



## Shifting renewable energy in transport into the next gear

Developing a methodology for taking into  
account all electricity, hydrogen and  
methane from renewable sources in the  
10% transport target

### **Report**

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# Summary

## **Background and scope of this study**

The European Union (EU) has an overall 20% renewable energy target in final energy consumption, and a 10% target of renewable energy in the transport sector, both for 2020. These targets and the associated calculation methodologies are set and defined in the Renewable Energy Directive (RED, Directive 2009/28/EC).

Regarding the transport target methodologies, the RED focusses on the direct use of biofuels in transport, where only those biofuels can contribute that are actually used in the transport sector. Regarding calculation of the contribution of electricity from renewable sources to the transport sector target, a different methodology was chosen. The electricity is typically taken from the electricity grid, where the exact source or origin of the energy used is not monitored, and Member States should use the average (national or EU) share of renewable electricity production in their calculations.

The RED requires the European Commission (EC) to present, if appropriate, a proposal to consider the whole amount of the electricity from renewable sources used to power electric vehicles, by December 31<sup>st</sup>, 2011. In addition, if appropriate, a methodology to include the contribution of hydrogen from renewable sources in the transport sector should be proposed. At the same time, there is the question how biomethane which is injected into the natural gas grid should be counted towards the transport target if vehicles are filled from that same grid - a similar route to that of electricity use in transport.

In this context, DG Energy of the Commission commissioned CE Delft, Ecologic Institute and Ludwig-Bölkow-Systemtechnik (LBST) to provide support to the decision making process related to these potential proposals and the issue of biomethane injected in the natural gas grid. The objective of this study was to provide the Commission with the considerations and inputs necessary to assess impacts of potential legislative proposals related to these issues.

## **Renewable electricity, hydrogen and methane in the EU's transport in 2020**

As a first step in this analysis, an overview was made of the expected contributions of these three routes (electricity, hydrogen and methane from renewable sources) to the 10% renewable energy target for transport in 2020. Based on the National Action Plans (NREAPs) submitted by the Member States to the EC, renewable electricity, hydrogen and 'other biofuels' (which include biomethane) are expected to represent 11.6% of all renewable energy in the transport sector in 2020, about 1.2% of the total energy used in road and rail transport. Most of this will be renewable electricity in rail transport, with only very limited contribution of electric road transport and other biofuels such as biomethane. The contribution of hydrogen from renewable sources is negligible.



## Public consultation

To support the decision making process, the Commission conducted a public consultation in the first half of 2011<sup>1</sup>, to which 39 responses were received. The results of this consultation were analysed as part of this study, and incorporated in the assessment.

In the period to 2020, none of the respondents sees the 10% target as being a strong driver of electric vehicle developments, and only one sees it as being a strong driver of methane-powered vehicles. Most respondents do not expect significant hydrogen production from renewable sources by 2020. There is a wide range of views on the appropriate conditions for counting the whole amount of electricity used in EVs as being renewable. The majority of respondents supported an approach using either tradable certificates or supply contracts which would also enable accounting for biomethane injected into the natural gas grid. However, there are some notable differences of opinion on this issue.

## Drivers for increasing the production of these renewable energies

The key drivers for the uptake of renewable energy in the EU were identified in order to understand to what extent the uptake of renewable energy is related to transport sector developments, and to assess how the transport sector could potentially become more of a driver for the production of renewable energy in the future.

A wide range of drivers exist, ranging from the EU policy framework and specific measures implemented at the Member State or sub-national level, to a range of commercial initiatives. Case studies are provided to illustrate the developments related to driving the use of electricity, methane and hydrogen from renewable sources in the transport sector.

We conclude that changing the accounting method for the full amount of renewable **electricity** used in transport is unlikely to have a material impact on the demand for renewable electricity, at least until 2020. Other policies (on EU and Member State level) are key drivers of developments in that field. Beyond 2020, there is greater potential for EVs to drive the uptake of renewable electricity production if, for example, the specific transport targets set in the RED were increased and made additional to the targets for consumption of electricity and heat from renewable sources. Alternatively, individual Member States could choose to stimulate additional consumption of renewable energy; for example, by introducing requirements on utilities to supply renewable electricity for transport purposes and not allowing them to benefit from existing measures or counting this consumption towards the general renewable energy target.

Where the production of **biomethane** for injection into the grid is concerned, the extent of measures being implemented is more limited. So far, no Member State has specified plans for implementing specific measures to drive production of biomethane for injection into the grid in its national action plan. However, there are a number of policy measures in place to encourage biogas production, encourage its injection into the natural gas network and to use biomethane in transport.

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<sup>1</sup> Accounting methods and conditions for the 10% renewable energy in transport target - and on the need for additional types of biofuels being listed in Annex III of the Renewable Energy Directive;  
[http://ec.europa.eu/energy/renewables/consultations/20110614\\_res\\_target\\_en.htm](http://ec.europa.eu/energy/renewables/consultations/20110614_res_target_en.htm).

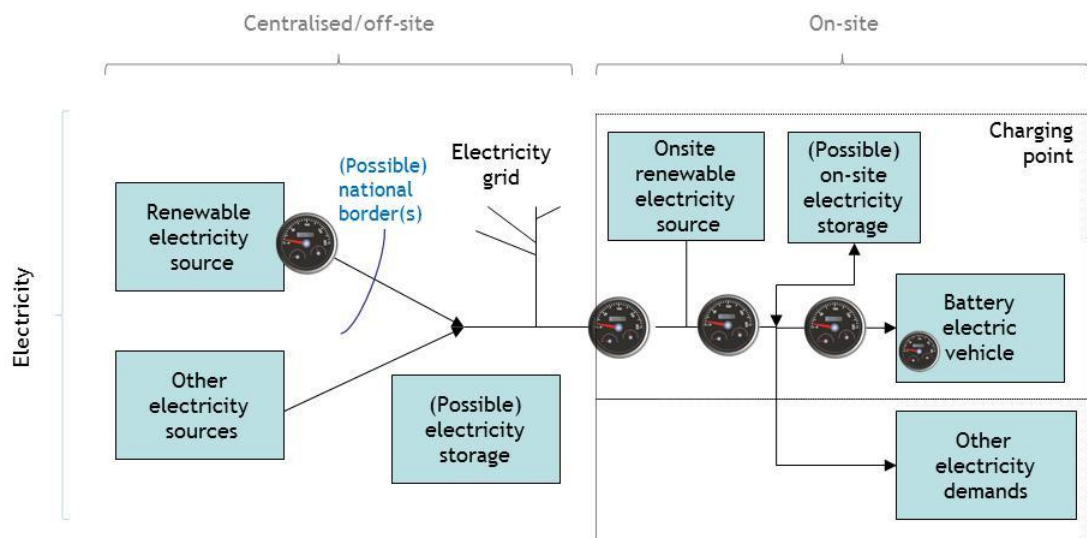


In the case of **hydrogen**, still in an embryonic stage of infrastructure deployment, the current outlook suggests that transport sector developments are likely to remain a very minor driver for the production of hydrogen from renewable sources over the period to 2020. There are a number of examples of policy support and industry initiatives for hydrogen infrastructure and demonstration projects. On a project level, renewable energy already plays a notable role. However, support instruments such as feed-in tariffs, etc. are not being targeted specifically at production of hydrogen from renewable energy for use in transport at this stage.

### Options to include these renewable energies in the RED

The different options to use renewable energies in transport are determined in order to identify and assess potential options to include renewable electricity, methane and hydrogen in the RED transport target. These range from a very simple set-up in which a vehicle is directly charged from a wind turbine without grid connection, to a much more complex situation in which various renewable energy sources feed into the grid, some of which are imports from outside the EU, and numerous customers and applications take their energy from that grid. To illustrate this, a schematic overview for the electricity case is shown in Figure 1. Actual and potential future metering points (e.g. on board, at the charging point and at the renewable electricity production site) are indicated. The potential routes for electricity and methane were found to be very similar to each other. Hydrogen requires similar but somewhat different steps, where it is produced from various energy sources and carriers (including electricity and biomass) which can be partly or fully renewable.

Figure 1 Overview of situations for electricity as transport fuel



From these situations, various options can be derived with which the actual amount of renewable energy used in the vehicles can be determined. In the case of **electricity** and **methane**, each methodology would require the following two steps:

1. *Determine the total energy input into the vehicle*

This can either be done by measurements at the feeding point or at the vehicle, or by using estimates.

2. *Assess the amount of renewable energy in the total energy input*  
This can be either based on the production mix of a country (or EU average), or by using the production mix that is specified in contracts for specific charging points. An additional variation is to use either average (e.g. annual) data or assess time-specific production mixes.

For **hydrogen**, two similar but somewhat different steps are required in the methodology:

1. *Assess the renewable energy share in the input volume of the hydrogen production process*  
This can be either based on the production mix of the country, or by using the production mix specified in contracts for specific production sites. Again, these data can be either (annual) averages or time specific.
2. *Determine the volume of hydrogen use in transport*  
This can be done by actual measurement or using estimates.

### **Assessment of the options**

The various options to address the steps were assessed per energy carrier type, looking at feasibility, additionality, costs, robustness, degree of accuracy and risk of privacy issues, and taking into account the results of the public consultation.

Some of the options were found to be easy to implement, whereas others are (much) more complex and costly. For example, for electricity and methane in road transport, the most simple option is to estimate the total energy input into vehicles (Step 1) and then use the annual average renewable energy share in a Member State (Step 2). This route, however, scores negative from an accuracy point of view. In case of electric rail transport, accuracy is not a concern as the estimates can be replaced by actual data (total energy input into the rail infrastructure is already being monitored). The other options require more effort, at least in the short term, such as setting up new metering and monitoring systems and administration of contracts, and double counting would have to be addressed. However, in the longer term, smart metering is likely to become much more common in the electricity sector (for reasons not related to RED monitoring), which will significantly reduce cost and efforts of implementing much more sophisticated and detailed monitoring systems.

### **Conclusions and recommendations**

We find that the transport target in the RED is unlikely to be a major driver for the production of renewable electricity, hydrogen and methane (injected in the grid) until 2020. Beyond 2020, this might change, depending on policies and technology development. However, the calculation methodology chosen for the RED is not considered to be a major driver in these developments.

We furthermore conclude that:

- For electricity, using the average production mix fits with current renewable energy monitoring practice but it may be quite inaccurate as time profiling is important<sup>2</sup>.
- Small scale ‘on-site’ production of renewable energy causes monitoring problems when these sources are not equipped with an extra meter and a billing and metering cycle. Small private filling stations for methane and hydrogen might be just a temporary niche solution but may also stay a solution for remote areas; whether they should be incorporated into

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<sup>2</sup> Illustrated by the example of an electric vehicle charged at night only, and production with solar PV at day time only.





RED monitoring can be decided in the future when it becomes clear how the market evolves. Small scale electricity charging causes similar monitoring problems with the notable difference that the situation will prevail as cars are expected to be charged at home in the future as well.

- Dedicated metering, also for small private charging or filling stations, may be driven by future tax legislation in Member States. This may also be a driver towards metering at the vehicle. Dedicated metering and reporting is already the *modus operandi* for electricity consumption for railway transport, the largest part of electricity consumption for transport.
- Smart grids, smart metering and smart tariff systems are regarded as the future way for the electricity distribution grids, but rates of transformation and implemented concepts may vary between Member States. The RED monitoring must give enough room for these different rates and implementations.

Because of these evolving future techniques, we split our recommendations in a short term (< 2020) and longer term (> 2020) part, distinguishing the methodological steps identified above.

For the short term (< 2020) methodology for **electricity** and **methane**, we recommend to use measurements at dedicated charging/feeding points to determine the total energy input into the vehicles (Step 1). The Member States could use metering at charging points that meet pre-defined criteria. The volume of electricity or methane supplied at non-authorized charging/filling points (i.e. those without site-specific metering) is then not counted. For electricity consumption by railways, trams, metros and trolley buses, this metering is already the *modus operandi*. As an intermediate step for road transport, estimates may be used, based on a monitoring of the number of cars, and average yearly energy consumption per car. For Step 2, the assessment of the share of renewable energy, we recommend the use of the national (or EU) production mix for assessment of the amount of renewable electricity and methane.

For the longer term (> 2020), more sophisticated techniques will become common. To deal with private small scale charging/filling, metering at the vehicle is necessary, unless most of these points will be separately metered within a metering/billing cycle. For Step 2, a contract-based approach is currently too complex and costly, but it can serve as a driver for the use of renewable energy in transport, and is exactly the approach that the utilities are already experimenting with. It is likely to be linked to the emergence of the smart-charging model, and is supported by many of the national authorities in their submissions to the consultation.

For electricity and methane, unless every vehicle driver is on a green contract, a mix of the application of the country grid factor (default approach) and the specific production mix for vehicles with green contracts seems inevitable. This raises double counting issues, and the question of additionality with respect to imports. We suggest to give Member States the option of adopting a mixed approach if they wish to, with rules for ensuring correction for double counting. Also, one might consider introducing sector-specific conditions, for example to keep track of the contribution of railways to the RED target (were monitoring is already in place).

For **hydrogen**, we recommend use of the national mix (and biomass sustainability criteria, where applicable) for the assessment of the renewable energy share in the input volume of the hydrogen production process (Step 1). For Step 2, the determination of the volume of hydrogen used in transport, we recommend measurement at the feeding point. For the longer term, we



recommend to switch to specific energy contract information for Step 1 in the case where hydrogen is produced from electricity or methane. To ensure a level-playing field (technology openness) among innovative drive-train options, we also recommend applying a factor of 1.5 for hydrogen used in vehicles.

Finally, we make the recommendation to review the RED in 2014, to see whether the actual pace of market developments suggests that solutions seen today as being appropriate for the longer term (> 2020) need to be brought forward (or not).



# 1 Introduction

## 1.1 Background

The European Union (EU) has an overall 20% renewable energy target in final energy consumption, and a 10% target of renewable energy in the transport sector, both for 2020. These targets and the associated calculation methodologies are set and defined in more detail in the Renewable Energy Directive (RED)<sup>3</sup>.

In addition to the EU wide target, the RED defines legally binding national renewable energy targets of the final energy consumptions for the Member States. The transport target is uniform throughout the EU, and each Member State has 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. All forms of renewable energy can contribute to the target, including liquid and gaseous biofuels, electricity and hydrogen produced from renewable sources. The methodology with which to include their contributions is defined in the RED, but with a focus on the direct use of biofuels in transport, given that this is currently the main renewable energy source in the transport sector. Given this emphasis, the RED contains a number of 'loose ends' that would have to be further developed in the coming years.

For biofuels, the calculation methodology was mainly designed for the current practice where liquid biofuels are directly applied in the transport sector - either as pure biofuels or, more often, blended with gasoline or diesel. A mass balance approach was chosen, which allows relatively straightforward monitoring and reporting, and ensures that only those biofuels can contribute that are actually used in the transport sector (in road, rail, aviation and shipping).

However, this methodology was not applied to calculate the contribution of electricity from renewable sources to the transport sector target. As this electricity is typically taken from the national grid, where the exact source or origin of the energy used is not monitored, a different approach was chosen to deal with electricity from renewable sources in transport: the average share of electricity produced from renewable energy sources (Member State or EU level) has to be taken into account in the calculation. Art. 3.4 (c) of the RED also states that electricity from renewable sources consumed by electric road vehicles<sup>4</sup> shall account 2.5 times towards the 10% target, reflecting the higher efficiencies compared to internal combustion engines.

The RED provides the opportunity to modify this methodology in the near future. It states in Art. 3.4 that the Commission shall present, if appropriate, a proposal to consider the whole amount of the electricity from renewable sources used to power electric vehicles, by December 31<sup>st</sup>, 2011. In addition, by the same date the Commission shall also present - if appropriate - a proposal for a methodology to include the contribution of hydrogen from

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<sup>3</sup> Directive 2009/28/EC.

<sup>4</sup> It is not further specified whether this provision applies to both battery electric vehicles and fuel cell electric vehicles running on hydrogen produced with electricity from renewable sources.



renewable sources in the transport sector - this was not yet included in the RED.

At the same time, there is some debate within the EU (e.g. in the Netherlands and the German association for CNG vehicles) whether or not biomethane that is injected into the natural gas grid could also count towards the transport target, if CNG or LNG vehicles are filled from that same grid. Even though this option was not mentioned for further study in the RED, there is a similarity with that of the electricity and hydrogen cases.

DG Energy of the Commission has now commissioned a consortium with CE Delft, Ecologic Institute and LBST (Ludwig-Bölkow-Systemtechnik) to provide support to the decision making process related to the two proposals that are required in Article 3.4 of the RED, and the issue of biomethane injected in the natural gas grid.

## 1.2 Project objectives and scope

The objective of this project is to obtain technical and scientific support in order to provide the Commission with the considerations and inputs necessary to assess impacts of potential legislative proposals related to the target for renewable energy in transport.

- Permitting, subject to certain conditions, the whole amount of the electricity originating from renewable sources used to power all types of electric vehicles to be considered.
- For a methodology for calculating the contribution of hydrogen originating from renewable sources in the total fuel mix.
- For a methodology for calculating the contribution of methane originating from renewable sources in the total fuel mix.

The considerations and inputs should take into account the extent to which transport is a driver for the production of electricity, hydrogen and methane from renewable sources. They should also take into account the overall methodology of the Energy Statistics Regulation<sup>5</sup>, the methodological reference in the Renewable Energy Directive.

The scope of the project is the EU 27. The main focus of analysis is the period until 2020, as this is the scope of the RED. However, the longer term (2020-2050) is also considered to ensure that results are robust and in line with expected future developments and to investigate longer term policy options that could be considered for the period after 2020.

## 1.3 Renewable energy in the transport sector

As part of the efforts to reduce greenhouse gas emissions of the transport sector, to reduce the sector's oil dependence and diversify energy sources, the EU aims to gradually increase the share of renewable energy in the transport sector's energy mix. The most relevant current EU policy in this respect is the Renewable Energy Directive (2009/28/EC), which sets a target of 10% renewable energy in transport for 2020, for each Member State. This Directive also defines the sustainability criteria that the biofuels need to meet in order to count towards the target, and describes the methodology with which this renewable energy share should be calculated (for example, renewable

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<sup>5</sup> Regulation (EC) No 1099/2008 OJ L 304, 14.11.2008.



electricity used in road transport shall be multiplied by 2.5 and biofuels that are produced from waste and residues count double). The Member States have all submitted National Action Plans in which they describe, among other things, how they intend to meet this target.

Also relevant is the GHG emission target set in the Fuel Quality Directive (2009/30/EC): fuel suppliers have to reduce GHG emissions by 6-10% between 2010 and 2020. This directive is also expected to drive the renewable energy use in transport, although it is not yet clear to what extent this will impact the renewable fuel mix, or if it will lead to renewable energy use that will be additional to the RED target.

Looking at the current situation in the EU, the renewable energy share is increasing steadily because of increasing biofuel use: from 2.1% in 2006 to 4.2% in 2009 (EU 27, Eurostat data), see Figure 2. Biofuel shares clearly differ between Member States: where some countries have achieved shares of more than 6%, others are still below 1%. The large majority of these biofuels is currently used in road transport, with some use in rail and inland shipping. Member States will have to report on the share of renewable energy in transport by 31 December 2011, and every two years thereafter.

These renewable energy shares are expected to further increase towards the 2020 target and beyond. In the Commission's White Paper 'Roadmap to a Single European Transport Area'<sup>6</sup>, ambitious goals regarding alternative transport fuels are set for the longer term, such as:

- halve the use of 'conventionally-fuelled' cars in urban transport by 2030, phase them out by 2050;
- low-carbon sustainable fuels in aviation to reach 40% by 2050.

It is expected that in the short to medium term, biofuels will continue to be the main renewable energy source in the road, air and maritime sector. However, alternatives such as electric and hydrogen powered vehicles are being developed and brought on the market, and especially battery electric cars have received much attention recently by car manufacturers, governments and car buyers. It is, nevertheless, expected that it will take at least another 5-15 years before these alternative drive systems have matured and start to gain significant shares in the EU's vehicle fleet<sup>7</sup>.

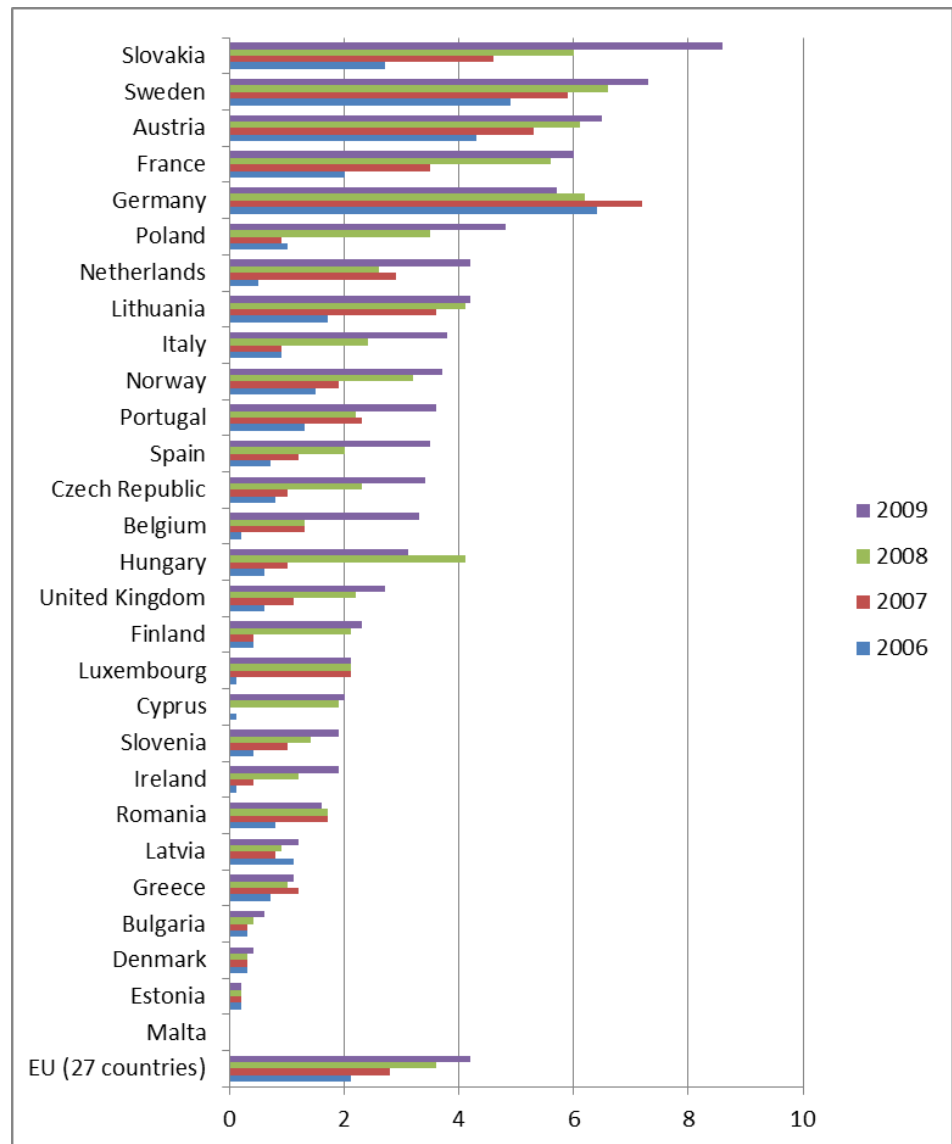
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<sup>6</sup> COM(2011) 144 final.

<sup>7</sup> See, for example, CE (2011) for scenarios for electric vehicles uptake in the EU.



Figure 2 Share of biofuels in transport energy use between 2006 and 2009



Source: EEA, Eurostat.

## 1.4 Report structure

This report consists of the following chapters:

- Chapter 2 provides an overview of the Member State’s intentions to rely on electricity, hydrogen and methane from renewable sources, to meet the 10% renewable energy target for transport in 2020.
- Chapter 3 is an overview of the results of the public consultation concerning the issues in the report, which DG Energy carried out between April and June 2011.
- Chapter 4 discusses the drivers for the increase in production of electricity, hydrogen and methane from renewable sources.
- Chapter 5 then identifies the various methodologies that could be used to include renewable electricity, hydrogen and methane in the 10% transport target, and discusses data requirements and conditions related to these methodologies.



- Chapter 6 contains a thorough assessment of the methodologies identified, and results in conclusions regarding how the various methodologies and conditions compare regarding a number of criteria such as practical feasibility, cost, driving for additional renewable energy production, etc.

In addition, Annex C provides an overview of the number of energy companies in the EU. This additional information was gathered to support further work on this issue for the European Commission, as this partly determines the administrative burden that various measures may cause.







# 2 Member State's intentions to rely on renewable electricity, hydrogen and methane

## 2.1 Introduction

The Renewable Energy Directive (RED) obliged Member States to submit National Action Plans (NREAPs) to the European Commission, outlining their plans on renewable energy policies and targets in the coming decade. Looking at the Member State's intentions regarding the 10% renewable energy target in transport, it can be concluded that this target will be met to a very large extent by biodiesel and bioethanol, partly sold as low-percentage blends and partly sold as higher percentage blends (see for example the ECN overview report (ECN, 2011)). The contributions of the routes investigated here, i.e. electricity, biomethane and hydrogen from renewable sources distributed via the grid, to the 2020 renewable energy mix in transport are expected to be relatively limited.

This chapter investigates the plans regarding the latter routes in more detail. It provides an overview of the current expectations of Member States regarding the use of renewable electricity, biomethane and hydrogen from the grid in the transport sector, and briefly assesses trends and differences between Member States.

Note that these data are limited to the period between 2010 and 2020, as this is the scope of the RED. It might well be that these routes develop further in the period after 2020, and make a more substantial contribution to the energy supply of the transport sector in the future<sup>8</sup>. This study will not make any quantitative forecasts on the future developments, but it is important that the methodology that will be developed allows for future growth and technical developments in these routes and technologies.

## 2.2 Electricity

The NREAPs distinguish between electricity from renewable sources in road transport and in non-road transport. The category non-road transport will mainly consist of railway.

In Table 1, the share of renewable electricity in the final gross energy consumption in the transport sector is given per Member State, as presented in the NREAPs. Due to different efficiencies of electricity production and use in road transport versus that of conventional fuels - in the first case, the efficiency of the engine (tank-to-wheel) is relatively high, but that of electricity production (well-to-wheel) relatively low; in the latter case, it is the other way round - the total amount of electricity in road transport counts 2.5 times according to Article 3.4 of the Directive. This does not apply for rail

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<sup>8</sup> See, for example, the scenarios developed in the project 'Impact of Electric Vehicles - Impact analysis for market uptake scenarios and policy implications' recently carried out for DG CLIMA, [http://ec.europa.eu/clima/studies/transport/vehicles/docs/d5\\_en.pdf](http://ec.europa.eu/clima/studies/transport/vehicles/docs/d5_en.pdf).



transport. In the numbers presented in Table 1 this factor has not been taken into account.

The following conclusions can be drawn from analysing the NREAPs regarding the contribution of electricity from renewable sources to the overall target of 10% in the transport sector:

- Renewable electricity, hydrogen and ‘other biofuels’ represent 11.6% of all renewable energy in the transport sector (= 100%) in 2020. Biodiesel and bioethanol account for the remaining 88.4%.
- In 2020 electricity from renewable sources will account on average for 8.6% of the renewable energy in the transport sector. The contribution of hydrogen and other biofuels is limited to 3.1% on average.
- In 2005 the share of electricity in the total renewable energy in the sector was 49.8%. The decrease from 49.8 to 8.6% can be explained by the choice made by Member States to invest mainly in biofuels to reach the target.
- In absolute numbers, Germany, France, Spain, Italy and Austria are the five Member States which will have the highest amount of electricity from renewable sources in 2020. Relatively, Austria, Sweden, Italy and Germany score high.
- In 2020 the use of electricity from renewable sources in road transport is still very limited in comparison to the use of electricity from renewable sources in non-road transport and in comparison to total energy consumed in the sector. Only 0.2% of total energy consumed can be accounted to electric vehicles (and other forms of electric road transport).
- The (intended) growth of electricity from renewable sources in the transport sector 2005-2020 is shown in Figure 3.

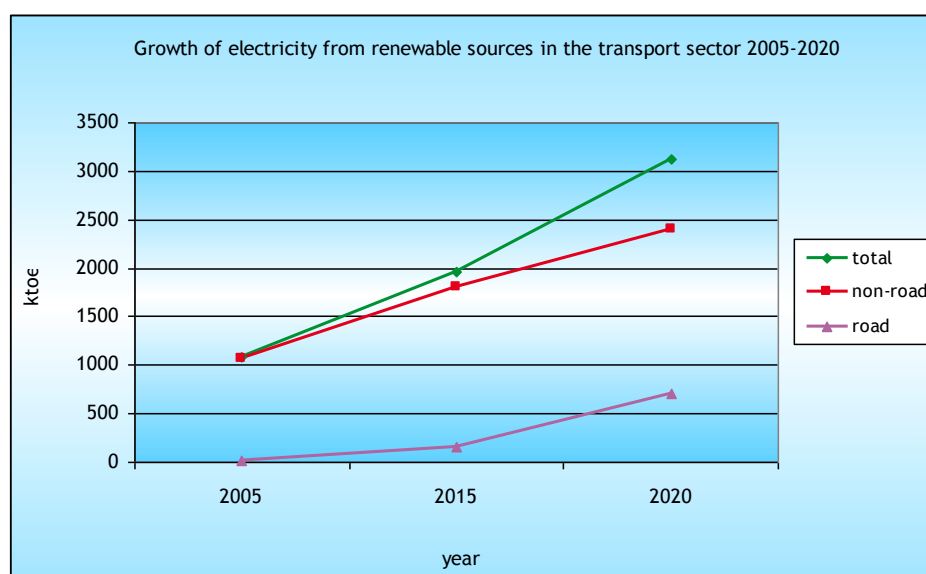


Table 1 Overview of electricity from renewable sources in the transport sector for EU 27 in 2020 (NREAPs)

Member State	Total		Road		Non-road	
	ktoe	%	ktoe	%	ktoe	%
Belgium	97	1.1%	42	0.5%	56	0.6%
Bulgaria	15	0.5%	8	0.3%	7	0.2%
Czech Republic	19	0.3%	1	0.0%	19	0.3%
Denmark	29	0.7%	12	0.3%	17	0.4%
Germany	667	1.4%	63	0.1%	604	1.3%
Estonia	1	0.1%	N/a	N/a	N/a	N/a
Ireland	37	0.6%	34	0.6%	2	0.0%
Greece	17	0.3%	5	0.1%	11	0.2%
Spain	381	1.2%	123	0.4%	258	0.8%
France	402	1.0%	110	0.3%	292	0.7%
Italy	369	1.1%	98	0.3%	271	0.8%
Cyprus	1	0.1%	1	0.1%	0	0.0%
Latvia	6	0.5%	2	0.2%	4	0.3%
Lithuania	3	0.1%	0	0.0%	0	0.0%
Luxembourg	10	0.4%	5	0.2%	5	0.2%
Hungary	24	0.4%	2	0.0%	22	0.4%
Malta	1	0.6%	1	0.6%	0	0%
Netherlands	71	0.7%	24	0.2%	47	0.5%
Austria	272	3.2%	68	0.8%	204	2.4%
Poland	50	0.3%	20	0.1%	30	0.2%
Portugal	58	1.0%	20	0.3%	38	0.7%
Romania	53	0.9%	14	0.2%	39	0.7%
Slovenia	11	0.6%	1	0.1%	9	0.5%
Slovakia	17	0.6%	5	0.2%	12	0.4%
Finland	40	1.0%	10	0.3%	20	0.5%
Sweden	198	2.4%	9	0.1%	190	2.3%
United Kingdom	267	0.6%	29	0.1%	238	0.5%

Note: Percentages are share of renewable electricity in the final gross energy consumption in the transport sector.

Figure 3 Growth of electricity from renewable sources in the EU transport sector 2005-2020 (NREAPs)



### 2.3 Hydrogen

Only Romania indicated that it expected renewable hydrogen to contribute to the 2020 renewable energy target in transport. The targeted volume is 2.5 ktoe or 0.3% of all renewable energies (= 100%) in transport in Romania in 2020.

