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PRIVATE CAR TRANSPORT AND THE 10% RES-T TARGET – QUANTIFYING THE CONTRIBUTION OF EVS AND BIOFUELS

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ABSTRACT

In 2008, renewable energy accounted for less than 1% of final energy consumption in the Irish transport sector. In order to increase this share to 10% by 2020 as required under EU directive 2009/28/EC, the Irish government has introduced two specific measures: 10% of the transport fleet is to be powered by electricity by 2020, and an obligation on road transport fuel suppliers that biofuels account for a certain portion of their fuel sales. This study forecasts the impact of these existing measures towards meeting the 10% RES-T target by 2020, focussing on private car transport. The methodology presented is derived from a forecast of private car fuel demand based on a technological stock model of Ireland's fleet. This paper demonstrates the use of this as a tool firstly as an energy forecasting technique and secondly as a method for evaluating the effects of policy measures on the technological composition and consequent renewable energy demand and related CO₂ emissions of private cars. Technological scenarios examined in this light are electric vehicles, compressed natural gas vehicles and biofuel blending.

Keywords: Private car, transport, modelling, stock, renewable energy, policy, CNG, Electric vehicles

1 INTRODUCTION

Expanding the share of renewables in Ireland's energy mix has been the focus of Government policy for a number of reasons. As a goal in itself, the EU has made mandatory renewable energy targets for each member state, with 16% of Ireland's gross final energy consumption required to come from renewable sources by 2020. Furthermore, increasing the share of renewables has the benefit of contributing to the Government's stated goals for CO₂ abatement, energy security and cost competitiveness, as set forth in the *National Climate Change Strategy 2007 to 2013* (DoEHLG, 2007).

This paper examines the potential for expanding renewable energy consumption in the transport sector through technology and fuel changes in private cars as a result of several Government measures. An econometric model of private car activity and sales is developed, and a bottom-up model of the technological composition of the Irish car fleet is used to forecast a baseline picture of private car energy demand up to 2020. Scenario analysis is then used to measure the expected impact of electric vehicle (EV) deployment and biofuels legislation on energy, emissions and renewable energy consumption. Also, a potential alternative target for compressed natural gas vehicles is discussed, with forecasted energy and emissions compared with EV scenarios.

The following sections outline the targets imposed on Ireland, historic and forecasted trends in energy consumption, and the significance that recent legislation bears on private car transport.

1.1 Targets and Forecasts

Renewable contribution to overall energy demand (RES) is required to be 16% by 2020, according to the European Renewable Energy Directive (2009/28/EC). In order to reach this goal, separate targets for renewable energy in transport (RES-T), electricity generation (RES-E) and heating (RES-H) have been set for 2020. For Ireland, these targets are 10%, 40% and 12%, respectively.

10% RES-T

First proposed in 2007 and the same for each member state, the 10% binding target for RES-T was originally a target for biofuel use in transport (CEC, 2007 (12)). However, concerns have grown regarding the sustainability of biofuels, in particular those coming from food sources (first generation biofuels). Directive 2009/28/EC revised this target, requiring 10% of transport energy to come from renewable sources, not from biofuels alone. Furthermore, the Directive ensures the sustainability of renewable energy by imposing minimum sustainability criteria on biofuels which can be counted towards meeting RES-T: by 2020, biofuels are to achieve a 60% greenhouse gas

emissions saving on fossil fuels, and the directive prohibits counting biofuels which cause ecosystem damage. The Directive also stimulates renewable energy from sources other than first generation biofuels by allowing a weighting factor of 2.5 to be applied to renewable energy from electricity, and a factor of 2 to renewable energy from second generation biofuels (from residues, non-food cellulosic material and lingo-cellulosic material).

The Sustainable Energy Authority of Ireland (SEAI) makes annual energy forecasts using top-down methodologies, relating energy consumption to the forecasted behaviour of the economy. They forecast that in a baseline scenario, RES-T would come to just over 3% by 2020, with renewables in transport almost totally coming from biofuels.

Non-ETS Emissions

A second EU decision impacting Ireland's energy policy, especially in relation to transport, is a target on greenhouse gas (GHG) emissions. In order for the EU to reach its target of 20% GHG reductions by 2020 relative to 1990, it has developed legislation imposing emissions caps on emissions trading sectors (ETS) as a whole, and non-ETS by member state (Decision 606/2009/EC).

