

EU 2030 Road Transport Decarbonisation Scenario Analysis

E4tech - Long report

UNICA

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Background

This study aims to inform the debate over long term EU road transport sector decarbonisation policy

Context

The EU 2030 Energy and Climate Package suggests a 40% EU GHG emissions reduction target in 2030 (compared to 1990) but no specific transport sector target (European Council, 2014)

Implication

Government, vehicle and fuel industry uncertainty over actions needed to decarbonise road transport in the absence of EU-wide sector target

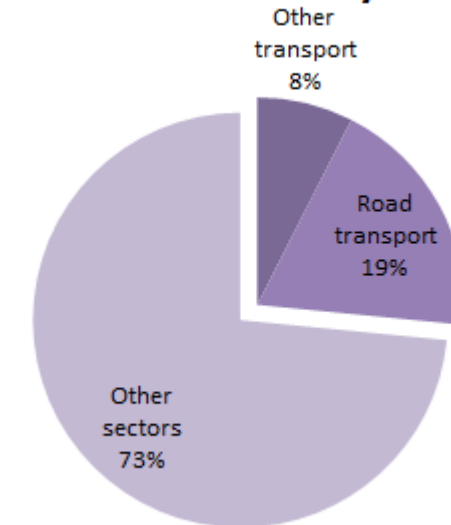
Study objective

To understand road transport decarbonisation under different scenarios to inform policy development

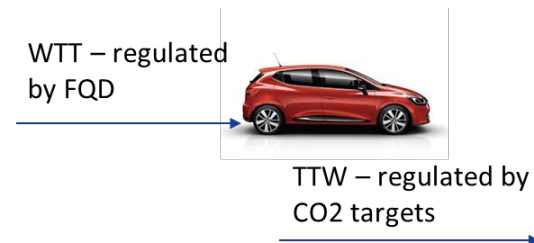
Beyond 2020 currently expected policies focus on vehicle TTW emissions....

- Tank to wheels (TTW) emissions from road transport represent around 19% of total EU emissions in 2010 and is the fastest growing source of EU emissions according to the new carbon inventory report by the EEA (EEA, 2014). Tackling road transport emissions is therefore essential to accomplishing the 60% reduction in GHG from transport by 2050 (EC, 2011).
- The Fuel Quality Directive (FQD), Renewable Energy Directive (RED) and vehicle CO₂ targets are the main drivers of EU road transport sector decarbonisation to 2020. These include the following targets:
 - *FQD target*: 6% reduction in the GHG emission intensity of fuels by 2020 compared to 2010 baseline (Directive 2009/30/EC).
 - *RED target*: 10% renewable energy share of transport fuel consumption by 2020 (Directive 2009/28/EC).
 - *Vehicle CO₂ targets*: 95 gCO₂/km for new vehicle sales in 2021 compared to 130 gCO₂/km in 2015 (Regulation (EU) 333/2014).
- At present, beyond 2020 the only expected policy is vehicle CO₂ targets (TTW); the current EC proposal suggests that the specific targets of the FQD and RED would be discarded post 2020.

EU CO₂ emissions by sector

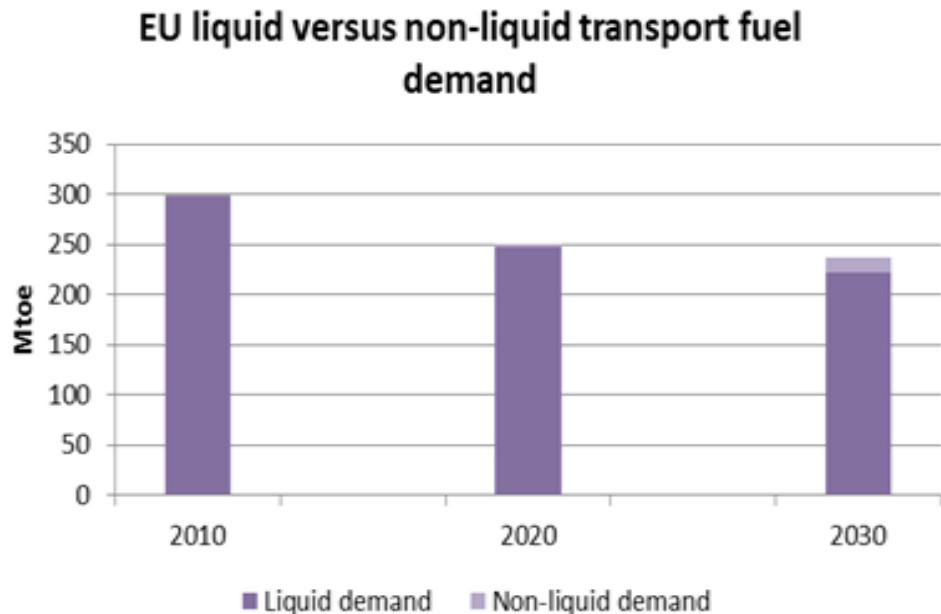


Source: E4tech internal based on EEA (2009)



