

Sustainable Energy Ireland
Energy Policy Statistical Support Unit
Building 2200
Cork Airport Business Park
Co. Cork
Ireland
t +353 21 454 7050
f +353 21 454 7059
e info@sei.ie
w www.sei.ie

Sustainable Energy Ireland
Glasnevin
Dublin 9
Ireland
t +353 1 836 9080
f +353 1 837 2848
e info@sei.ie
w www.sei.ie

Energy and CO₂ Efficiency in Transport
**Analysis of New Car Registrations
in Year 2000**



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Report prepared by
Martin Howley, Dr. Brian Ó Gallachóir & Kevin O'Rourke

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Sustainable Energy Ireland

Sustainable Energy Ireland (SEI) is Ireland's national energy agency. Established on May 1st 2002 under the Sustainable Energy Act 2002, SEI has a mission to promote and assist the development of sustainable energy. This encompasses environmentally and economically sustainable production, supply and use of energy, in support of Government policy, across all sectors of the economy. Its remit relates mainly to improving energy efficiency, advancing the development and competitive deployment of renewable sources of energy and combined heat and power, and reducing the environmental impact of energy production and use, particularly in respect of greenhouse gas emissions.

SEI is charged with implementing significant aspects of the Green Paper on Sustainable Energy and the National Climate Change Strategy as provided for in the National Development Plan.

SEI manages programmes aimed at:

- assisting deployment of superior energy technologies in each sector as required;
- raising awareness and providing information, advice and publicity on best practice;

- stimulating research, development and demonstration;
- stimulating preparation of necessary standards and codes;
- publishing statistics and projections on sustainable energy and achievement of targets.

SEI is responsible for advising Government on policies and measures on sustainable energy; implementing programmes agreed by Government; and stimulating sustainable energy policies and actions by public bodies, the business sector, local communities and individual consumers.

Energy Policy Statistical Support Unit

Sustainable Energy Ireland has a lead role in developing and maintaining comprehensive national and sectoral statistics for energy production, transformation and end use. This data is a vital input to meeting international reporting obligations, for advising policy makers, meeting international reporting obligations and informing investment decisions. Based in Cork, the Energy Policy Statistical Support Unit is SEI's specialist statistics team. Its core functions are to:

- Collect, process and publish energy statistics to support policy analysis and development in line with national needs and international obligations;
- Conduct statistical and economic analyses of energy services sectors and sustainable energy options;
- Contribute to the development and promulgation of appropriate sustainability indicators.

Analysis of New Car Registrations in Year 2000

The purpose of this report is to inform discussions relating to possible measures, identified in Government policy documents, which seek to improve energy and CO₂ efficiency in the private car segment of the transport sector. In particular, the report seeks to inform the debate regarding the possible rebalancing of Vehicle Registration Tax (VRT) and annual motor tax to favour the purchase of more fuel-efficient vehicles.

The scope of this report is confined to the period 1990 – 2000 and to energy related CO₂ emissions from the national fleet of private cars.

Highlights

The energy and CO₂ significance of car transport

- Transport now accounts for 30% of Ireland's primary energy consumption (4.3 million tonnes of oil equivalent (Mtoe) in 2001), compared with 22% in 1990. A significant proportion of this, 82%, is in road transport, half of which is consumed in private cars, which are thus responsible for 12% of Ireland's gross energy consumption. Over the period 1990 – 2001, transport was the fastest growing energy end use sector (7.1% average per annum).

- The average annual growth in the number of new private cars in the latter half of the last decade was 23%. The total number of private cars at end of year 2000 stood at 1,319,250, an increase of 66% on the figure of 796,408 at end of year 1990. In year 2000, some 87% of these were petrol cars, with almost all the remainder being diesel cars.
- Growth in car numbers peaked in 2000 when 225,269 new private cars were registered in Ireland¹, a 32% increase on 1999. Petrol cars accounted for 90% of these new car sales, the balance being diesel cars.
- The most significant driver of growth in transport energy demand has been the activity level of the economy as a whole, as measured by GDP. Over the past decade, transport is the sector for which energy demand was most closely coupled to GDP, resulting in the massive growth rate.
- Transport was responsible for 10.5 million tonnes (Mt) CO₂ emissions in 2000. Of this, it is estimated that private cars accounted for over 4.6 Mt CO₂. To place this in context, the National Climate Change Strategy (NCCS) projects that, without intervention, emissions from the transport sector will reach 14 Mt CO₂ by 2010, an increase of 180% above 1990 levels. Current

emission growth trends (120% above 1990 levels in 2001) are at least in line with this projection.

- The transport sector is now responsible for 26% of Ireland's energy related CO₂ emissions. This constitutes a larger share than industry (25%) or the services sector (18%), but is still lower than the residential sector (28%). This is markedly different from the situation in 1990 when transport was responsible for only 17% of such emissions, while the industry, residential and services sectors were responsible for 27%, 36% and 17% respectively.
- The NCCS targets a reduction of 2.67 Mt CO₂ from the transport sector relative to its projected emissions for 2010. Within this, the target abatement associated with proposed adjustments in VRT and annual motor tax is 0.5 Mt CO₂, while a further target reduction of 0.1 Mt CO₂ is associated with fuel economy labelling of all new cars as required under EU directive 1999/94/EC, in force since August 2001. An additional indicative NCCS target abatement of 0.35 Mt CO₂ per annum is foreseen from a range of 'modal shift' and 'demand management' measures in transport, which can logically be linked to reduced private car usage.

Profiling of new car registrations in 2000

- Between 1990 and 2000, the number of cars relative to population size grew by more than 50% to 348 cars per thousand of population. Comparing these figures with other Member States in the EU-15, it appears that this trend is likely to continue before saturation in car ownership levels is reached. In the EU-15 for example, there were 469 cars per thousand of population in 2000.
- The average sales weighted efficiency of new cars registered in Ireland during 2000 was 7.16 litres/100km (7.23 for petrol cars, 6.47 for diesel cars)². The overall average CO₂ efficiency was 166 g/km (it was also the efficiency separately for petrol and diesel cars), while the EU Voluntary Agreement target for the year 2008 is 140 gCO₂/km.
- The most efficient new petrol cars registered in 2000, in terms of CO₂ emissions, were in the 900 – 1200cc range, which represents 23.4% of new cars bought in 2000. The most popular new petrol cars were in the 1200 – 1500cc range, the third most efficient band for new petrol cars, representing approximately 50% of such cars.
- On average, the most efficient diesel cars were in the 1200 – 1500cc range, but these represent only a small number of

¹The respective figures for new private car registrations in years 2001 and 2002 were 160,908 and 150,485.

²These are the average of the urban, extra-urban and combined test values.

the cars (0.2%) newly registered in 2000. A large proportion (87%) of new diesel cars entering the fleet were in the 1700 – 2000cc range which is, on average, the second most inefficient band for such cars.

- If **all** cars on the road in 2000 were new models and if average annual mileage was assumed to be 20,000 km³, then the estimated total national emissions from private cars for that year would have been **4.4 Mt CO₂**.

Exploring the potential for CO₂ savings

- Assuming that the average car travels 20,000 km per annum, then the annual CO₂ emissions from new cars registered in 2000 are estimated at 731 thousand tonnes (**731 kt CO₂**).
- Rebalancing of VRT and annual road tax is proposed under the National Climate Change Strategy to reflect the CO₂ efficiency of cars and thereby to influence *purchasing patterns*. Using the above assumptions on mileage, shifting 10% of **new** cars in each engine capacity band for year 2000 to the nearest more efficient band would yield a reduction of **9 kt CO₂** in one year.
- It should be noted that this would be a cumulative effect. The annual avoided emissions would increase incrementally

as new vehicles enter the fleet each year, until entire fleet replacement has occurred. This has been estimated by exploring the impact of replacing the entire year 2000 fleet with new cars that are 2000 models. If this replacement fleet were to have the same structure (in terms of engine capacity) as the cohort of new cars added in 2000, then an assumed 10% shift in purchase selection of **all** cars on the road to the nearest more efficient engine capacity band would yield an annual emissions reduction of **53 kt CO₂**. This represents 1.2% of CO₂ emissions from the total private car fleet.

- Another approach is to again assess the impact of replacing the entire 2000 fleet with new cars that are 2000 models, but assuming retention of the actual structure of the entire fleet in 2000 (not the structure of the cohort of new cars added in 2000). On this basis, an assumed 10% shift in purchase selection of **all** cars on the road to the nearest more efficient engine capacity band would yield a lesser saving, of **30 kt CO₂** per annum. This represents 0.7% of CO₂ emissions from the total private car fleet. The lower impact reflects the fact that new additions to the fleet in year 2000 comprised a greater proportion of large (and less efficient)

models, with more scope for emissions reduction. No difference is attributable to efficiency improvements for individual models as they are assumed to be 2000 models in both cases.

- These hypothetical impacts relate to the effective NCCS target abatement of **600 kt CO₂** per annum by 2010 for VRT and annual road tax rebalancing plus fuel economy labelling. While the tax rebalancing is for all road vehicles, not just private cars, these assessments highlight the challenge posed in meeting this target.
- By way of exploring the impact of a shift in *usage patterns*, the effect of a 2,000km (some 40km per week) reduction in annual mileage driven by **new** cars registered in the year 2000 would be to reduce CO₂ emissions by **73 kt CO₂**.
- If the structure of the total private car fleet in 2000 remains unchanged, a reduction of 2,000km in the average annual mileage for **all** private cars would yield a saving of **441 kt CO₂** per annum. This effect would be recurring each year. This hypothetical impact can be compared against the indicative NCCS target abatement of **350 kt CO₂** per annum from a range of ‘modal shift’ and ‘demand management’ measures in transport.