From this Decision, Ireland is required to reduce non-ETS emissions by 20% compared to 2005 levels by 2020. The Environmental Protection Agency (EPA) has produced emissions forecasts for non-ETS sectors, indicating an overshoot of the target of 12.4Mt CO₂ in a *With Measures* scenario, a growth in 2005 emissions of 6.6%, and an overshoot of 7.6Mt CO₂ under a *With Additional Measures* scenario, a reduction of 3.6%, assuming that all relevant policies and measures outlined in recent Government policy documents will be adopted, fully implemented and fully successful (EPA, 2010). To put these figures in context, total non-ETS emissions were 67.4Mt CO₂ in 2008, and transport emissions in the *With Measures* scenario are forecast to reach 17.8 Mt CO₂ in 2020.

1.2 Private Car Transport

Energy demand in Irish transport has not decoupled from economic growth as it has in other sectors, having grown by 181% in the period 1990-2007 and increased its share of total demand from 28% to 43% in the same period (Howley et al., 2009a). Transport emissions have grown in line with energy demand – emissions grew by 177% between 1990 and 2007 – because transport fuel has not decarbonised: Transport is currently almost entirely fuelled by imported oil.

In the future, transport energy demand is forecast to grow by 1.5% per annum in a baseline scenario (Walker et al., 2009), therefore policies implemented in this sector will have an important role in determining our ability to meet the RES-T and emissions reduction targets.

Private cars, the focus of this research, are the most significant transport mode, accounting for 44% of transport energy demand and 77% of the vehicle fleet in 2008. Between 1990 and 2008 private car energy consumption and the fleet grew by 4.9% and 5% per annum respectively. (Howley et al., 2009a)

Looking ahead, it is forecast that in a baseline scenario (encompassing energy policies implemented from 2008), final energy demand from transport will grow on average 1.5% per annum between 2008 and 2020, increasing transport's share of total final demand from 42% to 45% in the period. The fuel share of oil in this scenario drops from 99% to 97% owing to an increase in the use of biofuels due to a legal obligation on suppliers put in place in 2008 (Walker et al., 2009). In a 'Policy' scenario, a range of measures effecting the efficiency of transport are applied, including electric vehicle deployment, mobility management measures and efficient driving measures. These measures reduce the forecasted annual growth in transport energy from 1.5% to 1.2%, therefore aren't anticipated to offset the energy demand to fuel the growth in mobility required by the rebounding economy.

1.3 Current Policies

In order to move away from fossil fuel based transport, a range of technological options have been mooted and are being introduced through legislative targets; examples include the hydrogen fuel cell, compressed natural gas (CNG) cars running on biomethane, and the electric car. The Irish Government has committed Ireland to the latter option, announcing a target that 10% of vehicles are to be powered by electricity by 2020 (DoEHLG, 2008). A main focus of this paper is to study the implications that this target will have: The concept of path dependency explains how the decisions available in the future will be limited by the decisions taken in the present. With regard to vehicle technology, this implies that policies implemented can create a 'lock-in' situation, where investment into capital infrastructure for one type of technology will make it difficult to switch in the

future. For example, the path dependency of vehicles has created a technological lock-in with regard to the internal combustion engine (Åhman and Nilsson, 2008), which is costly to break. It is important to study in as much detail the consequences of policies such as the EV target, which will lead to a technological lock-in.

Aside from implications for the vehicle fleet and transport energy consumption, electric vehicles will impact electricity supply in Ireland, especially if uncontrolled charging will be allowed, which will likely contribute to the peak electricity load and increase the cost and emissions intensity of supply (Foley et al., 2009). This paper doesn't focus on charging profiles however, but examines the implications for energy and takes an average electricity emissions factor to estimate the impact on CO₂.

