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Output C1.1
Report Summarizing the Results and Findings of the Sectoral Analysis and Baseline of Selected Sectors

TRANSPORT SECTOR TECHNICAL REPORT

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This report corresponds to "Output C1.1: Report Summarizing the Results and Findings of the Sectoral Analysis and Baseline of Selected Sectors" in the Advisory Services Agreement on "Romania: Climate Change and Low Carbon Green Growth Program" signed between the Ministry of Environment and Climate Change and the International Bank for Reconstruction and Development on July 23, 2013.

ABBREVIATIONS AND ACRONYMS

AVER	*Asociatia Pentru Promovarea Vehiculelor Electrice in Romania*, Romanian Electric Vehicle Association
BAU	Business As Usual
CAPEX	Capital Costs
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
$KgCO_2e/MJ$	Kilograms of Carbon Dioxide Equivalent per Mega Joule
COPERT	Calculation of Emissions from Road Transport
CR	Commuter Rail
DC	Direct Current
EBAA	European Business Aviation Association
EC	European Commission
EEA	European Environment Agency
EES	Economically and Environmentally Efficient Scenario
EMEP	European Monitoring and Evaluation Program
EPER	European Pollutant Emission Register
E-PRTR	European Pollutant Release and Transfer Register
ES	Economically Efficient Scenario
ETS	Emission Trading System
EU	European Union
EV	Electric Vehicle
FCEV	Fuel Cell Vehicle
GBP	Great Britain Pound
GDP	Gross Domestic Product
GHG	Greenhouse Gas Emissions
GPS	Global Positioning System
GTMP	General Transport Master Plan
HDV	Heavy Duty Vehicle
HEV	Hybrid Electric Vehicle
HGV	Heavy Goods Vehicle
HSR	High Speed Rail
IATA	International Air Transport Association
IEA	International Energy Agency
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
ITDP	Institute of Transportation Development and Policy
ITP	Integrated Transport Planning
ITS	Intelligent Transport Systems
KM	Kilometer
kW	Kilo Watt
KT	Kilo Ton
LDV	Light Duty Vehicle
LEZ	Low Emission Zone
LPG	Liquefied Petroleum Gas
MAC	Marginal Abatement Curve
MJ	Mega Joule

Mpkm	Million Metric Passenger Kilometer
Mt	Million Metric Ton
$MtCO_2e$	Million Metric Tons of Carbon Dioxide Equivalent
Mtkm	Million Metric Ton Kilometer
NTM	National Transport Model
OLEV	Office for Low Emission Vehicles
OPEX	Operating Costs
ORT	Open Road Tolling
PHEV	Plug in Hybrid Electric Vehicle
RATB	*Regia Autonomă de Transport Bucureşt*
RUC	Road User Charging
TRACE	Tool for Rapid Assessment of City Energy
TRANSEPT	Transport Strategic Emission Prediction Tool
TREMOVE	Economic transport and emissions model
UIC	*Union Internationale des Chemins de fer*, International Union of Railways
UK	United Kingdom
VAT	Value Added Tax
ULEV	Ultra Low Emission Vehicle
VKT	Vehicle Kilometer Travelled

TABLE OF CONTENT

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The World Bank's Romania Climate Change program is managed by Jian Xie and Erika Jorgensen, under the general guidance of Mamta Murthi, Kulsum Ahmed, Ivailo Izvorski, and Elisabetta Capannelli from the World Bank.

EXECUTIVE SUMMARY

Introduction

The Europe 2020 Strategy and the legislative package from the European Commission provide EU member states a framework and means for moving towards a greener and more competitive low carbon economy that makes efficient use of resources and is resilient to climate risk. As a member state of the EU, the Government of Romania is committed to fighting climate change and pursuing a low carbon development. The integration of both mitigation and adaptation actions into Romania's national policies, programs, and strategies will be a critical step in shifting its development path towards a climate resilient, low carbon and green economy.

This Report has been prepared by the World Bank for the Government of Romania, as part of an Advisory Services program on climate change and low carbon green growth. This component assists the Government of Romania in identifying climate change action mitigation actions through extensive greenhouse gas (GHG) modelling work. The objective under Task C is to model mitigation scenarios up to 2050 for the transport sector—Business as Usual, Green, and Super Green Scenario—through the development of a strategic model and to develop a marginal abatement cost (MAC) analysis of mitigation measures proposed, measured in terms of marginal abatement cost or net present value of costs and benefits per ton of GHG abated. The outputs are an Excel based Strategic Mitigation Model and this Report.

This Report's scope was to consider appropriate Government policy interventions and scenarios up to 2050 that would help minimize GHG emissions from the transport sector in a cost-effective way. To do that, the following tasks were undertaken:

- Development of an agile, flexible spreadsheet-based Strategic Mitigation Model that draws on the best available data sources and emission relationships appropriate to Romania;
- Definition of a Business-as-Usual (BAU) scenario for Romania, incorporating data from the GTMP, national data sources and other international trends;
- Identification of a range of policy interventions that show potential for emission reduction and complement and enhance some of the planned GTMP major infrastructure interventions;
- Use of the Strategic Mitigation Model to test the potential transport demand impacts and the consequent GHG emission impacts of all interventions versus the Business-as-Usual scenario;
- Preparation of broad cost estimates for the various interventions, drawing on international experience, but taking account of Romanian costs relative to international levels;
- Preparation of a marginal abatement cost curve, taking into account government costs associated with the modelled interventions; and

- Emission reduction potential, likely costs and broader implementation issues to define a preferred future Green Scenario that groups together the most promising interventions, as well as the development of a more ambitious Super Green Scenario.

Consideration of institutional arrangements for implementation of individual interventions and alternative financing arrangements for proposed investments were outside of the scope of this study.

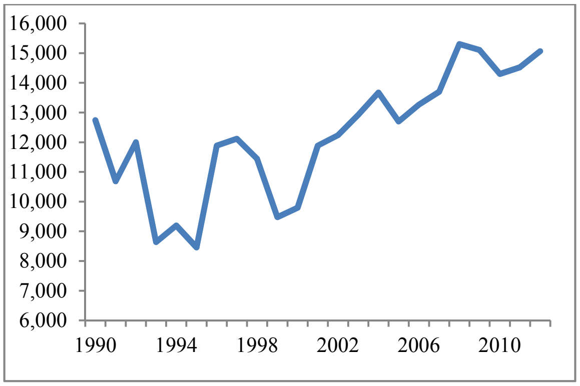
GHG emissions generated from transport are among the fastest growing in Europe, posing a challenge in creating a low-carbon future, as economic development has been paralleled with a modal share increasingly dominated by roads. This modal shift has been driven by a number of factors, including growing affluence, suburbanization, and falling land use densities in urban areas, which have translated into more widespread vehicle ownership, increasing trip numbers and lengths, while reducing the financial viability of public transport and non-motorized transport. On the freight transport front, while a number of East European countries had relatively high rates of rail modal share, these have generally been declining and have been approaching EU levels. Thus, Eastern European countries are moving toward EU motorization rates for passenger transport—with much higher GHG growth than in the EU-28, although overall levels remain lower—while trucks are making significant inroads vis-à-vis rail. Without any changes to transport policy, these trends in Eastern Europe, and in Romania, are likely to continue unabated in the next decades.

Greenhouse Gas Emissions from Transport in Romania

Figure ES1 shows the annual GHG emissions from the domestic transport sector in Romania and how it has grown since 1990. The steady upward trend since the turn of the century is particularly noteworthy. Figure ES2 shows how GHG emissions from transport have grown in Romania since 1990 in comparison with the EU-28, growing significantly faster than the EU average. As a percentage of total GHG emissions across all sectors, Romanian transport accounts for 12.7 percent (2012). While this is less than the EU's average of 19.7 percent, it is rising more quickly, driven in part by the declining modal share of rail and increased motorization. Road transport is the source of the majority of GHG emissions in the transport sector (93 percent of domestic transport emissions), similar to the EU-28 average.

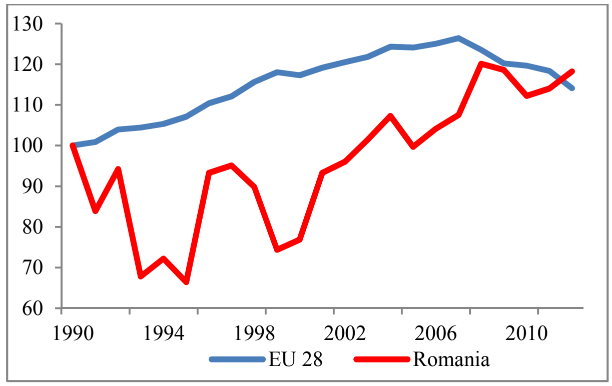
Although car mode share in Romania is at a similar level to the EU average, the motorization (or car ownership) rate in Romania is the lowest in the EU at 224 cars per 1000 inhabitants in 2012, but has grown significantly in recent years, up from 152 cars per 1000 inhabitants in 2006 (Figure ES3). Experience across the world suggests that as the Romanian economy grows, it will continue to grow in future. Without intervention to provide better transport alternatives and encourage their use, as car ownership grows, car use is also likely to grow. The reasons for the decline in rail passengers are linked to the decaying state of the Romanian railway system.

Figure ES1 : GHG Emissions from Domestic Transport in Romania (1,000 tons CO2)



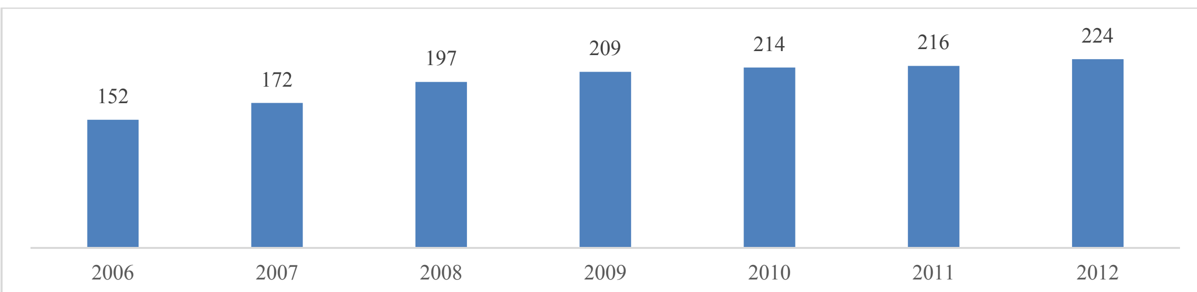
Source: EEA.

Figure ES2: Trends in Romania's Transport Emissions Compared to EU-28 (1990=100)



Source: EEA.

Figure ES3: Motorization Rates in Romania, 2006-2012 (passenger cars/1,000 inhabitants, 2012)



Source: Eurostat.

Mitigation Challenges

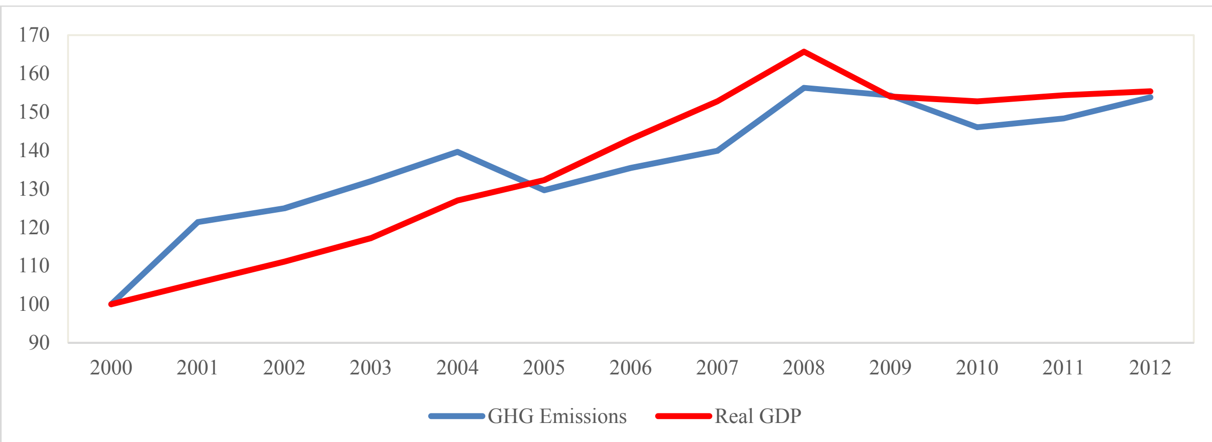
In a do nothing scenario, Romania's GHG emissions from transport are set to continue growing rapidly compared to the EU, particularly if its motorization rates converges to the EU average. The challenges for mitigating GHG in the transport sector are significant. This is illustrated by the recent European Environment Agency (EEA) report on the State of the European Environment which highlights the fact that 'transport, including emissions from international transport, is the only EU sector to have increased its GHG emissions since 1990'.[1]

A major overall challenge is decoupling economic growth from transport emissions. Figure Es4 presents real GDP growth and GHG emissions from the transport sector in Romania over 2000-2012, suggesting

[1] EEA (2015), SOER 2015 - The European Environment - State and Outlook 2015. A comprehensive assessment of the European environment's state, trends and prospects, in a global context. Available at: http://www.eea.europa.eu/soer

that they move in tandem, with an inflexion in 2009 when real GDP started growing more rapidly than transported related GHG emissions. Over the 2000-2012 period, GHG emissions rose by 54 percent, while real GDP rose by 55 percent. As noted in the EEA report, European demand for transport has increased in line with GDP in recent years, reflecting the close interdependence of transport and economic development. To mitigate GHG emissions, growth in demand needs to be either limited or managed in some way or targeted on low emission travel modes, coupled with reducing GHG rates (g/km emitted) from vehicles. The EEA report recognizes that while new engine technologies will help mitigate GHG, a more holistic approach is required. This includes measures to encourage change in people's travel behavior and choices (as well as technological measures), which is in line with the broad range of policy interventions examined in this Report.

Figure ES4: Real GDP Growth and GHG Emissions from Transport Sector (2000=100)



Sources: IMF, World Economic Outlook, April 2015; EEA.

Increasing motorization (car ownership) is a particular issue for the transport sector in Romania. Although car mode share in Romania is at a similar level to the EU average, the motorization (or car ownership) rate in Romania is the lowest in the EU at 224 cars per 1000 inhabitants in 2012, having grown significantly in recent years from 152 cars per 1000 inhabitants in 2006. Experience across the world suggests that as the Romanian economy grows, the motorization rate will continue to grow in future. Without intervention to provide better transport alternatives and encourage their use, as car ownership grows, car use is also likely to grow. The General Transport Master Plan projects rapid growth in car ownership, with the motorization rate exceeding 350 cars per 1,000 inhabitants by 2030, which would represent an increase in excess of 50 percent increase over 2012-2030.

Mitigation Modelling Approach

The overall objective of the transport mitigation modelling work was to develop a Green Scenario and an associated Action Plan that would guide the Romanian Government in their decisions on how best to invest in transport-related interventions that would contribute to climate change mitigation. The recommended scenario would take account of GHG benefit, as modelled in the study, and cost to the Government of

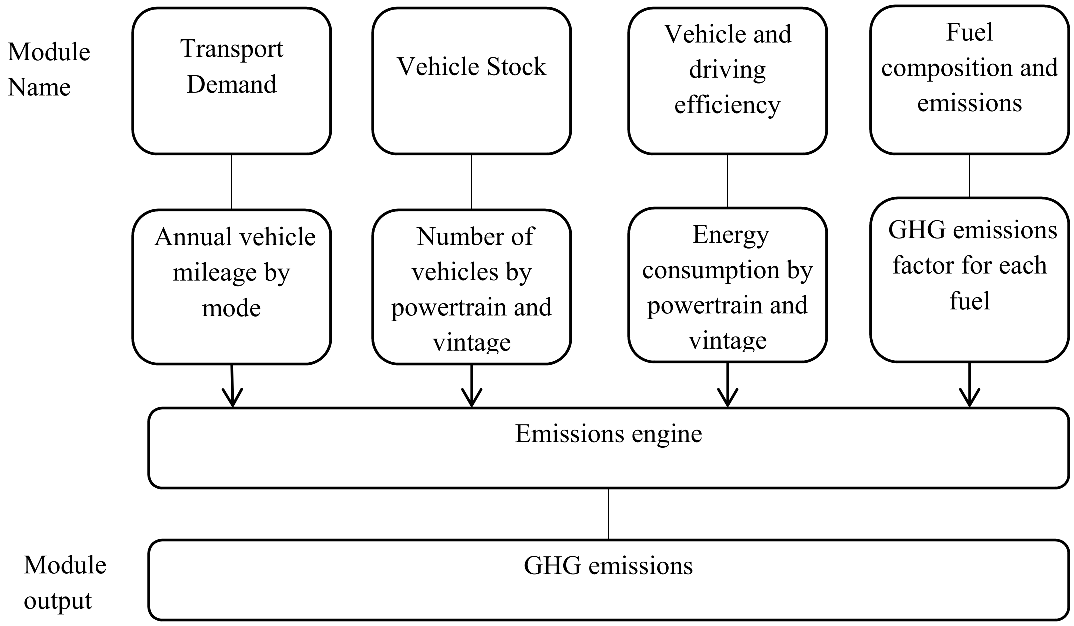
Romania of alternative interventions, as well as qualitative consideration of co-benefits and implementation issues. A second, more ambitious Super Green Scenario is also developed, in order to assess additional possible efforts, although measures.

The strategic mitigation model that has been developed for Romania, the Transport Strategic Emission Prediction Tool (TRANSEPT) includes four modules which produce the input matrices for the emissions engine which calculates the GHG emissions. The four modules are: (a) transport demand; (b) vehicle stock; (c) vehicle and driving efficiency; and (d) fuel consumption. Only the direct impact on transport fleet, vehicle activity and energy intensity have been modelled. Each module takes a number of baseline datasets as input and applies the effect of relevant policy interventions to them. The adjusted datasets are then input to the emissions engine which calculates the resulting GHG emissions. The process is outlined in Figure ES5. The TRANSEPT tool has the following main dimensions:

- It takes account of both direct (tailpipe) and indirect emissions.
- It covers road, rail, waterborne and air travel modes.
- Modes are split into passenger and freight transport.
- Transport activity and consequent emissions are split by urban / non-urban / highway locations.
- Different powertrain and fuel options are modelled as appropriate to each mode.
- Time horizons modelled are 2011 (base year), 2015, 2020, 2025, 2030, 2035, 2040, 2045, 2050.

The technical detail of the model including the source input data and basis for projections is included in Annex 1. The assessment of potential interventions to reduce GHG emissions from the transport sector were divided into five broad categories: (a) pricing instruments; (b) technology; (c) regulatory; and (d) operational efficiency; and (e) urban planning, behavioral change, and low carbon infrastructure investment. Modelling the impact of the various interventions makes use of the most relevant and appropriate case study evidence and research literature from across the EU, applied to Romanian specific baseline data in relation to vehicle fleet and transport activity. Where Romania specific evidence was available, for example, from the sensitivity testing using the National Transport Model, this was compared against the values selected from the literature review.

FigureES5: Overview of TRANSEPT Model Process



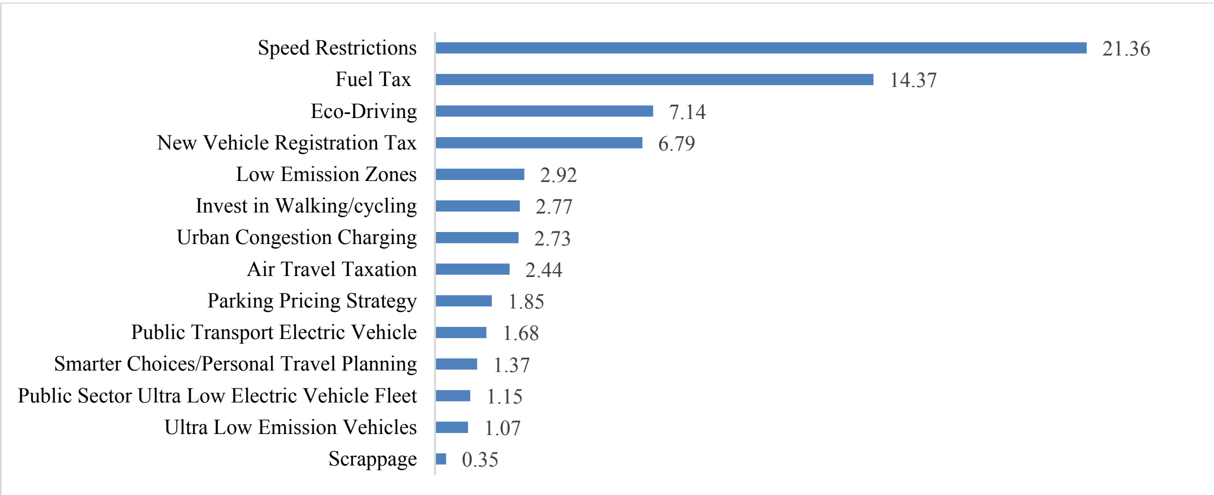
Source: World Bank.

Abatement Potential of Alternative Mitigation Interventions

The range of potential interventions have been defined and costed and assessed in terms of carbon abatement potential. The measures have been modelled individually to assess their relative mitigation potential and value for money in terms of investment against estimated abatement potential. These metrics sit alongside wider qualitative co-benefits to inform the ranking of those most appropriate for inclusion within the Green Scenario. The interventions performing best in the multi criteria appraisal were included in the Green Scenario, with explanation of why each should be pursued. An explanation of why the other options were not selected for adoption. However, all interventions have been included in the Super Green Scenario in order to assess an upper bound for slow GHG emission growth from the transport sector. No specific pre-defined GHG saving targets were used to constrain the choice of interventions, as a bottom-up approach was adopted. The identified measures have been drawn from a range of policy categories including: (a) pricing instruments; (b) technology; (c) regulatory; (d) operational efficiency; and (e) behavioral change and urban investments (Table ES1 and Table ES2).

Figure ES6 provide a summary of the cumulative abatement results for each intervention over 2015-2050, while the table below provides a breakdown of the abatement potential per intervention in three different time periods. The measures which have the potential to deliver the greatest absolute carbon savings over the course of the modelled period are as follows: (a) the lowering of speed limits (speed restrictions); (b) increasing the fuel tax (as a substitute to more sophisticated road user charging); (c) the implementation of a more progressive first registration tax (Environmental Stamp) promoting the adoption of low emission vehicles; and (d) eco-driving programs which encourage more efficient driving patterns, with advertising campaigns targeted at private car users and training programs focused on the freight and public transport sector.

Figure 1: Cumulative Abatement Potential per Intervention, 2015-2050 ($MtCO_2e$)



Source: TRANSEPT.

Table ES1: Carbon Abatement from Interventions ($MtCO_2e$)

Intervention	Action Plan (2015-2022)	Strategy (2015-2030)	2015-2050	% of Total Emissions
Fuel Price	1.032	4.139	14.365	2.08
Scrappage Scheme	0.241	0.331	0.354	0.05
Vehicle Registration Tax	0.071	0.566	6.789	0.98
Parking Pricing	0.191	0.639	1.852	0.27
Urban Cong Pricing	0.050	0.597	2.729	0.39
Air Travel Taxation	0.267	0.757	2.436	0.35
Ultra-low Emission Vehicles	0.019	0.118	1.075	0.16
Public Sector Electric Vehicles	0.020	0.130	1.149	0.17
Bus Electric Vehicles	0.036	0.231	1.678	0.24
Speed Restrictions	2.168	6.288	21.357	3.09
Eco Driving	1.059	2.693	7.140	1.03
Low Emissions Zones	0.229	0.724	2.920	0.42
Investment in Walking Cycling	0.464	1.203	2.774	0.40
Smarter Choices/Soft Measures	0.220	0.582	1.370	0.20

Source: TRANSEPT.

Table ES2: Summary of Intervention Measures Modelled

Policy	Policy Description	Implementation Timeframe	Investment Cost (Euro millions)	Modelling approach
Fuel Price Taxation	An increase in the rate of fuel price taxation which results in a 10% increase in the prevailing market price of fuel for both petrol and diesel. Price increases affect all vehicles with petrol or diesel drivetrains.	2015-2022	0.9	Modelled though application of a fuel price elasticity, using a long term elasticity of -0.3.
Scrappage Scheme	Rejuvinated scrappage scheme with higher incentives and tighter restrictions on emissions levels of new vehicles purchased. A higher incentive value of 7500 lei (€1700), with emissions requirements tightened to achieve a 120g/km average emissions rate for new vehicle purchase.	2016-2020	164	A take-up rate of 100,000 vehicles scrapped over the course of the 5 year period is modelled, with ageing vehicles removed from the existing fleet and replaced at a rate of two old vehicles to one new vehicle (as per evidence of existing scheme under the transferable voucher scheme). New vehicles modelled with average emissions of 120g/km with typical survival rates and replacement rates.
Vehicle Registration Tax	Adjusting of Vehicle Registration Tax (currently known as Environment Stamp) on first registration of vehicles to promote a move to more efficient and low polluting vehicles. The changes would maintain fiscal neutrality but increase the cost of registering high polluting vehicles, while decreasing the cost of registering low polluting vehicles.	2015-2022	0.9	The fiscal incentive regime has been modelled as a change in the vehicle purchasing profile, taking trajectories from the EU Commission transport emissions modelling work set out in the 'EU Transport GHG: Routes to 2050' work.
Parking Pricing	Widening of paid for parking to cover the major urban areas.	2015-2022	19	Application of case study evidence observed from other European cities which results in a 5% reduction in urban trips by 2030, ramping up from 2.5% in 2020 through 3.75% in 2025.
Urban Congestion Pricing	Application of congestion pricing in major urban areas. Charge proposed to be applied to private vehicle trips (car only).	2022-2030	1,600	Review of case study literature from London and Stockholm identifying the scale of reduction in traffic within the zone. Modelled impact of 5% reduction in urban traffic resulting from the scheme implementation.
Air Travel Taxation	Application of an air passenger duty on domestic (EU) and International flights levied at a level similar to that observed in Austria and Germany.	2015-2022	6*	Modelled as a 5% increase in ticket price, with demand impact modelled through the application of price elasticities of -1.2 for short haul and -0.9 for long haul.
Ultra-Low Emission Vehicles	Investment program in developing a national charging network for Electric Vehicles, with subsidy for home charging units and increased incentive rates for the purchase of Electric Vehicles.	2015-2030	195	Modelled impact based on an increased uptake in electric and plug in hybrid electric vehicles based on take-up rates observed in Estonia following implementation of the charging network and future trajectory taken from the Routes to 2050 ultra low emission vehicle modelled scenario.

Public Sector EV	Kick-starting the uptake of ultra low emissions vehicles by promoted use of new technology within public sector vehicle fleet. Public sector procurement targets of 5% of public sector fleet in 2020 increasing o 10% of public sector fleet in 2025.	2015-2030	35	Public sector vehicle fleet estimated to be c. 75,000 vehicles based on similar ratio to that observed in other EU countries. Targets modelled as a replacement of petrol based vehicles with electric vehicles at a rate which meets specified targets by 2020 and 2025.
Bus EV	Application of similar targets to the public transport sector, with the introduction of electric bus vehicles to the public transport fleet. Targets set at 5% of fleet in 2020 and 10% of fleet in 2025.	2015-2030	277	The policy is modelled to affect purchasing decisions of bus vehicles, with a switch from diesel buses to electric buses at a rate necessary to meet the specified targets.
Speed Restrictions	Reduction in speed limits to 100kph on all roads with higher current speed limits, applicable to all vehicle types.	2015-2022	39	Modelled as a reduction in the composite baseline speed (motorways and expressways) with an adherence rate of 70% to the new policy. This translates to a 10.5% reduction in average speed on motorways and expressways and a 1.8% reduction on national roads.
Eco-Driving	Promotion of the cost saving and efficiency benefits eco-driving through public awareness campaigns and driver training programs.	2015-2022	60	Case study evidence highlighting efficiency improvements of 8% in private car and 4% in HGV movements used as a basis for reduced vehicle energy intensity. Coverage of programs estimated to reach 25% of drivers by 2020.
Low Emissions Zones	Implementation of Low Emission Zones (LEZs) within the major urban areas restricting entry to vehicles meeting up-to-date emissions standards (Euro standards)	2015-2022	114	Vehicle purchasing decisions are affected for users who wish to continue to enter the zone. This is assumed to affect 5% of urban trips. In order to model the ongoing evolution of the zone as vehicle technologies improve, vehicle purchasing decisions by affected users are modelled through an advancement of purchasing profile of affected users by 10 years to the typical purchasing profile.
Investment in Walking Cycling	Investment in infrastructure to support walking and cycling, including cycle paths and parking facilities, footpaths and pedestrianization.	2015-2030	70	The investment has been modelled as a modal shift from urban car trips to walking and cycling, with a shift of 4% applied based on evidence from Bogota, based on a similar level of per capita investment spend that has been allowed for within this intervention.
Smarter Choices/Soft Measures	Investment in behavioral change programs and the supporting of improvements to public transport services and facilities.	2015-2022	23	Modal shift from urban car trips has been modelled based on case study evidence, amounting to a shift of 3.2% from car and 1.1% from motorcycle trips towards bus trips, rail and slow modes.

Note: Further information on each of the individual measures can be found in Chapter 3.
Source: World Bank.

Table ES31: Intervention Performance Table

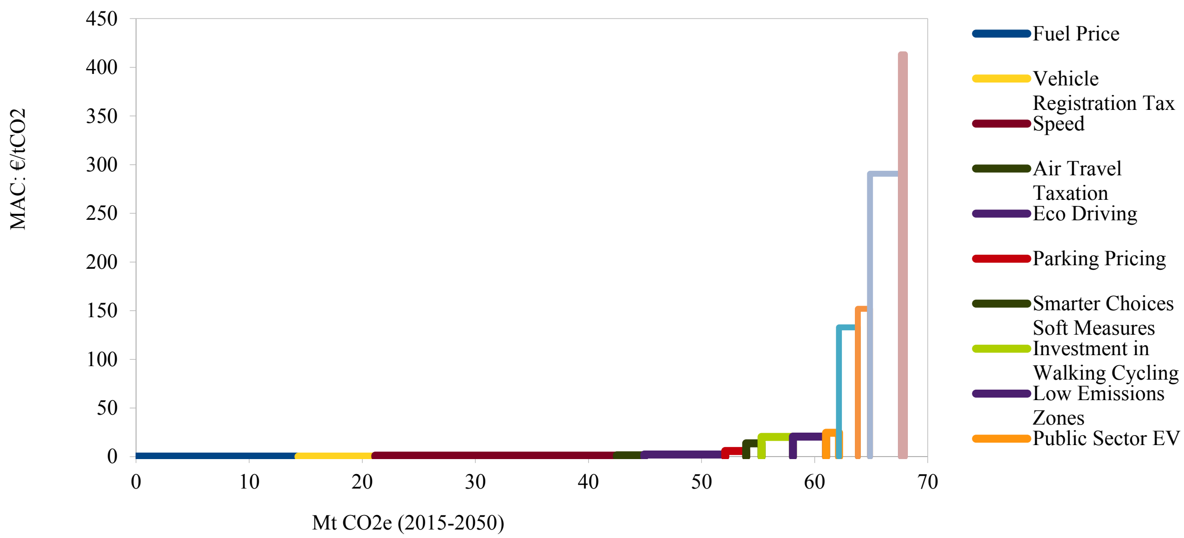
Intervention	Implementation	Investment Cost (Euro million)	Cost-Effectiveness (Euro/ton)	Co-benefits/Deliverability commentary
Fuel Tax	2015-2022	0.9*	0.06	Wider economic implications of higher fuel prices. Political resistance to increased taxation.
Scrappage Scheme	2016-2020	164	413	Economic boost to the domestic car industry and dealerships. Improved air quality from lower emissions vehicles.
Vehicle Registration Tax	2015-2022	0.9*	0.13	Economic and equity issues due to increasing the purchase cost of older (imported) vehicles. Potential boost for vehicle manufacturers. Political issues associated with previous tax.
Parking Pricing	2015-2022	19*	5.8	Enhancements to cityscape, urban safety and local air pollution. Barriers to implementation include political resistance and economic impacts on motorists and city commerce.
Urban Congestion Pricing	2022-2030	1,600	291	Air quality benefits. Equity issues. Technical barriers to implementation. Parking pricing a more efficient means of achieving similar results.
Air Travel Taxation	2015-2022	6*	1.4 #	Economic impacts of taxation. Positive equity impacts.
Ultra-low Emission Vehicles	2015-2030	195	152	Significant air quality benefits. Economic benefits to vehicle dealerships and manufacturers. Equity impacts.
Public Sector EV	2015-2030	35	24.5	
Bus EV	2015-2030	277	133	
Speed Restrictions	2015-2022	39	1.1 #	Safety and wider environmental benefits. Significant interest group pressure against reduction in speed limits expected.
Eco-Driving	2015-2022	60	2.3	Economic benefits of reduced fuel consumption. Increased safety.
Low Emissions Zones	2015-2022	114	20.7	Significant air quality benefits. Economic and equity impacts.
Investment in Walking Cycling	2015-2030	70	20.3	Health benefits and wider environmental and cityscape benefits expected.
Smarter Choices/	2015-2022	23	13.7	Health benefits.

* Public revenues also generated by scheme; # Particularly low values due to the consideration only of public investment.
Source: World Bank, ITP, TRANSEPT.

Having identified the abatement potential for each of the interventions modelled, consideration needs to be given to the most effective areas of investment to achieve emission reduction. Marginal abatement cost

(MAC) analysis provides a framework within which to guide investment decisions, identifying the levels of abatement possible and at what level of investment cost. A key component of the MAC analysis is the cost of each intervention, in terms both of capital cost and ongoing operational and maintenance costs. The implementation and ongoing costs of delivering the identified schemes have been estimated using case study evidence and a variety of sources of estimated costs applied to the Romanian context. The scope of the estimated costs are limited to those borne directly by the Government of Romania in terms of capital investment costs and ongoing operational and maintenance costs. The potential costs or operating cost savings borne by the private sector are not estimated or included within the MAC analysis. The basis for the cost estimation has been set out for each intervention in the preceding chapter.[2] Table ES3 summarizes the mitigation potential of each intervention against scheme value for money based on the cost per ton of carbon abated. A summary of the qualitative assessment of the wider societal impacts and deliverability issues (barriers to implementation) is also presented where relevant. The MAC can be found in Figure ES7.

Figure ES7: Marginal Abatement Cost Curve, 2015-2050



Source: TRANSEPT.

Development of the Green Scenario

The decision on which interventions to include in the Green Scenario were derived from a multi-criteria analysis that took into account the following: (a) scheme investment cost to the government; (b) cumulative

[2] Costs—capital and operational and maintenance costs—are discounted at a discount rate of 4 percent to provide the net present value (NPV). The abatement cost is hence cost (NPV) divided by total undiscounted cumulative carbon reduction over 2015-2050. The choice was made not to discount carbon savings as the resulting value is an abstract figure which cannot be directly compared back to any graph and would not be easily cross-compared to other literature evidence of abatement costs.

emission savings; (c) carbon reduction cost effectiveness; (d) deliverability and economic important; and (e) wider benefits. The wider benefits considered within the multi-criteria appraisal included local air quality, decongestion, noise, safety, equity and health benefits. These were considered at a qualitative level, and were not assigned a quantitative or monetary value. In order to achieve significant levels of carbon abatement, two schemes stand out above others. The implementation of speed restrictions is demonstrated to have significant potential to reduce vehicle emissions levels. Fuel taxation also can make a significant contribution to reducing emissions, through a combination of market forces acting to reduce the demand for travel and also in influencing purchasing decisions towards more efficient vehicles. Both of these policies have significant wider implications for the economy, with costs in terms of increased journey times in the case of speed restrictions and economic burden of higher taxation. In order to make meaningful reductions in carbon emissions in the transport sector, it is likely that at least one of these measures be adopted in some form. The wider costs and benefits will play an important role in determining the most appropriate, but ultimately it is likely that the political acceptability of one or other measure ultimately determines which may be more politically palatable.

Table ES4: Abatement Intervention Performance

Intervention	**Discounted Investment Cost**	**Absolute Emissions Savings (MtCO2e)**	**Carbon reduction cost-effectiveness (€/ton)**	**Deliverability/ economic impact**	**Wider Benefits**
Fuel Price Taxation	€0.9m	14.37	€0.06/ton	Challenging	Very high
Vehicle Registration Tax	€0.9m	6.79	€0.13/ton	Moderate	Moderate
Speed Restrictions	€22.6m	21.36	€1.1/ton	Challenging	Very high
Air Travel Taxation	€3.5m	2.44	€1.4/ton	Moderate	Moderate
Eco-Driving	€34.4m	7.14	€4.8/ton	Good	Very High
Parking Pricing	€10.7m	1.85	€5.8/ton	Moderate	Moderate
Smarter Choices/ Soft Measures	€18.8m	1.37	€13.7/ton	Good	Very High
Investment in Walking Cycling	€56.3m	2.77	€20.3/ton	Good	Very High
Low Emissions Zones	€60.4m	2.92	€20.7/ton	Moderate	Moderate
Public Sector EV	€28.2m	1.15	€24.6/ton	Good	Moderate
Bus EV	€222.2m	1.68	€133/ton	Moderate	Moderate
Ultra-low Emission Vehicles	€163.2m	1.07	€152/ton	Moderate	Moderate
Urban Congestion Pricing	€792.8	2.73	€291/ton	Politically Challenging	Moderate
Scrappage Scheme	€146.3m	0.35	€413/ton	Good	Very High

Note: Costs are discounted, using a 4 percent discount rate, while emissions are undiscounted.
Sources: World Bank, TRANSEPT.