- The combined impact of the changes in car purchasing behaviour and user behaviour as explored in this analysis would be an estimated potential abatement of **471 kt CO₂** per annum. This compares against a corresponding NCCS target of up to **950 kt CO₂** per annum.
- One element of policy pertinent to influencing purchasing behaviour is already in force in Ireland since August 2001, in the form of regulations giving effect to EU directive 1999/94/EC on fuel efficiency and CO₂ emissions labelling of new cars. All new passenger cars for sale must be individually labelled with fuel economy and CO₂ emissions information. Posters must be displayed in showrooms giving the information for all models for sale. Fuel consumption and CO₂ emissions data must be included in promotional material. A free guide is produced and regularly updated by the Society of the Irish Motor Industry (SIMI) for all models of new passenger car offered for sale or lease within the State.
- It has not been within the scope of this study to investigate the extent to which these market effects themselves (changing car purchase patterns and reducing private car fuel demand) are achievable. Whether this is the case

³ Average annual mileage estimated from mid-year fleet numbers, derived from *Vehicle Kilometres of Travel in Ireland 2001*, prepared by TRL for the National Roads Authority (Dec. 2002), was 20,345 km.

would require an analysis of economic elasticity of response to VRT, annual road tax and fuel tax rebalancing, as well as motivation to shift to public transport and other choices. Such analysis is beyond the scope of this report. It is to be noted however that the price elasticity of response in private car fuel consumption is often perceived to be low relative to other sectors of the economy.

- Based on a number of working assumptions, the shift in the structure (mix of engine capacities) of the national car fleet between 1990 and 2000 has resulted in an estimated additional **169 kt CO₂** being emitted in the year 2000 relative to what would have arisen had the structure remained the same. This is separate from any increase arising from aggregate growth in the car population or developments in more efficient engine technologies.

In order to gain a fuller picture of the impacts on emissions arising from the changing structure of the fleet and improvements in efficiency of new models, it would be necessary to source a database of test values for the car models that were on the market in 1990 and subsequent years. Sales weighting of the efficiencies of different models could then be carried out as was done here for the year 2000. This may be possible for the years 1997 onwards. In addition, moving forward, it is planned that this type of

analysis will be carried out for 2001 onwards as the data becomes available.

Next steps to deepen understanding of the evolution of energy use in private road transport will focus on sourcing and evaluating additional data. It may be possible to source a historical database of model test values internationally that would allow historical trends to be assessed. It may also be possible to source untapped domestic sources to fill gaps on average annual mileage perhaps by engine size and fuel type. There may also be scope to commission research into the actual fuel consumption of vehicles on the road to see how this differs from the test values and throw some light on driving habits.

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1 Introduction

The purpose of this report is to inform discussions relating to measures identified in the Government's Green Paper on Sustainable Energy and the National Climate Change Strategy (NCCS), which seek to improve energy and CO₂ efficiency of the transport sector. In particular, the report seeks to inform the debate regarding the rebalancing of Vehicle Registration Tax (VRT) and annual motor tax to favour the purchase of more fuel-efficient vehicles.

The report analyses the energy performance profile of new cars registered in Ireland during 2000 in order to make an initial assessment of some of the underlying factors affecting energy trends in the transport sector – in particular the purchase behaviour of new car buyers in that year. To help inform judgements on policy measures, it explores theoretical scenarios in which the scale of CO₂ abatement impact arising from hypothetical market shifts is estimated.

The manner in which energy demand in transport is directly coupled to economic growth is highlighted. The dramatic growth in car sales together with the trend towards larger cars is also discussed. While the trend towards bigger cars tends to increase energy consumption and CO₂ emissions of the car fleet, this is countered by technological improvements in the

efficiencies of new models of cars. An initial attempt is made to establish which of these influencing factors has the greater impact.

The aggregate energy and CO₂ efficiencies of new additions to the car fleet in 2000 are calculated using test values from car manufacturers on the performance of individual cars together with information from the Vehicle Registration Unit (VRU) of the Department of the Environment, Heritage & Local Government, on new cars registered during 2000. In addition, a number of theoretical market shift scenarios within the car fleet, in terms of both purchase and user behaviour, are explored to help in assessing the potential scale of energy and CO₂ impact of such shifts.

SEI gratefully acknowledges the co-operation of the VRU in providing the source data that made this analysis possible.

2 Transport Energy Policies and Trends

2.1 Policy need to contain energy growth in transport

2.1.1 Kyoto commitments

Ireland's target under the Kyoto Protocol is to limit annual greenhouse gas (GHG) emissions to 13% above 1990 levels by the period 2008 – 2012. This is part of an EU Burden Sharing Agreement whereby the overall EU target reduction of 8% in emissions is to be achieved through the combined efforts of the Member States.

Energy consumption in the provision of our needs for electricity, heating and transportation was responsible for 57% of Ireland's GHG emissions in 1990. Against this background, the Government's *Green Paper on Sustainable Energy* in 1999 presented growth projections for energy consumption up to 2010 and set out a number of options for meeting our energy requirements in a more environmentally and economically sustainable way.

The Green Paper identified transport as being the fastest growing sector in terms of GHG emissions. It projected that transport energy related CO₂ emissions would increase to 157% above 1990 levels by 2010.

The Green Paper pointed to some of the factors underpinning this growth, namely the coupling of energy demand in transport to economic growth and the dominance of road travel for passenger transport in Ireland. 80% of all passenger kilometres travelled in 1999 was by private car⁴.

The Green Paper also discussed a number of measures and policy options to encourage energy efficiency. It highlighted that *'transport users do not bear the full cost of the negative impacts of their transport use in terms of a direct economic consequence of their behaviour choices.'* In order to address this market failure, a number of economic instruments were proposed, namely:

- Re-balancing of Vehicle Registration Tax to reflect fuel consumption and / or emission levels;
- Adjusting annual road taxes to reflect vehicle consumption more accurately; and
- Fuel taxation offering the option of a use related and environmentally targeted instrument.

A number of these proposals were updated and further developed in the Government's *National Climate Change*

Strategy (NCCS), published in 2000. The NCCS projected that without the actions set out in the strategy, Ireland's annual emission levels will reach 37.3% above 1990 levels by 2010. It pointed out that, on a business as usual basis, emissions in the transport sector are projected to increase by **180% above 1990 levels by 2010**, representing a significant upward revision in projections relative to those presented in the Green Paper. The evidence to date, presented in SEI's report *Energy in Ireland 2002* and showing that by 2001 transport related CO₂ emissions were already 120% above 1990 levels, would seem to be at least in line with this projection.

In order to meet Ireland's Kyoto target, the NCCS states that a reduction of 13 Mt (million tonnes) of CO₂ equivalent below the projected levels is required by 2010. The quantified indicative total reduction achievable by the measures proposed in the strategy is 15.4 Mt.

The indicative reduction in the transport sector, which accounted for over 11 Mt CO₂ in 2001, is 2.67 Mt CO₂, to be achieved by:

• Fuel Efficiency Measures

Rebalancing of VRT and annual road tax to favour more fuel-efficient vehicles (0.5 Mt CO₂)

Fuel economy labelling for all cars to facilitate consumer choice (0.1 Mt CO₂)⁵
Vehicle efficiency improvements (0.77 Mt CO₂)

• Modal Shift Measures

Investment in public transport (0.15 Mt CO₂)
Optimising freight transport (0.05 Mt CO₂)

• Demand Management

Set fuel tax to limit the rate of increase in fuel consumption and remove the incentive for cross border purchases (0.9 Mt CO₂)
Development of integrated traffic management (0.2 Mt CO₂)
Spatial strategies to increase urban densities

The Kyoto Protocol requires all parties to make demonstrable progress towards their respective target by 2005. According to the EPA⁶, Ireland's GHG emission levels reached 31% above 1990 levels by 2001. This points to an urgent need for actions to achieve significant reductions.

This report is therefore timely in the context of current policy developments, given the commitments Ireland faces and trends that indicate a lack of progress to date.

⁴Source: Eurostat. TRL (Dec. 2002) *Vehicle Kilometres of Travel in Ireland 2001*, prepared for the National Roads Authority, estimates that motor cars account for 79% of vehicle kilometres travelled in 2001.

⁵The Department of the Environment & Local Government's *Progress Report: Implementation of the National Climate Change Strategy* (2002) indicates an abatement impact of 0.38 Mt CO₂ from this measure. It is possible that this may in part be associated with the tax rebalancing proposals.

⁶EPA (2003) *Ireland National Greenhouse Gas Inventory Report 2003*.

2.1.2 Import dependency

Ireland's dependency on imported energy grew from 65% in 1990 to 87% in 2001. This significantly exceeds the average dependency of 50% for the EU as a whole. The European Commission's *Green Paper on Security of Energy Supply*⁷ highlighted the need to address the current level of EU dependency which, based on current forecasts, is expected to reach 70% in 2030.

With over 98% dependency on imported oil, transport is potentially most vulnerable to a disruption in supply. The Green Paper states that given its limited scope to influence supply conditions, it is essentially on the demand side that the EU can intervene, including promoting

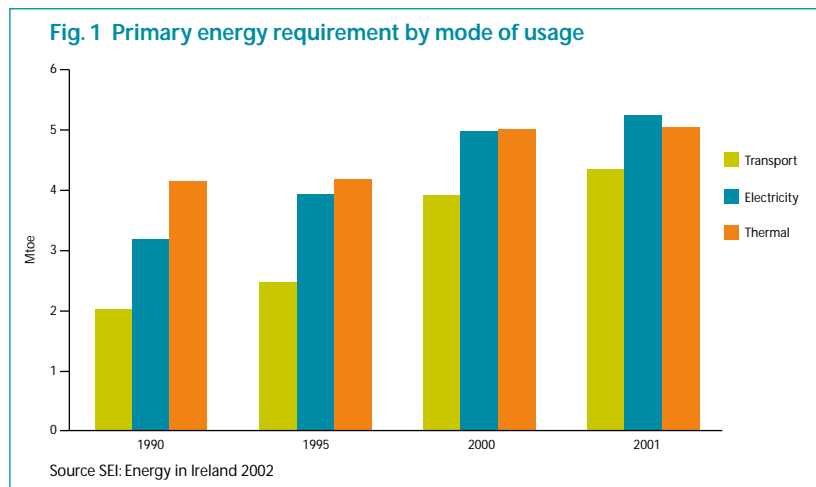
energy saving in the transport sector. This is clearly no less the case for Ireland.