Also studied are the implications of the 10% EV target for RES-T. Directive 2009/28/EC stimulates transport energy from renewable electricity by applying a 2.5 weighting when counting it towards the RES-T target. Furthermore, the Directive also sets out a RES-E target for Ireland, that a 40% share of electricity is generated from renewables by 2020. RES-E in 2009 stood at 14.4% (provisional), exceeding the 2010 EU target

for 13.2%, and putting RES-E on track for meeting the government's target of 15% in 2010 (Dennehy et al., 2010)

A second route for decarbonising private car transportation in Ireland is the increased use of biofuels: the 2010 Biofuels Obligation Bill requires all fuel sold to contain 4% of biofuels by volume by July 2010. According to Ireland's energy balance, 56 ktoe of the 2181 ktoe consumed by private cars in the country in 2008 came from liquid biofuel, a 2.6% mix by energy. In order to meet the minimum sustainability criteria as defined by Article 17 of Directive 2009/28/EC, biofuels and bioliquids must achieve GHG savings on fossil fuels: 35% to 2016, 50% in 2017 and 60% from 2018. This paper forecasts the effects of the Biofuels Obligation Bill in light of these criteria under different scenarios, including EV scenarios and possible increases in the obligation.

1.4 Structure

The rest of this paper is structured as follows: Section 2 describes the car stock methodology used to forecast the fleet composition and energy demand under technology scenarios until 2020; Section 3 quantifies the impact of EVs on emissions and RES-T; Section 4 examines biofuels and biogas options, and Section 5 summarises



Figure 1: Historic and forecast economic indicators, fleet activity and car sales

2 CAR STOCK METHODOLOGY

The basis for forecasting private car energy demand is founded on two methodologies: Top-down econometric modelling to forecast car activity and sales¹, and bottom-up modelling to generate a car stock model for each year up to 2020.

Scenario analysis is then performed on the makeup of car sales each year, what technologies and which technologies from the baseline are replaced. The composition of fuel is also varied in order to study biofuels.

This approach is beneficial firstly for creating a realistic baseline energy forecast for private cars. While it is a simplification that activity and sales on one hand, and the fleet fuel efficiency on the other are driven by separate drivers – there are rebound effects, for example more driving due to better efficiency and lower fuel cost – car activity and sales in this model are considered as demands derived from external economic forces. The second benefit of this type of modelling is that we can vary the technological parameters of the new stock (as a result of the 10% EV target for example), or of the existing stock (such as modelling the effects of a scrappage scheme (Daly and Ó Gallachóir, 2010a)) while keeping the overall activity level constant. This separates the effects of different policies and allows comparison of different technological scenarios, all else being equal. Another contribution of the bottom-up approach is the detailed picture it gives of energy consumption from a technological level, showing how for example the ageing of the fleet or the shift towards diesel sales adds to energy demand.

2.1 Top-down forecasting: Car fleet activity and sales

The first modelling step is the use of top-down modelling to forecast car sales and the car fleet's activity (in vehicle kilometres) up to 2020. These variables are modelled as the function of forecasted GNP and oil prices. The approach follows that taken in (Daly and Ó Gallachóir, 2010b), which contains a description of the derivation of the price and income elasticities used to make forecasts. Figure 1 shows historic GNP, fuel price, private car activity and sales from 1990 – 2008, data upon which regression analysis was performed to derive the dependencies between the variables. Projected

¹ “Sales” in this paper refers to new-car sales; second-hand sales (which are not imports) are not considered as they do not increase the size of the stock.

values for each variable are also shown for 2009 – 2020.

2.2 Bottom-up Stock Model

The following gives a summary of the car stock modelling methodology, which is based on a historic bottom-up study of Irish private car use (Daly and Ó Gallachóir, 2010) and is described in detail elsewhere (Daly and Ó Gallachóir, 2010b), where the approach was used to forecast the structure of Ireland's car fleet and the impact of efficiency measures on private car emissions.

Disaggregation

The base year fleet (2008) is disaggregated by annual vintage and engine type – for example, internal combustion engine (ICE) vehicles, electric vehicles (EVs), compressed natural gas (CNG) vehicles – and each technology category is subdivided further – for example, ICE vehicles are categorised by engine centilitre capacity (cc) and fuel type, and EVs are divided by battery electric vehicles (BEVs), plug-in hybrids (PHEVs) and hybrids (HEVs).

Car Fleet Profile

The composition of the car fleet in terms of vintage and technology category is approached from two sides: First, the fleet size is determined from fleet activity and average mileage; average mileage per vehicle is linearly extrapolated and reflects the 0.5% decrease per year observed between 2000 and 2008, then stock is the quotient of activity (from the top-down forecast) and average mileage.