### 2.4 Biomethane

The National Action Plan format did not provide a separate category to report the expected contribution of biomethane to the 2020 renewable energy target in transport. Biomethane could be, however, included in the category 'other biofuels', and Member States were asked to specify which biofuels would fall under this heading.

In the current NREAPs, there are 13 Member States that expected to partly meet the target with 'other biofuels', but none of these countries specified (quantitatively) which share biomethane was expected to have in that category.

In addition, the Member States were not asked to specify in the NREAPs whether the biomethane would then be used in transport via a dedicated distribution system, or via the general natural gas infrastructure. In the first case, the biomethane can be counted towards the 10% target with the standard biofuels methodology described in the RED. Only the biomethane distributed through the general natural gas infrastructure is part of the scope of this study.

Table 2 below provides an overview of the results for the 'other biofuels' category (such as biogas, vegetable oils, etc.).



Table 2 Overview on Member States' use of 'Other biofuels', among them biomethane, to fulfil the 2020 target of renewable energies in transport (data source: National Renewable Energy Action Plans - NREAP)

	Total amount of 'other biofuels' ktoe	Share of 'other biofuels' in the final gross energy consumption in the transport sector %
Belgium	0	0.0%
Bulgaria	7	0.2%
Czech Republic	49	0.7%
Denmark	0	0.0%
Germany	217	0.0%
Estonia	0	0.0%
Ireland	1	0.0%
Greece	N/a	0.0%
Spain	4	0.0%
France	160	0.4%
Italy	50	0.1%
Cyprus	0	0.0%
Latvia	31	2.4%
Lithuania	0	0.0%
Luxembourg	0	0.0%
Hungary	5	0.1%
Malta	N/a	0.0%
Netherlands	N/a	0.0%
Austria	94	1.1%
Poland	66	0.3%
Portugal	0	0.0%
Romania	7	0.0%
Slovenia	N/a	0.0%
Slovakia	5	0.2%
Finland	0	0.0%
Sweden	94	1.2%
United Kingdom	0	0.0%





# 3 Public consultation

## 3.1 Introduction and overview of the consultation

From 14/04/2011 to 14/06/2011 the Commission conducted a public consultation to inform its thinking. The consultation was titled *Accounting methods and conditions for the 10% renewable energy in transport target - and on the need for additional types of biofuels being listed in Annex III of the Renewable Energy Directive*<sup>9</sup>.

The consultation document poses a series of questions under the following sections:

### **Section A: Electricity from renewable sources in transport**

This section explores the significance of the 10% target in driving the uptake of EVs, the conditions for counting the whole amount of renewable electricity towards the 10% target, and the costs and benefits associated with preferred options for doing so.

### **Section B: Hydrogen from renewable sources in transport**

This section explores the techniques for producing hydrogen from renewable sources, and the possible ways of calculating the contribution of hydrogen originating from renewable sources towards the 10% target.

### **Section C: Biomethane via the natural gas grid in transport**

This section explores the significance of the 10% target in driving the uptake of methane-powered vehicles fuelled by methane from the gas grid, the conditions for counting the whole amount of methane towards the 10% target, and the costs and benefits associated with preferred options for doing so.

### **Section D: Energy content of biofuels**

This section explores the possible inclusion of types of biofuels not currently listed in Annex III of the RED, and the precision of energy content values<sup>10</sup>.

In total 39 responses were received<sup>11</sup> from a range of respondents including:

- national authorities (5 responses);
- companies (16 responses);
- industry associations (16 responses); and
- other organisations including one NGO and one academic institution.

Annex B provides a list of participants in the public consultation and an overview of the sections of the consultation paper which each participant responded to. Note: not all respondents provided comments on all of the questions. In many cases the number of responses for individual questions was only around 30 responses. This reduces the significance of a statistical analysis of the responses. Some respondents provided multiple answers to some

<sup>9</sup> [http://ec.europa.eu/energy/renewables/consultations/20110614\\_res\\_target\\_en.htm](http://ec.europa.eu/energy/renewables/consultations/20110614_res_target_en.htm).

<sup>10</sup> Note: the responses to this section have been included in the summary evaluation on the request of DG Energy, but were not part of the scope of this study.

<sup>11</sup> In total there are 40 responses to the consultation. However, two responses were received from one company. After clarification with the respective company, one response has been deleted.



questions, so the number of responses does not always reflect the number of submissions.

## 3.2 Headline results of the consultation

In the period to 2020, none of the respondents sees the 10% target as being a strong driver of electric vehicle developments, and only one of the respondents, the Natural Gas Vehicles Association (NGVA) sees the 10% target as being a strong driver of the development of methane-powered vehicles. More than half of the respondents who provided comments on these questions (questions A1 and C1) see the target as being 'not significant'.

There is a wide range of views on the appropriate conditions for counting the whole amount of electricity used in EVs as being renewable. No clear option emerged as the favoured approach, but it is notable that there was less support for tradable certificates compared with biomethane - roughly a quarter of respondents for electricity compared with nearly half for biomethane.

Around two thirds of respondents do not expect significant hydrogen production from renewable sources by 2020. There are almost no suggestions for calculating the contribution of hydrogen towards the 10% target.

The majority of respondents supported an approach using either tradable certificates or supply contracts which enable accounting for biomethane injected into the grid. However, there are some notable differences of opinion on this issue - for example, Germany is strongly opposed to the use of tradable certificates, whereas other countries such as the United Kingdom, Denmark, Sweden and the Netherlands are supportive of this option.

Several respondents noted risks relating to double counting of biomethane from the grid. Potential double counting could arise if, for example, biomethane is counted for electricity, heat and transport, biomethane is counted in the country of origin and the country of use if there is cross-border trading, or biomethane benefits from multiple support instruments (e.g. feed-in tariffs, certificates, subsidies and tax exemptions).

## 3.3 Summary of results from individual sections

### 3.3.1 Section A: Electricity from renewable sources in transport

*Question A1: How do you value the impact of the 10% target for renewable energy in transport by 2020 on the development of electric vehicles?*

- *Not significant.*
- *Significant, but other policies/developments will be of more importance.*
- *Important, along with other policies/developments.*
- *A key driver.*

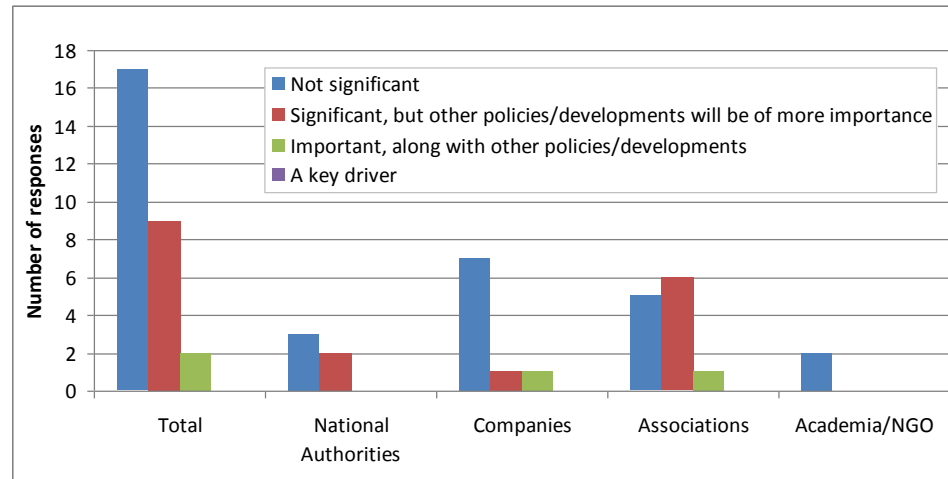
Respondents generally foresee a minor impact of the 10% target for renewable energy in transport by 2020 on the development of Electric Vehicles (EVs). 17 out of 30 respondents state that the impact will not be significant. The main reason provided is that electricity for EVs will mainly come from non-renewable sources as renewable electricity is envisaged to have only a minimal share of energy used in road vehicles by 2020. These responses are supported by the assessment of NREAPs in Chapter 2.





An additional 9 of the 30 respondents indicated that the impact would be significant, but that other policies are of more importance. Suggestions provided by two of the national authorities and the NGO include national strategies, national subsidies and CO<sub>2</sub> standards for cars. These policies are discussed in Chapter 4.

Figure 4 Responses to the impact of the 10% target on the development of electric vehicles



Source: Own presentation according to consultation responses.

**Question A2:** *Under what condition do you think it would be justified to count the whole amount of electricity in electric vehicles as renewable?*

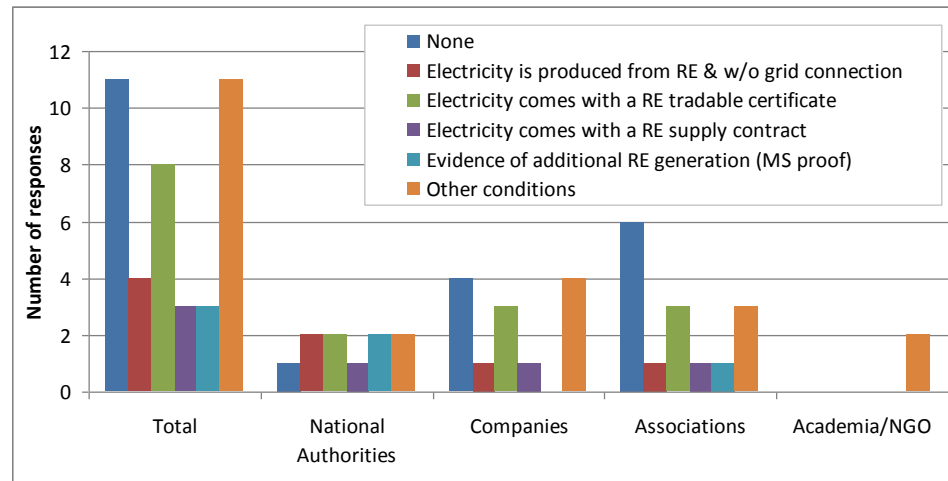
- None.
- When the electricity is produced fully from renewable energy and without connection to the electricity grid.
- When the electricity comes with a tradable certificate showing that that amount of renewable electricity was generated.
- When there is a supply contract showing that that amount of renewable electricity was generated.
- When there is evidence on a Member State level that the development of electric vehicles has led to that amount of additional renewable electricity generation.
- Other (please specify):

All of the respondents are opposed to the counting of the whole amount of electricity in EVs as renewable if there is no proof that it is renewable. However, of the 30 responses to this question, there was considerable divergence on the conditions that would justify this:

- Around one third of respondents (11) see no conditions as being adequate.
- 8 of respondents state that a certificate system would be adequate.
- 4 state that electricity must be produced fully from renewable energy and without connection to the electricity grid.
- 3 state that there need to be a supply contract showing that that amount of renewable electricity was generated. And
- 3 state that there needs to be evidence that the development of electric vehicles has led to additional renewable electricity generation.



Figure 5 Responses to the conditions to count the whole amount of electricity in EVs as renewable



Source: Own presentation according to consultation responses.

In addition, a number of respondents also suggested other options such as:

- A warranty of the energy supplier that the electricity is 100% renewable (supported by 3 respondents).
- Smart charging as a prerequisite which shows how much renewable electricity has been used (supported by 3 respondents).
- A statistical approach based on the electricity mix in each Member State during the hours of the most representative charging time, stated by TOTAL.
- If the electricity is delivered by a 100% renewable energy utility, stated by Mr. Creuzig of the Technical University (TU), Berlin.

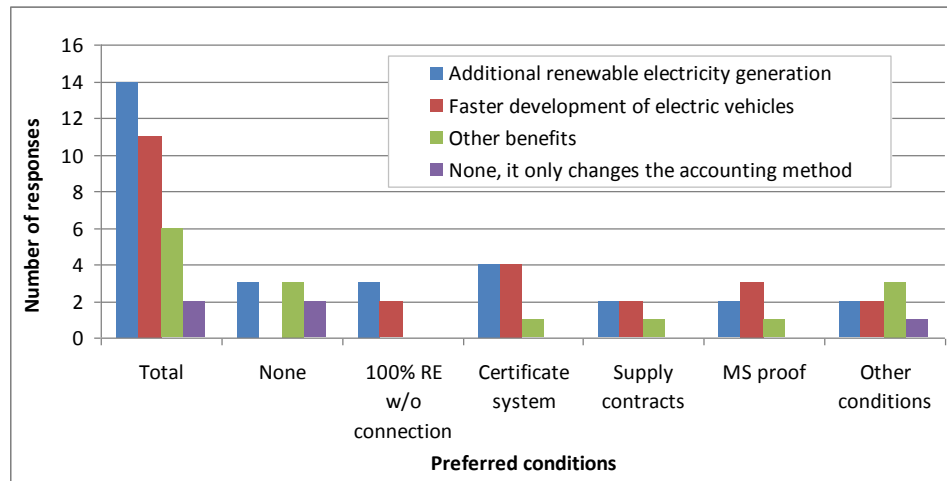
*Question A3: What benefits do you expect the option you selected under (2) will have?*

- *Additional renewable electricity generation.*
- *Faster development of electric vehicles.*
- *Other (please specify):*
- *None, it only changes the accounting method.*

There does not appear to be a strong relationship between the choice of conditions under Question A2 and the benefits identified by respondents under Question A3. Regardless of the approach preferred in terms of the conditions for counting renewable electricity, the most common benefit identified by respondents is additional renewable electricity generation (12 of 30 respondents). The second most popular benefit is faster development of EVs (7 of 30 respondents). In addition, a number of other benefits were also mentioned, including 3 respondents which indicated that it would help ensure that the 10% transport target is actually met.



Figure 6 Expected benefits based on the preferred conditions in Question A2



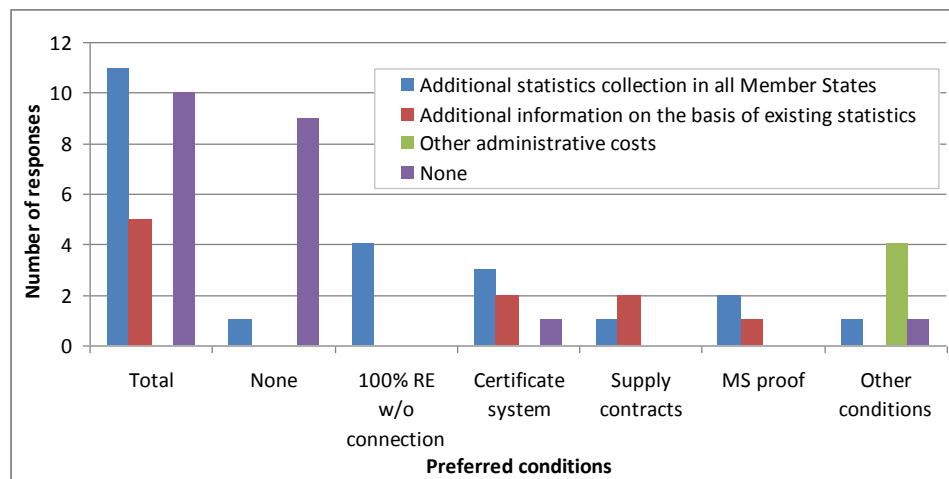
Source: Own presentation according to consultation responses.

Question A4: What costs in terms of administrative burden do you expect the implementation of the option you selected under (2) will have?

- Additional statistics collection in all Member States.
- Generating additional information on the basis of existing statistics.
- Other (please specify):
- None.

The expectations regarding administrative costs of implementing the preferred accounting method are related to the chosen method. Indeed, respondents which see no conditions as being appropriate to justify the counting of the whole amount of electricity as renewable also foresee no additional burden. The respondents which prefer that electricity must be produced fully from renewable energy and without grid connection and those in favour of a certificate-based system believe that additional statistics collection in all Member States will be required.

Figure 7 Expected administrative costs based on the preferred conditions in Question 2



Source: Own presentation according to consultation responses.



### 3.3.2 Section B: Hydrogen from renewable sources in transport

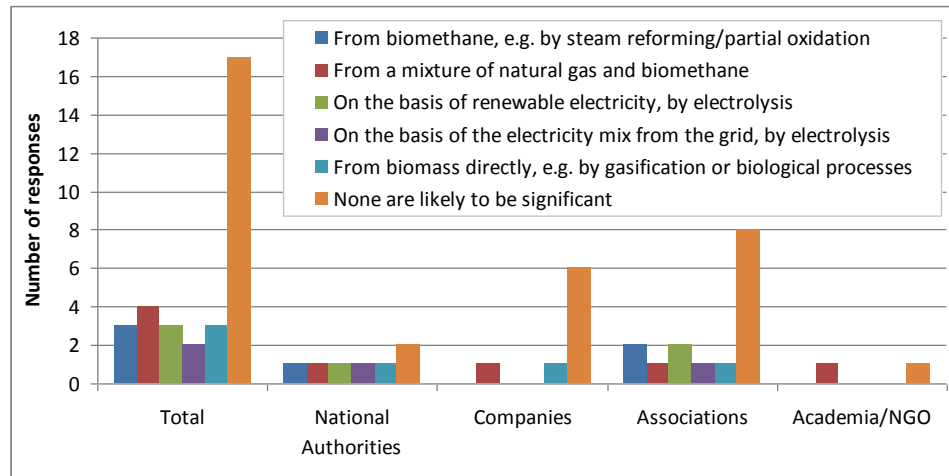
*Question B1: Which are in your view the most likely ways to produce hydrogen from renewable sources (partly or fully) by 2020?*

- From biomethane, e.g. by steam reforming/partial oxidation.
- From a mixture of natural gas and biomethane, e.g. by steam reforming/partial oxidation.
- On the basis of renewable electricity, by electrolysis.
- On the basis of the electricity mix from the grid, by electrolysis.
- From biomass directly, e.g. by gasification/partial oxidation or biological processes
- Other (please specify):
- None are likely to be significant by 2020.

Of the 26 responses to this question, 17 (around two thirds) stated that the production of hydrogen will not be significant by 2020 from any of the techniques listed or using other hydrogen production processes which could have been suggested.

Lack of cost-competitiveness is seen as the main reason, with several respondents (e.g. APPA, TOTAL) mentioning that fossil fuel-based hydrogen production will be the main choice by 2020.

Figure 8 Views on the most likely ways to produce renewable hydrogen by 2020



Source: Own presentation according to consultation responses.

Of those that do see a role for the production of hydrogen from renewable sources, there is no obvious preferred hydrogen production technology. Preferences are rather evenly distributed across the responses, reflecting the fact that infrastructure deployment is at too early a stage to draw robust conclusions regarding which process could emerge as the leading source of hydrogen production in Europe in the future. Indeed, the two submissions from European hydrogen and fuel cell industry associations notably do not single out any of the suggested hydrogen production pathways. Some points are worth noting:

- The EU Hydrogen Association is making the case for including ‘waste H<sub>2</sub>’ (by-product from industrial processes).
- For cost-reasons, some respondents (3) see natural gas being used at first, possibly successively complemented by biomethane.



- Several respondents mention high shares of renewable electricity in the grid as a driver for hydrogen production, i.e. for large-scale/long-term energy storage for fluctuating renewable energy sources (in particular, wind power).

*Question B2: For each option you selected under (2), if it would be used for transport, how would you suggest to calculate its contribution to the 10% target for renewable energy in transport?*

Since hydrogen is expected to play an insignificant role by 2020, most of the respondents do not propose a specific calculation method but state that the development of a calculation method must be in line with the respective production pathways that emerge.

Almost all respondents state that only the share of hydrogen produced from renewable energy (i.e. biomass gasification, biogas reforming or via electrolysis using renewable electricity) should be counted as renewable, excluding quantities derived from fossil fuel use in e.g. mixtures of biomethane and natural gas or when renewable hydrogen is supplied to a grid which is also distributing hydrogen from non-renewable sources.

The respondents are supportive of renewable sources being counted towards the 10% target as long as the Member States provide the respective evidence. This could, for example, be provided by a certificate system (supported by 3 respondents). One industry association (NEW-IG) suggests that until 2020 all of the hydrogen dispensed to vehicles should be counted as renewable as hydrogen use will remain a niche activity by 2020 anyway. Some general descriptions of other possible calculation methods are also provided:

- The calculations should be based on an average vehicle and on the average amount of fossil fuel that is replaced (Netherlands Ministry of Infrastructure and Environment).
- A mass balance system from the source to the final use such as for biofuels could be used, with the same sustainability and accountability conditions should be used (ePURE).
- One respondent (Choren Industry) suggests that the use of hydrogen produced from renewable sources in the mineral oil refining process should also be counted towards the 10% target where it substitutes fossil energy-based hydrogen in this process.

### 3.3.3 Section C: Biomethane via the natural gas grid in transport

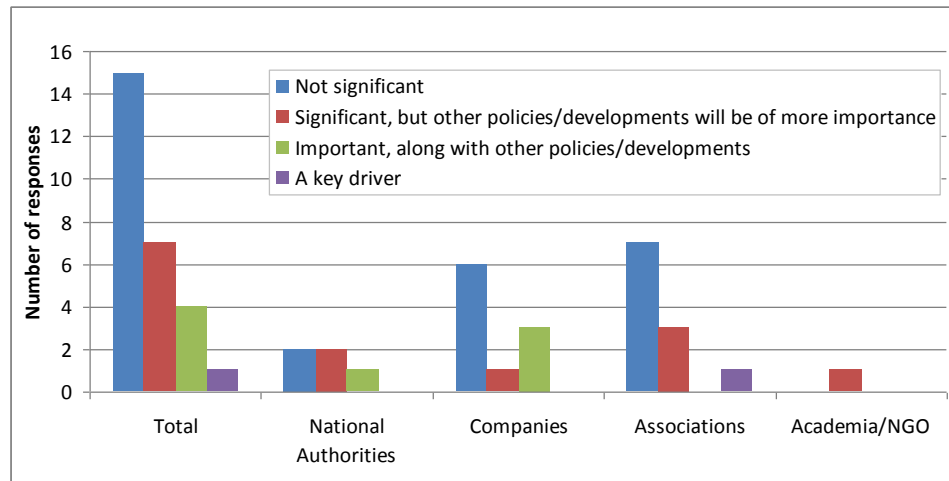
*Question C1: How do you value the impact of the 10% target for renewable energy in transport by 2020 on the development of methane vehicles fuelled by methane from the gas grid?*

- *Not significant.*
- *Significant, but other policies/developments will be of more importance.*
- *Important, along with other policies/developments.*
- *A key driver.*

Only one of the respondents, namely NGVA, identified the 10% RED target as a ‘key driver’ of the deployment of biomethane vehicles to 2020. Around half of the respondents (15 of 28) state that the impact will be ‘not significant’, with another third of respondents (11 of 28) believing that the target will have an important or significant impact next to other policies.



Figure 9 Responses to the impact of the 10% target on the development of methane fuelled vehicles



Source: Own presentation according to consultation responses.

An important reason provided for the expected low contribution of biomethane in the timeframe to 2020 is the significantly lower barriers to the deployment of liquid biofuels compared with biomethane from the grid<sup>12</sup>. Further, the competition with natural gas, LPG and the greater incentives to generate electricity also limit the use of biomethane as a transport fuel. Policies identified as being more important for the development of methane vehicles relate to the price of methane as a transport fuel, including tax incentives, support mechanisms for infrastructure requirements, or rebates on the purchase price of methane-powered vehicles.

*Question C2: Under what condition do you think it would be justified to count the whole amount of methane extracted from the gas grid for the use in vehicles as renewable?*

- None, until the time that all methane injected into the gas grid concerned is originating from renewable sources.
- When the methane comes with a tradable certificate showing that that amount of biomethane was generated.
- When there is a supply contract showing that that amount of biomethane was generated.
- When there is evidence on a Member State level that the development of methane vehicles has led to that amount of additional biomethane generation.
- Other (please specify):

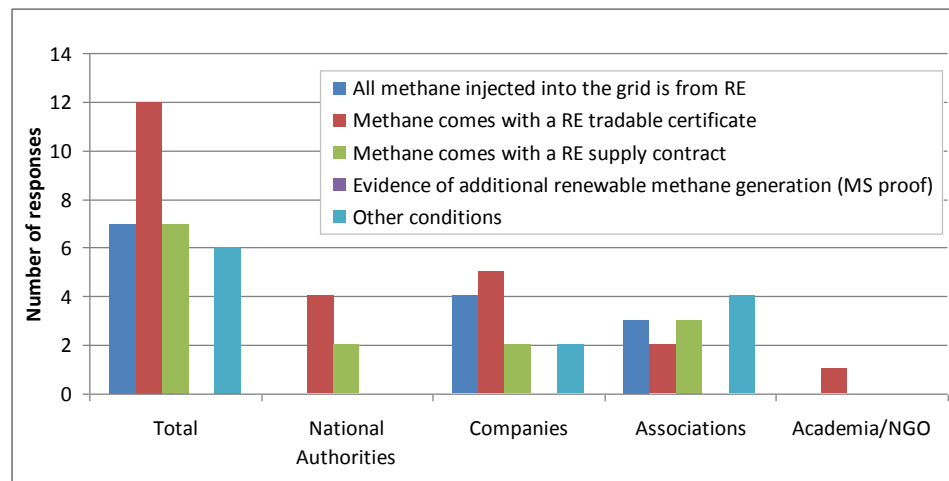
There is a split between respondents on the preferred conditions for counting of the whole amount of methane in methane vehicles as renewable:

- 7 of the 28 respondents do not want to count all methane as renewable until all methane in the grid is renewable.
- 12 of the 28 respondents support counting the methane as renewable when it comes with a certificate.
- 7 of the 28 are supportive if it comes with a direct supply contract.

<sup>12</sup> For biomethane, dedicated distribution infrastructure (such as fuelling stations), vehicle drive-trains as well as adjustments of national regulations to allow injection of biogas into the general natural gas grid are required, whereas liquid biofuels can generally 'drop in' to the existing distribution system.



Figure 10 Preferred conditions to count the whole amount of methane as renewable



Source: Own presentation according to consultation responses.

There is no obvious, preferred set of conditions for counting renewable biomethane, probably reflective of the lack of practical experience to date. Industry responses (companies and industry associations) mainly representing the interests of the liquid biofuels industry prefer that no methane is counted as renewable as long as not all methane in the grid is renewable. However, around half of the company responses are supportive of counting biomethane on the basis of tradable certificates, as were the majority of National Authorities. The United Kingdom, Denmark, Sweden and the Netherlands are supportive of tradable certificates; only Germany is opposed - it supports direct selling to the customer with no double counting due to a separate selling of a green certificate.

Several other respondents also stress that it is necessary to ensure that no double counting occurs (Denmark, the Netherlands, APPA Biocarburantes). Several potential fields for double counting are mentioned, for example with regard to biomethane being double counted for electricity, heat and transport; in the country of origin and the country of its use with cross-border trading; or based on different support instruments (feed-in tariffs, certificates, direct subsidies, tax exemptions).

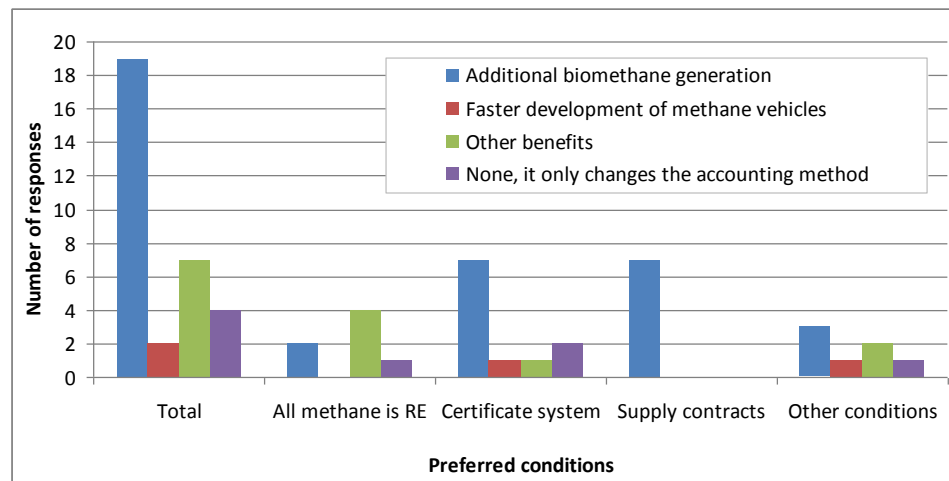
*Question C3: What benefits do you expect the option you selected under (2) will have?*

- Additional biomethane generation.
- Faster development of methane vehicles.
- Other (please specify):
- None, it only changes the accounting method.

Regardless of the conditions selected in response to Question 2, the most popular benefit identified by the respondents (15 of 27) was that they expect additional biomethane production to result. In many cases, the submissions did not explain in detail why this benefit was expected to result, however, Sweden for example noted that national measures would still be required, and that the 10% target (and accounting method) would not lead to additional biomethane production on its own. This is backed by our analysis of the drivers in Chapter 4.



Figure 11 Expected benefits based on the preferred conditions in Question C2



Source: Own presentation according to consultation responses.

Respondents also suggested a number of other benefits of tradable certificates or direct supply contracts, including the securing of correct and verifiable declarations and accounting and the clear identification of feedstock and processes applied to produce biomethane. The NGVA submission states that it expects significant job deployment in the Member States if any percentage of biomethane being injected into the gas grid is acknowledged.

*Question C4: What costs in terms of administrative burden do you expect the implementation of the option you selected under (2) will have?:*

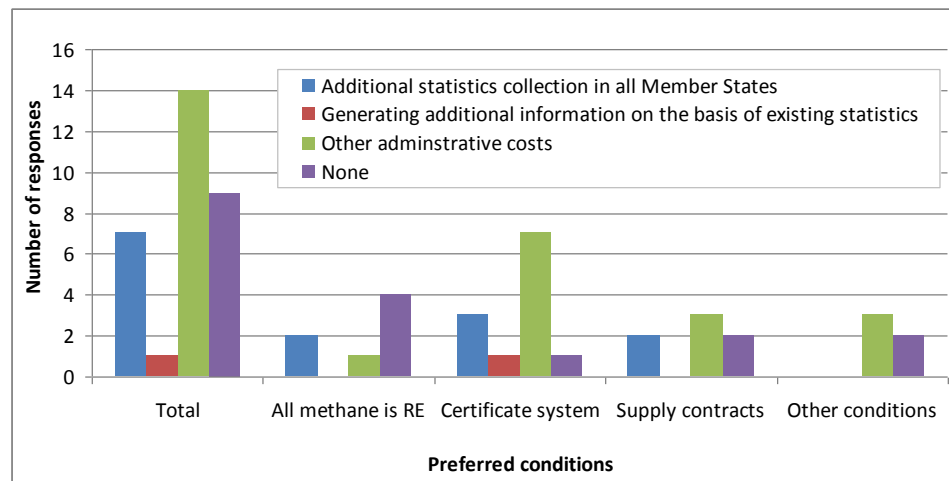
- Additional statistics collection in all Member States.
- Generating additional information on the basis of existing statistics.
- Other (please specify):
- None.

There is no consensus on the expected costs in terms of administrative burden for any of the accounting methods with the exception of the option that all methane injected is renewable, where no costs are expected. In general, industry (companies and industry associations) expects mainly no or low costs in terms of administrative burden, independently from the preferred option. Three out of five of the National authorities stated that there will be additional statistics collection required in all Member States if a certificate system or direct supply contracts are used; the Swedish submission also noted the need for a new administrative system to handle the certification of 'green' contracts.





Figure 12 Expected administrative burden based on preferred conditions in Question C2



Source: Own presentation according to consultation responses.