2.2 Energy trends and drivers

2.2.1 Energy and transport

Energy is consumed in three modal forms, as heat, electricity and for transport. As illustrated in figure 1, in 1990 heat and electricity respectively accounted for 44% and 34% of primary energy consumption, with just 22% of energy consumption being in transport.

Since 1990, transport has grown considerably faster than the other two modes of energy use. As a result, transport accounted for 30% of primary energy consumption in 2001. Over the same



⁷European Commission (2001) *Towards a European strategy for the security of energy supply*.

period, the electricity share of energy consumption increased to 36% while the heat share fell to 34%.

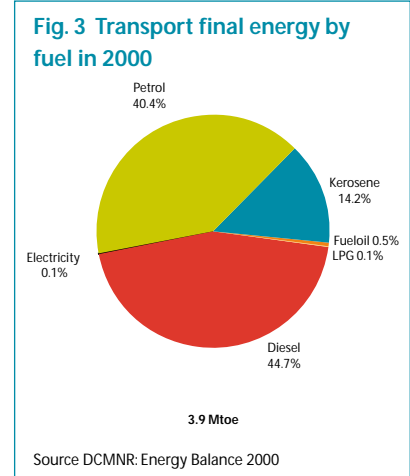
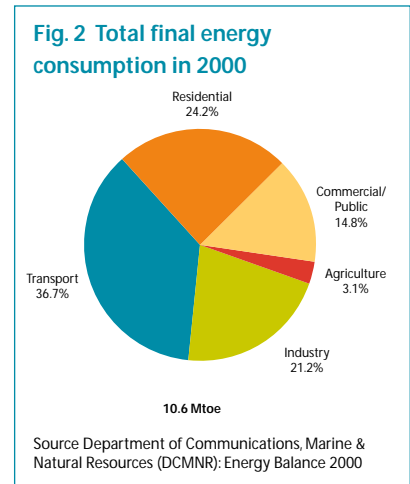
For the purposes of the subsequent analysis it is important to examine the year 2000 more closely. Transport represented 28.2% of primary energy consumption in 2000.

While transport can be considered as a mode of energy use, it is also viewed as a distinct sector of the economy, along with the industrial, (public and private) services, residential and agriculture sectors. This is useful, for example in the setting of targets on a sectoral basis for limiting GHG emissions.

Figure 2 shows the share of final energy consumption attributed to each of the main energy consuming sectors. In 2000, Transport accounted for almost 37% (3.9 Mtoe) of final energy demand.

A number of different fuels are used in the transport sector, closely aligned with the mode of transport used. The consumption of these fuels is shown in figure 3.

Kerosene consumption in transport is exclusively for aviation, fuel oil for shipping and electricity for the moment is only consumed by the Dublin Area Rapid Transit (DART). LPG is almost exclusively



used for road transport, as is petrol. The bulk of petrol consumption for road transport can be assumed to be for private

car use although there is a significant number of petrol driven taxis in operation. Diesel consumption is used for navigation, rail and road purposes but the bulk (92%) is used for road transport. This road diesel consumption is used for freight transportation, public transport in buses and taxis, private car transport and other applications such as agricultural, construction and other machines. On the basis of these assumptions, the estimated contribution from each mode of transport to energy demand is shown in figure 4. The correlation between modes and fuels used is clear when figure 3 is compared with figure 4.

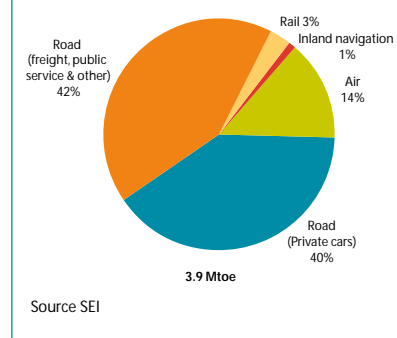
consumption in transport (3.2 Mtoe) in the year 2000. It is difficult to accurately separate out private road transport because data relating to petrol and diesel transport consumption is not classified by mode. However, it is estimated that private cars account for just less than 50% of road transport energy (1.6 Mtoe approx.) or approximately 40% of all transport energy⁸. Private cars thus account for approximately 15% of Ireland's final energy consumption or 12% of primary energy consumption.

With regard to GHG emissions, the growth in energy consumption within the transport sector has resulted in transport being responsible for 26%⁹ of energy related CO₂ emissions in 2001. Its growing importance compared with other sectoral energy applications is shown in figure 5.

Using the same assumptions as previously, private cars accounted for approximately 4.6 Mt CO₂ emissions in 2000.

The significant changes in the transport sector have also been visible through the growth in traffic volumes on the roads, increasing congestion and lengthened journey times over the last decade.

Fig. 4 Transport energy demand by mode (2000)

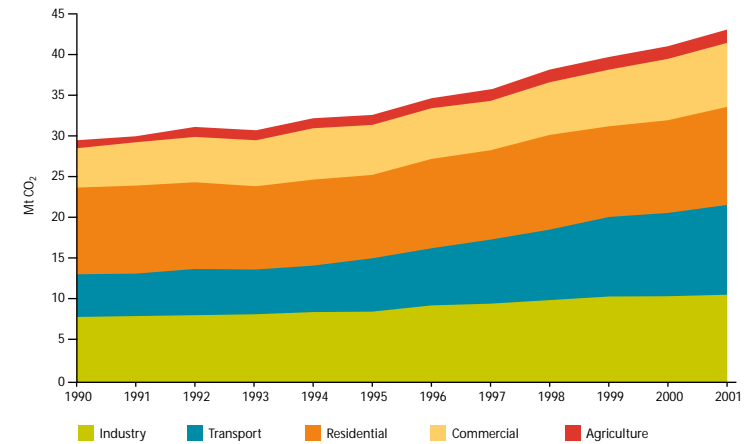


As illustrated in figure 4, road transport accounted for 82% of energy

⁸The estimated split in road transport is based on assumptions of 90% of petrol and 10% of diesel (from road transport) being consumed by private cars. Diesel private cars represent approx. 35% of all diesel vehicles but consume considerably less than large commercial vehicles so 10% of diesel consumption, while an estimate, is a reasonable assumption.

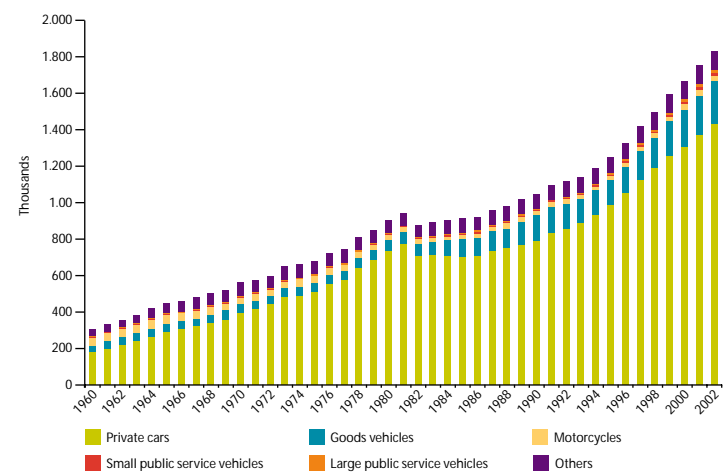
⁹This excludes energy consumption for international travel, as per Intergovernmental Panel on Climate Change (IPCC) guidelines.

Fig. 5 Energy related CO₂ emissions by sector 1990 – 2001



Source SEI: Energy in Ireland 2002

Fig. 6 Growth in vehicle numbers 1960 – 2002



Source VRU and CSO

2.2.2 Growth in vehicle numbers

Vehicle numbers have been growing consistently in Ireland since the 1960's, with a slight dip in 1982, which coincided with a downturn in the economy. The growth in vehicles numbers, by vehicle type, is shown in figure 6 (on previous page.)

Figure 7 shows the trend in new car sales since 1965. Also shown is the year on year growth in GDP at constant 1995 prices. The economic cycles of the last four decades and their impact on sales are clearly visible. It is clear that new vehicle sales in Ireland have been directly coupled to changes in economic growth. It is also clear that private cars are the dominant new vehicle type sold in the period. The average annual growth in the number of new private cars in the latter half of the last decade was 23%. The growth peaked in 2000 when 225,269 new private cars were registered in Ireland, a 32% increase on 1999. The total number of private cars registered at the end of year 2000 was 1,319,250. This was an increase of 66% on the figure of 796,408 private cars at end of year 1990.

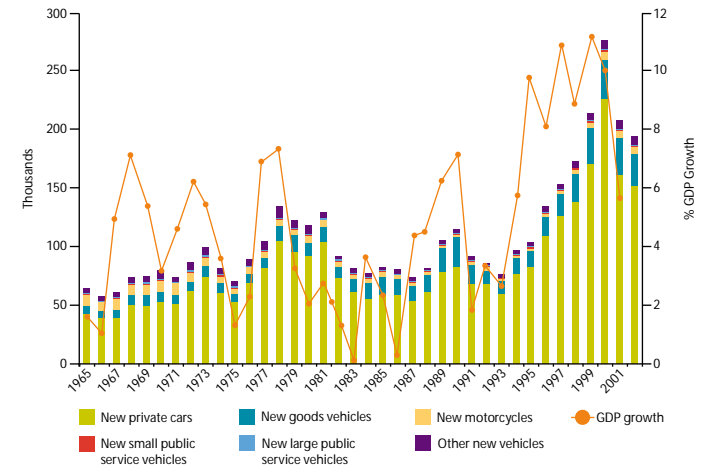
New cars thus accounted for 17% of the private car fleet in 2000. On average over the last five years however, new cars accounted for 13% of the fleet. If this average ratio were to be maintained with no further fleet growth and new cars displaced the oldest cohort of cars, it

would lead to a fleet replacement in over 7 years. In practice, the fleet is still growing and the numbers of new cars registered is more than double the attrition level of older cars. Since 1991, 786,884 private cars have left the fleet. There were 836,583 cars registered by the end of 1991, suggesting fleet replacement took 11 years. It is further interesting to note that at the end of 2002, 35% of private cars were 2000 or later models while 90% were 1992 or later models. This points to the irregularity with which fleet replacement occurs.