...but energy dense liquid fuels will continue to play a significant role, so biofuels will remain relevant

- In 2010 total energy demand for road transport was 299 Mtoe, of which liquid fuels contributed 298 Mtoe. The demand for liquid fuels is expected to decrease to 246 Mtoe in 2020, and 221 Mtoe in 2030. Despite a significant decrease in road transport fuel use, 236 Mtoe in 2030, liquid fuels will still contribute to 93% of total road transport demand
- Biofuels could then continue to play a relevant role in the decarbonisation of liquid fuels. The extent of this role will, however, depend on policy.
- The key factors influencing energy demand are transport activity and vehicle efficiency targets. A reduction in transport activity post the 2008 economic crisis, coupled with efficiency gains induced by the vehicle GHG emissions targets, could lead to a significant reduction in energy consumption, especially to 2020.



Source: E4tech internal based on E4tech, 2013

Approach

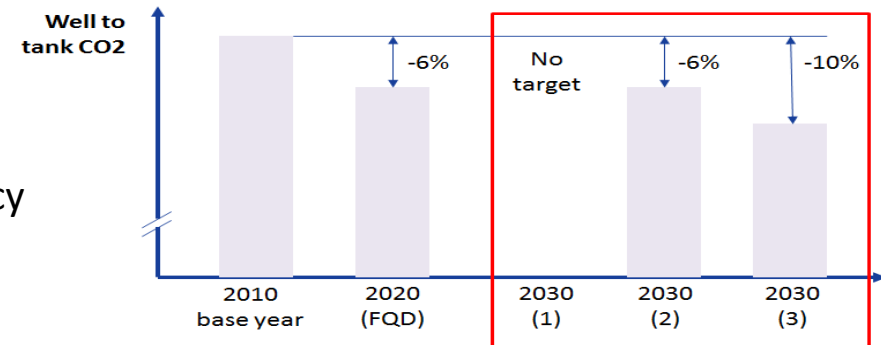
Three variations of an 'FQD' were modelled post-2020 to understand the implications of different policy scenarios

We set out to understand:

- GHG reduction in road transport to 2030.
- Relative role of reduction options in 2030 and their long-term implications for decarbonisation and policy making.

Therefore:

- FQD chosen as focused on GHG reduction.
- We focused on the mandatory 6% target which according to Article 7a of the FQD is likely to be met through the use of biofuels, electricity and a reduction in upstream flaring and venting (F&V). Additional 2%+2% target through CCS and CDM credits was not considered (EC, 2014).
- To get a full picture of WTW GHG emissions reduction options we included the net reduction in energy demand across the vehicle fleet (impacted by vehicle CO₂ targets and changes in transport activity).
- We assumed that member states will aim to meet 2020 targets
- Biofuel supply restricted by the minimum GHG savings threshold (50% and 60% GHG savings).



Scenario 1: No FQD target – FQD target scrapped after 2020.

Scenario 2: 6% FQD target – continuation of 2020 target to 2030

Scenario 3: FQD target increases to 10% by 2030.

Options considered

- Biofuels
- Other alternative fuels including electricity
- Reduced upstream flaring/venting
- Fuel efficiency

Other assumptions: ILUC factors not considered; new FQD fossil reference value used (EC, 2014); only road transport vehicles are considered; 7% cap food crop based biofuels

E4tech's EU Auto-Fuel model forms the basis for this projection, combining a biofuel supply potential model.....

- The modelling is based on the EU Auto-Fuel model (E4tech, 2013) that combines a biofuel supply potential model and a vehicle fleet biofuel uptake model to project the future growth of biofuels in the EU road transport sector. The focus of the model is on liquid fuels, but both electric and gaseous vehicles uptake is also modelled.
- The biofuel supply potential to the EU in 2020 and 2030 is based on 1G and 2G biofuels*, taking into consideration a range of factors that affect availability and mix, including RED GHG thresholds and broader environmental constraints (E4tech, 2013).
 - 1G biofuels* availability is determined by crop expansion rates (taking into consideration environmental constraints), achievable yield increases, food/feed demand, and competition for biofuels from different markets.
 - 2G biofuels* availability is determined by the plant built-rate in the period to 2030.
 - GHG emission factors are based on the Renewable Energy Directive (RED) typical values (Directive 2009/28/EC) and are assumed to improve by 1-2% p.a.
- The model calculates biofuel production costs, to establish a cost merit order. Biofuels are assumed to be more expensive than fossil fuels and import duties are excluded.
- The supply potential is influenced by five key parameters that can be varied in the supply model: 2G build rate, feedstock yields, competing demands, environmental constraints and export capacity to Europe