Secondly, the composition in terms of age and technology profile is determined from the previous year's profile plus sales and imports less scrapped cars. Historical analysis on the fleet's vintage profile indicated the likelihood of cars in each category being scrapped or imported each year.

Mileage

Mileage in each category is weighted from the average for each year to reflect trends observed, for example that diesel cars and newer cars are driven more than average.

Efficiency

The efficiency – the specific energy consumption (SEC), measured in MJ/km – of cars in each technological category in the base-year fleet were calculated by SEAI from official fuel test and vehicle registration data (Howley et al., 2009a).

The car stock fleet efficiency (in MJ/km) is a key indicator of performance: It is determined for each technology type as a product of new-car SEC (calculated for each ICE category from 2000 – 2008, extrapolated for cars predating 2000, and for future car sales this figure is a key scenario input) ageing, and an ‘on-road’ factor which counts for the differences between the official test consumption data and actual on-road usage. This last parameter has been calculated for Ireland’s cars using a Household Budget Survey (Daly and Ó Gallachóir, 2010).

The overall fleet efficiency can then be calculated as the average SEC over each technology subcategory, weighted by the overall *activity* (vehicle kilometres of each subcategory). It is important to weight according to activity as opposed to stock due to differences in average mileage across the stock: for example, in 2008, analysis of National Car Test (NCT) test results indicated that on average, diesel cars drive 59% more than petrol cars.

Energy Consumption

Energy consumption each year is then the sum of energy consumption in each vintage and technology category, which is the product of the stock, mileage and SEC in that category.

2.3 Baseline Forecast

The baseline new-car sales profile and SEC is calculated by assuming that Regulation (EC) 443/2009 will be met, which mandates a cap on average new-car emissions of 130g CO₂/km (equivalent to 1.91MJ/km) through vehicle technology improvements by 2015. The Regulation sets a further target of

95g CO₂/km (1.4MJ/km) to be met by 2020, but this is not reflected in the baseline case. Figure 2 shows baseline energy demand by vehicle technology

Policy scenarios are prepared by varying the technology profile of new-car sales and of the fuel mix between 2010 and 2020. Therefore for each scenario, the total car stock, total fleet activity and average fleet mileage are constant. Even in a scenario which assumes that EVs displace the sales of smaller petrol cars and have a smaller than average mileage, the mileage of ICE vehicles is increased to keep overall activity constant.

3 IMPACT OF 10% EV

3.1 EV Assumptions

1. We assume that the 10% fleet electrification target is to be met by private passenger cars, resulting in private car electrification of 11.5%, assuming that 87% of the fleet will be private cars in 2020. While it is unrealistic that the technology to electrify freight vehicles or machinery will mature to be viable by 2020, it is likely that some of the target will be met from taxis and other captured fleets. However, we confine the analysis to private cars, which in 2008 made up 97% of these vehicles (CSO, 2009).
2. EV purchasing begins in 2011 and accelerates each year in order to meet the 11.5% necessary to meet the target (262,068 vehicles). The sales and EV stock are illustrated in Figure 3.