Table ES5: Criteria for Defining the Performance of Each Intervention

Intervention	Good	Moderate	Poor/low
Scheme investment cost	Under Euro 10 million	Euro10-50 million	>Euro 50 million
Absolute Emissions Savings	>10 Mt	2-10 Mt	<2 Mt
Carbon reduction cost-effectiveness	<Euro10/ton	Euro 10-100/ton	>Euro 100/ton
Deliverability/economic impact	Positive impact/easily deliverable	Moderate, some challenges/some negative impacts	Politically challenging/significant economic impact
Wider Benefits	Strong wider benefits	Moderate benefits	Low wider benefits

Source: World Bank.

In the near term, whilst politically challenging and economically burdensome in particularly on the lower income households, applying increases in fuel taxation is more practicable. The requirements to change speed restrictions, with the associated awareness campaigns and need for reminder signage and enforcement would involve greater upheaval. It is therefore recommended that fuel taxation be considered as a key tool in achieving significant carbon abatement over the period of the Action Plan and Strategy. Of the 'second tier' intervention measures which may contribute valuable abatement to carbon emissions in absolute terms, the new vehicle registration tax is identified as a tool which can bring significant carbon savings through the influencing of purchasing decisions. Again, this measure has the potential to create adverse political pressure, even whilst remaining fiscally neutral, and may have negative equity implications in the increased taxation of older and less efficient vehicles. However, as seen in countries across Europe, influencing the make-up of the vehicle fleet at point of purchase is an effective means of encouraging evolution towards a lower emitting vehicle stock. The benefits of this continue to be realised over time, and represent a particularly important opportunity in the face of a high projected growth rate in motorisation levels and car ownership.

Eco-driving programs also offer significant potential for the reduction in vehicle emissions, and unlike the previous interventions, there are no significant barriers to implementation or adverse impacts. In fact, eco-driving offers significant potential wider benefits in the form of cost savings for motorists and enhanced environmental and safety benefits. Investment costs will vary according to the nature of the program implemented, but studies have highlighted the measures as performing strongly in terms of both overall impacts and value for money.

The following interventions perform strongly in value for money terms and should also be considered for adoption within the action plan, and as a feature of the Green Scenario.

- **Smarter choices programs** combined with investment in walking and cycling infrastructure have been demonstrated to lead to modal shift, achieving not only a reduction in emissions levels but also significant wider benefits including health and wellbeing, and decongestion. In cost-benefit analysis, these schemes typically perform strongly, with cost-benefit ratios in excess of 20 by comparison with highway and public transport schemes in the low single figures. This analysis demonstrates that with concerted and sustained investment over the strategy period, emissions savings realized at a reasonable level of cost effectiveness.

- **Parking pricing** is a further market based measure which offers the potential for emissions savings with a high level of cost effectiveness. Indeed, the measure would be expected to offer a stream of revenue which could facilitate some of the investment measures highlighted above. Parking pricing, in conjunction with tightened parking regulation and enforcement, may be considered to be a more cost effective more readily implementable solution to in town congestion instead of urban congestion charging and most European cities are following this strategy in preference to congestion charging; and

- **Air travel taxation** presents a mechanism for exerting some control over the growing demand for air travel at the margins, and also offers a revenue stream which may be put to useful purpose. The implications for the economy need to be considered, but there is are potentially positive equity impacts in what may be expected to be a strongly progressive form of taxation.

Based on the analysis of the abatement potential of the identified measures and on the results of wider assessment, the following measures are proposed for consideration within the Action Plan period under the Green Scenario:

- Fuel Price Taxation Increase
- New Vehicle Registration Tax
- Eco-Driving Program
- Smarter Choices/Personal Travel Planning Programs
- Investment in Walking and Cycling Infrastructure
- Parking Pricing
- Air Travel Taxation

Of the above measures, the market based policies where the taxation mechanisms already in place require no significant capital investment. The combined undiscounted capital investment of the above infrastructure dependent measures totals Euro 126 million over the timeframe of the Strategy under the Green Scenario, but rise sharply for the Super Green Scenario (Table ES4). For the Green Scenario, Euro 93 million of investment is profiled to fall within the period of the Action Plan, with ongoing investment in walking and cycling measures extending beyond 2022, based on a ten year investment profile. The mitigation impact of the combined bundle of interventions included within the Green Scenario is presented in Figure ES8, together with the mitigation potential of the Super Green Scenario. Note that the impact of the bundle of measures is not identical to the sum of the individual measures due to the inter-relationship between certain policies.

The remaining interventions modelled as part of the study have not been considered suitable for inclusion within the Green Scenario, reflecting either the lower value for money based on the MAC analysis, or deliverability challenges. Non-inclusion within the Green Scenario does not however mean that the schemes have no value or that these should not be considered for implementation in Romania based on wider appraisal criteria such as economic impact or local air quality. The high costs of the Super Scenario are driven by the high cost of urban congestion charging scheme, both in terms of initial investment and operating and maintenance costs.

Table ES6: Investment Costs of Green and Super Green Scenarios (Euro millions)

Scenario	Undiscounted Investment Cost			Discounted Investment Cost		
	Action Plan (2015-2022)	Strategy (2015-2030)	Model Period (2015-2020)	Action Plan (2015-2022)	Strategy (2015-2030)	Model Period (2015-2050)
Green Scenario	93	136	179	79	108	125
Super Green Scenario	885	1,477	2,603	748	1,136	1,562

Note: A 4 percent discount rate was used, in line with other sector reports.
Source: TRANSEPT.

The promotion of Ultra Low Emission Vehicles (ULEVs) has a place within government policy, and indeed incentives are currently offered for the purchase of low emitting vehicles both in terms of direct subsidy and as an additional stackable incentive under the existing scrappage scheme. Take-up of electric or plug-in electric vehicles to date has been low, which is likely to be a reflection of the limited existing infrastructure for such vehicles. Large scale investment in charging infrastructure would have the potential to increase take-up. However, this infrastructure has been seen to come at high cost, based on existing technology and the current commercial suppliers operating within this market. The technology is evolving rapidly, and already exposing mis-allocation of investment based on the approaches adopted by the countries early to provide supporting infrastructure. Equally, the marketplace is changing, and new business models relating to the provision of charging infrastructure are being developed, whether by vehicle manufacturers or by private suppliers identifying commercial potential. As such, it is considered that the high level of investment required to hasten the implementation of supporting infrastructure does not represent best value for money or lead to sufficient emissions reduction savings or wider benefits to merit immediate consideration.

Equally, whilst target setting relating to the acquisition of ULEVs within the public sector fleet and the public transport fleet may be considered laudable as a means of promoting and raising awareness about the technology, the cost of the new technology remains high by comparison with the emissions savings achieved, and the technological barriers to effective integration within the fleets are also notable in the near term. Speed restrictions have been rejected in preference to higher fuel duties due to the implementation difficulties, the economic impact and the lack of revenue generated by such a measure.

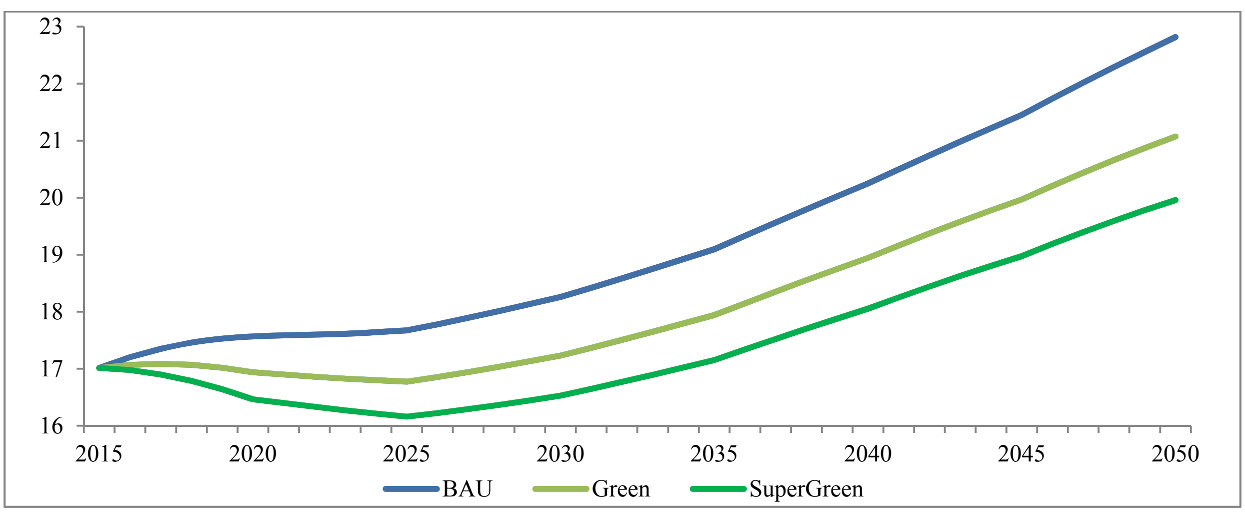
Low Emission Zones are demonstrated to have carbon saving potential, although the driving force behind implementation of such policies is typically local air quality. With its very poor air quality standards, Bucharest would potentially benefit most significantly from such a measure, and the policy should be considered within this context. However, with high implementation and operating costs, technological and enforcement barriers and potential political resistance, the pursuing of such a policy in the short/medium term is not considered cost effective as a means of carbon emissions saving.

Impact of Measures on GHG Emissions from the Transport Sector

To demonstrate the scale of mitigation achievable under a high intervention or Super Green scenario, the Green Scenario policies as well as policies which were not selected for inclusion within the Green Scenario, but which nevertheless provide GHG emission saving potential amongst wider benefits have been included. The Super Green Scenario therefore represents an all policy modelled scenario. The scale of abatement potential achievable in the Super Green Scenario by comparison with the Green Scenario and the BAU scenario is presented in Figure ES8.

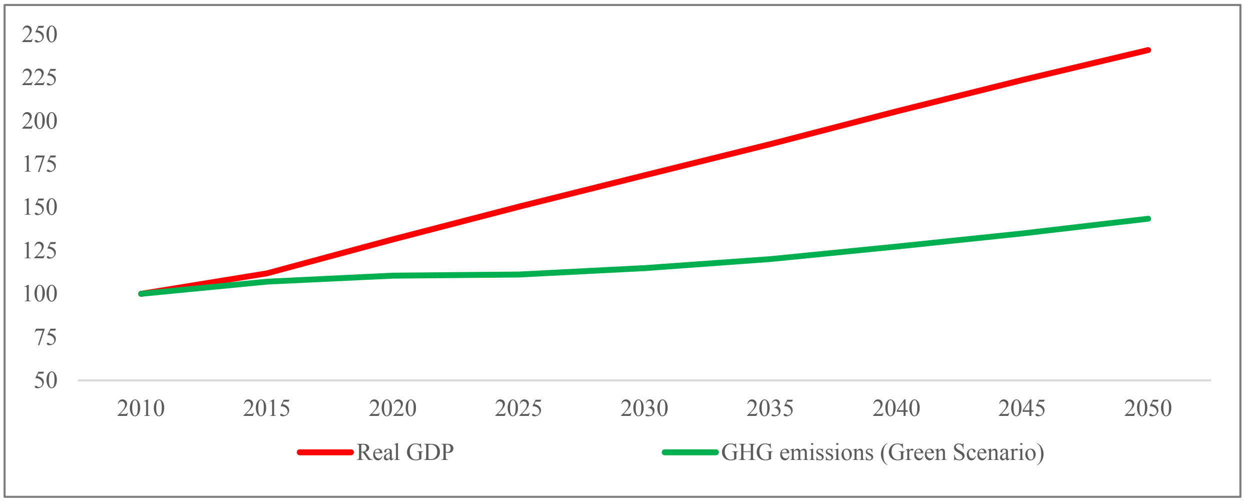
Under the BAU scenario emissions grow by 34 percent over 2015-2050, while under the Green Scenario emissions growth slows to 24 percent and under the Super Green Scenario growth slows to 17 percent. In all cases GHG emissions from the transport sector rise. These results are in line with many studies which suggest that reducing GHG emissions—as opposed to reducing GHG emission growth rate—is difficult in the transport sector. In order to reach a low emission scenario in 2050 Romania's transport sector has to have close to zero emissions, which will need large changes in behavior and technology. However, this growth in GHG emissions has to be seen in the context of a growing real economy. Figure ES9 reveals that under a Green Scenario GHG emissions from transport are projected to grow more slowly than the real economy.

Figure ES8: Transport Emissions under Alternative Carbon Abatement Scenarios (MtCO2e)



Source: TRANSEPT.

Figure ES9: Transport GHG Emissions and Real GDP Trends, 2010-2050 (2010 = 100)



Source: TRANSEPT.

1 INTRODUCTION

1.1 Introduction

1. The Europe 2020 Strategy and the legislative package from the European Commission provide European Union (EU) member states a framework and means for moving towards a greener and more competitive low carbon economy that makes efficient use of resources and is resilient to climate risk. The European Council further determined in February 2013 that the Multiannual Financial Framework will mainstream climate objectives. As a member state of the EU, the Government of Romania is committed to fighting climate change and pursuing a low carbon development. The integration of both mitigation and adaptation actions into Romania's national policies, programs, and strategies will be a critical step in shifting its development path towards a climate resilient, low carbon and green economy.

2. In this context, the Government of Romania has requested the World Bank to provide Advisory Services on climate change, including operationalizing its national climate change strategy and action plan, identifying and integrating climate-related actions in new Operational Programs, building a solid analytical base for impact assessment and climate-related decision making, and enhancing climate-friendly practices and monitoring system. The Program development objective is to assist the Government of Romania to: (i) develop a comprehensive national climate change and low carbon development strategy and action plan; (ii) integrate associated climate-related actions into the 2014-2020 EU-funded Operational Programs; (iii) develop the institutional tools necessary to inform climate change policies and monitor their economic and environmental impacts; and (iv) identify future carbon trading opportunities.

3. This Report is a deliverable under Component C of the Advisory Services, *Support to the Recipient to build strong and sustainable analytical capacity and a suitable knowledge base*. This component assists the Government of Romania in identifying climate change action mitigation actions through extensive greenhouse gas (GHG) modelling work. The objective under Task C is to model mitigation scenarios up to 2050 for the transport sector—Business as Usual, Green, and Super Green Scenario—through the development of a strategic model and to develop a marginal abatement cost analysis of mitigation measures proposed, measured in terms of marginal abatement cost or net present value of costs and benefits per ton of GHG abated. The outputs are an Excel based Strategic Mitigation Model and this Report.

4. The work presented in this Report builds on the Transport Rapid Assessment Report, which was a deliverable under the Advisory Services. That report identified promising climate change mitigation and adaptation actions for consideration for the country's 2014-2020 Operational Programs that are supported by European Union funding. These were based on a qualitative assessment drawing on international evidence of potential effectiveness and consideration of applicability in the local Romanian context. This

Report, and associated model, is also intended to complement the National Transport Model (NTM) developed for General Transport Master Plan (GTMP) for Romania.[3]

5. The timeframe under consideration in this study extends beyond that of the Transport Rapid Assessment Report (2014-2022) and that of the NTM (2012-2030). This Report's scope was to consider appropriate Government policy interventions and scenarios up to 2050 that would help minimize GHG emissions from the transport sector in a cost-effective way. To do that, the following tasks were undertaken:

- Development of an agile, flexible spreadsheet-based Strategic Mitigation Model that draws on the best available data sources and emission relationships appropriate to Romania;
- Definition of a Business-as-Usual (BAU) scenario for Romania, incorporating data from the GTMP, national data sources and other international trends;
- Identification of a range of policy interventions that show potential for emission reduction and complement and enhance some of the planned GTMP major infrastructure interventions;
- Use of the Strategic Mitigation Model to test the potential transport demand impacts and the consequent GHG emission impacts of all interventions versus the Business-as-Usual scenario;
- Preparation of broad cost estimates for the various interventions, drawing on international experience, but taking account of Romanian costs relative to international levels;
- Preparation of a marginal abatement cost curve, taking into account government costs associated with the modelled interventions; and
- Emission reduction potential, likely costs and broader implementation issues to define a preferred future Green Scenario that groups together the most promising interventions, as well as the development of a more ambitious Super Green Scenario.

Consideration of institutional arrangements for implementation of individual interventions and alternative financing arrangements for proposed investments were outside of the scope of this study. It needs to be highlighted that the abatement cost analysis only takes account of government investment costs, with no quantitative assessment of wider socio-economic impacts or benefits. The policy interventions `assessed are ones which have precedent of adoption within other countries on the basis of their carbon reduction impacts or wider benefits. The strategic modelling exercise forecasts the potential abatement impact of

[3] The Ministry of Transport commissioned AECOM Ingeneria SRL in April 2012 to develop a Transport Master Plan for Romania (GTMP). An integral part of that commission was the development of a NTM for Romania (NTM). The NTM is a 'classic 4-stage transport model' based on a well-known software package, EMME3, similar to those widely used for transport appraisal purposes around the world. The NTM covers all modes and include inland waterway transport. Constanta Port also has its own freight demand sub-model within the NTM, because of its national importance as a freight gateway. The GTMP involved extensive appraisal and modelling of national scale infrastructure investments and complementary policies, including consideration of greenhouse gas (GHG) emission impacts. The GTMP covers a timeframe up to 2030, with delivery of some projects and interventions continuing for up to five years beyond that date.

individual interventions and bundles of interventions through the development of two scenarios. Whilst abatement cost effectiveness is one element in the ranking and selection of interventions, it is not the only criteria, and an analysis of qualitative wider impacts have played a role in preferring certain policies above others, for example fuel taxation over speed limit reductions. Prior to deciding on the adoption of any proposed intervention or bundle of interventions to reduce GHG emissions from the transport sector, detailed cost-benefit analysis of likely impacts may be required.

1.2 EU Transport Strategy and Policies

6. There are several formal documents adopted by the EU that are relevant for Romania's transport sector. Key among them is the European Commission White Paper "*Roadmap to a Single European Transport Area: Towards a competitive and resource efficient transport system"* (White Paper) adopted in March 2011.[4] This document sets targets and directions for transport sector development—EU transport policy is focused on assuring sustainable mobility for people and goods with a strong emphasis on contributing to a very ambitious GHG emission targets set for the EU as a whole. More specifically, the policy and related activities are expected to significantly reduce Europe's dependence on imported fuels (mostly oil) and cut carbon emissions in transport by 60 percent by 2050 compared to 2005. By 2050, key transport strategic goals include:

(a) no new conventionally-fuelled cars in cities;
(b) at least 40 percent use of sustainable low carbon fuels in aviation;
(c) at least 40 percent reduction of emissions from maritime transport;
(d) at least 50 percent shift of medium distance intercity passenger and freight journeys from road to rail and waterborne transport.

7. Several important interim goals are also included in the White Paper and have to be taken into account when designing and implementing country specific transport strategies and programs. They are grouped into three categories: (a) developing and deploying new and sustainable fuels and propulsion systems; (b) optimizing the performance of multimodal logistic chains, including by making greater use of more energy-efficient modes; and (c) increasing the efficiency of transport and of infrastructure use with information systems and market-based incentives. The White Paper also includes 40 concrete initiatives for the next decade, which are expected to result in a competitive transport system that will increase mobility, remove major barriers in key areas, and stimulate growth and employment.

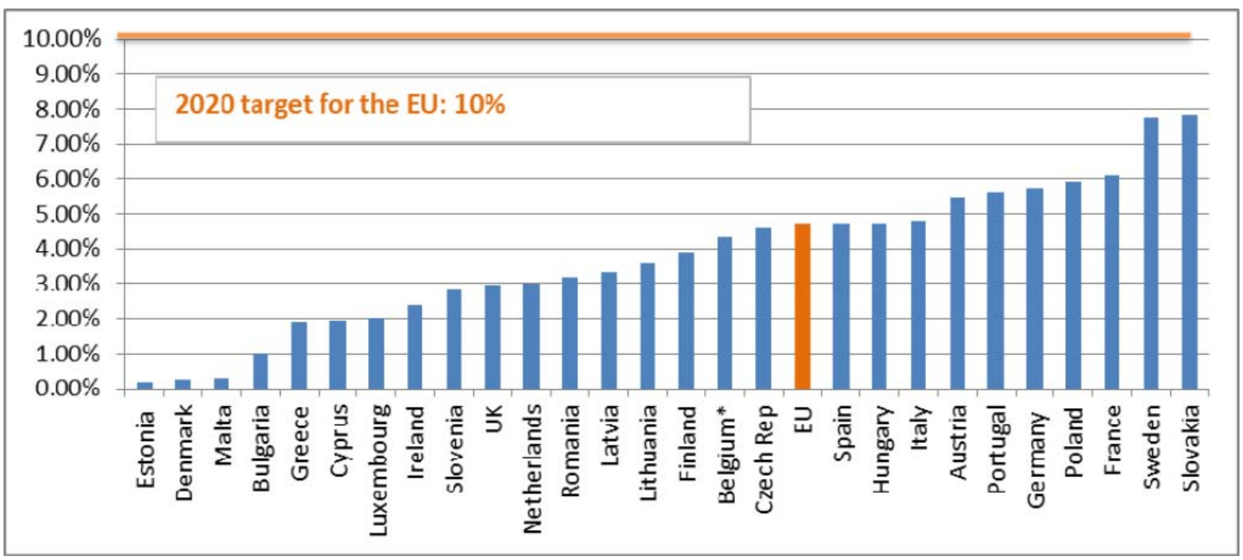
8. In order to ensure complementarity, the country specific strategic and policy directions should be coherent with the EU-level transport strategy, as well as country-wide specific programs and policy measures. In practice this means that national-level strategy, programs or Master Plan(s) should complement and "transpose" the guidelines from the European Commission White Paper and other

[4] European Commission (2011), *White Paper: Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system*. Brussels, March 28, 2011, COM (2011) 144 final.

important components of EU transport sector policy framework into Romania's transport sector. In addition, any regional, local or municipal transport strategies or programs should complement and be fully coherent with national level policies and EU policies. Therefore, Romania's transport strategy and policies across all modes of transport and all levels of transport sector public governance (from the national level down to the local level) should be internally coherent and should complement the EU transport strategy and policies by "translating" EU level documents into Romania reality. While all EU member states have to follow the general directions of the EU transport policy, they also have significant flexibility in designing their own transport strategies, programs and implementation arrangements reflecting country-specific needs in infrastructure development programs and policy measures. At the same time, country-level strategies should be aligned with and contribute to EU-wide transport policy goals.

9. The European Commission undertook a recent assessment of progress towards achieving the Europe 2020 targets, that is to say, to create 20 percent of energy consumption from renewables and increasing energy efficiency by 20 percent by 2020. For the transport sector, Romania needs to make significant efforts to increase the share of renewable energy used, which has an EU wide target of 10 percent (Figure 2). There is a need for further efforts aimed at reducing the energy intensity of the transport sector, as well as raising the use of renewable energy powering the transportation system. The low degree of efficiency of Romania's transport system was flagged in a recent European Commission assessment of Romania's progress with the national reform program.[5]

Figure 2: Share of Renewable Energy in the Transport Sector in 2010[6]



Source: European Commission.

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[5] European Commission (2013), Recommendation for a Council Recommendation on Romania's 2013 National Reform Program and Delivering a Council Opinion on Romania's Convergence Program for 2012-2016. COM (2013) 373 final. Brussels, 29.5.2013. Available at:
http://ec.europa.eu/europe2020/pdf/nd/csr2013_romania_en.pdf

[6] http://ec.europa.eu/clima/policies/g-gas/progress/docs/13_energy_and_ghg_en.pdf

1.3 Transport and Greenhouse Gas Emissions

10. Transport is responsible for around a quarter of EU GHG greenhouse gas (GHG) emissions making it the second biggest greenhouse gas emitting sector after energy. Road transport alone contributes about one-fifth of the EU's total emissions of carbon dioxide (CO_2), the main greenhouse gas. While emissions from other sectors are generally falling, those from transport have increased 36 percent since 1990. The EU has policies in place to reduce emissions from a range of modes of transport, including aviation in the EU Emissions Trading System (EU ETS) and CO_2 emissions targets for cars. The majority of domestic transport-related greenhouse gas emissions are from road transport. However, there are also significant emissions from the aviation and maritime sectors and these sectors are experiencing the fastest growth in emissions, meaning that policies to reduce GHG emissions are required for a range of transport modes.

11. GHG emissions generated from transport are among the fastest growing in Europe, posing a challenge in creating a low-carbon future, as economic development has been paralleled with a modal share increasingly dominated by roads.[7] This modal shift has been driven by a number of factors, including growing affluence, suburbanization, and falling land use densities in urban areas, which have translated into more widespread vehicle ownership, increasing trip numbers and lengths, while reducing the financial viability of public transport and non-motorized transport. On the freight transport front, while a number of East European countries had relatively high rates of rail modal share, these have generally been declining and have been approaching EU levels. Thus, Eastern European countries are moving toward EU motorization rates for passenger transport—with much higher GHG growth than in the EU-28, although overall levels remain lower—while trucks are making significant inroads vis-à-vis rail. Without any changes to transport policy, these trends in Eastern Europe, and in Romania, are likely to continue unabated in the next decades.

12. Transport is a key facilitator of economic well-being worldwide and is likely to continue to grow to meet continued demand and growing transport needs in Romania. Affordable transport services are crucial for development. They connect rural areas to sales opportunities and inputs, and nations to export markets and foreign technologies. Affordability refers not just to consumer prices but also to all costs to society: the time losses due to congestion, the sometimes dramatic consequences of accidents, the health costs of local pollution, and the damage that severe climate events inflict on the population. Transport decisions, particularly those for infrastructure investments, will determine these costs for decades to come, offering opportunities to countries whose transport systems are not yet mature.

13. Recognition of climate implications in transport, unlike other sectors, has had a slow start. One reason is that the transition to a low-carbon context appears to be more costly than in other sectors. But broadening the policy agenda to shift behavior changes the cost picture completely, especially measures

[7] In the case of the EU-27 in 2007 CO_2 emissions from the transport sector accounted for 25.1 percent of the total, up from 18.1 percent in 1990. Projections from the European Environment Agency estimate that the sector's emissions will increase by 25 percent over 1990-2020, whereas they are expected to decline from industrial and energy sectors.

to reduce congestion, local air pollution, safety risks, and road safety.[8] For example, a recent survey of 25 European cities found that Bucharest was the most polluted, and that air pollution reduced life expectancy by 2 years, due to high concentration of fine particles, largely due to emissions from diesel engines and heating.[9] Policies to guide demand to low-emission modes and technologies must be part of investment programs and projects. Such policies can reduce transport demand in the longer run by changing the economic geography of cities and countries. But that will take close coordination of transport, urban, environmental, and health policies.

14. Decoupling GHG emissions from the transport sector and economic growth or at least lowering the GHG intensity of future transport growth represents the key challenge and will require departure from the business as usual policies in the transport sector.[10] As noted in the EU's 2011 White Paper on transport, the main issue facing the transport sector is how to reduce the system's dependence on oil without sacrificing efficiency and compromising mobility—curbing mobility is not an option. The World Bank's own climate change strategy for the transport sector adopts a similar approach, arguing that climate change mitigation in the transport sector has to be seen in a broader context: sustainable transport should limit GHG emissions from transport and minimize other externalities, without compromising economic growth.[11]

15. Concerns about climate change are not likely to be the key driver of transport policies or investment decisions. Instead local co-benefits—such as reduced traffic congestion and noise, improved air quality and road safety, or enhanced energy security—are much more likely to drive the development of transport policies.[12] This is the same argument recently put forward in the World Bank's transport climate change strategy: attempting to sell measures to reduce GHG by marketing them as policies aimed at other social costs of transport can be much more attractive to policy-makers, who may not be concerned about climate change or who cannot gain political traction for policies if they are sold to the public exclusively on a climate change angle.[13] Looking at congestion levels in a city like Bucharest and trends toward increased motorization, the issue is as much a classic problem of transport and urban planning as it is a GHG emission problem. Co-benefits can motivate discussions on improved transport policies which are also GHG friendly policies.

[8] The number of road fatalities in Romania is 58 percent higher than the EU-27 when adjusted for population. In 2012, 32 percent of road accidents involved a vehicle and a pedestrian, suggesting that much can be done in urban areas to make cities safer.

[9] See http://www.aphekom.org/c/document_library/get_file?uuid=5532fafa-921f-4ab1-9ed9-c0148f7da36a&groupId=10347

[10] OECD/International Transport Forum (2008), *Greenhouse Gas Reduction Strategies in the Transport Sector*. Preliminary Report. Paris: OECD /International Transport Forum.

[11] World Bank (2011), Turning the Right Corner: *Ensuring Development through a Low-Carbon Transport Sector, Andreas Kopp, Rachel I. Block, and Atsushi Iimi.* Available at: http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/05/31/000445729_20130531125005/Rendered/PDF/780860PUB0EPI0050240130right0corner.pdf

[12] James Leather and the Clean Air Initiative for Asian Cities Center Team (2009), *Rethinking Transport and Climate Change*, Asian Development Bank Development Working Paper Series No.10, December 2009.

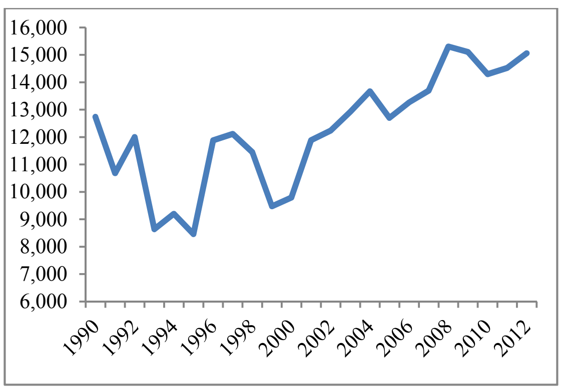
[13] One of the barriers to the use of a co-benefit approach to climate change is the cost and time it takes to measure co-benefits in a transport project, vis-à-vis the direct benefits.

16. The financing of the transport sector needs to be supported by adequate pricing policies, which can help change existing behavior and thus transport demand, allocate resources more efficiently, and raise funds to invest in more sustainable forms of transport. This means interlocking discussions about financing of transport infrastructure with pricing, as adequate financing needs to be supported by sound pricing policies. However, at present pricing does not reflect the full costs of transport, including costs of negative externalities, while investments tend to be heavily focused on roads, based on a motorization future which assumes ever growing vehicle ownership and usage.

1.4 Greenhouse Gas Emissions from Transport in Romania

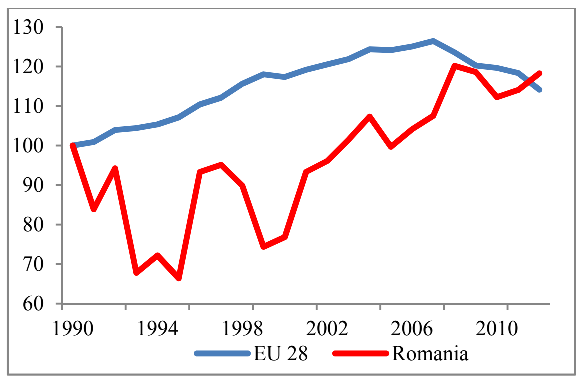
17. Figure 3 shows the annual GHG emissions from the domestic transport sector in Romania and how it has grown since 1990.[14] The steady upward trend since the turn of the century is particularly noteworthy. Figure 4 shows how GHG emissions from transport have grown in Romania since 1990 in comparison with the EU-28, growing significantly faster than the EU average. As a percentage of total GHG emissions across all sectors, Romanian transport accounts for 12.7 percent (2012). While this is less than the EU's average of 19.7 percent, it is rising more quickly, driven in part by the declining modal share of rail (Figure 6) and increased motorization. Road transport is the source of the majority of GHG emissions in the transport sector (93 percent of domestic transport emissions), similar to the EU-28 average.[15]

Figure 3: GHG Emissions from Domestic Transport in Romania (1,000 tons CO2)



Source: EEA.

Figure 4: Trends in Romania's Transport Emissions Compared to EU-28 (1990=100)

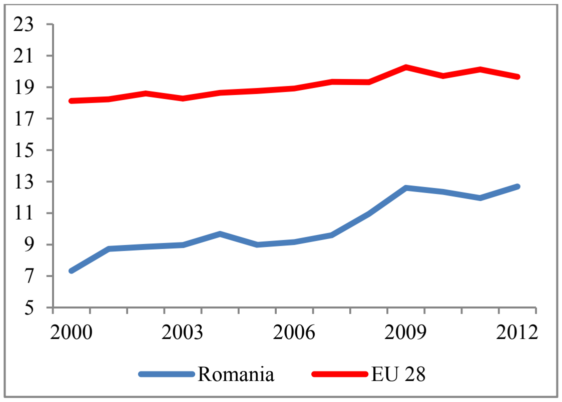


Source: EEA.

[14] This includes emissions from transport (road, rail, inland navigation and domestic aviation) of the GHG regulated by the Kyoto Protocol. Only three gases are relevant in the context of transport (carbon dioxide, methane, and nitrous oxide) and these have been aggregated according to their relative global warming potentials. Some of the downward fluctuations of emissions reflects slowdowns in economic activity.

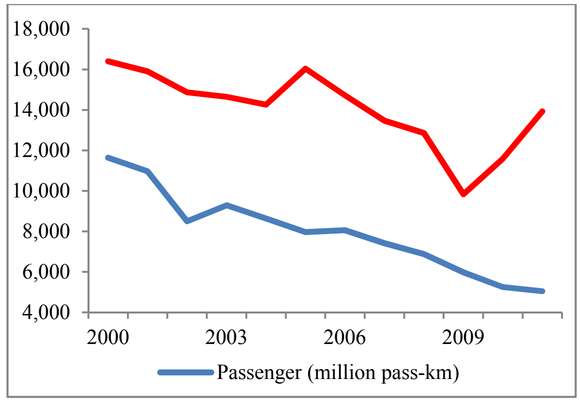
[15] European Environment Agency data, as of June 2013.

Figure 5: Transport GHG Emissions as a Percentage of Total GHG Emissions



Source: EEA.

Figure 6: Rail Traffic in Romania (2000-2012)



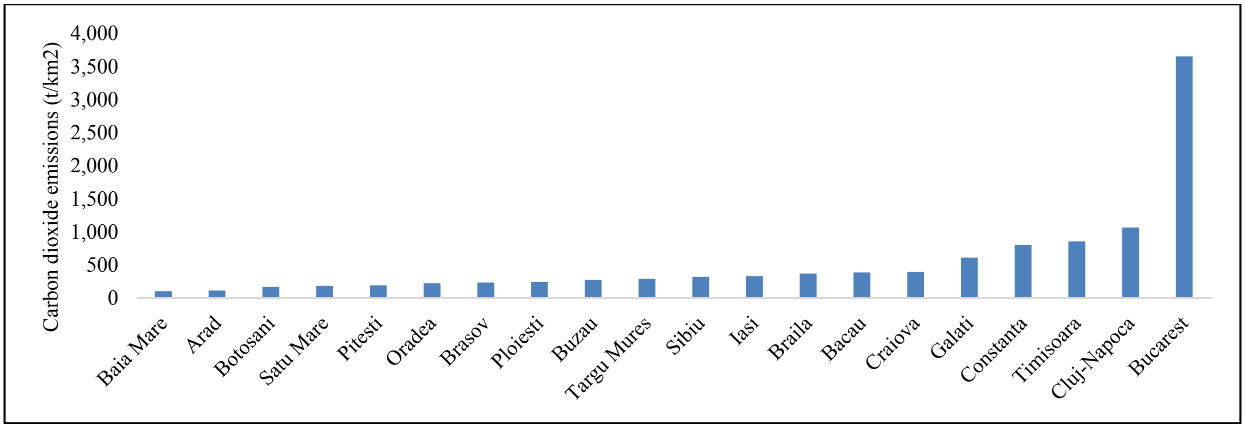
Source: UIC.

18. The E-PRTR dataset is a register that provides accessible environmental data from industrial facilities in European Union Member States and in Iceland, Liechtenstein, Norway, Serbia and Switzerland.[16] This data has been analysed to better understand the distribution of emissions between urban and non-urban areas. The largest 20 cities (with populations over 100,000) were identified and their respective emissions levels analysed. Bucharest's road transport emissions, at 833 kt/year is higher than that of the 19 next largest cities combined (596 kt/year). This is reflective both of the geographic size of the city, with six communes amalgamated to form the emissions estimate for the city and also the intensity of activity within the city. Figure 7 displays the emission density within each city by taking account of physical land area. Bucharest can be seen as having the greatest carbon dioxide emissions density, approximately 3.5 times that of the second largest city Cluj-Napoca. This would indicate that road transport activity is most concentrated within Bucharest when compared with other cities and is also reflective of a city which suffers from greater congestion pressures. As expected, urban areas in general display a substantially greater emissions density than the national average. The annual road transport CO_2 emissions from the 20 largest cities in Romania represent 10 percent of the national total for the road sector.[17]

[16] To date, there are only four countries in the EU that have spatially disaggregated emissions inventories at a national level, namely, the UK, the Netherlands, Denmark and Sweden. Meanwhile, the European Environment Agency in 2011 released a spatial emission database as part of the European Pollutant Release and Transfer Register (E-PRTR) at a 5km resolution, making it possible to estimate emissions for cities based on geographic boundaries.[16] The EU Framework Seven project Carbon Aware Travel Choices (CATCH) sets a goal of filling this information gap on city-level CO2 using these data, but there are issues relating to the use of E-PRTR data. The main one is that the methodology is a top-down approach, based on the spatial disaggregation of national emissions totals. Secondly, the resolution of the data is at a 5 km level, and CO2 emissions data are distributed into 5 km by 5 km grids using geospatial-referenced datasets, such as road networks for the road transport emissions. As a result, the CO2 emissions captured through this database at a sub-national level are not as accurate as if a bottom-up approach was adopted. See European Environment Agency (EEA), 2009. *E-PRTR: The European Pollutant Release and Transfer Register: Welcome to E-PRTR*. EEA; Copenhagen. Available at: http://prtr.ec.europa.eu

[17] This reflects the fact that for the exception of Bucharest urban areas are actually relatively low density, covering a large number of relatively small conurbations, the size of the haulage on Romania's highway network—Corridor IV is an important transit corridor--reflecting the importance of the ports and Romania's competitive advantage in haulage.