* 1G biofuels are produced from conventional crops or waste oils and fats

2G biofuels are produced from waste streams such as MSW, residues, or lignocellulosic materials, energy crops, microbial oils and macroalgae (E4tech, 2013)

....and a vehicle fleet model to estimate the biofuel uptake potential in the EU market

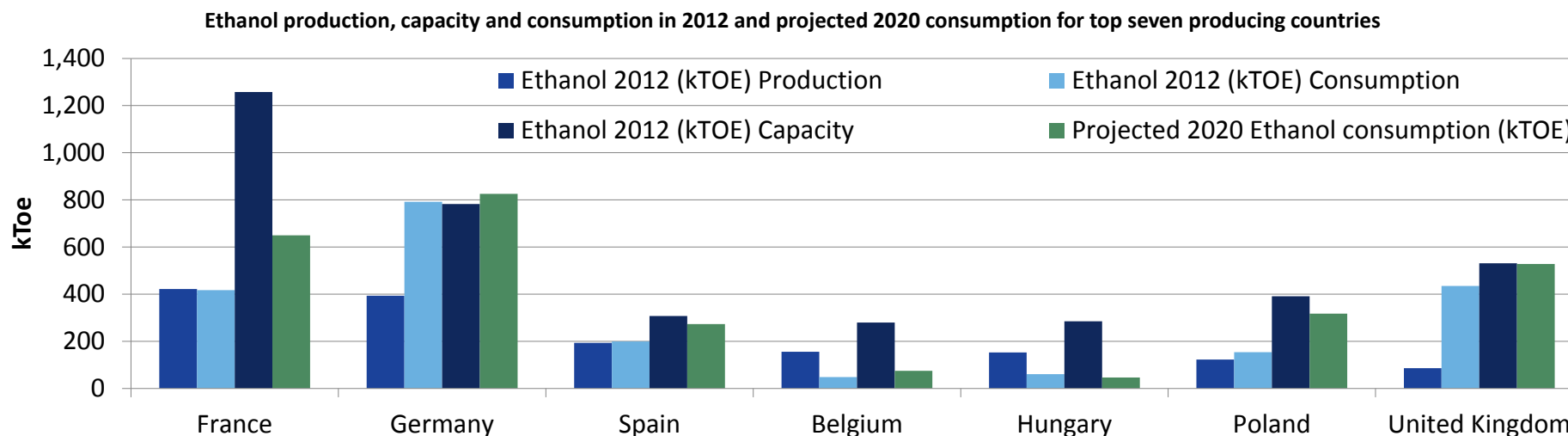
- The vehicle fleet model projects the evolution of the vehicle fleet (passenger cars, light duty vehicles and heavy duty vehicles) to 2030, the associated road transport energy demand, the maximum biofuel uptake capacity based on blend walls of different vehicle types, and a typical biofuel uptake potential considering biofuel availability at forecourts and predicted consumer behaviour (E4tech, 2013).
- The key factors influencing the total energy demand and biofuel uptake potential are changes in transport activity, sales rates of alternative fuel vehicles, new vehicle efficiency targets and the introduction date of higher biofuel blends.
 - The uptake modelling considers modal shifts because the underlying transport activity data considers this
 - As the focus of this study was to understand the biofuel supply potential, the central scenario from the EU Auto-Fuel study uptake model was selected and the uptake values were kept constant for all three 'FQD' scenarios
 - The projection of EV penetration assumes 50% of the IEA Blue Map sales targets, based on industry consultation in the EU Auto-Fuel Roadmap study (OECD/IEA, 2010).
 - TTW emission factors have been updated for fossil fuels with the values from the European Commission's October 2014 proposal (EC, 2014), and for electricity with the latest IEA data and projections from the EC Impact Assessment (EC, 2011a; IEA, 2012).
 - The following efficiency targets were used for new vehicle sales: 98gCO₂/km for PC in 2020, 67gCO₂/km in 2030*, 147gCO₂/km for LDV in 2020, 117gCO₂/km in 2030, 662gCO₂/km for HDV in 2020 and 585gCO₂/km in 2030 (E4tech, 2013a). We accounted for the emission difference between test and real driving. This discrepancy is not fixed across the fleet and increases with increasing test efficiency. In 2020 the discrepancy of new PCs is 34% (EC, 2012) and the assumed discrepancy of the PC fleet in 2030 is 44%.

