, the share of renewable energy consumed by these owners will often depend on the share of renewables in the electricity mix of their country.
 - a **Financial incentives provided could be made dependent upon purchasing renewable energy** (TNO et al., 2010) One example country could be found that has implemented such an innovative policy

Factsheet 17 - POLICIES TO INCREASE RE CONSUMPTION

element. Luxembourg provides a subsidy of € 5,000 to purchasers of FEVs and PHEVs/EREVs who have also concluded a renewable electricity contract with their energy provider. In the absence of such a contract, the premium is not rewarded to the purchaser (ACEA, 2014).

3. **Aligning targets:** Many countries (e.g. EU Member States) have mandatory targets with respect to the share of renewables in their electricity supply. Currently, this target is not linked to the share of BEVs, but is determined with other factors. To ensure a higher share of renewables in transport, governments could:
 - a **Implement a ‘hard coupling’ between the BEV market share and RES-E targets.** The higher the share of BEVs, the higher the targets for renewable electricity (TNO et al., 2010).

Interaction with other types of policy instruments

In general, the share of renewable electricity consumed by BEVs is highly dependent on the share of renewables in a country's electricity mix, and as such there is an interaction with many other policies which target electricity productions (e.g. emission trading, subsidies for producing renewable energy, etc.).

Assessment***Increase in alternative powertrains***

The innovative policies do not explicitly target the market share of BEVs/FCEVs, and hence this impact is likely to be limited, except for adjusting the incentives in vehicle policies. The latter simultaneously targets an increase in alternative vehicle purchases and in the consumption of renewable electricity by these vehicles.

Increase in renewable energy

Each of the innovative policies above aims to increase the renewable energy consumed by BEVs and FCEVs and hence, each of these policies will positively impact the share of renewable energy in transport. Whether the effect of these policies is larger compared to policies that explicitly target the electricity sector is unclear and will depend on the policy design.

GHG emissions reduction

As mentioned above, these policies aim to increase the share of renewable electricity consumed by BEVs/FCEVs. The impact on the emission savings from these vehicles can be significant. In Europe for example, a switch from the current electricity mix (150 g/MJ; AEA, 2012) to a renewable energy mix (incl. biomass, wind, solar) (55 g/MJ) results in an additional saving of 30 percentage points for a FEV (from -53 to -83%). For PHEV the additional savings are dependent on the frequency of charging, but the impact can be comparable to that of a FEV, if charged twice a day (TNO & CE Delft, 2013).

Coverage

As these are innovative policies, coverage is limited by definition. Each of these policies have the potential to result in significant coverage, if implemented by multiple countries/States or by Unions.

Cost-effectiveness

The difference in generation costs between conventional and renewable sources is very location-specific and therefore it is difficult to conclude on cost-effectiveness. In general, the difference between them is getting smaller and as a result hydro-energy and on-shore wind can now be competitive in some regions (IEA-RETD, 2013). However at the moment, this is generally not the case for solar PV and off-shore wind (ibid.). When comparing cost-effectiveness, external costs such as air pollution and energy security should be included as well, which improves the cost-effectiveness of renewable electricity. Moreover, the policies stimulating smart charging may result in cost savings as well, as smart charging may prevent significant disturbances in electricity grids and as such may prevent investments to secure the grid. The amount of such savings has not been quantified yet.

Ease of implementation

The ease of implementation differs significantly between the innovative policies described above. Incentives in vehicle policies are likely to be relatively easy to implement, while adjusting Regulations may be relatively more difficult.

Other considerations

n/a

C.5 OVERALL POLICY STRATEGY

CASE STUDY: Ethanol Programme: Proálcool – Brazil

Brazil's major push to turn ethanol into a mainstream fuel began in 1975 with Decree 76.953, which instituted the Proálcool program. While it is generally judged as a major success by most measures, it was not without growing pains.

As part of Proálcool, Brazil increased the mandated ethanol blend in gasoline and instituted a number of incentives for the sugar and ethanol industry. It also pushed for the introduction of ethanol-only vehicles in 1980, creating a captive market for ethanol producers and expanding ethanol demand considerably. Demand-side policies – such as fixing by decree the price of E100 at 65% of gasoline blends and instituting a lower IPI (federal value-added tax) on E100 vehicles – created incentives for consumers to use ethanol. Vehicle buyers migrated to E100 vehicles en masse during the first half of the 1980s.