### 3.4 Section D

*Question D1: Do you think additional types of biofuels need to be listed in Annex III of the Directive? If yes, which ones and could you provide values?*

Around half of the respondents (16 out of 30) would like the Commission to include additional types of biofuels in Annex III of the Directive. Biofuels that should be included are the following (sorted by frequency with most frequently named biofuel listed first):

Table 3 Proposed additional types of biofuels to be listed in Annex III

Type of fuel	Energy content	Mentioned by # respondents
<b>Hydrotreated Vegetable Oil (HVO)</b>		<b>4</b>
HVO petrol	44.87 MJ/kg	1
HVO jet fuel	44.30 MJ/kg	2
HVO LPG	46.33 MJ/kg	1
<b>Bio-Ethers</b>		<b>11</b>
TAME (Tert-Amyl Methyl Ether)	36.44 MJ/kg, 37.66 MJ/kg	4
TAAE (Tert-Amyl Ethyl Ether)	NV	2
THEME (Tertiary Heptyl Methyl Ether)	38 MJ/kg	1
THxME (Tertiary Hexyl Methyl Ether)	NV	1
THEE (Tertiary Heptyl Ethyl Ether)	NV	1
THxEE (Tertiary Hexyl Ethyl Ether)	NV	1
Diethyl Carbonate	NV	1
<b>Bio-Ester</b>		<b>2</b>
FAEE (Fatty Acid Ethyl Esters)	NV	2
<b>Jet fuels</b>		<b>4</b>
Fischer-Tropsch jet fuel	NV	2
HVO jet fuels (see HVO)		
Jet fuel produced via biomass liquefaction/pyrolysis	NV	1
Jet fuel produced via sugar/cellulose direct conversion	NV	1



Type of fuel	Energy content	Mentioned by # respondents
<b>Renewable Hydrogen</b>	120 MJ/kg, 10.80 MJ/m <sup>3</sup>	<b>3</b>
<b>Biofuels, produced from sugar</b>		<b>2</b>
Sugar to Y molecules	NV	1
Direct conversion via sugar/cellulose	NV	1
<b>Bio-Alcohols</b>		<b>2</b>
Bio-Propanol	31 MJ/kg	1
Bio-Methanol	NV	1
<b>Wood gas</b>	NV	<b>1</b>
<b>Bionaphtha</b>	NV	<b>1</b>
<b>Used oil</b>	NV	<b>1</b>

NV = No Value

Several respondents also propose the inclusion of a procedure that allows producers of biofuels to ask at any time for the inclusion of a type of biofuel and value to the Annex III.

*Question D2: Do you think more precision in terms of decimals is necessary in the values in the Annex? If yes, could you provide such values?*

All five of the responding National Authorities would like to see greater precision, to an accuracy of 1-2 decimal places. Most of the responding companies on the other hand do not see the need for more precision (only 3 out of the 12 company submissions were in favour). Industry associations were split, however several (3 of 5) would like to have more precision (to 2 decimal places). The Association of the German Biofuel Industry as well as the German Renewable Energy Federation states that it is necessary to clarify the intended purpose of the values listed in Annex III as well as moving to a greater level of accuracy - for example, if the values are to be used for statistical purposes only and not for other purposes such as determining taxation. They insist that Germany was planning to change the values for taxation according to the RED Annex.

With respect to the more precise values for different types of biofuels the respondents mainly referred to specific sources. For example, the Sweden Ministry of Enterprise, Energy and Communications refers to the values used in energy statistics of Sweden, the EU Biofuels Technology Platform and Neste Oil Corporation propose the use of German DIN51900-1:2000 or other standards such as ASTM D 4809-2009. The German Renewable Energy Federation and the Association of the German Biofuel Industry suggest the use of values already applied for taxation (in Germany: Decree of the German Federal Ministry of Finance, 17.06.2007, III A1 - V 8405/07/002). The Austrian Federal Economic Chamber refers to CONCAWE.

For the fuel types that have been proposed by the respondents to be included in Annex III (see Question D1) more precise values can be found in Table 3.



# 4 Drivers for the increase in production of electricity, hydrogen and methane from renewable sources

## 4.1 Introduction

This chapter provides an examination of the drivers for the uptake of renewable energy in the EU. It is important to identify the key drivers and to understand to what extent the uptake of renewable energy is related to transport sector developments (for example, initiatives aimed at promoting the emergence of electric vehicles). It is also important to try to identify how the transport sector could potentially become more of a driver for the production of renewable energy in the future.

There is a wide range of drivers that need to be considered: in particular, the EU policy framework, specific measures implemented at the Member State level, and sub-national initiatives. There is also a range of relevant commercial developments taking place, including the development of new business models and new technologies. The combined effect of these drivers will determine the rate and nature of the uptake of new technologies and the extent to which renewable energy is used in transport.

This chapter serves to provide background information for the assessment of options for counting the full amount of renewable electricity, biomethane and hydrogen from renewable sources towards the 10% target. These options are outlined in Chapter 5 and assessed in Chapter 6. Starting point of that assessment is that implementing more complex accounting arrangements is only justified if the methodology is likely to significantly support the drivers identified here, and thus leads to additional RE production. If increased transport sector demand for renewable energy leads to a reduction of consumption of renewable energy in other sectors such as stationary energy, then total demand for renewable energy does not increase and the renewable energy consumed by the transport sector cannot be considered to be additional.

## 4.2 Chapter overview

Increasing the share of electricity, hydrogen and methane from renewable sources in the transport sector requires a two-sided transformation. First, there is a need to shift away from conventional vehicles and fuels (links to measures to stimulate the demand for renewable energy sources in transport), and second, there is a need to shift to renewable energy sources (links to measures to stimulate the supply of renewable energy sources in transport). These steps can be taken in parallel or in sequence, but both require significant effort and changes.

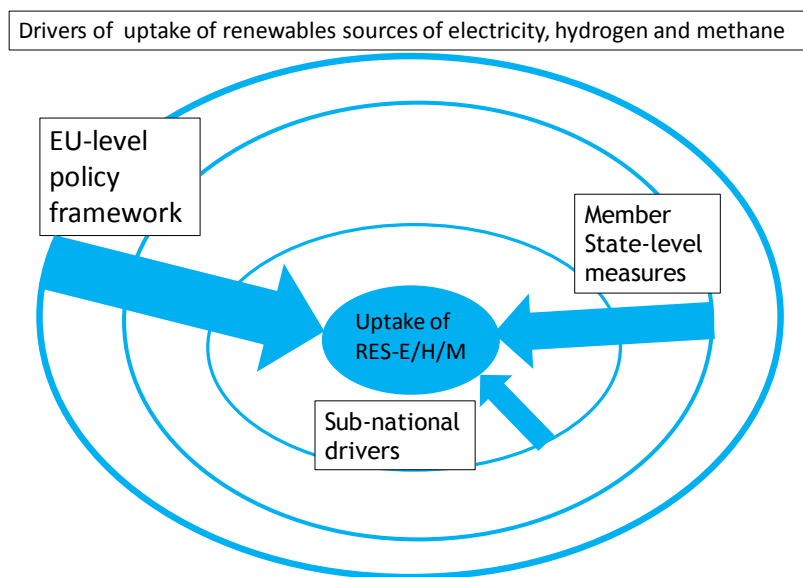


This chapter starts (Section 4.3) with a brief overview of the EU level policy framework relevant to the uptake of renewable energy. It then outlines the EU policy framework relevant to the transport sector.

The chapter then provides an overview of key policy drivers of renewable energy production across Member States (Section 4.4). Aside from these supply side drivers, there is also a range of drivers that relate more to the demand side - for example, incentives to encourage uptake of alternative vehicles. We provide a brief overview of various such initiatives being implemented at the city, regional and commercial level (Section 4.5).

The diagram below illustrates the different levels of drivers that act to influence the uptake of renewable sources of electricity, hydrogen and methane. Each level of policy, program or incentive can coexist with the policies, programs and incentives introduced at higher or lower levels of government.

**Figure 13** Different levels of drivers coexist at the EU, Member State and sub-national level



While the overview of policy drivers focuses on the period up to 2020, we also consider the potential for longer term developments in the transport sector to play a more significant role in the demand for renewable energy (Section 4.6).

Country case studies are used to explore the specific circumstances that exist in a number of Member States with relevant experiences (Section 4.7). Conclusions from the assessment of the drivers for renewable energy uptake are provided at the end of the chapter (Section 4.8).

### 4.3 EU level drivers for the promotion of renewable energy in transport

#### 4.3.1 EU policy framework

This section of the report provides a brief overview of the EU's broad policy framework relating to climate change and energy, and the policy directives aimed at driving the use of renewable energy in general and more specifically for use in transport. Aside from policies aimed at directly stimulating the uptake of renewable energy, there is also a range of policy instruments aimed



at improving the fuel efficiency of vehicles. These measures could act as indirect drivers to increase the uptake of renewable energy since fuel taxes and mandatory fuel efficiency targets will over time affect the purchasing behaviour of consumers when deciding on buying either a more efficient conventional vehicle versus an alternative drive-train vehicle (i.e. one powered by electricity, biomethane or renewable hydrogen). Further, since the transport target in the RED is expressed as a percentage of the overall energy consumption in the transport sector, a lower total fuel consumption for the same absolute amount of renewable energy consumed would increase the relative share of renewable energy in the total, offering a second approach to meeting the targets.

### Strategic policy framework

The 'Europe 2020 Strategy' for smart, sustainable and inclusive growth commits the EU to reducing greenhouse gas emissions by 20%<sup>13</sup>, increasing the share of renewable energy in the EU's energy mix by 20% (with differentiated Member State targets in the RED) and improving energy efficiency by 20%, by the year 2020.

The EU also has the objective of reducing its greenhouse gas emissions by 80-95% by 2050 compared to 1990 levels. The Commission recently released a number of key documents that start to map out the pathway for the EU to achieve this challenging objective:

- 'A Roadmap for moving to a competitive low carbon economy in 2050' (Roadmap 2050), accompanied by the Energy Efficiency Plan 2011 (both released 8 March 2011). And
- 'White Paper: Roadmap to a Single Transport Area - Towards a competitive and resource efficient transport system' (Transport White Paper, released 28 March 2011).

The Roadmap for 2050 estimates that to achieve the EU's 80-95% greenhouse gas emissions reduction target, the transport sector will have to reduce its emissions by somewhere between 54-67% by 2050. Up until 2025 the main driver for reversing the current trend of *increasing* greenhouse gas emissions in transport is likely to remain improving fuel efficiency (EC, 2011a). Beyond this, a major shift to electric mobility for road transport - or, if this is not feasible on a large-scale - a significant role for biofuels and other alternatives is foreseen.

In March 2011 the Commission adopted the White Paper 'Roadmap to a single European Transport Area - Towards a competitive and resource efficient transport system' (EC, 2011b). The White Paper recommends a target of cutting transport emissions to around 20% below their 2008 level by 2030 and to 60% by 2050 (EC, 2011b).

Included in its ten goals for a competitive and resource efficient transport system are further detailed goals of:

- halving the use of 'conventionally-fuelled' cars in urban transport by 2030; phasing them out in cities by 2050; achieving essentially CO<sub>2</sub> free city logistics in major urban centres by 2030;
- low carbon sustainable fuels in aviation reaching 40% by 2050; reducing CO<sub>2</sub> emissions from maritime bunker fuels by 40% by 2050;
- 30% of road freight over 300 km shifting to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050.

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<sup>13</sup> The strategy allows for increasing this target to 30%, if the conditions are right (i.e. in the case of a comprehensive global agreement).



The first of these goals could represent a significant driver for the uptake of renewable electricity in transport over the longer term. This would require the targets to be transformed into legally-binding requirements on Member States. EVs are particularly suited to urban transport due to their range being more limited paired with lower noise characteristics and benefits for local air quality. For the foreseeable future, the second goal is unlikely to be relevant to the energy carriers being investigated in this study. Technologies that would allow for the use of renewable electricity (battery electric aircraft or solar-powered aircraft), biomethane or renewable hydrogen are not currently available, and are not expected to be feasible any time soon. The third goal could be a significant driver if, for example, the binding shift in mode resulted in a significant increase in the use of rail for freight haulage. Combining this with an accounting method for counting renewable electricity consumed in rail transportation, Member States would be able to count this towards their 10% target.

The White Paper also calls for innovation in the field of intelligent infrastructure for electro-mobility, backed up by a regulatory framework for the inter-operability of charging infrastructure, interface standards for smart charging and funding programs for the deployment of smart technologies (EC, 2011a). These are not specifically drivers for the uptake of renewable energy in transport, but can be seen as critical enablers for a future transport system that maximises the potential benefits of EVs.

Prior to these documents, the Communication from the Commission 'A European Strategy on clean and energy efficient vehicles' was adopted in April 2010. It sets out a strategy for encouraging the development and uptake of clean and energy efficient 'green' vehicles including cars, trucks, buses and other vehicles. The strategy contains a wide range of actions relating to both conventional vehicles and low carbon vehicle technologies such as EVs.

While many of the direct drivers for the uptake of EVs will be implemented by Member States themselves, the Commission's work on standardisation is worth highlighting. The standardisation of EV charging is seen as a critical enabler for the more widespread uptake of EVs because it will give consumers confidence that they can charge anywhere at any time (EC, 2010). A standardised approach for EV grid communications is also seen by the electricity industry as a critical prerequisite for maximising the benefits of EVs through 'smart charging', defined by Eurelectric as "a controlled charging process that optimises the use of the grid and the available electrical energy to minimise additional investments in the grid and facilitates the integration of RES" (Eurelectric, 2011).

The Commission is currently working to develop a standardised approach for vehicle recharging.<sup>14</sup>

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<sup>14</sup> Within the framework of Directive 98/34/EC22: The European standardisation bodies were asked in 2010 to develop by 2011 a standardised charging interface to ensure interoperability and connectivity between the electricity supply point and the charger of the electric vehicle, to address safety risks and electromagnetic compatibility and to consider smart charging (ITRE report, 2010).



## Renewable Energy Directive

The RED is currently the most significant policy driver at the EU level. It contains an overall 20% renewable energy target in final energy consumption and a 10% target of renewable energy in transport for the EU for 2020. The RED also defines a legally binding national renewable energy target in final energy consumption for each Member State and requires Member States to meet the 10% transport target by 2020. All forms of energy from renewable sources can count towards meeting the transport target, and all transport sectors may contribute (numerator). The 10% target is accounted against the final energy use in road vehicles and rail (denominator).

In order to take the higher energy efficiencies of electric drive-trains into account (and the lower efficiencies of the well-to-tank energy chain), the EU RED stipulates a 2.5 multiplier to be applied to the electricity fed into battery electric vehicles. The multiplier thus levels out the otherwise existing bias towards internal combustion engines (~25-40% efficiency tank-to-wheel in the New European Driving Cycle, subject to gasoline or diesel process) compared with battery electric vehicles (~70-80% charge-to-wheel efficiency, subject to conditions). Auxiliary energy requirements, such as for heating/cooling, are not included in these figures.

## Fuel efficiency performance standards

Regulation (EC) No 443/2009 sets fuel efficiency performance standards (CO<sub>2</sub> emission limits) for manufacturers of new passenger cars. Recently, CO<sub>2</sub> standards have been extended to the regulation of vans and light commercial vehicles under Regulation (EC) No 510/2011 of 11 May 2011. Due to the similarity in the approach and time restrictions, focus is on the regulation for passenger vehicles.

Under Regulation 443/2009, an emission limit of 130g CO<sub>2</sub>/km is applied to the average of all new passenger cars registered in the EU in each calendar year, starting gradually in 2012.

Car manufacturers have to meet this target, but may form a pool or group to meet their targets. Penalty payments for small excess emissions until 2018 will remain relatively low, while fees will significantly rise in 2019. Longer term targets are to reduce the average emissions to 95 g/km for the year 2020.

There are certain aspects of the regulation that are drivers for EVs, but some concerns have also been raised. Firstly, the regulation is based on end-of-pipe emissions. EVs, FEVs and plug-in hybrid EVs when operating in electric mode are counted as emission-free by the Regulation, regardless of the up-stream emissions. Thus, the emissions standards may not act as an effective driver for the uptake of renewable energy since any resulting shift to EVs would not take into account the source of electricity consumed. Secondly, car manufacturers are currently allowed to count 'super credits' for cars that emit below 50 g/km. This is intended to be a temporary incentive for low-emission cars. The multiplier factor fades out over time to avoid the risk that a small number of low emission vehicles with super credits reduce numerically the total fleet emissions such that conventional cars have no incentive to improve fuel efficiency which might even entail a deterioration of fuel efficiency in the conventional segment (CE, 2010).





## Fuel Quality Directive

In 2009, Directive 2009/30/EC revised the Fuel Quality Directive (FQD), which aims to achieve a number of improvements in the environmental impact of diesel and petrol transport fuels. Under Article 7a of the Directive, Member States are required to oblige fuel suppliers to gradually reduce the life cycle greenhouse gas intensity of energy supplied for road transport and allows for a wide range of measures to be applied to meet the target.

Article 7a (2) stipulates that a reduction of up to 10% of the GHG intensity of transport fuels is to be achieved by the end of 2020 against the baseline year 2010. Electricity suppliers that supply electricity for use in road vehicles are able to opt in and have this electricity counted towards the target as long as they can demonstrate that they can adequately measure and monitor electricity supplied for use in those vehicles.

A minimum 6% reduction is to be achieved by 2020, with an indicative additional target of 2% to be achieved via one or both of two options. Firstly, energy supplied in road transport, non-road mobile machinery, agricultural or forestry tractor or recreational craft; and secondly, the use of technologies (including carbon capture and storage) that can reduce the life cycle emissions of energy supplied. An additional indicative 2% reduction target can be met through the purchase of credits under the Clean Development Mechanism of the Kyoto Protocol.

The methodology to calculate the contribution of electric road vehicles should be compatible with the accounting methodology in the RED.

## Clean Vehicles Directive

Directive 2009/33/EC, the Directive on the Promotion of Clean and Energy Efficient Road Transport Vehicles (Clean Vehicles Directive), aims to support the broad market introduction of environmentally-friendly vehicles and extends to all purchases of road transport vehicles, as covered by the public procurement Directives and the public service Regulation.

Starting in December 2010, Article 5 of the Directive requires Member States to oblige responsible agencies to take into account operational lifetime energy and environmental impacts (including energy consumption and emissions of CO<sub>2</sub>) when purchasing vehicles. Article 5 (3) allows a choice of two options to meet the requirements - firstly, by setting technical specifications for energy and environmental performance in the purchasing documentation; or secondly, by including energy and environmental impacts in the purchasing decision by monetising those impacts in accordance with a methodology set out in the Directive.

By way of encouraging public procurement of electric vehicles, biomethane-powered vehicles and hydrogen-powered vehicles, the Clean Vehicles Directive could in theory support the use of renewable energy from these sources in the transport sector. However, as concluded by the impact assessment associated with the introduction of the Directive, the nature of the policy measure suggests that rather than causing a shift to new technologies - for example, from petrol to electric or biomethane-powered vehicles - it would encourage a greater focus on more efficient models within the same technology category (EC, 2007). Thus the Directive is unlikely in itself to act as a major driver of the uptake of renewable energy sources relevant to this study.





## Taxation of motor fuels

Directive 2003/96/EC provides for minimum rates of taxation for motor fuel to be applied by Member States. The harmonisation of minimum rates is designed to reduce the potential for economic distortions across EU borders. The revision of the Energy Taxation Directive will be an opportunity to ensure better coherence between the Directive and the other main market-based instrument for GHG reduction, namely the EU Emissions Trading System (EU ETS).

The taxation of fossil-based motor fuels can help stimulate a shift to renewable transport fuels, including biomethane, provided that lower tax rates apply to the latter. This will be driven by the extent to which the taxes reduce the cost differential between conventional fuels and renewable fuels. To this end, many Member States already provide tax incentives for renewable transport fuels (mainly liquid biofuels, but also biomethane in some cases) as is outlined in Section 4.5.1.

In addition, the Commission has tabled proposed revisions to the Energy Taxation Directive which aim to rebalance the charges between different fuels, including biofuels and biomethane, and provides for a framework for CO<sub>2</sub> taxation of emissions not covered by the EU ETS (EC, 2011d ). The Commission's intention is to level the playing field for all fuels - for example, biofuels such as ethanol E85 are disadvantaged under the existing taxation regime. The proposal combines a minimum tax rate for the CO<sub>2</sub> component and the energy component of all fuels to produce revised minimum tax levels. The CO<sub>2</sub> component does not apply to electricity (already covered under the EU ETS), and the carbon component would have a zero value for all biofuels that comply with the sustainability criteria laid down in Article 17 of the RED. The combined effect is that a set of minima increases for all fuels is to be phased-in, with the new values designed to level the playing field for all fuels.

While unlikely to be an issue for the timeframe being considered in this study, the mass market shift to electro-mobility could erode the motor fuel tax base over the longer term if the taxation of electricity does not provide an equivalent revenue stream to that of liquid motor fuels. A recent study by CE Delft, Ecologic, and ICF for DG Clima estimated the potential losses under the fiscally least favourable scenario as being € 20 billion below the reference case in 2020 and € 38 billion below in 2030 (CE, 2011). There is considerable uncertainty about the timing of penetration of EVs beyond 2020. Theoretically at least, if this issue were to emerge as a concern for Member States they could consider taxing the non-renewable electricity consumption of EVs at a higher rate. Provided that the accounting framework allows for this approach it could - in theory - also encourage the consumption of renewable electricity in transport (although EV market uptake might also be impacted). Other revenue sources such as differentiated road charging and phasing out the tax breaks currently offered for EVs may also help to balance out any revenue losses<sup>15</sup>.

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<sup>15</sup> It has been suggested in the media that the Dutch Government is already considering scrapping the tax breaks for the purchase of hybrid vehicles due to the loss of tax revenues (DutchNews.nl: *Tax breaks on green cars set to go because they are too successful*, 2011).



## EU Emissions Trading Scheme

Directive 2003/87/EC established the EU Emissions Trading Scheme (EU ETS). The EU ETS operates in 30 countries - the EU 27 Member States, plus Iceland, Lichtenstein and Norway. Coverage of electricity generation emissions under the EU ETS means that a shift to EV use will add demand for electricity, and hence emissions allowances (EUAs) to the extent that this electricity is not emissions-free.

Assuming no increase to the EU ETS cap to accommodate the shift to electro-mobility, this could theoretically support upward pressure on both carbon and electricity prices and therefore stimulate renewable energy investment to meet the additional demand. However, the expected slow pace of EV uptake means the extent to which this shift would impact on EUA prices is likely to be limited. The study by CE Delft, Ecologic and ICF mentioned above concluded that the impact of EVs on the EUA price is likely to be insignificant up to 2030 under all three considered scenarios in that study: demand for EUAs from the EV fleet is likely to remain within 0.5-2.4% of total demand and should not impact on carbon prices (CE, 2011).

Over time, the additional demand for EU ETS EUAs by higher EV market penetration could in theory become an effective driver for additional renewables in transport<sup>16</sup>. However, this would require a) a tight cap, and b) mass-market penetration of alternative vehicles.

Where rail transport is concerned, electricity consumed by rail is already covered by the EU ETS. A switch to rail transport away from other modes such as road transport (e.g. for freight) could result in additional demand for electricity, and depending on the extent of this switch and the stringency of the EU ETS cap, this could add to upward pressure on EUA prices over time. As discussed above, the Transport 2050 White Paper includes a target to shift 30% of road freight over 300 km to other modes such as rail by 2030 and more than 50% by 2050. The Commission could at a future point in time consider the potential impact of this shift combined with the shift to e-mobility for passenger vehicles: that is, to estimate the extent of the increase in demand on electricity, and hence EUA prices and electricity prices, and what this would mean for investment signals for additional renewable electricity generation.

The aviation sector will be included in the EU ETS from 2012 onwards. However, as discussed earlier, this will drive uptake of liquid biofuels only - with biofuel-kerosene certification pending.

## EU initiatives aimed at stimulating transport sector innovation

The policy framework outlined above is complemented by a range of EU level funding initiatives aimed at stimulating innovation in the transport sector. While not the focus of this study, some examples of these are discussed briefly in this section.

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<sup>16</sup> That is, if EUA prices are impacted on significantly by the switch to electricity, be it directly used to charge batteries or to produce hydrogen via water electrolysis.



### *Green Cars Initiative*

The public-private partnership Green Cars Initiative (GCI) provides financial support for research into green vehicle technologies. Such technologies can include cleaner and more efficient combustion engines, biomethane, electric and hybrid vehicles, as well as infrastructure R&D. Under the GCI, grants for research are provided from the European Commission and loans can be obtained from the European Investment Bank (EC, 2010d). The Commission is currently looking into how funding for R&D through the EIB can be continued into the future (EC, 2010).

Under this initiative, Green eMotion is an EU wide demonstration project that will connect regional and national electro-mobility initiatives to demonstrate the integration of electro-mobility into electrical networks and contribute to development of standardised approach for electro-mobility (Green eMotion press release, April 2011). The project started in March 2011 and will run for four years with a total budget of € 42 million.

### *Fuel Cells and Hydrogen Joint Undertaking (FCH JU)*

Launched as a stakeholders' 'Technology Platform' under the sixth Framework Programme for Research (FP6) the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) is a public-private partnership supporting research, technological development and demonstration activities in fuel cell and hydrogen energy technologies in Europe.<sup>17</sup> Its aim is to accelerate the market introduction of fuel cell and hydrogen energy technologies and achieve mass market growth in the transport sector in the timeframe 2015-2020. Three members form the FCH JU: the European Commission; fuel cell and hydrogen industries represented by the NEW Industry Grouping; and the research community represented by Research Grouping N.ERGHY. The European Commission will contribute up to € 470 million for the six-year period until 2013 (EC, MEMO/07/404, Brussels, 10 October 2007). This as well as other public sources of funding (Member States) have to be at least matched by private investments.

In the framework of FCH JU, the H<sub>2</sub> Coalition Study (H<sub>2</sub> Coalition, 2010) has been presented end of 2010. In a benchmarking exercise, vehicle performance data of a portfolio of alternative drive-trains have been collected from major automotive stakeholders. Fuel cell electric vehicles appear to be the lowest carbon solution for long distance driving and family-size cars.

## **4.4 Member State level drivers of renewable energy development**

As described above, the RED is the key policy document at the EU level driving the uptake of renewable energy. The RED must be implemented by Member States, which were required to submit a National Renewable Energy Action Plan (NREAP) by 2010. In its NREAP each Member State reports to the European Commission how it intends to fulfil its target as set out by the RED. All 27 Member States have now submitted their NREAPs.

The tables in Annex A provide a comprehensive review of policy measures in use for the promotion of renewable energy across the EU 27 Member States (Ecologic Institute, 2010).

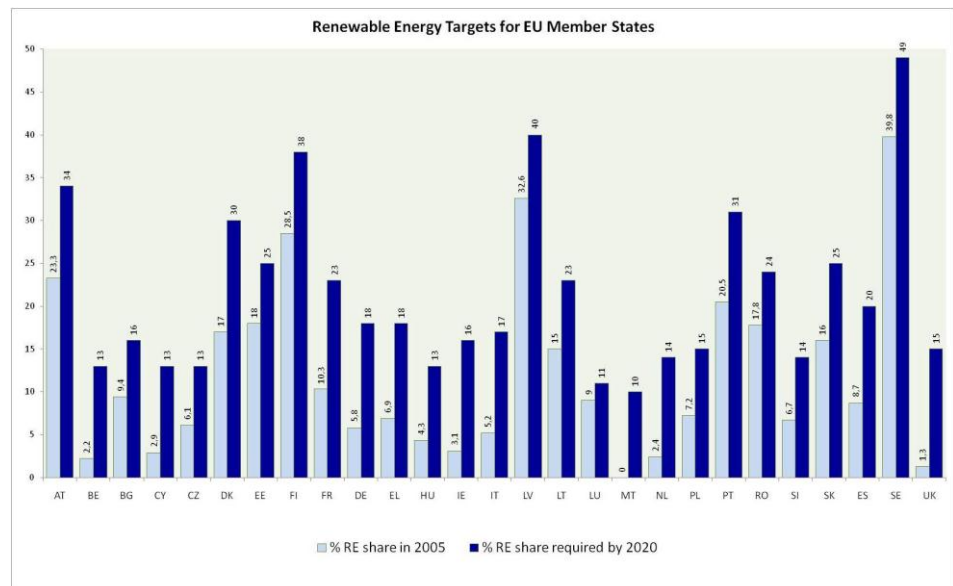
The specific RE targets of the Member States are outlined in Figure 14 below, which also provides a comparison of individual targets against actual renewable energy generation in 2005.

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<sup>17</sup> <http://www.fch-ju.eu>



Figure 14 Comparison of actual RE share in 2005 and 2020 targets for EU Member States



Based on *EU renewable energy policy*. Published: 2 August 2007, updated 22 June 2010.

In order to reach the prescribed targets, Member States are applying a wide range of different policy approaches. Table 4 below describes the types of instruments being utilised and provides a selected list of examples of these measures as implemented across Member States.

Table 4 Brief overview of policy measures being employed by EU Member States

Type of policy	Brief description	Examples
Quota systems	Assures that a specified amount of energy (e.g. percentage of electricity) supplied is being generated from renewable resources. Can be combined with 'green certificate' trading, allowing liable parties flexibility in meeting targets.	Systems in place in UK, Italy, Poland, Belgium, Romania, Sweden
Feed-in tariffs	Guarantees renewable energy producers a fixed price or a bonus on top of the regular market price. Can be combined with preferential grid access.	Systems in place in Germany, Austria, Spain, Ireland, Czech Republic, Bulgaria, Finland, France, Greece, Italy, Latvia and many other countries
Fiscal incentives	Consumption of energy from renewable sources can receive tax deductions, or be completely tax-free. Investment costs for renewable energy generation systems can be made tax deductible or tax-free.	UK (exemption from climate change levy) France (50% tax credit for renewable energy installations, insulation in homes)
Tendering schemes	Scheme to allocate subsidies, loans or contracts for supply to support supply from renewable energy sources.	France (tender for a special tariff for large renewable electricity projects)



Type of policy	Brief description	Examples
Grants	Non-repayable financial aid provided by Member State to support project investment.	Austria (up to 10% of costs for medium sized hydro plants); Sweden (for PV installations, farm-based biogas <sup>18</sup> ), Romania (up to 50% of project costs)
Soft loans	Could include special payment conditions such as extended grace periods and below-market interest rates to reduce financing costs for investors in renewable energy projects.	France (zero interest loans for projects), Denmark, Poland
Regulation	Non-market or financial measures, typically for the promotion of renewable energy in specific sectors or industries.	E.g. priority (guaranteed) grid access for renewable generators in Germany and Spain
Information	Promotion, education, outreach, capacity building and other communication activities aimed at supporting renewable energy.	Some examples of successful information campaigns are Germany, Denmark, Austria <sup>19</sup>
R&D support	Financial and/or technical support for research and development activities in the field of renewable energy technologies.	Netherlands (covers up to 40% of R&D investment costs in renewable energy), Finland (also up to 40% of costs)

The electricity generation sector has witnessed the most widespread development of both policies and technologies for the adoption of renewable energies. The existence of relatively well-developed markets, ease of implementation and public support for government action has contributed to the uptake of measures in the electricity sector.

All 27 EU Member States have adopted at least one policy measure to drive renewable energy uptake in the electricity generation sector. Many Member States have either implemented a feed-in tariff or a quota system, both of these being particularly powerful ‘market pull’ measures because they provide a guarantee of either price (in the case of feed-in tariffs) or volume of renewable energy (in the case of quota systems).

Two examples of the two most widely used market-based measures are provided in Table 5 below - the German system of feed-in tariffs and the UK quota system, known as the Renewables Obligation (RO).

<sup>18</sup> During the period 2009-2013, SEK 200 million are earmarked for investments linked to farm-based biogas production (The Green European Foundation, 2010).

<sup>19</sup> Most countries have implemented campaigns, but strong differences exist among Member States. These countries were assessed in previous study for the European Commission as having implemented successful campaigns (Ecorys, 2010).



Table 5 Examples of feed-in tariff system and quota system

Type of policy	Country example	Key features
Quota system	UK Renewables Obligation (RO)	<ul style="list-style-type: none"> <li>– In place since 2002</li> <li>– In 2011 electricity suppliers (retailers) must purchase around 11% of electricity from renewable sources, which can create certificates (ROCs)</li> <li>– Suppliers are able to trade ROCs to minimise costs</li> <li>– Banding introduced in 2009 to give an advantage to less established technologies (e.g. offshore wind, wave power, energy crops receive 2 ROCs/MWh while onshore wind farms only receive 1 ROC/MWh)</li> </ul>
Feed-in tariff	German feed-in tariffs (Erneuerbare Energien Gesetz-EEG law)	<ul style="list-style-type: none"> <li>– In place since 2000</li> <li>– Guarantees priority connection to the grid</li> <li>– Obligates grid operators to purchase, transmit and distribute the renewably-produced electricity</li> <li>– Tariffs are differentiated by technology to reflect the different costs of generation</li> <li>– Tariffs are guaranteed for a period of 20 years except for large (&gt;5MW) hydropower which is for 15 years</li> <li>– Tariffs digress every year</li> <li>– Bonuses are applied for certain technologies (e.g. biomass using energy crops up to 20MW, CHP)</li> </ul>

In addition, most Member States have complemented these mechanisms with other market pull measures, in particular grants and tax allowances.

