

# **LAND USE & TRANSPORT INTEGRATION IN SCOTLAND (LATIS) A NATIONAL CARBON FOOTPRINT**

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## **1. INTRODUCTION**

Interest in carbon emissions associated with the transport sector has intensified in recent years. The impact on carbon levels now forms a key indicator in the assessment of potential transport infrastructure, policy and land use interventions. The assessment tools available for calculating the emissions and other environmental impact or benefits of transport decisions are therefore also becoming increasingly important and sophisticated.

The recently passed Climate Change (Scotland) Bill includes targets for Scotland's greenhouse gas emissions to be at least 80% lower than 1990 levels by 2050, with an interim target of 34% by 2020 (or 42% if a global deal is reached). The transport sector (excluding aviation) is required to deliver 18% (or 27%) reductions by 2020.

Transport Scotland's Land use and Transport Integration in Scotland (LATIS) service provides a land use and transport modelling framework which covers the whole of the Scottish strategic road and public transport network. The framework forecasts changes in land use, traffic levels and travel patterns over time, and can appraise impacts associated with the introduction of transport schemes or policy decisions. It can also forecast changes in traffic and travel levels associated with different economic or demographic scenarios.

The framework uses a combination of traffic levels, traffic speed data, and vehicle fleet assumptions to generate a 'National Carbon Footprint' which covers road transport-related emissions. As noted above, these calculations also include forecast changes to engine and fuel efficiency over time along with an ability to vary the composition of the vehicle fleet. This 'footprint' offers a national perspective and provides a mechanism to assess the potential for various transport interventions to help deliver the challenging targets proposed for reducing carbon emissions.

With challenging targets ahead, interventions for reducing carbon emissions and the methods that predict their potential impact, will have a valuable role to play in the delivery of Scotland's future transport provision.

This paper discusses how the LATIS framework can forecast a road transport related carbon footprint at a national as well as regional and local

level over time, by taking into account interactions between land uses, demographic changes, transport demand, various transport interventions and changes in vehicle technology.

## 2. POLICY BACKGROUND

In June 2009, the Scottish Government passed climate change legislation, the Climate Change (Scotland) Bill (Scottish Government, 2009a), the most ambitious in anywhere in the world, with a target of at least 80% reduction in greenhouse gas emissions in 2050 compared with 1990 levels. The Bill also requires an interim target, 34% emissions reductions by 2020 (42% by 2020 if the EU increases its 2020 emission target from 20% to 30% below 1990 levels - following a potential global deal on climate change).

Total greenhouse gas emissions from all forms of transport (including international aviation and shipping) in Scotland is equivalent to almost a quarter of total Scottish emissions in 2006 and road transport accounted for 70% of all Scottish transport emissions. There has been an average growth of 0.9% p.a. in emissions from road transport since 1990. Table 1 displays a full breakdown of figures for road emissions by source (Scottish Government, 2009b – Consultation on Low Carbon Vehicles).

Table 1. Emission levels and trends in road transport by sources (ktCO<sub>2</sub>e – kilo-tons of carbon dioxide equivalent)

Source	Emissions 2006 (ktCO <sub>2</sub> e)	% of road transport emissions (2006)	Average % growth p.a. (1990-2006)
<b>Cars</b>	6,055	57.6	0.3
<b>HGVs</b>	2,221	21.1	0.5
<b>LGVs</b>	1,716	16.3	4.2
<b>Buses &amp; coaches</b>	421	4.0	0.5
<b>Other</b>	53	0.5	5.9
<b>Motorpeds &amp; Motorcycles</b>	39	0.4	-1.8
<b>TOTAL</b>	10,506	100	0.9

To deliver the overall targets, the transport sector (excluding aviation but including shipping) is required to deliver 18% (or 27%) reductions from 1990 levels by 2020 (based on the 34% and 42% interim reduction targets by 2020). This is equivalent to 23% (or 32%) from 2006 levels (Scottish Government, 2009c – Climate Change Delivery Plan).

The Scottish Government Climate Change Delivery Plan (2009c) includes a range of transport related measures that are required to contribute to the delivery of the 34% Scottish target in 2020. These include:

- Improvements in energy efficiency of petrol and diesel vehicles, and increasing uptake of hybrid and electric engines with supporting infrastructure;
- Smarter Measures including reduced travel and modal shift to less carbon-intensive modes of transport, e.g. public transport and active travel ( e.g. walking and cycling);
- Demand management including road space reallocation;
- Changes to the pattern of development to reduce the need to travel;
- Efficient driving: through improved driving behaviour, e.g. eco-driving, car sharing or lower speed limits;
- Sustainable biofuels; and
- Improved energy efficiency of new ships.

To deliver the more substantial 42% Scottish target in 2020, additional contributions from other measures would be required, potentially:

- More widespread uptake of improved vehicle efficiency in vans and HGVs;
- More widespread adoption of eco-driving; and
- Speed limit reductions on motorways.

In order to deliver such ambitious targets, the Delivery Plan specifies almost complete decarbonisation of road transport by 2050 with significant progress by 2030 through the adoption of electric cars and vans, and significant decarbonisation of rail by 2050 (assuming a decarbonised electricity generation sector).

Most recently, the Scottish Government produced a consultation document on low carbon vehicles (Scottish Government, 2009b). This aims to set targets for the expansion of low carbon vehicles in Scotland and for the development of a realistic action plan to significantly reduce road transport related emissions. Adoption of the new mandatory European targets (EC No 443/2009) which require new vehicles to emit less than an average of 95gco<sub>2</sub>/km by 2020 is perhaps the first step towards the evolution of low carbon vehicles in Scotland.