The model has been adapted for this study to account for the focus on the FQD target and the new food crop based biofuel cap

- In both scenario 2 (6% FQD) and scenario 3 (10% FQD) the biofuel contribution was limited to satisfying the 6% and 10% GHG emission savings target (including flaring & venting and EV emission savings), and assumes that no over-compliance would occur
- The 7% cap on food and feed crop based biofuels as currently suggested by the European Council was considered as an additional constraint on the biofuel contribution (European Biofuels Technology Platform, 2014)
- 2G biofuels were prioritised in the 10% FQD scenario, assuming strong policy support

Scenarios

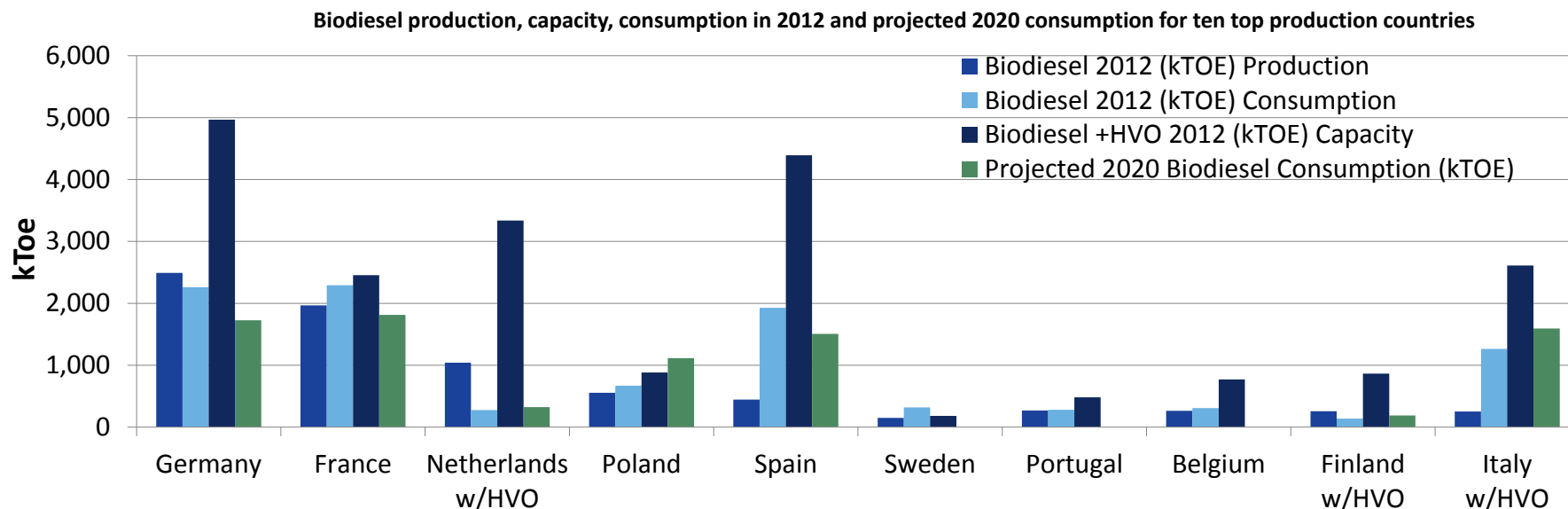
Scenario 1: No transport sector GHG reduction target post 2020 but some MS maintain ethanol consumption at 2020 levels



Source: E4tech internal based on E4tech, 2013; EBB, 2014; ePure, 2014; Eurostat, 2014; UPMBiofuels, 2014; ENI, 2010; UFOP, 2013

- Larger EU producers assumed to maintain consumption of biofuels at 2020 levels for industrial and agricultural reasons, and because of the existing contribution to GHG emissions reduction targets
- The seven largest **bioethanol** producers are assumed to maintain constant consumption at forecast 2020 levels - **2.7Mtoe**. This represents a decrease by 1.2Mtoe from **3.9 Mtoe** from EU consumption levels up to 2020 (E4tech, 2013), as other countries are assumed to reduce consumption and production without a transport sub-target.
- 2.7 Mtoe represents a 0.3 Mtoe increase from 2012 consumption levels.
- Imports in some main producer countries could be required creating a continued export market for other countries with excess production such as Hungary.