Figure 7: Road Transport CO_2 Emission Density for the Top 20 Romanian Cities

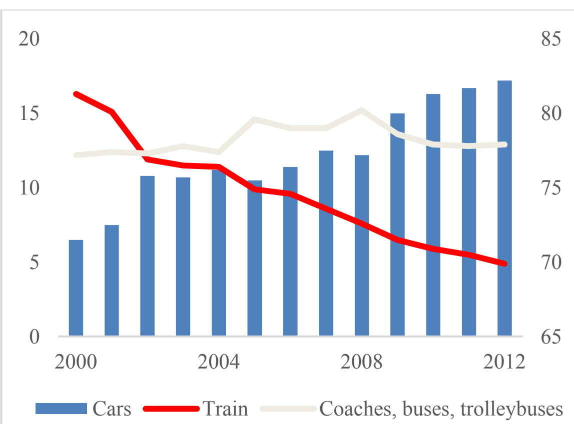


Source: World Bank, E-PRTR.

1.5 Passenger Transport

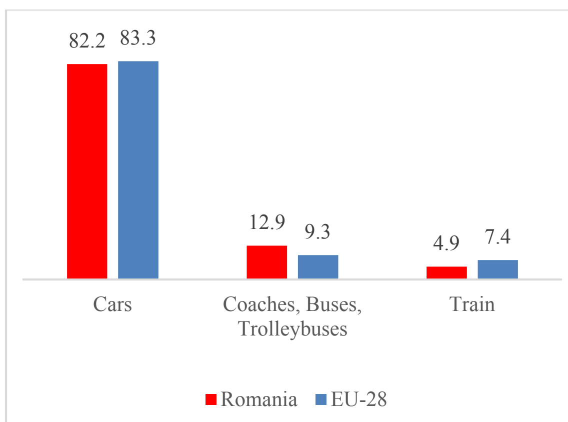
19. *Passenger land transport.* Figure 8 shows the modal split for passenger transport (in terms of percentage of total person-km travelled) between the three main land-based modes of domestic travel – private car, rail and bus/coach since 2000. This shows a marked rise in mode share of the private cars and a significant decline in rail mode share (with 2012 rail mode share being approximately one third of the 2000 figure). Bus and coach travel mode share has grown slightly between 2000 and 2011. Figure 9 shows how the modal split figures for Romania compare with the EU average. Private car mode share is now approaching the EU average, having been considerably lower at the turn of the millennium. Passenger rail mode share is lower than the EU average, having been above average in 2000.

Figure 8: Passenger Transport Mode Share (land-based modes)



Source: Eurostat.

Figure 9: Comparison of Passenger Modal Split with EU-28 average (2012)

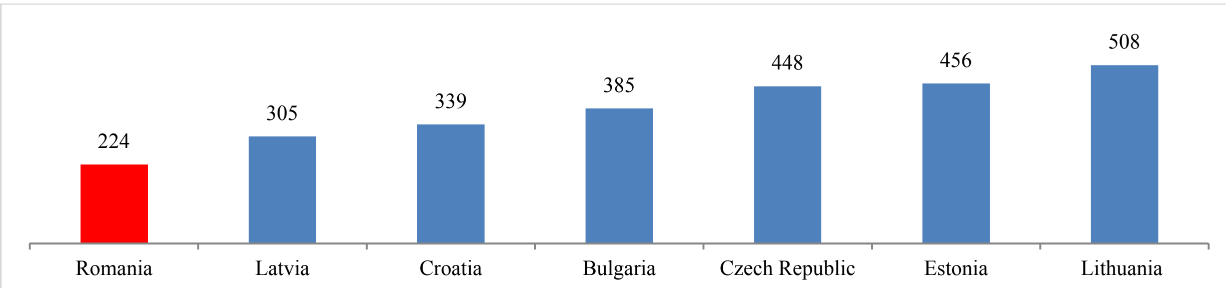


Source: Eurostat.

20. Although car mode share in Romania is at a similar level to the EU average, the motorization (or car ownership) rate in Romania is the lowest in the EU at 224 cars per 1000 inhabitants in 2012 (Figure

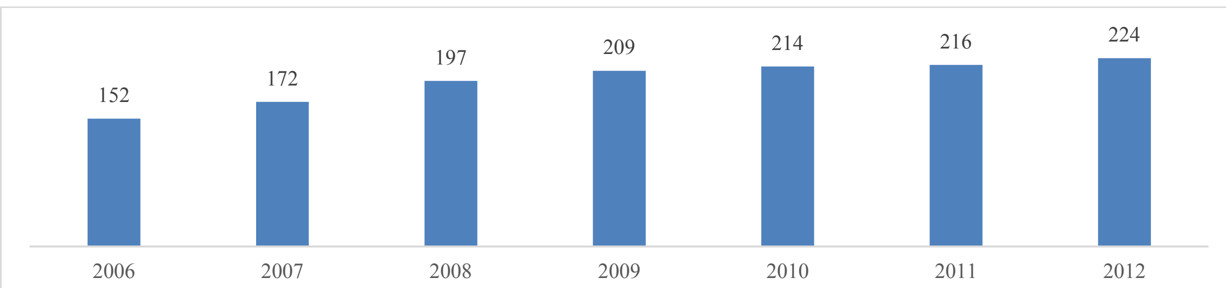
10), but has grown significantly in recent years, up from 152 cars per 1000 inhabitants in 2006 (Figure 11). Experience across the world suggests that as the Romanian economy grows, it will continue to grow in future. Without intervention to provide better transport alternatives and encourage their use, as car ownership grows, car use is also likely to grow. The reasons for the decline in rail passengers are linked to the decaying state of the Romanian railway system. In its Position Paper on Romania in preparation for the 2014-2020 funding round, the European Commission notes that the railway system is suffering from underinvestment and poor maintenance, leading to slow and unreliable train services.[18]

Figure 10: Motorization Rates in Selected EU Countries (passenger cars/1,000 inhabitants, 2012)



Source: Eurostat.

Figure 11: Motorization Rates in Romania, 2006-2012 (passenger cars/1,000 inhabitants, 2012)



Source: Eurostat.

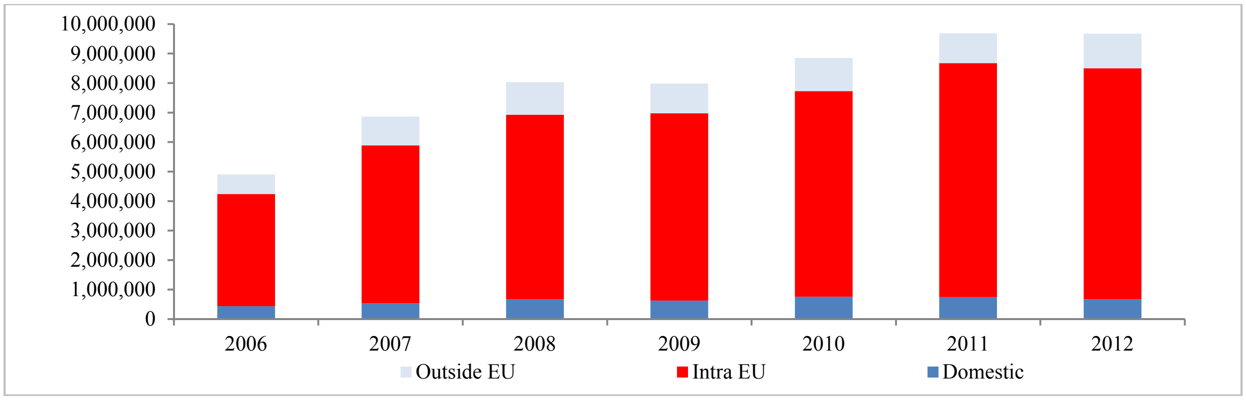
21. *Domestic air transport.* Air transport is well known as being an intensive emitter of greenhouse gases[19] – although there are a number of industry initiatives to reduce emissions. Domestic air passenger transport activity (internal within Romania) forms a small part (7 percent) of total passenger movements through Romanian airports. This is a relatively low level compared to other EU countries (the EU-27 average is 18 percent), although it has increased in recent years, as shown in **Error! Not a valid bookmark self-reference.**, despite the international economic downturn in 2007. Passengers flying to and from other

[18] European Commission (2012), Position of the Commission Services on the development of Partnership Agreement and programs in Romania for the period 2014-2020. European Commission, Ref. Ares (2012)1240252 - 19/10/2012.

[19] Factsheets: UK transport greenhouse gas emissions. UK Department for Transport. Available at www.gov.uk.

EU countries form the great majority of passengers using Romanian airports (81 percent), with the remainder (12 percent) flying to and from destinations outside the EU.

Figure 12: Air Passengers using Romanian Airports (excluding transit passengers)



Source: Statistical Office.

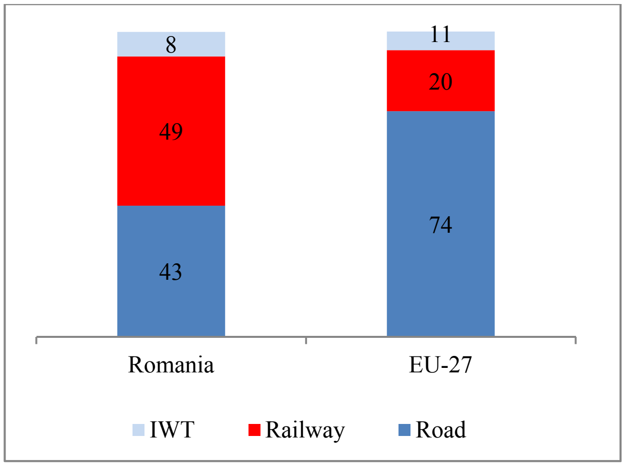
1.6 Freight Transport

22. The modal split for freight movements in Romania, in terms of ton-km, and how it has changed in recent years is shown in Figure 13 and Figure 14.[20] This shows a marked fall in rail freight mode share in recent years, together with a marked rise in road freight mode share. Also notable is the much larger waterborne freight mode share since 2009.[21] The reasons for the decline in rail freight and transfer to road and inland waterways are likely to be similar to those set out above for passenger transport. Rail freight mode share is higher than the EU average, in spite of its decline. Inland waterborne freight also has a much higher mode share than the EU average, while road freight is still below the EU average, despite its recent growth. It is important to stress that the growth of a clean transport mode, IWT, is an important development, and that the decline in rail's modal share has not translated into a one on one rise of road modal share. Also worth stressing is that the green transport modes (IWT and rail), had in 2010 a modal share of 51 percent in Romania, compared to only 24 percent for the EU-27.

[20] Eurostat data at http://epp.eurostat.ec.europa.eu. The amount of freight moved by air (which is excluded from the modal split figures shown above) is very small - 28,523 tons in 2011, up from 19,229 tons in Romania's first year of EU membership in 2007. For comparison, some 65 million tons of freight were transported on Romania's railways in 2007.

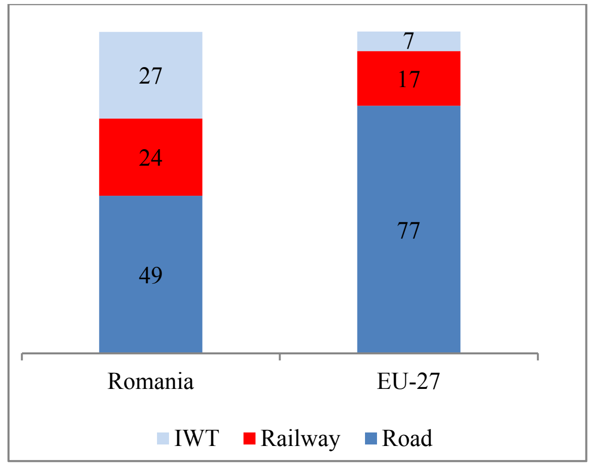
[21] According to a recent report, the three most important port locations in terms of transshipment volumes on the Danube are Izmail (Ukraine), Linz (Austria) and Galați (Romania). The seaport of Constanța in Romania is important as it is connected to the Danube via the Danube-Black Sea Canal and plays an important role as a transhipment gateway to the Black Sea, facilitating trade with Asia, the Middle East and the Black Sea region. See via Donau (2013), Manual on Danube Navigation. Available at: http://www.via-donau.org/fileadmin/site_upload/viadonau/HBDS_en.pdf

Figure 13: Freight Land Modal Share (2000)



Source: Eurostat.

Figure 14: Freight Land Modal Share (2010)



Source: Eurostat.

1.7 Urban Transport

23. Urban transport forms a major part of overall transport movements in Romania. Some 54 percent of the country's population lives in towns and cities, according to the 2011 national census.[22]. Transport within urban areas forms a vital part of the functioning of those areas as economic and social entities. There are nine cities in Romania with populations in excess of 200,000. As well as Bucharest (by far the largest city at 1.9 million), seven others (Constanta, Craiova, Ploiesti, Iasi, Brasov, Cluj-Napoca and Timisoara) have been designated as regional "growth poles". Galati is the other city of over 200,000 people. There are also 11 Romanian cities with populations between 100,000 and 200, 000 and a further 21 towns/cities with populations between 50,000 and 100,000.

24. However, readily available quantitative information on the urban transport situation across Romania is limited, and consultation and information gathering with all the individual municipal authorities is beyond the scope of the Transport Mitigation Report. Recent TRACE[23] studies assessing the potential for energy efficiency improvements undertaken by the World Bank in individual cities (Brasov, Cluj, Ploiesti) have yielded information, and some further information is also available through the Sustainable Energy Action Plans prepared by various Romanian towns and cities through the European Covenant of Mayors program.[24] In addition, the World Bank held an initial discussion meeting with the Executive Director for Transport in the Municipality of Bucharest on challenges and ambitions in Bucharest. This section presents information from these sources which, while not comprehensive, "paints a picture" of the urban transport scene in Romania. As described later in this Report, eight of the main cities (the seven "growth poles" plus Bucharest/Ilfov County) will soon be in the process of developing sustainable urban mobility plans, which will each investigate the urban transport challenges in depth and develop an overarching strategy for addressing them.

[22] http://www.recensamantromania.ro/rezultate-2/
[23] http://esmap.org/TRACE
[24] http://www.covenantofmayors.eu/actions/sustainable-energy-action-plans

25. As noted in the TRACE study reports, there is limited reliable information on modal split in many Romanian cities. The Brasov study sums the situation up as follows "Like in other growth poles, the city lacks information on the transport mode split. The local government does not have information on how many people use public transport, how many walk, and how many of them commute using their own cars. City authorities should document information on trips, to understand exactly how many people complete trips and commute in the city and by what means. Without documenting such information, it is almost impossible to do proper transport planning."

26. *Traffic congestion*. Traffic congestion is reported to be an increasing problem in a number of cities, as vehicle ownership grows. For example, the rapid review of the situation in the TRACE studies in Brasov,[25] Cluj-Napoca[26] and Ploiesti[27] all identified traffic congestion as a problem issue. In Bucharest, congestion is also a significant problem,[28] as confirmed in our discussion with the Municipality of Bucharest. Congestion, with the resulting start-stop nature of the driving cycle it imposes on vehicles, significantly increases greenhouse and other gaseous emissions from road traffic. Bucharest has a traffic signal and control system, which is currently in the process of being upgraded. Other cities are also known to have traffic signal systems – but there is no readily available information on their type or operating status.

27. *Parking.* With the rapid growth in ownership and use of private vehicles since Romania started the transition to a market economy, the supply of designated parking spaces in Romania's cities has come under pressure and the number is often inadequate to meet demand. This often leads to "informal" parking arrangements, with vehicles parking on footways, cycle tracks and public spaces as well as on every available meter of legitimate roadside parking space. As well as causing difficulties for pedestrians, cyclists and other road users, this also adds to the congestion problems noted above. Management of parking in some Romanian cities is rudimentary or non-existent, with little or no enforcement of parking regulations, nor any attempt to use parking restraint (through charging or enforcement of restrictions) as a demand management tool. In other cities such as Brasov and Cluj-Napoca, new parking management systems including use of parking meters, mobile phone payment, among others, are however taking hold.

28. *Public transport*. Public transport in Bucharest includes a metro system (operated by Metrorex), a tram network, trolley buses, and an extensive bus network (all operated by RATB). RATB is an operating company overseen by the Municipality of Bucharest, while Metrorex is an operating company under the auspices of the Ministry of Transport and Infrastructure. Rail lines also exist which could potentially provide suburban transport services for commuting.[29] In other Romanian cities and towns, public transport

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[25] Improving energy efficiency in Brasov, Romania: TRACE city energy efficiency diagnostic study. World Bank (under the Romania Regional Development Program), undated.
[26] Improving energy efficiency in Cluj-Napoca, Romania: TRACE city energy efficiency diagnostic study. World Bank (under the Romania Regional Development Program), undated.
[27] Improving energy efficiency in Ploiesti, Romania: TRACE city energy efficiency diagnostic study. World Bank (under the Romania Regional Development Program), undated.
[28] Bucharest - sustainable mobility case study. Mihaila Raducu, Goteborg University, 2010.
[29] European funds warm up modernization works in Romania. Railway Pro, 26th February 2013 issue, available at http://www.railwaypro.com/wp/?p=11645

consists of buses, minibuses, trolley buses and trams. The city of Brasov took the decision in 2005 to abandon its tram line due to the prohibitive cost of upgrading and maintaining it. It now focuses on buses and trolley buses. Cluj-Napoca has upgraded its tram system, while other cities have similar plans but lack funding to implement them.

29. Although data is hard to obtain, it is understood that public transport patronage in many Romanian towns and cities is in decline, with a corresponding increase in private traffic levels. For example, in Ploiesti, public transport patronage fell from 7 million trips per month in 2011 to 6.7 million in 2012. Ridership is going slightly down[30]. Some cities are making concerted efforts to reverse this trend through modernization of infrastructure and services, although lack of funding remains a serious constraint. For example, the Brasov Municipality and by operating company renewed its bus fleet with 109 new vehicles in 2006, using an EBRD loan, and purchased a further 15 Euro V diesel buses in 2011[31]. The whole fleet purchased in 2006 is reaching the end of its life, however, and will need replacement by2015.

30. *Taxis, pedestrian and cycling infrastructure.* There is a plentiful supply of taxis in most Romanian cities. However, many of the vehicles are old and not fuel-efficient, mirroring the make-up of the national vehicle park. Some cities have an age limit for taxi vehicles, but this varies significantly (Brasov has an age limit of five years, while in Cluj-Napoca the age limit is 12 years). Pedestrian and cycling infrastructure varies greatly in quality and quantity between different towns and cities, and within different city areas. A number of Romanian towns and cities have recognized the value of these modes in improving energy efficiency, reducing congestion and creating pleasant urban environments. For example, efforts to improve walking and cycling facilities are reported in all three TRACE studies cited above, and mention is made of encouraging these modes in some Sustainable Energy Action Plans.[32] As with other modes, however, data is hard to come by on the numbers of urban trips being made on foot or bicycle.

31. In Brasov in 2008, the Municipality developed a pedestrian area in the historical center with 10 streets closed to car traffic and streets repaved with cobblestones, using funding from the 2007-2013 Regional Operational Program. In Ploiesti, an EU-supported CIVITAS project promoted walking and a pedestrian zone was created in the city center, backed by a campaign to encourage behavioral change. As a consequence, there has reportedly been a 20 percent improvement in public transport speed, in addition to a 15 percent reduction in pollution in the central zone of the city.

32. In terms of cycling, good cycling infrastructure exists in some cities but it is generally patchy and does not form a coherent network, and is often poorly maintained. As noted above, parking on cycle lanes is also a problem, reducing their usability further. However, there are examples where the cycling environment is being improved. In Cluj-Napoca, the municipality is extending its cycle lane network by 18km (to 58km in total) in the city and out to the suburbs; 50 self-service bicycle docking stations in the

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[30] Improving energy efficiency in Ploiesti, Romania: TRACE city energy efficiency diagnostic study. World Bank (under the Romania Regional Development Program), undated.
[31] Improving energy efficiency in Brasov, Romania: TRACE city energy efficiency diagnostic study. World Bank (under the Romania Regional Development Program), undated.
[32] Sustainable Energy Action Plan of Vaslui 2011-2020. Municipality of Vaslui, 2009.

metropolitan area are also being built. The Municipality of Ploiesti also took part in SPICYCLES[33], a project developed under the EU Intelligent Energy Europe program, along with Barcelona, Bucharest, Berlin, Goteborg, and Rome. Ploiești ran a bike-sharing pilot scheme which was promoted among commercial companies, local government institutions and educational institutions.

1.8 Mitigation Challenges

33. The previous section has reviewed GHG from the transport sector in Romania and presented a brief overview of modal share, as well as some of the challenges facing urban transport. In a do nothing scenario, Romania's GHG emissions from transport are set to continue growing rapidly compared to the EU, particularly if its motorization rates converges to the EU average. The challenges for mitigating GHG in the transport sector are significant. This is illustrated by the recent European Environment Agency (EEA) report on the State of the European Environment which highlights the fact that 'transport, including emissions from international transport, is the only EU sector to have increased its GHG emissions since 1990'. [34]

34. A major overall challenge is decoupling economic growth from transport emissions.[35] Figure 15 presents real GDP growth and GHG emissions from the transport sector in Romania over 2000-2012, suggesting that they move in tandem, with an inflexion in 2009 when real GDP started growing more rapidly than transported related GHG emissions.[36] Over the 2000-2012 period, GHG emissions rose by 54 percent, while real GDP rose by 55 percent. As noted in the EEA report, European demand for transport has increased in line with GDP in recent years, reflecting the close interdependence of transport and economic development. To mitigate GHG emissions, growth in demand needs to be either limited or managed in some way or targeted on low emission travel modes, coupled with reducing GHG rates (g/km emitted) from vehicles. The EEA report recognizes that while new engine technologies will help mitigate GHG, a more holistic approach is required. This includes measures to encourage change in people's travel behavior and choices (as well as technological measures) – which is in line with the broad range of policy interventions examined in this Report.

35. Increasing motorization (car ownership) is a particular issue for the transport sector in Romania. Although car mode share in Romania is at a similar level to the EU average, the motorization (or car ownership) rate in Romania is the lowest in the EU at 224 cars per 1000 inhabitants in 2012, having grown significantly in recent years from 152 cars per 1000 inhabitants in 2006. Experience across the world

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[33] Newsletter Spicycles Available at: http://www2.trafikkontoret.goteborg.se/resourcelibrary/SPICYCLES percent20Newsletter percent201.pdf

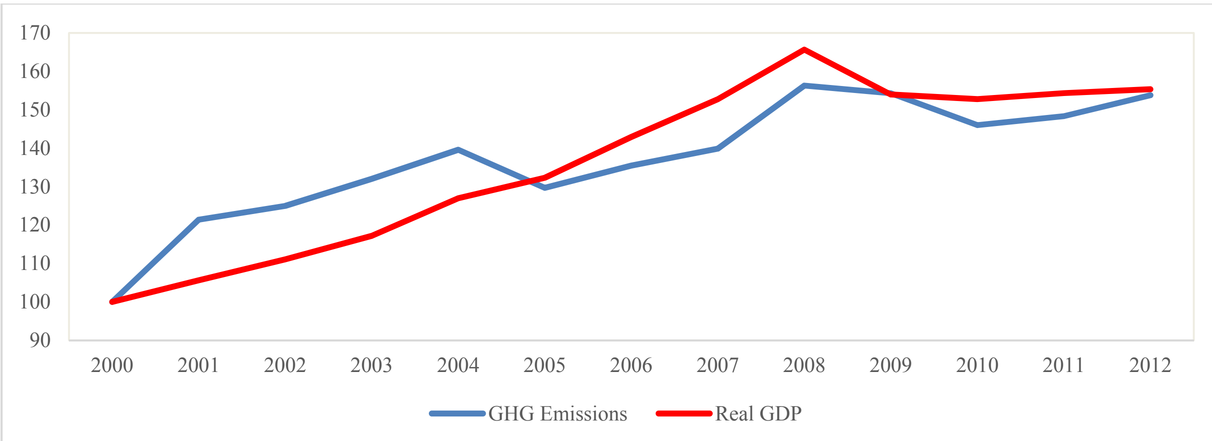
[34] EEA (2015), SOER 2015 - The European Environment - State and Outlook 2015. A comprehensive assessment of the European environment's state, trends and prospects, in a global context. Available at: http://www.eea.europa.eu/soer

[35] Decoupling can be understood in different manners. One interpretation would be that transport emissions go down while real economic activity is positive. This is a very ambitious target, but a more realistic one is ensuring that the growth of GHG emissions from the transport sector is slower than the growth of real GDP.

[36] The observed decoupling of transport GHG emissions to GDP may be in part attributable to the evolution I fuel prices which rose rapidly in 2004 and 2006, before falling back by 2008. By 2010 fuel prices had bounced back, reaching new highs and continued to rise rapidly, constraining travel demand and leading to a fall in emissions.
See: https://energypedia.info/wiki/Fuel_Price_Data_Romania

suggests that as the Romanian economy grows, the motorization rate will continue to grow in future. Without intervention to provide better transport alternatives and encourage their use, as car ownership grows, car use is also likely to grow. The General Transport Master Plan projects rapid growth in car ownership, with the motorization rate exceeding 350 cars per 1,000 inhabitants by 2030, which would represent an increase in excess of 50 percent increase over 2012-2030.[37]

Figure 15: Real GDP Growth and GHG Emissions from Transport Sector (2000=100)



Sources: IMF, World Economic Outlook, April 2015; EEA.

36. The current state of the railway system in Romania is also a key issue when considering mitigating GHG emissions in the transport sector. Both passenger and freight movements by rail have declined dramatically in recent years. This is linked to the decaying state of the Romanian railway system. In its Position Paper on Romania in preparation for the 2014-2020 funding round, the European Commission noted that the railway system is suffering from underinvestment and poor maintenance, leading to slow and unreliable train services.[38] The GTMP report argues that Romanian railways 'are in a crisis situation', and recommends:

- serious structural reforms;
- substantially increased spending on maintenance and renewals;
- increased investment in rehabilitation to current design speeds; and
- introduction of regular interval timetables, convenient for passenger needs.

37. These measures are built into the GTMP, and thus are included in the Business-as-Usual scenario for this study. Inevitably, however, there will be a process of transition to go through, during which it

[37] The draft version of the GTMP of October 2014 was used for the purposes of the modelling.
[38] European Commission (2012), Position of the Commission Services on the development of Partnership Agreement and programs in Romania for the period 2014-2020. European Commission, Ref. Ares (2012)1240252 - 19/10/2012.

would be difficult to implement effective additional interventions aimed at encouraging greater rail use (which would reduce emissions compared with road or air travel). At the same time, significant GTMP investments in improved road infrastructure would increase demand for road travel.

38. Lack of infrastructure for alternative fuels is an issue that needs to be addressed if take-up of low carbon vehicle technologies (with associated GHG emission savings) is to be accelerated beyond the trajectory achievable by market forces alone. This has already been recognized in other countries where governments have invested to provide such infrastructure. It is also recognized by the European Commission—a directive for the deployment of the alternative fuels infrastructure was adopted in October 2014, requiring EU member states to provide a minimum infrastructure for alternative fuels such as electricity, hydrogen and natural gas, as well as common EU-wide standards for equipment needed and user information.[39] Member States must set and make public their targets and present their national policy frameworks by the end of 2016. At present, Romania has a low level of such infrastructure—there are only 20 electric vehicle charging stations according to the Romanian Electric Vehicle Association (AVER)[40]. This clearly constrains the use of alternative fuel vehicles, even if the number of such vehicles available on the commercial market is growing rapidly.

39. Finally, integrated land use and transport planning in urban areas is a key issue that needs to be addressed if transport emissions are to be minimized in future. Although this aspect is covered under the Bucharest modelling work undertaken by the World Bank urban sector team, it is worth noting that failure to consider land use and transport in an integrated manner in Romania's towns and cities in the future will inevitably lead to unnecessary motorized travel and consequent GHG.

1.9 Structure of the Report

40. Following this introductory chapter, Chapter 2 presents a brief overview of the methodological approach to modelling emissions in the transport sector, a more detailed discussion can be found in Annex 1. Chapter 3 assesses potential interventions aimed at limiting GHG emissions, focusing on pricing instruments, technology, regulatory, and operational efficiency interventions, before turning to urban planning, behavioural change, and zero carbon urban investments. Chapter provides a presentation of the marginal abatement cost curve, the underlying framework for developing the Green and Super Green Scenarios, before providing the final results of the modelling work, comparing business as usual emissions with those from the two modelled scenarios.

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[39] Directive 2014 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the Deployment of Alternative Fuels Infrastructure. See: http://ec.europa.eu/transport/themes/urban/cpt/index_en.htm

[40] www.aver.ro

2 METHODOLOGICAL APPROACH TO MODELLING TRANSPORT EMISSIONS

2.1 Introduction

41. The overall objective of the transport mitigation modelling work was to develop a Green Scenario and an associated Action Plan that would guide the Romanian Government in their decisions on how best to invest in transport-related interventions that would contribute to climate change mitigation. The recommended scenario would take account of GHG benefit, as modelled in the study, and cost to the Government of Romania of alternative interventions, as well as qualitative consideration of co-benefits and implementation issues. A second, more ambitious Super Green Scenario is also developed, in order to assess additional possible efforts, although measures. This chapter will provide a succinct overview of the general approach to GHG emission modelling adopted in the study—further details can be found in Annex 1—before turning to the intervention cost estimation and the marginal abatement cost curve analysis. This sets the stage for the next chapter which provides an assessment of alternative interventions to reduce GHG emissions in the transport sector.

2.2 General Approach to Transport GHG Emission Modelling

42. A fundamental task involved developing a flexible, agile and user-friendly modelling tool that could be used for appraisal of the emission impacts of alternative interventions. Only the direct impact on transport fleet, vehicle activity and energy intensity have been modelled. Second order impacts on the wider economy would require further modelling. TRANSEPT (Transport Strategic Emission Prediction Tool) is an Excel spreadsheet based tool, which draws on data and relationships from a variety of sources, including:

- **National Transport Model (NTM)**: The NTM was developed to appraise a wide range of potential interventions (both infrastructure and policy interventions) within the GTMP study. It has been designed to provide a robust tool for assessment of: (a) national and regional impacts of changes in population and its distribution; (b) national and regional changes in economic activity; (c) strategic inter urban highway schemes; (d) rail infrastructure and service proposals including major investment such as high speed rail; national and regional bus strategy development; and (e) national policy measures such differential pricing for rail and air; internalization of external transport costs; climate change policies (e.g. subsidy of low emission modes); implementation of a road tax; and car ownership and its linkage to level of taxation.

  The NTM includes modelling of both passenger and freight movements, by road, rail, air and inland waterways. It is based on the EMME3 transport planning software platform and has spatially detailed representation of travel demand patterns and transport networks. It has been calibrated using existing data and validated using internationally accepted standards. A number of transport policy interventions have been appraised using the NTM—including

GHG impacts assessed using the NTM in conjunction with the TREMOVE emissions module. The NTM can be used directly to model alternative mitigation policy options and provide outputs to TREMOVE that can calculate GHG impacts. Data inputs and outputs from the model runs undertaken within the GTMP study and various modelling reports were used to develop the transport mitigation modelling work.

- **TREMOVE**: The publicly available EU wide policy assessment model, designed to study the effects of different transport and environment policies on the transport sector. The model estimates for technical and non-technical measures and policies such as road pricing, public transport pricing, emission standards, subsidies for cleaner cars etc., the transport demand, modal shifts, vehicle stock renewal and scrappage decisions as well as the emissions of GHG, air pollutants and the welfare level. TREMOVE models both passenger and freight transport. The model covers all inland urban and interurban transport modes - road, rail, water and air transportation, from 1995-2030. Input databases are calibrated to feed the model for 30 countries (EU-28 plus Norway, Switzerland and Turkey).[41]
- **COPERT**. COPERT 4 is a software tool used world-wide to calculate air pollutant and greenhouse gas emissions from road transport.[42] COPERT has been developed for official road transport emission inventory preparation in EEA member countries. The COPERT 4 methodology is part of the EMEP/EEA air pollutant emission inventory guidebook for the calculation of air pollutant emissions and is consistent with the 2006 IPCC Guidelines for the calculation of GHG emissions. The use of a software tool to calculate road transport emissions allows for transparent and standardized, consistent and comparable, data collecting and emissions reporting procedure, in accordance with the requirements of international conventions and protocols and EU legislation.
- **SULTAN**. The SULTAN (**SU**stainab**L**e **T**r**AN**sport) Illustrative Scenarios Tool has been developed as a high-level calculator to help provide indicative estimates of the possible impacts of policy on transport in the EU (primarily energy use and GHG emissions, also costs, energy security, NOx and PM emissions). The purpose of the tool is to allow the quick scoping of a wide range of transport policy options to help get a feel for what scale of action might be required and will also be used as part of the analysis for the final written technical outputs of the project. Many of the core inputs to the TRANSEPT model were taken from SULTAN as the SULTAN emissions forecasting module as part of the model, including the fleet evolution profile (technologies, survival rates), emissions factors, and fuel mix.[43]

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[41] For more information visit the website http://www.tremove.org/

[42] The development of COPERT is coordinated by the European Environment Agency (EEA), in the framework of the activities of the European Topic Centre for Air Pollution and Climate Change Mitigation. The European Commission's Joint Research Centre manages the scientific development of the model.

[43] SULTAN was developed as part of the *EU Transport GHG: Routes to 2050 II* project, a 15-month project funded by the European Commission's Directorate General Climate Action that started in January 2011 and was completed in July 2012.

- **Eurostat data**. Eurostat is the statistical office of the European Union situated in Luxembourg. Its task is to provide the European Union with statistics at European level that enable comparisons between countries and regions.
- **General Transport Master Plan (GTMP)**. The GTMP produced by AECOM for the Romanian Government in October 2014, has formed a key input to the emissions modelling process. The GTMP sets out the investment objectives over the period to 2030. The proposed investment program covers a range of measures including highway infrastructure, rail network extension and enhancement and the upgrading of ports.
- **E-PRTR**. The CO_2 emissions from road transport in the 20 cities in Romania with a population in excess of 100,000 have been estimated using ArcGIS software with the E-PRTR dataset in 2011 at the 5km by 5km grid level. This allowed factoring urban measure impacts to that which would be likely to be achieved with the 20 largest cities appropriate for which urban interventions were considered.

43. The impact of the planned investment as foreseen in the GTMP on travel demand, vehicle activity and implicitly on transport emissions are tested within the NTM which underpins the development of the GTMP. The outputs of the NTM have been utilized within the emissions modelling as the most thorough and robust source of projections for future transport activity, taking account of planned investment. It should be noted however that the NTM outputs are subject to the following constraints:

- Only the strategic route network is included within the model. This includes all of the motorways, expressways, major national routes and also the strategic urban routes. However, local urban roads and smaller rural roads are not included within the modelled network. Urban and non-strategic highway network emissions have been calculated based on COPERT vehicle activity data.
- The future year projections cover the period of the GTMP—up to 2030—with a further modelled year of 2040. Beyond 2040 trends must be extrapolated.
- The NTM includes representation of private vehicles, goods vehicles, passenger and freight rail, maritime and air transport. However, travel activity is represented in terms of vehicle-km with no detailed modelling of the characteristics of the vehicle fleet. Hence, the evolution in vehicle fleet technology needs to be derived from other sources (with the exception of rail, for which details of planned investment in new units is provided within the GTMP).

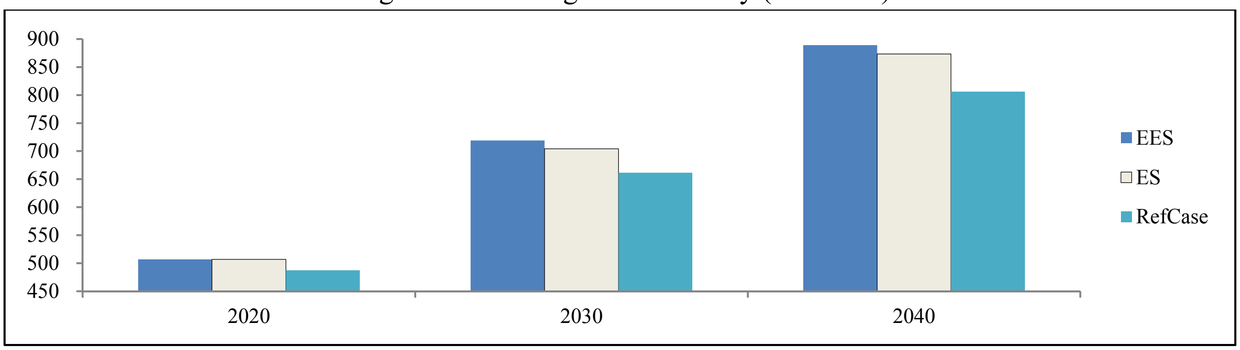
The GTMP sets out two future scenarios, an economically efficient scenario (ES) and an economically and environmentally efficient scenario' (EES), both of which are modelled within the NTM, and a reference case, with slightly different phasing of investments.

The context of the project was the Commission's long-term objective for tackling climate change. Further information can be found at: http://ec.europa.eu/eurostat/about/overview

44. Figure 16 highlights the increase in forecast vehicle activity under the projected scenarios, driven primarily by investment in improved highway infrastructure which offers increased opportunity to travel, with a marginal difference in trajectory of vehicle activity between the alternative scenarios.