Annual traffic levels (vehicle km travelled) have been increasing almost constantly since 1975 (Scottish Government, 2008 - Main Transport Trends). In the face of these rising traffic levels, there is an emerging consensus that meeting these targets will require a combination of behavioural change (particularly in the early years) and the wider decarbonisation of road and other transport through a move to electric and other vehicle types.

The challenge is to predict the potential impacts of the above measures at a national level in achieving the Scottish Government's road transport related

emission targets. The remainder of this paper explores how the Land use and Transport Integration in Scotland (LATIS) service has the potential to assist in the appraisal of potential strategies and interventions for reducing emissions.

### 3. OVERVIEW OF THE LATIS SERVICE

The Land use and Transport Integration in Scotland (LATIS) service plays an important role in facilitating decision making across a range of policy areas, including transport, planning, the environment, demographics, health, education and the utilities. It also offers the use of the LATIS Modelling capability, through the Transport Model for Scotland (TMfS) and the Transport, Economic, Land-Use Model of Scotland (TELMoS).

These services provide a framework and range of appraisal tools that allow for a consistent approach to land use and transport appraisal across Scotland.

The LATIS Service consists of four key elements:

- **User Engagement** - A programme of consultations and events providing opportunities for stakeholders to discuss the application and development of LATIS;
- **Modelling** - Use and support for the transport and land-use models (TMfS / TELMoS);
- **Planning** - The collection and provision of Local Authority based planning data; and
- **Data Collection** - The collection of travel data and other user specified data.

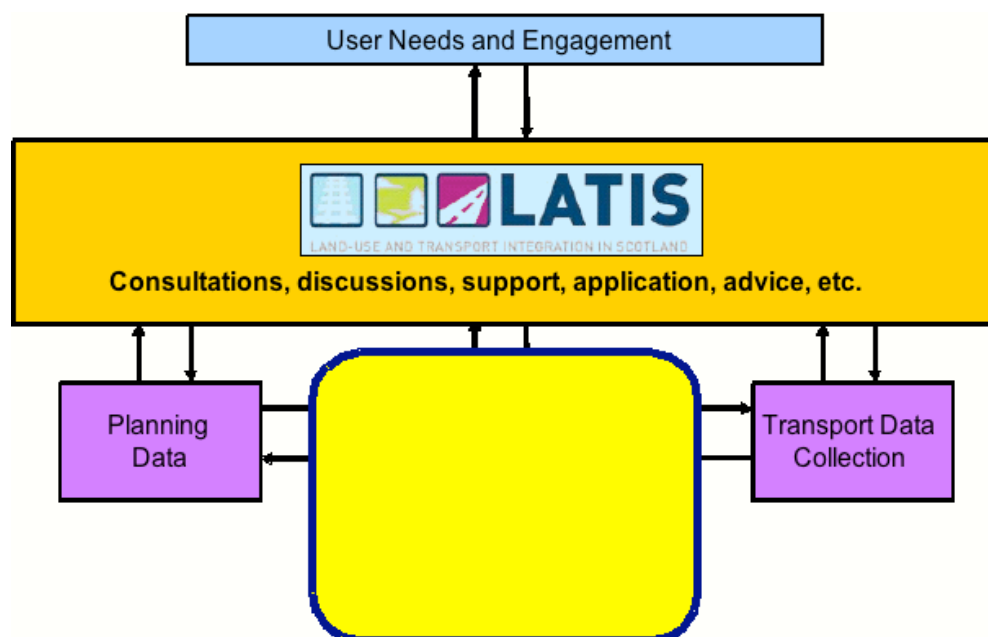


Figure1. Services Offered by LATIS

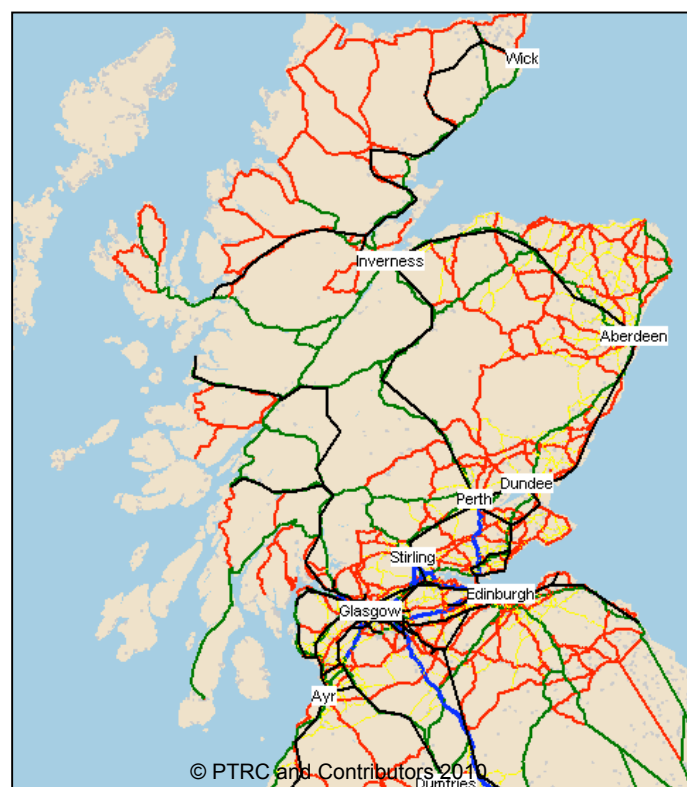
More information about these services is available at the LATIS website: [www.latis.org.uk](http://www.latis.org.uk) or the LATIS team at [LATISsupport@mvaconsultancy.com](mailto:LATISsupport@mvaconsultancy.com).