Scenario 1: ... and a similar logic for biodiesel



Source: E4tech internal based on E4tech, 2013; EBB, 2014; ePure, 2014; Eurostat, 2014; UPMBiofuels, 2014; ENI, 2010; UFOP, 2013

- Applying a similar logic for **biodiesel** as for ethanol: France, Germany, Poland, Netherlands, Finland, Spain and Italy would maintain consumption at 2020 levels of **8.3 Mtoe**. This represents a drop from 2012 consumption levels of **9.7 Mtoe**, and from forecast 2020 levels of **11 Mtoe** (E4tech, 2013).
- As with ethanol some countries may require imports to maintain consumption levels, e.g. Italy, creating a potential export market for those countries with excess production.
- Finland and Italy were assumed to maintain their consumption levels due to a high existing capacity and a focus on HVO

Scenario 2: The current transport sector GHG target of 6% would be prolonged at the same level to 2030

- In the 2nd scenario we assumed that the current FQD target of 6% in 2020 would be continued to 2030 at the same level.
- Compliance beyond the 6% target is very unlikely. Therefore, we capped the total supply and uptake of biofuels at a 6% GHG emission contribution, including the reductions achieved via Flaring & Venting (F&V) and electric vehicles (EVs) as it was assumed that these would occur first.
 - This leads to a maximum biofuel contribution of 4.6% GHG emission savings in 2030.
 - Under the 4.6% GHG emission contribution cap, biofuel chains were selected on a cost-merit order basis. Consequently, ethanol chains are prioritised over biodiesel chains.
- Given that a 6% target (including F&V and EVs) would almost be achieved in 2020, a continuation of this target would not provide sufficient incentive nor investment security for 2G. 2G chains are thus also selected on cost-merit order and not prioritised.
- Medium values (out of low-medium-high) have been used for all five supply parameters: 2G built rate, Feedstock yields, competing demands, environmental constraints and export capacity to Europe.

Scenario 3: The transport sector GHG target of 6% would be increased to 10% by 2030 and 2G biofuels prioritised

- In the 3rd scenario the current FQD target of 6% in 2020 is increased to 10% by 2030
- Compliance beyond the 10% target is very unlikely. Therefore, we capped the total supply and uptake of biofuels at a 10% GHG emission contribution, including the reductions achieved via Flaring & Venting (F&V) and electric vehicles (EVs) as it was assumed that these would occur first.
 - This leads to a maximum biofuel contribution of 7.8% GHG emission savings in 2030.
 - Under the 7.8% GHG emission contribution cap, biofuel chains were selected on a cost merit order basis. Consequently, ethanol chains are prioritised over biodiesel chains.
- A 10% target would create a stronger incentive to invest in 2G biofuels, and a specific 2G biofuel target is assumed to be included in the policy. 2G chains are thus prioritised over 1G in the model independent of their costs.
- The following levels have been used for the five supply parameters leading to the most optimistic values among the three scenarios (E4tech, 2013a):
 - 2G built rate: High
 - Feedstock yields: High
 - Competing demands: Low
 - Environmental constraints: Low
 - Export capacity to Europe: High

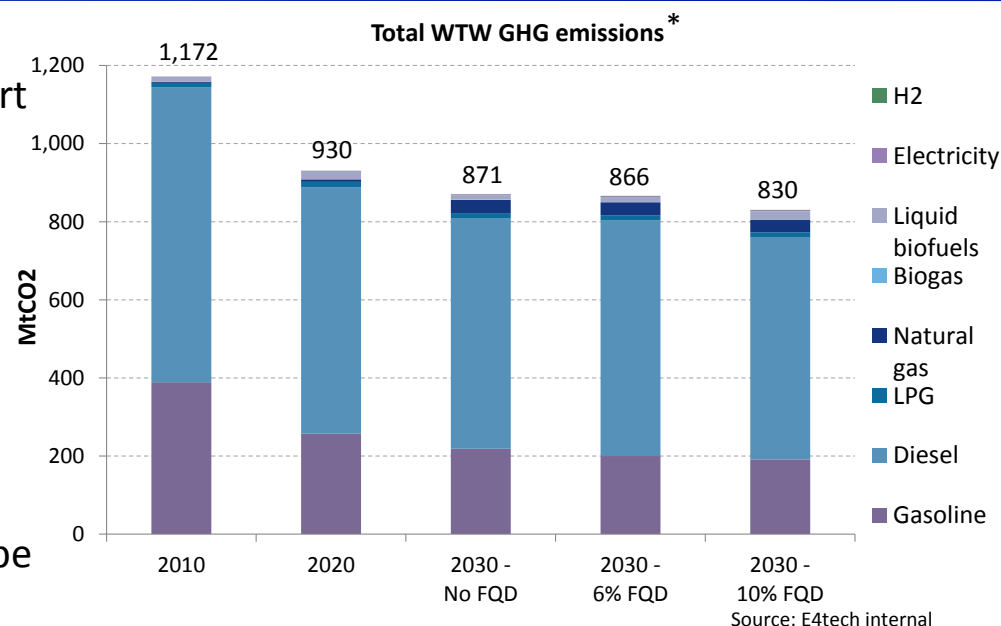
Potential savings through reduced flaring and venting remain very uncertain but could play an important role in meeting the FQD