Specific measures to drive the use of renewable energy in the heating and cooling sector are less developed, with far fewer Member States having active measures in place. Existing measures mainly deal with increasing the efficiency of systems and processes. One example of specific legislation aimed at increasing the uptake of renewable energy in heating/cooling is the German ‘Erneuerbare-Energien-Wärmegesetz’ (EEWärmegesetz, 2008) as of 2008.

The consumption of renewable energy in heating and cooling is not as relevant for this project. However, it is relevant in the sense that there is a risk that increasing demand from the transport sector for renewable energy resources (e.g. biomethane from the grid for CNG vehicles) could simply reduce the availability of renewable energy for heating and cooling (e.g. in buildings connected to the gas grid).

In relative terms, the transport sector has seen limited use of policy options and technology development to date. The adoption of renewable energy in transport has been dominated by the uptake of liquid biofuels (biodiesel and bioethanol) and to a much lesser extent, renewable electricity, biomethane or hydrogen.

As is shown in the detailed information provided in Annex A, in the transport sector the most widely-employed policies are quota systems requiring fuel suppliers to blend biofuels with fossil fuel products and tax allowances (excise reductions or exemptions) to support liquid biofuels demand. In addition, other commonly used measures include grants for the production of biofuels and government-supported R&D programs. All Member States have now implemented or plan to implement specific policies aimed at biofuels, but very few Member States specifically target measures towards biomethane for



injection into the grid for use in transport. One example of the latter is Sweden, with further detail provided in the Case Study in Section 4.7.2. Another noteworthy example of a Member State's transport policy approach is the Dutch Government's introduction of tradable 'biotickets' in the biofuel sector. In May 2011, the Government passed legislation implementing the RED and the FQD and will place obligations on fuel suppliers to help meet the 10% transport target (Dutch Ministry of Economic Affairs, Agriculture and Innovation, 2011). In order to meet their obligations, biofuel suppliers will be allowed to use biotickets which can be bought from utilities that opt-in to have the supply of electricity to EVs counted (counting 2.5 times the electricity used for charging regardless of whether it is from renewable sources). The suppliers can also count biomethane purchases (without the 2.5 multiplier), although it is not yet clear how biomethane is to be treated if it is taken from the grid<sup>20</sup>. While this mechanism may not act as a particularly powerful driver for the production of additional renewable energy in itself, it is an example of how Member States can implement their obligation to meet the 10% transport target in a way that includes a wide range of energy carriers (liquid biofuels as well as electricity and biomethane). The tradable certificates element of this approach is discussed further in Chapter 5 where the different options for accounting for renewable energy are considered.

A number of other Member States is also supporting the uptake of biomethane in transport with a variety of measures including tax allowances, subsidies and information. Tax incentives and subsidies aimed at driving the uptake of cleaner vehicles (exemptions based on CO<sub>2</sub> emissions levels) are discussed in detail in Section 4.5.1. The case study of Italy is discussed in Section 4.7.2. Italy has an unusually high penetration of methane-powered vehicles compared with other EU Member States.

The relevant drivers for the uptake of renewable hydrogen and biomethane for injection into the grid are considered in more detail in the next section.

#### **4.4.1 Drivers for the production of biomethane for injection into the grid**

The broad motivations for the uptake of biomethane in transport fuel are:

- Diversification of the transport fuel supply base, including reduced dependency on imports.
- Reduction of GHG emissions from the transport sector.
- Reduction of particulate matter (PM) emissions from diesel-powered drive-trains. And
- The option to introduce a renewable fuel which:
  - a Utilises existing internal combustion engine technology.
  - b Utilises a form of bioenergy that can meet the sustainability criteria, if often produced locally and has very high technical potential.

If battery or fuel cell electric vehicles take off, biomethane may be a robust solution to high-power and high-energy requiring transport modes, in particular heavy-duty trucks, ships and possibly even aircraft. This technology pathway would require liquefied biomethane over compressed biomethane. Biomethane production technology can be considered technical state-of-the-art with room for further technical refinement and development and cost reduction.

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<sup>20</sup> In order to participate, biomethane and electricity suppliers may choose to 'opt-in' and sell their 'over-performance' to companies that must comply with the obligation.





In terms of policy drivers, the following can be identified:

**‘Push’ drivers:** Funding for Research and Development, subsidised capital costs for plant construction, etc.

**‘Pull’ drivers:** Financial incentives, such as feed-in tariffs or tax deductions/refunds allow for financial ‘low or no regret’ decisions by customers. Mandatory targets such as company renewable portfolio standards can serve as strong drivers for the production of biogas, subsequent upgrading to biomethane (i.e. natural gas quality) and eventual feeding into the natural gas grid.

**‘Eco-tariffs’** could be another driver for biomethane in the natural gas grid, similar to the German electricity market today. In some Member States, electricity consumers can select ‘eco electricity tariffs’ as part of the deregulation of the electricity market. Despite deregulation efforts in the natural gas sector, developments of ‘eco-tariffs’ for natural gas/biomethane are, however, only slowly developing.

**‘Information obligations’** such as the CO<sub>2</sub> labelling of cars, allow for an informed decision of environmentally conscious buyers.

The availability of CNG and/or LNG filling stations is a prerequisite. If available to sufficient extent, they act as a pull driver for the admixture of biomethane for use in transport.

Any demand of biomethane from the grid, be it for electricity, heat or transport fuel provision, acts as a driver towards the deployment of biogas fermenters, biogas upgrading, and feeding into the natural gas pipeline. Increased technology readiness and decreasing costs (learning curve and economies of scale) allow for an easier uptake of additional biomethane production for use in the transport sector.

As for the limited availability of biomass for bioenergy, faster moving sectors such as electricity and heat production may be in a position to early allocate large shares of the available biomass in Europe. Reallocation boils down to financial competitiveness, including non-biomass uses and other uses of arable land.

#### 4.4.2 Drivers for the production of hydrogen from renewable sources

The reason for marginal visibility of hydrogen in the NREAPs (Romania only, see Chapter 2) is that the low amounts of energy needed in the early ramp-up phase for hydrogen from renewable energy sources are well below the TWh to be reported in the NREAPs.

If hydrogen (and especially hydrogen from renewable energy feedstocks) takes off as a fuel in road transport, significant shares in the existing stock of vehicles will be achieved only after 2020.

There are push and pull drivers for hydrogen. Being of generic nature, push and pull drivers for renewable hydrogen are similar to those mentioned above for the case of biomethane.

A prerequisite for the production of hydrogen from renewable resources is the availability of renewable primary resources. Because of their potential and cost structure, in this decade hydrogen from renewable energy sources will be produced predominantly from wind energy in Europe. The faster the ramp-up





of wind power and the slower the enforcement of the electricity grid and the lower the flexibility to shift electricity demand to times when there is an abundance of wind available, the more ‘excess wind energy’ will become available that is not consumed. The central production of hydrogen at major feed-in points of renewable power into the grid could make use of this ‘excess wind energy’ and provide for an alternative energy storage and transmission vector.

#### 4.5 Transformation of the transport sector in EU Member States

This section discusses factors that are driving the shift away from conventional technologies in the transport sector within Member States, including an overview of the tax exemptions and other financial measures to encourage the purchasing of alternative vehicles (primarily EVs, but also hydrogen-powered vehicles and CNG vehicles in some cases). Since these incentives are typically not conditional on renewable energy consumption, they do not necessarily stimulate renewable electricity production itself. However, in helping to demonstrate the viability of new technologies and new business models, such incentives can enable the transition to a transport sector based on renewable energy if future policy settings are put in place.

The section also provides an overview of some of the city-based initiatives, and commercial partnerships that help demonstrate the viability of such business models. Finally, it briefly looks at whether consumer tastes and preferences can influence the demand for renewable energy sources in transport.

##### European Gas Highway

“A European project called GasHighWay has been established, aiming at promoting the uptake of gaseous vehicle fuels, namely biomethane and CNG, and especially the realisation of a comprehensive network of filling stations for these fuels spanning Europe from the north, Finland and Sweden, to the south, Italy” (<http://www.gashighway.net>).



Picture: Martti Hänninen, Finland.

Source: <http://www.gashighway.net>.



#### 4.5.1 Financial incentives for alternative vehicle purchases at the Member State level

A growing number of Member States are using various types of fiscal incentives to encourage the purchase of EVs. A key barrier facing more widespread uptake of battery-powered EVs and fuel-cell powered vehicles (FCEVs) at present are the high costs of battery and fuel cell technology. The lack of full-scale vehicles is also a current barrier, however, a number of manufacturers are planning to introduce more attractive vehicles in the near future.

Industry analysis suggests that, on a total cost of ownership basis, hybrids will remain more economic than fully electric battery EVs and FCEVs in the short term, but that all electric vehicles may be cost effective alternatives to conventional vehicles in the longer term (after 2020) (see for example the report ‘A Portfolio of Power Trains for Europe: a fact-based analysis’, H<sub>2</sub> Coalition, 2010). Other studies have been less optimistic, including the aforementioned CE Delft, Ecologic Institute and ICF International study (CE, 2011).

The lack of widely available and standardised charging infrastructure also acts as a disincentive to consumer adoption at present. However, recent research by industry analysts Frost and Sullivan predicts that the EU market will grow from less than 10,000 public charging points in 2010 to close to 2 million public charging points by 2017 (Frost and Sullivan, 2011). This will largely be motivated by local government initiatives (see examples provided in Section 4.5.2) and will also be influenced by the results of the Commission’s work on standardisation.

Against this backdrop, tax incentives and subsidies have the potential to accelerate the competitiveness of alternative vehicles once better vehicle options are available and the necessary infrastructure exists. The European Automobile Manufacturer’s Association (ACEA) has compiled a list of tax initiatives adopted by Member States to encourage the uptake of alternative vehicles (ACEA, 2010). The information provided by ACEA has been updated with other recent sources.

Table 6 Member State tax and financial incentives for alternative vehicle uptake

Member State	Tax/financial incentives
Austria	Under a bonus-malus system, cars emitting less than 120 g/km receive a maximum bonus of € 300. Alternative vehicles including hybrid electric vehicles attract an additional bonus of maximum € 500. Electric vehicles are exempt from the fuel consumption tax and from the monthly vehicle tax.
Belgium	Purchasers of electric cars receive a personal income tax reduction of 30% of the purchase price (up to maximum € 9,000).
Cyprus	A premium of € 700 is granted for the purchase of an electric car.
Czech Republic	Electric, hybrid and other alternative fuel vehicles are exempt from the road tax applied to cars used for business purposes.
Denmark	Registration tax exemption is the key measure currently used. In Denmark this tax can range from increasing the total cost to 105-180% of value of car. EV purchasers still pay VAT.
France	Bonus-malus program offers a € 5,000 incentive to consumers who buy a vehicle with CO <sub>2</sub> emissions of 60 g/km or less, which includes all-electric cars and many plug-in hybrids.



Member State	Tax/financial incentives
<b>Germany</b>	Electric vehicles are exempt from the annual circulation tax for a period of five years from first registration. The tax then increases on a sliding scale by vehicle weight. The Federal Government announced in May 2011 that it is currently considering extension of this exemption to ten years.
<b>Ireland</b>	Electric and hybrid vehicles benefit from a reduction of VAT. Scheme has been extended until 31 December 2012 with VRT relief of up to € 1,500.
<b>The Netherlands</b>	Tax breaks for HEVs recently ended. Tax breaks for full EVs extended to 2013 .
<b>Portugal</b>	Electric vehicles are totally exempt from the registration tax. Hybrid vehicles benefit from a 50% reduction of the registration tax.
<b>Romania</b>	Electric and hybrid cars are exempt from the special pollution tax (registration tax).
<b>Spain</b>	Many regional governments grant tax incentives for the purchase of alternative fuel vehicles including electric and hybrid vehicles: € 2,000 for hybrids and € 6,000 for EVs. The state of Andalucia provides funding for up to 70% of the investment.
<b>Sweden</b>	Hybrid vehicles with CO <sub>2</sub> emissions of 120 g/km or less and electric cars with an energy consumption of 37 kwh per 100 km or less are exempt from the annual circulation tax for a period of five years from the date of their first registration. For electric and hybrid vehicles, the taxable value of the car for the purposes of company car taxation is reduced by 40% compared with the corresponding or comparable petrol or diesel car. The maximum reduction of the taxable value is SEK 16,000 per year.
<b>United Kingdom</b>	All vehicles with emissions below 100 g/km are exempt from circulation tax. EVs and E-vans receive a five-year exemption from company car taxes and van taxes. Purchasers of EVs and PHEVs receive a discount of 25% of the vehicle's list price up to a maximum of £ 5,000.

Primary source: ACEA, 2010.

Additional sources:

[http://www.citizensinformation.ie/en/moving\\_country/moving\\_to\\_ireland/coming\\_to\\_live\\_in\\_ireland/importing\\_car\\_into\\_ireland.html](http://www.citizensinformation.ie/en/moving_country/moving_to_ireland/coming_to_live_in_ireland/importing_car_into_ireland.html).

[http://www.dutchnews.nl/news/archives/2011/05/tax\\_breaks\\_on\\_green\\_cars\\_set\\_t.php](http://www.dutchnews.nl/news/archives/2011/05/tax_breaks_on_green_cars_set_t.php).

[http://www.bmu.de/english/mobility/electric\\_mobility/doc/44821.php](http://www.bmu.de/english/mobility/electric_mobility/doc/44821.php).

Currently, the financial incentives listed above are not coordinated or harmonised between Member States, resulting in a large variety of both levels and types of incentives and the potential for market distortions. The Commission is currently preparing guidelines for the design and implementation of such incentives to help ensure a harmonised approach (EC, 2011c).



#### 4.5.2 City-based and regional initiatives

A number of European cities have undertaken pilot projects and incentive programs aimed at demonstrating the viability of e-mobility and, to a lesser extent, hydrogen mobility.

##### E-mobility initiatives

###### *City of Amsterdam*

The City of Amsterdam is planning for 10,000 EVs by 2015. By the end of 2011 there are expected to be 300 charging points in the city, and by 2012 this number is to reach 1,000 (City of Amsterdam, 2011)<sup>21</sup>.

Under the city's grants scheme, grants of between € 15,000 and 45,000 per vehicle will be made available to cover up to 50% of the additional costs of buying EVs compared with conventional alternatives. Recently, this grant scheme has been closed, and a revised scheme is being put in place.

The city offers free charging (with green electricity, in cooperation with an electricity company) and pays for parking whilst charging until April 1, 2012. After this date it is expected that customers will pay for their own charging.

Essent NV, a unit of German utility RWE AG, recently won a contract with Amsterdam City Council to supply and install at least 125 electric-vehicle charging stations (Bloomberg, 2011)<sup>22</sup>. Nuon, the Dutch utility (acquired by Vattenfall in 2010), has already installed 300 charging facilities in partnership with the City of Amsterdam (Nuon, 2011)<sup>23</sup>.

The city is introducing 300 Daimler Car2go (Fortwo) Smart cars as part of an EV car sharing scheme. It has also signed agreements with Mitsubishi Motors, Renault/Nissan and Peugeot/Citroen.

###### *City of Copenhagen*

The City of Copenhagen's objective is that by 2015, 85% of the city's own municipal vehicles should be electric, hydrogen or hybrid powered. The city is considering to set aside € 5-10 million for hydrogen cars/buses. € 103 million will go into an EV charging network, scheduled for completion in 2011. DONG Energy will contribute to development and supply renewable energy to the network.

Copenhagen offers free parking for EVs in charge zones. It has reserved 500 parking spaces for charging stations and is offering free charging for EVs. The car rental company Sixt offers EVs for hire in Copenhagen.

Hyundai has selected Copenhagen to be the first city in the world outside of South Korea to test their new hydrogen car.<sup>24</sup>

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<sup>21</sup> [www.Amsterdam.nl](http://www.Amsterdam.nl).

<sup>22</sup> <http://www.bloomberg.com/news/2011-04-15/rwe-unit-essent-to-install-amsterdam-electric-vehicle-charging-stations.html>.

<sup>23</sup> <http://www.nuon.com/press/newsfacts/20110309/electric-transport-amsterdam.jsp>.

<sup>24</sup> <http://www.visitcopenhagen.com/media/news/business-news/first-company-to-introduce-electric-car-rental-in-copenhagen>.



### *City of London*

The City of London is aiming for a target of 100,000 EVs ‘as soon as possible’ (Mayor of London, 2009). As part of this, the city will purchase 1,000 electric vehicles for the Greater London Area fleet by 2015.

Electric cars are fully exempt from the city’s congestion charge<sup>25</sup> and can be parked at a discounted rate in some boroughs. To stimulate the uptake of EVs, the City will deliver 1,300 public charge points across London by 2013 (City of London, 2011<sup>26</sup>). The target for 2015 is 25,000 charging points.

### *Model Regions for E-Mobility in Germany*

The Federal German Government’s flagship program ‘Model Regions for E-Mobility’ is actually a program of regional initiatives aimed at enabling market readiness for electro-mobility. It has involved actors from science, industry and regional municipalities in pilot projects in eight ‘model regions’: Hamburg, Berlin/Potsdam, Stuttgart, Munich, Bremen/Oldenburg, Rhein-Ruhr, Rhein-Main, and Dresden/Leipzig.

The Federal Government has provided around € 500 million for the program, which was initially funded up to 2011, but was recently extended as part of the ‘Nationale Plattform Elektromobilität’<sup>27</sup>.

Actions are taking place at the inter-regional level as well. One example is that France and Germany are collaborating on a cross-border pilot project connecting the Stuttgart model region and the city of Strasbourg.

## **Hydrogen fuel cell vehicle initiatives**

### *Clean Energy Partnership (CEP)*

CEP is a partnership between vehicle manufacturers, oil and gas companies, and municipal transport authorities (Hamburg and Berlin) to test the introduction of hydrogen fuel cell vehicles, filling stations and associated infrastructure (CEP, 2011)<sup>28</sup>.

The first phase took place in Berlin (2004-2008) and led to the demonstration of several hydrogen fuel cell cars. Both in Hamburg as well as in Berlin, three hydrogen buses each had been running in public transport service in the context of the ‘CUTE’ European demonstration project.

The second phase aimed at establishing a ‘Hydrogen Region Hamburg-Berlin’ (2008-2010), destined to implement technology validation. This included further operation of hydrogen fuel cell buses (‘HyFleet: CUTE’) and additional cars in both cities. Hamburg added a hydrogen fuel cell passenger ferry to service maritime public transport.

The third phase focuses on market preparation for the large-scale commercial deployment of hydrogen-powered vehicles (2011-2016). This will start with a lighthouse demonstration project, co-funded by the German National Hydrogen and Fuel Cell Technology Innovation Program (NIP).

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<sup>25</sup> The congestion charge is £ 8 per day (£ 7 for fleet account users) and up to £ 1,700 per year.

<sup>26</sup> <http://www.london.gov.uk/priorities/transport/green-transport/electric-vehicles>.

<sup>27</sup> <http://www.bmwi.de/BMWi/Navigation/Wirtschaft/Industrie/elektromobilitaet>.

<sup>28</sup> <http://www.cleanenergypartnership.de/index.php?id=7&L=1>.



The City of Hamburg has set the goal to buy the last diesel bus for its public transport by the end of this decade<sup>29</sup>.

#### *'CHIC' - Clean Hydrogen in European Cities Project*

For the commercial deployment of hydrogen-powered buses, the EU project 'CHIC'<sup>30</sup> is to become the EU cornerstone. The objective is to bring demonstration vehicles towards full commercialisation by 2016. The project involves 25 partners and 26 hydrogen fuel cell buses in five locations Aargau (Switzerland), Bolzano/Bozen (Italy), London (GB), Milan (Italy), and Oslo (Norway). The European Union Joint Undertaking for Fuel Cells and Hydrogen (FCH JU) provides co-funding of € 26 million.

### 4.5.3 Commercial initiatives

Many major utilities in Europe have formed partnerships with car manufacturers to explore various e-mobility models.

#### **RWE**

Germany-based utility RWE has formed partnerships with both Daimler and Renault-Nissan. It has developed its own charging station technology which has been rolled out at over 40 cities in Germany as well as other locations in Europe.

The 'smart control module' of its 'Smart-Station' supports the more efficient use of renewable energies through selective charging when a lot of renewable energy is available in the grid. This is combined with free access to the public RWE charging infrastructure in the RWE 'Autostrom' offer, which is also supplied with 100 % renewable energy sources<sup>31</sup>.

#### **E.On**

Germany-based utility E.On has entered into a partnership with Audi in the 'Munich Model Region on Electromobility' supported by the German Federal Ministry of Transport (see Section 3.4 above). As part of the trial, 20 Audi A1 e-trons will come onto the roads in the region by the middle of 2011 and 200 new charging stations will be installed (E.On, 2011)<sup>32</sup>.

The company is testing use of its wall-mounted charging station, the 'Wallbox'. A meter inside the charging box records information about the duration and power required - smart metering will allow for the application of new rates, which will encourage charging green power when supply is high (E.On, 2010).

E.On previously conducted a trial with Mini in 2010, in which it provided the 15 cars included in the trial with electricity generated by hydroelectric power stations. E.On tested hybrid vehicles in cooperation with Volkswagen in 2008.

#### **EDF**

France-based utility EDF has been involved in the development of EVs for over 50 years and claims to own the largest EV fleet in the world. It signed a Memorandum of Understanding in 2008 with the Renault-Nissan Alliance with the intention of enabling France to be one of the first markets in the world to

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<sup>29</sup> <http://www.daimler-technicity.de/guenter-elste/?output=pdf>.

<sup>30</sup> <http://chic-project.eu>.

<sup>31</sup> <http://www.rwe-mobility.com/web/cms/en/236726/rwemobility/>.

<sup>32</sup> [http://www.eon-energie.com/pages/eea\\_en/Innovation/Innovation/E-Mobility/Pilot\\_project\\_eflott/index.htm](http://www.eon-energie.com/pages/eea_en/Innovation/Innovation/E-Mobility/Pilot_project_eflott/index.htm).



adopt the vehicles developed by the Alliance. The partnership commenced a trial of 100 electric passenger cars and light commercial vehicles in Paris in 2010. In the partnership with Renault-Nissan, it will act as the Electric Mobility Operator.

EDF has also trialled plug-in hybrid vehicles with Toyota and PSA Peugeot-Citroën, both in France and in the UK. The company plans to soon introduce charging technology for use in private, public and semi-public facilities. It is also conducting research into battery technology.

### **Vattenfall**

Sweden-based utility Vattenfall has undertaken a number of e-mobility projects in recent years. In cooperation with BMW, 50 Mini E cars and charging stations were put into operation in Berlin between 2009-10 via a combination of private user, Vattenfall corporate use and hire car sharing (in cooperation with Sixt Car Club). The project was supported by the German Federal Environment Ministry. As part of the project, Vattenfall supplies its 100% renewable 'Autostrom' product, backed with electricity produced by wind and hydro power plants, and certified under the 'OK Power' scheme and TÜV-Nord (Vattenfall, 2011)<sup>33</sup>.

The charging infrastructure developed by Vattenfall was coupled with a 'Wind-to-vehicle' application which enabled the maximisation of the utilisation of renewable electricity. In a related trial, local grid balancing was also explored.

Vattenfall is also involved in the Clean Energy Partnership described above, in which it is involved in the production of hydrogen using renewable electricity<sup>34</sup>.

### **DONG Energy**

Denmark-based utility Dong Energy has invested over € 100 million in Californian-based Better Place to enable deployment of its battery-charging network in Denmark. Dong will also be the principal supplier of renewable electricity to the charging network (Project Better Place, 2009)<sup>35</sup>.

Dong also invested in LiTHIUM BALANCE, a Danish cleantech company that develops, produces, and markets large battery systems-based on lithium.

Dong is supplying electricity to the City of Copenhagen's charging infrastructure and is a project partner in the EDISON demonstration project on the island of Bornholm (see case study below).

### **MoU 'H<sub>2</sub> Mobility'**

A Memorandum of Understanding for 'H<sub>2</sub>-Mobility' was signed 10 September 2009 in Berlin by ten key stakeholders from industry (OEM, oil, utility and industrial gas) on the one side and the German National Organisation Hydrogen and Fuel Cell Technology (NOW) as a public-private partnership on the other side<sup>36</sup>. Key automotive stakeholders are Daimler, Opel/GM, BMW, VW, Toyota,

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<sup>33</sup> <http://www.vattenfall.de/de/autostrom.htm>.

<sup>34</sup> <http://www.vattenfall.de/de/wasserstoffprojekte.htm>.

<sup>35</sup> <http://www.betterplace.com/the-company-pressroom-pressreleases-detail/index/id/better-place-dong-energy-investment-for-denmark-electric-car-network>.

<sup>36</sup> <http://www.daimler.com/dccom/0-5-658451-1-1236356-1-0-0-0-0-0-13-7165-0-0-0-0-0-0.html>.





Honda, Hyundai, Nissan, and Kia. Energy companies comprise TOTAL, OMV, Shell, ENI, EnBW and Vattenfall. Gas suppliers involved are Air Liquide, Air Products, and Linde. The initiatives' objective is to build up a hydrogen refuelling infrastructure and establishing Germany as a lead market for hydrogen fuel cell vehicles.

Phase 1 (2009-2011) is the preparatory phase, e.g. comprising techno-economic evaluation and roll-out scenarios as well as the deployment of H<sub>2</sub> refuelling stations in parallel to the expected ramp-up of fuel cell electric vehicles in Germany. The deployment of new H<sub>2</sub> stations is supported by the German Administration (Konjunkturpaket II subsidy scheme).

Phase 2 (2011 onwards) is foreseen for the implementation of the hydrogen retail infrastructure by parties participating in the consortium H<sub>2</sub> Mobility.

#### 4.5.4 Public perceptions and consumer tastes

The question of willingness to pay for renewable electricity or biomethane taken from the grid for consumption by the transport sector has not been widely explored in the literature to date.

Compared with the stationary energy sector, however, it is notable that the transport sector offers one distinct advantage from a green marketing perspective - the existence of the vehicle as a physical embodiment of the consumer's decision to opt for an environmentally-friendly product. The purchase of a gas and electricity product by contrast does not offer such a visible means of showing the consumer's green credentials. Research in the field of marketing has shown that the purchasing of cars in particular represents a powerful part of many people's identity; the research has shown that this certainly includes low emissions vehicles such as hybrids, the purchase of which is often motivated by the desire to make a statement (cite report 1750-29).

The green potential of the purchase of a fully electric vehicle is complex because of the issue of the source of grid electricity. A negative image of electricity derived from fossil fuels or nuclear could impact on the extent to which EVs can be marketed as being green. If image and status are an important factor in making an EV purchase, this would suggest that the willingness of consumers to pay for renewable electricity contracts bundled with their EV could be impacted on, even if there is a technical means of accounting for the full amount of RES-E consumed by the vehicle. Thus, if the way in which the customer ensures that they are charging on RES-E cannot be made visible and easily understood to the wider public, one might expect that the status benefits of the EV may be diluted. The same will hold for vehicles driving on biomethane or hydrogen from renewable sources.

To our knowledge, the willingness to pay for renewable energy in transport has not been extensively examined in the academic literature to date. It is difficult to make strong statements about the level of consumer preference for 'green' electric vehicles. A recent econometric study by Hidrue et al. (2011) on the willingness to pay for EVs in the United States tested a wide range of variables, including different levels of pollution reduction. Consumers were asked what extra amount they would pay for increasingly more efficient vehicles, including a 95% reduction relative to the petrol-fuelled baseline vehicle as a proxy for a 'renewable energy-fuelled' vehicle. The study found that pollution reduction has the lowest value of all the attributes included in the study, with the authors concluding that 'people were driven more by expected fuel savings than by a desire to be green or help the environment'





(Hidrué et al., 2011). The study found that moving to a 95% reduction (the most efficient case) was valued at around \$ 4,300 by respondents, considerably lower than features such as fast charging (going from 10 hours to 10 minutes was valued at \$ 8,500) or vehicle speed (going 20% faster than the baseline was valued at \$ 7,300). The results of this study may not be that relevant to EU Member States, however. In countries such as Denmark or Germany for example, in which consumer education campaigns are seen as having been successful, it is possible that consumers will demand renewable electricity contracts bundled with the purchase of an EV. Anecdotal evidence provided by Vattenfall Europe AG during research conducted for this study indicates that consumers held a strong preference for green electricity during EV trials carried out in Germany in 2010 (Wentrup, 2011). An academic study of the Mini E trial in Berlin suggested that 10% of participants identified the use of and/or support provided for renewable electricity as a benefit of the trial (Bühler et al., 2010).

The additionality of greenhouse gas reduction through renewable energy consumed by alternative vehicles is another issue that requires further consideration. For example, if marketing campaigns cannot claim that running an EV on renewable sources will reduce emissions because of the existence of the EU ETS cap, or because feed-in tariffs already support the production of renewable electricity, customers may be left confused about the benefits of their behaviour.

The public perception and acceptance of hydrogen in transport has been researched in several studies, such as Accept H<sub>2</sub> (LBST, 2005) or Institut für Mobilitätsforschung, 2000; Lossen, 2003 and Mourato, 2003. A common result from these analyses is that hydrogen is generally perceived as being environmentally benign. Experiences with hydrogen in everyday life - such as in the context of demonstration projects - supports acceptance and adoption of hydrogen technology.

## 4.6 Longer term considerations and the additionality issue

### 4.6.1 The shift to e-mobility

It is generally recognised that the use of renewable energy sources of electricity, biomethane from the grid and hydrogen are likely to see a relatively slow rate of uptake in the transport sector in the period up to 2020. As discussed earlier, for road transport alternative vehicles will only become competitive with conventional vehicles beyond this timeframe.

According to the European Commission, studies forecast a market share of battery EVs in new car sales of 1 to 2% in 2020 rising to 11 to 30% in 2030; for plug-in hybrid vehicles a share of 2% is forecast in 2020, and 5 to 20% by 2030 (EC, 2010). There are some slightly higher estimates available: for example, the aforementioned study by CE Delft, Ecologic, ICF International assumed around 5% penetration of EVs by 2020 in the base case (with a majority of PHEVs and EREVs; CE Delft, 2011); the 'CITIES' study foresees a similar rate of penetration of all types of electric vehicles of around 7% by 2020 in the base case<sup>37</sup> (Creutzig et al., 2010). However, even at these higher penetration rates there is broad consensus that a mass market uptake is only likely beyond 2025 or even 2030.

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<sup>37</sup> CITIES: Car industry, road transport and an international emission trading scheme. 'All types' of electric vehicles includes BEV, PHEV, and BEV with range extenders.



The slow rate of uptake of EVs in the near term will mean their integration into the grid will not require any significant expansions in generation capacity, network capacity or major changes in communications technology in most Member States. Even with large-scale introduction of EVs beyond 2020, the impact on the overall electricity supply sector may be fairly small for many European countries. The study by CE Delft, Ecologic Institute and ICF International concluded that even a complete electrification of the European fleet would result in an additional demand in the order of 10-15% (CE Delft, 2011). (Also, see for example various studies cited in the Öko-Institut literature review 'Environmental impacts and impact on the electricity market of a large-scale introduction of electric cars in Europe', Öko-Institut, 2009).

The need for new technological solutions becomes important with mass market penetration if the benefits of switching to electric transportation are to be fully reaped. A mass market share of electric vehicles would require an intelligent connection between EVs and the electricity distribution grid, ensuring their optimised integration through smart charging (Eurelectric, 2011). Control over the charging process by the network operator, electricity retailer or EV 'fleet operator' is required such that it can optimise the benefits for:

1. The customer (ensure adequate charge for the customer's needs).
2. The environment (maximise the utilisation of renewable energy).
3. The electricity network (balancing supply and demand to ensure stability and avoid the need for investment in additional network infrastructure).