The significance of the year 2000 with regard to new vehicle sales and new private car sales in particular is evident from figure 7. The economic boom of the 'Celtic Tiger' was certainly a major factor in driving these sales but this does not fully explain the marked increase compared with previous years. The fact that it was a millennium year also had a bearing. Anecdotal evidence suggests that many people saw it as desirable to purchase a new car in that year and have a double zero for the year on the number plate.

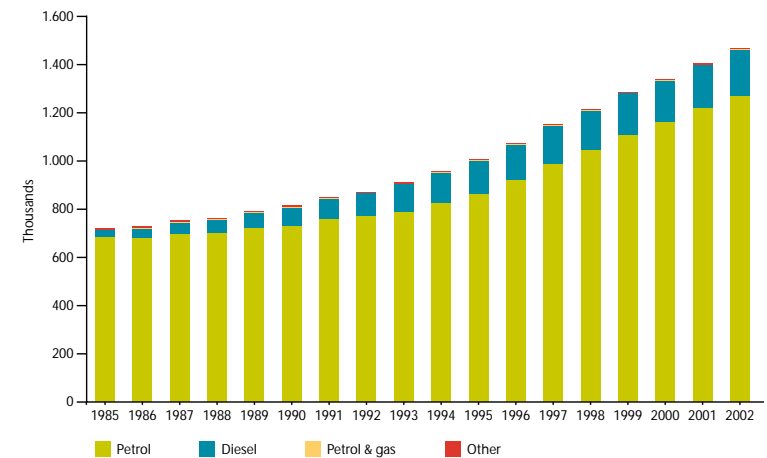
As shown in figure 8, petrol is still the dominant fuel within the private car fleet, with nearly 87% of private cars being petrol driven. The remainder are predominately diesel cars with very small numbers of others such as petrol/gas, electric and hybrids.

Fig. 7 Sales of new vehicles 1965 – 2002



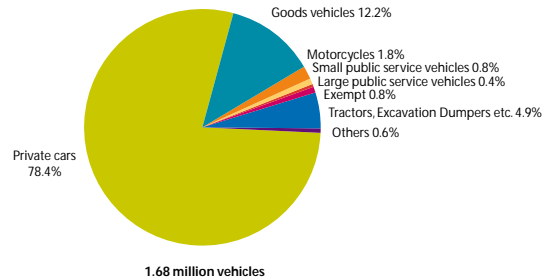
Source CSO (GDP – Discontinuities for 1985 & 1990) and VRU: Irish Bulletin of Vehicle and Driver Statistics

Fig. 8 Private cars by fuel 1985 – 2002



Source VRU: Irish Bulletin of Vehicle and Driver Statistics

Fig. 9 Vehicles by taxation class (2000)



Source VRU: Irish Bulletin of Vehicle and Driver Statistics

Figure 9 shows the breakdown of the national fleet by taxation class. Private cars thus accounted for 78.4% of vehicles, 40% of transport energy consumption and approximately 44% of transport related CO₂ emissions.

2.2.3 Factors influencing transport growth

Changes in overall growth rates and patterns of energy consumption within transport can be attributed to a number of underlying factors, as follows:

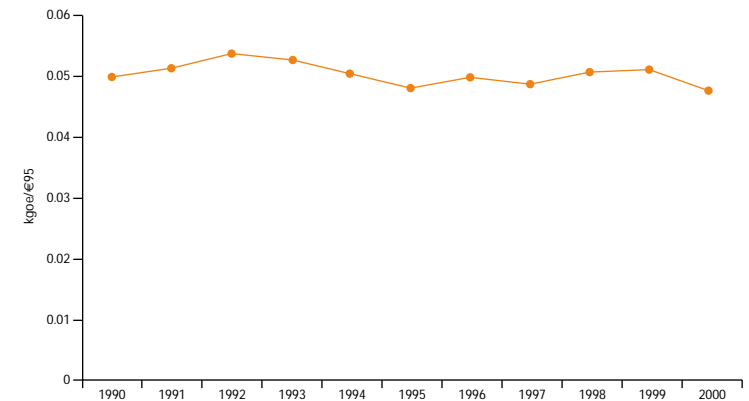
- Economic growth
- Increased affluence
- Purchase behaviour
- Travel behaviour
- Vehicle efficiency
- Availability of alternatives

The most significant influencing factor over the last decade has been the growth

of the economy. This can be readily seen in figure 10, which shows transport energy intensity as the ratio between energy consumption in transport (in kg of oil equivalent) and GDP (in euro at 1995 prices). This relatively flat curve throughout the decade reflects the direct coupling between transport energy demand and economic growth. In times of low growth in the economy such as the early 1990s there was also low growth in transport energy consumption. Conversely, when economic growth was extremely high at the end of the decade, transport energy growth matched this high rate.

In part this relationship can be explained by the fact that manufacturing normally drives economic growth. When manufacturing increases there is a corresponding need for an increase in transport services to

Fig. 10 Energy intensity of transport 1990 – 2000



Source SEI: Energy in Ireland 2002

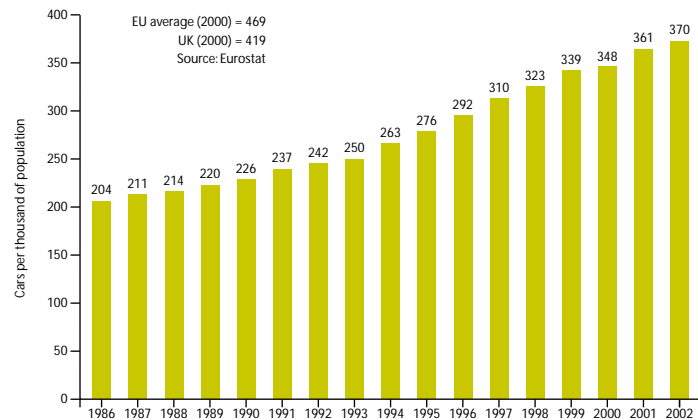
deliver raw materials to the manufacturing plants and subsequently to take the finished products to the marketplace. Increased economic activity also brings increased employment. This in turn leads to an increase in the amount of travel to and from work. Moreover, an increased incidence of leisure travel by car tends to be associated with higher disposable income.

High economic growth has increased affluence levels and this in turn has led to an increased number of vehicles on the road. The extent of this increase is shown in figure 11. Between 1990 and 2002, the number of cars relative to the size of the population has grown by

more than 60% to 370 cars per thousand of population. Households that may not previously have had a car can now afford one. Likewise, one-car households may now be able to afford two and may indeed require two to facilitate travel to work by both partners. The changing demographic profile of Ireland has also influenced this development, as have patterns of spatial settlement. There is a higher proportion of adults in the population now than in 1990.

Comparing these figures with elsewhere, this trend is likely to continue before saturation in car ownership levels is reached. In the EU-15 for example, there were 469 cars per thousand of population in 2000.

Fig. 11 Private cars per thousand of population 1986 – 2002



Source SEI: Energy in Ireland 2002 (updated)

Increased affluence also has an effect on the type of vehicles purchased and has led to a trend towards bigger and more luxurious cars, as evidenced in figure 15 in section 4. Large cars tend to be less efficient and have higher environmental emissions.

As mentioned already, car usage has also increased, due in part to the increased service requirement such as travel to work and also due to the trend towards greater convenience. In these hectic times, the term *time poverty* has recently come into existence. People increasingly perceive themselves to value time highly and will drive short distances rather than

walk to save time. So frequent short journeys to the shop, school, gym etc become the norm. This type of travel by car is very inefficient in energy terms.

The availability of alternative modes of transport can have an effect on the prevalence of car use. In 1999, Eurostat reported that 80.3% of the passenger kilometres travelled in Ireland was by car. The extent to which this predominance of car transport for passengers is as a result of lack of alternative public transport or reluctance by people to use public transport for other reasons is open to debate, in the absence of firm data.

2.2.4 EU labelling directive in force: private cars

The technical energy efficiency of cars is improving and this has tended to decrease the emissions from transport. The EU reached a voluntary agreement with the car manufacturing associations to achieve an average specific CO₂ emission figure for new passenger cars of 140 gCO₂/km by the year 2008/9.

The EU also introduced a directive on fuel economy rating (Directive 1999/94/EC) to ensure that consumers will have full information relating to fuel economy and CO₂ emissions so as to make an informed choice. This directive was transposed into Irish law by means of Statutory Instrument S.I. No. 339 of 2001, *European Communities (Consumer information on fuel economy and CO₂ emissions of new passenger cars) Regulations, 2001*, which has been in force since August 2001.

The Department of the Environment & Local Government, in its *Progress Report: Implementation of the Climate Change Strategy (2002)*, anticipated that the impact of energy/ CO₂ labelling on the entire car fleet's fuel consumption and CO₂ emissions would be a 4% – 5% reduction over the next ten years, equivalent to 0.38 Mt CO₂ per annum by 2010.

The NCCS predicted that the combined impact of these measures will be to reduce emissions by 0.87 Mt CO₂ by 2010, relative to projections without this measure.

The abovementioned progress report pointed out that the necessary information is now available to help car buyers see at a glance the CO₂ emissions of different new car models, and thus factor climate change into their purchasing decisions, and to compare fuel efficiency across models and makes. The regulations of S.I. No. 339 of 2001 require all new passenger cars for sale to be individually labelled with fuel economy and CO₂ emissions information. Posters must also be displayed in showrooms giving the information for all models for sale, and fuel consumption and CO₂ emissions data must now be included in promotional material. A guide is produced and regularly updated by the Society of the Irish Motor Industry (SIMI) for all models of new passenger car offered for sale or lease within the State, and is available free of charge from showrooms or SIMI.

3 Methodology

This report tries to shed some light on the issues raised above and to help with answering questions such as:

- 1 To what degree does purchase behaviour increase energy use and emissions from transport?
- 2 Are we negating efficiency improvements by car manufacturers in engine design by our purchase behaviour?
- 3 What are the options for policy makers to try to address the situation in within the context of implementation of the NCCS?