45. For each input required by the model, the available data sources were reviewed, and the most robust data selected to populate the model. The Romania specific COPERT dataset formed the preferred primary data source for existing vehicle stock and vehicle activity, having consistency with the TREMOVE Routes to 2050 modelling work. The NTM represents the most detailed set of projections for future vehicle activity on the Romanian highway, rail and waterways network. SULTAN EU wide data formed a secondary source of data, where Romania specific data was not available. The NTM focuses on the strategic highway network and as such, much of the urban activity taking place on local roads, and activity on small rural roads are not represented in the NTM outputs. To capture this missing activity, COPERT vehicle activity data was used as the reference point for the split of urban, non-urban and expressway activity. This COPERT data estimates the proportion of activity taking place in in urban areas, disaggregated by vehicle type. This split formed the basis for baseline emissions estimates.

Figure 16: Passenger Car Activity (‘000s km)



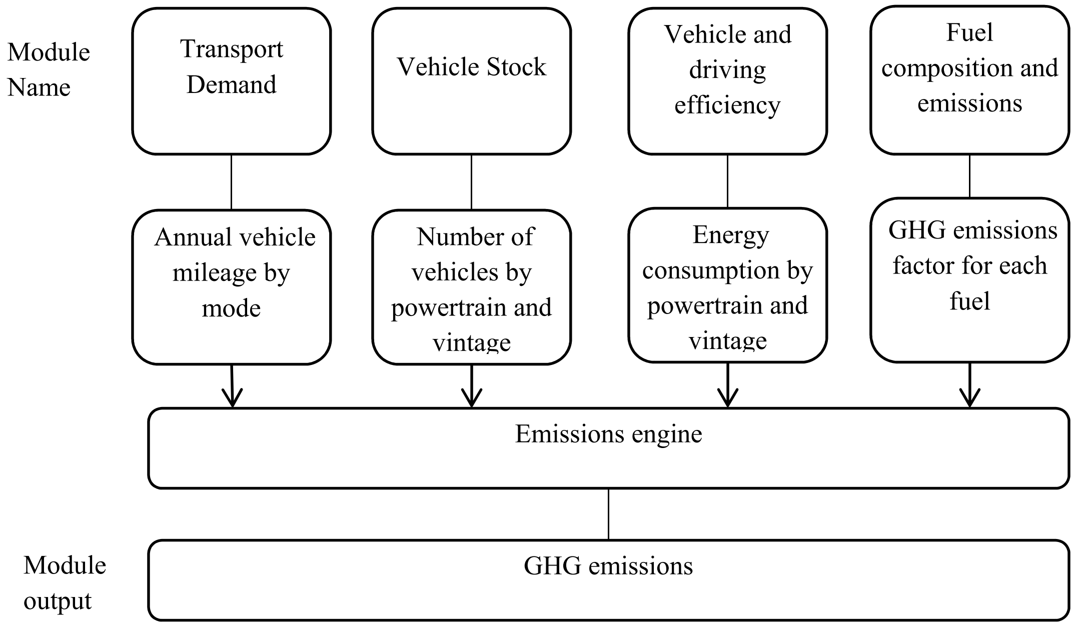
Sources: TRANSEPT derived from AECOM NTM.

46. In determining the appropriate baseline scenario for the transport emissions model, the merits of the three NTM modelled scenarios were considered. The reference case includes none of the proposed investment and hence represents an unrealistic projection of future travel growth. Given Romania’s objectives of delivering both an economically efficient and environmentally sustainable transport network, the EES scenario and its modelled investment profile has been adopted within the baseline for the emissions modelling. It should be noted that the proposed investments underpinning the EES scenario may only materialize with significant delays and consideration was given to lagging transport demand growth accordingly. However, the development of a hybrid profile to reflect this would require divergence from the wide range of output statistics from the NTM, including vehicle and passenger activity and vehicle speeds across different modes. In practical terms, this was considered to potentially undermine the integrity of the data inputs, and therefore the inclusion of the EES scenario as modelled was adopted as the preferred approach. It should be noted that if implementation of investments falls short of the investment profile proposed within the GTMP, this would likely to lead to *lower* transport emissions across all scenarios. As such, the modelled business as usual (BAU) represents a conservative projection of transport emissions to the upper side.

47. TRANSEPT includes four modules which produce the input matrices for the emissions engine which calculates the GHG emissions. The four modules are: (a) transport demand; (b) vehicle stock; (c) vehicle and driving efficiency; and (d) fuel consumption. Each module takes a number of baseline datasets as input and applies the effect of relevant policy interventions to them. The adjusted datasets are then input to the emissions engine which calculates the resulting GHG emissions. The process is outlined in Figure 14. The TRANSEPT tool has the following main dimensions:

- It takes account of both direct (tailpipe) and indirect emissions.
- It covers road, rail, waterborne and air travel modes.
- Modes are split into passenger and freight transport.
- Transport activity and consequent emissions are split by urban / non-urban / highway locations.
- Different powertrain and fuel options are modelled as appropriate to each mode.
- Time horizons modelled are 2011 (base year), 2015, 2020, 2025, 2030, 2035, 2040, 2045, 2050.

Figure 17: Overview of TRANSEPT Model Process



Source: World Bank.

The technical detail of the model including the source input data and basis for projections is included in Annex 1. The assessment of potential interventions to reduce GHG emissions from the transport sector were divided into five broad categories: (a) pricing instruments; (b) technology; (c) regulatory; and (d) operational efficiency; and (e) urban planning, behavioral change, and low carbon infrastructure investment. The model is able to forecast the impact on GHG emissions of individual interventions and bundles of interventions, with the synergies between interventions reflected in the abatement results under the scenarios. In other words, the sum of carbon savings from each individual intervention will not match the combined impact under the Green or Super Green Scenario.

48. For all urban measures that are modelled, the intervention is applied to Romania's largest 20 cities, with the exception of urban congestion charging which has been costed for one major scheme in Bucharest, as the only city appropriate for this intervention. For each intervention, the Report summarizes the key issues associated with that intervention in a succinct format, as set out in subsequent sections of this Report. This included the potential GHG emission reduction impacts, the costs involved, and implementation issues. Taken together, this allowed us to reach conclusions on which interventions should be included in the recommended Green Scenario. The TRANSEPT model was then re-run with all the constituent scenario interventions included. To demonstrate the potential impact of adopting the full package of identified measures, a Super Green Scenario was developed, which included all modelled interventions.

49. A large proportion of the population in Romania live in urban areas, with significant transport activity concentrated in these areas accordingly. The COPERT Romania dataset suggests that 44 percent of private road vehicle activity takes place within the urban areas.[44] Whilst the scope of the project does not extend to detailed modelling of individual urban areas, Bucharest is being covered by the Urban Report under Task C, the scale of carbon emissions generated within the urban areas are sizable and therefore form an essential component of national emissions estimates. Urban emissions are therefore included within the baseline at a strategic level, through their inclusion as a single 'urban' area type—that is to say, not broken down to the individual city level. The impact of urban intervention measures are also estimated, based on assessment at the strategic level. Where the applicability of certain policies relate to only the largest cities or only Bucharest (urban congestion charging for example), the relative scale of vehicle activity within these locations is considered in assessing likely scheme impact. This strategic analysis draws on the scale of vehicle activity within the major cities, data related to spatial coverage, population, population density and also from the EU road transport emissions database (E-PRTR data).

2.3 Intervention Cost Estimation

50. In parallel with the emission modelling, broad cost estimates have been calculated for the interventions under consideration. These were prepared at a level of accuracy that is appropriate to the strategic nature of this study, and included both capital costs and operating costs relative to the business-as-usual scenario. Costs considered were costs to Government in implementing the interventions under consideration. Existing knowledge of the potential costs of the interventions was supplemented through further research and investigation as required, including:

- Published research and information on the costs of interventions (for example, from EU research projects);
- Consideration of the general level of Romanian cost in comparison to other European countries;
- Cost databases (where appropriate); and
- Cost estimates used in the World Bank's recent Macedonia Mitigation Study.

51. Where schemes generate ongoing revenues, these revenues have not been included within the scheme cost projections. The revenues are typically transfer payments from the private sector, and without inclusion of the corresponding private sector costs—which have been excluded from the analysis—would paint an imbalanced picture of scheme merit.

2.4 Marginal Abatement Cost Analysis

52. A marginal abatement cost (MAC) analysis was made drawing on the emission impact forecasts and the discounted cost estimates over the appraisal period to 2050. This was originally restricted to the

[44] COPERT vehicle activity data is broken down by Urban, non-urban and highway.

policy interventions associated with new transport technology options. This is because, within the transport sector, planning a low carbon development pathway should generally involve more than choosing the options with the largest GHG abatement potential per euro, as this forms a very narrow, one-dimensional view. Outside the area of technological interventions, other transport interventions have impacts in many other key areas such as economic, safety, social and other environmental impacts which may well be larger in magnitude than GHG abatement potential. In order to inform the appraisal of alternative policies for inclusion in the Green Scenario, a high level marginal abatement cost analysis was undertaken to provide a means of comparison. The results of this analysis are also included within the MAC curve reporting, although caveats are made in relation to the unquantified nature of the wider benefits of these schemes.

3 ASSESSMENT OF POTENTIAL INTERVENTIONS

3.1 Introduction

53. A good way of thinking of mechanisms to reduce emissions in the transport sector is the avoid-shift-improve (A-S-I) paradigm, associated with Holger Dalkmann:[45]

(a) **Avoid** growth of CO_2 emissions through urban and interurban development that reduces the need for long-distance travel in passenger vehicles. Singapore is a good example of a coherent and comprehensive set of land use and development policies aimed at reducing the dependence on passenger vehicles, in contrast to the US suburbanization model. This is clearly linked to urban development issues and transport policies developed in response to these.

(b) **Shift** transport to modes with lower emissions, by shifting passenger traffic to buses, rail or metro and freight to rail, and away from passenger vehicles and trucks. Given that cities produce a large share of emissions, this would require developing policies to encourage modal shift from passenger vehicles to mass transit, either to increase the modal share of public transport or to slow down a declining modal share. Increasing the role of rail, particularly for freight, is critical; a successful example that comes to mind is Switzerland.

(c) **Improve** vehicles, fuels and operations in order to mitigation emissions with existing and future vehicles technologies, fuel economy standards, and through traffic management policies.

54. The set of policies aimed at dealing with A-S-I can be broadly considered to be pricing instruments, regulatory, operational efficiency, and investments. Pricing policies, such as the introduction of a congestion charge aimed at encouraging modal shift from passenger vehicles to public transport and non-motorized transport, but could be combined with restrictive parking regulations and investing funds from the congestion charge for improving and extending mass transit. All three sets of policies, pricing, regulatory, and investment decisions are clearly needed, and in practice, it is a whole set of policies, rather than one policy introduced in isolation, which has helped reduce the usage of passenger vehicles in a number of European cities. In what follows a menu of individual policy options is presented, with a greater focus on roads, as this is the sector which generates the most emissions in the transport sector. It goes without saying that greater investments in public transport is needed in order to reduce vehicle use, and this has not been elaborated in this section, as this is embedded into the BAU.

[45] This chapter draws on Monsalve, Carolina (2013), Controlling Greenhouse Gas Emissions Generated by the Transport Sector in ECA: Policy Options, World Bank Transport Paper TP-40, February 2013. Available at: http://siteresources.worldbank.org/INTTRANSPORT/Resources/336291-1227561426235/5611053-1229359963828/TP40-Final.pdf

55. The range of interventions selected and tested within this study focus on measures which could conceivably be implemented within the period of the Action Plan (2015-2022) or the preparatory studies undertaken to allow implementation by 2030, consistent with the GTMP investment horizon. The impact of the policies extends beyond 2030, with the majority of the modelled interventions continuing to have an impact on vehicle activity and purchasing decisions through to 2050. A focus on policy measures which would not be implementable or appropriate before 2030 was not pursued, as these would not have great relevance to actions which could be taken by the Government of Romania within the action plan period, and the evolving landscape would be likely to undermine the relevance of such long term proposals within the extended timeframe.

56. This chapter begins by reviewing pricing instruments, then turns to regulatory and operational efficiency, and ends with a review of urban planning, behavioral change, and low carbon infrastructure investment. Each potential intervention is described, together with examples from around the world, potential implementation timeframe, information on costs, how the intervention was modelled (where applicable), and likely GHG benefits. With all interventions, implementation was assumed to take place as early as is likely to be feasible in order to maximize benefits.[46]

3.2 Pricing Instruments

57. **Road User Charging (RUC).** When deciding to make a journey a driver will normally consider the costs to him/herself, that is to say the cost of fuel, personal cost if delayed due to heavy traffic, and parking costs, when in fact there are many other associated costs. Road pricing theory argues that the socially optimal amount of transport in total and by mode requires that users be confronted with a price at the point of use that reflects the full social cost of his/her trip at the margin or marginal social cost pricing. Social costs are defined to include private marginal costs (fuel, vehicle maintenance, driver and passenger time for a specific vehicle trip), together with any damage done to the infrastructure, the capital costs of the infrastructure, the impact of exhaust emissions locally, regionally or globally in the form of CO_2 or GHG emissions, and the contribution to congestion, noise, and accidents. Internalizing these costs—adopting the user pays principle—requires making each driver pay for their part of the general costs generated.

58. Road pricing can be used as a flexible way of charging people and can help end the idea that one can drive a vehicle without thinking about the external consequences to society. Pricing is critical to

[46] No direct intervention was modelled with regard to railways. Enhancements to the rail network are modelled within the GTMP, in terms of extended network coverage and new units to provide greater service levels. If service levels are not achieved then the mode share of the rail system may be expected to continue to decline and ultimately cease to function. Improvements to the rail network are implicit to the business as usual forecasts. Additional measures, not modelled, would focus on ensuring greater commercial orientation in the running of the state-owned rail companies, through for example, the hiring of commercially orientated executives through a best practice international recruitment effort. Individual railway infrastructure projects need to be implemented as part of a holistic package to improve the attractiveness of rail travel (including rolling stock, maintenance, operational efficiency and customer service) on the relevant rail lines. Without such an approach, neither the economic nor the GHG mitigation benefits will be realized.

reducing GHG emissions and represents one of the key transport policies to reduce demand by raising the relative price of vehicle use to alternative mass transit in cities or other modes outside of urban areas. This section presents a brief overview of some of the pricing policy options available to policy makers wishing to contain the growth of the modal share of vehicles, drawing on international experience. Road user charging can be seen as an alternative to fuel taxation, which is also based on the 'user pays' principle. However, the adoption of road user charging allows greater flexibility and adaptability, for example with differential pricing on particularly congested roads or within cities for example.

59. A policy of making road users pay for their use of the highway network can be an efficient means of internalizing the externality of carbon emissions in addition to contributing to the upkeep of the highways as a public utility. Road user charging can be seen as an alternative to fuel taxation, which is also based on the 'user pays' principle. However, the adoption of road user charging allows greater flexibility and adaptability, for example with differential pricing on particularly congested roads or within cities for example.

60. Extension and enhancement to the motorway network in Romania is forecast to generate increased desire and opportunity to travel, leading to an increase in vehicle km. User charging on the motorway network would allow the gathering of funds to contribute to the maintenance of the network and place some constraint on the growth in travel. Currently, a vignette is payable to permit travel on national roads and expressways in Romania. The cost varies by vehicle weight, and can be bought for periods ranging from one week (daily for HGVs) to one year. The annual cost of the vignette is Euro 28 increasing to Euro 320 for 7.5 ton trucks and Euro 560 for heavier vehicles.

61. Some examples of road user charging are seen in Europe, for example in France in the form of motorway tolls. Tolls have been generally used for specific roads, bridges and tunnels, although increasingly they are being introduced for networks. There are two main types—a closed toll system, where any vehicle entering the facility collects a ticket and pays a graduated fee at the exit point—as occurs in motorways in the EU.[47] The introduction of such a system requires that the road be fully 'closed' so no user can gain access to the road without collecting the ticket and paying the toll. The level of facilities required increases, and the provision of a free alternative route is usually mandated by law. Open road tolling (ORT), also known as free-flow tolling, is the collection of tolls without the use of toll booths. The major advantage is that users are able to drive through the toll plaza at highway speeds without having to slow down to pay the toll. ORT may also reduce congestion at the plazas, and hence GHG emissions, by allowing more vehicles per hour per lane. A disadvantage is the increased risk of violators who do not pay. Collection of tolls on open toll roads is usually conducted through the use of transponders or automatic plate recognition. Both methods aim to eliminate the delay on toll roads by collecting tolls electronically by debiting the accounts of registered vehicle owners without requiring them to stop. Given the technological requirements, ORT is more expensive and may be appropriate for only some countries in EU-12.

[47] The introduction of a closed system normally requires the availability of a free alternative route for road users who chose not to use the tolled route.

62. Elsewhere, there has been much research into the potential for road user charging, but to date no move has been made to implement such a system beyond the use of certain toll roads. Advancement in technology including the more widespread use of black boxes and in-car advances with GPS technology bring the potential for the implementation of accurate However, at present, the majority of EU countries rely on a combination of road user licencing—for example the vignette—and fuel taxation which provides a progressive means of linking taxation with the level of transport activity. The main area in which fuel taxation is lacking is in the lack of differentiation between the location of the travel activity, and the inability to fully capture the high 'externality' cost of travel activity in certain areas in terms of congestion and local air pollution.

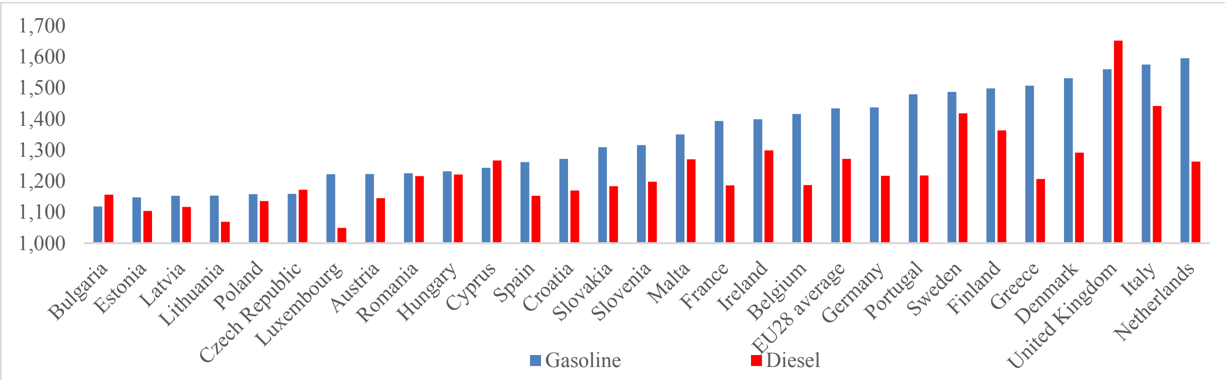
63. The cost of implementation of road user charging would be strongly dependent on the nature of the scheme, with tolling on the expressways requiring different infrastructure to a national road user charging scheme with costs varying according to the location in which travel is made. As technology advances however, the feasibility of intelligent road user charging increases, and the cost of implementation is likely to fall. Nevertheless, infrastructure costs of such a scheme are likely to remain significant, in terms of the technological equipment necessary to accurately collect travel movements and the back office infrastructure to support invoicing and payments. Given the existing mechanism of fuel taxation already in place, the use of this lever to bring about similar impacts to road user pricing at much lower cost would suggest that in the short to medium term, any move towards greater taxation of travel activity should be focus on this. Consequently, modelling efforts have been focused on the fuel taxation level in preference to national road user charging.

64. **Fuel Taxation**. Fuel pricing is a particularly effective policy instrument in that it can discourage vehicle usage—although this is a function of the short, medium, and long-term price elasticity of demand—and encourage the purchase of more fuel-efficient vehicles, thereby reducing vehicle-fuel intensity. Fuel taxes are relatively inexpensive to collect, easy to administer and reasonably equitable, since the charge is broadly proportional to road use. They do not however discriminate between road type, location of the road, or time of usage. On the latter point, this means that fuel taxes cannot tackle the issue of high externalities associated with congestion in peak traffic times. Another weakness is that they do not fully reflect the additional damage done and road space demanded by heavy vehicles. For this reason, fuel taxes are frequently supplemented by additional charges on heavy vehicles. Taxes on fuel are also used by governments for other purposes such as restraining fuel consumption or more commonly raising revenues for the budget, reflecting weaknesses in revenue collection in developing and emerging economies.

65. All EU member states levy excise duty on fuel. The fuel price payable is hence a combination of the cost price of fuel in each nation state, and the level of taxation on that fuel. The level of the duty is set nationally, but is subject to minimum levels as set by the EU. Most EU countries levy fuel duty rates well in excess of the EU minimum. Until 2014, Romania's fuel duty rate was one of the lowest in EU at 32 euro cents /liter for diesel and 35 euro cents/liter for gasoline, but in April 2014, an increase in the fuel duty amounting to 7 euro cents/liter was applied. Increasing fuel taxes remains an option for Romania,

although issues of affordability need to be taken into account when considering fuel tax rises. Nevertheless, gasoline and diesel prices remain significantly below the EU-28 average, using April 2015 data (Figure 18).

Figure 18: Gasoline and Oil Prices as of April 13, 2015 (Euros per 1,000 liters)



Source: European Commission[48]

66. *Modelling approach used and GHG benefits.* Adopting the proposal of increased fuel taxation would be rapidly implementable, given the existing structures in place. The intervention has been modelled an increase in fuel taxation, leading to a 10 percent overall increase in fuel prices. At current prices, this amounts to an increase of around 12.5 cents/liter (including VAT) on petrol and diesel. Evidence of fuel price elasticities, suggest values of -0.15 in the short term and -0.3 in the long term, an increase on this scale will be expected to lead to a reduction in km travelled in the order of 3 percent over the longer term.[49] One would also expect second order effects in terms of a move towards more efficient vehicles in response to the higher fuel prices. A 5 percent increase in fuel price has been modelled for 2020 which increases to 10 percent in 2025 where it remains till 2050. Application of the 30 percent elasticity results in a 3 percent reduction in trips in the long term for vehicles which use either gasoline or diesel. The profile of annual GHG emission savings to 2050 is presented below when the policy is applied as part of the Green Scenario package of measures. The policy reduces annual GHG emissions by 0.4 $MtCO_2e$ by 2025 and 0.6 $MtCO_2e$ by 2050. The main barrier to implementation would be political. In 2014, a fuel tax increase of 7 euro cents was enacted despite strong opposition.

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[48] https://ec.europa.eu/energy/sites/ener/files/documents/2015_04_13_with_taxes_1747.pdf

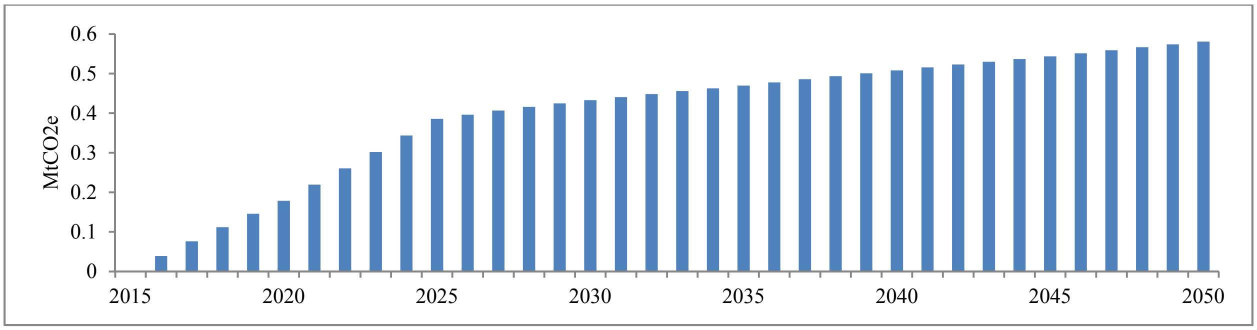
[49] *Unit elasticity* refers to a 1.0 absolute value (1.0 or -1.0) elasticity, meaning that price changes cause proportional consumption changes. Elasticities of less than 1.0 absolute value are called *inelastic*, meaning that prices cause less than proportional consumption changes. Elasticity values greater than 1.0 absolute value are called *elastic*, meaning that price changes cause more than proportional consumption changes. As normally measured, vehicle travel is considered *inelastic*, meaning that changes in fuel, parking and road toll prices generally cause proportionately smaller changes in mileage and fuel consumption, but this reflects the way these impacts are measured. People often focus on short-run (within a year) impacts, which are typically only a third of long-run effects. See Todd Litman (2012), Changing Vehicle Travel Price Sensitivities, *The Rebounding Rebound Effect,* Victoria Transport Policy Institute, 10 September 2012. Available at: http://www.vtpi.org/VMT_Elasticities.pdf. Analysis conducted as part of the NTM work in Romania found an elasticity of fuel price increase of -0.29, which is within the range found elsewhere.

Table 2: Summary of Modelling Approach – Fuel Price Taxation

	Modelling Approach
Policy	10% increase in gross fuel prices (petrol and diesel)
Implementation timeframe	10% increase by 2025, with ramp up from 0% in 2015 through 5% in 2020
Vehicles Affected	All petrol and diesel vehicles
Geographical Areas/Road Types affected	All areas and road types
Impact	Reduction in trips
Mechanism	Elasticity response to fuel price changes -0.3%

Source: World Bank.

Figure 19: GHG Emissions Savings – Fuel Prices



Source: TRANSEPT.

67. **Vehicle scrappage scheme**. Romania has had a vehicle scrappage scheme in place since 2005, known as the '*Rabla*' (clunkers) scheme. This has seen the scrapping of approaching 500,000 ageing and high-polluting vehicles, and the subsidized purchase of around 250,000 more efficient vehicles. Uptake of the scrappage scheme peaked in 2010, with almost 190,000 cars scrapped, and has since fallen to much lower levels (c. 20,000). Whilst the impact of the scrappage scheme to date on vehicle fleet age and characteristics are reflected in the baseline emissions forecasts, the business as usual scenario projects an evolution in vehicle fleet which does not reflect a return to the high levels of new vehicle purchase achieved by the scrappage scheme in its top performing years.

68. The objective of the scrappage scheme is to encourage the removal of the oldest and highest polluting vehicles from the fleet, and the purchase of new lesser polluting models. The intervention considered focuses on a renewed and re-invigorated scrappage scheme which adopts more stringent standards and greater generosity in the level of subsidy for the purchase of the most efficient vehicles. The rate of the incentive for vehicle scrappage is proposed to be increased to 7,500 lei (Euro 1,700), which represents an increase of 1000 lei from the 6,500 lei in recent years (originally 3500 lei). The scrappage vouchers remain transferable and 'stackable' as under the existing scheme, with the criteria for eligible vehicles also remaining the same (over 8 years old as of 2014). However, the level of the emissions requirements are tightened to achieve a new vehicle purchase average emissions level of 120g/km.

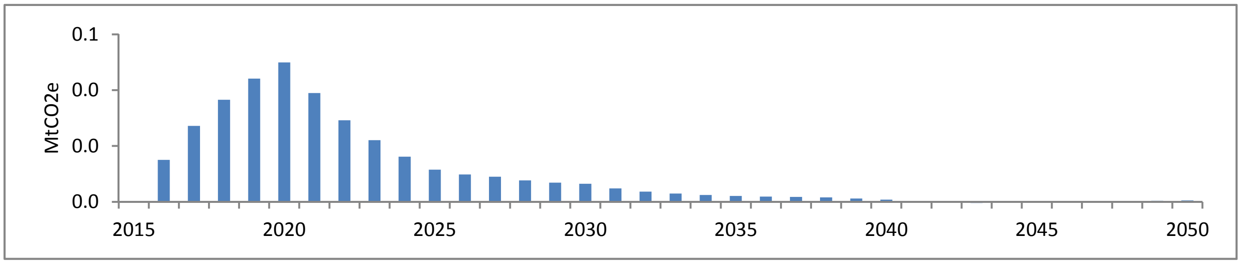
69. Romania is already familiar with the benefits and impacts which a scrappage program can bring, with evidence collected from the historical scheme. There are many other examples of successful scrappage schemes, with other European countries including Germany, Austria, France and the UK. The

level of the incentive is an important aspect of the scrappage program. Only vehicles with a lesser value than the incentive may be expected to be scrapped. The conditions attached to the vehicles eligible for scrapping and also those which may be purchased with the vouchers are also important determinants of the overall impact as regards emissions reduction. The value of scrappage scheme incentives typically ranged from Euro 1,000 to Euro 2,500 for European schemes. As such, the proposed 7500 lei (Euro 1,700) is in line with other schemes, with the increase over previous years' values reflective of the tightening conditions regarding the emissions standards of the new vehicle purchased.

70. *Costs.* The cost of the scheme has been estimated based on historical scheme costs, increased to reflect the higher level of the incentive. A take-up rate of 100,000 vehicles scrapped over the course of 5 years (20,000 in each year) has been adopted as the scheme target, based on the average annual scrappage rate achieved under the historical scheme. The total cost of the scheme is estimated to be Euro 177.5 million. Note that this is the full cost of the program rather than the net cost of the increased incentive value. Accordingly, the full impact of the scheme carbon savings are quantified against the counterfactual of the scrappage scheme drawing to an end.

71. *Modelling approach used and GHG benefits.* Ageing vehicles fitting within the scrappage criteria are removed from the vehicle fleet. It is assumed that the target number of vehicles to be scrapped are achieved over the five years of the modelled scheme period, 2016 to 2020. These vehicles are replaced by new vehicles meeting the emissions standards required, at a rate of one new vehicle to two scrapped vehicles, based on the historical ratio of new to old vehicles (more than one scrappage voucher can be used towards the purchase of a new vehicle). Older vehicles which are scrapped may be expected to have a lower utilization rate, in terms of annual km travelled, than new vehicles. This is reflected in the modelling, taking typical usage rates according to age as featuring in the fleet model. In practice, scrappage schemes typically lead to the advancement of anticipated purchasing decisions and therefore the impact relates to the quickening of fleet turnover compared to the natural rate of evolution under the counter-factual. New vehicles purchased under the scrappage scheme are subject to the same survival rates as other vehicles of the same vintage, and therefore fleet evolution continues to be affected beyond the period of the scrappage scheme. The annual GHG emission savings are presented below. Overall the scheme has a minimal impact, attaining a maximum annual saving of 0.1 $MtCO_2e$ in 2020. However due to the nature of the scrappage scheme the impacts reduce over time. The mechanisms for implementing the scrappage scheme are well set up and have undergone a number of revisions during the life of the current scheme. Therefore, a reinvigorated scheme supported by increased funding is not seen to present any significant technical barriers.

Figure 20: GHG Emissions Savings – Vehicle Scrappage Scheme



Source: World Bank.

72. **New Vehicle Registration Tax (Environmental Stamp)**. Romania currently has an 'Environment Stamp' tax on new vehicle registrations, introduced in 2013 as an evolution from the pollution tax which was deemed illegal under EU law. The Environment Stamp is levied under according to a vehicle's Euro standard, CO_2 emissions, engine displacement, with a discount rate applied depending on the age of the vehicle being registered. The amendment to the system from the pollution tax means that older vehicles receive a significant discount to newer vehicles and that non-Euro standard vehicles and Euro 1 and 2 vehicles would pay less than under the previous system. In its present form, the cost of registration falls for registering older vehicles, even if these are higher polluting vehicles. It is proposed that the rates payable under the Environmental Stamp be reviewed and the potential for greater encouragement to purchase more efficient lower polluting models be explored. Most European countries charge a vehicle registration tax based on CO_2 emissions, Euro standard or engine displacement. A gradual pre-announced increase in the levy payable for registration of the most polluting cars has been a means of influencing purchasing decisions. In the UK for example, the following rates are payable on first registration of a vehicle, demonstrating the significant fiscal penalty applied for the purchase of higher polluting models.[50]

Table 3: First Year Vehicle Registration Tax Rates UK

CO2 emission (g/km)	First Year Registration Tax	
	£	EUR
Up to 100	£0.00	€ 0.00
101-110	£0.00	€ 0.00
111-120	£0.00	€ 0.00
121-130	£0.00	€ 0.00
131-140	£130.00	€ 175.50
141-150	£145.00	€ 195.75
151-165	£180.00	€ 243.00
166-175	£290.00	€ 391.50
176-185	£345.00	€ 465.75
186-200	£485.00	€ 654.75
201-225	£635.00	€ 857.25
226-255	£860.00	€ 1,161.00
Over 255	£1,090.00	€ 1,471.50

Source: UK Government.[51]

[50] Note that after the first year, an annual road tax is levied. This is also a progressive tax related to the CO2 emissions of the vehicle, but the scale of the annual payment for the highest polluting vehicles reaches a maximum of £500 (Euro 675)

[51] See https://www.gov.uk/vehicle-tax-rate-tables

73. Given the existence in Romania of a first year registration tax, the regulatory framework is already broadly in place. As such, the cost of making changes to the rates payable under the scheme would be negligible. In terms of wider costs to society, it is assumed that the change to tax rates is fiscally neutral so that higher taxes for high polluting vehicles are offset by lower taxes for more efficient vehicles. As the Environment Stamp rates are subject to regular review, changes to the rates payable could be quickly implemented and able to influence the purchasing decisions of motorists within the Action Plan period.

74. *Modelling approach used and GHG benefits*. The modelled intervention relates to evolution in the Environment Stamp at a rate greater than the natural evolution in fleet technology within the BAU to further incentivise the adoption of clean vehicle technologies. The adjustments to the scheme have been modelled to lead to increased trajectory in greener vehicle technology uptake, with new trajectories taken from the EU Transport GHG: Routes to 2050 work. The policy is applied to the purchase of new cars from the years 2016 onwards as a shift in the powertrain of new vehicles purchased from gasoline and diesel to plug-in hybrid electric vehicle (PHEV) gasoline, PHEV diesel and electric vehicles (EV). The size of the shift is presented in the table below. This is shared between PHEV gasoline, PHEV diesel and EV by the following respective shares, 29 percent, 29 percent and 43 percent. The annual GHG emission savings are presented in the graph below when the policy is applied as part of the Green package of measures. By 2050 the policy saves 0.6 $MtCO_2e$. Although the policy is applied in 2020, interpolation from 2015 to 2020 presents the policy as if it were ramped up from 2015 to 2020.

Table 4: Assumptions Concerning Shift Away from Gas and Diesel Vehicles

	2020	2025	2030	2035	2040	2045	2050
Gasoline	-2.3%	-4.0%	-5.8%	-6.9%	-8.0%	-11.5%	-15.0%
Diesel	-1.0%	-1.8%	-2.4%	-2.7%	-3.0%	-4.5%	-6.0%

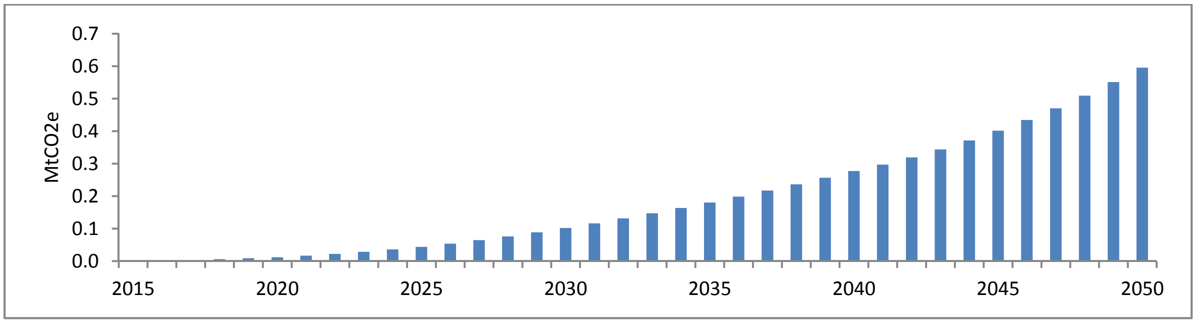
Source: Europe Transport GHG: routes to 2050 Work, TRANSEPT.

Table 5: Summary of Modelling Approach – New Vehicle Registration Tax

	Modelling Approach
Policy	Review of the new vehicle registration tax (Environmental Stamp) rates to promote a shift to low emitting vehicles
Implementation timeframe	2016
Vehicles Affected	Cars
Geographical Areas/Road Types affected	All areas and road types
Impact/Mechanism	Shift in the powertrain of new vehicles purchased from gasoline and diesel to PHEV gasoline, PHEV diesel and EV through the adjustment of new vehicle purchasing profiles.

Source: World Bank.

Figure 21: GHG Emissions Savings – New Vehicle Registration Tax



Source: World Bank.

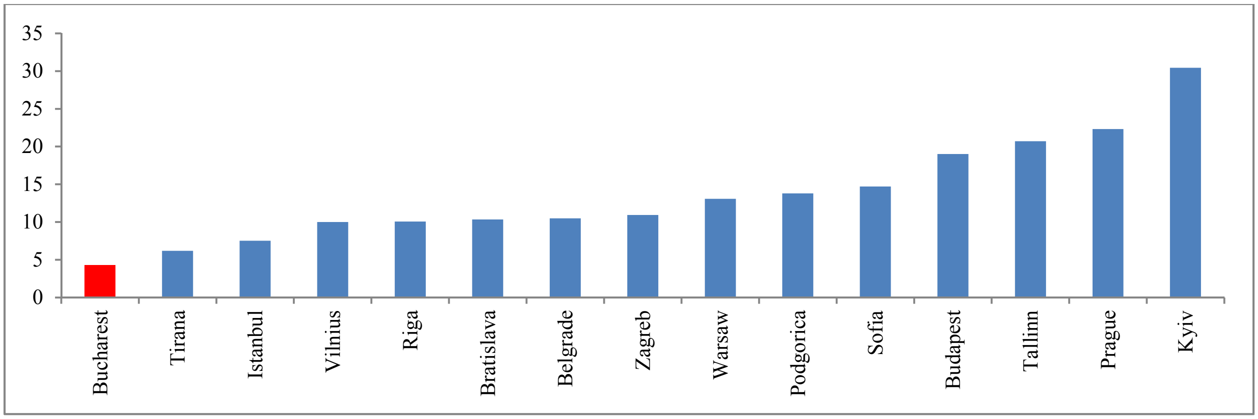
75. The main barrier to significant change in the first registration tax regime is likely to be political. The previous pollution tax was disliked due to the additional burden it placed on the purchase of older vehicles, and was ultimately overturned leading to the new Environment Tax scheme.