Nevertheless, worsening budget deficits and a growing external debt burden reduced the government's ability to afford these incentives. The volume of rural credit that the government could extend declined sharply, and the remaining loans that were available became more expensive due to increased interest rates. Indexation of interest rates to inflation meant that sugar and ethanol mills no longer enjoyed negative real interest rates on loans that they had in years before. The government also raised the price parity of E100 to gasoline from 65 to 80%, making it less attractive to consumers. The crash in world sugar prices in 1989 further diminished the finances of players within the sector.

The period between 1990 and 2000 brought a gradual reduction of the Brazilian state's role in the economy in general, and the sugar and ethanol sector was not spared from the turbulence associated with this period of institutional flux.

The Sugar & Ethanol Institute (IAA), which had overseen many of the programs instituted in the early Proálcool days, was abolished and responsibility for the sector was passed on to a succession of government entities. Careful coordination of policy was extremely difficult in such a changing environment.

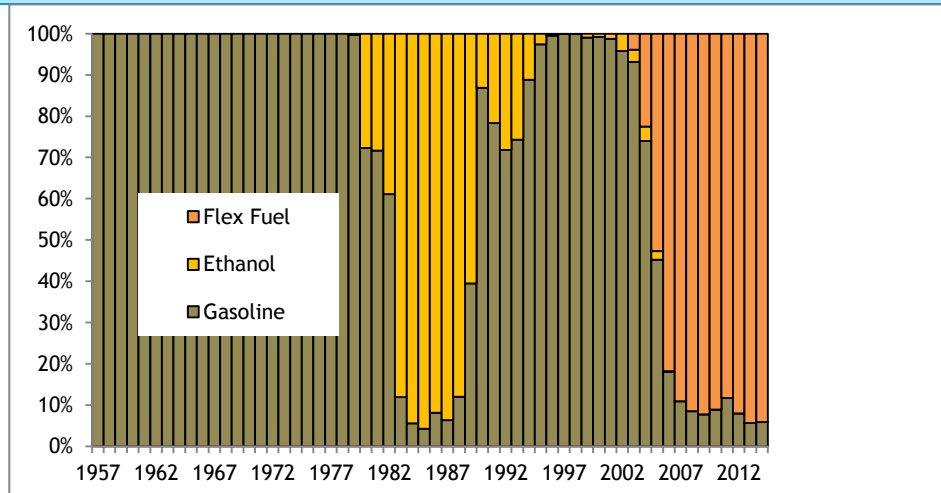
Costs increased, ethanol production declined, and the country had to turn to ethanol imports to stem a complete crisis in supply. This environment acted as a severe disincentive on both consumers and automakers, which were now facing their own competitive pressures as a result of the sudden removal of high tariffs on imported vehicles. The auto market reversed course and gasoline vehicles once again took the lion's share of sales.

Ethanol's viability as a fuel began to recover, thanks in large part to the advent of flex-fuel vehicles in 2003. Flex-fuel vehicles enabled consumers to take advantage of ethanol's lower cost in times of plentiful supply while still allowing them to switch to gasoline should ethanol supply disruptions occur. On a more global scale, a growing realization of the need for renewable sources of energy – both to reduce reliance on non-renewable resources and to mitigate the carbon intensity of economic activity in general and road transport in particular – also helped ethanol to recover some of its lost lustre. The rally on food commodities started in 2003 placed Brazil on more solid fiscal footing and enabled directed lending to the agro-industry sector to rebound. Total production and crop acreage grew as a result, along with a more gradual increase in yields, owing to the dissemination of more productive varieties of sugarcane. This confluence of events led to substantial growth in sugarcane acreage, cane processed volume and ethanol production.