Due to the prevalence of private car usage to meet Ireland's transport demand, the report focuses on the energy and CO₂ efficiency of cars.

The approach taken is necessarily one of compromise in the absence of the full range of data required to conduct a comprehensive analysis. Specifically, data availability restricts this initial analysis to new additions to the car fleet. SEI plans to extend this type of analysis to the full fleet as more data become available.

Had more extensive data been available, a useful way to assess and monitor efficiency of the national private car fleet would have been to track the average on-road fuel efficiency. This could be done by taking a statistically representative sample of the fleet and

tracking the efficiency, in litres per 100 kilometres (l/100km), over a period of time. From this a weighted average could be calculated for the entire fleet. Over time this figure would show how the efficiency of the fleet is evolving taking into account changes in engine efficiency, changing proportions of urban/rural mileages and driver behaviour. Surveys such as this are very expensive and very few countries carry them out; however examples can be found in France and Canada.

In the absence of such data, and against the background of energy trends and policy needs outlined above, the approach taken in the present report is to focus on a segment of the national car fleet, viz. new entrants to the fleet in 2000, to profile this segment and to draw inferences on national energy patterns and policy options by means of extrapolation from this segment and by exploring, somewhat artificially, the CO₂ saving impacts of a number of scenarios of market shift or user behaviour change.

The approach taken in assessing the progression of the efficiency of the car fleet is to record the efficiency of the new cars entering the fleet replacing older less efficient models. All new cars have fuel consumption figures (measured under test conditions) quoted for urban, extra urban and combined driving in addition to estimated CO₂ emissions per

kilometre driven. It is possible to arrive at an average test efficiency figure for new cars entering the national fleet weighted by the sales of each individual model.

Based on such source data for new car registrations in the year 2000 as provided by the Vehicle Registration Unit and data on fuel consumption and CO₂ from the UK VCA (Vehicle Certification Agency), this report for the first time presents these average or aggregated national figures. Approximately 2,000 model variants of cars are covered in this database.

After profiling these new entrants to the fleet, a number of scenario exercises are then applied to assess the potential CO₂ saving impact of:

- A shift in new car purchase behaviour in a single year entailing a move from the current engine size band to the next most efficient band (for example in response to changes in VRT and/or road tax structure);
- A reduction in annual kilometres travelled by new entrants to the fleet in a single year (for example in response to fuel price changes, and/or improved public transport services, other consumer choices);

• Extending the above scenarios to the total national car fleet using working assumptions.

Finally, an assessment is made of the relative impacts of changes over the period 1990 – 2000 in the national car fleet structure on the one hand, and improved fuel economy in new car models (technological efficiency) on the other.

4 Key Findings

Table 1 presents energy efficiency of new additions to the fleet in terms of litres/100km and miles per gallon (mpg). Separate results are also presented for new petrol and new diesel cars. Also presented is the CO₂ efficiency of new cars in g/km. It is interesting to compare the average specific CO₂ emission figures for new passenger cars in 2000 of 166 g/km with the EU Voluntary Agreement target of 140 gCO₂/km by the year 2008/9.

The full set of results is presented in tabular form in *Appendix A*.

These figures are based on the results of tests carried out in accordance with EU Directive 1999/100/EC of 15 December 1999 relating to the CO₂ emissions and the fuel consumption of motor vehicles. Such testing is obligatory on all new car models on sale from 1 January 2001.

It must be stressed that these are test figures and actual consumption on the road will be somewhat different, the extent of which will depend on driving conditions and behaviour. However, it is assumed that a more efficient car driven

inefficiently will still be more fuel-efficient than an inefficient one driven inefficiently. International experience (Canada's Office of Energy Efficiency, 2000, p49-50) suggests that actual on-road fuel consumption (and consequently the level of CO₂ emissions) may be as much as 20 – 25% higher than the quoted test figures.

It is interesting to note from these weighted averages that the new diesel cars added to the fleet in 2000 were 13% more energy efficient than the new petrol cars. Diesel has a higher energy content (per litre) than petrol, which gives rise to the higher efficiencies.

This in turn is due to the higher carbon content of diesel compared with petrol, which explains the fact that petrol narrows the efficiency gap to 0.2% when CO₂ emissions rating rather than energy efficiency is examined.

The results presented here relate to a single year, but in the coming years it will be possible to examine the trend over time. This will shed light on whether the

influence of engine size will be greater than the influence of improved car efficiency on the fleet efficiency as a whole.

The full set of results is presented in tabular form in *Appendix A*.

The main observations from figure 12 are:

4.1 Energy and CO₂ emissions profiles by new car engine size bands

The data from the Vehicle Registration Unit allow the average fuel and CO₂ efficiencies to be calculated for each taxation band. Figures 12 & 13 show how the CO₂ efficiency varies across engine size ranges together with the number of new cars in each category for petrol and diesel cars respectively.

Out of the total new private car sales of 225,269 in the year 2000, 89.6% were petrol cars and 10.4% were diesel cars.

- The most efficient petrol cars in terms of CO₂ emissions are in the 900 – 1200cc range, in which 23.4% of new petrol cars in 2000 were bought. While it might be anticipated that larger cars are generally less efficient, it is interesting to note that smaller cars, in the range less than 900cc, are also on average less efficient.
- The most popular new petrol cars were in the 1200 – 1500cc range, representing approximately 50% of new petrol cars and 45% of all new cars. This was followed by the 900 – 1200cc range, which represented 21% of all new cars.

Table 1 Energy and CO₂ efficiency of new additions to the car fleet in 2000

| | Litres/100km | | | | Miles per Gallon (mpg) | | | | CO ₂ g/km |
|----------------|--------------|-------------|----------|---------|------------------------|-------------|----------|---------|----------------------|
| | Urban | Extra-Urban | Combined | Average | Urban | Extra-Urban | Combined | Average | |
| Overall | 9.08 | 5.56 | 6.84 | 7.16 | 32.04 | 51.68 | 42.22 | 41.98 | 166.10 |
| Petrol | 9.18 | 5.61 | 6.91 | 7.23 | 31.65 | 51.06 | 41.70 | 41.47 | 166.14 |
| Diesel | 8.15 | 5.08 | 6.18 | 6.47 | 35.61 | 57.43 | 47.06 | 46.70 | 165.75 |

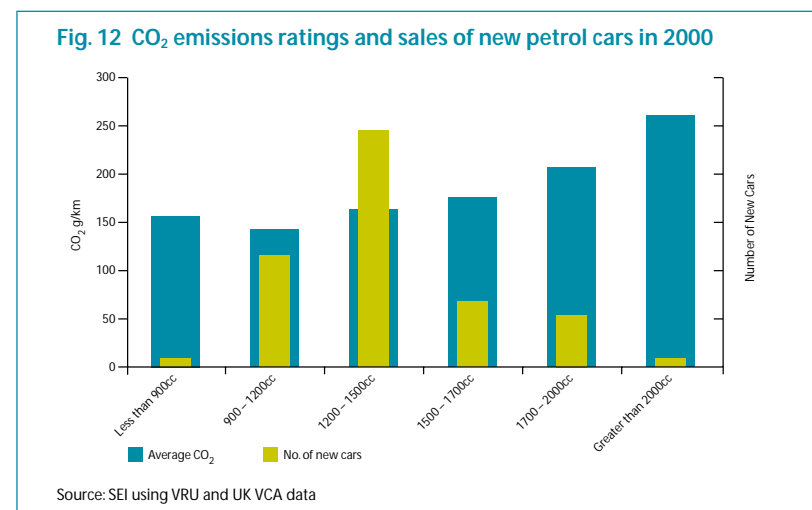
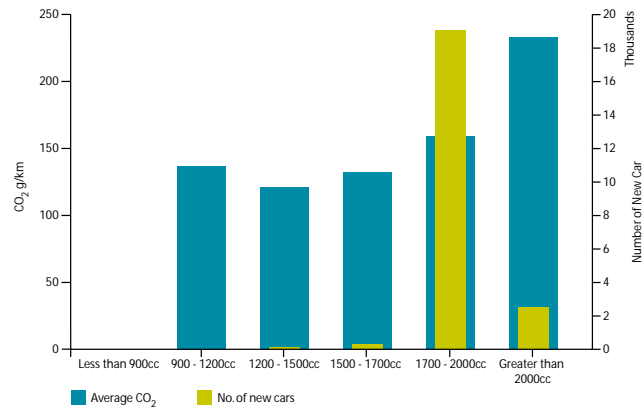


Fig. 13 CO₂ efficiency and sales of new diesel cars in 2000



Source: SEI using VRU and UK VCA data

- Sales diminish progressively through the higher bands of engine size, which also correspond to the larger, less energy and CO₂ efficient cars.

It is important to reiterate, however, that this is a snapshot from a single year and that similar future exercises will help to establish whether the trend for the new additions as a whole is towards an increase or decrease in efficiency.

Similarly interesting observations exist from figure 13, for new diesel cars registered in Ireland in 2000:

- The trend in efficiency with growing engine size generally mirrors the case

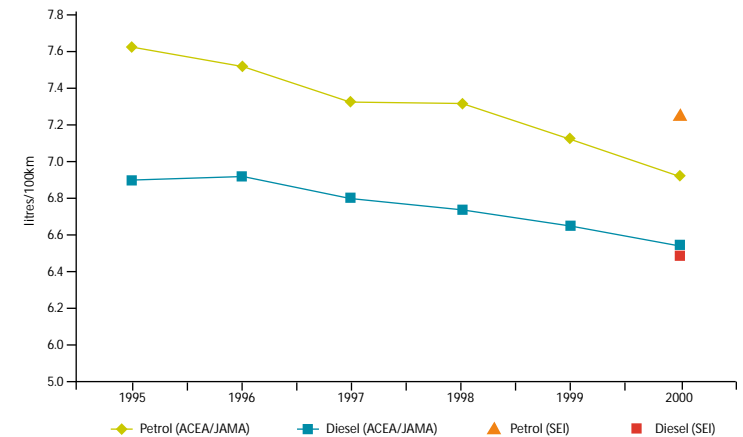
for petrol cars. An initial increase in efficiency is followed by a trend towards inefficiency as engine size increases;

- Diesel cars in the 1200 – 1500cc range were the most efficient on average, but account for only a small number (0.2%) of the cars registered in 2000;
- The dominant segment (87%) of new diesel cars entering the fleet was in the 1700 – 2000cc range. This is on average the second least energy efficient band.