- As F&V emission reductions count towards the FQD they will likely have an impact on the relative contribution of biofuels and other emission savings options.
- E4tech discussed the UER potential with industry sources and, based on the latest list of CDM/JI projects, concluded that ~9 MtCO₂ savings by 2020 is a conservative, but realistic, estimate assuming 30% of 'registered' and 'for validation' reduction projects reach implementation.
 - Given the uncertainty to 2020, we assumed that in a noFQD and 6%FQD scenario to 2030 no further incentive exists for additional F&V emission reduction projects. However, in a 10%FQD scenario we estimate that the total emission reductions would increase to ~15 MtCO₂ in line with the increased incentive of the higher FQD target.
- However, emission savings potential estimates from F&V vary significantly and the mechanisms how to count them towards the FQD still need to be fully defined
 - A very recent project by the ICCT (ICCT, 2014), commissioned by the European Commission, examines the inclusion of F&V to count towards the mandatory 6% FQD target (as opposed to the optional 2% target only) either by allowing CDM/JI initiatives or creating a new dedicated trading arrangement for carbon credits under the FQD.
 - The range in the ICCT study varies significantly from ~14 – 43 MtCO₂ of emission savings potential by 2020 based on the regulatory options chosen and the assumed carbon price. The study considers the lower part of this range to be the most realistic and the achievable volumes will depend heavily on the proportion of CDM/JI projects that reach implementation.
- The actual number of implemented projects will depend on the policy options chosen for integrating UERs in the FQD, the carbon price and the abatement costs of F&V compared to competing emission reduction options.

Results & Conclusions

Liquid fuels will remain an important source of emissions despite efficiency savings, though many alternatives will also be used by 2030

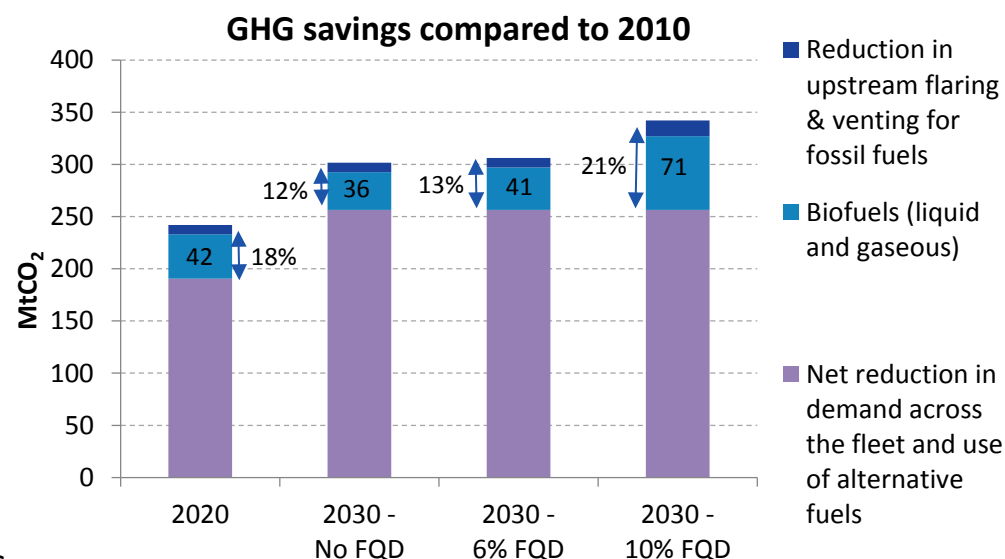
- Total WTW GHG emissions from road transport in the EU are projected to decrease by 242 MtCO₂ from 2010 to 2020, and by 59 to 100 MtCO₂ from 2020 to 2030, mainly due to net reduction in road transport energy demand.
- Emissions will continue to be dominated by diesel and gasoline fuel consumption.
- Total emissions by 2030 vary by 41 MtCO₂ between the 3 scenarios.
- The differences between the 3 scenarios can be explained as follows:



- The energy demand is the same in all 2030 scenarios as the transport modelling assumptions were kept constant, but the composition of biofuels changes: the biofuel consumption is similar in the noFQD and 6%FQD scenario at 10.9 Mtoe and 12.3 Mtoe, but is significantly higher at 21.8 Mtoe in the 10%FQD scenario leading to lower overall emissions in this scenario.
- The similarity of the noFQD and 6%FQD scenario is due to the projection in the noFQD scenario that several countries would maintain biofuels production at 2020 levels post 2020 and in the 6%FQD scenario biofuel supply would be within a 6% GHG emission savings (including F&V and EVs). We assume that over-compliance would not occur. This results in a marginal difference between the two scenarios.
- The 10% FQD scenario has significant volumes of 2G biofuel (~36% of energy demand) whereas in the two other scenarios the contribution of 2G biofuel is marginal as the incentive for investment is too weak.

Overall road transport GHG savings are led by efficiency in all scenarios, but biofuels could contribute up to 21% of savings in 2030

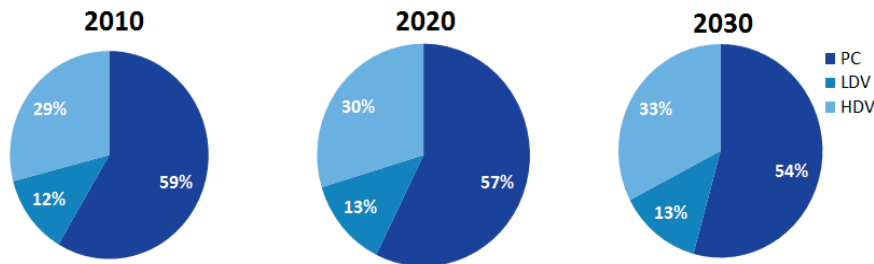
- The net reduction in demand, and to a lesser extent associated electrical energy, together make the most significant contribution to GHG savings in 2020 (82%) and 2030 (79-88%). The absolute savings due to net reduction in demand remain the same in 2030, as the uptake assumption and thus the energy demand is the same.
- Our modelling shows that the share of biofuels contribution to GHG savings decreases from 18% in 2020 to 12% in the noFQD scenario, 13% in 6%FQD and increases to 21% in the 10%FQD scenario.



- The decrease from 2020 to 2030 in the noFQD and 6%FQD scenario is due to the net reduction in demand across the vehicle fleet.
 - The same applies to the 10%FQD scenario, however due a higher target more biofuels, including one third 2G with a lower GHG intensity, will be supplied and taken up by the vehicle fleet.
- Biofuel uptake is limited to 4.6% in the 6%FQD scenario and 7.8% in the 10%FQD scenario due to the contribution from F&V and electric/H₂ vehicles.
- However, the reduction potential from F&V remains uncertain and would allow for higher or lower biofuel uptake (see slide 15).

Electrification makes a growing contribution, but energy dense liquid fuels are likely to be required in the long term

Energy demand by vehicle category



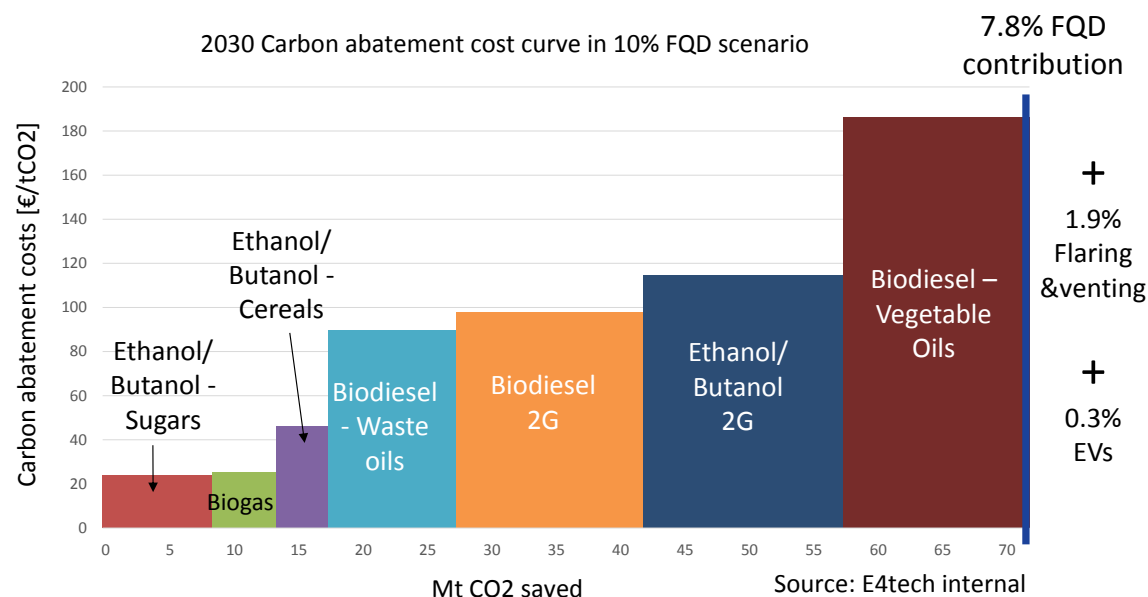
Impact of electric and hydrogen vehicles in Passenger Car and Light Duty Vehicle categories