There are circumstances in which the second (environmental) and third (power system optimisation) objectives are likely to be at odds with each other. For example, the literature review by the Öko-Institut (2009) concludes that in some Member States such as the Netherlands, UK and Germany, the current power mix suggests smart charging to optimise the utilisation of existing generation capacity in off-peak times (night valley filling) which would tend to favour capital-intensive base load plants (coal, lignite and nuclear). This will increase the incentive for investment in these technologies - potentially displacing investment in renewable energy. The extent to which valley filling could enhance the utilisation of renewable energy is harder to predict, due partly to their intermittency, but also because conditions will vary from country to country. For example, in certain northern European countries with strong wind generation which tends to be strongest at night time, delayed charging might reduce emissions compared with charging at peak times shortly after people return home from work.

There is also potential tension between the realisation of the first benefit and the others listed above if more sophisticated vehicle-to-grid (V2G) integration is considered.<sup>38</sup> Consumers need to be convinced that the availability and lifetime of their EV will not be jeopardised by their contract with the utility/fleet operator. An increasing number of studies is exploring the V2G concept. The results are still inconclusive, and are likely to vary from country to country and case to case. The aforementioned study by CE Delft, Ecologic Institute and ICF International concluded that the potential for storing large-scale electricity from intermittent sources such as offshore wind is limited by the small storage capacity of EV batteries (CE, 2011). Feeding this energy back into the grid at peak times is deemed to be too costly as the charging/ discharging cycles reduce the lifetime of the batteries.

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<sup>38</sup> V2G refers to the potential for EVs to provide services such as regulated reserve capacity or the ability to store excess renewable electricity and feed this back into the grid or buildings when needed to meet demand for stationary electricity or heating/cooling.



The aforementioned literature review by Öko-Institut (2009) also cites two country studies. For the case of Northern Germany, the study concluded that even an optimistic market penetration of EVs would not be sufficient to tap large amounts of excess electricity from wind power if grid constraints remain. By contrast, a US study cited in the review concluded that a 40% penetration of EVs with V2G would result in wind capacity and renewable electricity generation doubling compared to the base case (noting that there is a lower starting point for wind penetration compared with Germany). A recent study for the National Grid by consultancy Ricardo found that in the UK the provision of V2G services would not be profitable if rolled-out on a fleet-wide basis due to the capital cost of the bi-directional power interface. However, the study also concluded that plug-in vehicles could help balance supply and demand in the context of increasing renewable energy in the generation mix, and that this could lead to lower greenhouse gas emissions: “reducing the reliance on ‘conventional’ generation for the provision of balancing services...has the potential to reduce CO<sub>2</sub> emissions” (National Grid, 2011).

These studies suggest that V2G enabled by smart charging may hold net benefits, but only over the longer term, and only in certain circumstances and in certain Member States. In the meantime, new business models will be required to demonstrate the viability of this and the success of these will depend on many complex factors including: the cost-competitiveness of EVs, the ability of battery technology to withstand cycling and fast charging, the terms of contracts that consumers would be forced to enter into in return for payments, and electricity prices being sufficiently high to make the demand response profitable. Another critical enabler for the realisation of V2G benefits across the EU is the standardisation of the EV charging interface.

#### *Biomethane for transport taken from the grid*

Only a few EU Member States have significant numbers of vehicles running on methane. Most dominantly, these are Italy, Sweden and Germany (LBST, 2010). For reasons of infrastructure build-up and phase-in of alternative powertrains and infrastructure into existing fleets, ramp-up of CNG vehicles and biomethane infrastructure (fermenter, upgrading) would result in significant shares later this decade/beginning next decade only. However, the question arises how far contributions from biomethane in transport can go beyond 2020 as biomass and waste feedstocks are limited compared to today's fuel demand and will increasingly compete with other uses, e.g. biomethane for heat and power generation.

#### *Hydrogen produced from renewable sources*

Large-scale hydrogen production from renewable sources via electrolysis, hydrogen station infrastructure and fuel cell electric vehicles are in an infant stage of commercial deployment. This calls for longer time horizons for realisation of significant demand from hydrogen fuel cell vehicles in the existing fleet after 2020 only. However, it is widely recognised among major automotive players (e.g. Daimler, GM/Opel, Honda, Toyota) that hydrogen fuel cell vehicles are the preferred option to achieve local and global (full) zero emission driving while maintaining car performances similar to today.

## 4.7 Country case studies

A second step in our analysis of the drivers of renewable energy uptake includes the consideration of a number of country case studies. These case studies can help to understand the real world conditions that apply in specific



Member States, which will help in thinking about the possible approaches for accounting for renewable energy sources in Chapter 5.

The country case studies focus on examples where the developments taking place in the renewable energy sector relate specifically to the objectives of this project. That is, where country-specific experiences can help in identifying the conditions in which accounting for the full amount of renewable energy used in transport may be possible by adopting a new approach in the RED.

#### 4.7.1 Renewable electricity in transport

##### Case study 1: Potential for grid balancing through EV penetration in Denmark

With 20% of its electricity demand being met by wind, Denmark is already the country with the world's largest share of wind-based power generation (REN21 2010 Status Report). The Danish Government is required to meet 30% of energy consumption from renewable energy by 2020, and also plans to achieve a 50% wind production share of the electricity generation by 2030. Achieving this level of wind penetration will increase the need for balancing power and/or investments in new reserves and expansion of the transmission network and add complexity for the role of the Danish grid operator, Energinet.dk. In a paper released in May 2011, Energinet.dk argues that the costs associated with large transmission expansions are much higher than those related to increasing the amount of regulating power (EDISON consortium, 2011). Energinet.dk is thus exploring the opportunity for expanding the regulatory framework so electricity demand and smaller units such as EVs can be more active in the regulating market.

Figure 15 illustrates the balancing challenge for the Danish grid in moving from 25 to 50% wind energy (Ostergaard et al., 2009). It shows how at certain times the available supply of wind energy is likely to exceed total demand, but that at other times the supply of wind energy will still be well below forecasted demand.

Figure 15 Danish load supply and demand with 25 and 50% wind

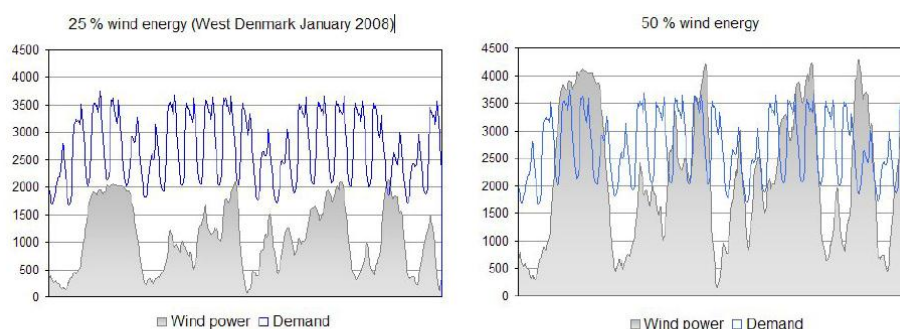


Fig. 1. Wind power generation and demand during 3 weeks of January 2008 in the western Danish area with: a) current wind power penetration and b) when assuming 50% wind power penetration.

Denmark is also a leader in terms of the pace of development in electro-mobility. The Danish Government aims to address transport emissions through stimulating the uptake of EVs. This makes sense in a country heading for such a high share of renewable sources in the generation mix, and also because Denmark has such high taxes on conventional vehicles (up to 180% of the



purchase price) and high petrol prices. Car importers expect to put 2,000 electric cars on Danish roads over the course of 2011 and as many as 2,000 public and semi public charging stations will be installed in Copenhagen, Bornholm and Malmö (EC, 2011c). The company Better Place, which uses a combination of home-charging, public charging and battery-swap stations, has chosen Denmark as one of its first locations for the roll-out of its platform.

The use of EVs to help balance the grid is therefore seen as a potential win-win solution for Denmark. A cost-benefit analysis has shown that intelligent bidirectional charging could provide net benefits of € 150 mln./year in the Danish electric power system in 2025 assuming that 15% of the Danish road transport need is supplied by electricity (Ostergaard et al., 2009)<sup>39</sup>. In this study, the net benefit becomes a net cost if simple time-of-day charging is assumed<sup>40</sup>. An earlier study by Pillai and Bak-Jensen (2009) concluded that less than 10% of electric vehicles used for V2G power could ensure a stable operation of the grid with a large-scale grid integration of renewables.

Different V2G models are being investigated for Denmark. While the battery-swap platform of Better Place and fast charging infrastructure is seen as being necessary for longer distance travel or where a high level of convenience is needed, the short distances covered in cities and towns are suited to a more decentralised model-based on low power charging.

A particularly interesting demonstration project is the EDISON project on the island of Bornholm. EDISON was established in February 2009, and will run to 2012. The project has a total budget of € 6.5 million, including public funding of € 4.5 million. The partners include the Danish Energy Association, IBM, DONG Energy, Siemens, Technical University of Denmark (DTU), Eurisco and Østkraft.

The location for testing EV infrastructure and grid integration is ideal. Bornholm is an island situated in the Baltic Sea. Electrically, Bornholm is only connected to the mainland power grid through a sea cable to Sweden. This gives a possibility of running in 'island mode', giving unique possibilities of studying the power grid, including the impact of electric vehicles. Bornholm also has a high share of wind energy in the consumed power; in 2008 the share was approximately 30%. This makes Bornholm a small model of the expected energy production mix of Denmark by year 2020.

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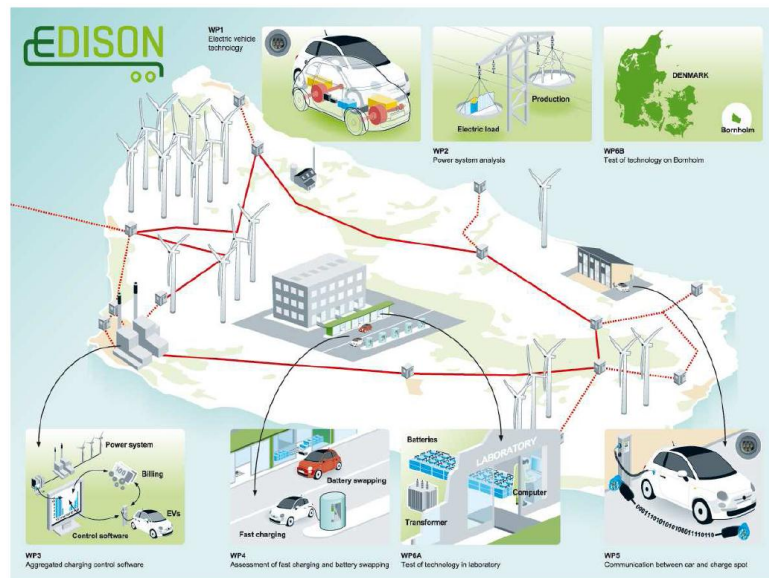
<sup>39</sup> This study also included a penetration of heat pumps to cover 10% of district heating needs and 33% of individual heating needs by 2020.

<sup>40</sup> The reason for this is that many people would normally tend to charge their vehicles at the same time of the day (in the evening), adding to peak demand and network congestion.





Figure 16 Overview of EDISON project and work packages



Source: February 16<sup>th</sup>, 2010 by Anders Holm Foosnæs - Danish Energy Association.

Three different charging scenarios have been identified in the EDISON project:

1. **Immediate charging**, based on today's infrastructure: simple, requires smart metering, but does not deliver benefits such as additional demand for renewable energy generation - more likely to lead to a surge in peak demand and need for peaking plants such as an open-cycle gas turbine (OCGT).
2. **Time-delayed charging**, based on user command: also requires smart metering, and has some shortcomings in avoiding peak demand increase because users cannot be expected to spread out load.
3. **'Smart charging'** - also requires smart meter, could be either price-based, or managed by the Fleet Operator (FO), who could seek to maximise the utilisation of renewable energy production.

It has been estimated that the Danish electricity generation and transmission system can handle more than 25% electrification of transport. The EDISON project has also concluded that there is significant potential for utilisation of the local grid infrastructure without expansion - 25% penetration can be handled even if only 18% spare capacity exists in the grid and even if the majority of users charged their EVs when returning home from work.

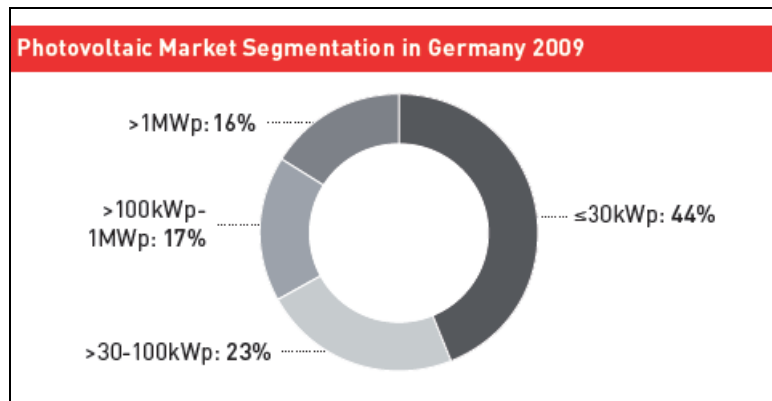
For the end-user to benefit from the demand response services an interval meter is required in all cases. Grid companies comprising 50% of all Danish end-users have installed, or will install, new meters within a few years. These meters will be able to read the consumption per hour (or more frequently), and thereby make it possible to use price contracts with prices varying per hour (spot prices), by weekdays/weekends or day/night. Without an interval meter the end-user is part of a profiling system that prevents any economic motivation for demand response.

### Case study 2: Potential for off-grid PV charging in Germany

Germany has the world's largest PV market, with installed capacity of 9.8 GW by the end of 2009, amounting to 47% of existing global solar PV capacity (REN21, 2010). Systems below 100 kW represent the largest segment of the market, accounting for 67% of installed capacity in 2009 as shown in the graph below (Germany Trade and Invest, 2010).



Figure 17 PV market segmentation in Germany



Source: Federal Network Agency, 2010.

The German Renewable Sources Act (EEG) is the primary legislative instrument, setting out the German feed-in tariff system. The Act provides more generous tariffs for smaller scale PV systems in recognition of the cost disadvantage faced by small scale installations. In addition, Section 33 (2) of the Act provides special incentives for the own-consumption of electricity generated by PV systems with an installed capacity of up to 500 kW (EEG law, 2008).

Renewable electricity not consumed can be fed into the grid and has to be taken up by the distribution/transmission service provider and sold at the spot market. In order to avoid double counting, EEG electricity must be sold as 'grey energy', i.e. without the attribute of being 'green'.

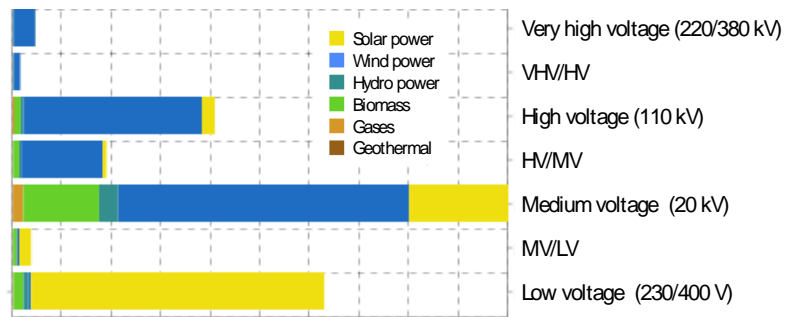
With nearly 70% of installed PV systems being owned by mainly private residents and businesses, and incentives for own-consumption, the potential for electric vehicle charging is obvious. Householders would effectively receive a subsidy to charge their EVs at home with renewable electricity, at times when solar power is most abundant, and thus reduce pressure from the electricity grid.

Figure 18 below shows that if PV electricity is used to charge EVs in Germany it will most likely come directly from the low-voltage local distribution network (230/400 V lines) when charging is done in a local area with significant amounts of installed PV capacity.

The methodology for accounting PV electricity that is used to charge battery electric vehicles would thus ideally include 'small holders' (private households, commerce, small enterprises) if possible. The feasibility of defining conditions for enabling this are considered in Chapter 5 and Chapter 6.



Figure 18 Renewable electricity capacities connected to the grid at different voltage levels



Source: EnergyMap.info (translated).

#### 4.7.2 Biomethane via natural gas pipeline for transport

##### Case study 3: Biomethane used in transport in Sweden

The Swedish government supports municipally owned biogas plants<sup>41</sup> and in the past co-financed investments for biogas production, upgrading and CNG filling stations. By 2009, there were some 230 biogas production plants installed in Sweden mostly exploiting waste streams with 60% using sewage sludge as a feedstock and 25% are landfill plants. 36% of the 1.4 TWh biogas produced in 2009 in Sweden was used as 'vehicle gas'. An outstanding number of more than 60% of the methane consumed in transport is from biomethane origin (Mathiasson, 2010).

Furthermore, there are various incentives for CNG vehicles and the use of biomethane in transport according to Mathiasson, 2010 and NGVA<sup>41</sup>:

- a 40% reduction of income tax for use of CNG company cars;
- free municipal parking for CNG vehicles in many cities;
- priority lanes at airports, railway stations and ferry terminals for CNG taxi cabs;
- financial (investment) support for some types of biomethane production units;
- a zero fuel tax on biomethane.

Incentives have resulted in some 26,000 CNG light duty vehicles, 1,300 CNG buses and 600 CNG heavy-duty trucks being on the road in Sweden in 2010, the third largest CNG vehicle fleet in Europe. For refuelling, 119 public CNG filling stations and 45 non-public ones for fleets, busses and heavy-duty vehicles were available in 2010 (Mathiasson, 2010).

In Sweden, biomethane is distributed to CNG filling stations in three different ways (Ekengren, 2010), namely via:

- local biomethane grids;
- mobile storage; and
- grid injection-based on the 'green gas principle'.

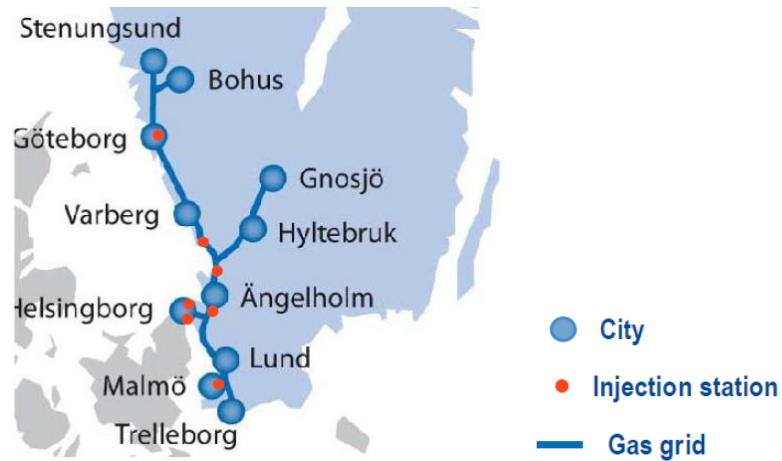
The Swedish methane grid is small with some 300 km in length along the western coastline only. In 2008 there were almost 40 biomethane upgrading plants (Dahlgren, 2008) and 7 stations for injection into the gas grid in Sweden as depicted in the following map.

<sup>41</sup> <http://www.ngvaeurope.eu/sweden>.





Figure 19 Gas grid and locations of biomethane injection stations in Sweden

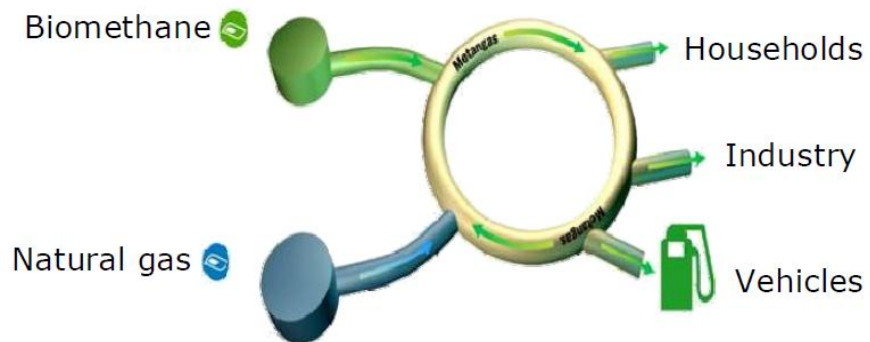


Source: Dahlgren, 2008.

Injection into and use of biomethane from the gas grid is handled based on the 'green gas principle'. It is a system of selling biomethane similar to green electricity in Sweden. This is how it works (Dahlgren, 2008; Mathiasson, 2010):

- biomethane injection into the natural gas grid;
- end-user can order 100% biomethane from the grid, independent of the purpose of its use (see below chart);
- renewable energies are exempted from energy and CO<sub>2</sub> taxes.

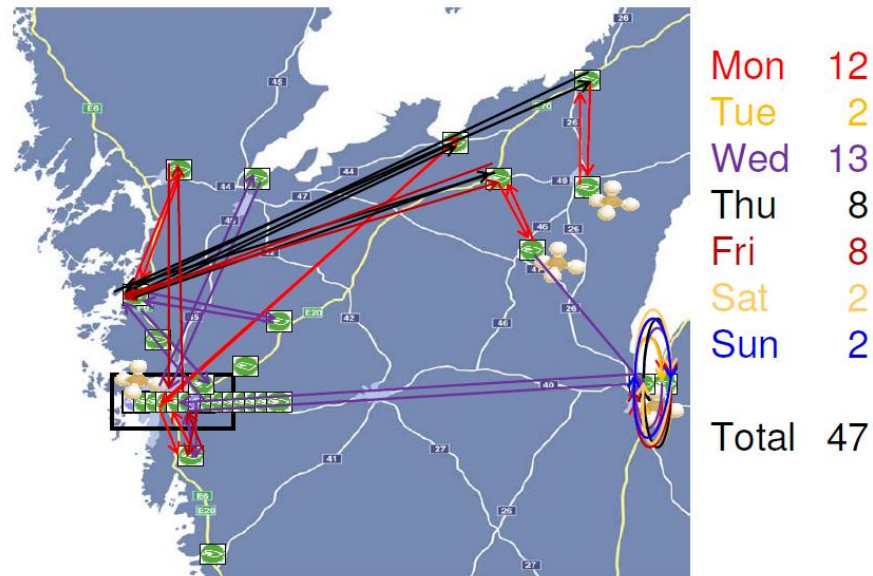
Figure 20 Green gas principle



Source: Dahlgren, 2008.

In order to provide 'vehicle gas' to off-grid CNG stations, methane is containerised and economically trucked over distances of up to 50-100 km (see next chart).

Figure 21 Methane container movements to supply off-grid CNG stations in week 35



Source: Ekengren, 2010.

Recently, liquefied (bio)methane is being pursued for both biomethane distribution to filling stations and as a fuel for long-distance, heavy-duty trucking.

#### Case study 4: Biomethane used in transport in Germany

Since the year 2000 electricity production from biogas is incentivised by the German Erneuerbare Energien Gesetz (EEG). With the EEG update in 2009, power production from upgraded biogas fed into the natural gas is incentivised with a so called 'Technologiebonus'. So far, the sole focus of the EEG has been the provision of renewable electricity and heat. There is yet no EEG mechanism to support the use of biomethane in transport (neither directly from upgraded biogas nor via pipeline).

The overall raw biogas quantities produced in Germany are derived (BEE, 2010) for the years 2006, 2007, 2008, and 2009 with respective raw biogas quantities of 22.9, 32.0, 36.4, and 40.0 TWh (estimated amounts-based on installed capacities). As biogas feedstock livestock manure, municipal waste and maize are typically used in Germany. With a further increase of biomethane production, such as for use in transport, dedicated energy crops for biogas production have to be produced, e.g. energy maize (whole plant) and double-cropping. Imports from eastern neighbouring countries have been discussed.

With regard to biogas for feeding into the natural gas grid, there are currently some 100 biogas upgrading facilities in Germany<sup>42</sup>.

With regard to biomethane for transport, biomethane today is available from a number of public methane fuelling stations. Stadtwerke München (SWM - Municipal Utility Munich) sells natural gas for road vehicles blended with 50% methane from biogas at all of their 10 stations in the greater Munich area (SWM, 2010). Energy companies GASAG and Energie Mark Brandenburg GmbH

<sup>42</sup> <http://www.gashighway.net/default.asp?sivulD=25922&component=/modules/gmap2.asp>.

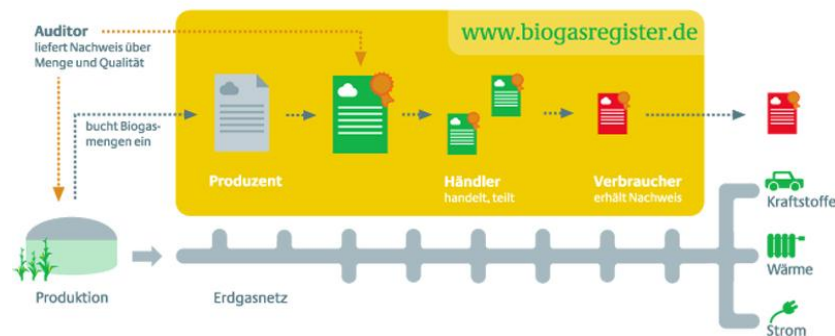


(EMB) sell CNG including ‘virtual delivery’ of 51% biomethane at their CNG stations in Berlin and the greater Berlin area (GASAG, 2011). Energieversorgung Weser-Ems (EWE - Weser-Ems Regional Utility) is selling a 10% admixture of biomethane at more than 50 CNG refuelling stations. The first refuelling station dispensing 100% biomethane has been opened in May 2006 in Jameln, Wendland, Germany by the Raiffeisen- und Warengenossenschaft e.G. In Jameln the biomethane is supplied directly via a dedicated biomethane pipeline from the biogas plant as the station is not connected to the natural gas grid (Marklewitz, 2011). Another station to dispense 100% biomethane is scheduled to open by mid 2011 in Dannenberg. It will be supplied via the natural gas grid (two meters). According to the German natural gas vehicle association Erdgas Mobil (Rieth 2011), currently some 15% of CNG filling stations are dispensing some 15% of biomethane in average.

There are three potential sources for information on biogas in Germany with regard to accounting biomethane to the EU 2020 target.

1. In 2009, the German Energy Agency (dena) has started a Biogas Registry (<http://www.biogasregister.de>) which is designed to function as depicted in the following figure. The registration criteria include sustainability provisions according to the German BioKraftNachV, which is the national implementation of the EC-RED, and an IT interface to the NABISY mass balance system. To date, no registrations have been made for biogas used in transport (Moll, 2011).

Figure 22 Functioning of the German ‘Biogas Registry’ mass balance system



Source: <http://www.biogasregister.de>.

2. Furthermore, biofuel producers with an installed production capacity of more than 1,000 t/a are obliged by the Energy Taxation Law (EnergieStG) to submit their actual production quantities once a year to the Biofuel Quota Body of the Federal Customs Office Frankfurt/Oder (Zoll, 2011).
3. Point 2 of § 27c (1) of the draft 2012 amendment of the German Renewable Energy Law (Bundesrat, 2011) foresees a mass balance system for the use of biomethane from the grid for power production, e.g. through the dena Biogas Registry (see above). This mechanism could also be used for accounting of biomethane from the grid for use as a transport fuel.

### Case study 5: CNG vehicles in Italy

By March 2010, there were some 300 biogas plants in operation or under construction that were to use manure or energy crops as feedstocks. The vast majority of them are to be found in Northern Italy (ENEA, 2011). To-date,



biogas is primarily used for electricity production as there are yet no incentives in place (neither feed-in tariffs, nor investment subsidies, nor green certificates) that would support biomethane to be injected into the gas grid (IEE-BiogasIN, 2010).

However, in May 2011, the Italian Decree no. 28 was introduced giving priority and regulating biomethane injection into the gas grid. Furthermore, incentives for biomethane infrastructure are to be defined.

### 4.7.3 Renewable hydrogen in transport

#### Case study 6: Hydrogen used in transport in Germany

The German National Innovation Program (NIP) is a public-private initiative to bring forward hydrogen and fuel cells in transport. The budget is some € 1.4 billion for the timeframe 2008 to 2017. It plays a similar role like the European Fuel Cell and Hydrogen (FCH) Joint Undertaking (JU).

According to on-going industry stakeholder discussions in the framework of the H<sub>2</sub> Mobility consortium, some 250,000 fuel cell electric vehicles could be moving on German streets being refuelled at some 1,000 hydrogen refuelling stations.

As of end 2010, there were some:

- 11 hydrogen refuelling stations in operation in Germany; and
- 50 hydrogen fuel cell cars and buses running in Germany.

In July 2011, Daimler announced to bring forward the commercial sales of FCEV by one year (now 2014 instead of 2015). Daimler targets a total production volume of more than 10,000 FCEVs per year by 2015 at sales prices in the range of a diesel hybrid vehicle (Südkurier, 2011).

Beginning of June 2011, Daimler and Linde have announced to jointly erect 20 hydrogen filling stations in Germany by 2015, which will triple the number of public hydrogen filling stations there.

Up to now a broad range of hydrogen production and distribution vectors have been used to supply the hydrogen refuelling stations in Germany for technology validation reasons:

- centralised hydrogen production (mostly reformation of natural gas) which is currently usually liquefied and trucked to the filling stations;
- use of by-product hydrogen from chemical processes and supply via dedicated high-pressure pipeline;
- on-site hydrogen production via small-scale reforming of natural gas or water electrolysis.

Stakeholders consider renewable energy for hydrogen production important for the mid to long-term development for reasons of benefiting from maximum environmental performance of hydrogen and public acceptance<sup>43</sup>. The German industrial initiative 'CEP' (Clean Energy Partnership) has the goal to have at least 50% of their hydrogen fuel dispensed by 2016 to originate from renewable sources. First developments are e.g. the use of certified green electricity for on-site production of green hydrogen at the TOTAL hydrogen filling station (part of CEP) that was opened mid 2010 in Berlin, Holzmarkstraße<sup>44</sup>. End of 2011, a similar hydrogen filling station is due in Hamburg 'HafenCity' with

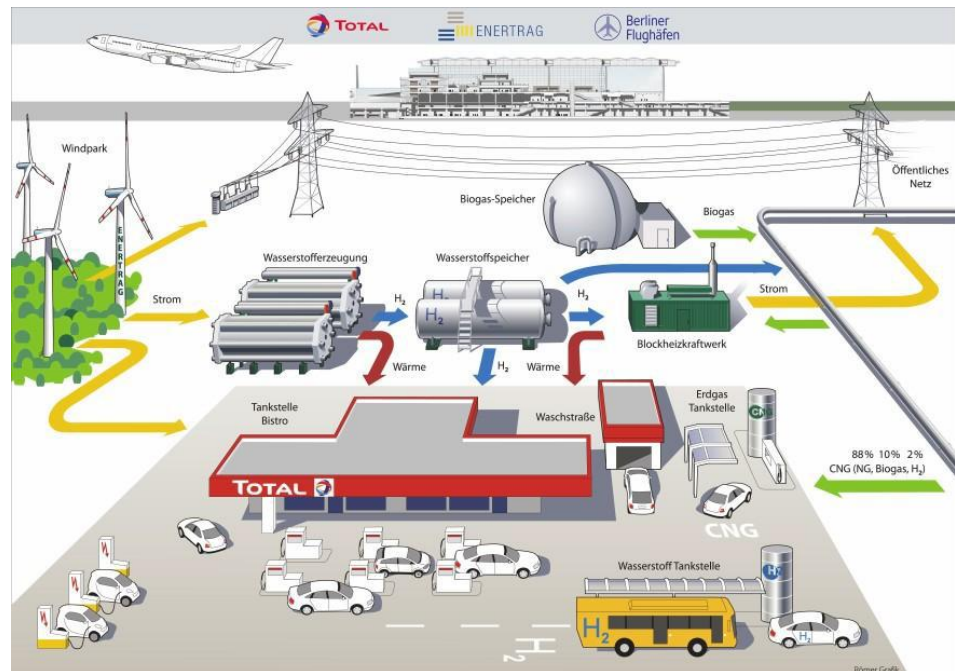
<sup>43</sup> [http://www.cleanenergypartnership.de/uploads/tx\\_ceppressev2/PM.pdf](http://www.cleanenergypartnership.de/uploads/tx_ceppressev2/PM.pdf).