#### 4. LAND USE, TRAFFIC AND CARBON EMISSIONS FORECASTING

Achieving closer ties between the land use and transport sectors has been a long-standing issue within the transport and development planning sectors. There is growing recognition within both professions that realising the transport impacts associated with development strategies earlier in the planning process can play an important role in minimising pressures on the transport system, and in encouraging a more sustainable approach across the planning system. In Scotland, this approach has been recognised with the adoption of reforms to the way development plans covering key regional areas are prepared.

Traditional development and transport impact assessment techniques, whereby individual developments or local plans are studied in isolation are changing - as there is an increasing necessity to investigate the combined impacts of large scale development and land use strategies at the regional or national level.

LATIS provides a land use and transport modelling framework which covers the whole of the Scottish strategic road and public transport network. The framework offers the ability to forecast changes in land use and travel patterns over time and appraise the operational, economic and environmental impacts associated with the introduction of transport schemes or policy decisions. It can also assist in the prediction of changes



associated with different economic or demographic scenarios.

Figure 2. LATIS Geographical Coverage

LATIS uses Local Authority based planning policy data, demographic and economic forecasts and changes in transport infrastructure to forecast changes in travel and traffic patterns over time. These traffic forecasts are then used to predict future changes in road-based Carbon emissions.

The processes applied within the LATIS modelling capability are summarised in Figure 3.

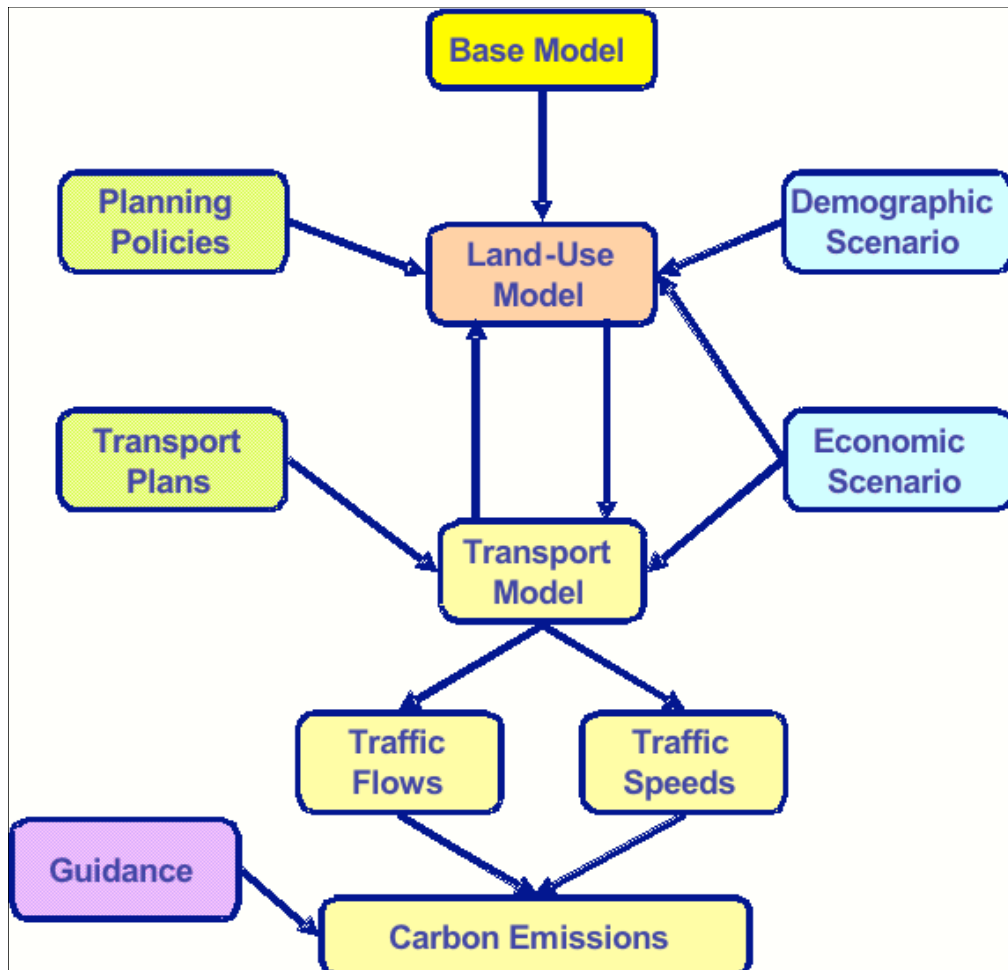


Figure 3. LATIS Modelling Process

LATIS focuses on the calculation of road based Carbon emissions from vehicle exhausts (ie cars, buses and light and heavy goods vehicles). At present, the service does not attempt to reflect Carbon emissions associated with housing or business developments, construction or operation of transport infrastructure or travel by rail, air or sea. Motorcycle emissions are also excluded from the current modelling.

The land use, transport and emissions components that are included within the modelling framework are discussed further within the following sections.