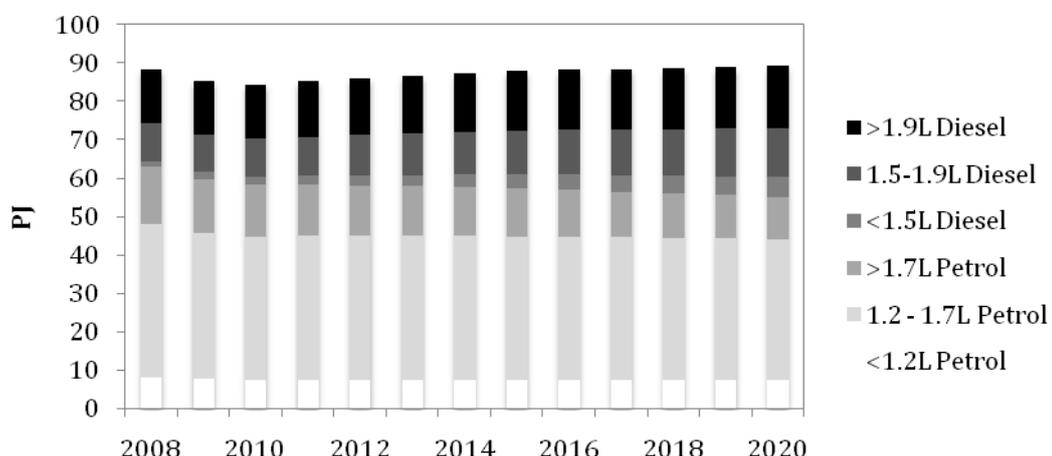


Figure 2: Baseline energy demand by vehicle technology

Variable	Methodology	2008	2020	Change
Sales (vehicles)	Econometric	129,697	69,984	-46.0%
Activity (bn vkms)	Econometric	32.8	36.5	11.4%
Average mileage (kms)	Extrapolated from trend	17,109	16,032	-6.3%
Stock (thousand vehicles)	=Activity/Mileage	1,917	2,278	18.8%
New-car ICE SEC (MJ/km)	Reg 443/2009 assumed met	2.52	2.15	-14.8%

Table 1: Summary of Baseline parameters and the methodology for their calculation

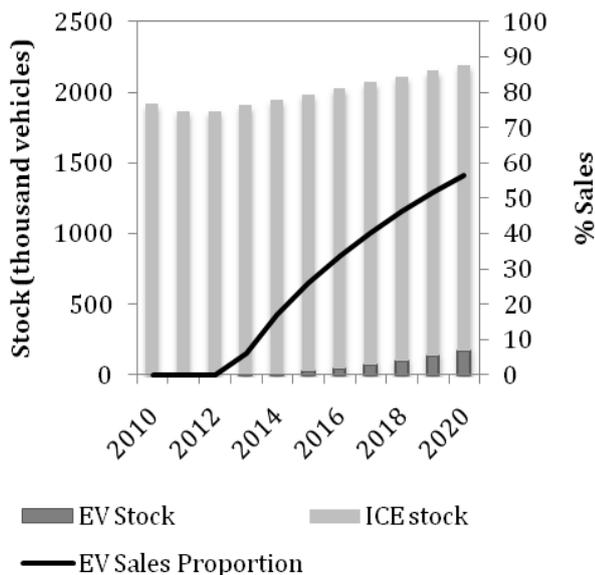


Figure 3: EV sales and stock required to meet the 10% target

- Three scenarios are considered with regard to the ICE vehicle sales from the baseline that are to be displaced by EVs.
- outlines these and consequences for SEC and EV mileage. A first scenario considers an optimistic sales trajectory in terms of ICE displacement: EVs displace large diesel

Displaced ICE Technology	MJ/km	Mileage
Petrol <1.5L	2.21	13,315
Stock average	2.25	16,032
Diesel >1.5L	2.51	20,148

Table 3: SEC and mileage for three different ICE displacement scenarios, derived from baseline forecasts.

engines, and therefore reduce the number of powerful cars and do more mileage. A second scenario has ICE engines displaced evenly and average EV mileage is the average of the fleet. In a third scenario we consider the situation in which EVs displace only smaller petrol ICE vehicles which have lower mileage and lower SEC.

- Overall fleet activity isn't affected by EVs; EVs are assumed to have the same mileage as the

Table 2: Assumptions for different EV technology scenarios and representative vehicles

EV Technology	Notes	MJ/km
HEV	Hybrid electric vehicle, e.g., Toyota Prius 2008.	1.50
PHEV	Plug-in hybrid electric vehicles, e.g., Toyota Plug-in Prius, Assumed 50% driven in all electric mode.	1.20
BEV: High		0.95
BEV: Medium	e.g., Nissan LEAF, 120km range; Tesla Roadster.	0.72
BEV: Low	Mitsubishi iMiEV, 10km range.	0.58

ICE vehicles they displaced.