<sup>44</sup> <http://www.statoil.de/en/NewsAndMedia/News/Pages/ceptankstelleneroeffnung.aspx>.



on-site electrolysis using certified green power (CEP, 2011). The next step is foreseen for 2012 with the opening of the public hydrogen filling station at the new airport in Berlin-Schönefeld. The station will be part of a larger pilot project to demonstrate the feasibility of an integrated renewable energy system with high shares of intermittent renewable energies (see scheme below). Conventional (petrol, diesel) as well as alternative fuels (hydrogen, methane, LPG) will be dispensed under one ceiling, including hydrogen from wind power (supplied via the power grid) and (bio)methane mix (supplied via the gas grid; CEP, 2011).

Figure 23 Scheme of the integrated public hydrogen filling station in Berlin-Schönefeld, planned 2012



Source: CEP, 2011.

Recently, the latest infrastructure development plans for Germany until 2015 were presented by the 'H<sub>2</sub> Mobility' initiative, these are shown in Figure 24.



Figure 24 H<sub>2</sub> infrastructure development plans for Germany as laid out by the 'H<sub>2</sub> Mobility' initiative



Source: Ronald Grasman (Daimler AG), Flottenbetrieb Mercedes-Benz F-CELL, Presentation at NIP General Assembly, Berlin, 07.11.2011.

#### 4.8 Conclusions

In line with the RED, all Member States have now submitted NREAPs containing a wide range of measures to drive the increase in production of **electricity from renewable sources** in the general energy mix up to 2020. It is unlikely that incentives being provided for electric vehicles uptake at the Member State or local government level can play a major role in driving further production of renewable energy this time frame. Indeed, the low rate of uptake of electric vehicles - expected to reach no more than 10% of the new vehicle market by 2020 - suggests transport sector developments will not play any significant role in driving renewable electricity production in this time period.

Changing the specific method for accounting for the full amount of renewable electricity used in transport is therefore unlikely to have a material impact on the demand for renewable electricity. A hypothetical exception to this assessment would be, for example, if a utility offered a product which is linked to a *new* renewable energy project (e.g. wind farm, biogas plant) that is *not* financially supported by existing schemes such as feed-in tariffs and *not* counted towards meeting the relevant Member State's general renewable energy target under the RED, but *is* counted towards meeting the Member

State's transport target. In this hypothetical case, the full amount of electricity supplied in association with that contract could be considered additional. To our knowledge, no such contracts exist on the market as yet and no Member States have announced plans to consider such an approach.

Beyond 2020, there is greater potential for EVs to drive the uptake of renewable electricity production if, for example, the specific transport targets set in the RED were increased and made additional to the next round of targets for consumption of energy from renewable sources more broadly. This would entail the Commission making transport consumption additional on a top-down basis. Alternatively, individual Member States could choose to stimulate additional consumption of renewable energy via bottom-up approaches; for example, by introducing requirements on utilities to supply renewable electricity for transport purposes and not allowing them to benefit from existing measures or counting this consumption towards the general renewable energy target.

The potential for EVs to play a major role in supporting a greater reliance on renewables (wind generation in particular) through smart charging is still being assessed, is likely to vary from country to country and depends heavily on the extent of mass market uptake and the willingness of consumers to enter into new contractual relationships with their suppliers (i.e. this is also a longer term proposition).

Where the production of **biomethane** for injection into the grid is concerned, the extent of measures being implemented is more limited. As outlined in Chapter 2, not a single Member State has specified plans for implementing specific measures to drive production of biomethane for injection into the grid in its NREAP. However, there are a number of policy measures in place to encourage biogas production, and in some Member States (e.g. Germany) specific incentives exist for encouraging its injection into the natural gas network (for the time being for the purpose of power generation only). The Case Studies in Section 4.7.2 also highlight that there are examples of Member States - such as Sweden and Germany - which are providing incentives for the use of biomethane in transport (not specifically for supply via the gas grid).

In the case of **hydrogen**, which is still in an embryonic stage of infrastructure deployment, the current outlook suggests that transport sector developments are likely to remain a very minor driver for the production of hydrogen from renewable sources over the period to 2020. There is a number of examples of policy support and industry initiatives for hydrogen infrastructure and demonstration projects. On a single project level, renewable energy already plays a notable role (see e.g. German 'Clean Energy Partnership'), however, support instruments like feed-in tariffs, etc. are not being targeted specifically at production of hydrogen from renewable energy for use in transport at this stage.

Table 7 provides a high level qualitative assessment of the strength of the different drivers for the uptake of renewable energy considered in this chapter. The overall message is that transport sector developments are only likely to have a low or at best low-medium impact on the production of renewable electricity, biomethane and renewable hydrogen in the period to 2020. This suggests that it may be hard to justify the development and introduction of a more complex accounting methodology in the RED for this timeframe. Some initial comments are also provided, including possible conditions for increasing the role of drivers - for example, making the transport target additional in the RED post 2020. In Chapter 5, the different



options for accounting for the renewable energy consumed in transport will be considered in detail, including the identification of specific circumstances or situations in which the full amount of energy could be counted as renewable.

Table 7 Overview of drivers of renewable energy production to 2020

Drivers	Assessment of current contributions from drivers for renewable energy production across different renewable energy sources (RES)			
	Renewable electricity	Renewable hydrogen	Biomethane (grid)	Comments
<i>Supply-side drivers</i>				
<b>EU renewable energy policy framework</b> E.g. targets for production of renewable energy in RED	HIGH	LOW	MEDIUM	Strongest where there are specific requirements on Member States
<b>EU level policy instruments</b> E.g. EU ETS	MEDIUM	LOW	LOW	Price signal not strong enough on its own at present
<b>Member state incentives for RE development</b> E.g. FiTs, portfolio standards, grants, etc.	HIGH	LOW	MEDIUM	Specific policy measures for renewable hydrogen yet to be developed
<b>Technological/commercial developments</b> E.g. capital cost, operating cost, market prices	MEDIUM	MEDIUM	MEDIUM	Depends on technology e.g. PV electricity to decrease, CAPEX for on-shore wind nearly mature
<i>Demand-side drivers</i>				
<b>EU transport policy framework</b> E.g. EU FQD; EU 10% transport target; EU strategy on clean/efficient vehicles	LOW	LOW	LOW	Could make transport target additional post 2020
<b>EU transport policy measures</b> E.g. vehicle CO <sub>2</sub> performance standards	LOW	LOW	LOW	Current treatment of EVs doesn't distinguish between RE and non-RE
<b>Member state policies and programs on transport sector</b> E.g. tax exemptions for purchasing EVs	LOW	LOW	LOW-MEDIUM	Tax exemptions specifically for biomethane CNG in Sweden EV incentives do not require RE generation
<b>City/regional initiatives</b> E.g. City funding for EV charging, parking, separate lane, entry into inner-city	LOW	LOW	LOW	Depends on initiative design, but at present there are few initiatives involving small numbers of vehicles only





Drivers	Assessment of current contributions from drivers for renewable energy production across different renewable energy sources (RES)			
	Renewable electricity	Renewable hydrogen	Biomethane (grid)	Comments
<b>Commercial initiatives</b> E.g. JVs between utilities, infrastructure companies and car manufacturers	LOW-MEDIUM	LOW-MEDIUM	LOW-MEDIUM	Potential for direct contracts to support additional investment
<b>Technological developments</b> E.g. falling costs of EV batteries, increasing battery and fuel cell performance	LOW	LOW	LOW	Battery performance and costs a major issue, but only will have an impact over longer term with mass uptake
<b>Consumer tastes and preferences</b> E.g. WTP for renewable electricity in transport	LOW	LOW	LOW	Could be more of a driver in the longer term





# 5 Design of different sets of methods and conditions

## 5.1 Introduction

In this section we go into the different policy options which could make it possible to take into account the entire amount of electricity, hydrogen and methane from renewable sources when calculating the share of energy from renewable sources towards the 10% target of the Renewable Energy Directive (RED).

In the RED (Article 3(4)), provisions are in place which determine how Member States should deal with calculating the share of renewable energy in the transport sector. At this moment, Member States have the option to base the share of renewable electricity in the transport sector on the average share of either the total renewable electricity consumption in the EU or in their own country, whichever is higher. In this section, policy options are studied which should make it possible to take into account the total amount of electricity used in the transport sector instead of basing it on the average renewable electricity consumption. Next to this, policy options for taking into account the amount of hydrogen energy and biomethane when calculating the share of renewables in transport are also considered.

The aim of this section is to identify the various options that exist, without yet making judgements regarding their feasibility, cost or benefits. The pros and cons of the different policy options are briefly addressed, but this is done much more thoroughly in Chapter 6. There, a set of assessment criteria is defined and applied to the identified methodologies in order to weigh them against each other.

This chapter is structured as follows:

First, we describe different *situations* in which renewable energy (electricity, hydrogen and methane) may be fed into a vehicle. The subject is complex, with many physical possibilities. Therefore, we use these situations as building blocks for building up the analysis, starting with simple situations that are relatively easy to understand, and then moving towards more complex situations. For each situation we will give indications whether or not they will be used in practice.

We then consider possible *methodologies* and formulas for incorporating the renewable electricity used in transport in the RED target for transport. After that we will go into the question whether these methodologies are relevant for/could also be applied to hydrogen and methane from renewable sources. In that part, we will also go into the differences between real time use of the produced renewable energy in a vehicle, or using an energy grid as a kind of storage.

Finally, we analyse the *conditions* under which the methodologies can be applied, also regarding the data requirements for monitoring.



Relevant questions in this respect are:

- Under what condition(s) would it be justified to count the whole amount of energy used in transport as renewable?
- How would such a methodology work in practice (calculating and monitoring the share of renewables in transport)?

## 5.2 Attributing renewable energy to transport (situations)

A large variety of routes from renewable energy production to the vehicle can be envisaged. In order to structure these, the following schemes of *electricity* production and use in battery electric vehicles can be sketched to describe prototype situations<sup>45</sup>. The situations are described as general as possible, so that the situations also capture the situations for methane, and most also for hydrogen.

The scope of this study is grid connected renewable energy. However, to deal with the complex matter, we first describe island systems (i.e. not grid connected) to build up the analysis step by step.

### Situation 1: Direct feeding from an island system renewable source to vehicle

This situation occurs when a vehicle is directly connected to an island system renewable energy source (e.g. a PV system or a small wind turbine) that is not grid-connected, and there is no other electricity demand from the source nor storage outside the vehicle. All the energy flows into the vehicle when it is charged, real time. The only energy demand is from the vehicle.

The amount of renewable energy used by the vehicle can be measured at the source or at/in the vehicle.

Figure 25 Situation 1: Direct feeding, from an island system renewable source to a vehicle



### Situation 2: Direct feeding with island system renewable system *and storage*

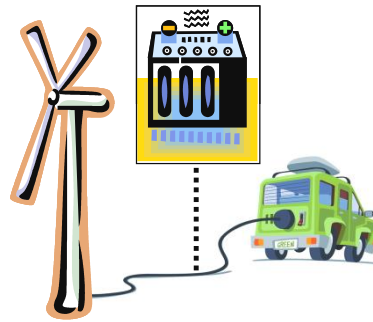
When the source from Situation 1 is equipped with a storage facility, some of the energy will be lost in the storage/destorage-cycle, which may be substantial in some cases. The only energy demand is from the vehicle, just as in Situation 1.

The amount of renewable energy used by the vehicle can be measured at the feeding point of the vehicle or in the vehicle.

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<sup>45</sup> Note that these vehicles can be either full electric vehicles, plug-in hybrid vehicles or electric vehicles with range extenders.

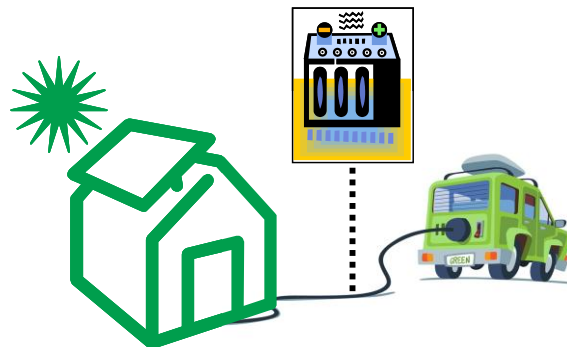
Figure 26 Situation 2: Direct feeding with island system renewable system *and storage*



### Situation 3: Feeding with island system renewable system *and various other energy demands*

This might e.g. be the case with an island system household with no grid coupling that is operating a renewable energy source, a storage facility and no other fossil powered generator. The difference with Situations 1 and 2 is that also other energy demands exist in this situation, beside the vehicle. Therefore, measurement of the renewable energy production is not related to the feeding energy of the vehicle anymore. But all the feeding energy for the vehicle is produced by the renewable energy source. The amount of renewable energy used by the vehicle can be measured at the feeding point of the vehicle or in the vehicle.

Figure 27 Situation 3: Direct powering of a vehicle on private property on an island system household, without making use of a public grid, but with other demands also



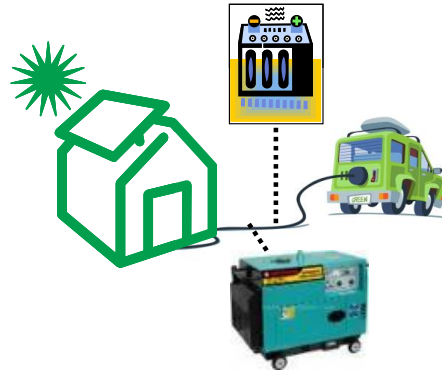
### Situation 4: Feeding with island system mixed renewable and non-renewable system and various other energy demands

This might e.g. be the case where a stand alone household with no grid coupling is operating a renewable energy source and other (fossil) energy sources. The difference with Situation 3 is the fossil energy source, e.g. a diesel generator. Therefore, measurement of the energy at the feeding point of the vehicle or in the vehicle has no direct relationship anymore with the type of energy production, which in this situation might be the renewable energy source or the fossil energy source. This situation stands as a model for 'real life', where many different types of generators and many different types of demand exist, all coupled to the energy grid. The amount of renewable energy used by the vehicle can not be measured at one point anymore in this situation. It can be calculated from measurements of the total production per time unit (e.g. one year) of the renewable source and the fossil source (i.e. the production mix), and the energy used by the



vehicle in the same period. That way, information on the question whether the vehicle is charged with renewable power or diesel power is lost, since only volume measurements over a period of time are used. To determine whether the vehicle is charged with solar or with diesel power in this situation, real time measurements of the production curves of both generators have to be used and compared to real time measurement at the feeding point of the vehicle or in the vehicle itself.

Figure 28 Situation 4: Feeding with island system mixed renewable and non-renewable system and various other energy demands



### Situation 5: Grid coupled household with renewable energy system

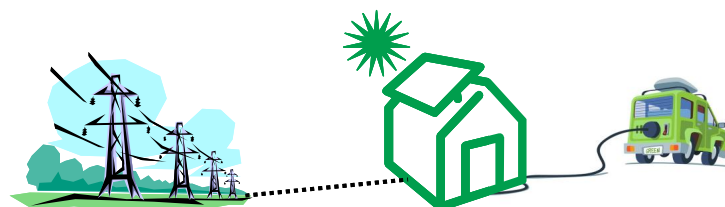
The grid coupling adds more complexity. In Situation 4, the only energy generators were the renewable energy system and the ‘fossil’ energy generator. Now, the household exchanges energy with the grid, and is coupled to thousands of large and small generators, both renewable and fossil. For methane, this situation describes a private methane filling station ‘behind’ the gas meter of the household. The ‘production mix’ from Situation 4 has now become a real statistical production mix.

The amount of renewable energy used by the vehicle can be calculated now from the measurement of the energy used by the vehicle (metering in the vehicle or at its feeding point, since the metering of the household also feeds other demands in the house) and either:

1. The (national) energy production mix that is fed into the grid. Or
2. The energy production mix that is contracted for the specific feeding point of the vehicle.

Again, in the first case, either the average production mix can be used, or the real time production mix (see the text box below).

Figure 29 Situation 5: Grid coupled household with renewable energy system



#### Are time related measurements relevant?

For methane (and also for hydrogen), the grid is in fact used as a kind of storage facility. The determination of the amount of biomethane in the consumption is determined by the amount of biomethane that is fed into the grid. For electricity however, the factor 'time' enters far more strongly into the analysis.

The time of feeding can be very relevant in some cases, which can be explained with a 'thought experiment'. Imagine a hypothetical situation where electric cars are feeding only at night, and where the only renewable sources of electricity are solar PV panels, producing only during the day. It is clear in that case that a calculation using yearly sums of electricity use by electric cars and the yearly production mix of electricity would not provide a realistic estimate for determining the amount of renewable electricity actually used in the electric cars. This extreme situation underlines the point that real time measurements can be very relevant. In real life of course, the situation is more complex, since renewable sources such as wind turbines also produce at night time, and since electric cars do not only charge at night. See also the remarks on this subject under 'Conditions'.

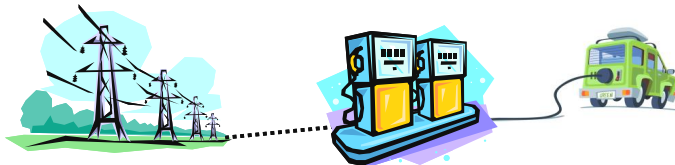
#### Situation 6: Grid coupled dedicated feeding point for vehicles

This situation seems one step less complex than Situation 5. All energy used at the vehicle charging point is fed into vehicles, and the feeding point may be used by different vehicles - for example, at a public charging station, or CNG filling station, on a highway. The amount of renewable energy can therefore be calculated from the measurement of the energy fed into the vehicles (requiring measurement at the feeding point or in the vehicles), and either:

1. The (national) energy production mix that is fed into the grid. Or
2. The energy production mix that is contracted for the specific feeding point.

However, taking into account that vehicles can charge at different feeding points, measurement of the energy used at dedicated feeding points can cause problems with either double counting or with data gaps: when at other feeding points the only way to calculate the amount of energy used by the car is measuring in the car<sup>46</sup>. Measuring and counting both at the cars and at feeding points will then cause double counting at these points, whereas data gaps occur when the energy fed in at other points is not measured.

Figure 30 Situation 6: Grid coupled dedicated feeding point for vehicles



#### Situation 7: Green energy contracts using certificates

This situation resembles Situation 5, but now with a specific 'green energy contract' for the household, that uses green certificates. That may, for example, be green 'certificates of origin' for renewable electricity, or the bioticket that is introduced in the Netherlands (see Section 4.4). This situation is also relevant for dedicated feeding points for electric or CNG vehicles (see Situation 6).

<sup>46</sup> Note that electric cars can in principle be charged ('slow charging') at every possible plug and socket outlet, not especially dedicated for charging of electric vehicles. We assume that not every single grid socket will be metered.

There is in this situation no direct physical 'link' between the feeding point of the vehicle and the renewable energy source. The link is an administrative one, via certificates that guarantee that the energy that is used by the vehicle (or the household, or company) is produced by renewable sources. These sources can be within the same country, within the EU or outside the EU, depending on the specific contract.

Note that real time measurements are no option in this type of administrative volume contracts.

### Situation 7a: 'Green contracts' from within the country or the EU

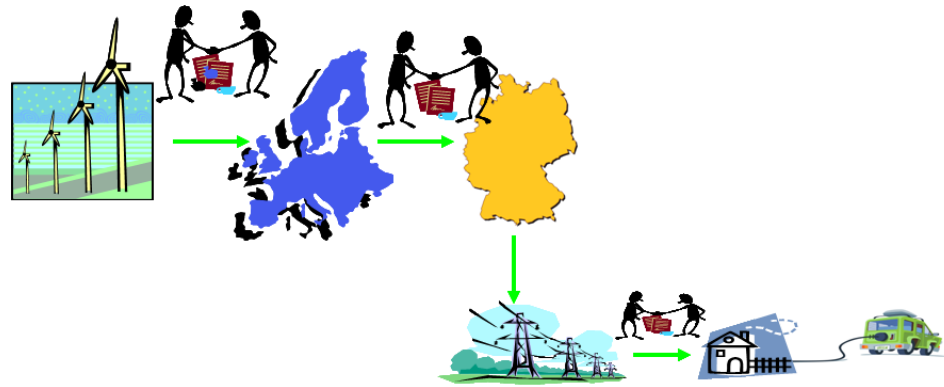
In this methodology a certificate system is set up in order to determine the share of renewable electricity (large-scale solar PV, wind on shore, wind off shore, hydro, biomass and possibly CSP) that can be attributed to transport. Such a scheme is comparable with the green contracts that are in place between consumers and electricity suppliers in the Netherlands. In the Netherlands small consumers have the option to enter into a green electricity contract with their electricity supplier. The electricity supplier has to buy green certificates from producers in order to meet its contract obligations with its 'green electricity consumers'. In so far as these contracts are in place, and the consumers concerned make use of EVs, the electricity consumed by these EVs can be considered as coming from renewable sources. Instead of having a contract which covers total electricity of a consumer concerned one could also think of a scheme in which the consumer specifically enters into a green electricity contract for its EV only. However, this only seems possible if separate EV metering is in place. With respect to railway infrastructure the operator could also enter into such a green electricity contract. Note that these contract may cover the whole or part of the electricity consumed. This green certificate system can be applied to renewable electricity generated within the member state, but also for renewable electricity imported from other countries using a similar scheme (see Figure 28 and Figure 29). In order to prevent double counting, regulation has to be put in place which safeguards that green certificates are not issued/sold more than once per MWh of renewable electricity concerned. This to make sure that a growing demand for renewable electricity in the transport sector indeed increases renewable electricity generated within the EU.

Figure 31 Situation 7a: Indirect powering, within one EU member state and via a contract system





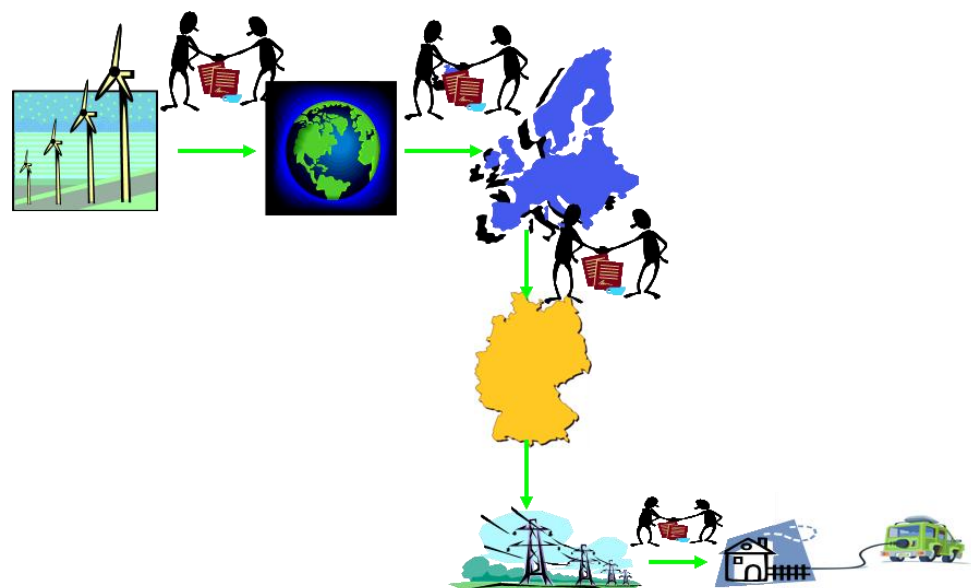
Figure 32 Situation 7a: Indirect powering, with renewable energy production in one EU member state and powering the vehicle in another EU member state



### Situation 7b: Electricity from outside the EU

Situation 7a could also apply to renewable electricity from outside the EU under the condition that it is possible to take sufficient measures to safeguard that there is no double counting and countries apply the same criteria/methodology (Figure 30). Articles 9 and 10 of the RED have provisions to deal with this.

Figure 33 Situation 7b: Indirect powering, with production of renewable energy in a country outside the EU (e.g. hydropower from Norway, solar power from the Sahara, or even as far as China or the USA)



Since countries concerned fall outside of the EU legislative area, effective supervision (instruments to enforce compliance) is limited.

### 5.2.2 Situations for hydrogen

For hydrogen, the situation is slightly different. There are three different technical ways for the production of hydrogen; using electricity, using methane or using biomass. Hydrogen can be produced centrally or on-site at the filling station via electrolysis using electricity, via reforming of methane (fossil or bio) or via gasification of biomass. The electricity-based routes can be regarded as an extension of the situations described in the case of

renewable electricity, with a hydrogen production line as an added 'building block' in the supply chain. The points in the H<sub>2</sub> production process that are relevant for the RED are:

- the total amount of energy (i.e. electricity, methane) or biomass that is used in the H<sub>2</sub> production process;
- assessment of the part of that energy or biomass that can be counted as renewable.

The third step, that is extra compared to the situations for electricity and methane, is:

- measurement of the amount of hydrogen that is used for transport purposes.

This last step is very similar to the 'other (on-site) demands' described for electricity and methane.

If hydrogen is produced centrally, the distribution is done via liquefied hydrogen (LH<sub>2</sub>) or compressed gas hydrogen (CGH<sub>2</sub>) trailer trucks or H<sub>2</sub> pipelines. Electricity is required for both liquefaction and compression of hydrogen. CGH<sub>2</sub> storage in vessels and transport in H<sub>2</sub> pipelines can be considered 'loss free'. However, similar to batteries' self-discharge, long-term storage of *liquefied* hydrogen may induce losses from hydrogen blow-off (heat intake leads to evaporation of LH<sub>2</sub>, pressure builds up, CGH<sub>2</sub> has to be used in CGH<sub>2</sub> applications or vented).

LH<sub>2</sub> storage in cars is practically no longer followed by the automotive industry. LH<sub>2</sub> for the purpose of supplying hydrogen filling stations is an option being followed especially in the early commercialisation stage.

We do not consider the situation of a large-scale hydrogen pipeline distribution grid towards feeding points for vehicles here. A distribution logistics via truck is already existing, provided by technical gases suppliers such as Air Liquide, Air Products, Linde, etc. From large hydrogen production facilities, the hydrogen is shipped to different customers by truck and sometimes even through (local) pipelines.

### 5.2.3 Overview of situations

When all building block are taken together, we get the overview pictures as given in Figure 34 (electricity), Figure 35 (methane), and Figure 36 (hydrogen). The various measuring points described above are included in the diagrams. The pictures are given from the viewpoint of the renewable energy source.



Figure 34 Overview of situations for electricity as transport fuel

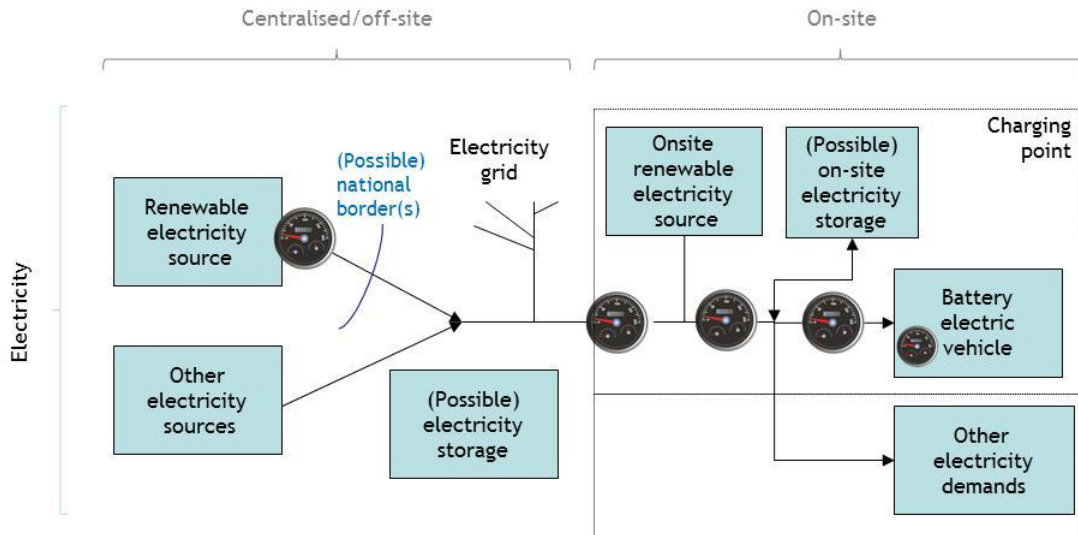


Figure 35 Overview of situations for methane as transport fuel

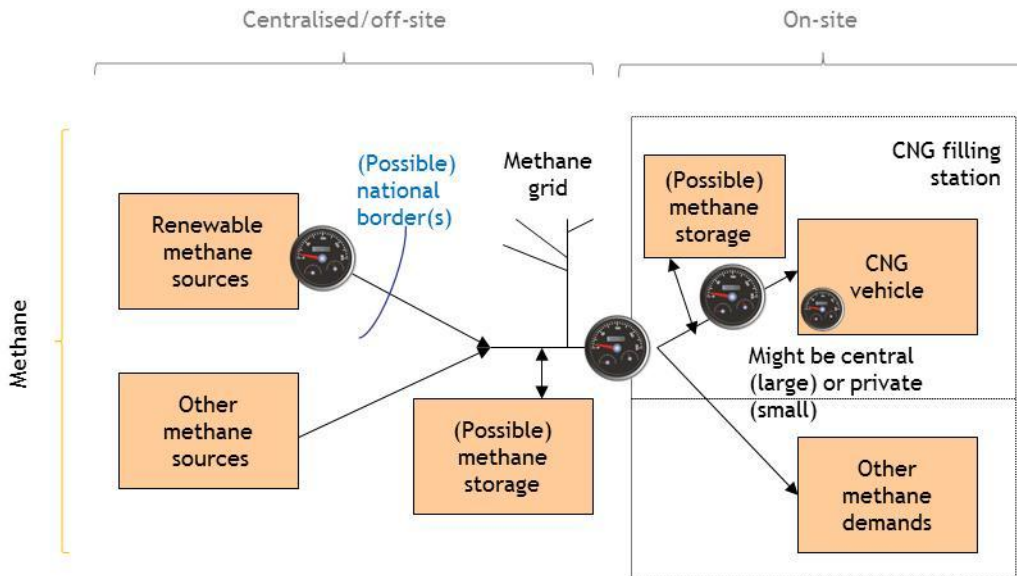
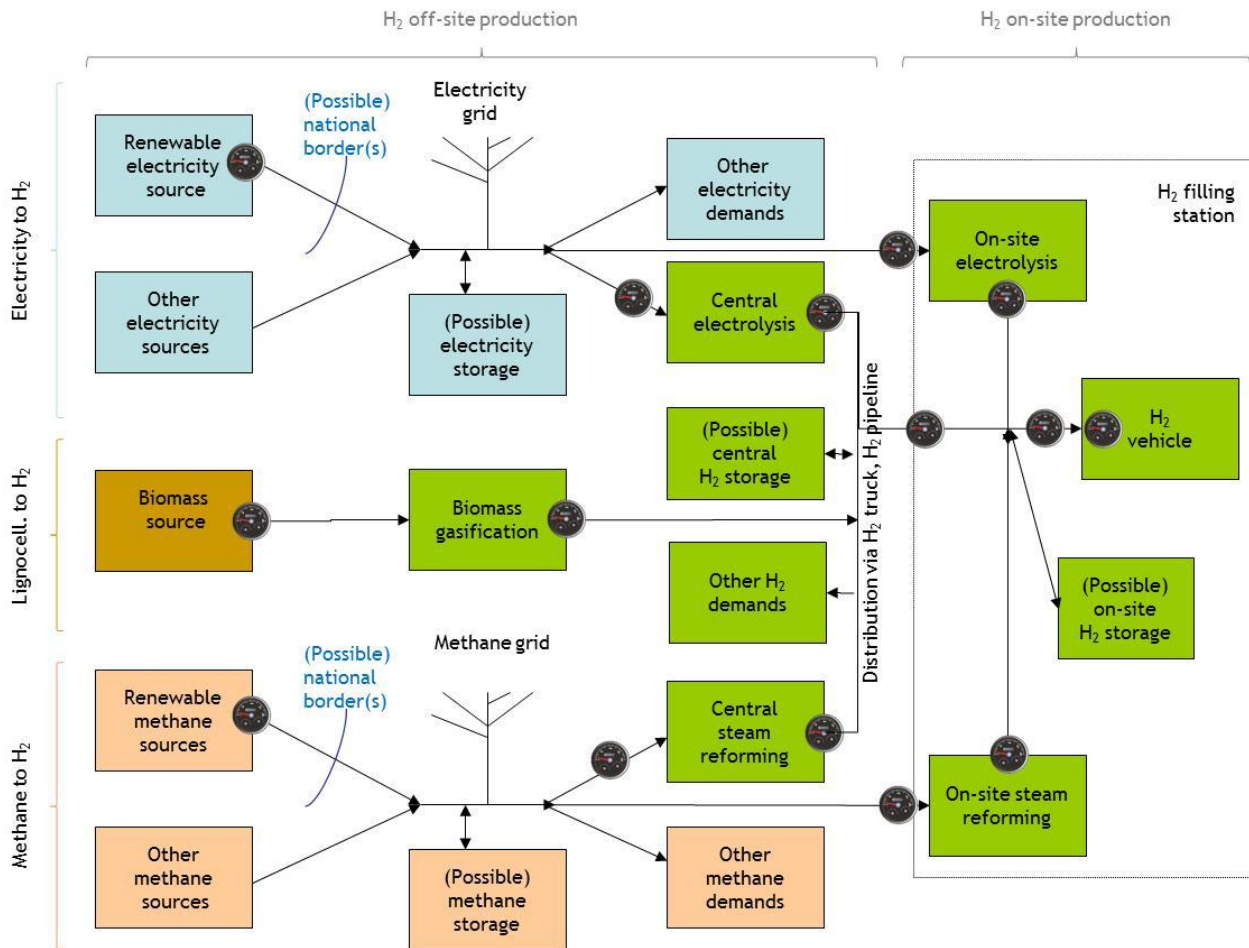


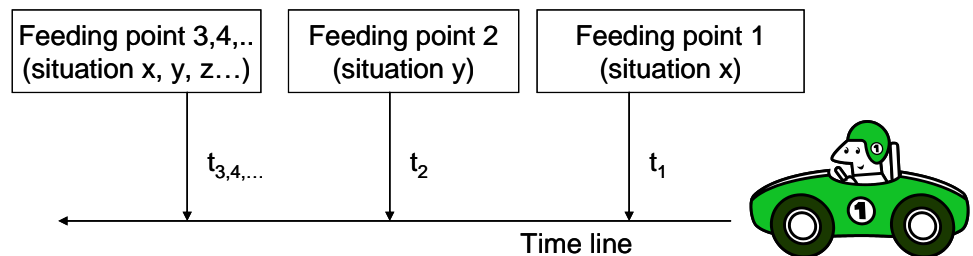
Figure 36 Overview of situations for hydrogen as transport fuel



### 5.2.4 Point of view: From the vehicle

When we change the point of view from the renewable energy source to the vehicle, we can analyse the situation where a vehicle is being fed at different feeding points, each with a different 'situation' as described above. The methodologies should cover both points of view, taken e.g. into account problems with possible overlap and double counting.