76. **Parking pricing**. One pricing mechanism to discourage using vehicles is adopting a policy of high parking pricing, particularly if parking is expensive in relation to mass transit public transport. An annual survey on daily parking rates shows that Bucharest's parking fees are quite low compared to other EU-12 cities, although this information is dated and the picture may be slightly different now (Figure 22).[52] In the EU, changing parking policies are part of larger goals, such as complying with air quality standards or reducing GHG emissions. While London and Stockholm and a few other cities have introduced congestion charging, this has not spread widely, whereas charging for parking is widespread, and thus raising rates would be relatively straightforward.[53] Parking pricing also represents a source of potential revenue for the authority through the control of public parking provision.

77. The use of parking charges as a means of demand management is well established and can be an effective means of promoting modal shift to more sustainable travel such as by public transport or walking and cycling. Parking charging is fundamentally an urban measure, and can be flexibly applied in ways to influence different categories of user whilst minimising the economic impact for commerce. The intervention considered here does not relate to significant increases in parking charges but a widening of the control of parking within the urban areas, and a reduction in the proportion of free on-street parking. The policy is focused on the 20 largest conurbations, with the increase in the proportion of paid parking intended to discourage private vehicle usage and promote modal shift.

[52] A critical aspect in Bucharest is enforcement of parking regulations—cars occupy sidewalks, forcing pedestrians on to streets. Enforcement of parking regulations and recovery of penalties are essential steps, in addition to higher parking pricing.
[53] Parking pricing policies are usually complemented with policies aimed at controlling the growth of parking spaces.

Figure 22: Daily Parking Rate (US dollars)[54]



Source: Colliers International (2011), Global/Central Business District Parking Rate Survey.

78. Parking charges are widely used as a means of demand management in cities across Europe. Best practice examples typically combine the disincentive of high parking charges with an effective and efficient public transport system, good walking and cycling facilities and other travel options such as Park and Ride. Those which achieve the highest rates of modal shift are the cities perceived to be non-car friendly, and for which the thought of talking the car into the city is considered to be more challenging than the alternative options. Examples of such cities include most of the capital European cities. ITDP has reviewed case studies of parking best practice in Europe and sets out the key principals and conclusions in its report 'Europe's Parking U-Turn.[55] It highlights the experience in Paris, where on-street parking supply has been reduced by over 9 percent since 2003, and of the remaining stock, 95 percent is paid parking. The result, along with other transport infrastructure improvements, has been a 13 percent decrease in driving.

79. In Bucharest, there are both public and private parking facilities in addition to free on street parking. The extension of paid-for parking across the city will require the implementation of new parking regulations to the on-street parking within the main conurbations, and the need for stronger enforcement. Other major cities will have varying levels of parking provision. The necessary signage and road markings constitute the main capital costs. An allowance of Euro 2.5 million is estimated in order to cover the associated capital costs in the major conurbations.[56] Increase in enforcement personnel and parking fee collection requirements would be funded by increased revenue generated by the wider measures.

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[54] Available at:
http://downtownhouston.org/site_media/uploads/attachments/2011-07-19/Colliers_International_Global_Parking_Rate_Survey_2011.pdf

[55] Europe's Parking U-Turn: From Accommodation to Regulation, ITDP, 2011. Available at:
https://www.itdp.org/wp-content/uploads/2014/12/Euro-Parking-Fact-Sheet.pdf

[56] The largest cities already have in place payment machines within the city centres. Therefore the investment is incremental through widening the coverage, but also tightening up enforcement of existing provision/facilities

80. *Modelling approach used and GHG benefits*. The modelling of the parking charges has been applied to urban trips in the major urban areas (top 20 cities). The experience of Paris identified a 9 percent reduction in car trips, whilst Munich saw a 14 percent reduction in car trips within the inner city resulting from a combination of traffic demand measures which in addition to the parking management measures included improving cycling infrastructure and enhancing public transport. The parking management measures have been assumed to result in a reduction in urban car trips of 5 percent—the urban areas have not been modelled separately in this study. However, the impact of the policy is felt incrementally, firstly achieving a reduction in car trips of 2.5 percent in 2020, 3.75 percent in 2025 and finally 5 percent by 2030. The annual GHG emission savings are presented in the graph below when the policy is part of the Green package of measures, achieving a maximum reduction in annual GHG emission savings of 0.07MtCO_2e in 2030. The savings decline thereafter to the year 2050 as other policies act to reduce the car mode share in urban areas.

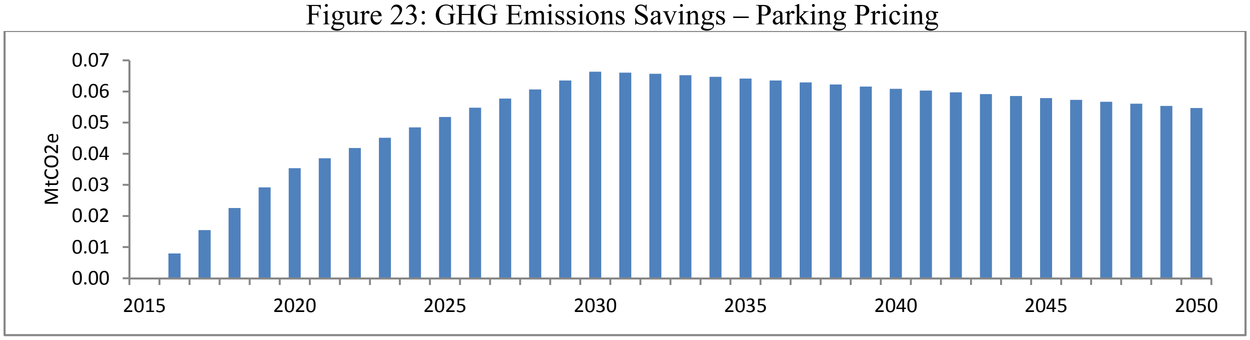
81. Parking charges remain a contentious issue with city residents and commerce alike. The benefits of an effective and strong parking policy are often not universally recognized, particularly by those who are subject to penalty under the necessary enforcement measures. The revenue generation potential for authorities under the extended parking charge scheme offers an opportunity to mitigate against the impacts, for example by ring-fencing funding for the provision of improved walking and cycling infrastructure, enhanced public transport provision and an improved cityscape environment.

Table 6: Summary of Modelling Approach – New Vehicle Registration Tax

	Modelling Approach
Policy	Implementation of parking charges in Bucharest and other major cities
Implementation timeframe	Full implementation in 2030 with ramp up from 2015
Vehicles Affected	Cars
Geographical Areas/Road Types affected	Urban
Impact/Mechanism	Reduction urban trips made by car of 2.5% in 2020, 3.75% in 2025 and 5% in 2030 and beyond.

Source: World Bank.

Figure 23: GHG Emissions Savings – Parking Pricing



Source: TRANSEPT.

82. **Urban Congestion Pricing**. This a system of charging users of a transport network to reduce traffic congestion. The application on urban roads is limited to a small number of cities, including London, Stockholm, Singapore, and Milan. The London Congestion Charge is a fee paid by drivers travelling within the Congestion Charge Zone and as its name suggests was introduced with the aim of reducing congestion, as well as raise investment funds for London's transport system.[57] The charge, standing currently at GBP 11.50 (Euro 16) generates significant revenues. During the first decade of the scheme, criticism was made of the high proportion of the revenues taken up by operating costs. However, increases in the level of the charge, and reductions in operating costs have occurred, due to the reduction in marketing and awareness campaigns required with the maturing of the scheme mean that the operating costs have gone down as a proportion of generated revenues. Implementing a congestion charging scheme can involve significant capital costs and also ongoing operational costs. The scale of these costs are dependent on the nature of the scheme and the technology adopted in the collection and monitoring of the charge. There are however revenues generated by the scheme which should outweigh the cost of operation.

83. The infrastructure costs involved in implementing the London Congestion Charge were estimated to be GBP 197million in 2007 market prices (Euro 340 million in 2015 prices). An indicative infrastructure cost estimate of Euro 150m is provisioned, based on the London experience, but accounting for falling cost of the technology to implement the scheme. Ongoing operating costs of the scheme are estimated to be Euro 50 million per annum. Whilst these would be covered by the expected scheme revenue, only infrastructure and operating and maintenance costs are included within the MAC analysis as the scheme revenues represent a transfer payment from motorists.

84. *Modelling approach used and GHG benefits*. The model has assumed that this policy reduces urban car trips in urban areas by 5 percent when fully implemented. The policy is scheduled to come into full effect in 2025, however a ramp up between 2020 to 2025 has been modelled. The annual GHG emission savings are presented in the figure below when the policy is implemented as part of the Super-Green package of measures. The policy reduces GHG emissions by 0.14MtCO_2e by 2050.

[57] The zone was introduced in central London in February 2003, and extended into parts of west London in February 2007, although this was discontinued in 2008. The 2007 report prepared by Transport for London found that traffic entering the charging zone was 21 percent lower than in 2002, creating opportunities over this period for re-use of a proportion of the road space made available. Reduced levels of traffic mean that when compared to conditions without the scheme congestion charging continued to deliver congestion relief that was broadly in line with the 30 percent reduction achieved in the first year of operation. Congestion charging was also estimated to have led directly to reductions of about 16 percent in CO_2 emissions from traffic within the charging zone over 2002-2003, these more directly reflecting the overall traffic reductions and efficiency gains. Over the post-charging period 2003-2006, vehicle fleet improvements are estimated to have reduced emissions from road traffic, both within the central London charging zone and more widely, by 17 percent for NO_x, 24 percent for PM_{10} and 3 percent for CO_2, assuming a stable traffic mix. In terms of revenues and costs, over 2006-2007, the London Congestion Charge generated GBP 213 million in total revenues, compared to total operating and administrative costs of GBP 90 million, with revenues used for upgrades to bus infrastructure and operations.

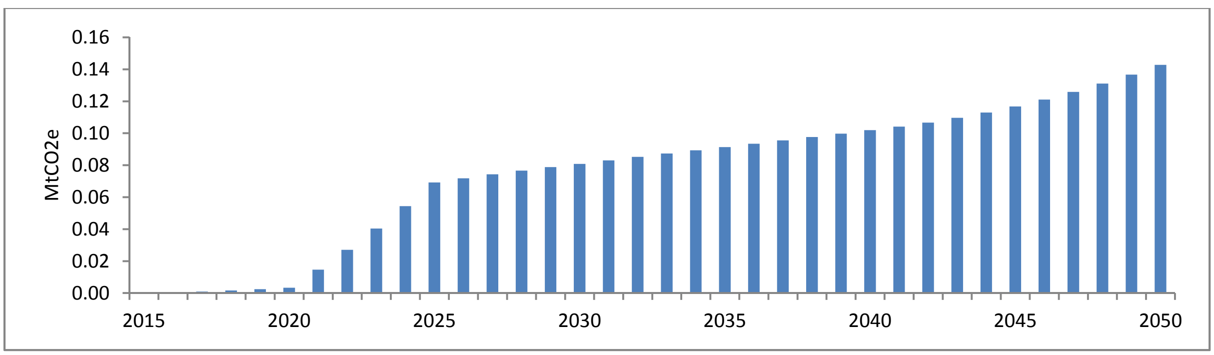
Figure 24: Summary of Modelling Approach – Urban Congestion Pricing

	Modelling Approach
Policy	Urban Congestion Charging implemented in Bucharest and other major cities
Implementation timeframe	Full implementation in 2025 with ramp up from 2020
Vehicles Affected	Cars
Geographical Areas/Road Types affected	Urban
Impact/Mechanism	Reduction urban trips made by car of 5%

Source: World Bank.

85. The main barriers to implementation of a congestion charging scheme are political and technical. Many cities have concluded that the positive benefits which congestion charging may bring about can more cost effectively be delivered through the use of parking restrictions and increasing parking charges. As parking charging is already in place in the majority of cities, this intervention can be delivered at much lower cost whilst leading to similar impacts.

Figure 25 : GHG Emissions Savings – Urban Congestion Charging



Source: TRANSEPT.

86. **Aviation Travel Tax**. A number of countries in the EU apply aviation taxes to travellers on short and long haul flights departing from the country. These are variously identified as a civil aviation tax, airport tax, luxury tax or air passenger duty. In certain cases the tax is related to a particular impact such as the tax on air transport noise pollution in France. Romania currently has no airport departure tax. The emissions from aviation make up a small proportion of overall emissions in the transport sector but are projected to increase in absolute terms over time at a slightly faster rate than overall travel activity. Applying a departure tax to those travelling domestically or internationally would provide a stream of revenue and may be expected to lead to suppression in the growth of air travel, which as one of the most polluting forms of travel on a per-km basis, would contribute to the low carbon scenario. The table below shows the rate of duty applicable in selected EU countries. The introduction of a departure tax at the rates

observed in Austria and Germany would generate significant revenues from 10 million or more passengers each year travelling from airports in Romania.

Table 7: Air Passenger Duty in Selected EU Countries (Euro, 2014)

	Short Haul	Medium Haul	Long Haul
Austria	7	15	35
Bosnia		12	
Germany	7.50	23.43	42.18

Source: EBAA[58]

87. The cost of collection of the air passenger duty would depend on the mechanism and could either be collected at the airport or as a supplement on the airline ticket. A capital cost of Euro 1 million is allowed as the setup costs across the major airports in Romania as well as office back up costs for processing the tax. Ongoing collection costs of Euro 150,000 per annum are allowed for. The ongoing cost of collection would be far outweighed by the revenue generated by the departure tax which would be expected to be in the order of Euro 125 million per annum, increasing in line with ticket price inflation. This revenue is not included within the marginal abatement cost analysis as it is a transfer payment. The tax could be rapidly implemented, following the necessary impact assessment, and could be in effect within the Action Plan period. No barriers to implementation are expected, except pressure from airlines and regular travellers.

88. *Modelling approach used and GHG benefits*. An elasticity based approach has been used to model the impact of the tax. The departure tax has been modelled as a 5 percent increase to the fare paid for a return journey, noting that the tax only applies to outbound flights. Price elasticity information was derived from IATA's Air Travel Demand Briefing.[59] The policy was modelled to be implemented in 2020. The resulting impact is a reduction in EU aviation trips of 6 percent and 4.5 percent reduction in International aviation trips. The policy has been applied from 2020, however interpolation between the years 2015 and 2020 present the policy as ramping up between these years. The annual GHG emission savings are presented in the figure below when the policy is implemented as part of the Green package of measures. Annual savings of 0.1 MtCO2e are forecast by 2050.

Table 8: Summary of Modelling Approach – Air Travel Taxation

	Modelling Approach
Policy	Introduction of an Air Travel Duty on international travel
Implementation timeframe	Full implementation in 2020 with ramp up from 2015
Vehicles Affected	EU and International Aviation
Geographical Areas/Road Types affected	All
Impact/Mechanism	Reduction EU aviation trips of 6% and international aviation of 4.5%

Source: World Bank.

[58] http://www.ebaa.org/documents/document/20140116101401-aviation_taxes_in_europe_-_a_snapshot_jan_2014.pdf
[59] https://www.iata.org/whatwedo/Documents/economics/air_travel_demand.pdf

3.3 Technology

89. This section covers a number of interventions that have the potential to reduce carbon emissions from the adoption of new more efficient technologies, including vehicle engine technologies and alternative fuels. The encouragement of the more rapid adoption of new vehicle technologies is an objective of many of the market based interventions and also on the regulation side. The potential for the government to promote and encourage the uptake of more efficient technologies beyond fiscal or regulatory measures is considered. The following interventions are considered:

- Roll-out of an electric charging network to support the uptake of electric and plug in hybrid electric vehicles;
- Adoption of ultra-low emissions vehicles within the public sector vehicle fleet; and
- Introduction of electric vehicles into the public transport vehicle fleet

90. **Electric Vehicle Charging Network**. The vehicle fleet in Romania is older and less efficient than elsewhere in Europe. The scrappage scheme has encouraged the purchase of newer vehicles, and further incentives have been put in place to entice the purchase of the least polluting models. However, the adoption of ultra-low emissions vehicles (ULEVs) such as electric vehicles (EVs), hybrid vehicles and plug in hybrid electric vehicles (PHEV) is lagging behind that observed in other countries, and particularly those which have in place programs to strongly promote and invest in supporting infrastructure for these alternative technologies.

91. In 2014 just 7 electric or hybrid electric vehicles were registered in Romania. By comparison, a total of over 75,000 electric vehicles (all electric, range extender electric and plug in hybrid electric vehicles) were registered across the EU. A factor likely to hamper the uptake of EV/PHEV vehicle technology is the lack of public charging infrastructure. Investment in a rapid charging network which focuses on the major urban areas and charging points interspersed across the strategic highway network would facilitate much greater potential for the usage of electric vehicles. This intervention considers the investment required to roll out a national charging network to complement the fiscal and regulatory measures which encourage the take-up of electric vehicles.

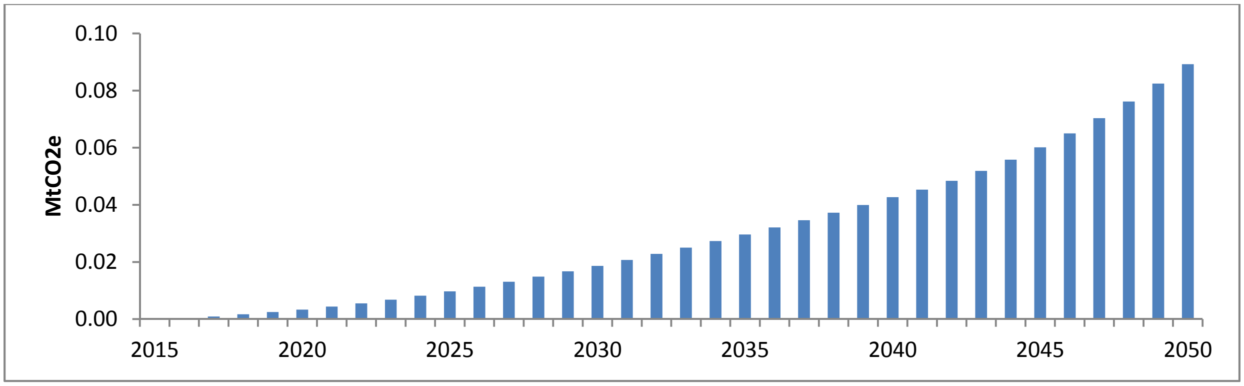
92. As well as early adopter countries such as Norway and Holland, there has been recent examples of successful investment programs in other countries designed to boost uptake of alternative fuelled vehicles. Estonia has become the first country to install a nationwide fast charging network for electric vehicles. A network of 165 rapid charging posts have been located in urban areas with more than 5,000 inhabitants and on major roads throughout the country. These 50kW DC rapid charging posts have the ability to charge vehicles in around 30 minutes as compared to 8-10 hours for conventional 3.3kW charging points. The deal was financed through the sale of 10 million surplus CO_2 emission permits to Japan's Mitsubishi Corporation. This deal also included the provision of a fleet of 500 electric vehicles for use by the public authorities to help kick-start EV usage, and also the funding for EV subsidies for private purchasers.

93. The modelled intervention takes costs from infrastructure roll-outs in Estonia and OLEV in UK to estimate the cost of provision of strategic charging network. The costs are based on the installation of a network of 500 rapid charging points in major conurbations and on the strategic highway network throughout Romania, at a cost of Euro 50,000 each. In addition, a subsidy for up to 50,000 home charging points has been costed, at a unit rate of Euro 3,500, reflecting the potential rate of electric vehicle take-up given a concerted investment program. The ongoing costs in terms of electricity are assumed to be funded by user charging tariffs/subscriptions. However, the maintenance of the charging points has been allowed for in ongoing operations and maintenance costs as experience has demonstrated that inclusion of these costs in user charging rates makes them uneconomic for electric vehicle users. The upfront cost of electric vehicles is assumed to be offset by fuel efficiency savings, reflecting rational decision making on the part of private purchasers.

94. *Potential implementation timeframe*. Estonia was able to deliver a national charging network within 2 years of tendering the contract. However, in a larger and more densely populated country with greater numbers of charging points required, implementation in Romania may be expected to take a little longer, and the preparatory studies required prior to contracting mean that delivery of the national network within the 2015-2022 action period timeframe is likely to be challenging. However, implementation could be phased, with a focus on the most strategic locations, including densely populated cities and selected points along the most well used expressways. Barriers to implementation may include planning approval issues relating to the identification of sites for the units, technical barriers regarding the supply of electricity to the units and commercial barriers in identifying a suitable business model for the installation and ongoing maintenance of the units.

95. *Modelling approach used and GHG benefits*. The delivery of the charging network does not in itself provide carbon emissions savings, but acts as an important enabler to the take-up of low emissions vehicles. The impact of the provision of the charging infrastructure has therefore not been modelled in isolation but in combination with the ultra-low vehicle emissions incentives. Purchasing profiles have adjusted to reflect projected take-up rates bringing Romania's vehicle electric vehicle adoption rates into line with those observed in Estonia. Forward looking projections build on these relative rates, taking reference from Sultan Green Scenario profiles regarding electric vehicle take-up. The annual GHG emission savings are presented in the figure below when the policy is implemented as part of the Super-Green package of measures. Annual savings of 0.09 $MtCO_2e$ are forecast by 2050.

Figure 26: GHG Emissions Savings – ULEV Investment



Source: TRANSEPT.

96. **Adoption of Ultra Low Emissions Vehicles in the Public Sector**. The uptake of ultra-low emissions vehicles (ULEVs) and in particular the adoption of electric vehicles can be given a kick-start through the promoted use of this technology within the state's own vehicle fleet. Setting targets for the proportion of the public sector fleet which are electric or plug-in hybrid is a means of accelerating the trajectory of new technology uptake. For this scenario, we have taken a similar target to that adopted in the modelling of Macedonia interventions, with electric vehicles making up 5% of the public sector fleet in 2020, increasing to 10 percent in 2025. Again looking to the flagship case of Estonia with its national charging network roll-out and strong promotion of electric vehicles through fiscal subsidies, the scheme was kick-started with a large-scale demonstration project involving 500 electric vehicles adopted by government agencies. These vehicles provided a conspicuous demonstration of the technology, a test-bed for collection of research data and to test the infrastructure.

97. The purchase of electric vehicles comes at a higher cost to standard vehicles. However, there are ongoing operations and maintenance savings to be made resulting from the lower vehicle operating costs. The scheme costings draw on achieving the target rates of 5 percent and 10 percent of the public sector vehicle fleet of 75,000 vehicles by 2020 and 2025 respectively, with a cost premium on the purchase of the electric vehicles of Euro 4,450 per vehicle. The cost of phased vehicle purchase from 2016-2025 equates to Euro 3.5 million per annum (undiscounted 2015 prices), with total investment costs of Euro 35 million.

98. *Modelling approach used and GHG benefits*. Utilization of ULEVs within the governmental fleet can be increased incrementally, supported by the necessary infrastructure, which will include workplace charging points initially, whilst the wider infrastructure roll-out is underway. A target of 5 percent of the vehicle fleet by 2020 is proposed, increasing to 10 percent by 2025. The modelling focuses on the targeting of the introduction of electric vehicles to the public transport vehicle fleet at 5 percent in 2020 increasing to 10 percent in 2025. This may be achieved through the setting of vehicle regulation for certain routes within the regulated network. The additional investment cost relating to the purchase of electric vehicles, be it by state owned operator or private bus company, is included within the costing of this intervention.

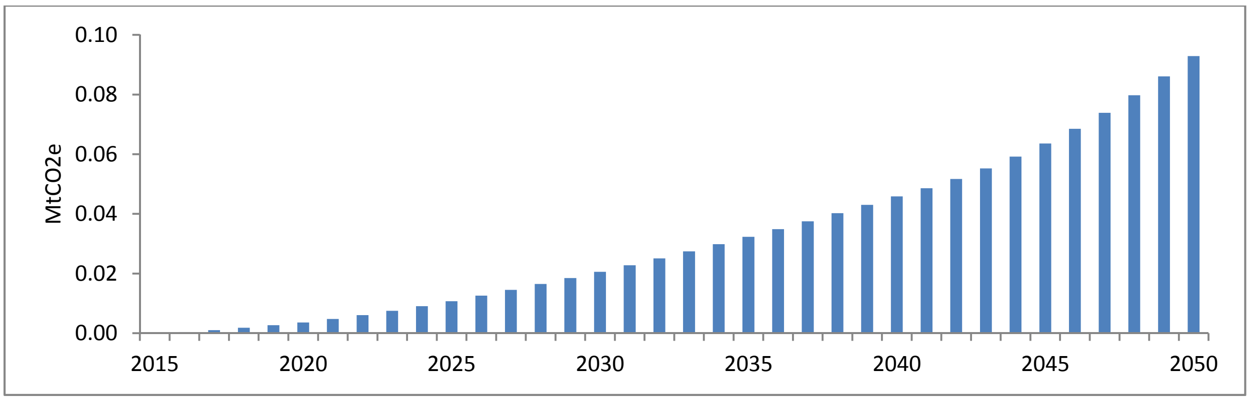
A resultant shift in new vehicle powertrain is modelled for cars from gasoline to EV from the year 2020 onwards. The annual GHG emission savings are presented in the graph below when the policy is implemented as part of the Super-Green package of measures. Annual savings of 0.09 MtCO2e are forecast by 2050.

Table 9: Summary of Modelling Approach – Ultra Low Emissions Vehicles in the Public Sector

	Modelling Approach
Policy	Targeting of EV adoption within public sector vehicle fleet
Implementation timeframe	Full implementation in 2020 with ramp up from 2015
Vehicles Affected	Cars
Geographical Areas/Road Types affected	All
Impact/Mechanism	Shift in the powertrain of new cars purchased from gasoline to EV

Source: World Bank.

Figure 27: GHG Emissions Savings – Public Sector Fleet ULEV Targets



Source: TRANSEPT.

99. *Implementation barriers*. Budgetary pressure constitute the main barrier to implementation, with the higher cost of vehicles incurring greater upfront capital costs. However, manufacturers have been keen to promote the new technology and the cost premium over conventional vehicles has fallen recently. The potential scope for preferential terms in the purchase of a fleet of electric or plug-in hybrid electric vehicles is strong given the quantity of vehicles in question. Technical barriers to adoption of the new vehicle technologies might feature initially in the roll-out, with issues such as finding suitable charging locations and ensuring that the vehicles are placed in usage best suited to their range limitations. These issues may be expected to be overcome early in the roll-out and new generations of electric and hybrid electric vehicles with increased range combined with the implementation of the supporting infrastructure will make the vehicles more practical across the wider range of usage patterns exhibited by agency vehicles.

100. **Electric Public Transport Fleet**. The adoption of electric or hybrid electric vehicles is also feasible within another key area of urban transport activity, which is the public transport sector. Diesel powertrain buses contribute significantly to urban transport emissions, and in particular local air pollution.

As with the public sector vehicle fleet scheme presented above, this intervention focuses on the targeting of the introduction of electric vehicles to the public transport vehicle fleet at 5% in 2020 increasing to 10% in 2025. This may be achieved through offering subsidy for particular routes or by including the requirement for electric or hybrid electric vehicle usage within the franchising on certain routes within the regulated network. Many European cities have introduced hybrid powertrain vehicles into their public transport fleets recently. Hybrid electric vehicles will be operating in Stockholm, Hamburg and Luxemburg. In Milton Keynes, UK, a fleet of fully electric vehicles operates a busy route between the city centre and the suburbs which is able to charge wirelessly on the stand at the beginning and end of each trip. This allows the bus to remain in operation for the whole day with a full charge before leaving the depot and top-up charges whilst in service.

101. The additional investment cost relating to the purchase of electric vehicles, be it by state owned operator or private bus company, is included within the costing of this intervention. The supplemental cost of the purchase of hybrid-electric vehicles over conventional powertrains is Euro 100,000 per vehicle. To meet the proposed targets, the purchase of an average of 285 hybrid electric vehicles per year is require. This equates to an investment of Euro 28.5 million per annum, totalling Euro 300 million over the 10 year time frame. The timeframe for implementation is phased roll-out to 2025, with an initial pilot of 100 vehicles commencing in 2016.

102. *Modelling approach used and GHG benefits*. The policy is modelled by shifting the powertrain of a proportion of new vehicles purchased from diesel to EV. The policy comes into full effect in 2025 when the powertrain of 10 percent of new buses shifts from diesel to EV, with an intermediate step of 5 percent shifting in 2020. The annual GHG emission savings are presented in the graph below when the policy is implemented as part of the Super-Green package of measures. Annual savings of 0.12 $MtCO_2e$ are forecast by 2050.

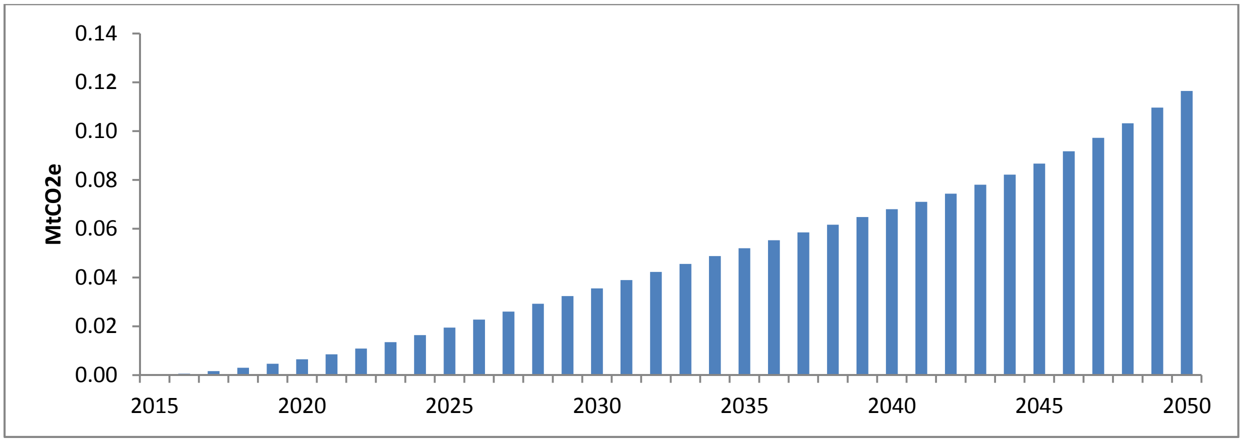
103. The purchase of hybrid vehicles is costly, and operators are typically unwilling to invest in such vehicles without strong incentives, typically in the form of capital cost subsidy. In addition, the vehicles require specialist maintenance regimes, and whilst the uptake is still in its infancy this is seen as challenging in the bus operating environment. Operating cost savings are to a large extent offset by the specialist maintenance required. However, as the technology becomes more widespread, and industry knowledge in operations and maintenance increases, these concerns will diminish.

Table 10: Summary of Modelling Approach – Electric Public Transport Fleet

	Modelling Approach
Policy	Targeting of electric bus vehicle adoption within public transport fleet.
Implementation timeframe	Full implementation in 2025 with ramp up from 2015
Vehicles Affected	Buses
Geographical Areas/Road Types affected	All
Impact/Mechanism	Shift in the powertrain of new buses purchased from diesel to EV. A full shift of 10% experienced in 2025, with 5% shift in 2020.

Source: World Bank.

Figure 28: GHG Emissions Savings – Electric Public Transport Fleet



Source: TRANSEPT.

3.4 Regulatory

104. **Traffic Management Measures**. This intervention is outlined here as an identified measure for consideration. As an urban measure, and one which is of most relevant to Bucharest in the first instance, it is pertinent that a significant investment in this area has already been made recently. The modelling of potential impacts are therefore not appropriate given the current context, as these form part of the baseline. The historical policies of 'predict and provide' in terms of highway infrastructure provision to serve an ever increasing demand for motorised transport have been replaced by those promoting achieving maximum efficiency from the existing infrastructure. This is particularly pertinent in urban areas where space constraints set against increasing traffic levels set a path for increasing congestion without measures to facilitate efficient movement. Traffic cities across Europe to enhance the smooth flow of traffic on the urban routes and to enable rapid response to incidents or issues which can lead to downstream congestion.

105. Bucharest has an Urban Traffic Control Centre recently implemented as a joint-venture of SWARCO AG and UTI International, with funding from Bucharest Municipality and the European Bank of Reconstruction and Development. The project delivered a new traffic control centre including an adaptive urban traffic control and public transport management system which it is estimated has reduced travel times within the controlled area by about 20 percent and achieved a 10 percent reduction in CO_2 within the area.[60] The extension and wider roll-out of such a system within the capital and in the largest cities, and areas where urban congestion is most felt could bring about wider benefits.

106. The cost of implementation of urban traffic control systems with the control centres themselves and the infrastructure which provide the intelligent traffic management functions are highly bespoke to the situation and requirements. High capital costs combined with ongoing support mean that significant

[60] http://www.swarco.com/mizar-en/Projects/ITS-References/URBAN-TRAFFIC-MANAGEMENT,-Romania,-Bucharest-City-of-Bucharest

investment must be made in the implementation of such systems. However, the benefits in terms of decongestion, both time savings for highway users and operating cost savings, and the benefits to the city environment and air quality are identified as key benefits. Further extension of traffic management systems may be appropriate as other cities begin to experience significant congestion. As noted above, the impacts of this measure were not modelled in this study.

107. **Parking Regulation**. Effective parking regulation is important to a well-functioning urban network. In addition to parking charging policies which have been set out earlier in the pricing instrument analysis, effective regulation on existing parking places and the provision of parking under new developments is critical. As previously referenced, ITDP has reviewed case studies of parking best practice in Europe and sets out the key principals and conclusions in its report 'Europe's Parking U-Turn'.[61] The mechanisms and procedures for applying parking regulations are in place and can be used to extend parking regulation wider across the urban areas, to tackle problem areas and to control new development parking provision. Effective enforcement is however also important, which requires ongoing resources. Parking regulations can be applied rapidly, subject to the necessary drafting of parking orders and adherence to notice periods etc. The impact of parking regulation measures are considered to be complementary to a logical parking charge regime and have not been modelled separately.

108. **Low Emission Zone**. A Low Emission Zone (LEZ) is an area in which vehicles entering are restricted or deterred based on their emissions levels. This may take the form of a blanket ban on vehicles with emissions higher than a certain level or by higher emitting vehicles incurring a charge for entering the zone. These zones may be applied to heavy goods vehicles and or buses only, or to all vehicles. The driving factor behind the introduction of these zones has typically been due to local air pollutant concerns and meeting EU air quality standards rather than GHG emissions. More than a dozen EU countries now have LEZs of some form in place in one or more of their major cities or in some cases to particular routes or tunnels (eg the Mont Blanc Tunnel which is only accessible to Euro 3 and onwards lorries).[62] City based LEZ examples include Bergen, Durham, London and Oslo for which all vehicles, whether locally registered or foreign are subject to the access regulations. The regulations vary by scheme and can be quite complicated. For example, in Milan, from 15th October to 15th April each year, Monday to Friday 0930-1930, petrol vehicles not conforming to Euro1 and diesel vehicles to Euro3 are not allowed within the zone. Two stroke motorcycles and mopeds not conforming to Euro1 are banned throughout the year.

109. In the context of Romania, Bucharest would represent the most likely target for implementation of an LEZ, given the city's reputation not only as the worst for air quality in Romania but in its ranking as one of the worst in Europe.[63] Bucharest already has access restrictions which apply to vehicles over 5 tons, which are banned from the central area of Bucharest at certain times, and only allowed to circulate outside of these times with a permit. Extending these restrictions to smaller vehicles, and those with greater

[61] Europe's Parking U-Turn: From Accommodation to Regulation, ITDP, 2011. Available at: https://www.itdp.org/wp-content/uploads/2014/12/Euro-Parking-Fact-Sheet.pdf

[62] http://urbanaccessregulations.eu/general-overview/low-emission-zones-overview

[63] Aphekom project. Available at: http://www.aphekom.org/c/document_library/get_file?uuid=5532fafa-921f-4ab1-9ed9-c0148f7da36a&groupId=10347

emissions levels, in the form of a Low Emissions Zone, could be strongly beneficial to local air quality. The impact in terms of carbon emissions savings would be expected to be less marked, with little variation in fuel consumption between the different Euro standards, although the purchase of newer more efficient vehicles would lead to some gains. There may however be offsetting impacts, with trips by larger vehicles replaced by a greater number of smaller vehicle journeys to maintain the city delivery requirements whist conforming to the restrictions. The costs of implementing a Low Emission Zone would involve the preparatory studies and impact assessments, the necessary awareness campaigns and signage, and importantly the ongoing monitoring and enforcement of the regulations. The scale of these costs may vary significantly be nature and complexity of the scheme and by means of enforcement (for example automatic number plate recognition).