Ethanol producers have been badly affected by the financial crisis of 2008 as well as adverse weather events leading to bad harvests. Even the rise of crude oil price in 2009 did not at first help the industry since the price of fuel is controlled by the government in Brazil. However, in September 2014, as the price of crude oil was falling, the president signed Law 13033 which increased the ethanol blend range in gasoline from 18 to 25 vol% to 18 to 27.5 vol%. Then in March 2015 the blending level was increased to 27 vol% with the provision that premium gasoline should remain at 25% to ensure that older and imported vehicles would not be harmed by the higher ethanol level while more tests were carried out.

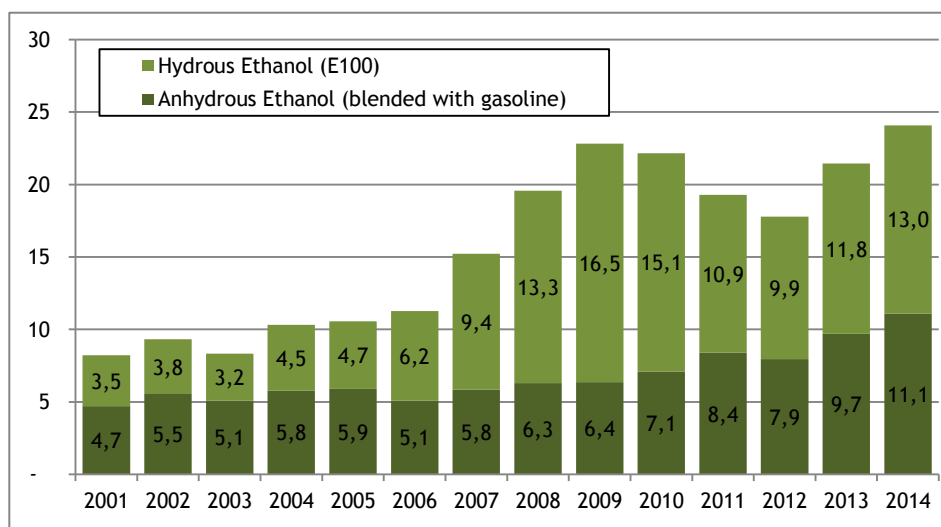
The following figure shows the type of light vehicles sold in Brazil from 1957 to 2014 as a share of the total. The figure shows the introduction of gasoline vehicles in the 1980s and the introduction of flex fuel vehicles in the 2000s and their market take over.

CASE STUDY: Ethanol Programme: Proálcool – Brazil



Source: Stratas Advisors based on ANFAVEA data, February 2015.

The following figure shows the volumes of ethanol sold in Brazil from 2001 to 2014 by type of ethanol (hydrous and anhydrous ethanol). Hydrous ethanol is sold as ethanol in Brazil (E100) and anhydrous ethanol is sold as gasoline, also known as gasoline C, and is a blend that currently contains 25 or 27 vol% anhydrous ethanol.

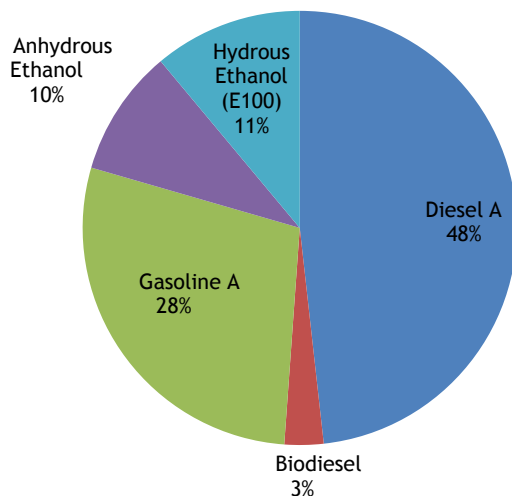


Source: Stratas Advisors, based on ANP data, February 2015.