Figure 37 Point of view from the vehicle. The picture holds for all considered types of cars (e.g. electric, methane, hydrogen)



Things get even more complicated if vehicle or driver specific fuel supply contracts are considered, take e.g. the case of 'Better Place' and their concept of 'pay-per-use'. Similar to mobile phone contracts, 'roaming' of



electricity, methane and hydrogen supply contracts may have to be considered. Whether this type of use will find acceptance with vehicle owners/users or not and whether there will be technical procedures to allow for such contractual models, is highly uncertain to date. Given the complexity and uncertainty of such a case, we recommend to monitor the developments and revise accounting methodologies when and as far as needed at a later point in time, e.g. in the course of another RED review.

#### **5.2.5 Point of view: Where to meter and who is the reporting entity?**

There are in principle three ‘information carriers’ involved in the use of transport use. Any of them could be held responsible in the future for monitoring (metering) and reporting the renewable fuel quantities fuelled to any regulatory body/statistics bureau:

1. The dispenser.
2. The vehicle.
3. The client.

Depending on the ‘situation’ given (see descriptions above), the dispensing entity could also be the fuel customer (‘own consumption’, e.g. from homemade PV electricity); the fuel customer not necessarily needs to be the vehicle owner, etc.

### **5.3 Methodologies**

#### **5.3.1 Electricity and methane**

Having identified all the different situations that might occur in practice, the next step is to define the various methodologies with which the renewable energy used in transport via these routes can be included into the RED transport target. We will first analyse the methods for electricity and methane, and then for hydrogen.

The methodologies for electricity and methane have to consist of two essential steps:

1. Monitoring the total energy input into the vehicle (volume).
2. Assessment of the part of that volume that can be counted as renewable.

From the analysis in the previous paragraph, we conclude that at least for electricity, measurements in the vehicle are a necessary part of every methodology *that wants to cover all situations and with very high accuracy (i.e. using measurements and not estimates)*. The only alternative would be to ensure that measurements are taken at all possible vehicle feeding points, including household power plugs. However, attributed costs and reporting efforts may then create quite a severe barrier to the market uptake and use of battery electric vehicles.

The question now is what methodologies exist to determine the amount of (grid connected) renewable energy that is fed into the vehicle. The methods differ in the accuracy with which the amount of electricity in transport can be assessed. The total amount of energy used by the vehicles is known by adding up the meter readings of all the cars (e.g. on a yearly base). When the attribution of renewable electricity to transport is made dependent on the exact moment in time when EVs are charged (see Section 5.2), a more complex methodology is needed. In that case more sophisticated metering (‘smart metering’) and total transparency on all current electricity suppliers is vital in order to be able to know, ex post, exactly when the EVs concerned



were charged and what the exact production mix was. Of course, this is only one aspect of smart grids and smart metering.

### Step 1 (Measurement of the total energy input into the vehicle)

Considering measurements, two main measurement methodologies can be distinguished, where the distinguishing feature is the position of the meter:

1. Measurement of the energy input at the feeding point.
2. Measurement of the energy input in the vehicle.

Using a mix of these two methodologies might be necessary to measure all energy inputs into all vehicles, where problems with double counting have to be solved.

3. Instead of *measuring* the energy input, also estimates (e.g. based on statistics), can be used to get an approximation of the energy input. For example, the average yearly energy consumption of a typical vehicle might be known from statistics, or the average yearly amount of kilometres an ‘average vehicle’ drives which then has to be multiplied by the average energy consumption per kilometre.

A mix between measurements and estimates might be used for practical reasons, using a different method for different transport systems. For example, the electricity consumption by railway (and tram, metro and trolleybus) can be monitored relative easily at feedings points since they use dedicated feeding points, whereas for road transport, the use of estimates might be preferred as long as no single measurement system is in place that covers all situations.

### Step 2 (Assessment of the amount of renewable energy)

For Step 2, again two main methodologies can be distinguished:

1. Using the production mix per country (the ‘default option’ in the RED for electricity).
2. Using the production mix in the specific contract for every specific charging point, which opens e.g. the possibility for counting specific ‘green contracts’.

Also for Step 2, using a mix of the two main methodologies is possible, where problems with double counting have to be solved.

For the second option in Step 2, using the production mix in specific contracts, the difference between renewable energy produced in the member state or in the EU, and outside the EU, is important to address the question of ‘additionality’.

Each of the two methods in Step 2 can be subdivided into ‘volume monitoring’ and a more elaborate ‘time profile monitoring’. This is shown in Table 8.

Table 8 Volume monitoring versus time profile monitoring

Category	Volume monitoring	Time profile monitoring
National production mix	√	Not possible yet, future option
Energy contract (or known ‘greenness’) of each specific feeding point	√ (Including methodologies 1 & 2, and green contracts)	Not possible yet, future option



### 5.3.2 Hydrogen

For hydrogen, as described in the situations, a third step is required. In the first step, the total amount of energy input (electricity, methane, or biomass) into the hydrogen production process is measured. In the second step, the assessment of the amount of renewable energy in that volume is carried out. The third step deals with the measurement of the volume of hydrogen from the production facility that is actually used for transport purposes.

1. Measuring the total energy, or biomass, input into the hydrogen production process (volume).
2. Assessment of the part of that volume that can be counted as renewable.
3. Measuring the volume of hydrogen that is used for transport.

The first two steps are already described in Table 8. In the case of hydrogen, these two steps do not determine the amount of energy used in the car and the assessment of the amount of renewable energy in that volume, but determine the amount of energy to produce the hydrogen and the renewable part of that amount.

However, the targets in the RED are defined by *final* energy consumption, not by primary energy consumption. Therefore, the input into the hydrogen production process is not relevant for the RED, only the percentage of the input (of electricity, methane or biomass) that can be counted as renewable, and the first step can be omitted in the method. The method for hydrogen consists also of two steps.

1. Assessment of the percentage of renewable energy (or biomass) in the input volume of the hydrogen production process.
2. Measuring (or estimating) the volume of hydrogen used in transport.

We consider small scale on-site hydrogen production, without separate monitoring of the energy input of the production process, not a realistic option. Therefore, we assume that the total energy input of the hydrogen production processes is always monitored.

### 5.4 Railways (and tram, metro, trolleybus)

The previous sections were mainly focussed on renewable energy use in vehicles (road transport), but some of them are also relevant for rail transport, and rail transport may be one of the easiest options to contribute to the RED 10% target. The same analysis can be used for tram, metro and trolleybus. Railway transport is easier to cover in statistics than road transport, as there are much less parties involved, and the number of feeding points is much more limited. It seems appropriate for the Commission to set calculation standards in order to ensure that Member States apply a uniform calculation method.

When looking at the situations described in Section 5.2, Situation 6 seems the most relevant when looking at rail transport, although also Situations 5 or 7 could apply. An island situation (Situations 1, 2, 3 and 4) is not applicable when it comes to rail transport; electricity infrastructure for rail transport is always grid-connected. Note that also 'own power generation' is part of the picture. Diesel trains (and diesel-electric trains) are already covered by the RED.

When looking at Situation 6, problems with regard to double counting when a mixed approach is used, using both monitoring at vehicles and at feedings points, are not an issue when it comes to rail transport. In that sense the situation for rail transport is less complicated than it is for road vehicles. The reason is that one does not need to know the electricity consumption of





every individual train in order to determine the total electricity consumption in rail transport. Only insight into the overall electricity consumption of the rail transport infrastructure itself and possibly the share of renewable electricity therein is needed.

When looking at metering in general, for rail transport this appears to be less complicated than for electric vehicles, since keeping track of the electricity consumption of each individual train is unnecessary for determining the total electricity consumption involved in rail transport. Besides operating own power generation plants, the rail transport infrastructure operator makes use of (several) grid connections which will already be metered in order for the transmission/distribution system operator to measure the amount of electricity consumed and invoice accordingly. It will therefore be relatively easy to determine the total amount of electricity which can be attributed to rail transport (Step 1, as described in Section 5.3) by adding up the meter readings of the different grid connections (energy inputs at the feeding points) related to rail transport<sup>47</sup>.

Regarding Step 2 of Section 5.3 (assessment of the amount of renewable energy) the same methodologies apply as for electric vehicles. As for electric vehicles, if a more sophisticated methodology is desired, e.g. real time monitoring of the type of electricity actually consumed by rail transport at any given moment, more sophisticated metering (time resolved, which is already becoming the standard for most of the larger electricity consumers) is necessary in order to determine, ex post, what type of electricity (mix) was feeding the rail transport infrastructure, and by that the trains making use of that infrastructure, at specific moments in time.

## 5.5 Conditions

In this paragraph, the conditions will be described for each method. The main question here is: what are the necessary conditions to enable the required monitoring of a) the relevant energy use in transport and b) the share of renewable energy in that energy use. We will also consider situations in which a vehicle charges at different feeding points with different 'situations'.

### 5.5.1 Conditions for time profile monitoring

If the methodology is to be based on time profile measurements, the following conditions have to be met:

- smart meters at both the feeding point of every vehicle or every vehicle itself, and at every renewable energy source;
- installed procedures ('who is reporting to whom?').

Maybe an intermediate way is possible, by working with comparison of profiles for charging or feeding, and production.

This may seem very complex and costly in the current situation, but smart grids (including smart meters) and unique (electric) vehicle IDs, combined with smart tariffs, are expected to be required in the future, if the potential for balancing local electricity production with local demand is to be possible in a two-way communication system. Smart grids are the expected future for the electricity grids in the built environment. The real time measurements are an essential part of such an electricity network, which also enable the monitoring of the amount of renewable energy that is used for feeding of electric

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<sup>47</sup> Taking into account, if and where relevant, the fact that for some feeding points green energy contracts could be in place (Situation 7).





vehicles. For now, this is not a feasible option. For gas grids, such two-way communication on a distribution level is not yet foreseen.

### **5.5.2 Conditions for volume monitoring**

From situations where the energy use is metered at a higher level than the feeding point of a vehicle (e.g. on the level of a ‘single user’, like a household or an office), one way to monitor the volume of energy fed into the vehicle is by having a meter in the vehicle itself. Another way is to install a dedicated *extra* meter for each charging point, that is then used for monitoring the volume of energy fed into the vehicle. The latter might evolve from future tax legislation, if Member States were to want to put electricity and methane used for transport purposes under a different tax regime than the use of electricity and methane for other purposes.

Another pragmatic way might be to simply neglect in the monitoring all energy that is fed into vehicles where robust monitoring does not exist, i.e. where the charging point does not have a specific meter within a metering and billing regime, or the charging point is also used for other purposes than charging vehicles.

### **5.5.3 Conditions for metering at feeding points**

Feeding points have to be identified (‘transport use only’) and separately metered. For central feeding points (e.g. dedicated charging points at highways or CNG-filling stations) this should be no big problem. Once identified, the meter readings have to be collected on a national scale for each Member State. The identification and subsequent data collection will need some kind of legislation and protocols.

For hydrogen production, the energy (or biomass) input into the hydrogen production process is already known for centralised hydrogen production sites. Some legislation and a protocol are needed to be able to use that data for monitoring of the RED.

### **5.5.4 Conditions for metering in the vehicles**

Metering in the vehicle itself solves the problem of monitoring the (renewable) energy use in transport while vehicles can feed at feeding points that are not equipped with separate meters.

The metering in the vehicle is in most cases already present. The question is how to get access to that data for RED monitoring purposes, and with good quality of the monitoring process. For electricity, the future smart grids with smart meters and smart tariff systems will probably solve this problem. If all feeding points are equipped with separate meters, the necessity for metering in the vehicles itself disappears.

### **5.5.5 Conditions for using the national production mix**

The national production mix fed into the grid, for electricity and methane, is already monitored by each Member State. No additional conditions apply.

### **5.5.6 Conditions for using production mix in individual energy contracts**

As described, instead of using the national production mix, a different method is to use the production mix for every energy contract for every feeding point. This way, a direct link and thus a direct driver is established between the electricity, methane or hydrogen used in transport, and the demand for renewable energy. There is not an already existing data process that can be used. This will require large-scale data processes and has implications for each



energy company; legislation will be needed to get access to the data, and possible privacy risks have to be addressed.

### 5.5.7 Combining methodologies: green contracts *and* production mix

It is possible to use a mixed method, using the greenness of the energy contract for specific charging points, and the national production mix for other charging points. However, this requires corrections for possible double counting, since the renewable energy production that is sold in the green energy contract is also counted as part of the national production mix; see the textbox for an example. Since all volumes are known, the correction can be carried out, but might be complex. This will be addressed further in Chapter 6.

#### Example: data requirement

Consider the relatively simple example of an electric vehicle that charges at only two points:

1. At home. Situation: grid connected with one meter 'at the front door', several PV panels on the roof (not separately metered), and the vehicle charges at an ordinary grid socket, not separately metered. No 'green electricity contract'.
2. And at a special EV feeding point, with a dedicated meter at the feeding point, and no other demands, with 'green electricity contract' (100%).

Analysis:

- All the electricity that is fed in at point 2 can be counted towards the 10%. Time profile metering is also possible at this point, but that is not yet incorporated into 'green contracts'; we can point that out.
- The electricity from the PV panels is not metered separately, and can not be counted (unless as 'statistically counted' contribution to the national production mix', which is out of the scope of this study).
- The feeding point of the car is not separately metered. The way to take the electricity of the car into account is to have a meter in the car itself, or use an extra meter for each specific feeding point (that has to be dedicated). The amount of renewable electricity has to be calculated from the national production mix. Time profile metering (at the car) might be possible in the future.
- Note that there might be overlap between the attribution of point 1 and point 2, because the 'green contract' for point 2 might also be counted in the national production mix. Since the volume of electricity fed into cars is known at point 2, the national production mix used for the calculation used at point 1 can be corrected. Another practical solution will be to simply choose (as a country): either use only data from dedicated feeding points combined with data about the 'greenness' of their contract, or only data from meters in cars combined with the national production mix. In the future, with smart grids, mixed solutions can be applied.

## 5.6 Overview of methods

In conclusion, for electricity and methane the following six methods are identified. Each method consists of two steps:

1. Measuring the total energy input into the vehicle.
2. Assessment of the amount of renewable energy.

The assessments can be by volume or with a time profile. Time profiling is regarded as a future option. In each step, the main methodologies can be mixed, where problems with double counting have to be solved.



Table 9 Overview of methods for electricity and methane

Method	Step 1: Measurement of energy input into vehicle			Step 2: Assessment of amount of renewables	
	A: Measurement at feeding point	B: Measurement at the vehicle	C: Using estimates	A: Production mix of country	B: Production mix in contracts
1	X			X	
2	X				X
3		X		X	
4		X			X
5			X	X	
6			X		X

**Current method of data collection by Eurostat**  
 Member States report to Eurostat the amount of renewable electricity used in transport. The amounts of biomethane and hydrogen are still negligibly small, below the reporting limit. By far the largest portion is the electricity used for rail transport, which is already part of the energy statistics of the Member States. This amount is multiplied by the percentage of renewable electricity production (national mix). The same way, the electricity consumption for trams, metro and trolley bus is treated. For road transport, estimates are used based on the number of electric vehicles and the average yearly energy consumption.

From an abstract viewpoint, the methods for hydrogen resemble those for renewable electricity and biomethane. Since the physical process steps are however different, i.e. using electricity or biomethane (or biomass) for the production of hydrogen, we treated the methods for hydrogen separate from those for renewable electricity and biomethane.

Table 10 Overview of methods for hydrogen

Method	Step 1: Assessment of percentage of renewables in hydrogen production process		Step 2: Measurement the volume of hydrogen used in transport		
	A: Production mix of country (n.a. for biomass)	B: Production mix in contracts	A: Measurement at feeding point	B: Measurement at the vehicle	C: Using estimates
1	X		X		
2	X			X	
3	X				X
4		X	X		
5		X		X	
6		X			X





# 6 Assessment of methods and conditions

## 6.1 Introduction

For the detailed assessment of the methods and conditions, a three step approach is followed:

1. Definition of evaluation criteria.
2. Assessment of methodologies against the criteria.
3. Scoring of the options.

In the end of this chapter we draw some conclusions on the practical feasibility of the methods for the use that is envisaged.

## 6.2 Definition of evaluation criteria

Before assessing the feasibility and relevant impacts of the different sets of methods and conditions, criteria have to be defined that can serve as a guideline for the analysis.

Different types of criteria can be distinguished. For example, some can indicate the extent of the contribution towards a certain policy goal, whilst others are more concerned with ensuring practical feasibility and reasonable costs. Alternatively, some criteria could be seen as key requirements, i.e. a methodology will need to score positively on these criteria, whereas others are more 'nice to have'. In other words, the criteria may be prioritised. This will not be done here explicitly, but may be a factor to be considered when drawing conclusions from the assessments.

Looking at both policy aims and feasibility issues, we can identify the following list of criteria for this assessment of methodologies:

- **Feasibility:** Practical feasibility/ease of implementation and use.
- **Additionality:** Extent to which options have the potential to lead to additional renewable generation.
- **Cost:** Distinguishing between administrative cost to stakeholders and other cost (such as cost of metering equipment).
- **Robustness:** Flexibility and openness to all actors<sup>48</sup>.
- **Degree of accuracy:** Does the renewable energy counted towards the 10% transport target accurately reflect the actual value?
- **Risk of privacy issues:** May privacy issues arise, e.g. from energy data collection?

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<sup>48</sup> This criterion implicitly includes level playing field for different technologies and stakeholders, as future developments in this respect are still quite uncertain.



### **Additionality**

The two questions with additionality are: additional to what, and when?

The renewable energy targets for the EU as a whole and for each Member State are defined as a percentage of total energy consumption that has to be produced from renewable sources, *including* renewables for transport, in 2020. The overall renewable energy targets for 2020 are generally seen as hard to achieve. *Within* these targets, at least 10% of the energy consumption for transport has to be produced from renewable sources, in 2020. The aim of the specific transport target is that the shift towards renewables will also take place for the energy carriers used for transport, which might not be the case without this specific transport target.

The definition of the overall target is such that the renewables used for transport count towards that overall target in 2020, and are not additional to that target. However, after 2020 new targets have to be set, and in those targets a separation could be made between renewables for transport and renewables for other use, thus fulfilling additionality (i.e. a target for renewables in transport 'on top of' a target for renewables for other use).

In some countries, additionality is also dominating discussions about selling 'green electricity' to the consumers of electricity. By buying green energy, consumers get the impression that they are fostering the production of renewable electricity, whilst in reality their choice has not necessarily a discernible impact. This is, for example, the case in the Netherlands where consumers can buy 'green electricity', where power companies have built wind turbines and biomass installations with subsidy from the government, and not because of the consumer's choice. The 'green electricity' is thus not originating from new renewable production sources (under the target) but from already existing sources.

This can, in principle, be addressed: Renewable production that is sold as 'green energy' is not allowed to count towards the target. Subsidised renewable energy production is not allowed to be sold as 'green'. Both conditions make that green energy additional to the existing target. In Germany, electricity that is remunerated according to German feed-in law (EEG) is sold at the power exchange as 'grey energy', and for this power companies must not claim a green price premium from the consumer.

Additionality also comes into the discussion when renewable energy is bought from countries outside the EU, such as Norway, which might not have their own target for renewable energy production or consumption, or with other monitoring rules.

The question then arises: additional to what?

The question of additionality is closely related to the matter of double-counting.

Furthermore, additionality may apply in the context of a sustainable (transport) energy system in the future. If electricity, hydrogen, and methane from renewable sources are to contribute significantly to the energy provision of transport, sustainable biomass potentials can be used in other sectors, or in transport modes where these alternatives are less suitable.

## **6.3 Assessment of methodologies against the criteria: electricity and biomethane**

### **6.3.1 Step 1: Measuring the amount of energy input into the vehicle**

#### **Criterion: Feasibility**

In case of measurement at the feeding point of the vehicle, two situations can be distinguished. Both require metering at a point where the energy, being electricity or methane, is dedicated for use in transport, with no other type of energy demands. The first situation is the most easy one, when the meter is a 'normal' meter that is used by the energy company for metering and billing. In that case, all necessary processes and infrastructure for data collection are already there. What has to be solved in addition, is the identification of these



metering point as ‘transport use only’, and a process to collect the readings of all these ‘transport use only’ meters from all the energy utilities.

The second situation is when there are several energy demands at the ‘normal’ meter, and the measurement of the energy that is dedicated for transport use requires an extra meter that is not used in the metering and billing processes of the energy utilities. Technically, this is possible, but the set up (and maintenance) of all necessary processes and infrastructure will be a difficult task.

In the future, feeding points of vehicles, especially electric vehicles, might be all equipped with a dedicated meter for energy utilities to be able to deal with the extra capacity demand, but this is not certain yet.

For hydrogen, the same argumentation holds, but with the feeding point of the vehicle replaced with the production process of the hydrogen.

In case of measurement at the vehicle itself, the metering is per definition ‘dedicated’. Usually, each vehicle has a sensor measuring the filling status of the tank or battery. The challenge will be to design and implement the processes and infrastructures to collect and process all these data. Again, in the future, these processes might be a natural part of two way communication smart grids.

Measurement of the energy uptake at the vehicle seems not required for railway, since all energy consumed in railway use is already dedicatedly metered. This holds also for tram, metro and trolleybus.

In case of using estimates, feasibility is not a problem.

#### **Criterion: Additionality**

Additionality is only relevant for Step 2 (Assessment of the amount of renewable energy)

#### **Criterion: Cost**

Relatively speaking, for measurements the cheapest way is to use current processes and infrastructures as much as possible. The introduction of extra meters, and the necessary design and implementation (and maintenance) of data collection processes, might be a highly expensive step.

Using estimates is lower cost than using measurements.

#### **Criterion: Robustness**

Using existing data collection processes that are used for metering and billing are very robust, since they are maintained by stakeholders which business is critically dependent on these processes.

The implementation of entirely new structures and processes that are only used for monitoring purposes and are not required for other business operations seems to be not very robust.

For electric vehicles, the future smart grids with smart tariffs open a possibility to use these data for monitoring purposes. The extensive use of information systems to this end as well as the significantly increasing number of actors involved in the process (compared to using national mixes or compared to biofuel case) may put question marks regarding the robustness of this approach. For this, additional research is needed at some point in time when there are clearer indications regarding the technology development routes of smart grids and tariff concepts.

The future use of electric vehicle batteries as electricity *storage* provides a new challenge for RED monitoring.



Estimates instead of measurements can be used always, so using estimates is a robust solution.

### **Criterion: Accuracy**

There is likely a trade-off relation between the robustness of a measurement regime versus its accuracy. Simple (i.e. robust) regimes are rather not accurate in terms of having all relevant actors (private!) and energy supplies (direct contracts) included, and vice versa. We suggest to rather begin with a robust, more 'all inclusive' methodology, that may be elaborated in the future when actual developments provide for appropriate and firm decisions. When all feeding points are 'transport use only', and equipped with dedicated meters within a regular metering and billing regime, the accuracy of monitoring at the feeding points only is high. Accuracy problems arise especially with small private charging and filling stations, 'behind the meter' and probably also used for other types of demand. An obvious way to deal with this is to monitor only dedicated metered charging and filling points. Thereby placing most of the small private feeding points out of scope for monitoring the RED, affecting the accuracy of the method. For methane, small private filling stations are not yet largely spread and may be just a temporary market phase.

For the case of measuring in the vehicles itself, the accuracy can be very high, provided a very good data collection process can be established. This is regarded as a future option.

Using estimates instead of measurements introduces uncertainties. The outcome is as good as the accuracy/representativeness of the input values. The larger the number of EVs and vehicles using biomethane, the better the fit between using estimates and actual consumption and consequently the monitoring accuracy of the 10% RED-target. A relevant question regarding the use of 'averages' is, for example, whether an EV or a vehicle using biomethane is used in the same way as a conventional gasoline/diesel vehicle. Different driving regimes require the use of technology specific average numbers, such as the amount of kilometres driven per year.

### **Criterion: Privacy risk**

Privacy risks emerge when energy consumption can be pinpointed to a specific vehicle (or even a specific driver or person), at a specific time or location. For measurements at feeding points that are used by different vehicles, that seems to be no problem, provided the volume energy data are not 'enriched' with data of the vehicle or the driver.

For measurements at the vehicle itself, this is a potential problem. The longer the volume data stay coupled with data of the vehicle (ID), its driver or even vehicle locations/routes in the data processing, the more critical this problem will be.

An overview of the assessment of Step 1 methodologies is given in Table 11.





Table 11 Assessment of methods for measuring energy (Step 1, for volume measurements, not time profiles)

Criterion	Measurement at feeding point	Measurement at the vehicle	Using estimates
Feasibility	Requires identification of, and data collection from, all feeding points for transport. For data collection of 'normal' meters <sup>49</sup> , the processes and infrastructures are already available, but not for 'extra' meters <sup>50</sup> .	Requires identification of, and data collection from, all cars. There are no processes and infrastructures available yet. Not necessary for railway.	No problem
Additionality	Not relevant for this step	Not relevant for this step	Not relevant for this step
Cost	Relatively low cost while using 'normal' meters. Addition cost while using additional meters for the purpose of monitoring only.	Additional cost because the processes and infrastructure has to be build up; on the other hand: it is being discussed to include this option in the future anyway, e.g. for demand side management.	Low cost
Robustness	Most robust: using existing data collection processes that are critical in other businesses. For future, use of electric cars for electricity storage has to be taken into account.	The expectation is that in the future electric and methane cars will have their own ID and energy contract. For future, use of electric cars for electricity storage has to be taken into account.	No problem
Accuracy	Feeding points that are not dedicated for transport are out of scope. Possible risk of mismetering, depending on quality of identification process of dedicated meters.	Can be high, but only when all vehicles have an ID and their own meter, and a good data collection process is established. Regarded as future option.	Depending on the quality of the estimates used. The lower the number of these vehicles, the poorer the statistics (but also: the smaller the impact on the <i>overall</i> monitoring accuracy).
Privacy risk	No extra risk if consumption data is collected without personal information.	Privacy at risk if vehicle, driver/holder and/or location data is collected.	No problem

<sup>49</sup> With 'normal', we mean the meter that is used by the energy utility company for metering and billing.

<sup>50</sup> 'Extra': E.g. separate metering would be required in households as the 'normal' utility meter will not differentiate between overall household power consumption and the electricity used for vehicle charging. Similar arguments would apply to household filling concepts for methane and hydrogen.



## 6.3.2 Step 2: Assessment of the amount of renewable energy

### Criterion: Feasibility

The production mix data of every EU Member State (or EU as a whole) is already available, and therefore this method causes no problems. Using data of specific energy contracts for monitoring of the RED requires new data collection processes (and maintenance) and cooperation of all energy utilities, to which legislation is probably needed. Legal provisions<sup>51</sup>, instead of voluntarily cooperation, might be necessary, since this contract data is seen as market sensitive.

### Criterion: Additionality

Additionality could be arranged in all three methods. Using the national production mix, the amount of renewable energy used in *transport* could be wholly or partly not counted to the *total* national renewable energy production target. This way, the target for renewable energy used in transport would be put 'on top of' the national target for renewable energy production, instead of being a specific part of that target.

The same can be done using specific contracts. However, this will most probably stimulate the market to use 'green energy' from outside the EU for transport use. On the other hand, the contract option offers energy consumers to buy 'additional green energy' for their vehicle(s), or 'additional green energy from inside the EU' or from inside their own country or region. Contracts that use renewable energy production from outside the EU will cause the largest problems with 'additionality' since their production takes place outside the legislation of the EU.

### Criterion: Cost

Relatively speaking, the cheapest way is to use current processes and infrastructures as much as possible. The use of the national production mix is no doubt the cheapest option. The contracts option requires new data collection processes and is more expensive. Annex C provides an overview of the number of energy utilities (per Member State) that would be involved.

### Criterion: Robustness

Also on this criterion, the use of national production mix data is the most robust option, since that monitoring is an already existing and important process. Uncertain is, however, households' own energy generation and consumption in transport.

### Criterion: Accuracy

The national production mix data is the most accurate. The contracts option has a larger accuracy risk because of the necessary cooperation of a large number of parties and the large-scale of data collection and processing. Contracts that use both renewable energy production from within and from outside the EU will cause the largest problems with accuracy (including risk of false claims or fraud), since legislation and monitoring protocols in those countries can differ from those within the EU.

### Criterion: Privacy risk

There is no privacy risk with national production mix data, which is already available. However, the use of data of specific energy contracts for monitoring purposes might cause severe privacy risks, especially if households are included.

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<sup>51</sup> We mean legal provisions like the RED articles for biofuels (biomass data need to be communicated for the mass balance and proof to comply with sustainability criteria).