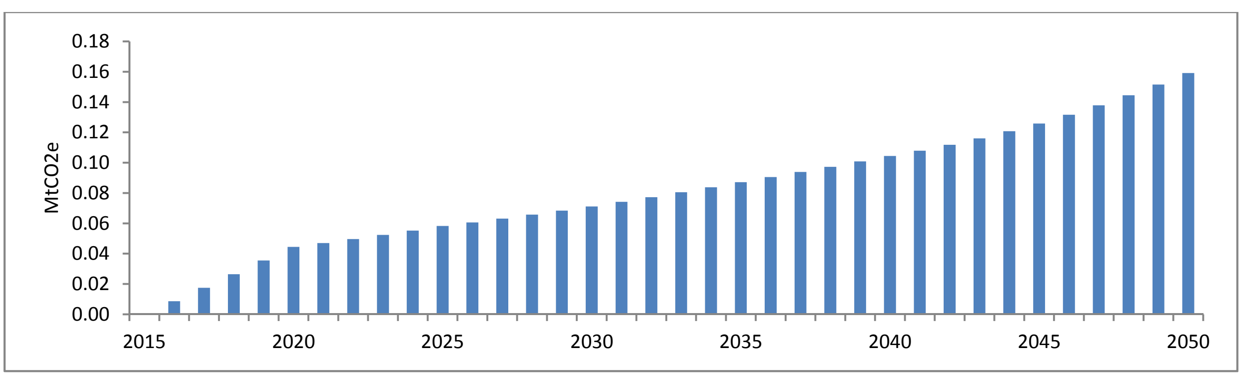
110. *Modelling approach used and GHG benefits*. It has been assumed that the LEZ influences affected users to purchase more energy efficient vehicles. Affected users will be those who currently undertake travel activity in the major urban areas. It has been assumed that 5 percent of car users will be affected. The influence on purchasing decisions has been modelling by bringing forward the average emissions factors of affected vehicles by 10 years, reflecting the purchase of more efficient vehicles within the affected user fleet. The annual GHG emission savings are presented in the graph below when the policy is implemented as part of the Super-Green package of measures. Annual savings of 0.16 $MtCO_2e$ are forecast by 2050.

Table 11: Summary of Modelling Approach – Low Emission Zones

	Modelling Approach
Policy	Implementation of Low Emission Zones in all major urban areas
Implementation timeframe	Full implementation in 2020 with ramp up from 2015
Vehicles Affected	Car, motorcycle, bus, van, medium and heavy truck
Geographical Areas/Road Types affected	Affects 10% of urban trips
Impact	Promotes the uptake in more energy efficient vehicles
Mechanism	Brings forward the average energy efficiency of affected vehicles by 10 years.

Source: World Bank.

Figure 29: GHG Emissions Savings – Low Emissions Zones



Source: TRANSEPT.

111. **Speed Restrictions**. Vehicle fuel consumption increases rapidly when speed progresses beyond the optimally efficient speed of around 90 km/hour, with fuel consumption rising by up to 20 percent when cruising at 120 km/hour. Limiting the speed of vehicles to more fuel efficient levels represents a powerful means of reducing emissions. Romania's speed limits are currently set at 130 km/hour on motorways, 110 km/hour on expressways, 90 km/hour on other non-urban roads for cars and motorcycles; trucks and buses are limited to 110 km/hour, 90 km/hour and 80 km/hour respectively. A lowering of the speed limit for all vehicle types to a speed of 100kph on all road types could be implemented to increase fuel efficiency levels and reduce emissions.

112. Many European countries have similar speed limits to those in force in Romania. However, certain countries have applied more stringent speed limits, such as Switzerland which introduced lower speed limits in 1984 for the environmental benefits the new measures would bring. The Swiss have a speed limit of 120 km/hour on motorways whilst the speed limit on national roads is just 80 km/hour. Other countries which have a lower speed limits on motorways include Sweden (110-120 km/hour) and the United Kingdom (70 miles/hour or 113 km/hour) and Latvia (100 km/hour). The most significant implementation barrier to reduced vehicle speeds is the political dimension of enforcing the lower speeds and hence extended journey times on road users. Strong political protest from interest groups including the freight sector (both domestic and pan-European) may be expected.

113. The cost of implementing a change of speed limits would include the necessary revisions to regulation and the sensitisation and awareness raising of the public through advertising campaigns.[64] The capital cost of implementing speed reminder signs in the period also need to be taken into account. It is estimated that these costs could amount to Euro 10 million, which would be incurred within the period of implementation. Enforcement of speed limits is also a key factor to the effectiveness of the policy. Allowance has been made within the modelling for a lack of compliance. However, expenditure on enforcement on high traffic roads enhance policy effectiveness. An allowance of Euro 1 million per annum for speed limit enforcement has been made. It should also be noted that speed restrictions have wider economic impacts, including disbenefits associated with longer journey times, which need to be taken into account when assessing this intervention.

114. *Modelling approach used and GHG benefits*. In the model motorways and expressways are combined together into a single classification referred to only as motorway as the length of motorway in Romania is very short, so we have used the expressway speed limit to estimate current average vehicle speeds. The modelled change in average vehicle speeds which result from reducing the speed limit is presented below. We have assumed there is 70 percent adherence to the new speed limits. Reducing the speed limit acts to increase driving efficiency, but also reduce the demand for travel. The increase in driving efficiency is measured in terms of the reduction in energy consumed. The reduction in trip demand uses an elasticity between travel time and demand of 0.5 for cars and motorcycles and 0.25 for vans. The

[64] An alternative and related intervention which was not modelled was enhanced speed limit enforcement. To model this in detail would require having data on present levels of adherence and an assumption relating to enforcement effectiveness.

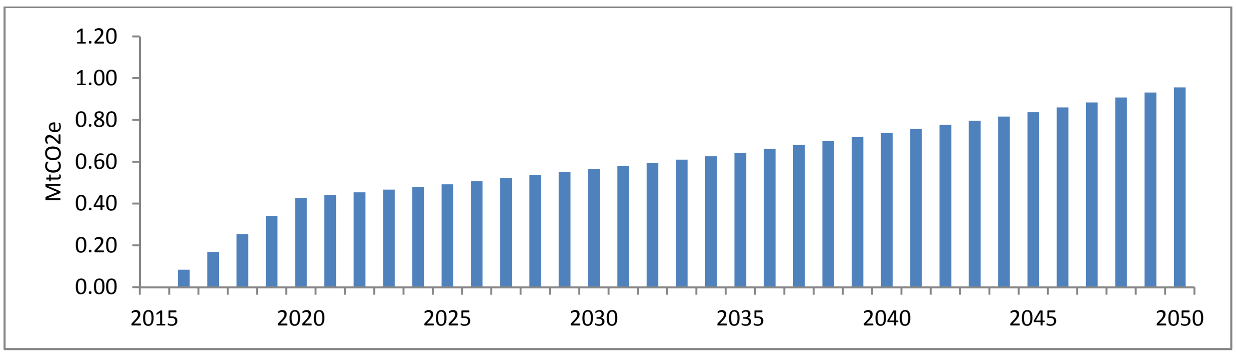
annual GHG emission savings are presented in the figure below when the policy is implemented as part of the Super-Green package of measures. Annual savings of 1.0 $MtCO_2e$ are forecast by 2050.

Table 12: Summary of Modelling Approach – Speed restrictions

	Modelling Approach
Policy	Reduction in speed limits on Motorways and Expressways to 100kph
Implementation timeframe	Full implementation in 2020 with ramp up from 2015
Vehicles Affected	Car, motorcycle, van
Geographical Areas/Road Types affected	Motorway and non-urban trips
Impact	Increases driving efficiency and reduce demand for travel
Mechanism	Reduce the energy consumed per km and reduce the overall demand for trips on motorways and non-urban roads.

Source: World Bank.

Figure 30: GHG Emissions Savings – Speed Restrictions



Source: TRANSEPT.

3.5 Operational Efficiency

115. **Eco-Driving**. Eco-driving reduces emissions by reducing the amount of fuel consumed through efficient driving techniques to reduce the intensity of engine activity to cover the same distance. Eco-driving programs are well established within the freight sector, given the importance of minimising fuel consumption to commercial performance. However, eco-driving techniques can equally be applied to all road usage, to the benefit of drivers operating costs and to environmental objectives. A recent EU funded study looked at the potential benefits of eco-driving amongst others. The stated aim of the eCoMove project was to achieve fuel savings of 20 percent through a combination of intelligent transport systems (ITS) and eco-driving measures.[65] The cost of the eCoMove program was Euro 20 million, covering a

[65] The eCoMove concept is that of the "perfect eco-driver" travelling through the perfectly "eco-managed" road network, i.e. a combination of cooperative applications for eco-driving and eco-traffic management can – for any given trip by a particular driver in a particular vehicle – help to approach the theoretical least possible fuel consumption (and thus CO2 emissions), all without compromising the quality of people's and goods mobility. See: http://www.ecomove-project.eu/

range of research streams. A similar budget is proposed for the implementation of a package of measures to encourage eco-driving in Romania, including marketing campaigns and driver training programs targeted initially at drivers of high polluting vehicles including those in the freight sector and public transport vehicles.

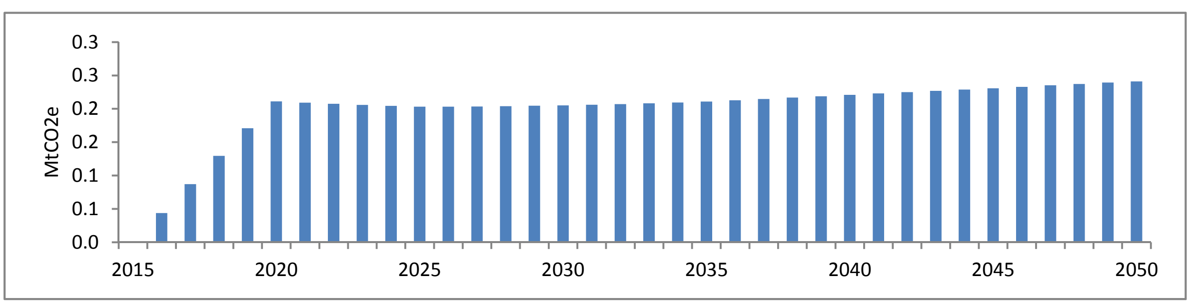
116. *Modelling approach used and GHG benefits*. This package of measures could be included within the Action Plan timeframe, with a targeted campaign to promote eco-driving commencing by 2020. The impact of eco-driving measures have been modelled based on evidence of fuel efficiency savings observed in similar programs, which found that 8 percent efficiency improvements in private car and 4 percent efficiency improvements in HGV movements (recognizing that eco-measures such as fleet monitoring are already present in much of the freight sector). It has been assumed that the package of measures will achieve a 25 percent coverage rate in terms of changing driving behavior, applicable across all journeys, and as such has been applied as a 2 percent efficiency improvement in car activity and 1 percent in HGV activity. The policy has been modelled to reduce the energy consumption as measured in MJ/km. The annual GHG emission savings are presented in the graph below when the policy is implemented as part of the Green package of measures. Annual savings of 0.3 $MtCO_2e$ are forecast by 2050.

Table 13: Summary of Modelling Approach – Eco-Driving

	Modelling Approach
Policy	Eco-driving awareness campaigns and training programs
Implementation timeframe	Full implementation in 2020 with ramp up from 2015
Vehicles Affected	Car, motorcycle and van
Geographical Areas/Road Types affected	All
Impact	Increases driving efficiency
Mechanism	Reduce the energy consumed per km

Source: World Bank.

Figure 31: GHG Emissions Savings – Eco-driving



Source: TRANSEPT.

117. **Freight Measures**. A number of freight sector interventions were identified as potential schemes for consideration. These included freight consolidation centres and vessel management systems. The freight sector represents a significant source of road traffic emissions, reflecting the high polluting nature

of the vehicles and the high levels of transport activity undertaken by these vehicles. Logistics therefore represents an area for potential carbon abatement. However, the freight industry has very strong incentive to maximise efficiency, as lower fuel usage leads to cost savings. Given the competitive nature of the logistics industry, operators are typically considered to be best placed to drive efficiency improvements. Government intervention is best directed to areas in which the industry cannot deliver investment, or where market failure is occurring within the competitive environment, such is in the area of air quality for example. Government assistance to enhance efficiency within the freight sector may include investment in consolidation centres or freight hubs linking road with rail for example.

118. Investment in freight hubs and logistics hubs forms part of the General Transport Master Plan, and as such has been included within the baseline. Further proposals regarding the potential for specific freight investment require more detailed examination than is possible at the strategic level. Given the inclusion of freight investment proposals within the baseline, and the efficacy of the industry in making efficiency savings where they are able to, further freight interventions have not been modelled, with preference placed on other areas of policy in which Government investment can be better focused.

3.6 Urban Planning, Behavioral Change, and Zero Carbon Urban Investment

119. **Integrated Land Use and Transport Planning in Urban Areas**. Romania has seen large changes in residential housing following the post-socialist transition, which have contributed to rising suburbanization.[66] While population growth has not been significant in many cities, this has been compensated by a large reduction in the size of the average household, reflecting a response cramped living conditions in former communist times. Other significant changes to the housing market have been the privatization of the existing housing stock, development of residential mortgages, high demand for residential property from international buyers, and a marked increase in average dwelling unit size. As a result of these changes, there has been (a) a decrease of residential use in the urban core, as commercial uses outbid other activities from central zones, leading to residential depopulation and gentrification; (b) an increased rate of residential suburbanization; and (c) a relaxation of land development controls. The high growth of vehicle ownership seen over the same period in the region has reflected in large part suburbanization, which has been supported by large public investments. Thus, unlike many other developing regions, suburbanization is taking place in the context of slow or negative population growth. On the positive side, suburbanization patterns have tended to be much denser than in the US. Nevertheless, the trend of rapid suburbanization over the last two decades is a worrying one if projected forward.

120. Once a country has developed an urban form characterized by extensive urban sprawl, it becomes exceedingly difficult to control GHG emission growth. This is because low-density development where there is separated land use, as is common in the US, makes a passenger vehicle the only efficient transport option. The population density and vehicle km relationship can be weakened according to the type of land-

[66] See Kiril Stanilov (2007), "Housing Trends in Central and Eastern European Cities During and After the Period of Transition", in Stanilov (ed), *The Post-Socialist City: Urban form and Space Transformations in Central and Eastern Europe After Socialism*. Dordrecht: Springer. Turkey was obviously not affected by the post-socialist transition, but has also faced the development of suburbanization.

use policies in place, such as zoning for mixed use, raising density maximums, and eliminating minimum parking regulations. Avoiding the development of a US high-energy model and instead developing one based on more compact, transit served urban city, could reduce transport energy needs by up to three-quarters. From a transportation perspective, urban sprawl has a number of negative effects, apart from increasing VKT. It also makes it more difficult to develop financially viable mass transit systems.

121. Sustainable Urban Mobility Plans are being developed for a number of cities in Romania and are likely to be looking at the implementation of some or all of these interventions; these plans are expected to be finalized before end 2015. This intervention is outlined in this Report for completeness. However, it is essentially an urban strategy intervention that would form part of an urban package of measures, and is within the remit of the urban report under Task C. Emission impacts and costs of this intervention were therefore not modelled within our project. Integrated land use and transport planning in urban areas essentially involves close consideration of transport requirements when planning development of urban areas. The physical layout and design of a city has a direct impact on daily travel patterns (including travel distance and mode choice) and thus on annual vehicle-km travelled. Many studies have shown that vehicle dependence and transportation energy consumption per capita are far greater for cities with low-density suburban residential areas that are a significant distance from the areas where people work and conduct other significant activities. Using the planning system to reduce the need for long-distance vehicular travel is potentially an effective contributor to minimising or reducing carbon emissions. A recent World Bank study on GHG emission mitigation in FYR Macedonia[67] identified the following land use planning policies and regulations that could be used to reduce the need to travel and dependence on the private car:

- Developments permitted only where good quality access to public transport, walking and cycling facilities is provided as part of the development.
- New developments that in-fill sites close to city centres and/or refurbish and re-use derelict buildings are encouraged, potentially through regulation or financial incentives.
- Car parking provision in new/refurbished developments is limited to a maximum and developers are encouraged/required to provide high quality alternatives to the car instead.
- New developments are required to complement existing uses in the area or where large developments are planned, they are required to be mixed-use, ensuring that amenities such as shopping, schools and other public services are located near to residential areas avoiding the need to travel further afield by car.

There are many examples of good practice that the Romanian Government could look at. Singapore is often quoted as a good example of a coherent and comprehensive set of land use and development policies

[67] World Bank. Support to the Government of Macedonia: Transport sector green growth and climate change analytical work. Mitigation Report prepared by Atkins and iC Consulenten, January 2013.

aimed at reducing the dependence on motorised vehicles.[68] In Europe, the new development of Hammarby Sjostad forms another good example.[69]

122. The cost to the Romanian Government of implementing integrated land use and transport planning would primarily consist of the cost of establishing well-informed, educated and trained planning departments in local governments, together with the administrative cost of implementing any regulations at local or national level. Integrated land use and transport planning could be implemented in a short timeframe, working within existing government structures. Implementation could start immediately, with the aim of all Romanian municipalities fully using the approach by 2018. The main barrier to implementing integrated land use and transport planning would be getting political support and recognition that such an approach is in the long term interest of Romania rather than a 'laissez-faire' approach to planning. Study tours of places—for example through the European Covenant of Mayors program—with good practice may help gain high level acceptance for the intervention.

123. **Investment in Infrastructure for Zero Carbon Modes**. Investment in infrastructure for zero carbon transport modes (walking and cycling) has the potential for reducing carbon emissions by encouraging shift towards those modes. This can result from provision of infrastructure and services that make use of such modes more feasible for more journeys, quicker, more convenient, safer, more comfortable or more pleasant. In the context of this project, we focussed on urban infrastructure improvements because urban areas are where there is greatest potential for shifting significant numbers of people to walking and cycling because of the relatively short distances travelled. Infrastructure investment may include investing in packages to improve the quantity or quality of some or all of the following:

- Cycle paths and cycle lanes
- Cycle parking facilities
- Footpaths
- Pedestrianization of streets
- Pedestrian and cycle crossings

124. A number of European cities have excellent cycling and pedestrian infrastructure and as a result have high levels of cycling and walking embedded in their culture. Well-known examples include Copenhagen, Amsterdam, Utrecht, Groningen and Munich. Many other European cities are currently investing in cycling and walking infrastructure in an attempt to grow their trip modal share. The investment

[68] World Bank (2013). Romania Climate Change and Low Carbon Green Growth Program Transport Rapid Assessment Report, November 2013.

[69] This is the biggest development project in Stockholm - when complete in 2017 it will be home to 24,000 people and workplace for 5000. 3km from the city centre on a 160 hectare brownfield industrial site, the street layout and the mix of land uses is designed to make the streets attractive to pedestrians and cyclists, with traffic and services concentrated along the central avenue. The latest modal split figures for Hammarby Sjostad show that 52 percent of trips are made on public transport, 27 percent on foot or by bike, with car journeys accounting for only 21 percent. See: Thriving cities: Integrated land use and transport planning. Report for pteg by Transport for Quality of Life, 2011.

in infrastructure required to achieve modal shift towards cycling and walking depends on local circumstances and the extent of the targeted shift.

125. The city of Bogotá (Colombia) provides an interesting illustration of potential costs and benefits. Here, based on advice from Dutch cycling planners, Euro 178 million was invested in transforming the city's cycling infrastructure over a 10 year period from the mid-1990s.[70] This resulted in an increase in cycling trip mode share in the city from 0.9 percent to 4 percent over that period. Taking account of dollar inflation, Euro 178 million in 2000 values (the midpoint of the implementation period) is equivalent to around Euro 232 million in 2011 dollar values. At that mid-point, the population of Bogota was around 6.3 million people, so the investment per person over 10 years was equivalent to Euro 37 per person (2011 values). Based on a similar level of investment per head of population, an investment cost of Euro 75 million is adopted for the 20 largest cities in Romania. Investment in improved cycling and walking infrastructure would require a long term program. However, such a program could in principle be started (subject to availability of funding) in the near future. The main barrier to implementation would be political and public acceptance that the benefits of investment in these modes outweigh any disbenefits arising from reallocating road space or traffic priority away from motorized vehicles.

126. *Modelling approach used and GHG benefits*. The investment in walking and cycling implemented in Bogota saw cycling trips increase from 0.9 percent to 4 percent of daily trips within a decade. This scale of increase is considered to be feasible within the context of Romania, as despite climatic differences, the potential for certain trips to be replaced by cycle trips is present. The trips replaced by cycle trips tend to be the shorter distance trips by nature. Overall, a 4 percent shift in urban car trips to walking and cycling was modelled for all major urban areas. The annual GHG emission savings are presented in the graph below when the policy is implemented as part of the Green package of measures. A maximum annual saving of 0.09 $MtCO_2e$ is projected for between 2020 and 2025, however the impact tails off to 0.07 $MtCO_2e$ in 2050 as other polices act to suppress trips.

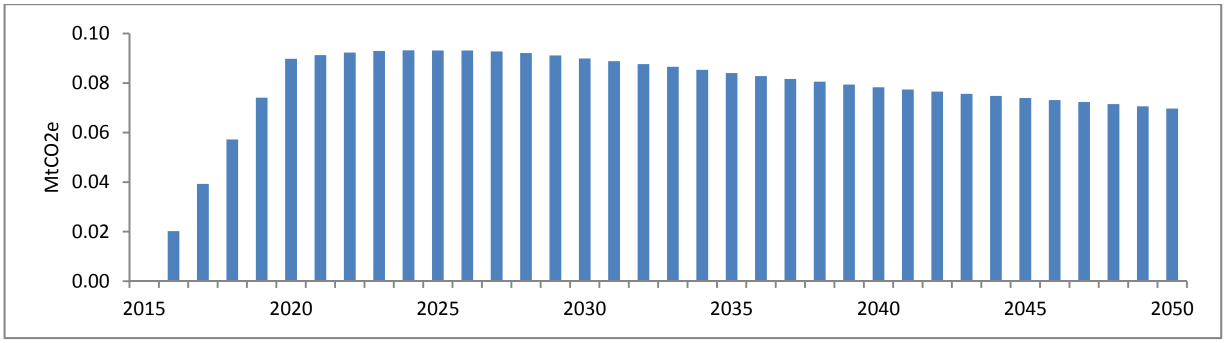
Table 14: Summary of Modelling Approach – Investments in Zero Carbon Modes

	Modelling Approach
Policy	Investment in Waking and Cycling Facilities
Implementation timeframe	Full implementation in 2020 with ramp up from 2015
Vehicles Affected	Car
Geographical Areas/Road Types affected	Urban areas
Impact/mechanism	4% mode shift in urban car trips to walk/cycle

[70] Cevero, R (2005). Accessible Cities and Regions: A Framework for Sustainable Transport and Urbanism in the 21st Century. University of California at Berkeley Working Paper UCB-ITS-VWP-2005-3. Available at: http://www.its.berkeley.edu/publications/UCB/2005/VWP/UCB-ITS-VWP-2005-3.pdf

Source: World Bank.

Figure 32: GHG Emissions Savings - Investment in Zero Carbon Modes



Source: TRANSEPT.

127. **Investment in public transport infrastructure**. Investment in public transport infrastructure has the potential for reducing carbon emissions by encouraging shift towards that mode. The Romanian General Transport Master Plan (GTMP) that is included in the Business as Usual scenario already includes very significant investment in public transport infrastructure on the strategic transport network, including the national rail system. Investment is also required to maintain and enhance the urban public transport system. It not within the scope of this study to undertake modelling of specific transport infrastructure schemes at the urban level, but the importance of an efficient and well-functioning public transport systems is highlighted here as a prerequisite to ensuring that the modelled strategic policies are effective in achieving the expected levels of carbon mitigation. Without insufficient investment in maintaining and enhancing the urban public transport network, modal shift towards private car will accelerate and the policies which promote modal shift will be less effective without a sufficiently attractive alternative to private modes.

128. Public transport in Bucharest includes a metro system (operated by Metrorex), a tram network, trolley buses, and an extensive bus network (all operated by RATB). In other Romanian cities and towns, public transport consists of buses, minibuses, trolley buses and trams. The city of Brasov took the decision in 2005 to abandon its tram line due to the prohibitive cost of upgrading and maintaining and is focusing on buses and trolley buses. Cluj-Napoca has upgraded its tram system, while other cities have similar plans but lack funding to implement them. Although data is hard to obtain, it is understood that public transport patronage in many Romanian towns and cities is in decline, with a corresponding increase in private traffic levels. For example, in Ploiesti, public transport patronage fell from 7 million trips per month in 2011 to 6.7 million in 2012.[71]

129. Many European cities provide excellent examples of high quality urban public transport infrastructure. The 2011 COST action TU0603 report 'Buses with High Level of Service' presents

[71] Improving energy efficiency in Ploiesti, Romania: TRACE city energy efficiency diagnostic study. World Bank (under the Romania Regional Development Program), undated.

examples of different aspects of good practice from 35 European cities.[72] The investment in infrastructure required to achieve modal shift from private cars towards public transport depends strongly on local circumstances (including the state of current infrastructure and patronage levels) and the extent of the targeted shift. Modelling of the potential impact of particular public transport schemes at the city level requires a level of detailed city level information and modelling assumptions that was outside the scope of this study. However, investment in improved public transport infrastructure in Romanian cities requires a long term program which must not be neglected as ancillary to the strategic objectives of the GTMP.

130. **Investment in smarter choices/behavioural change programs.** Over recent years there has been an increasing interest in and focus on 'soft' transport policies as a means of changing travel behaviour. 'Smarter choices' behavioural change programs seek to provide better information to travellers on the travel choices they have available to them, and in highlighting the potential benefits which considering more sustainable transport modes (eg walking and cycling) may bring to them. Schemes and policies which typically fall under the 'smarter choices' banner include: (a) workplace and school travel plans; (b) personalized travel planning, travel awareness campaigns and public transport information and marketing; (c) car clubs and car sharing schemes; and (d) teleworking, teleconferencing and home shopping.

131. Examples of best practice can case study evidence can be found across Europe. In the UK a number of cities have received funding to implement smarter choices programs as part of the Sustainable Travel Demonstration Town initiative and in Scotland, soft policies were trialled in seven cities as part of the Smarter Choices Smarter Places Program. Each of these initiatives involved investment of GBP 15 million spread across the cities, with investment in active travel infrastructure and behaviour change activities targeted at achieving an increase in active travel, increased public transport use and reduced emissions. Follow up monitoring of the programs identified statistically significant increases in walking and cycling and a reduction in car trips.

132. In Romania, a Smarter Choices program could be effectively focused on the largest urban areas, such as the twenty cities with over 100,000 population, and designed to complement the investment programs such as the walking and cycling infrastructure investment scheme. Travel planning programs concentrated on the largest employment sites and schools, combined with travel awareness campaigns would enhance the effectiveness of infrastructure investment. A proposed investment budget of Euro 23 million spread across the largest urban areas is proposed, based on similar spend levels to the UK based schemes (not including infrastructure which is covered in other policies here).

133. *Modelling approach used and GHG benefits*. This policy has been modelled as a mode shift for urban trips from car and motorcycle to bus, rail and walking modes. A mode shift of 3.2 percent from car and 1.1 percent from motorcycle have been assumed. These values represent a shift of 5 percent of car trips and 2.5 percent of motorcycle trips. The trips are reapportioned in equal measure to bus, rail and walk. The annual GHG emission savings are presented in the graph below when the policy is implemented

[72] Buses with High Level of Service: Fundamental characteristics and recommendations for decision-making and research - Results from 35 European cities. Final report – COST action TU0603, October 2011.

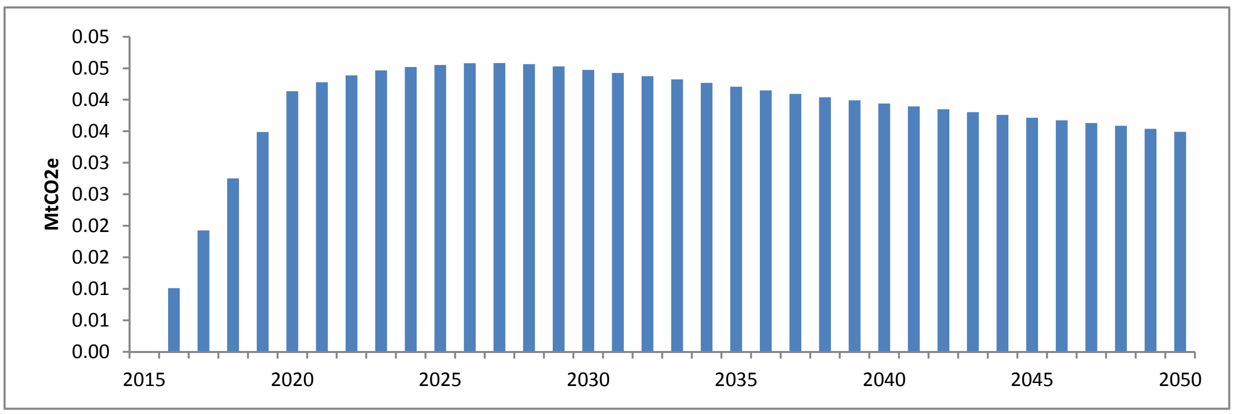
as part of the Green package of measures. A maximum annual saving of 0.05 $MtCO_2e$ is projected for 2025, however the impact tails off to 0.04 $MtCO_2e$ in 2050 as other polices act to supress trips.

Table 15: Summary of Modelling Approach – Investment in Smart Choices

	Modelling Approach
Policy	Investment in smart choices
Implementation timeframe	Full implementation by 2020 with ramp up from 2015
Vehicles Affected	Car and motorcycle trips shift to bus, rail and walk/cycle
Geographical Areas/Road Types affected	Urban areas
Impact/mechanism	4% mode shift in urban car and motorcycle trips to bus, rail and walk/cycle

Source: World Bank.

Figure 33: GHG Emissions Savings - Investment in Smart Choices



Source: TRANSEPT.

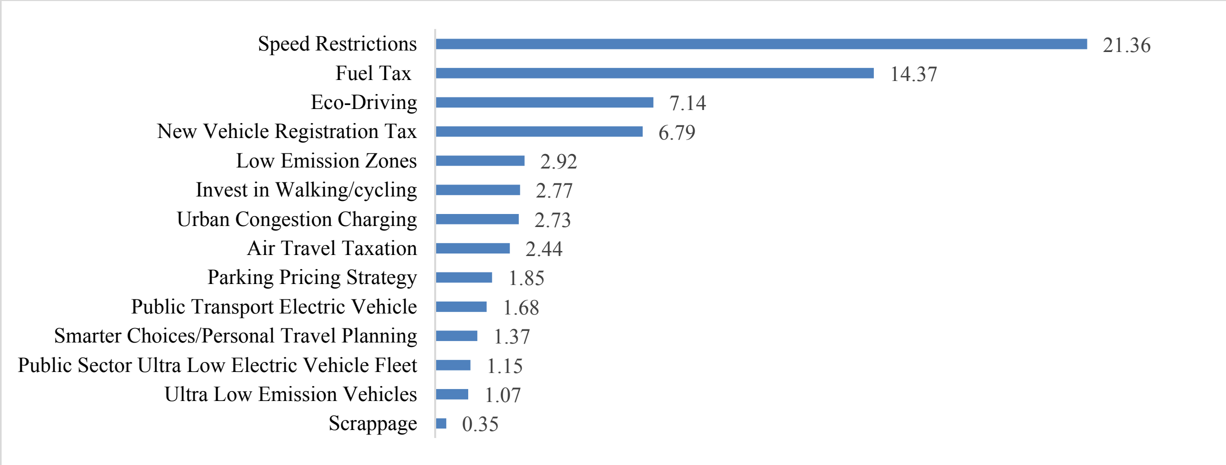
4 MARGINAL ABATEMENT CURVE, GREEN AND SUPERGREEN SCENARIOS

4.1 Introduction

134. The range of potential interventions have been defined and costed and assessed in terms of carbon abatement potential. The measures have been modelled individually to assess their relative mitigation potential and value for money in terms of investment against estimated abatement potential. These metrics sit alongside wider qualitative co-benefits to inform the ranking of those most appropriate for inclusion within the Green Scenario. The interventions performing best in the multi criteria appraisal were included in the Green Scenario, with explanation of why each should be pursued. An explanation of why the other options were not selected for adoption. However, all interventions have been included in the Super Green Scenario in order to assess an upper bound for slow GHG emission growth from the transport sector. No specific pre-defined GHG saving targets were used to constrain the choice of interventions, as a bottom-up approach was adopted. The identified measures have been drawn from a range of policy categories including: (a) pricing instruments; (b) technology; (c) regulatory; (d) operational efficiency; and (e) behavioral change and urban investments.

135. Figure 34 provide a summary of the cumulative abatement results for each intervention over 2015-2050, while the table below provides a breakdown of the abatement potential per intervention in three different time periods. The measures which have the potential to deliver the greatest absolute carbon savings over the course of the modelled period are as follows: (a) the lowering of speed limits (speed restrictions); (b) increasing the fuel tax (as a substitute to more sophisticated road user charging); (c) the implementation of a more progressive first registration tax (Environmental Stamp) promoting the adoption of low emission vehicles; and (d) eco-driving programs which encourage more efficient driving patterns, with advertising campaigns targeted at private car users and training programs focused on the freight and public transport sector.

Figure 34: Cumulative Abatement Potential per Intervention, 2015-2050 ($MtCO_2e$)



Source: TRANSEPT.

Table 16: Carbon Abatement from Interventions ($MtCO_2e$)

Intervention	Action Plan (2015-2022)	Strategy (2015-2030)	2015-2050	% of Total Emissions
Fuel Price	1.032	4.139	14.365	2.08
Scrappage Scheme	0.241	0.331	0.354	0.05
Vehicle Registration Tax	0.071	0.566	6.789	0.98
Parking Pricing	0.191	0.639	1.852	0.27
Urban Cong Pricing	0.050	0.597	2.729	0.39
Air Travel Taxation	0.267	0.757	2.436	0.35
Ultra-low Emission Vehicles	0.019	0.118	1.075	0.16
Public Sector EV	0.020	0.130	1.149	0.17
Bus EV	0.036	0.231	1.678	0.24
Speed Restrictions	2.168	6.288	21.357	3.09
Eco Driving	1.059	2.693	7.140	1.03
Low Emissions Zones	0.229	0.724	2.920	0.42
Investment in Walking Cycling	0.464	1.203	2.774	0.40
Smarter Choices/Soft Measures	0.220	0.582	1.370	0.20

Source: TRANSEPT.

4.2 Marginal Abatement Cost Analysis

136. Having identified the abatement potential for each of the interventions modelled, consideration needs to be given to the most effective areas of investment to achieve emission reduction. Marginal abatement cost (MAC) analysis provides a framework within which to guide investment decisions, identifying the levels of abatement possible and at what level of investment cost. A key component of the MAC analysis is the cost of each intervention, in terms both of capital cost and ongoing operational and maintenance costs. The implementation and ongoing costs of delivering the identified schemes have been estimated using case study evidence and a variety of sources of estimated costs applied to the Romanian context. The scope of the estimated costs are limited to those borne directly by the Government of Romania in terms of capital investment costs and ongoing operational and maintenance costs. The potential costs or operating cost savings borne by the private sector are not estimated or included within the MAC analysis. The basis for the cost estimation has been set out for each intervention in the preceding chapter.[73] Table 17 summarizes the mitigation potential of each intervention against scheme value for money based on the cost per ton of carbon abated. A summary of the qualitative assessment of the wider

[73] Costs—capital and operational and maintenance costs—are discounted at a discount rate of 4 percent to provide the net present value (NPV). The abatement cost is hence cost (NPV) divided by total undiscounted cumulative carbon reduction over 2015-2050. The choice was made not to discount carbon savings as the resulting value is an abstract figure which cannot be directly compared back to any graph and would not be easily cross-compared to other literature evidence of abatement costs.

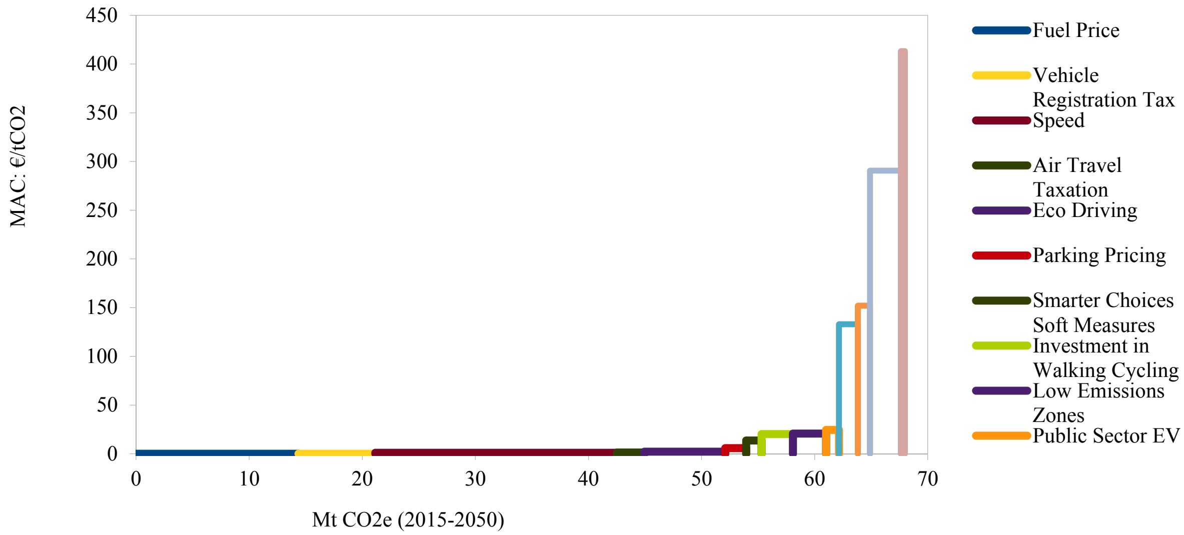
societal impacts and deliverability issues (barriers to implementation) is also presented where relevant. The MAC can be found in Figure 35.