#### **4.1. LAND USE MODELLING**

Land use and transport provision are closely related issues, with each being reactive to the other. New transport schemes or policies may influence land use changes in forthcoming years and likewise, land use pressures may necessitate investments in transport. As a result, LATIS must account for the impact of current and projected land use patterns across Scotland.

The TELMoS land use model works in interaction with the transport model (TMfS). TELMoS supplies TMfS with forecasts of the land-uses which generate the demands for travel, and TMfS supplies TELMoS with the transport data (or travel costs) which influences the subsequent location of households and jobs.

The LATIS team consults with and collects land use data from each Scottish Local Authority. This includes information relating to existing levels of floor space associated with residential, business, industrial, leisure, retail, health and education based land uses. Information associated with future development plans and planning permissions is also collected at a disaggregate level.

Current and future land use data is input to TELMoS and provides a basis for forecasting changes in land use and levels of population and economic activity across Scotland.

National economic information along with national population projections are applied to the modelling methodology to ensure the model reflects nationally based forecasts at the Scotland-wide level.

The economic strategy applied has been estimated so as to reproduce levels of national economic growth that are consistent with externally generated forecasts and assumptions. For the period to 2021, the strategy reflects the rates of growth agreed with the Scottish Government for the appraisal of transport interventions.

The demographic model within TELMoS has been constrained so that the totals of households and population reflect the population trends implicit within the General Register of Scotland's (GRoS) national population forecasts for the period to 2021.

Using this information, the land use model generates future planning data forecasts, predicting changes in household, population, employment and car ownership levels. These forecasts are input to the transport model to

generate travel and traffic forecasts over the short, medium and long term horizons.

Note that the current forecasts are based on planning information and growth assumptions brought together at the end of 2007 and are therefore not expected to account for recent changes to the UK economy. The forecasts aim to present 'one longer term view' of potential changes to population and land uses over time based on a set of agreed assumptions. These assumptions are subject to change as development plans evolve over time and the impact of the recent economic downturn to future growth expectations is taken into account. This should be borne in mind when interpreting the forecasts discussed within this Paper.

LATIS is capable of appraising different economic / demographic and land use scenarios which may have a substantial effect on traffic forecasts and therefore on carbon emissions. For example, lower economic growth will have an impact on land use developments over time (ie housing and employment take-ups) and employment levels which in turn will have a clear impact on trip generation (need to travel and frequency of travel) and distribution (trip destination and therefore trip length) and mode choice. In such scenarios, it is likely that local journeys on foot and cycling will increase for most journey purposes, reducing the need to travel by car.

TELMoS comprises a number of different sub-models (economic, urban and migration models). Some of these operate at the TMfS zone level and calculate change in household and population numbers, car ownership levels, location and property markets, employment activity, physical development and environmental quality. Others work at an area level and calculate change in economic activity and migration (the areas are based on travel-to-work patterns). As a result of the interactions between economic activities and the travel of household members, LATIS forecasts traffic levels.

LATIS is also capable of testing one of the Scottish Government's Climate Change Delivery Plan measures, 'choices about the location of new developments' through its TELMoS and TMfS interaction to demonstrate the reductions in need to travel or to reduce the carbon intensity of travel.

## **4.2. TRANSPORT MODELLING**

TMfS provides a platform for predicting the challenges which could be posed by changing land uses and travel patterns, helping to ensure that appropriate mitigation measures are in place when they are needed.

TMfS is designed to forecast how the current observed pattern of travel in Scotland will evolve over time under the influence of the various factors which affect people's travel choices. Its outputs also provide predictions of



the corresponding impacts of these changing travel patterns on congestion, road accident casualties, public transport and traffic emissions.

TMfS contains road and public transport assignment models and a four stage demand model covering the principal traveller choices of route, mode and destination. These components are used to assess responses to changes in transport interventions, policies and land use.

The base year transport model reflects the Scottish road and public transport system in 2007. Relevant committed transport infrastructure schemes (such as the M74 Completion, Airdrie to Bathgate Rail Scheme, Glasgow Airport Rail Link etc) are added into the model to generate a 'Do Minimum' scenario, which aims to reflect the impacts associated with changes to the transport network expected to be introduced in the future.

Land use forecasts and assumed changes to travel costs, (such as fuel price) are included into the Do Minimum scenario to predict changes in traffic levels and travel patterns over time.

These changes in travel demand (or trips) are assigned to the Scottish transport network allowing the model to generate traffic flow and speed forecasts on a road or link-by-link basis. Traffic forecasts include separate estimates for cars, buses and light and heavy goods vehicles and are applied to the DMRB methodology for calculating Carbon emissions from road traffic vehicle exhausts. The model uses 'standard' WebTag assumptions for forecasting values of time and fuel prices into the future.

Based on the land use, demographic and transport assumptions described above, Figure 4 illustrates the current LATIS predictions associated with future traffic levels across Scotland. Note that the figure for modelled flows in 2007 is close to the published total for 2007 – this shows that the model, although strategic, accounts for the large majority of Scottish traffic.

The modelling demonstrates a consistent growth in traffic levels (measured by vehicle kilometres) over time, generating around a 25% growth in traffic between 2007 and 2021. This outcome generally follows the input data, which assumes a growth in household, population and employment levels over the long term horizon. This increase in traffic may also reflect changes in travel patterns associated with new transport infrastructure schemes.