Prior to this work, the only available data on the efficiency of new vehicles in Ireland came from industry sources such as ACEA, JAMA and KAMA¹⁰. Their results are presented in figure 14 together with the new national figures for year 2000

¹⁰ACEA: European Automobile Manufacturers Association
JAMA: Japanese Automobile Manufacturers Association
KAMA: Korean Automobile Manufacturers Association

Fig.14 Fuel efficiency of new cars – Industry figures and new national figures



Source: EU SAVE Energy Indicators Project¹¹

from table 1 representing average data of 7.23 litres/ 100 km for petrol cars (triangle) and 6.47 litres/ 100 km for diesel cars (square) for comparison.

Appendix B gives extracts from independent test data on the best CO₂ performing and top selling new car models on the Irish market in year 2000.

4.2 CO₂ emissions from new cars

The actual impact of changing levels of efficiency on GHG (and other) emissions will only be possible when information on actual patterns of car usage is

available. However, by making some informed assumptions about average annual mileage travelled, some insight can be gained into the effect that purchasing behaviour can have on environmental emissions.

Assuming that the average car covers 20,000 km per annum¹² then the CO₂ produced by this cohort of new cars can be calculated by weighting and multiplying the average CO₂ g/km for each engine size band by the number of cars sold in each corresponding band. The results are given in table 2, showing that annual CO₂ emissions from new cars

¹¹Energy Efficiency in Ireland (1990 – 2000). Sustainable Energy Ireland, May 2002.

¹²This compares well with the estimated average of 20,345 km in 2001 derived from the TRL report 'Vehicle Kilometres of Travel in Ireland 2001' for the National Roads Authority, December 2002.

registered in 2000 are estimated at 731 thousand tonnes (**731 kt CO₂**).

Table 2 Total CO₂ emissions estimate from new cars on the road in 2000

| | CO ₂ emissions from cohort of new cars |
|---------------|---|
| Petrol | 658.8 kt CO ₂ |
| Diesel | 72.0 kt CO ₂ |

Again it has to be stressed that these figures are theoretical, based on the test consumption figures. Therefore, actual emissions will be different (subject to the mileage assumptions, on-road driving patterns and maintenance).

4.2.1 Exploring a shift in purchasing behaviour

It is now possible to carry out a scenario analysis, based on different purchasing patterns. This is important in terms of assessing the strength of the case behind proposals to rebalance the VRT and annual road tax in order to influence these patterns – possibly with the assistance of provisions already in force under the EU directive on fuel economy and CO₂ emissions labelling of new cars.

What if purchase behaviour could be influenced so as to affect a shift of say 10% from one engine range band to the nearest more efficient band? In this scenario 10% of sales from the range

greater than 2000cc are transferred to the 1700 – 2000 cc range. Similarly 10% of the cars sold in the 1700 – 2000 range are now assumed to be sold in the 1500 – 1700cc range and so on. In all cases but two, the 10% shift will be towards a lower band. There is no 10% shift from the 900 – 1200 cc band as this is the most efficient band. In the case of cars less than 900 cc, the 10% shift is towards the more efficient 900 – 1200 cc band.

The impact of this scenario for a single year would be an annual saving of **9 kt CO₂**, or *1% of the total*, compared to emissions for the actual profile of car sales. If this scenario continued, the savings would be **cumulative** on a yearly basis until full turnover of the stock occurred.

4.2.2 Exploring a shift in user behaviour

For comparison, another useful scenario may be developed by examining annual mileage to see what effect reducing mileage levels would have on emissions. The annual mileage figures are clearly estimates however and if we consider a fixed reduction in mileage it is immaterial what these estimates are. If a reduction of say 2,000 km/annum (10% of the estimated annual mileage) is considered, but with no change in proportionality between urban and non-

urban driving, this is estimated to result in the annual savings shown in Table 3.

Table 3 Annual CO₂ emissions avoided from new cars (2000) with a 2,000km reduction in mileage

| | |
|---------------|-------------------------|
| Petrol | 65.9 kt CO ₂ |
| Diesel | 7.2 kt CO ₂ |

Thus reducing the annual mileage driven by 2,000km would reduce the CO₂ emissions of just the new cars on the road for the year 2000 by **73 kt CO₂**. This represents 10% of their total estimated emissions.

These exercises point to potential impacts that might arise from successfully influencing purchasing behaviour and limiting car usage. It is worth recalling that the NCCS target emissions reduction to be achieved by adjusting VRT and annual road taxes is 500 kt CO₂, while a further target reduction of 100 kt CO₂ is associated with fuel economy and CO₂ labelling of all new cars as required under EU directive 1999/94/EC.

4.3 CO₂ emissions from the total national fleet of cars

The preceding analysis focused on the 225,269 new additions to the private

car fleet in 2000 only, which accounted for 17% of the total fleet (1,319,250 cars). This section provides a preliminary extension of the above type of analysis to the total fleet. Some further conclusions are then drawn regarding the impacts of changes in purchasing patterns and in car usage on GHG emissions.

A further scenario exercise is applied to the total stock of cars on the road based on the hypothetical assumption that all cars on the road in the year 2000 were year 2000 models. The resultant emission figures calculated will be potential minimum figures, at some level below the actual emission levels, for two reasons: firstly because the actual cars on the road will be a mixture of new and old with the old generally tending to be less efficient than the new; and secondly because the emissions are based on idealised test figures and are likely to be greater in practice.

If all cars on the road in 2000 were 2000 models and average annual mileage is assumed to be 20,000km, then the emissions from private cars would have been **4.4 Mt CO₂**. This estimate appears quite a reasonable starting point, when compared with the estimate of 4.6 Mt CO₂¹³ provided in section 2.2.1.

¹³EPA's emissions inventory for Ireland for 2000 attributes 4.6 Mt CO₂ from petrol and 4.9 Mt CO₂ from diesel within road transport. Under the assumption that 90% of petrol and 10% of diesel from road transport is attributed to private cars, the calculated figure concurs with the inventory data.

4.3.1 Potential impact of changes in purchasing behaviour

It was noted in section 4.2.1 that the effect associated with shifts in purchasing behaviour would be cumulative. This means that the annual avoided emissions would increase incrementally as new vehicles enter the fleet each year, until entire fleet replacement has occurred. This has firstly been estimated by exploring the impact of replacing the entire year 2000 fleet with new cars that are 2000 models. If this replacement fleet were to have the same structure (in terms of engine capacity) as the cohort of new cars added in 2000, then an assumed 10% shift in purchase selection of **all** cars on the road to the nearest more efficient engine capacity band would yield an annual emissions reduction of **53 kt CO₂**. This represents 1.2% of CO₂ emissions from the total private car fleet.

Another approach is to again assess the impact of replacing the entire 2000 fleet with new cars that are 2000 models, but assuming retention of the actual structure of the entire fleet in 2000 (not the structure of the cohort of new cars added in 2000). On this basis, an assumed 10% shift in purchase selection of **all** cars on the road to the nearest more efficient engine capacity band would yield a lesser saving, of **30 kt CO₂** per annum. This represents 0.7% of CO₂ emissions from the total private car fleet. The lower

impact reflects the fact that new additions to the fleet in year 2000 comprised a greater proportion of large (and less efficient) models, with more scope for emissions reduction. No difference is attributable to efficiency improvements for individual models as they are assumed to be 2000 models in both cases.

These hypothetical impacts relate to the effective NCCS target abatement of **600 kt CO₂** per annum by 2010 for VRT and annual road tax rebalancing plus fuel economy labelling. While the tax rebalancing is for all road vehicles, not just private cars, these assessments highlight the scale of the challenge posed in meeting this target.

4.3.2 Potential impact of changes in user behaviour

It will be recalled that in section 4.2.2 the single year effect of a 2,000 km per annum reduction in average mileage by new cars registered in year 2000 was assessed. This effect is now considered for such a change in car usage extended to the entire fleet.

In such an event, with the structure of the private car fleet remaining unchanged and with no change in proportionality between urban and non-urban driving, a reduction in average mileage by 2,000km for the full fleet would yield a saving of **441 kt CO₂** per annum. (In practice, the

savings in such a scenario would be likely to be higher as the exercise assumed all cars to be 2000 models whereas the fleet as a whole is on average less efficient than the new cohort for year 2000.) This would represent a 10% reduction in the total estimated CO₂ emissions from the entire national car fleet, and would be recurring each year.

This hypothetical impact can be compared against the NCCS target abatement from a range of 'modal shift' and 'demand management' measures in transport. While the target breakdown is unclear, a figure of **350 kt CO₂** per annum by 2010 is associated with public transport and traffic management measures, which can logically be linked to reduced consumption from private cars.

4.3.3 Potential combined impact of behaviour changes

The combined impact of the changes in car purchasing behaviour and user behaviour as explored in this analysis would be an estimated abatement of **471 kt CO₂** per annum. This compares against an indicative corresponding NCCS target of up to **950 kt CO₂** per annum.

It has not been within the scope of this study to investigate the extent to which these market effects themselves (changing car purchase patterns and reducing private car fuel demand) are achievable. Whether this is the case would

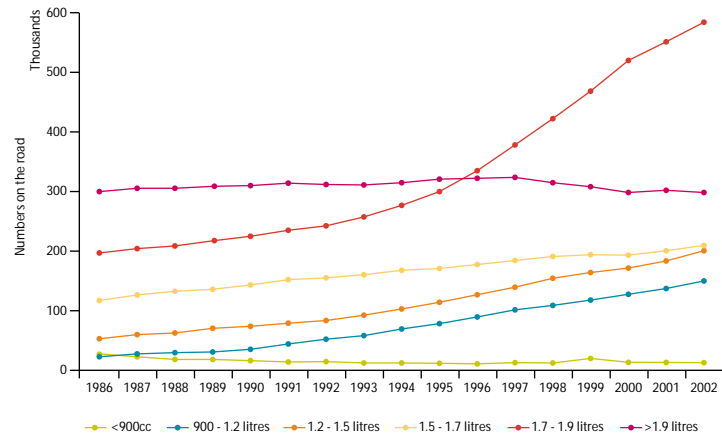
require an analysis of economic elasticity of response to VRT, annual road tax and fuel tax rebalancing, as well as motivation and facility to shift to public transport and other choices. Such analysis is beyond the scope of this report. It is to be noted however that the price elasticity of response in private car fuel consumption is often perceived to be low relative to other sectors of the economy.