Table 17: Intervention Performance Table

Intervention	**Implementation**	**Investment Cost (Euro million)**	**Cost-Effectiveness (Euro/ton)**	**Co-benefits/Deliverability commentary**
Fuel Tax	2015-2022	0.9*	0.06	Wider economic implications of higher fuel prices. Political resistance to increased taxation.
Scrappage Scheme	2016-2020	164	413	Economic boost to the domestic car industry and dealerships. Improved air quality from lower emissions vehicles.
Vehicle Registration Tax	2015-2022	0.9*	0.13	Economic and equity issues due to increasing the purchase cost of older (imported) vehicles. Potential boost for vehicle manufacturers. Political issues associated with previous tax.
Parking Pricing	2015-2022	19*	5.8	Enhancements to cityscape, urban safety and local air pollution. Barriers to implementation include political resistance and economic impacts on motorists and city commerce.
Urban Congestion Pricing	2022-2030	1,600	291	Air quality benefits. Equity issues. Technical barriers to implementation. Parking pricing a more efficient means of achieving similar results.
Air Travel Taxation	2015-2022	6*	1.4 #	Economic impacts of taxation. Positive equity impacts.
Ultra-low Emission Vehicles	2015-2030	195	152	Significant air quality benefits. Economic benefits to vehicle dealerships and manufacturers. Equity impacts.
Public Sector EV	2015-2030	35	24.5	
Bus EV	2015-2030	277	133	
Speed Restrictions	2015-2022	39	1.1 #	Safety and wider environmental benefits. Significant interest group pressure against reduction in speed limits expected.
Eco-Driving	2015-2022	60	4.8	Economic benefits of reduced fuel consumption. Increased safety.
Low Emissions Zones	2015-2022	114	20.7	Significant air quality benefits. Economic and equity impacts.
Investment in Walking Cycling	2015-2030	70	20.3	Health benefits and wider environmental and cityscape benefits expected.
Smarter Choices/	2015-2022	23	13.7	Health benefits.

* Public revenues also generated by scheme; # Particularly low values due to the consideration only of public investment.
Source: World Bank, ITP, TRANSEPT.

Figure 35: Marginal Abatement Cost Curve, 2015-2050



Source: TRANSEPT.

4.3 Development of the Green Scenario

137. The decision on which interventions to include in the Green Scenario were derived from a multi-criteria analysis that took into account the following: (a) scheme investment cost to the government; (b) cumulative emission savings; (c) carbon reduction cost effectiveness; (d) deliverability and economic important; and (e) wider benefits). The performance of each intervention against these criteria are provided in The tables above provide a basis for identifying the schemes which perform well in terms of investment value, and also in terms of required investment cost and potential implementation barriers. The scheme performance is summarized below, ranked by value for money in terms of carbon reduction cost effectiveness. Scheme performance under each criteria has been assigned a rating, based on straightforward three tier ranking as detailed in Table 19.

138. In order to achieve significant levels of carbon abatement, two schemes stand out above others. The implementation of speed restrictions is demonstrated to have significant potential to reduce vehicle emissions levels. Fuel taxation also can make a significant contribution to reducing emissions, through a combination of market forces acting to reduce the demand for travel and also in influencing purchasing decisions towards more efficient vehicles. Both of these policies have significant wider implications for the economy, with costs in terms of increased journey times in the case of speed restrictions and economic burden of higher taxation. In order to make meaningful reductions in carbon emissions in the transport sector, it is likely that at least one of these measures be adopted in some form. The wider costs and benefits will play an important role in determining the most appropriate, but ultimately it is likely that the political acceptability of one or other measure ultimately determines which may be more politically palatable.

Table 18: Abatement Intervention Performance

Intervention	Discounted Investment Cost	Absolute Emissions Savings (MtCO2e)	Carbon reduction cost-effectiveness (€/ton)	Deliverability/ economic impact	Wider Benefits
Fuel Price Taxation	€0.9m	14.37	€0.06/ton	Challenging	Very high
Vehicle Registration Tax	€0.9m	6.79	€0.13/ton	Moderate	Moderate
Speed Restrictions	€22.6m	21.36	€1.1/ton	Challenging	Very high
Air Travel Taxation	€3.5m	2.44	€1.4/ton	Moderate	Moderate
Eco-Driving	€34.4m	7.14	€4.8/ton	Good	Very High
Parking Pricing	€10.7m	1.85	€5.8/ton	Moderate	Moderate
Smarter Choices/ Soft Measures	€18.8m	1.37	€13.7/ton	Good	Very High
Investment in Walking Cycling	€56.3m	2.77	€20.3/ton	Good	Very High
Low Emissions Zones	€60.4m	2.92	€20.7/ton	Moderate	Moderate
Public Sector EV	€28.2m	1.15	€24.6/ton	Good	Moderate
Bus EV	€222.2m	1.68	€133/ton	Moderate	Moderate
Ultra-low Emission Vehicles	€163.2m	1.07	€152/ton	Moderate	Moderate
Urban Congestion Pricing	€792.8	2.73	€291/ton	Politically Challenging	Moderate
Scrappage Scheme	€146.3m	0.35	€413/ton	Good	Very High

Note: Costs are discounted, using a 4 percent discount rate, while emissions are undiscounted.
Sources: World Bank, TRANSEPT.

Table 19: Criteria for Defining the Performance of Each Intervention

Intervention	Good	Moderate	Poor/low
Scheme investment cost	Under Euro 10 million	Euro10-50 million	>Euro 50 million
Absolute Emissions Savings	>10 Mt	2-10 Mt	<2 Mt
Carbon reduction cost-effectiveness	<Euro10/ton	Euro 10-100/ton	>Euro 100/ton
Deliverability/economic impact	Positive impact/easily deliverable	Moderate, some challenges/some negative impacts	Politically challenging/significant economic impact
Wider Benefits	Strong wider benefits	Moderate benefits	Low wider benefits

Source: World Bank.

139. In the near term, whilst politically challenging and economically burdensome in particularly on the lower income households, applying increases in fuel taxation is more practicable. The requirements to change speed restrictions, with the associated awareness campaigns and need for reminder signage and enforcement would involve greater upheaval. It is therefore recommended that fuel taxation be considered as a key tool in achieving significant carbon abatement over the period of the Action Plan and Strategy.

Of the ‘second tier’ intervention measures which may contribute valuable abatement to carbon emissions in absolute terms, the new vehicle registration tax is identified as a tool which can bring significant carbon savings through the influencing of purchasing decisions. Again, this measure has the potential to create adverse political pressure, even whilst remaining fiscally neutral, and may have negative equity implications in the increased taxation of older and less efficient vehicles. However, as seen in countries across Europe, influencing the make-up of the vehicle fleet at point of purchase is an effective means of encouraging evolution towards a lower emitting vehicle stock. The benefits of this continue to be realised over time, and represent a particularly important opportunity in the face of a high projected growth rate in motorisation levels and car ownership.

140. Eco-driving programs also offer significant potential for the reduction in vehicle emissions, and unlike the previous interventions, there are no significant barriers to implementation or adverse impacts. In fact, eco-driving offers significant potential wider benefits in the form of cost savings for motorists and enhanced environmental and safety benefits. Investment costs will vary according to the nature of the program implemented, but studies have highlighted the measures as performing strongly in terms of both overall impacts and value for money.

141. The following interventions perform strongly in value for money terms and should also be considered for adoption within the action plan, and as a feature of the Green Scenario.

- **Smarter choices programs** combined with investment in walking and cycling infrastructure have been demonstrated to lead to modal shift, achieving not only a reduction in emissions levels but also significant wider benefits including health and wellbeing, and decongestion. In cost-benefit analysis, these schemes typically perform strongly, with cost-benefit ratios in excess of 20 by comparison with highway and public transport schemes in the low single figures. This analysis demonstrates that with concerted and sustained investment over the strategy period, emissions savings realized at a reasonable level of cost effectiveness.

- **Parking pricing** is a further market based measure which offers the potential for emissions savings with a high level of cost effectiveness. Indeed, the measure would be expected to offer a stream of revenue which could facilitate some of the investment measures highlighted above. Parking pricing, in conjunction with tightened parking regulation and enforcement, may be considered to be a more cost effective more readily implementable solution to in town congestion instead of urban congestion charging and most European cities are following this strategy in preference to congestion charging; and

- **Air travel taxation** presents a mechanism for exerting some control over the growing demand for air travel at the margins, and also offers a revenue stream which may be put to useful purpose. The implications for the economy need to be considered, but there is are potentially positive equity impacts in what may be expected to be a strongly progressive form of taxation.

142. Based on the analysis of the abatement potential of the identified measures and on the results of wider assessment, the following measures are proposed for consideration within the Action Plan period under the Green Scenario:

- Fuel Price Taxation Increase
- New Vehicle Registration Tax
- Eco-Driving Program
- Smarter Choices/Personal Travel Planning Programs
- Investment in Walking and Cycling Infrastructure
- Parking Pricing
- Air Travel Taxation

143. Of the above measures, the market based policies where the taxation mechanisms already in place require no significant capital investment. The combined undiscounted capital investment of the above infrastructure dependent measures totals Euro 136 million over the timeframe of the Strategy under the Green Scenario, but rise sharply for the Super Green Scenario (Table 20). For the Green Scenario, Euro 93 million of investment is profiled to fall within the period of the Action Plan, with ongoing investment in walking and cycling measures extending beyond 2022, based on a ten year investment profile. The mitigation impact of the combined bundle of interventions included within the Green Scenario is presented in Figure 36, together with the mitigation of the Super Green Scenario. Note that the impact of the bundle of measures is not identical to the sum of the individual measures due to the inter-relationship between certain policies.

144. The remaining interventions modelled as part of the study have not been considered suitable for inclusion within the Green Scenario, reflecting either the lower value for money based on the MAC analysis, or deliverability challenges. Non-inclusion within the Green Scenario does not however mean that the schemes have no value or that these should not be considered for implementation in Romania based on wider appraisal criteria such as economic impact or local air quality. The high costs of the Super Scenario are driven by the high cost of urban congestion charging scheme, but in terms of initial investment and operating and maintenance costs.

Table 20: Investment Costs of Green and Super Green Scenarios (Euro millions)

Scenario	Undiscounted Investment Cost			Discounted Investment Cost		
	Action Plan (2015-2022)	Strategy (2015-2030)	Model Period (2015-2020)	Action Plan (2015-2022)	Strategy (2015-2030)	Model Period (2015-2050)
Green Scenario	93	136	179	79	108	125
Super Green Scenario	885	1,477	2,603	748	1,136	1,562

Note: A 4 percent discount rate was used, in line with other sector reports.
Source: TRANSEPT.

145. The promotion of Ultra Low Emission Vehicles (ULEVs) has a place within government policy, and indeed incentives are currently offered for the purchase of low emitting vehicles both in terms of direct subsidy and as an additional stackable incentive under the existing scrappage scheme. Take-up of electric or plug-in electric vehicles to date has been low, which is likely to be a reflection of the limited existing infrastructure for such vehicles. Large scale investment in charging infrastructure would have the potential to increase take-up. However, this infrastructure has been seen to come at high cost, based on existing technology and the current commercial suppliers operating within this market. The technology is evolving rapidly, and already exposing mis-allocation of investment based on the approaches adopted by the countries early to provide supporting infrastructure. Equally, the marketplace is changing, and new business models relating to the provision of charging infrastructure are being developed, whether by vehicle manufacturers or by private suppliers identifying commercial potential. As such, it is considered that the high level of investment required to hasten the implementation of supporting infrastructure does not represent best value for money or lead to sufficient emissions reduction savings or wider benefits to merit immediate consideration.

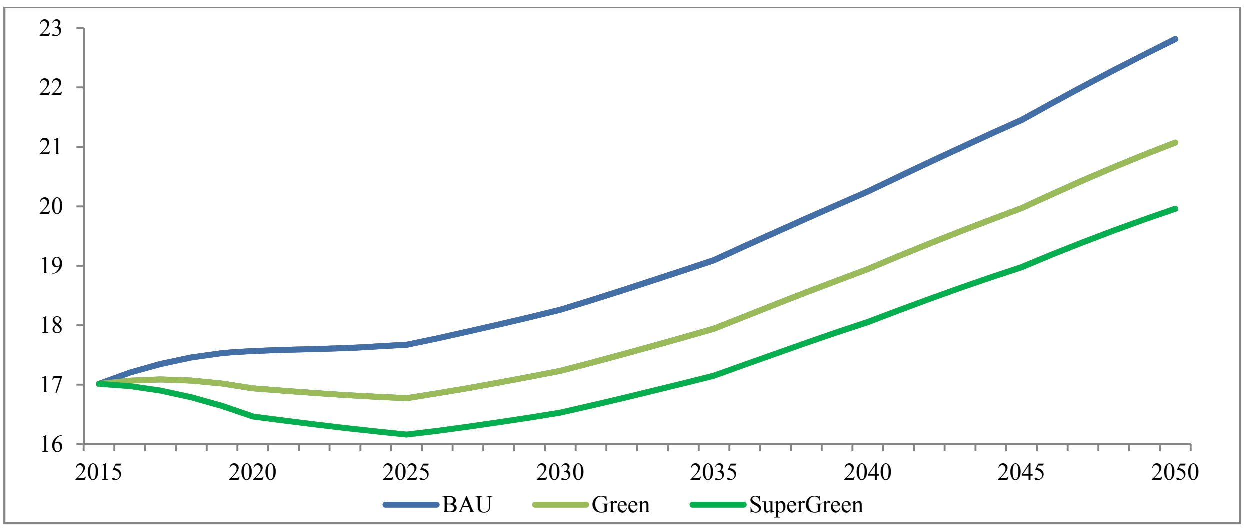
146. Equally, whilst target setting relating to the acquisition of ULEVs within the public sector fleet and the public transport fleet may be considered laudable as a means of promoting and raising awareness about the technology, the cost of the new technology remains high by comparison with the emissions savings achieved, and the technological barriers to effective integration within the fleets are also notable in the near term. Speed restrictions have been rejected in preference to higher fuel duties due to the implementation difficulties, the economic impact and the lack of revenue generated by such a measure. Low Emission Zones are demonstrated to have carbon saving potential, although the driving force behind implementation of such policies is typically local air quality. With its very poor air quality standards, Bucharest would potentially benefit most significantly from such a measure, and the policy should be considered within this context. However, with high implementation and operating costs, technological and enforcement barriers and potential political resistance, the pursuing of such a policy in the short/medium term is not considered cost effective as a means of carbon emissions saving.

4.4 Conclusion

147. To demonstrate the scale of mitigation achievable under a high intervention or Super Green scenario, the Green Scenario policies as well as policies which were not selected for inclusion within the Green Scenario, but which nevertheless provide GHG emission saving potential amongst wider benefits have been included. The Super Green Scenario therefore represents an all policy modelled scenario. The scale of abatement potential achievable in the Super Green Scenario by comparison with the Green Scenario and the BAU scenario is presented in Figure 36.

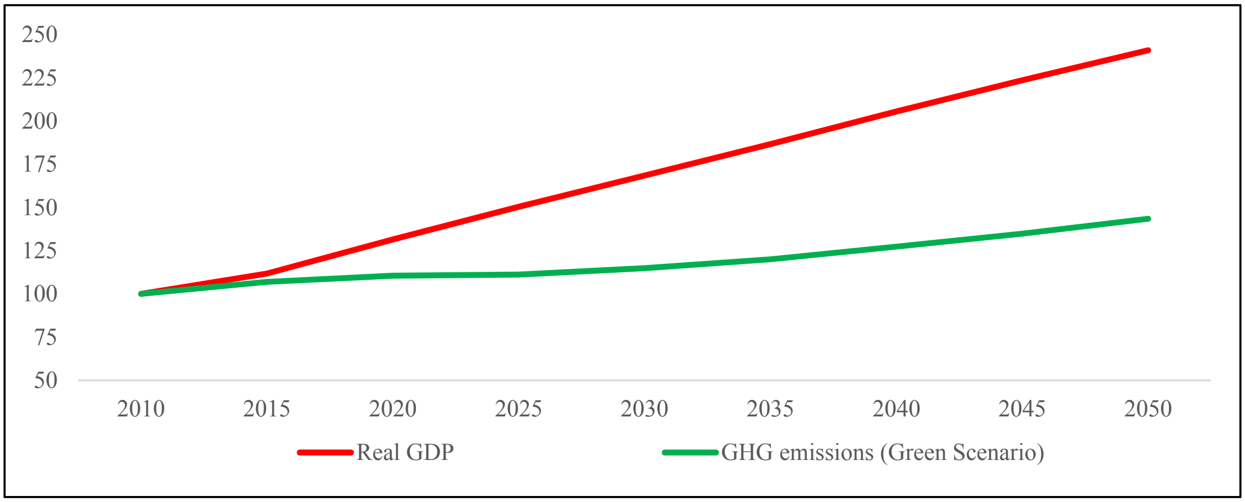
148. Under the BAU scenario emissions grow by 34 percent over 2015-2050, while under the Green Scenario emissions growth slows to 24 percent and under the Super Green Scenario growth slows to 17 percent. In all cases GHG emissions from the transport sector rise. These results are in line with many studies which suggest that reducing GHG emissions in the transport sector—as opposed to reducing GHG emission growth rate—is difficult in the transport sector. In order to reach a low emission scenario in 2050 Romania's transport sector has to have close to zero emissions, which will need large changes in behavior and technology. However, this growth in GHG emissions has to be seen in the context of a growing real economy. Figure 37 reveals that under a Green Scenario there is a gradual decoupling of GHG emissions from transport with growth in the economy.

Figure 36: Transport Emissions under Alternative Carbon Abatement Scenarios (MtCO2e)



Source: TRANSEPT.

Figure 37: Transport GHG Emissions and Real GDP Trends, 2010-2050 (2010 = 100)



Source: TRANSEPT.

ANNEX 1: TECHNICAL MODELLING NOTE

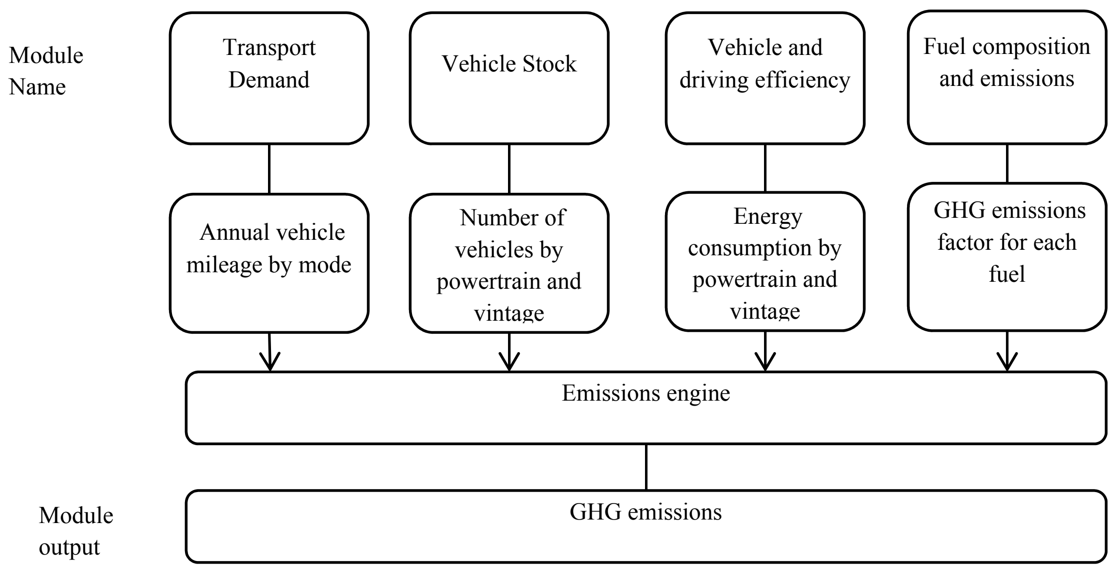
Overview

This technical note sets out the structure of the Romania Transport Emissions Model and the development of the emissions baseline projections. This note identifies what the key datasets are, defines the values used for the BAU scenario, and later benchmarks the resulting GHG emissions of this baseline scenario. The emissions model is comprised of four modules which produce the input matrices for the emissions engine which calculates the GHG emissions. The four modules are:

- Transport Demand
- Vehicle Stock
- Vehicle and driving efficiency
- Fuel consumption and emissions

Each module takes a number of baseline datasets as input and applies the effect of relevant policies to them. The adjusted datasets are then input to the emissions engine which calculates the resulting GHG emissions. The process is outlined in the figure below.

Table A1: Overview of Model



Source: World Bank.

Description of Input Datasets

This emissions model has been developed in a format which ensures as far as possible that it is straightforwardly compatible with the datasets which are used as model inputs. These datasets are discussed in detail below, but include the National Transportation Model, COPERT and Eurostat statistics.

Model outputs are also structured to provide relevant output statistics and results which can be compared with other studies. The format of the model outputs have been drawn from the SULTAN emissions model which was used to conduct Europe wide transport emissions modelling work for the European Commission. The model operates using a number of key desegregations including mode, powertrain, fuel used and location type (urban, non-urban, highway)

Table A2: Mode Coverage

Passenger	**Freight**
Car Motorcycle Bus and coach Rail, includes metro and tram Aviation to the EU Aviation to outside of the EU Walk and cycle	Van Medium Truck Heavy Truck Rail Inland Shipping Maritime Shipping

Source: World Bank.

Table A3: Powertrain Specific to Each Mode

Passenger transport					
Car	Bus	Rail	EU Aviation	Int Aviation	Motorcycle
Gasoline Diesel HEV gasoline HEV diesel PHEV gasoline PHEV diesel EV FCEV CNG	Diesel HEV diesel EV FCEV CNG	Diesel CR Eclectic HSR Electric	Short-haul	Long-haul	Gasoline FCEV EV
Freight transport					
Van	Medium Truck	Heavy Truck	Rail	Inland Shipping	Maritime Shipping
Gasoline Diesel HEV gasoline HEV diesel PHEV gasoline PHEV diesel EV FCEV CNG	Diesel HEV diesel PHEV diesel EV FCEV CNG	Diesel HEV Diesel FCEV CNG	Diesel Electric	Diesel CNG	Conventional LNG Conv + wind LNG + wind

Source: World Bank.

Table A4: Fuel Specific to Each Mode

Passenger transport					
Car	Bus	Rail	EU Aviation	Int Aviation	Motorcycle
Gasoline Diesel Electricity Hydrogen LPG CNG	Diesel Electricity Hydrogen CNG	Diesel Electricity	Kerosene	Kerosene	Gasoline Electricity Hydrogen
Freight transport					
Van	Medium Truck	Heavy Truck	Rail	Inland Shipping	Maritime Shipping
Gasoline Diesel Electricity Hydrogen LPG CNG	Diesel Electricity Hydrogen CNG	Diesel Electricity Hydrogen CNG	Diesel Electricity	Diesel LNG	Ship fuel LNG

Source: World Bank.

As mentioned above, a number of datasets belong to each of the four modules. The module holds the baseline values for each dataset as default and applies the effect of the policies to them. The datasets which each module contains are listed in the table below.

Table A5: List of Model Input tables

Model module	**Input table**	**Units**	**Disaggregation**
Demand	Vehicle capacity	Passengers/tons	By mode
	Vehicle load	% of capacity	By mode and location
	Total passenger and freight demand	Million Passenger-kms / million ton-kms	
	Split of demand by location and mode	% of demand	By mode and location
Stock	Total number of vehicles		By mode
	Split of all vehicles in use in 2011 by powertrain	% of vehicles	By mode and powertrain
	Split of new vehicles by powertrain	% of new vehicles	By mode and powertrain
Vehicle and driving efficiency	Energy consumption of all vehicles in use in 2011	Mega Joules/km	By mode and powertrain
	Energy consumption of new vehicles	Mega Joules/km	By mode and powertrain
Fuel	Fuel source of powertrain	% of power used	By mode and powertrain
	GHG direct emissions factor	Kg CO_2e	By mode
	GHG indirection emissions factor	Kg CO_2e	By mode

	Biofuel substitution	% of fuel energy	
	Biofuel GHG life cycle emissions factor reduction	% reduction of GHG emission factors	

Source: World Bank

The data is required for each of the model time horizons which are: 2011 (the base year), 2015, 2020, 2025, 2030, 2035, 2040, 2045 and 2050. The terminology for Mega and million or kilo and thousand are used interchangeably depending on the usual use for each data. A range of data sources were considered to identity the most appropriate baseline values for Romania. These sources include:

- COPERT: a database of road transport demand, stock and emissions– provides Romania specific dataset.
- TREMOVE: a behavior based transport model for the EU - model inputs include Romania specific data
- SULTAN: a transport emissions model for the EU – provides average values for the EU
- Eurostat – provides transport data specific to Romania
- EU Energy, Transport and GHG Emissions, Trends to 2050, Reference Scenario 2013, – used outputs specific to Romania
- Romanian National Transport Model

No single source provides all of the data required for the emissions model because different sources specialise in certain modes and because sources differ on their definitions of mode -for example Eurostat groups some van journeys with passenger cars, while COPERT separates out all van journeys.

Demand Module

Vehicle Capacity

SULTAN provides EU wide average capacity for all modes. The TREMOVE dataset, which is specific to Romania, largely matches that of SULTAN, however does not include every mode and it used different categories for truck. We have taken most values from SULTAN with the exception of inland shipping. The nature of inland shipping in Romania is atypical within the EU because of the heavy use of push and dumb vessels on the Danube.[74]

The average capacity was instead calculated using Eurostat data, by dividing the total tonnage of inland vessels (including dumb) by the number of push vehicles. This provides a value of 4,566 tons which is more than double that of the EU average used in SULTAN of 2,000 tons.[75] Vehicle capacity remains constant across the time horizons.

[74] These vessels can transport much higher loads than the normal barge, a comparison of vessel capacities can be found here: http://www.binnenvaart.be/en/binnenvaartinfo/scheepstypes.asp.

[75] http://ec.europa.eu/eurostat/web/products-datasets/-/iww_eq_age_loa
http://ec.europa.eu/eurostat/web/products-datasets/-/iww_eq_age.

Table A6: Average Vehicle Capacity

Mode	Chosen value	Source
Passenger transport, average maximum people per vehicle		
Car	5	SULTAN & TREMOVE
Bus	50	SULTAN & TREMOVE
EU Aviation	121	SULTAN
Int. Aviation	350	SULTAN
Passenger Rail	400	SULTAN
Motorcycle	2	SULTAN & TREMOVE
Freight transport, average maximum tons per vehicle		
Van (van and LGV <3t)	1.2	SULTAN
Medium Truck (3-16t)	4	SULTAN
Heavy Truck (16-32t)	15	SULTAN
Inland Shipping	4,566	Eurostat
Maritime Shipping	17,904	SULTAN
Freight Rail	1,000	SULTAN

Source: World Bank

Vehicle Load

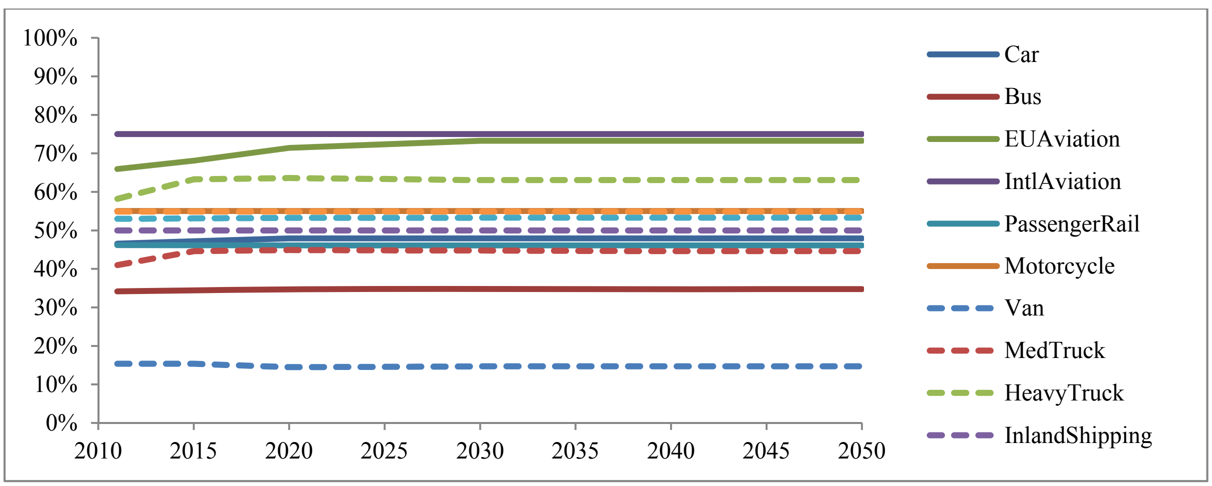
SULTAN and TREMOVE use values for average load from 2010 to 2050 for the EU and Romania respectively. Average loads are all higher in TREMOVE, which is to be expected in Romania. We have therefore used the TREMOVE values for load where available. Table A7 presents the values for load used in 2011 and their source and Figure A1 shows how the chosen profiles vary through time. There are two deviations from the available TREMOVE or SULTAN data:

- The load for passenger rail in TREMOVE appears too high and produces values for rail energy demands much lower than those reported in Eurostat, therefore the load for passenger rail was taken from SULTAN.
- The load of inland shipping provided by SULTAN is probably not typical of Romania because of the unique use of the Danube, we have therefore taken a provision value of 50% which yields levels of energy usage expected by Eurostat.

Table A7: Average Vehicle Load

Mode	Chosen value (2011)	Source
Car	46.5%	TREMOVE
Bus	34.1%	TREMOVE
EU Aviation	65.4%	SULTAN
Int. Aviation	75.0%	SULTAN
Passenger Rail	46.2%	SULTAN
Motorcycle	55.0%	TREMOVE
Van	15.4%	SULTAN
Medium Truck	41.0%	SULTAN
Heavy Truck	58.2%	SULTAN
Inland Shipping	50.0%	Provisional estimate
Maritime Shipping	53.0%	SUTLAN
Freight Rail	54.9%	TREMOVE

Figure A1: Profile of Vehicle Load by Mode (2011 to 2050)



Source: World Bank

Passenger and Freight Demand

Estimations of total transport demand are provided by COPERT, Trends to 2050, TREMOVE and Eurostat. Table A8 compares data from these datasets and presents the chosen values for the base year, 2011. Statistics for road transport demand provided by COPERT and Eurostat differ, however COPERT provides more detailed within the data, for example it identifies demand by location and it separates out more modes. We have therefore taken COPERT values in most cases for road transport. The exception is the demand for heavy trucks, for which COPERT records double the ton-km than Eurostat. One possible reason is that Eurostat data relates only to vehicles registered in Romania, whereas COPERT data might relate to all heavy trucks operating inside Romania. To help benchmark the model we have used the Eurostat value provisionally as this is the value that would have been used as part of the Trends to 2050 modelling.

Table A8: Total Transport Demand within Romania, 2011

Mode	Eurostat	COPERT	Chosen value	Source and notes
Passenger transport in Million Passenger-kms				
Car	75,000 (Car+MC)	70,593	70,593	COPERT
Bus	11,800	9,052	9,052	COPERT
EU Aviation	6,600	-	5,900	NTM finds 90% flights within EU
Int. Aviation		-	700	
Passenger Rail (Inc. Metro and Tram)	12,200 (of which 7,199 tram/metro)		12,000	Eurostat
Motorcycle	653	329	12,200	COPERT
Walk/Cycle	8,468 (cycle only, from TREMOVE)		8,468	TREMOVE
Freight transport in Million Ton-Kms				
Van	5	2,345	2,345	COPERT
Medium Truck	4,760	5,052	5,052	COPERT
Heavy Truck	21,584	43,108	21,584	Eurostat
Inland Shipping	11,409	-	11,409	Eurostat
Maritime Shipping		-		
Freight Rail	14,719	-	14,719	Eurostat

Source: World Bank

The emissions model requires the total demand to be broken down by location. COPERT provides this data for road transit. For the remaining modes we have used the EU wide averages presented in SULTAN.

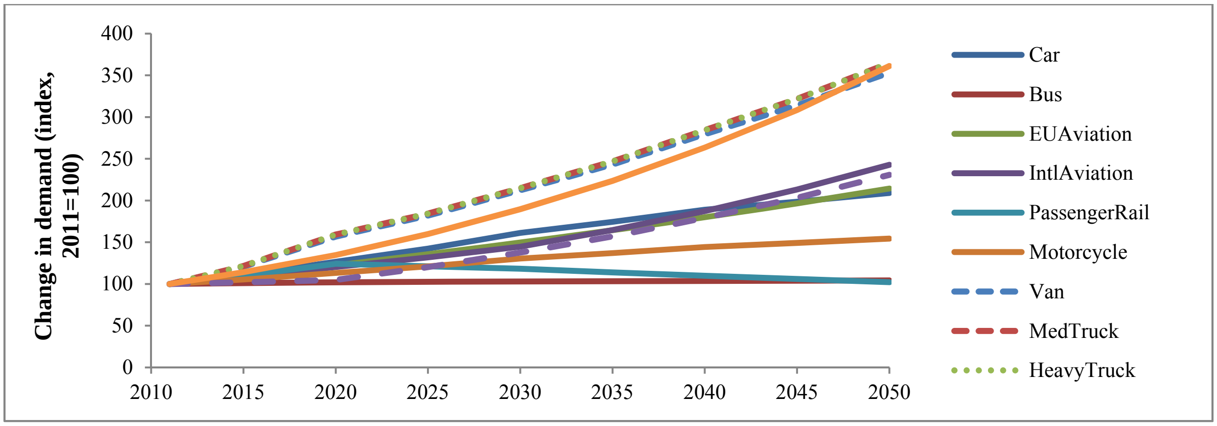
Table A9: Split of Demand by Location, 2011

Mode	**Urban**	**Non-urban**	**Motorway**	**Source**
Car	44%	42%	14%	COPERT
Bus	67%	16%	18%	COPERT
EUAviation	0%	100%	0%	SULTAN
IntlAviation	0%	100%	0%	SULTAN
PassengerRail	31%	69%	0%	SULTAN
Motorcycle	72%	17%	11%	COPERT
WalkCycle	97%	3%	0%	SULTAN
Van	37%	37%	26%	COPERT
MedTruck	35%	35%	30%	COPERT
HeavyTruck	35%	35%	30%	COPERT
InlandShipping	0%	100%	0%	COPERT
MaritimeShipping	0%	0%	0%	SULTAN
FreightRail	0%	100%	0%	SULTAN

Source: World Bank

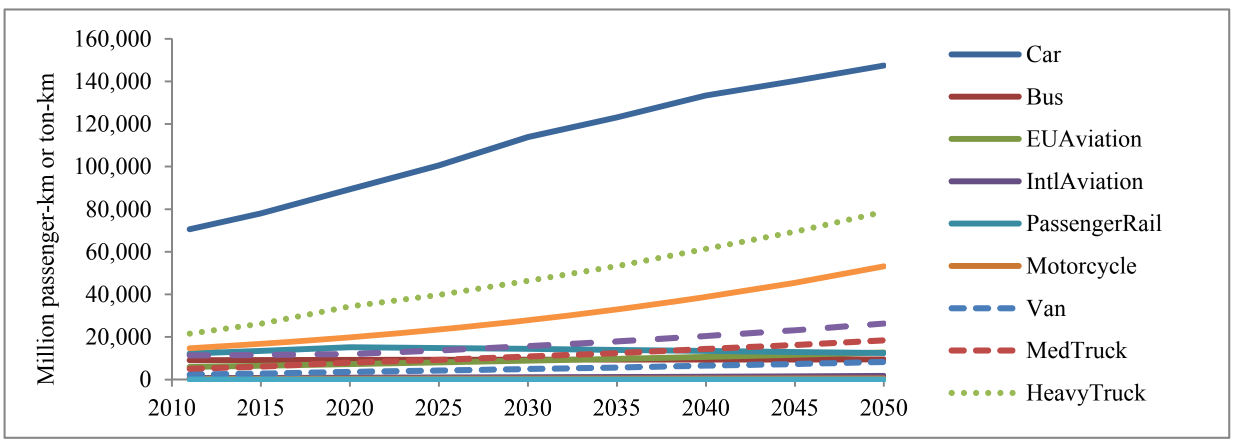
Projected changes to future demand have been taken from the 'Environmental and Economic Scenario' of the NTM. This model forecasts transport demand up to 2040, so the trends were extrapolated to 2050. The NTM only models non-urban and highway trips, therefore the projected growth has only been applied to demand at these locations. This also serves to avoid an overlap with the urban modelling team. Figure A2: presents the change in demand that is forecast by the NTM, and Figure A3 applies these trends to the demand for transport.

Figure A2: Relative Change in Transport Demand taken from NTM



Source: World Bank.

Figure A3: Projected Transport Demand to 2050



Source: World Bank.

Vehicle Stock Module

Estimates of the total vehicle stock in 2011 are provided by Eurostat and COPERT. The chosen values for 2011 are presented in Table A10 below. Values presented by COPERT and Eurostat often differ. For example Eurostat reports there to be 4,335,000 cars in 2011 compared to 5,284,494 by COPERT. However we have chosen to use COPERT values for most modes because this data explicitly concerns vehicle data.

Table A10: Total Vehicle Stock in 2011

Mode	Chosen value	Source and notes
Car	5,284,494	COPERT
Bus	28,487	COPERT
EU Aviation	50	Eurostat, with 10% of flights external to EU
Int. Aviation	4	
Passenger Rail	794	Eurostat
Motorcycle	166,157	COPERT
Van	565,092	COPERT
Medium Truck	130,564	COPERT
Heavy Truck	209,621	COPERT
Inland Shipping	341	Eurostat
Maritime Shipping		
Freight Rail	926	Eurostat including use of Marfa statistics

Source: World Bank

To project vehicle stock to 2050 we have set the number of vehicles as proportional the change in demand.[76] The split of each mode by powertrain for all vehicles in use in 2011 is presented in Table A11. COPERT provides the most detailed data on the number of vehicles by powertrain, so its values have been used where possible. Eurostat data has been used in conjunction with Marfa, the Romania's rail freight operator, to provide the split between diesel and electric rail locomotives. SULTAN values were used for air and shipping.