Share in:	2010	2020	2030
Final energy consumption	0.002%	0.057%	0.904%
WTW CO2 Emissions	0.005%	0.103%	1.096%
Total vehicle km	0.010%	0.238%	3.776%

- Heavy Duty Vehicles will continue to make up $\frac{1}{3}$ of road transport energy demand in 2030.
- Due to weight, range and size of HDVs, electrification is not a realistic option for most of this vehicle category.
- While the share of electric and H₂ PC and LDV mileage increases by a factor 16 from 2020 to 2030 total CO₂ emissions from these vehicles only increases 11 times, due to a quicker decarbonisation of electricity than of liquid fuels.
- Electric and hydrogen PC and LDV may only represent around 4% of total vehicle mileage in 2030. While the share is likely to increase rapidly to 2050, liquid fuels will probably continue to play a role in road transport for decades due to infrastructure transition times and possible limits on the extent of liquid fuel displacement.

A wide range of sustainable 1G and 2G biofuels would be utilised by 2030 in a '10% FQD' scenario

- Marginal abatement cost curves carry several uncertainties, in particular the fossil fuel reference cost, but they do provide an indication of the relative abatement cost of different types of biofuels and other vehicle options.
- 1G Ethanol/Butanol chains could provide the lowest carbon abatement costs, but their GHG saving potential is limited by their uptake in the vehicle fleet.



- 2G biofuels are prioritised in the 10%FQD scenario and due to their lower GHG intensity they would contribute around 30 MtCO₂ savings.
 - Despite the higher capex of 2G biodiesel, its abatement costs are lower than 2G Ethanol / Butanol as it is assumed to have no processing GHG emissions in the RED due to an electricity credit (Directive 2009/28/EC).
- Waste biodiesel provides lower abatement costs due to lower GHG intensity than vegetable oil-based biodiesel; the volume of available vegetable oil biodiesel is constrained by sustainability and high cost.
- The fossil fuel price is based on the current average diesel and gasoline crude prices at the pump (excl. margin and all taxes) across the EU plus refinery production costs (Europe's Energy Portal, 2014): ~15€/GJ for gasoline and ~14€/GJ for diesel

In summary, a higher 'FQD' contributes significantly to GHG savings and maintains biofuels as an option for deep decarbonisation

- Under a 'no FQD' or '6% FQD' scenario to 2030, biofuels could continue to contribute 12-13% of total road transport emission savings in 2030.
- Due to the uptake of additional biofuels to meet the target of a '10% FQD' scenario, in particular 2G biofuels, biofuels could contribute 21% of savings, resulting in an additional 30 MtCO₂ emissions savings compared to a '6% FQD' in 2030.
- A higher FQD target could be achieved by a shift to lower GHG and more sustainable biofuels, with 2G biofuels representing 36% of biofuels in 2030, and the bulk of the growth post 2020.
- This analysis assumes that ~19% of savings in a '10% FQD' scenario are from flaring & venting, but it should be noted that uncertainty over its role could affect the role that biofuels could play.
- Liquid fuels are likely to provide a significant share of road transport energy beyond 2030 because of HDVs and possible limits to full electrification of LDV/PCs.
- Therefore, biofuels could remain an essential component of achieving deep emissions savings in road transport in the longer term, and also be used in other transport sectors e.g. aviation.
- No policy support to 2030, however, would likely mean less biofuels available towards 2050 as the main producing countries gradually phase out production and the investment uncertainty for 2G is too high.
- A higher 'FQD' policy could provide the signal necessary to encourage further road transport emissions reductions beyond efficiency gains and to achieve long-term decarbonisation targets.

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