6. A plug-to-wheel approach is taken, in which energy consumed from the plug is modelled. A plant-to-battery approach has been adopted previously, which takes losses in the electricity system, the time of charging and impact on electricity load into account (Foley A. M. et al., 2010).
7. For measuring the impact of EVs, the model introduces five archetypal EVs outlined in Table 3 with different efficiencies and fuel mixes, reflecting the range of EVs available and soon for sale in Ireland. For hybrid electric vehicles (HEVs, characterised by having both an electric motor and an internal combustion engine), two models are considered: one in which the battery is charged by the ICE (for example the Toyota Prius) and one in which the battery can be plugged in (a plug-in HEV). Three types of pure battery electric vehicles (BEVs) are considered to reflect the range of efficiencies possible. For example, the Nissan LEAF has a 24kWh battery and an expected cruising range of 160kms²; the smaller Mitsubishi i MiEV has a 16kWh battery with a 130km range³. The 26kWh/100km (0.95MJ/km) is at the lower range of expected EV performance and represents a conservative view of a technology still under development and one representative of figures used in other forecasting studies (Sandy Thomas, 2009)

In calculating the emissions and RES-T impact of EVs it is assumed that the target for 40% RES-E (the share of electricity generated from renewable sources) will be met by 2020. RES-E was 14.4% (provisional) in 2009 (Dennehy et al., 2010). In a scenario with 42% RES-E and electricity demand of 54TWh in 2020, the All-Ireland Grid Study projected that the total energy-related CO₂ emissions associated with electricity generation will be 15.3MtCO₂, giving a projected carbon intensity of the electricity supply of 78.7 gCO₂/MJ in 2020, falling from the 2008 value of 161.5 gCO₂/MJ (Howley et al., 2009b). RES-E and carbon intensity values are linearly interpolated for interim years.

3.2 EV Results

Analysis of the potential impact of the 10% EV target on energy, emissions, renewable energy in private cars and impact towards the RES-T target was done for 15 different technical scenarios, representing the introduction of five different EV technologies displacing three different ranges of ICE vehicle. The technological assumptions for introduced EVs and displaced ICE vehicles are presented in Table 2 and Table 3.

Results are given in Table 4. Unsurprisingly, the most favourable outcomes in terms of emissions reductions and the RES-T targets come from scenarios in which large diesel cars are displaced: in these scenarios EVs are driven more and there is a bigger gap between the SEC of displaced and introduced vehicles.

When it comes to the EV technology introduced it is interesting to note the difference in outcomes in terms of the two targets: The introduction of less efficient BEVs contributes the most to the RES-T target, whereas the most efficient EVs are most favourable in terms of emissions reductions. This difference highlights the opposing goals of the two energy targets.

The calculation of each scenario's contribution towards the RES-T target encompasses the 2.5 weighting that Directive attributes to electricity from renewable sources, and uses the simplified assumption that in 2020, private car transport has a 51% share of road and rail transport, equal to that of 2008 according to the energy balance (Howley et al., 2009b). The maximum achievable RES-T from the 10% EV target is 3.2%, and this is with very generous mileage and efficiency assumptions. A more likely scenario is medium BEVs displacing small petrol cars, leading to a 1.5% contribution towards RES-T. Considering the significant challenge in reaching the 10% EV target, and indeed the 40% RES-E target, the payback in terms of achieving RES-T seems slight.

Table 4 also quantifies the emissions reductions achievable as a result of each scenario.

²<http://www.reuters.com/article/idUSTRE5710IH20090802>

³ <http://www.mitsubishi-cars.co.uk/imiev/introduction.aspx>

	ICE Technology	Electric Technology				
		HEV	PHEV	BEV: High	BEV: Medium	BEV: Low
Energy Displaced - TJ	Petrol <1.5L	2,477	3,540	4,399	5,201	5,704
	Stock average	3,135	4,415	5,449	6,415	7,020
	Diesel >1.5L	5,304	6,912	8,212	9,426	<u>10,186</u>
Emissions Displaced - kt CO ₂	Petrol <1.5L	112	196	264	327	366
	Stock average	146	246	328	404	451
	Diesel >1.5L	276	402	505	600	660
Private Car Renewable Energy %	Petrol <1.5L	0%	0.7%	1.6%	1.2%	1.0%
	Stock average	0%	0.9%	1.9%	1.5%	1.2%
	Diesel >1.5L	0%	1.1%	<u>2.5%</u>	1.9%	1.5%
RES-T %	Petrol <1.5L	0%	0.9%	2.0%	1.5%	1.2%
	Stock average	0%	1.1%	2.4%	1.9%	1.5%
	Diesel >1.5L	0%	1.5%	<u>3.2%</u>	2.4%	2.0%

Table 4: Results for energy displacement, emissions reductions, private car renewable energy and contribution to RES-T for each of the 15 EV scenarios.