Table A11: Split of vehicles by powertrain for all vehicles in 2011

Mode	Powertrain	Split of all vehicles	Source
Car	Gasoline	68%	COPERT
	Diesel	28%	
	LPG	4%	
Bus	Diesel	100.0%	COPERT
EU Aviation	Short-haul	100.0%	SULTAN
Intl Aviation	Long-haul	100.0%	SULTAN
Passenger Rail	Diesel	62.7%	Eurostat & Marfa
	CR Electric	38.3%	
Motorcycle	Gasoline	100.0%	COPERT
Van	Gasoline	33%	COPERT
	Diesel	67%	
Med Truck	Diesel	100.0%	COPERT
Heavy Truck	Diesel	100.0%	COPERT

[76] The vehicle lifecycle model is taken from SULTAN, and is based on survival rates which decline with vehicle age. Vehicles drop out of the fleet according to this survival profile, and are replaced in the quantity required to meet the fleet size growth profile.

Inland Shipping	Diesel	100.0%	COPERT
Maritime Shipping	Conventional	100.0%	COPERT
Freight Rail	Diesel	59.4%	Eurostat & Marfa
	Electric	40.6%	

Source: World Bank

Split of New Vehicles by Powertrain

The powertrain split of all vehicles in 2011 provides the baseline conditions for the model. However a key element for future projections of emissions is the type of vehicles that will be purchased in the future. Values for the powertrain split of new vehicles have been taken from the BAU scenario of the Trends to 2050 scenario set used in SULTAN. Although these projections are not specific to Romania, these are taken presently as the best estimates available. Table A12 presents the split of new vehicles for the decadal time horizons.

Table A12: Split of New Vehicles

Mode	Powertrain	2011	2020	2030	2040	2050
Car	Gasoline	52.5%	55.2%	51.3%	46.4%	44.6%
	Diesel	47.2%	36.3%	32.3%	31.7%	29.6%
	HEV gasoline	-	2.6%	7.4%	10.6%	13.2%
	HEV diesel	-	1.7%	5.0%	7.1%	8.8%
	PHEV gasoline	-	0.01%	0.01%	0.01%	0.01%
	PHEV diesel	-	0.01%	0.01%	0.01%	0.01%
	EV	-	0.00%	0.00%	0.00%	0.00%
	FCEV	-	0.00%	0.00%	0.00%	0.00%
	LPG	0.3%	3.7%	3.5%	3.5%	3.3%
	CNG	-	0.6%	0.5%	0.5%	0.5%
Bus	Diesel	98.2%	98.9%	97.9%	98.7%	98.5%
	HEV diesel	0.2%	0.6%	1.1%	1.3%	1.5%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%
	FCEV	0.0%	0.0%	0.0%	0.01%	0.01%
	CNG	1.5%	0.5%	1.0%	0.01%	0.01%
EU Aviation	Short-haul	100.0%	100.0%	100.0%	100.0%	100.0%
Intl Aviation	Long-haul	100.0%	100.0%	100.0%	100.0%	100.0%
Passenger Rail	Diesel	29.0%	15.0%	1.0%	1.0%	1.0%
	CR Electric	71.0%	85.0%	99.0%	99.0%	99.0%
Motorcycle	Gasoline	100.0%	100.0%	100.0%	100.0%	100.0%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%
Van	Gasoline	36.6%	38.4%	32.3%	33.8%	32.6%
	Diesel	62.8%	56.3%	55.8%	48.6%	44.6%
	HEV gasoline	0.3%	2.2%	5.2%	7.9%	10.5%

	HEV diesel	0.3%	3.0%	6.3%	9.3%	11.9%
	PHEV gasoline	0.0%	0.1%	0.1%	0.1%	0.1%
	PHEV diesel	0.0%	0.1%	0.2%	0.2%	0.2%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%
Medium Truck	Diesel	99.5%	97.6%	95.7%	93.0%	89.9%
	HEV diesel	0.5%	2.4%	4.3%	7.0%	10.1%
	CNG	0.0%	0.0%	0.0%	0.0%	0.0%
Heavy Truck	Diesel	100.0%	100.0%	100.0%	100.0%	100.0%
Inland Shipping	Diesel	100.0%	100.0%	100.0%	100.0%	100.0%
Maritime Shipping	Conventional	100.0%	100.0%	100.0%	100.0%	100.0%
Freight Rail	Diesel	49.0%	40.0%	25.0%	5.0%	5.0%
	Electric	51.0%	60.0%	75.0%	95.0%	95.0%

Source: World Bank

Vehicle and Driving Efficiency Module

The emissions model calculates the total energy used by vehicles of each powertrain. This requires an estimation of the average energy consumption for each powertrain, which is measured in Mega Joules per km (MJ/km). The model uses values presented in the BAU scenario for SULTAN as part of the Trends to 2050 scenario set. SULTAN uses 2009 as its base year instead of 2011, therefore we derived values for the average energy consumption by powertrain for vehicles operating in 2011 by applying historical changes in Romania's vehicle stock from 2009 to 2011.

Table A13: Average Energy Consumption of All Vehicles in Use by Powertrain (2011)

Mode	Powertrain	MJ/km
Car	Gasoline	2.97
	Diesel	2.62
	HEV gasoline	1.73
	HEV diesel	1.64
	PHEV gasoline	1.15
	PHEV diesel	1.11
	EV	0.63
	FCEV	1.06
	LPG	2.71
	CNG	2.57
Bus	Diesel	9.66
	HEV diesel	6.76
	EV	2.90
	FCEV	8.39
	CNG	10.73
EUAviation	Short-haul	166.39

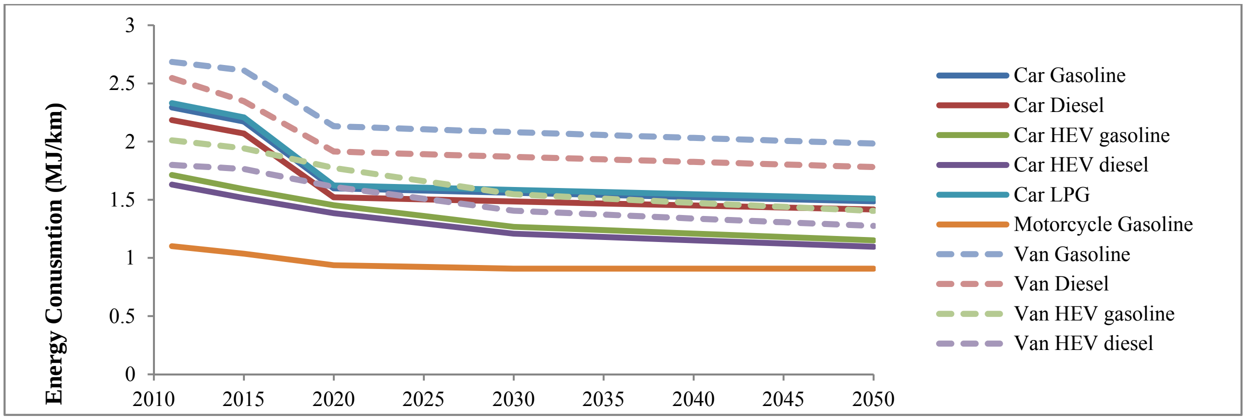
IntlAviation	Long-haul	465.18
PassengerRail	Diesel	43.01
	CR Electric	35.48
	HSR Electric	43.30
Motorcycle	Gasoline	1.13
	FCEV	0.19
	EV	0.11
Van	Gasoline	3.49
	Diesel	3.17
	HEV gasoline	2.02
	HEV diesel	1.80
	PHEV gasoline	1.33
	PHEV diesel	1.21
	EV	0.73
	FCEV	1.22
	LPG	2.65
	CNG	2.93
MedTruck	Diesel	4.98
	HEV diesel	3.99
	PHEV diesel	3.12
	EV	1.49
	FCEV	3.01
	CNG	5.67
HeavyTruck	Diesel	12.47
	HEV diesel	11.50
	FCEV	4.15
	CNG	14.09
InlandShipping	Diesel	734.61
InlandShipping	LNG	699.52
MaritimeShipping	Conventional	2413.99
	LNG	2413.99
	Conventional + Wind	1931.19
MaritimeShipping	LNG + Wind	1931.19
FreightRail	Diesel	114.05
	Electric	51.85

Source: World Bank

Energy Consumption of New Vehicles

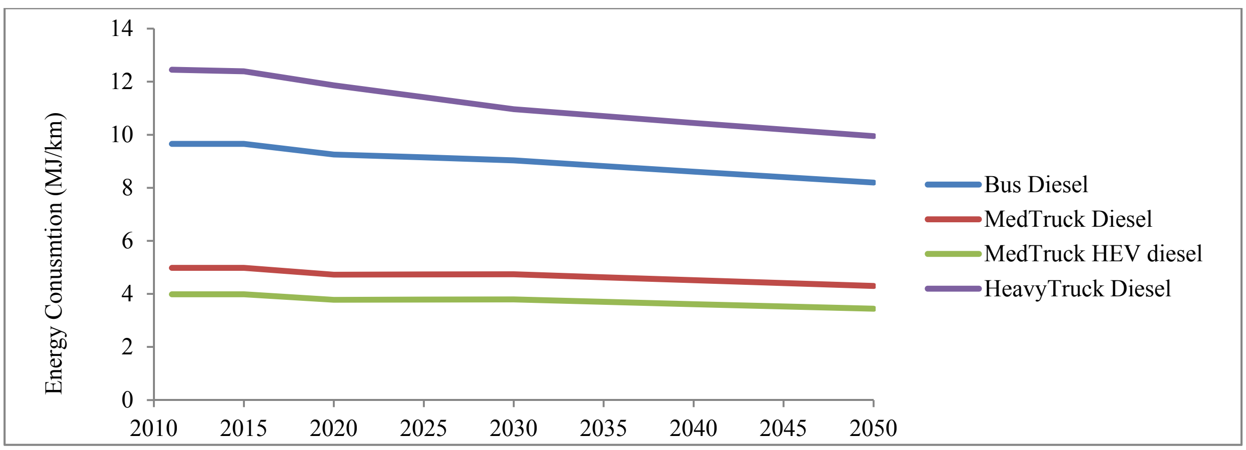
The energy consumption of new vehicles has been taken from the SULTAN BAU scenario. The values for a selection of powertrains by mode are presented in the four graphs below.

Figure A4: Energy Consumption of New Cars, Motorcycles and Vans to 2050



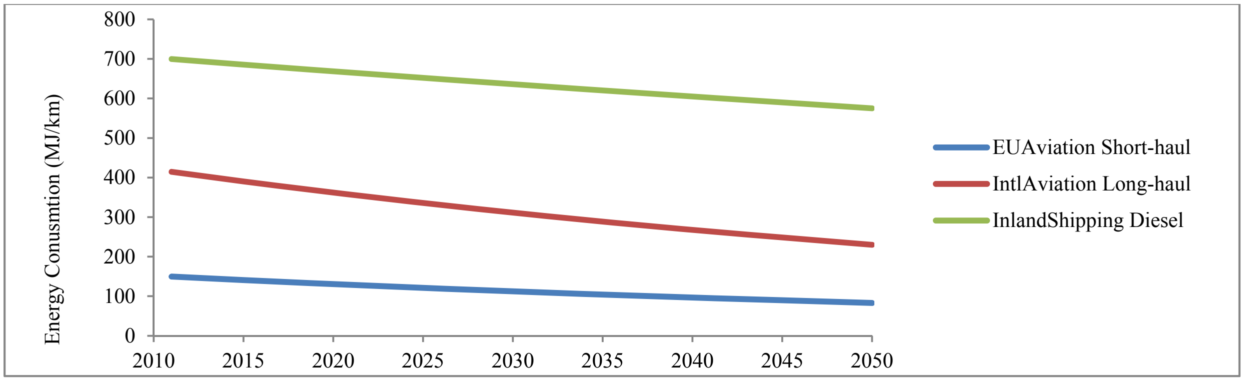
Source: World Bank

Figure A5: Energy Consumption of New Buses, Medium Trucks and Heavy Trucks to 2050



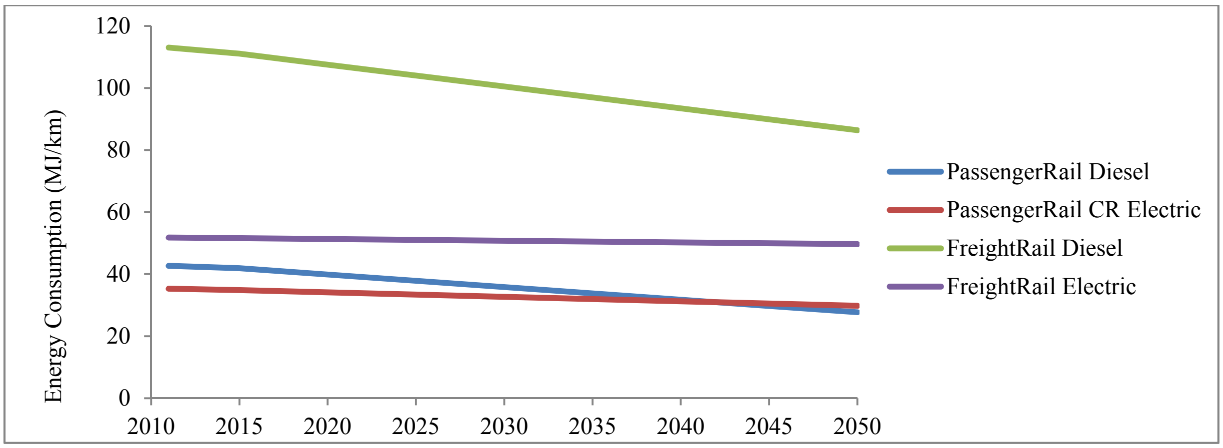
Source: World Bank.

Figure A6: Energy Consumption of New Planes and Inland Ships to 2050



Source: World Bank.

Figure A7: Energy Consumption of New Passenger and Freight Locomotives to 2050



Source: World Bank.

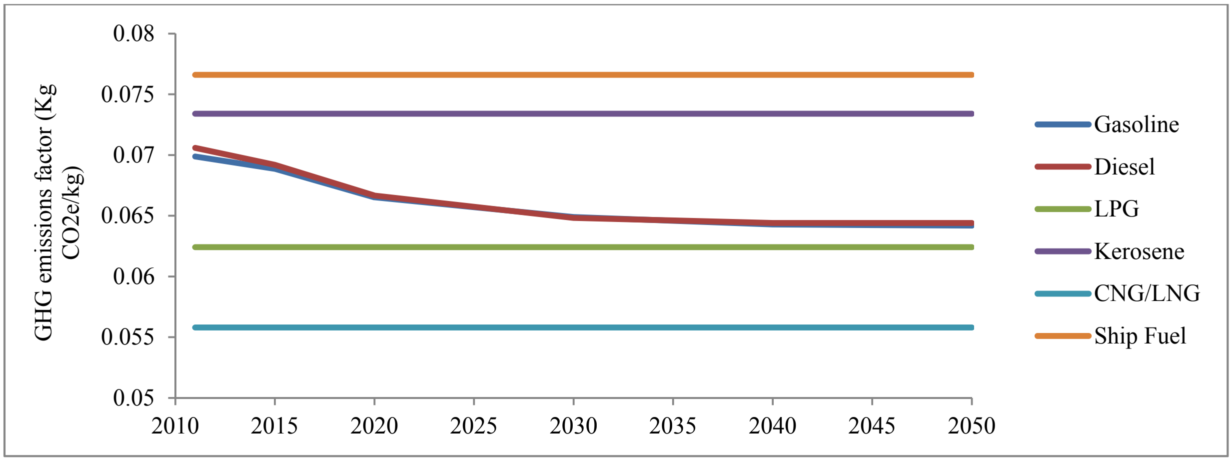
Fuel Composition and Emissions Module

Hybrid vehicles have dual power sources, combining electricity with gasoline or diesel. This model uses a ratio of energy consumption of 70 percent electricity to 30 percent gasoline or diesel. This split follows that used in the SULTAN scenarios. Direct GHG emissions are those produced from the vehicles' exhaust pipe due to combustion of the fuel. As such vehicles running on electricity and hydrogen don't create any direct GHG emissions. The quantity of GHG gasses emitted for each Mega Joule of energy provided is referred to as the emissions factor - this is measured in Kg of CO_2e per Mega Joule ($KgCO_2e/MJ$). The GHG emission factors for each fuel have been provided by the SULTAN BAU dataset.[77] This dataset foresees improvements in the quantity of GHGs emitted over time as shown in Figure A8. The SULTAN

[77] The electricity generation mix has been taken as the EU average mix which is adopted in the SULTAN model, underpinning the Routes to 2050 work. The fuel assumption is incorporated into the model and an indirect emission factor which evolves over time as electricity production becomes cleaner. Emissions factors in kgCO2e/MJ have been modelled as followed: 0.1109 (2011), 0.10258 (2015), 0.09908 (2020), 0.0892 (2025), 0.07939 (2030), 0.06466 (2035), 0.050 (2040), 0.040 (2045), and 0.030 (2050).

dataset actually features slight differences in the emissions factors for fuel used by the different modes, which this model also adopts.

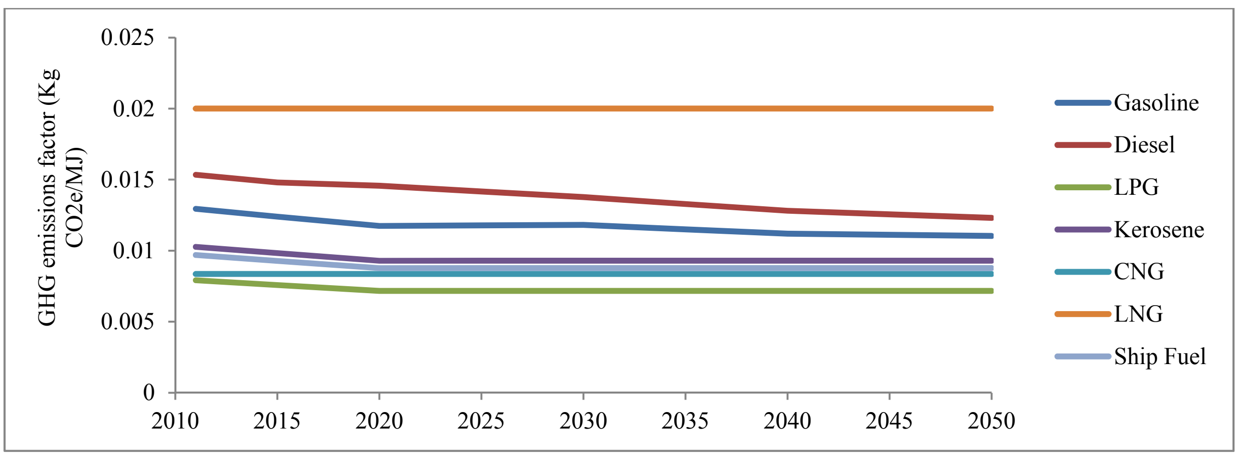
Figure A8: Direct GHG Emission Factor for Each Fuel, to 2050[78]



Source: World Bank

Indirect emissions are those produced in the course of sourcing, refining and transporting the fuel from its source to the vehicle. Again we have referred to the SULTAN BAU dataset for these values. As supposed to direct emissions, all fuels have indirect emissions associated with them, especially electricity and hydrogen power. The baseline trend in indirect emissions to 2050 is presented in Figure A9 and Figure A10.

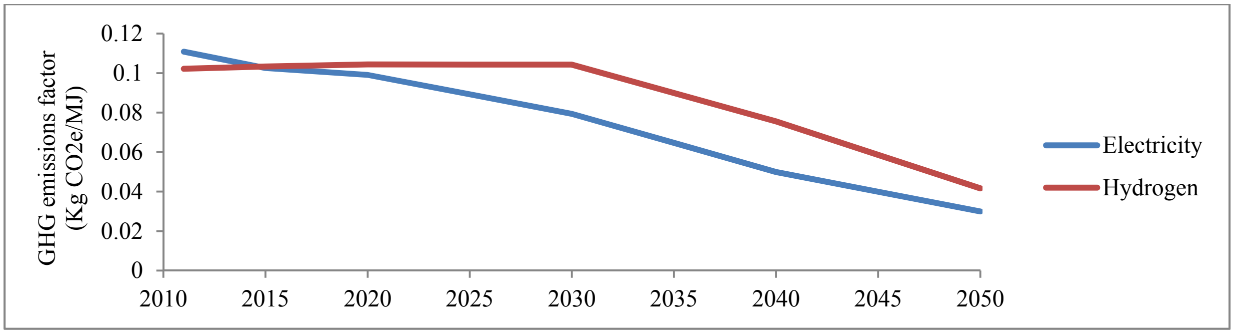
Figure A9: Indirect GHG emissions factor for fossil fuels, to 2050



[78] The direct fuel emission factors were taken from the SULTAN routes to 2050 baseline, based on best estimates of EU-wide fuel emissions factors.

Source: TRANSEPT.

Figure A10: Indirect GHG Emissions Factor for Electricity and Hydrogen Power, to 2050



Source: TRANSEPT.

Biofuel Substitution

Gasoline and diesel sold within the EU contains a proportion of biofuel, at present approximately 3% of gasoline and 5% of diesel is biofuel. Biofuels aim to be carbon natural because the GHG emissions produced when they are burnt are offset by the abstraction of CO_2 from the atmosphere when they are grown. Table A14 presents the projected increase in biofuel as a share of fuel to 2050; this data follows that of the SULTAN BAU scenario. Biofuels are an emerging technology therefore the carbon savings they currently yield are modest at 64% for gasoline and 54% diesel. However as the technology improves we expect these rates to improve into the future, as shown in Table A15. Again this data follows that of the SULTAN BAU scenario.

Table A14: Biofuel Substitution, Measured in % of Energy Substituted, to 2050

Fuel	2011	2015	2020	2025	2030	2035	2040	2045	2050
Gasoline	3.4%	4.8%	8.0%	9.2%	10.3%	10.7%	11.1%	11.2%	11.3%
Diesel	4.8%	6.7%	10.1%	11.4%	12.6%	12.9%	13.2%	13.2%	13.2%

Source: World Bank.

Table A15: Percent of Biofuel Energy that is Carbon Neutral

Fuel	2011	2015	2020	2025	2030	2035	2040	2045	2050
Gasoline	64%	67%	72%	73%	75%	78%	82%	83%	84%
Diesel	54%	65%	69%	74%	79%	84%	88%	90%	92%

Source: World Bank.

Benchmarking BAU Results

The emissions model produces three key outputs which are readily benchmarked against existing studies, these are:

- Transport activity - measured in million passenger-kms (Mpkm) or million ton-kms (Mtkm)

- Final energy demand – in kilo ton of oil equivalent (ktoe)
- GHG emissions - in Mega ton of CO_2 equivalent ($MtCO_2e$)

The first point, transport activity, is a key input to the model in the base year however the projection of how transport activity changes from 2011 to 2050 is an important output which requires to be benchmarked against other studies. The following two publications are useful sources of information to benchmark base year (2011) results:

- EU Energy, Transport and GHG Emissions: Trends to 2050, reference scenario 2013
- Eurostat figures, as presented in the Statistical pocketbook for Transport 2013

There is a considerable degree of cross over between these publications. The statistical pocketbook presents Eurostat data tables in an easily understood manner, and the Trends to 2050 study used Eurostat data for its baseline. Both sources are referred to because neither source is complete for the benchmarking task:

- The Trends to 2050 study provides estimates for final energy demand which are not provided by the statistical pocketbook, and
- The statistical pocketbook provides values for 2011, the base year, whereas Trends to 2050 provides data for 2010.

Transport Activity

As expected levels of transport activity provided by Trends to 2050 match those of Eurostat for the year 2010, with the exception of Inland navigation. The reason for the discrepancy with inland navigation is unknown. The activity levels for car and buses used in our emissions model are lower than Eurostat because we have used values from COPERT were possible. This is also the reason why truck activity is slightly higher. Activity levels for all other modes have been taken from Eurostat or Trends to 2050, so they must match.

Table A16: Comparison of Base Year Transport Activity

Source	Trends to 2050	Statistical Pocketbook 2013 (Eurostat)		Emissions Model
Year provided	2010	2010	2011	2011
Passenger transport demand (Mpkm)				
Cars	78,300	75,000	75,000	70,593
Motorcycles		No data	No data	329
Buses and coaches	12,000	12,000	11,800	9,052
Rail passengers	12,600	12,500	12,200	12,200
Aviation	6,600	No data	No data	6,600
Freight Transport Demand (Mtkm)				
Trucks	25,900	25,890	26,350	28,982
Rail	12,400	12,400	14,700	14,719
Inland navigation	6,900	14,300	11,400	11,409

Note: Trends to 2050 and Statistical pocketbook values are rounded to nearest 100.
Source: World Bank.

Energy Demand

The unit for energy which is used in the emissions model is the Mega Joule (MJ) and Peta Joule (PJ). However Trends to 2050 and the statistical pocketbook use kilo ton of oil equivalent (ktoe). 1 PJ is equal to 41.868 ktoe. The base year energy demand from our emissions model matches well the values provided by Trends to 2050 and Eurostat for road based transit. Our model doesn't match so well the rail and aviation values.

Table A17: Comparison of Base year Energy Demand (ktoe)

Source	Trends to 2050	Statistical Pocketbook 2013 (Eurostat)	Emissions Model
Year provided	2010	2011	2011
Car and motorcycles	2,018	No individual values	2,080
Buses and coaches	137		122
Trucks	2,245		2,098
All road transport	4,400	4,500	4,300
Rail – pax and freight	221	300	120
Aviation	272	200	324
Inland navigation	42	100	88
Total energy demand	4,953	5,200	4,832

Note: Statistical pocketbook values are rounded to nearest 100.
Source: World Bank.

GHG Emissions

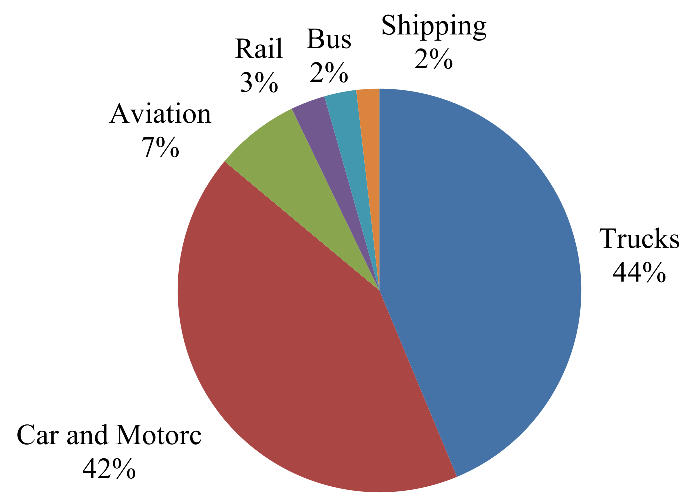
Neither Trends to 2050 nor the Statistical pocketbook provide GHG emission values for our base year, 2011. We have therefore extrapolated our model results backwards from 2011 to 2010 to provide a dataset we can compare. Table A18 shows a close correlation between the results of our emissions model and Eurostat estimations of emissions for 2010 for most modes. Emissions from aviation do appear to be higher in our emissions model. It should be remembered here that TRANSEPT uses Eurostat values for heavy truck activity in place of COPERT values which were twice as high. If we used the COPERT measure of heavy truck activity then this would add on 2.57 $MtCO_2e$.

Table A18: Comparison of Base Year GHG Emissions (MtCO2e)

Source	Trends to 2050	Statistical Pocketbook 2013 (Eurostat)	Emissions Model	
Year provided	2010	2010	2010 (extrapolation)	2011
All road transport	No breakdown provided	14.1	14.0	14.8
Rail – pax and freight		0.4	0.5	0.5
Aviation		0.8	1.1	1.1
Inland navigation		0.3 (incl. 0.1 as international)	0.3	0.3
Total GHG emissions	14.5	15.8	15.9	16.7

Source: World Bank

Figure A11: Modal Share of Transport Related GHG Emissions, 2011



Source: World Bank

We have compared our BAU results to the Trends to 2050 study. This study made projections of transport activity, energy demand and GHG emissions for every European country to 2050.

Transport Activity

The table below compares the projections of transport activity (demand) from our emissions model with Trends to 2050. The projections in our model have been taken from NTM to 2030 and extrapolated thereafter. It should be remembered that we only applied growth in trips to non-urban and highway locations. The key differences in the projections are:

(a) The emissions model forecasts less passenger growth than Trends to 2050, however this is to be expected because our urban trips do not grow (Figure A12).

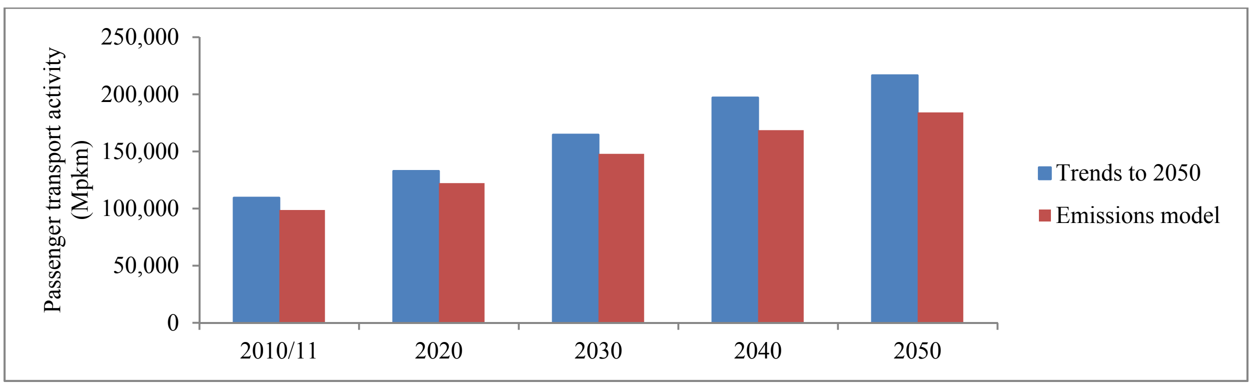
(b) The emissions model forecasts nearly double the growth in freight activity to 2050. This is partly due to the extrapolation of a high rate of growth from 2040 to 2050. The difference in freight activity is presented in Figure A13.

Table A19: Comparison of Transport Activity Projections to 2050

	Trends to 2050						Emissions Model				
Year	**2010**	**2020**	**2030**	**2040**	**2050**		**2011**	**2020**	**2030**	**2040**	**2050**
Passenger transport demand (Mpkm)											
Cars and motorcycles	78,300	91,800	111,100	130,300	139,200		70,922	89,771	114,264	133,863	147,963
Buses	12,000	13,600	15,400	17,100	18,800		9,052	9,240	9,309	9,371	9,426
Rail passengers	12,600	16,400	20,700	25,900	29,000		12,200	15,131	14,417	13,385	12,453
Aviation	6,600	11,100	17,500	23,900	29,600		6,600	8,067	9,860	11,927	14,348
Passenger total	**109,500**	**132,900**	**164,700**	**197,200**	**216,600**		**98,774**	**122,208**	**147,849**	**168,546**	**184,191**
Freight Transport Demand (Mtkm)											
Trucks	25,900	46,700	58,500	65,600	69,000		28,982	46,072	62,242	82,326	105,482
Rail	12,600	16,400	20,700	25,900	29,000		14,719	19,812	27,904	38,778	53,164
Inland navigation	6,900	9,000	10,800	12,100	12,700		11,409	11,964	15,715	20,446	26,344
Freight total	**45,200**	**73,000**	**90,900**	**102,100**	**108,000**		**55,110**	**77,848**	**105,861**	**141,549**	**184,990**

Source: World Bank

Figure A12: Comparison of All Passenger Transport Activity, to 2050



Source: World Bank

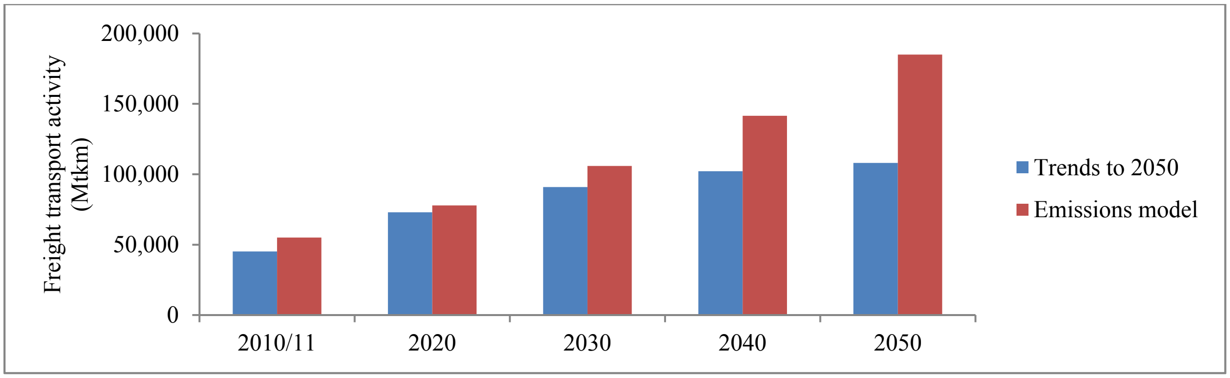
On a mode by mode basis the difference as:

(a) The emissions model forecasts higher growth in car and motorcycle trips, despite no increase in urban trips

(b) The growth in Bus, rail and aviation activity is much smaller in our emissions model compared to Trends to 2050. It could be that Trends to 2050 observes considerable increases in buses and rail use in the urban areas.

(c) All freight modes see considerably more use in our emissions model compared with Trends to 2050.

Figure A13: Comparison of All Freight Transport Activity, to 2050



Source: World Bank

Energy Demand

Projections for energy demand largely match the growth in transport activity described above. The emissions model see less growth in the energy demand for bus, rail, air, but much larger increases for trucks. Overall our emissions model projects a greater increase in energy demand to 2050 compared to Trends 2050, despite holding urban area activity constant.

Table A20: Comparison of Energy Demand Projections, to 2050 (ktoe)

	Trends to 2050						Emissions Model				
Year	2010	2020	2030	2040	2050		2011	2020	2030	2040	2050
Cars and motorcycles	2,018	1,992	1,952	2,096	2,161		2,080	2,007	1,928	2,017	2,117
Buses	137	152	161	171	183		122	121	118	114	109
Trucks	2,245	3,060	3,221	3,338	3,336		2,098	2,864	3,458	4,274	5,171
Rail passenger & freight	221	282	325	346	334		120	148	163	176	194
Aviation	272	418	524	619	733		324	348	376	401	417
Inland navigation	59	76	89	97	99		88	90	112	137	169
Total	4,953	5,980	6,272	6,668	6,846		4,832	5,578	6,154	7,120	8,177

Source: World Bank

GHG Emissions

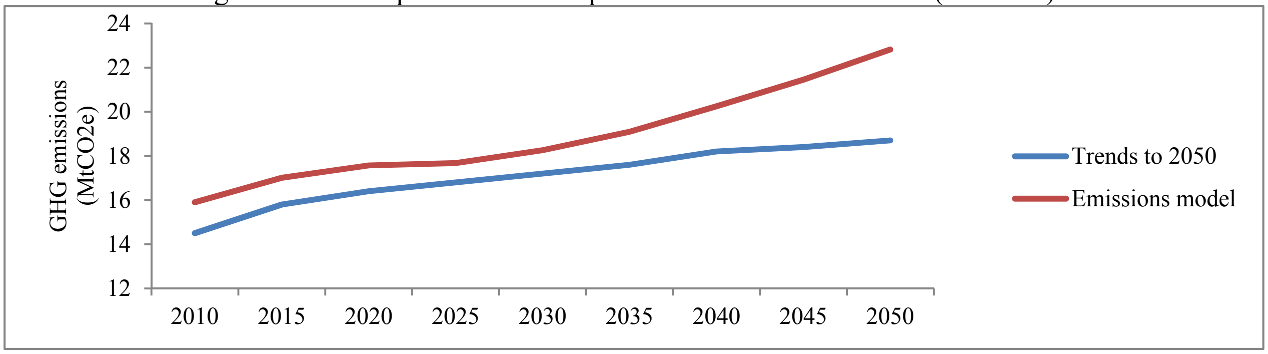
The key output of the Trends to 2050 study is projections of GHG emissions to 2050. It should be noted that the estimation of GHG emissions by Trends to 2050 in 2010 has been revised upwards in the Transport Statistical Pocketbook 2013. This raised the value from 14.5 $MtCO_2e$ to 15.8 $MtCO_2e$. This indicates that the Trends to 2050 model might underestimate emissions overall. Table A10 compares the projections of GHG emissions, which is also presented graphically in Figure A14. Overall our emissions model forecasts a greater growth in GHG emissions to 2050; this is to be expected because our growth in energy demand is higher. The principal driver of higher GHG growth in TRANSEPT is the higher projected vehicle activity levels taken from the National Transport Model. This model represents the planned investment in highway, rail and port infrastructure as well as the underlying drivers of travel demand such as growth in real GDP and car ownership.

Table A21: Comparison of Transport GHG Emissions to 2050 (MtCO2e)

Source	2010	2011	2020	2030	2040	2050
Trends to 2050	14.5		16.4	17.2	18.2	18.7
Emissions model	15.9	16.7	17.6	18.3	20.2	22.8

Source: World Bank

Figure A14: Comparison of Transport GHG emissions to 2050 (MtCO2e)



Source: World Bank.