Impacts and costs:

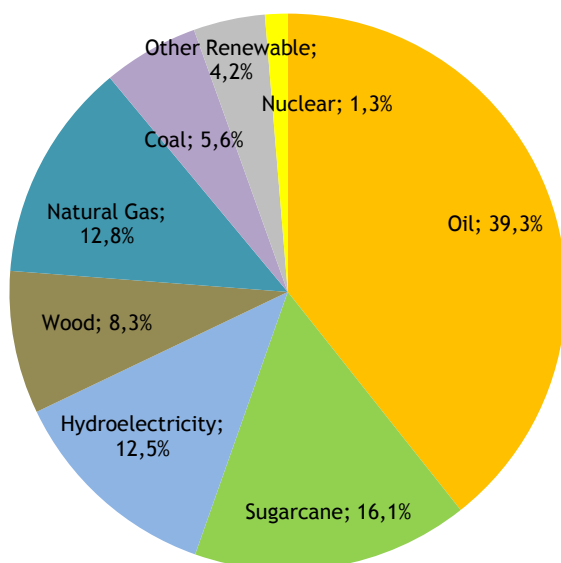
- **Increase in alternative powertrains:** The mandate is applicable nation-wide so all the gasoline sold in Brazil contains a high blend of ethanol (E20-25) and all vehicles can use that fuel. In addition, the introduction of flex fuel vehicles has been very successful and around 90% of vehicles sold in Brazil since 2008 have been flex fuel vehicles. This in turn has helped increase the consumption of hydrous ethanol.
- **Increase in renewable energy in transport:** The direct impact of this policy on the volume of ethanol consumed in Brazil in the transportation sector is clear. In 2008 light duty vehicles consumed as much ethanol as gasoline on a volumetric basis. No other country has achieved that level of renewable energy in the gasoline pool. The figure below shows the volumetric share of the respective fuels in the on-road sector in Brazil in 2014. Ethanol and biodiesel contributed to 24% of the fuel pool in 2014.

CASE STUDY: Ethanol Programme: Proálcool – Brazil



Source: ANP, March 2015.

According to the Ministry of Mines and Energy, sugar cane provided 16.1% of all energy consumed in Brazil in 2013, second source after oil. The transportation sector is the second largest energy consuming sector at 32% after industry which consumes 33.9% of all energy consumed in Brazil in 2013 according to data released by the Ministry and Mines and Energy.



Source: Ministry of Mines and Energy, March 2015.

- The efficient production of ethanol from sugar cane in Brazil allows for significant **GHG emissions savings** in the transportation sector. The European Renewable Energy Directive (RED) grants a 71% GHG emission saving factor to sugar cane ethanol compared to gasoline. When using the energy content by volume provided in Annex III of the RED and the default greenhouse gas emissions coefficients provided in Annex V the ethanol consumption figures for 2014 show that Brazil achieved at least a 16% GHG reduction compared to a scenario where only gasoline would have been used. It must be noted that the use of sugar cane waste,

CASE STUDY: Ethanol Programme: Proálcool – Brazil

bagasse, to produce heat and electricity in sugar and ethanol mills, makes the ethanol production process even more sustainable than from other feedstock. The issue of Indirect Land Use Change (ILUC) does not affect the production of ethanol in the southern regions or the north east of Brazil where sugar cane plantations have been established for many years and where no deforestation or other land use change phenomena take place. The ministry of agriculture has implemented a programme, ZAEcana that reviews new sugar cane planting requests against environmental criteria in order to avoid negative environmental impacts. Certain areas of ecological value like the Amazon, the Pantanal or the High Paraguay Basin, are off-limit for sugar cane plantation. What's more, the government is aiming at ending the burning of sugar cane before the harvest by 2017. For further increasing the share renewable energy in the transportation sector, the government has not only implemented an ethanol mandate but it also introduced a biodiesel mandate in diesel in 2008 and the level of the mandate reached B7 in November 2014.

- **Impacts on costs for government and users:** Even though there are no direct subsidies provided by the federal government for ethanol production in Brazil, ethanol has enjoyed a differentiated treatment under several states' taxation regimes. In addition, In August 2014 the Ministry of Mines and Energy included ethanol production in its priority investment for energy infrastructure projects. The initiative aims to raise capital for the ethanol sector. In September 2014, the Ministry of Finance included sugar and ethanol industries into the Reintegra programme, Brazil's special tax refund programme, allowing the sector to gain a tax refund of the export value of its good. Government sources estimate that this measure alone will cost around 400 million USD in revenues to the government in 2015. There are no official figures for the overall cost of the ethanol policy. Car drivers have benefited from the capped gasoline price and the competition between the price of gasoline C (capped) and that of hydrous ethanol (E100) and have been able to purchase the cheapest option as their vehicles were able to function with any blend of the two fuels.
- **Cost-effectiveness:** No official data show the overall cost-effectiveness of the ethanol programme in Brazil. It must also be noted that few studies have looked into the overall emissions linked to gasoline C and hydrous ethanol.
- **Economic impacts:** The net benefits to society are most felt in ethanol producing state since in addition to any environmental benefit associated with the use of ethanol, the employment opportunities linked to the ethanol sector are more diverse in ethanol producing states. These states also tend to have lower taxes on hydrous ethanol making the fuel more competitive against gasoline C and thus granting a cheaper fuel to consumers.