4.4 CO₂ emissions resulting from change in car fleet structure since 1990

The scenario exercises above have made assumptions regarding potential changes in purchasing patterns based on data for a single year. However, some more detailed data is available from the VRU on the changes in the car population on the roads, based on engine size since 1990.

It is clear from this data, presented in figure 15, that consumer behaviour has changed over time regarding the engine size of cars purchased. In 1990 for instance the dominant engine size was in the 900 – 1200cc range, accounting for 38.6%. As the graph shows, this has been overtaken to a large extent by the 1200 – 1500cc range, which has increased significantly over the period and now accounts for 40.1% of all private cars (both petrol & diesel). Cars within the 1700 – 1900cc range have also increased considerably since 1990 from a share of

Fig. 15 Change in car engine size 1990 – 2002



Source SEI: Energy in Ireland 2002 (updated)

4.4% to 10.5%. The share in the over 1900cc range grew from 9.1% in 1990 to 13.9% in 2002.

It is clear then from figure 15 that the structure of the fleet in 2000 has shown a pronounced shift from what it was in 1990.

It has been claimed¹⁴ that the efficiency of cars on Irish roads has increased in recent years. Without doubt newer versions of each model tend to be more fuel-efficient than their counterparts of ten years ago. However, taking the fleet

as a whole, if the structure of the fleet is changing to one that has a higher proportion of larger engine sizes, that are generally less efficient than other models, then this will tend to diminish the gains associated with the increases in technical efficiency.

It would appear from figure 14 that the increases in car technological efficiencies have outweighed efficiency reductions arising from structural changes in the purchase of new cars. This will be further evaluated in future reports when data for 2001 and for 1997

– 1999 are incorporated into the analysis and a trend is produced.

The structural effects can be examined in isolation from efficiency gains and from increases in car usage to determine their role in increasing emissions. This is carried out by comparing the actual emissions from cars in 2000 with what the emissions would have been had the structure of the fleet remained as it was in 1990.

This scenario requires a number of working assumptions. The first theoretical assumption is that all models on the road in 2000 are 2000 models. This as already stated will understate the actual emissions. The next step is to reconstruct the 2000 fleet but using the structure of 1990 and again assuming that they are all 2000 models.

This again will understate the emissions. Details of the car models that were extant in 1990 are not available. However, assuming the models to be 2000 models allows assessment of the effect that the structural change alone has had on emissions from car transport. The final assumption is that the average mileage is 20,000 km/annum.

Based on these assumptions and the data supplied by VRU and the EU database on fuel consumption and CO₂ emissions, it is estimated that the shift in structure of the national car fleet between 1990 and 2000 has resulted in an additional **169 kt CO₂** being emitted in the year 2000.

¹⁴ Emissions from Road Transport 1990-2000, Goodbody Economic Consultants, Sept. 2001

5 Conclusion and Next Steps

Energy consumption in transport in Ireland is increasing in line with economic growth and is the fastest growing source of CO₂ emissions. Energy related CO₂ emissions in transport were 120% above 1990 levels in 2001, by which time transport represented 26% of Ireland's energy related CO₂ emissions.

It is estimated that private car transport accounted for approximately 40% of transport energy usage in 2000. This represents approximately 1.6 Mtoe of energy usage and approximately 4.6 Mt CO₂ (this excludes other greenhouse gases arising from private cars). Between 1990 and 2000, the number of cars relative to the size of the population grew by more than 50% to 348 cars per thousand of population.

Ireland's private car fleet at the end of year 2000 consisted of 1,319,250 vehicles, of which 225,269 (17%) were purchased during 2000. On average over the last five years however, new cars accounted for 13% of the fleet. If this average ratio were to be maintained with no further fleet growth and new cars displaced the oldest cohort of cars, it would lead to a fleet replacement in over 7 years. In practice, the fleet is still growing and the numbers of new cars registered is more than double the attrition level of older cars. Since 1991, 786,884 private cars have left the fleet. There were 836,583 cars registered by the end of

1991, suggesting fleet replacement took 11 years.

One of the series of measures for consideration under the National Climate Change Strategy regarding energy use in transport relates to rebalancing VRT and annual road tax to reflect the CO₂ efficiency of cars, rather than basing the taxes on engine size per se. The target annual emissions reduction for these measures is 0.5 Mt CO₂ by 2010, compared with NCCS business as usual projections. A further target reduction of 0.1 Mt CO₂ is associated with fuel economy and CO₂ labelling of all new cars, as required by EU directive 1999/94/EC.

On average, the most efficient new petrol cars registered in 2000 in terms of CO₂ emissions are in the 900-1200cc range, in which 23% of the new cars in 2000 were bought. While it might be anticipated that larger cars are generally less efficient, it is interesting to note that smaller cars, in the range less than 900cc, are also less efficient.

The most popular new petrol cars were in the 1200 – 1500cc range, representing approximately 50% of new petrol cars.

Assuming that the average car (petrol or diesel) travels 20,000 km per annum, the annual CO₂ produced by new cars registered in 2000 would be 731 kt

(based on the weighted average test values for CO₂ efficiency).

Using the above assumptions on mileage, shifting 10% of cars in each engine capacity band to the nearest more efficient band would result in an abatement of **9 kt CO₂** in one year. This would be cumulative until full fleet replacement had taken place, at which point the annual abatement would reach **30 kt CO₂** per annum.

This compares with the theoretical effect of a 2,000 km reduction in annual mileage driven by new cars registered in the year 2000, which would be to achieve a recurring abatement in CO₂ emissions by **73 kt CO₂**. The abatement for such a shift in user behaviour extending across the entire fleet is estimated at **441 kt CO₂** per annum.

The combined impact of the changes in car purchasing behaviour and user behaviour as explored in this analysis would be an estimated potential abatement of **471 kt CO₂** per annum. This compares against a corresponding NCCS target of up to **950 kt CO₂** per annum by 2010, which is composed of approximately 600 kt CO₂ and 350 kt CO₂ from changes in purchase behaviour and user behaviour respectively.

The increase in emissions from the private car segment of transport reflects

an increase in the number of cars on the road, an increase in car usage and changes in the structure of the fleet towards larger cars. Against this, there are continued improvements in the technical efficiency of new cars. Based on data supplied by the motor industry it would appear that the positive impact of improved technical efficiency is exceeding the negative efficiency impact arising from the trend towards purchasing bigger cars. Comparing the results of the analysis carried out for one year with the figures from the motor industry, the efficiency of new additions to the fleet as a whole seems to be improving over time.

An examination of the changing structure of the private car fleet, separate from improvements in efficiency or car usage, indicates that such structural changes have led to at least **169 kt CO₂** in additional emissions in 2000 compared with 1990.

It is noteworthy that an element of policy pertinent to influencing purchasing behaviour is already in force since August 2001, in the form of regulations giving effect to the EU directive on fuel efficiency and CO₂ emissions labelling of new passenger cars. All new passenger cars for sale must be individually labelled with fuel economy and CO₂ emissions information. Posters must also be displayed in showrooms giving the

information for all models for sale, and fuel consumption and CO₂ emissions data must be included in promotional material. A free guide is produced and regularly updated by the Society of the Irish Motor Industry (SIMI) for all models of new passenger cars offered for sale or lease within the State.

The scenario analysis carried out on the possible effect of shifting the purchase behaviour of car owners to more efficient models should help to give a sense of quantifiable impacts to policy makers. The analysis does not attempt to assess what the possible effect on purchase behaviour (or economic elasticity of response) will be from measures such as rebalancing of VRT or annual road tax or vehicle labelling. What it does is to quantify what the effect on emissions would be were a particular target level of change in behaviour achieved as a result of such measures.

In order to gain a fuller picture of the impacts on emissions arising from the changing structure of the fleet and improvements in efficiency of new models, it would be necessary to source a database of test values for the car models that were on the market in 1990 and subsequent years. Sales weighting of the efficiencies of different models could

then be carried out as was done here for the year 2000. This may be possible for the years 1997 onwards.

In addition, moving forward, it is planned that this type of analysis will be carried out for 2001 onwards as the data becomes available.

Next steps to deepen understanding of the evolution of energy use in private road transport will focus on sourcing and evaluating additional data. It may be possible to source a historical database of model test values internationally that would allow historical trends to be assessed. It may also be possible to source untapped domestic sources to fill gaps on average annual mileage perhaps by engine size and fuel type. There may also be scope to commission research into the actual fuel consumption of vehicles on the road to see how this differs from the test values and throw some light on driving habits. Indeed the former *An Foras Forbartha* and the former *National Board for Science and Technology* had first mooted the need for this type of research in 1980¹⁵.