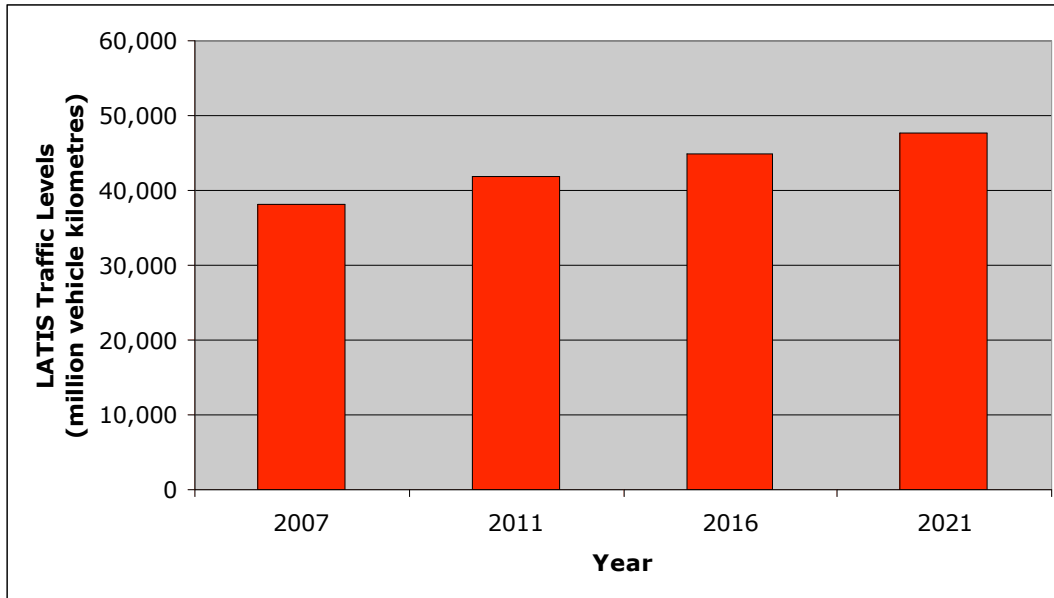
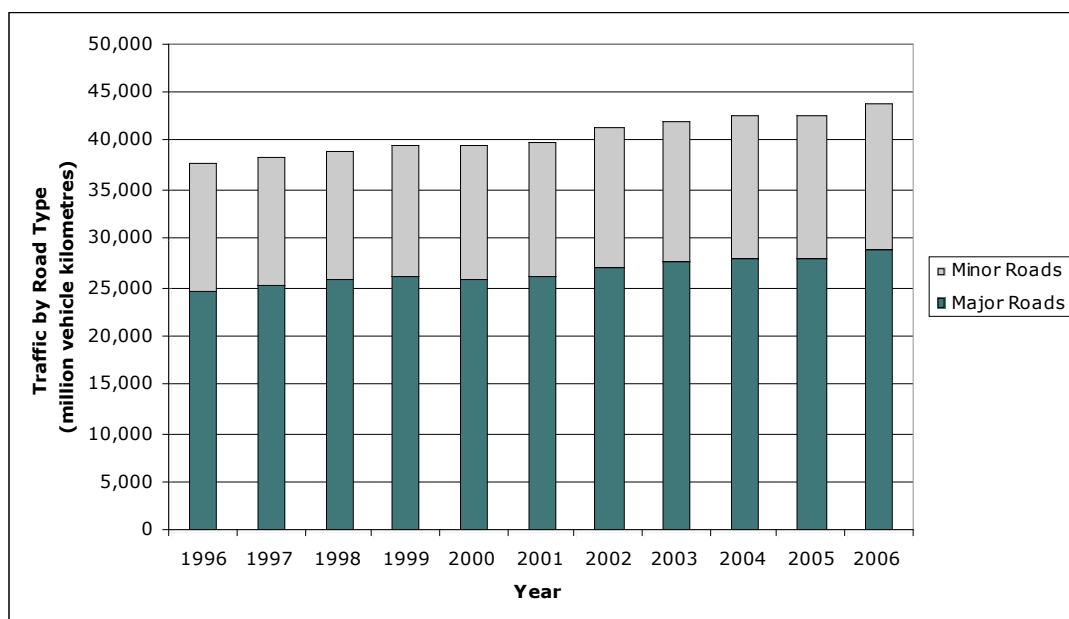


Figure 4. Predicted Road Traffic Levels (LATIS: 2007-2021)

These traffic forecasts also compare similarly to recent trends associated with Scottish traffic levels. Figure 5 describes recent changes to recorded traffic levels over a 10 year period from 1996 to 2006.

The information, (extracted from Scottish Transport Statistics) indicates that during the last 10 years, Scottish traffic levels (measured by vehicle kilometres on all roads) have increased by around 16%. The LATIS forecasts generally reflect these recent trends and suggest that, based on the current assumptions, this level of traffic growth is likely to continue in the future.



## Figure 5. Scottish Road Traffic Levels – Vehicle Kilometres (1996-2006)

Source: Scottish Transport Statistics 2007, Table 6.1: Traffic by Road Class and type.

As the emission of carbon is closely linked to the distance travelled (or fuel used) by motorists, increased traffic levels clearly pose an additional challenge to policies that aim to stabilise or cut carbon emissions associated with road traffic, unless offset by technological improvements.

LATIS is capable of testing the impact of many of the measures listed in the Scottish Government's Climate Change Delivery Plan on road traffic levels and carbon emissions over time. These include changes in fuel price, road space reallocation, parking strategies, speed reductions and smarter choices. In addition the impacts of alternative fuel and vehicle technologies can be assessed through the assumptions made regarding the vehicle fleet.