Table 12 Step 2: Assessment of amount of renewable energy

Criterion	Country production mix	Production mix of contract
Feasibility	Data is already available	Data not available on national scale, requires new data collection processes (and legislation needed for market parties for data delivery)
Additionality	Possible on national scale by not counting renewable energy used in transport towards the national targets	Possible, opens possibility of 'green contracts', necessary separation of contribution from inside country from other EU countries. When the contracts also use contributions from outside the EU, the point of additionality becomes more difficult.
Cost	Data is already available	Might be large (building up of data collection processes)
Robustness	Data is already available	Risk
Accuracy	High accuracy	Risk
Privacy risk	None	Yes - with potential for high levels of risk

## 6.4 Assessment of methodologies against the criteria: hydrogen

### 6.4.1 Step 1: Assessment of the percentage of renewable energy in the hydrogen production process

This analysis is carried out for the routes using electricity or methane for hydrogen production. For the biomass gasification route, the sustainability criteria for biomass can be used for each batch of biomass to ensure that every batch of biomass used in the production process will only count towards the RED target if it meets these criteria.

#### Criterion: Feasibility

The production mix data of every EU country (or the EU as a whole) is already available, and therefore this method causes no problems. Using data of specific energy contracts for monitoring of the RED requires new data collection processes (and maintenance) and cooperation of all energy utilities, for which legislation is probably needed. Legislation, instead of voluntarily cooperation, might be necessary, since this contract data is seen as market sensitive.

#### Criterion: Additionality

Additionality can be arranged in all three methods. Using the national production mix, the amount of renewable energy used in transport can be wholly or partly not counted to the total national renewable energy production target. This way, the target for renewable energy used in transport will be put 'on top of' the national target for renewable energy production, instead of being a specific part of that target. The same can be done using specific contracts. However, this will most probably stimulate the market to use 'green energy' from outside the EU for transport use. On the other hand, the contract option offers energy consumers to buy 'additional green energy' for their vehicle(s), or 'additional green energy from inside the EU' or from inside their own country or region.

Contracts that use renewable energy production from outside the EU will cause the largest problems with 'additionality' since this production is outside the legislation of the EU.



### Criterion: Cost

Relatively speaking, the cheapest option is to use current processes and infrastructures as much as possible. The use of the national production mix is no doubt the cheapest option. The contracts option requires new data collection processes and is more expensive. Annex C provides an overview of the number of energy utilities (per Member State) that would be involved.

### Criterion: Robustness

Also on this criterion, the use of national production mix data is the most robust option, since that monitoring is an already existing and important process.

### Criterion: Accuracy

The national production mix data are the most accurate. The contracts option has a larger accuracy risk because of the necessary cooperation of a large number of parties and the large-scale of data collection and processing. Contracts that use both renewable energy production from within and outside the EU will cause the largest problems with accuracy.

### Criterion: Privacy risk

There is no privacy risk with national production mix data, which is already available. However, the use of data of specific energy contracts for monitoring purposes might cause privacy risks.

Table 13 Step 1: Assessment of percentage of renewable energy (for hydrogen production)

Criterion	Country production mix	Production mix of contract
Feasibility	Data is already available	Data not available on national scale, requires new data collection processes (and legislation needed for market parties for data delivery).
Additionality	Possible on national scale by not counting renewable energy used in transport towards the national targets.	Possible, opens possibility of 'green contracts', necessary separation of contribution from inside country from other EU countries. When the contracts also use contributions from outside the EU, the point of additionality becomes more difficult.
Cost	Data is already available	Potentially high (building up of data collection processes)
Robustness	Data is already available	Risk
Accuracy	High accuracy	Risk
Privacy risk	None	Yes - with potential for high risks

## 6.4.2 Step 2: Measurement of the volume of hydrogen used in transport

### Criterion: Feasibility

Feasibility should be no problem, considering the number and size of the production sites, and considering that each shipment of hydrogen is monitored and billed. NB: The data is market sensitive for the hydrogen production companies.

Measurement at the vehicle is not necessary since all feedings points are metered.

Using estimates also causes no feasibility problems.



**Criterion: Additionality**

N/a

**Criterion: Cost**

See argument under ‘feasibility’, no problem in case of measurement at the feeding point. For measurement at the vehicle, a new data collection process is needed. Using estimates will be the lowest cost option.

**Criterion: Robustness**

No problems envisages with any of the options.

**Criterion: Accuracy**

No problem when using measurements. Using estimates will introduce the same accuracy problems as in the cases of electricity and biomethane, with the note that at least until 2020 the consumption of hydrogen for transport will be very small.

**Criterion: Privacy risk**

Maybe a problem for the hydrogen production companies, for the case of measurement at the feeding point.

For measurement at the vehicle, there are the same privacy risks as already described for electricity and methane.

Table 14 Step 2: Measurement of volume of hydrogen used in transport

Criterion	Measurement at feeding point	Measurement at the vehicle	Using estimates
Feasibility	No problem, provided it is possible to get access to the (market sensitive) data	Not necessary	No problem
Additionality	N/a	N/a	N/a
Cost	Low cost	Problem, new data collection infrastructure is needed	Low cost
Robustness	No problem	No problem	No problem
Accuracy	No problem	No problem	Depending on the quality of the estimates used. The lower the number of these vehicles, the poorer the statistics (but also: the smaller the impact on the <i>overall</i> monitoring accuracy).
Privacy risk	Maybe for the hydrogen production companies	There are privacy risks	No problem



### 6.4.3 Scoring of the options

To get an overview, we put the scores for each step in one table. The scores are made qualitatively, based upon the analyses above.

In the tables:

++ stands for very good possibilities;

-- for real problems; and

= for indifferent.

Table 15 Overview score table for electricity and methane

Criterion	Step 1: Energy input into vehicle			Step 2: Assessment amount of renewables	
	Measurement at feeding point	Measurement at vehicle	Using estimates	Country production mix	Production mix of contract
Feasibility	= (for cars) ++ (for railways)	-	++	++	-
Additionality	N/a	N/a	N/a	=	+ (inside EU) -- (outside EU)
Cost	=	-	++	++	--
Robustness	=	-	+	++	-
Accuracy	+	+	-	++	=
Privacy risk	- (for cars) ++ (for railways)	--	+	++	-

Table 16 Overview score table for hydrogen

Criterion	Step 1: Percentage of renewables in hydrogen production process		Step 2: Amount of hydrogen used by transport		
	Country production mix	Production mix of contract	Measurement at feeding point	Measurement at vehicle	Using estimates
Feasibility	++	-	+	-	++
Additionality	=	+ (inside EU) -- (outside EU)	N/a	N/a	N/a
Cost	++	--	+	-	++
Robustness	++	-	+	+	+
Accuracy	++	=	+	+	-
Privacy risk	++	-	-	--	++

## 6.5 Conclusions and recommendations

### 6.5.1 Drivers

The outlook from our assessment in Chapter 4 is that the transport sector is unlikely to be a major driver of the production of renewable electricity, hydrogen produced from renewable sources or methane for injection into the grid, for the foreseeable future. Similarly, as confirmed by the stakeholder consultation, the 10% target is in itself not going to be a major driver of the uptake of EVs or CNG-vehicles powered by biomethane, and hydrogen production will not be significant in this time frame.



Beyond 2020, this picture might change, but this will depend on the rate of consumer uptake of such vehicles, which is driven by many factors - the rate of technology development, the policy measures put in place by Member States and the way that the transport target is treated beyond 2020.

### 6.5.2 Methods

From the analyses in Chapter 5 and Chapter 6, we conclude that:

- For methane and hydrogen, there is no problem with matching of time of production of the renewable energy with the time of consumption; this fits with the current renewable energy monitoring and market. For electricity, the time profiling is important (see text box with ‘though experiment’ in Section 5.2 on charging at night only, and production with solar PV at day time only).
- For electricity, a volume approach might be used. This is in line with current renewable energy monitoring and market (‘green electricity’), but this way the important point of time profiling is shifted to the future.
- Small scale ‘on-site’ production of renewable energy causes monitoring problems, when these sources are not equipped with an extra meter and a billing and metering cycle; for large-scale production this is not a problem since it is always metered and the information can be used for monitoring.
- Small private filling stations for methane and hydrogen are maybe just a temporary niche solution in the market; the decision whether they should be incorporated into RED-monitoring can therefore be shifted to the future when more becomes clear on how the market evolves. With the footnote that maybe this will stay a solution for remote areas.
- Regarding small scale electricity charging (at home): this might be the same situation as above for methane and hydrogen with the notable difference that the situation will prevail as cars likely will be charged at home in the future as well. Also, the question is relevant whether home charging of hydrogen fuelled cars in general is likely to develop.
- Dedicated metering, also for small private charging or filling stations, may be driven by future tax legislation in Member States. This may also drive a route towards metering at the vehicle.
- Dedicated metering is already the *modus operandi* for electricity consumption for railway transport, and also for tram, metro and trolley bus. This data is already used in national energy consumption statistics by the Member States and by Eurostat, and covers the largest part of electricity consumption for transport. For road transport, such a monitoring structure based on measurements of energy consumption is not yet feasible.
- Smart grids, smart metering and smart tariff systems, including measurement in vehicles, time profile measurement, and vehicle-to-grid (V2G) communication, is regarded as the future way for the electricity distribution grids. The rate of transformation and implemented concepts may vary from Member State to Member State. The RED monitoring must give enough room for these different rates and implementations.

Because of these evolving future techniques<sup>52</sup>, that partly go hand in hand with the transition of the transport system towards renewable energy, we split our advice in a short term (< 2020) and longer term (> 2020) part.

For the short term, the use of renewable hydrogen on a large-scale in the transport system is not regarded as feasible, whereas for renewable electricity and methane it is feasible, even if the rate of uptake may be quite slow. We describe the approach for hydrogen at the long-term, with the

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<sup>52</sup> E.g. it is not yet clear which hydrogen production pathways are deployed the most.



recommendation to review this part of the RED again in the scheduled review in 2014.

For the short term (< 2020), we recommend that counting of the full amount of renewable energy could be done using measurements at dedicated charging/feeding points for Step 1. The Member States could use metering at charging points that meet pre-defined criteria. The volume of electricity or methane supplied at non-authorised charging/filling points (i.e. those without site-specific metering) is then not counted. For electricity consumption by railways, trams, metros and trolley buses, this type of measurement is already the *modus operandi*. As an intermediate step for road transport, estimates may be used, based on a monitoring of the number of cars, and average yearly energy consumption per car (average kilometres/year multiplied by final energy consumption/km).

For Step 2, we recommend the use of the national production mix for the assessment of the amount of renewable electricity and methane.

For the longer term (> 2020), more sophisticated techniques will become common. To deal with private small scale charging/filling options, metering at the vehicle, instead of at the feeding point, is necessary, unless most of these points will be separately metered within a metering/billing cycle. For Step 2, a contract-based approach is currently costly, risky, runs into privacy issues and leads to potential double-counting problems, but it serves as a driver for the use of renewable energy in transport, and is exactly the approach that the utilities are already experimenting with. It is likely to be linked to the emergence of the smart-charging model (smart tariffs), and is already supported by many of the national authorities in their submissions to the consultation.

For electricity and methane, unless every EV/CNG vehicle driver is on a green contract, a mix of the country grid factor (default approach) and the specific production mix in the green contracts seems inevitable. This raises double counting issues, and the question of additionality with respect to imports (also raised in some of the submissions). We suggest the Commission to consider giving Member States the option of adopting a mixed approach if they wish to, but with rules for ensuring correction for double counting if they want to take this approach. Also, one might consider introducing sector-specific conditions in order to (separately) keep track of the contribution of railways to the RED target, if necessary.

For hydrogen, we recommend the use of the national mix (and biomass sustainability criteria, where applicable) for Step 1, and measurement at the feeding point for Step 2. For the longer term, we recommend to switch to specific energy contract information at Step 1 in the cases where hydrogen is produced from electricity or methane.

In order to ensure a level-playing field (technology openness) among innovative drive-train options, we further recommend to apply a factor of 1.5 for hydrogen fuel cell vehicles (FCEVs). This factor takes into account the higher efficiency of the fuel cell electric vehicles (FCEVs) compared to internal combustion engines (ICE), and their lower efficiency compared to battery electric vehicles (BEVs, factor 2.5 according to RED Article 3, Paragraph 4, Point C).





Table 17 Overview of the conclusion on the methods

Electricity	< 2020	> 2020 (subject to review in 2014)
Step 1 Energy input into vehicle	Feeding point, only when used for metering & billing  For road transport, as intermediate step: use of estimates	Vehicle (because of home charging without dedicated meter)
Step 2 Assessment amount of renewables	National mix	Contract (both feeding point and vehicle)
<b>Methane</b>		
Step 1 Energy input into vehicle	Feeding point or estimates (road transport)	Feeding point (unless home filling becomes dominant)
Step 2 Assessment amount of renewables	National mix	Contract
<b>Hydrogen (NB: small contribution on short term)</b>		
Step 1 Percentage of renewables in hydrogen production process	National mix (electricity and methane); Sustainability criteria (biomass)	Contract
Step 2 Volume of hydrogen used for transport	Feeding point or estimates (road transport)	Feeding point

Finally, we make the recommendation to review the RED in 2014, to see whether the actual pace of market developments suggests that solutions seen today as being appropriate for the longer term (> 2020) need to be brought forward (or not).





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# Abbreviations and acronyms

BEV	Battery electric vehicle
CGH <sub>2</sub>	Compressed Gas hydrogen
CH <sub>4</sub>	(Bio)methane
CNG	Compressed Natural Gas
CSP	Concentrated Solar Power
EC	European Commission
ETS	Emissions Trading Scheme
ETS EUA	Emission allowance within the ETS
EU	European Union
EV	Electric Vehicle
FCEV	Fuel Cell powered electric vehicle
FO	Fleet owner
FQD	Fuel Quality Directive
H <sub>2</sub>	Hydrogen (H <sub>2</sub> )
HVO	Hydrotreated Vegetable Oil
ICE	Internal combustion engine
ktoe	Kilotonne of oil equivalent
LH <sub>2</sub>	Liquefied hydrogen
LNG	Liquefied Natural Gas
MS	Member State
NGO	Non-governmental organisation
NREAP	National Renewable Energy Action Plan
PHEV	Plug-in hybrid vehicles
PV	Photovoltaics
R&D	Research and development
RE	Renewable Energy
RED	Renewable Energy Directive
TWh	TeraWatt-hour (=1.000.000.000 kWh; kiloWatt-hour)
V2G	Vehicle-to-grid





# Annex A Renewable energy incentives in the EU Member States

Each Member State is represented by its country code along the far left column<sup>53</sup>. Action is differentiated across policy types (columns) and technologies supported (within each cell). The key below each table identifies the technologies by their abbreviations. For ease of presentation, the overview is provided separately for each of the three broad sectors - electricity generation, heating and cooling and transport.

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<sup>53</sup> <http://publications.europa.eu/code/en/en-370100.htm>



**Table 18 Promotion measures employed by MS and RE types promoted. Electricity Generation sector**

ELECTRICITY GENERATION

Country	Quota System	Feed-in Tariffs	Tax Allowances	Tendering Models	Grants	Soft Loans	Regulations	Information	R & D
	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted
AT		Wi-So-Ge-Bg-Bm-Hy	Wi-So-Ge-Bg-Bm-Bf-Hy-Co		Wi-So-Hy		Wi-So-Ge-Bg-Bm-Hy	Wi-So-Ge-Bg-Bm-Bf-Hy-Co	Wi-So-Bm-Hy
BE	Wi-So-Ge-Bg-Bm-Hy		Wi-So-Ge-Bg-Bm-Bf-Hy-Co		Wi-So-Ge-Bg-Bm-Bf-Hy-Co		Wi-So-Ge-Bg-Bm-Bf-Hy-Co	Wi-So-Ge-Bg-Bm-Bf-Hy-Co	Wi-So-Ge-Bg-Bm-Bf-Hy-Co
BG		Wi-So-Ge-Bg-Bm-Hy							
CY		Wi-So-Bg-Bm			So-Wi-Hy				
CZ		Wi-So-Ge-Bg-Bm-Hy	Wi-So-Ge-Bg-Bm-Hy		Wi-So-Ge-Bg-Bm-Hy	Wi-So-Ge-Bg-Bm-Hy			
DK		Wi-So-Ge-Bg-Bm-Hy			So-Hy	Wi			
EE		Wi-So-Ge-Bg-Bm-Hy							
FI		Bm	Bg-Bm-Hy		Wi-So-Ge-Bg-Bm-Hy	Bm		Bm	Bm
FR		Wi-So-Ge-Bg-Bm-Hy	Wi-So-Bm-Hy	Wi-So-Ge-Bg-Bm-Hy			Co		
DE		Wi-So-Ge-Bg-Bm-Hy			Ge-Bm	Ge-Bm			Ge-Bm
EL		Wi-So-Ge-Bg-Bm-Hy			Wi-So-Ge-Bg-Bm-Hy		So		
HU		Wi-So-Ge-Bg-Bm-Hy				Bm-Co			
IE		Wi-Bg-Bm-Hy							

Key: Wi = Wind Energy; So = Solar Energy; Ge = Geothermal Energy; Bg= Biogas; Bm = Biomass; Bf = Biofuel; Hy = Hydropower; Co = Combined heat and power

ELECTRICITY GENERATION (cont'd.)

Country	Quota System	Feed-in Tariffs	Tax Allowances	Tendering Models	Grants	Soft Loans	Regulations	Information	R & D
	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted
IT	Wi-So-Ge-Bg-Bm-Hy		Wi-So-Ge-Bg-Bm-Hy				Wi-So-Ge-Bg-Bm-Hy		
LV		Wi-Bg-Bm-Hy		Wi-So-Ge-Bg-Bm-Hy					
LT		Wi-So-Bg-Bm-Hy			Wi-So-Ge-Bg-Bm-Hy				
LU		Wi-So-Bg-Bm-Hy	So		Wi-So-Ge-Bg-Bm-Hy				
MT		So			Wi-So				
NL		Wi-So-Bg-Bm	Wi-So-Ge-Bg-Bm-Hy						Wi-So-Ge-Bg-Bm-Hy
PL	Wi-So-Ge-Bg-Bm-Hy		Wi-So-Ge-Bg-Bm-Hy			Wi-So-Ge-Bg-Bm-Hy			
PT		Wi-So-Ge-Bg-Bm-Hy	Wi-So-Ge-Bg-Bm-Hy						
RO	Wi-So-Ge-Bg-Bm-Hy								
SI		Wi-So-Ge-Bg-Bm-Hy			Wi-So-Ge-Bg-Bm-Hy	Wi-So-Ge-Bg-Bm-Hy			
SK		Wi-So-Ge-Bg-Bm-Hy	Wi-So-Ge-Bg-Bm-Hy		Wi-So-Ge-Bg-Bm-Hy				
ES		Wi-So-Ge-Bg-Bm-Hy	Wi-So-Ge-Bg-Bm-Hy						
SE	Wi-So-Ge-Bg-Bm-Hy		Wi		So				Wi
UK	Wi-So-Ge-Bg-Bm-Hy		Wi-So-Ge-Bg-Bm-Hy		Wi-So-Ge-Bg-Bm-Hy				Wi-So-Ge-Bg-Bm-Hy

Key: Wi = Wind Energy; So = Solar Energy; Ge = Geothermal Energy; Bg= Biogas; Bm = Biomass; Bf = Biofuel; Hy = Hydropower; Co = Combined heat and power

Source: Renewable Promotion measures employed by MS and RE types promoted. Electricity Generation Sector. Based on IEA, Global Renewable Energy Policies and Measures Database, available on the internet at < <http://www.iea.org/textbase/pm/?mode=re>> and RES LEGAL, Legislation on Renewable Energy Generation Database, available on the internet at <<http://res-legal.eu/en.html>> and L. Pelkmans et al., Inventory of biofuel policy measures and their impact on the market, September 2008.



**Table 19 Promotion measures employed by MS and RE type promoted. Heating & Cooling Sector**

HEATING & COOLING

Country	Quota System	Feed-in Tariffs	Tax Allowances	Tendering Models	Grants	Soft Loans	Regulations	Information	R & D
	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered
AT					So-Ge-Bm-Co		So-Ge-Bg-Bm-Co	So-Ge-Bg-Bm-Bf-Co	So-Bg-Bm
BE			So-Ge-Bg-Bm-Bf-Co		So-Ge-Bg-Bm-Bf-Co		So-Ge-Bg-Bm-Bf-Co	So-Ge-Bg-Bm-Bf-Co	So-Ge-Bg-Bm-Bf-Co
BG									
CY									
CZ					So-Bm		So-Ge-Bg-Bm-Bf-Co		
DK							So-Ge-Bg-Bm-Bf-Co		
EE									
FI					Bm	Bm		Bm	Bm
FR							Co		So-Ge-Bg-Bm-Bf-Co
DE				Co	So-Ge-Bg-Bm	So-Ge-Bg-Bm	So-Ge-Bg-Bm-Co		So-Ge-Bm
EL		Co					Co		
HU						Bm-Co			
IE					So-Ge-Bm				

Key: So = Solar Energy; Ge = Geothermal Energy; Bg= Biogas; Bm = Biomass; Bf = Biofuel; Co = Combined heat and power

HEATING & COOLING (cont'd.)

Country	Quota System	Feed-in Tariffs	Tax Allowances	Tendering Models	Grants	Soft Loans	Regulations	Information	R & D
	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered
IT									
LV									
LT									
LU				Co			Co		
MT									
NL			So-Ge-Bg-Bm-Bf-Co						
PL									
PT					So	So			
RO									
SI									
SK					So-Bm				
ES									
SE					So-Ge-Bm		Bm	Bm	
UK			Bm		Bm-Co				

Key: So = Solar Energy; Ge = Geothermal Energy; Bg= Biogas; Bm = Biomass; Bf = Biofuel; Co = Combined heat and power

Source: Renewable Promotion measures employed by MS and RE types promoted. Heating & Cooling Sector. Based on IEA, Global Renewable Energy Policies and Measures Database, available on the internet at < <http://www.iea.org/textbase/pm/?mode=re> > and RES LEGAL, Legislation on Renewable Energy Generation Database, available on the internet at <<http://res-legal.eu/en.html>> and L. Pelkmans et al., Inventory of biofuel policy measures and their impact on the market, September 2008.



**Table 20 Promotion measures employed by MS and RE types promoted. Transport Sector**

TRANSPORT

Country	Quota System	Feed-in Tariffs	Tax Allowances	Tendering Models	Grants	Soft Loans	Regulations	Information	R & D
	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered
AT	Bf		Bg-Bf				Bg-Bf	Bg-Bf	Bg-Bf
BE	Bf		Bg-Bf		Bg-Bf		Bg-Bf	Bg-Bf	Bg-Bf
BG	Bf		Bf					Bf	
CY	Bf							Bf	
CZ			Bf				Bf		
DK	Bf		Bf						Bf
EE			Bf		Bf				Bf
FI					Bf		Bf		
FR			Bf						Bg-Bf
DE	Bf		Bf						
EL			Bf						
HU	Bf		Bf						
IE			Bf						

TRANSPORT (cont'd)

Country	Quota System	Feed-in Tariffs	Tax Allowances	Tendering Models	Grants	Soft Loans	Regulations	Information	R & D
	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered
IT	Bf		Bf						
LV									
LT			Bf						
LU	Bf		Bf		Bf		Bf		
MT	Bf								
NL	Bf		Bf						
PL	Bf		Bf						
PT	Bf		Bf				Bf		
RO	Bf				Bf				
SI	Bf		Bf				Bf		
SK	Bf		Bf						
ES	Bf		Bf		Bf		Bf	Bf	Bf
SE	Bf		Bf				Bf		
UK	Bg-Bf		Bf						

Key: Bg= Biogas; Bf = Biofuel

Source: Renewable Promotion measures employed by MS and RE types promoted. Transport Sector. Based on IEA, Global Renewable Energy Policies and Measures Database, available on the internet at < <http://www.iea.org/textbase/pm/?mode=re>>; RES LEGAL, Legislation on Renewable Energy Generation Database, available on the internet at <http://res-legal.eu/en.html>; L. Pelkmans et al., Inventory of biofuel policy measures and their impact on the market, September 2008; National Renewable Energy Action Plans available at [http://ec.europa.eu/energy/renewables/transparency\\_platform/action\\_plan\\_en.htm](http://ec.europa.eu/energy/renewables/transparency_platform/action_plan_en.htm).



# Annex B Responses to the public consultation

Organisation	Country	Section			
		A	B	C	D
<b>National Authorities</b>					
Danish Energy Agency	Denmark	x	x	x	x
German Ministry for the Environment	Germany	x	x	x	x
Netherlands Ministry of Infrastructure and Environment	Netherlands	x	x	x	x
Sweden Ministry of Enterprise, Energy and Communications	Sweden	x		x	x
United Kingdom Department for Transport	UK	x	x	x	x
<b>Companies</b>					
AGRARplus	Austria	x	x	x	x
APAG (CEFIC-APAG)	Belgium	x		x	x
APPA Biocarburantes	Spain	x	x	x	x
Better Place	Denmark	x			
BioMCN	Netherlands			x	x
CHOREN Industries	Germany		x		x
Diester Industrie	France	x	x	x	x
edp (Energias de Portugal)	Portugal	x			
ENI	Italy				x
IFPEN (IFP Energies nouvelles)	France		x		x
INEOS	France	x		x	x
Neste Oil Corporation	Finland				x
Rossi Biofuel	Hungary			x	x
Scania	Belgium	x	x	x	x
Shell	Netherlands	x	x	x	x
TOTAL	France	x	x	x	x
<b>Associations</b>					
Austrian Federal Economic Chamber	Austria	x	x	x	x
Association of the German Biofuel Industry (VDB)	Germany	x	x	x	x
Bundesverband Erneuerbare Energien (BEE)	Germany	x	x	x	x
Central Europe Energy Partners (CEEP)	Belgium	x	x	x	x
Community of EU Railway & Infrastructure Companies (CER)	Belgium	x			
ePURE - European Renewable Ethanol	Belgium	x	x	x	
ESTERIFRANCE (biodiesel producers group)	France	x	x	x	x
EU Biodiesel Board (EBB)	Belgium	x	x	x	x
EU Biofuels Technology Platform (EBTP)	Germany	x		x	x
EU Fuels Oxygenates Assoc. (EFOA)	Belgium				x
EU Hydrogen Association, EHA	Belgium		x		
EU Petroleum Assoc. (EUROPIA)	Belgium	x	x	x	x
Natural & Bio Gas vehicle Assoc. (NGVA)	Spain	x	x	x	
New Energy World Industry Grouping (NEW-IG)	Belgium		x		
SNPAA (Asoc. bioethanol producers, France)	France	x	x	x	
Société Nord Ester	France	x		x	x
<b>Other</b>					
TU Berlin/Mr. Creuzig	Germany	x	x		
Transport & Environment (T&E)	Belgium	x	x	x	x
Total number of responses to each section		30	26	28	30







# Annex C Number of energy utilities

## C.1 Number of energy utilities per Member State

For the calculation of administrative costs, the number of energy retailers in each Member State of the EU 27 is one of the input parameters. In Table 21, this number is given for natural gas retailers and electricity retailers respectively.

The numbers add up to a total of 2,800 (electricity) for the EU 27 as a whole, of which 1,000 in Germany, and with an average of roughly 100 per Member State. Most of these are small retailers with market share <5%. There are also large differences between the Member States.

Most of the retailers who sell gas also sell electricity. Only the large companies sell in more than one Member State. Some of the small companies are in fact owned by the large retailers, but for the question of administrative costs that does not make a difference, since these companies have their own separate customers administration.

Table 21 Number of energy retailers per Member State, for gas and electricity (2009 data)

Member State EU 27	# Gas retailers (Eurostat data)	For calculation of total	# Electricity retailers (Eurostat data)	For calculation of total
Austria	>30	31	>140	141
Belgium	41	41	34	34
Bulgaria	18	18	17	17
Cyprus	0	0	1	1
Czech Republic	18	18	281	281
Denmark	13	13	33	33
Estonia	27	27	40	40
Finland	25	25	>100	125
France	36	36	177	177
Germany	820	820	>1,000	1,000
Greece	4	4	3	3
Hungary	26	26	35	35
Ireland	8	8	9	9
Italy	295	295	360	360
Latvia	1	1	4	4
Lithuania	6	6	9	9
Luxembourg	7	7	11	11
Malta	0	0	1	1
Netherlands	24	24	32	32
Poland	52	52	150	150
Portugal	15	15	6	6
Romania	56	56	47	47
Slovakia	10	10	67	67
Slovenia	19	19	17	17
Spain	28	28	142	142
Sweden	6	6	75	75
United Kingdom	17	17	21	21



Member State EU 27	# Gas retailers (Eurostat data)	For calculation of total	# Electricity retailers (Eurostat data)	For calculation of total
<b>TOTAL</b>		<b>1,603</b>		<b>2,838</b>
<b>Average (= Total/27)</b>		<b>59</b>		<b>105</b>

NB: Eurostat does not give an exact number for each Member State, see e.g. Germany. In the next column, the number is given that is used for calculation of the average; for Germany that number is based on other market data.

Sources:

Gas:

[http://epp.eurostat.ec.europa.eu/statistics\\_explained/index.php/Natural\\_gas\\_market\\_indicators](http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Natural_gas_market_indicators) (see Table 4 in that report).

Electricity:

[http://epp.eurostat.ec.europa.eu/statistics\\_explained/index.php/Electricity\\_market\\_indicators](http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Electricity_market_indicators) (see Table 5 in that report).

For comparison, in Table 22 the number of large retailers (with a market share larger than 5%) is given, per Member State. The total is about 100 (with an average of 4 per Member State), and most of these companies sell both electricity and gas. Most of them are active in more than one Member State, but underlying data was not available in the Eurostat public database.

The question of administrative costs potentially affects all energy retailers, not only the big ones. For very small companies, the administrative labour takes less time than for the large companies, but is not negligible.

Table 22 Number of main energy retailers per Member State (market share >5%), for gas and electricity (2009 data)

Member State EU 27	Number of main gas retailers	Number of main electricity retailers
Austria	4	6
Belgium	5	3
Bulgaria	2	5
Cyprus	0	1
Czech Republic	3	3
Denmark	5	8
Estonia	1	1
Finland	1	3
France	2	1
Germany	3	3
Greece	3	1
Hungary	9	8
Ireland	3	5
Italy	5	2
Latvia	1	1
Lithuania	1	2
Luxembourg	5	4
Malta	0	1
Netherlands	3	4
Poland	1	7
Portugal	5	2
Romania	6	8
Slovakia	2	6



Member State EU 27	Number of main gas retailers	Number of main electricity retailers
Slovenia	3	7
Spain	6	3
Sweden	6	3
United Kingdom	8	6
<b>TOTAL</b>	<b>93</b>	<b>104</b>
<b>Average (= Total/27)</b>	<b>3</b>	<b>4</b>

NB: The number for Denmark is from 2006, Eurostat does not give this number for 2009.

Sources:

Gas:

[http://epp.eurostat.ec.europa.eu/statistics\\_explained/index.php/Natural\\_gas\\_market\\_indicators](http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Natural_gas_market_indicators)  
(see Table 5 in that report).

Electricity:

[http://epp.eurostat.ec.europa.eu/statistics\\_explained/index.php/Electricity\\_market\\_indicators](http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Electricity_market_indicators)  
(see Table 6 in that report).

It can be seen in Table 21 that the number of energy retail companies in Germany (more than 1.000) is clearly larger than in the other Member States. Part of these companies are the so-called 'Stadtwerke', another part are relatively small companies that only sell 'green energy'.

Because this large number of companies has effect on the administrative costs of various policy options described in this report, the number of small 'green energy' companies in Germany was investigated further, using other market reports. Different market reports were found to state different numbers, depending on the market definitions used. Verivox (2011) mentioned 121 green electricity suppliers in Germany, i.e. more than 10% of the total number of suppliers. The number comprises 'independent' as well as 'dependent' suppliers. Verivox hesitates to make a distinction here as many companies - directly or indirectly - belong to established players (producers, traders, ...). Another market report from ATKearney (2011) states that there were some 13 independent green electricity suppliers in Germany in 2010 (for example Lichtblick, Naturstrom, Schönau, Greenpeace, etc.). In addition, the term 'green' is difficult to capture. There are many 'shades of green' (new/existing capacity, power or energy balance, imports, etc.) as can be seen from the several green electricity labels available in Germany.