Data Sources

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Appendix A Sales weighted fuel consumption data for Irish car market

A.1 Sales weighted fuel consumption for petrol cars (2000)

| | Litres/100km | | | Miles per Gallon (mpg) | | | CO ₂ g/km |
|----------------------------|--------------|-------------|----------|------------------------|-------------|----------|----------------------|
| | Urban | Extra-Urban | Combined | Urban | Extra-Urban | Combined | |
| Overall | 9.18 | 5.61 | 6.91 | 31.65 | 51.06 | 41.70 | 166.14 |
| Less than 900cc | 7.90 | 5.10 | 6.10 | 35.80 | 55.40 | 46.30 | 157.39 |
| 901 – 1000cc | 7.34 | 4.95 | 5.81 | 38.59 | 57.18 | 48.68 | 140.74 |
| 1001 – 1100cc | 8.53 | 5.07 | 6.33 | 33.17 | 55.83 | 44.70 | 151.33 |
| 1101 – 1200cc | 8.21 | 5.12 | 6.26 | 34.51 | 55.30 | 45.26 | 148.79 |
| 1201 – 1300cc | 8.51 | 5.39 | 6.55 | 33.61 | 52.84 | 43.59 | 155.18 |
| 1301 – 1400cc | 9.14 | 5.57 | 6.86 | 31.03 | 50.83 | 41.29 | 165.96 |
| 1401 – 1500cc | 8.78 | 5.65 | 6.77 | 32.19 | 50.13 | 41.81 | 162.41 |
| 1501 – 1600cc | 9.96 | 5.84 | 7.33 | 28.47 | 48.61 | 38.68 | 175.98 |
| 1601 – 1700cc | 9.70 | 6.10 | 7.40 | 29.10 | 46.30 | 38.20 | 178.00 |
| 1701 – 1800cc | 11.40 | 6.55 | 8.33 | 25.04 | 43.56 | 34.22 | 199.95 |
| 1801 – 1900cc | 11.22 | 6.23 | 8.09 | 25.30 | 45.51 | 35.00 | 192.57 |
| 1901 – 2000cc | 12.62 | 7.11 | 9.13 | 22.51 | 39.95 | 31.06 | 218.54 |
| 2001 – 2100cc | – | – | – | – | – | – | – |
| 2101 – 2200cc | 13.02 | 7.38 | 9.45 | 21.88 | 38.42 | 30.08 | 226.78 |
| 2201 – 2300cc | 14.03 | 7.33 | 9.81 | 20.18 | 38.61 | 28.79 | 234.21 |
| 2301 – 2400cc | 16.44 | 8.33 | 11.28 | 17.49 | 34.10 | 25.30 | 270.66 |
| 2401 – 2500cc | 13.57 | 7.47 | 9.71 | 20.97 | 37.99 | 29.28 | 233.77 |
| 2501 – 2600cc | 15.72 | 7.84 | 11.13 | 18.06 | 36.12 | 25.65 | 259.47 |
| 2601 – 2700cc | 14.70 | 7.47 | 10.01 | 19.18 | 37.88 | 28.23 | 247.00 |
| 2701 – 2800cc | 15.69 | 7.85 | 10.73 | 18.17 | 36.14 | 26.49 | 257.63 |
| 2801 – 2900cc | – | – | – | – | – | – | – |
| 2901 – 3000cc | 16.17 | 8.36 | 11.24 | 17.56 | 33.86 | 25.21 | 277.71 |
| Greater than 3000cc | 17.81 | 8.88 | 12.12 | 16.04 | 32.40 | 23.63 | 291.73 |

Appendix B Best performing and top selling new models on Irish market 2000

A.2 Sales weighted fuel consumption for diesel cars (2000)

| | Litres/100km | | | Miles per Gallon (mpg) | | | CO ₂ g/km |
|----------------------------|--------------|-------------|----------|------------------------|-------------|----------|----------------------|
| | Urban | Extra-Urban | Combined | Urban | Extra-Urban | Combined | |
| Overall | 8.15 | 5.08 | 6.18 | 35.61 | 57.43 | 47.06 | 165.75 |
| Less than 900cc | - | - | - | - | - | - | - |
| 901 – 1000cc | 7.00 | 4.53 | 5.43 | 41.00 | 62.63 | 52.53 | 135.33 |
| 1001 – 1100cc | - | - | - | - | - | - | - |
| 1101 – 1200cc | - | - | - | - | - | - | - |
| 1201 – 1300cc | - | - | - | - | - | - | - |
| 1301 – 1400cc | 5.80 | 3.70 | 4.50 | 48.70 | 76.30 | 62.80 | 120.00 |
| 1401 – 1500cc | 5.80 | 3.70 | 4.50 | 48.70 | 76.30 | 62.80 | 120.00 |
| 1501 – 1600cc | 6.90 | 4.30 | 5.30 | 40.90 | 65.70 | 53.30 | 139.00 |
| 1601 – 1700cc | 6.08 | 4.05 | 4.81 | 46.48 | 69.79 | 58.81 | 130.02 |
| 1701 – 1800cc | 8.28 | 4.98 | 6.18 | 34.88 | 57.69 | 46.65 | 165.13 |
| 1801 – 1900cc | 7.47 | 4.64 | 5.64 | 38.03 | 61.18 | 50.36 | 151.11 |
| 1901 – 2000cc | 8.04 | 5.03 | 6.12 | 35.53 | 57.34 | 46.85 | 164.50 |
| 2001 – 2100cc | - | - | - | - | - | - | - |
| 2101 – 2200cc | 9.62 | 5.87 | 7.24 | 29.81 | 49.56 | 39.91 | 192.85 |
| 2201 – 2300cc | 11.90 | 7.80 | 9.30 | 23.70 | 36.20 | 30.40 | 246.00 |
| 2301 – 2400cc | 7.20 | 4.30 | 5.30 | 39.20 | 65.70 | 53.30 | 143.00 |
| 2401 – 2500cc | 11.92 | 8.00 | 9.42 | 24.17 | 36.71 | 30.84 | 254.46 |
| 2501 – 2600cc | - | - | - | - | - | - | - |
| 2601 – 2700cc | 11.50 | 7.67 | 9.06 | 24.76 | 37.77 | 31.65 | 239.64 |
| 2701 – 2800cc | 10.80 | 8.30 | 9.20 | 26.20 | 34.00 | 30.70 | 244.00 |
| 2801 – 2900cc | 13.12 | 8.19 | 10.00 | 21.75 | 34.62 | 28.36 | 265.88 |
| 2901 – 3000cc | 11.69 | 7.15 | 8.81 | 24.62 | 40.99 | 32.89 | 234.29 |
| Greater than 3000cc | 12.07 | 6.90 | 8.80 | 23.81 | 42.95 | 33.07 | 233.70 |

B.1 Best CO₂ performing models (2000)

| Petrol | | | | | | |
|------------|----------|------|------------------------------|-------------|----------|----------------------|
| Make | Model | Size | Specific Consumption l/100km | | | CO ₂ g/km |
| | | | Urban | Extra Urban | Combined | |
| Toyota | Prius | 1.6L | 5.9 | 4.6 | 5.1 | 120 |
| Daihatsu | Cuore | 1.0L | 6.4 | 4.4 | 5.1 | 124 |
| Daihatsu | Sirion | 1.0L | 6.7 | 4.7 | 5.5 | 129 |
| Suzuki | Swift | 1.0L | 6.9 | 4.7 | 5.5 | 130 |
| Suzuki | Alto | 1.0L | 7.3 | 4.8 | 5.7 | 134 |
| Toyota | Yaris | 1.0L | 6.8 | 5.0 | 5.6 | 134 |
| Opel | Corsa | 1.0L | 7.2 | 4.7 | 5.6 | 135 |
| Fiat | Punto | 1.2L | 7.3 | 4.8 | 5.7 | 136 |
| Seat | Arosa | 1.0L | 7.8 | 4.7 | 5.8 | 139 |
| Volkswagen | Lupo | 1.0L | 7.8 | 4.7 | 5.8 | 139 |
| Fiat | Seicento | 1.1L | 8.3 | 4.7 | 6.0 | 143 |
| Volkswagen | Polo | 1.0L | 8.0 | 4.8 | 6.0 | 144 |

| Diesel | | | | | | |
|---------------|-----------------------|------|------------------------------|-------------|----------|----------------------|
| Make | Model | Size | Specific Consumption l/100km | | | CO ₂ g/km |
| | | | Urban | Extra Urban | Combined | |
| Opel | Astra Y1.7DL | 1.7L | 6.0 | 3.5 | 4.4 | 119 |
| Volkswagen | Polo | 1.4L | 5.8 | 3.7 | 4.5 | 120 |
| Opel | Corsa | 1.7L | 5.8 | 4.1 | 4.7 | 127 |
| Fiat | Punto JTD HLX | 1.9L | 6.6 | 4.0 | 4.9 | 130 |
| Skoda | Fabia 1.9 SDI classic | 1.9L | 6.2 | 4.0 | 4.8 | 130 |
| Audi | A3 | 1.9L | 6.6 | 4.2 | 5.0 | 135 |
| Peugeot | 206 | 2.0L | 6.6 | 4.1 | 5.0 | 136 |
| Volkswagen | Polo | 1.9L | 6.8 | 4.1 | 5.1 | 138 |
| Seat | Cordoba | 1.9L | 6.5 | 4.2 | 5.1 | 138 |
| Mercedes benz | A 170 | 1.7L | 6.8 | 4.4 | 5.2 | 139 |
| Citroen | Saxo | 1.5L | 6.9 | 4.3 | 5.3 | 139 |

B.2 Top selling models (2000)

| Petrol | | | |
|---------------|--------------|--------------------------|---|
| Make | Model | Number registered | Average CO₂ for model Range (CO₂ g/km) |
| Fiat | Punto | 10461 | 139.4 |
| Ford | Focus | 9749 | 161.4 |
| Toyota | Yaris | 8765 | 136.0 |
| Toyota | Corolla | 8712 | 162.0 |
| Nissan | Almera | 8622 | 158.8 |
| Ford | Fiesta | 8555 | 167.6 |
| Nissan | Micra | 8522 | 149.0 |
| Opel | Astra | 8146 | 172.8 |
| Volkswagen | Polo | 7432 | 147.6 |
| Opel | Corsa | 6393 | 137.6 |

| Diesel | | | |
|---------------|--------------|--------------------------|---|
| Make | Model | Number registered | Average CO₂ for model Range (CO₂ g/km) |
| Volkswagen | Passat | 2314 | 154.5 |
| Toyota | Avensis | 1487 | 158.0 |
| Peugeot | 406 | 1367 | 147.1 |
| Volkswagen | Golf | 1216 | 141.1 |
| Skoda | Octavia | 1082 | 143.0 |
| Volkswagen | Bora | 1024 | 160.4 |
| Nissan | Primera | 787 | 179.4 |
| Opel | Vectra | 783 | 154.0 |
| Ford | Mondeo | 734 | 186.6 |
| Ford | Focus | 597 | 142.6 |