Future plans

- As of March 2015, E27 is available on the Brazilian market. The government plans on making this blend the new gasoline C if the car manufacturers association finds that there are no issues with old or imported vehicles. This is the highest level of ethanol into gasoline found anywhere in the world.

Key lessons learnt

- **Fuel and vehicle policies must go hand in hand:** Proálcool not only promoted the production of ethanol, it also promoted the manufacturing of vehicles that could run on ethanol. This element was fundamental to the success of the policy overall as these vehicles allowed for increasing levels of ethanol in the gasoline pool, but also granted drivers the option to select the most cost-effective fuel between ethanol blended gasoline and pure ethanol depending on the relative fluctuations of the prices of these two fuels.
- **Set policy drivers coupled with some flexibility:** Proálcool was driven by the need to lessen Brazil's dependence on imported fuel and buffer it from the price increases of crude oil. To these drivers can be added the intention to develop a local industry providing domestic jobs. Even though the market changed significantly in recent years (Brazil discovered huge crude oil resources off its coast in the zone known as pre-salt and the price of crude oil has gone up and down), the policy was maintained but was given some flexibility to adjust to temporary market conditions: the government could lower the ethanol content of gasoline C within established boundaries at times when ethanol supply was low.
- **Pitfalls:** Most of the ethanol is produced in the South of the country and consumed there. However, the mandate applies nationwide so ensuring the supply of the North and North West regions has been difficult at times and Brazil has been relying on ethanol imports in the inter-harvest period. New legislation requiring that producers keep stocks of ethanol has helped. Ethanol producers have struggled in recent years as labour and land costs increased and several ethanol mills have had to close. In addition, the Brazilian government controls the price of gasoline in Brazil. As a result, hydrous ethanol (E100) has at times not been competitive with the relative low price of gasoline.
- **Note:** This policy was put in place at a time when a military regime was in charge in Brazil. It relied both on

CASE STUDY: Ethanol Programme: Proálcool – Brazil

the large ethanol production facility of the country but also on the fact that ethanol producers have to sell ethanol to the national oil company, Petrobras, who also purchases domestic ethanol to meet its obligation. The price of fuel is controlled by the government in Brazil so Petrobras at times loses significant amounts of money by selling fuel on the domestic market. In addition, when the Proálcool programme was introduced the car fleet was relatively modest. It has expanded along with the ethanol consumption and domestic vehicles have been designed to cope with high ethanol levels, either as flex fuel vehicles or gasoline vehicles (with E25 compatibility). These conditions are difficult to replicate elsewhere.

References used

ANP; Ministry of Mines and Energy; Ministry of Agriculture; ANFAVEA; Renewable Energy Directive.

ANNEX D LIST OF INTERVIEWS

Paul Argyropoulos	US EPA, Office of Transportation and Air Quality (OTAQ), USA
Jos Dings	Transport & Environment, Brussels, Belgium
Neville Fernandez	Neste Oil US., Inc., USA
Hirohiko Hoshi	Cordict Cordia Corp. Ltd., Japan
Peter Mock	ICCT, Brussels, Belgium
Chris Malins	ICCT, Brussels, Belgium
Michael McAdams	Advanced Biofuels Association, USA
Philip Owen	EC DG CLIMA, Brussels, Belgium
Sudo-san	Ministry of Economy, Trade and Industry, Japan
Candice Wheeler	General Motors, USA
Peter Whitman	US Dept. of Energy, USA
Robert Wimmer	Toyota Motor North America, Inc., USA



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