This allows the Scottish Government to assess their climate change policies, legislation and action plans as they evolve over time.

### **4.3. EMISSIONS MODELLING**

There are various methodologies available for calculating the emission of Carbon from road traffic. LATIS uses a program called 'ENEVAL' to calculate changes in emissions, based on traffic flow and speed forecasts output from the transport model. These traffic outputs cover cars, LGV's, HGV's and buses and are used in tandem with the guidance contained in the DMRB.

The emissions calculations apply an average emission of Carbon (grams per km) for each vehicle travelling at a given speed. Different emission rates are applied to the various vehicle types and these rates are assumed to change over time. An example rate or curve applied for the emission of Carbon (relating to car traffic) is shown in Figure 6.

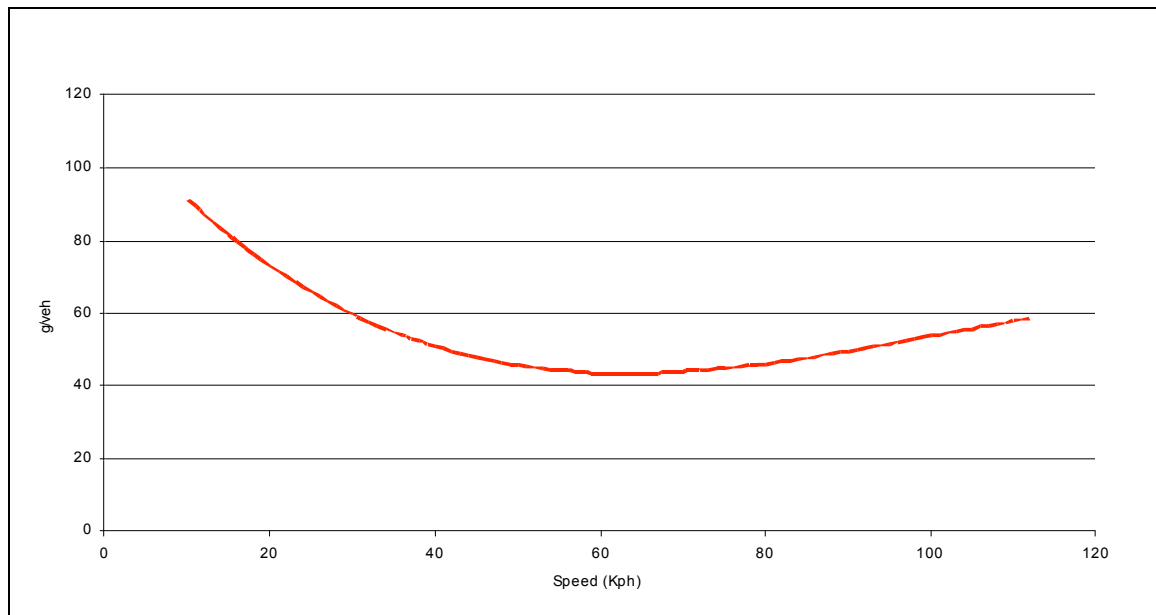


Figure 6. Example Emission Rate of Carbon from Car Traffic

Generally, the methodology applies a higher carbon emission rate for vehicles travelling at low speeds, where fuel consumption (and subsequently emissions) is generally higher due to the stop-start driving conditions associated with these speeds. This speed data is extracted from the transport model for each forecast year scenario.

The DMRB carbon emissions guidance includes assumed changes in vehicle characteristics over time, including:

- Vehicle fleet composition;
- Type of fuel (Petrol & Diesel); and
- Engine and fuel efficiency.

The ENEVAL program can be adjusted to appraise alternative assumptions or targets relating to vehicle characteristics, including technological advances or investment in low carbon vehicles.

These alternative assumptions can be modelled in tandem with land use or other transport policy options to provide a combined assessment or impact of various interventions to future Carbon emission levels.

These tools can also be used to ascertain the magnitude of interventions that would be required to meet 18% and 27% carbon reduction requirements (excluding aviation) within the transport sector by 2020 (based on 34% and 42% interim global reduction targets). Targets can be assessed through combining different vehicle fleet composition, type of fuel and engine/fuel efficiency improvements in tandem with various land use, economic and transport intervention assumptions included within future year scenarios.

The ENEVAL program generates Carbon emissions on a link-by-link basis, and can therefore be used (along with GIS software) to produce emissions maps, which can be used to identify where changes in emissions are predicted to occur over time.