4 BIOFUELS AND BIOGAS

4.1 CNG Potential: Comparing targets

This section explores a second alternative technology future based on a scenario with a Government target for compressed natural gas vehicles (CNGV) similar to the 10% target for EVs. We present an initial estimate of the emissions reductions and renewable energy demand as a result of meeting such a target from private cars, requiring 11.5% of the private car fleet to be powered by CNG by 2020.

There has been growth in the availability and use of CNGV in recent years. In the EU they are used in Austria, Sweden and Germany, with bi-fuelled vehicles, burning either CNG or gasoline in a standard ICE, for example the Volvo S80 Bi-Fuel car. For private cars there are two possible types of recharging infrastructure, public refuelling stations, which are supplied either by piped natural gas from the grid, or by delivery trailers (O'Brien, 2008).

Table 5: Comparing the emissions reduction and private car renewable energy

Scenario	CO ₂ Reduction %	Private Car Renewable %
CNGV replacing stock average	1.5%	0.9%
Med BEV replacing stock average	7%	1.5%
PHEV replacing small petrol cars	3%	0.7%

The potential for the production of biomethane from cleaned and upgraded biogas in Ireland has been studied: (Singh et al.) estimates that a maximum potential of 33% of natural gas in Ireland may be substituted with biomethane from sustainable sources, such as residues from slurry

and slaughter waste together with energy crops, with a practical obtainable level of 7.5% estimated. Furthermore, (Smyth et al., 2010) indicates that the sustainability criteria imposed on biofuels in Directive 2009/28/EC and requirements for cross-compliance indicate that biomethane produced from grass is a favourable indigenous biofuel, contributing to RES targets, energy security and emission reduction targets.

We use the stock model to quantify the impact of the introduction of such an CNGV target:

of CNGV by 2020 (262,068 vehicles), assume that these vehicles have the same average mileage and efficiency as petrol and diesel engines (Korres et al.), and that 7.5% of the natural gas mix comes from renewable biomethane which meets the minimum sustainability criteria of Directive 2009/28/EC. To calculate emissions we subtract the 7.5% renewable content from the emission factor of natural gas (63.9 gCO₂/MJ) to get 59.1 gCO₂/MJ.

Table 5 compares the emissions reduction and renewable energy demand as a result of this