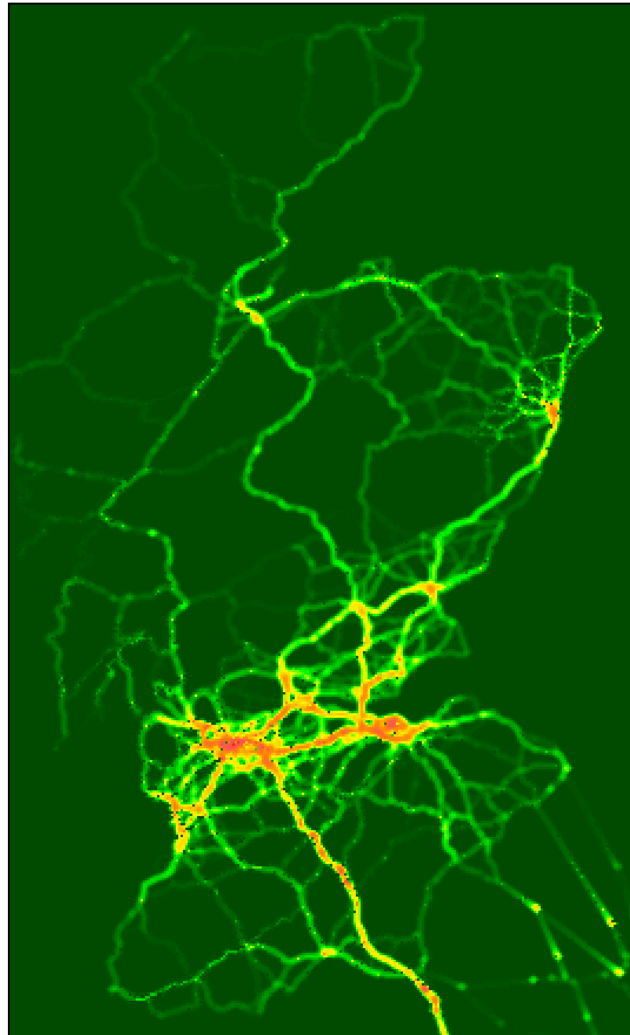


Figure 7. Example Emissions Map - Carbon Emissions (LATIS: 2007)

## 5. CARBON EMISSIONS

Using the methodology described in section four, the level of carbon emissions for the TMfS 2007 Base Year model was calculated, along with each subsequent forecast year Do Minimum scenario.

The predicted changes in Scottish Carbon emissions forecast by the LATIS modelling from 2007 to 2021 are described in Figure 8. These forecasts reflect the (tail-pipe) emission of Carbon from cars, light & heavy goods vehicles and buses.

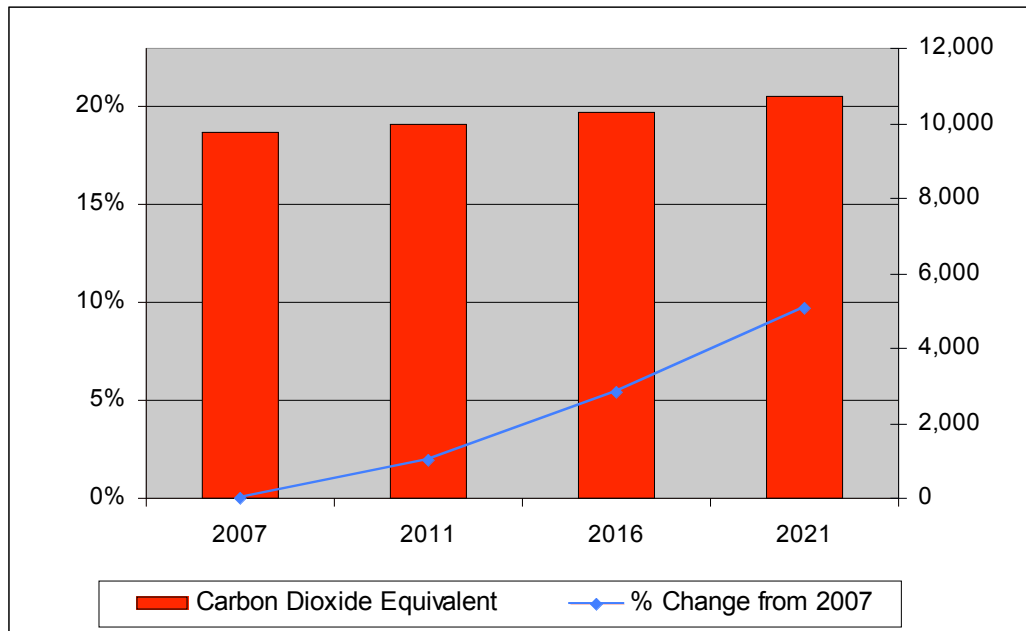


Figure 8. Predicted Road Transport Carbon Emissions and Percentage Changes from 2007 Levels (LATIS: 2007-2021)

The necessary carbon reductions contained within the Climate Change Delivery Plan for the transport sector by 2020 (excluding aviation but including shipping) is 23% to 32% from 2006 levels (based on 34% and 42% interim global reduction targets).

Based on the current assumptions (WebTag & DMRB), the modelling suggests a consistent increase in emissions from road transport over the short medium and long term horizons, with around a 2% increase to 2011, 5% to 2016 and around 10% to 2021 compared to 2007 levels. This is around 33% and 42% higher than the Scottish Governments targets for carbon reductions for the transport sector. Note that these forecasts result from a Do Minimum scenario with relatively high economic growth assumptions which do not reflect the current economic downturn. Neither does it reflect the Government's recent proposed commitments to fuel efficiencies, alternative fuels and/or vehicle technologies.

These forecasts do take account of the impact of introducing several committed transport infrastructure schemes however, various land use / development plans and assumed economic and population growth within Scotland.

The modelling also assumes various changes to the make-up of the vehicle fleet and also engine and fuel efficiency improvements (as specified in DMRB). For example, if traffic levels and vehicle speeds were to remain

constant and continue to reflect 2007 conditions, applying these assumptions would lead to a 7% reduction in Carbon emissions between 2007 and 2011, a 11% reduction to 2016 and around a 13% decrease in Carbon levels between 2007 and 2021.

However, when analysed in combination, the modelling suggests that the predicted increase in future car travel (discussed in Section 4) outweighs the benefits assumed to vehicle efficiencies over time, leading to an overall increase in Carbon emissions. This is an important conclusion and clearly highlights the differences between current assumptions and the newly anticipated pathway to meeting climate change targets.

The base year Carbon forecasts predicted by LATIS appear closely related to the recent level of Carbon emissions attributed to Scotland. Figure 9 describes recent changes to the level of Carbon emissions attributed to Scotland over a seven year period from 1998 to 2005.

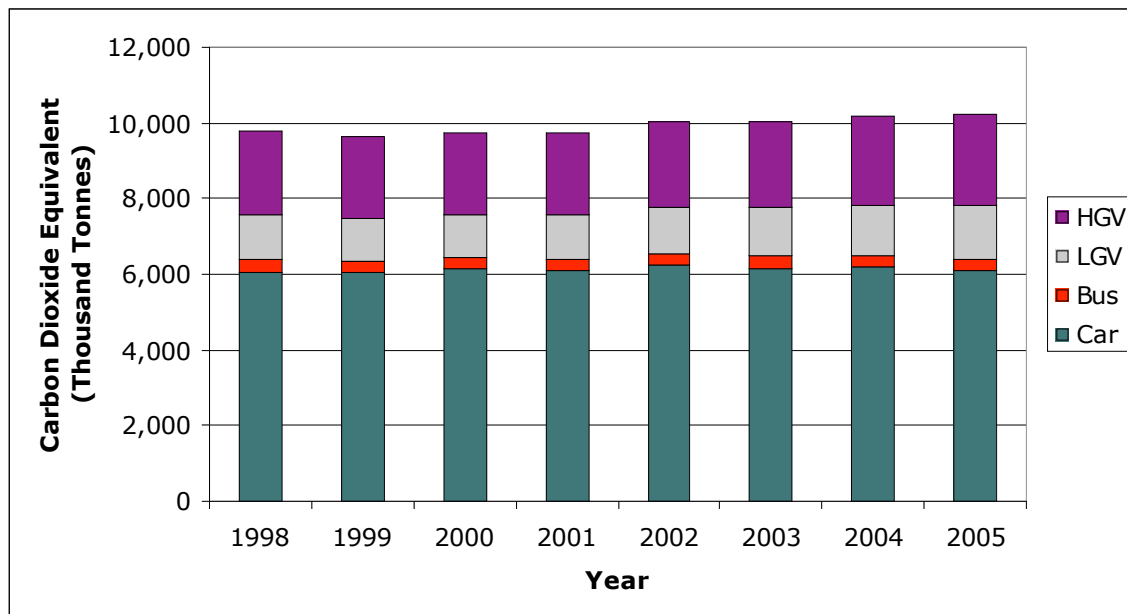


Figure 9. Scottish Road Transport Carbon Emissions (1998-2005)

Notes: Scottish Transport Statistics 2007, Table 6.13: Emissions of greenhouse gases by type of transport allocated to Scotland). Measured using fuel sales and presented in thousand tonnes of Carbon Equivalent (data excludes Motorcycles & Mopeds).

The information, extracted from Scottish Transport Statistics (STS) indicates that, during the last seven years, Carbon emissions attributed to the level of Scottish road traffic has increased by around 4%-5%. The largest growth in Carbon emissions is associated with light goods vehicles.

The LATIS forecasts (illustrated in figure 8) generally reflect these recent trends and suggest that, based on current assumptions and without further intervention, the amount of Carbon emitted from road traffic in Scotland is likely to rise over time.

Note that in absolute terms, the comparison of modelled base year Carbon emissions shows a close match with these national statistics and suggests that the national modelling reflects around 95% of Scotland's vehicle exhaust-related emissions (road, bus and Goods vehicles).

The work undertaken to feed into Scottish Transport Statistics uses fuel sales information to calculate the amount of emissions calculated from road traffic in Scotland, and therefore would aim to reflect a full inventory of Scottish emissions. As the transport model does not model every road in Scotland, it does not include all local traffic volumes, and therefore is not expected to match the full level of Scottish emissions as detailed by STS.

With this in mind (and noting that the base years of these data sets differ slightly), the modelling is expected to take account of the majority of Scottish road traffic related Carbon emissions, and offers a robust platform to forecast emissions over time.

Please note that future carbon forecasts are expected to change to what is reported in this analysis since the assumptions made for this Do Minimum scenario does not include possible implications of the recent Scottish and EU legislation, economic downturn and the proposed investments in low carbon vehicle technologies and alternative fuel.

## **6. CONCLUSIONS & POLICY IMPLICATIONS**

The Climate Change (Scotland) Bill with its ambitious 80% reduction targets, Climate Change Delivery Plan and Low Carbon Vehicle Consultation during 2009 demonstrated the Scottish Government's commitment to Climate Change. The policy implications of these legislations are yet to be seen at the national, regional and local level.

A number of 'behavioural change' initiatives, combined with dramatic improvements to the vehicle fleet composition through supporting the development of alternative fuel technologies and adaptation of the European vehicle carbon emission legislation, are anticipated to bring about these cuts in emissions. However, current 'core' modelling assumptions clearly do not reflect the emerging strategies for delivering emissions reductions. At present, current assumptions lead to a significant rise in road based emissions rather than reductions. The extent to which these assumptions need to be revisited in the light of the recent setting of emissions reduction targets and the anticipated delivery of these is clearly a key issue to be considered moving forward.

## **References**

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