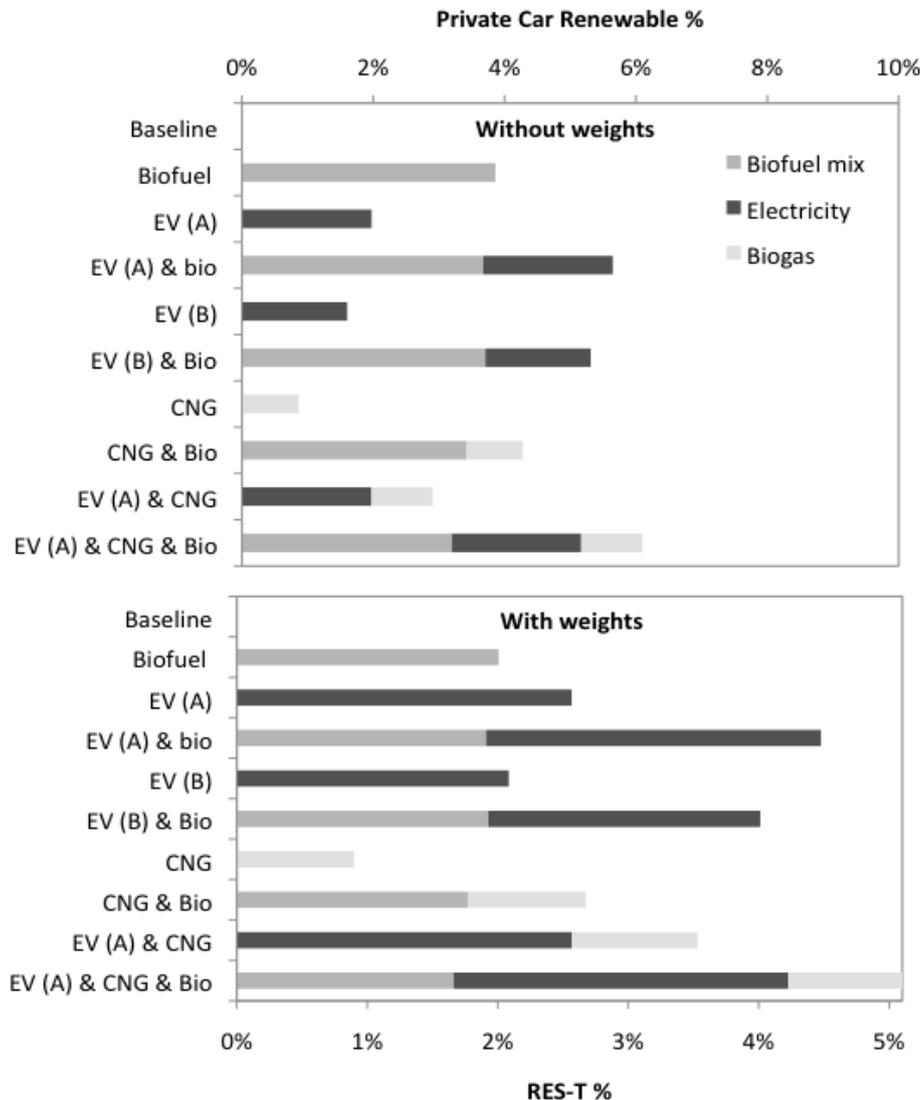


Figure 4: Comparison of 10 fuel and technology scenarios for their contribution towards private car renewable energy demand. The bottom figure includes a 2.5 weighting of renewable electricity and a double weighting of biogas. EV(A) refers to the “BEV High/Stock Average” scenario; EV(B) refers to the “BEV High/Petrol <1.5L” scenario.

To compare results directly with the 10% EV target we again assume an 11.5% private car penetration

scenario compared with two EV scenarios from the previous section, one of which is an ‘average’

scenario, with medium BEVs displacing average ICE vehicles. The second EV scenario is less optimistic, with PHEVs replacing small petrol cars. Both EV scenarios reduce CO₂ emissions more (7% and 3%) compared with CNGV (1.5%). For renewable energy demand, the CNGV scenario achieves 0.9%, better than the 'pessimistic' EV scenario (0.7%) but not as good as the 'optimistic' EV scenario (1.5%).

When considering contribution to RES-T renewables from electricity are given a 2.5 weighting, while biofuels from second generation biofuels (from residues, non-food cellulosic material and lingo-cellulosic materials) receive a double weighting. It has not been established yet whether biomethane from grass will count for this weighting.

4.2 Biofuel Mixing

The 2010 Biofuels Obligation Bill requires each fuel supplier to include a 4% mix of biofuels by volume in road fuels by July 2010. We assume that this is met by a 4% mix of bioethanol in petrol and a 4% mix of biodiesel in diesel. The share of biofuel by energy content is calculated using the energy content by volume of each fuel as defined by Annex III of Directive 2009/28/EC and the overall petrol and diesel share as projected in the baseline scenario.

5 CONCLUSION: MEETING 10% RES-T

Figure 4 compares four scenarios: Biofuel mixing, EV(A) (BEV High/Stock Average), EV(B) (BEV High/Petrol<1.5L) and CNG, and several mixed scenarios, for their contribution towards renewable energy demand in private cars (without weightings), and for their contribution towards RES-T (with weightings). It shows that with an optimistic scenario for EVs, with a target for CNGV similar to the EV target, with 40% RES-E and 7.5% renewable natural gas in the pipeline and with the Biofuel Obligation Bill, an estimated 5.2% of the RES-T target will be met from private cars.

Almost entirely fuelled by fossil oil, the issue of energy security and carbon abatement is especially pertinent to private car transportation. The purpose of this study is to determine the effects of purely technological and fuel-switching policies on the energy profile of cars. This paper has used a detailed bottom-up stock model to quantify the possible emissions and renewable energy demand as a result of several policies and targets relating to private car energy demand.

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