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MITIGATING THE IMPACT OF THE ROAD SYSTEM ON CLIMATE CHANGE

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ABSTRACT

This national report aims to fulfil the following objectives:

- To communicate the present Carbon Footprint situation for Portugal, giving particular attention to the Road System. Where are we? Where are we going to? How will be the future until Kyoto´s end, in 2012 and how will be the after-2012?
- To understand how the transformations occurred on the National Road Network (NRN) in the last decades and how the consequent increase in the quality of those roads is, or not, responsible for the increase of the Portuguese Carbon Footprint related with mobility.
- To qualitatively identify some of the weaknesses and robustness of the road system regarding Greenhouse Gases Emissions (GHGE) and to allow a better understanding of how roads can better cooperate in the Climate Change mitigation, namely for the pos-Kyoto commitment which will probably mean new Carbon reduction targets of around 20% to 30%.

An ABC analysis was done to policy measures and shows that the mitigation policies and measures (P&M) with real impact are mainly related with fuel and motor efficiency (73% of the predicted reductions). As can be seen, the second group of measures with impact on carbon reduction is the improvement of the PT Services (20,6%). Demand Management and Fleet Renewal groups of P&M are not significant when compared with the overall 22 measures. Of the 22 proposed measures only one is directly related with the road system. This measure implies the reduction of motorways speeds implying also a reduction of the carbon intensity of road transport. The expected target is the reduction of the average speed on the motorways at about 6 km/h. The expected effect in GHGE is reduced (0.6 Mt CO_2e).

The report shows that it is very likely that Portugal can fully realize the Kyoto targets, even using the Portuguese Carbon Fund. A second conclusion must be taken. If a new pos-Kyoto commitment must be assumed, and implies a reduction of 20% or even 30% of GHGE until 2020, then Portugal must have an even more proficient attitude about the subject. This will certainly imply a strong reduction on the GHGE from the transport sector and we must be prepared for that.

1 INTRODUCTION

The national report gives a panoramic view of the Portuguese situation regarding the impact of the transport sector and in particular the road system on climate change. Mitigation measures to face the Portuguese commitments are also presented. The role of the road system, as eventual part of the problem and as part of the solution, is also put in evidence. Some future insights about pos-Kyoto are also identified.

The objectives to fulfill with the national report are three fold:

- To communicate the present Carbon Footprint situation for Portugal, giving particular attention to the Road System. Where are we? Where are we going to? How will be the future until Kyoto´s end, in 2012 and how will be the after-2012?
- To understand how the transformations occurred on the National Road Network (NRN) in the last decades and how the consequent increase in the quality of those roads is, or not, responsible for the increase of the Portuguese Carbon Footprint related with mobility.

- To qualitatively identify some of the weaknesses and robustness of the road system regarding Greenhouse Gases Emissions (GHGE) and to allow a better understanding of how roads can better cooperate in the Climate Change mitigation, namely for the pos-Kyoto commitment which will probably mean new Carbon reduction targets of around 20% to 30%.

The report is divided in five sections. The first section is this introduction. The second one presents an overall, but synthetic, view of the evolution on the last decades of the national road system. The current 'market' organization is also described. The third section presents the description of the Portuguese approach to the GHGE problem. The institutional arrangements and the complying measures for the transport sector are also presented. On section 4 a qualitative analysis of the data presented on sections 2 and 3 is done. Based on that analysis some conclusions can be taken about the main drivers for the current transport and mobility situation, particularly in relation to the significant increase in transport GHGE observed since 1990. Finally, in section five the most relevant conclusions are put into evidence and some future actions related to the next phase of the World commitments are presented.

2 BRIEF DESCRIPTION OF THE ROAD TRANSPORT SECTOR

2.1 The National Road Network

The Portuguese National Road Network is framed by PRN2000 – the National Road Plan approved in 1998 (the third during the XX century). It represents a built extension of around 13 000 km (2008 data). The network is composed of a main network and a complementary one. The main network is formed by the Principal Itineraries (IP's). The complementary network is composed by the Complementary Itineraries (IC's) and the National Roads (EN's). Additionally, the actual National Road Plan created another road category - the Regional Roads (ER's).

Figure 1: Map of the Portuguese National Road Network
Source: InIR, (2009)

Thousands of kilometers of old national roads (now transformed into Municipal Roads, MR) where declassified when the PRN2000 was approved. These roads were transferred to the municipalities. There are still 3 400 km of old national roads not accepted by the

local authorities due to the conditions of the pavement and/or insufficient municipal funds to operate and maintain these roads.

The table gives a good idea of the implementation of PRN2000, which in December 2008 was approximately 85% of the total planned

Table 1: Execution of the National Road Plan (PRN2000)

		Extension in service (Dec 2008)	Total extension planned	% built
Main network	IP	2 197	2 535	87%
Complementary network	IC	1 470	3 358	44%
	EN	4 911	4 911	100%
Subtotal		8 578	10 792	79%
Regional Roads	ER	4 409	4 804	92%
Total		**12 987**	**15 210**	**85%**

Notes: IP – Principal Itinerary, IC - Complementary Itinerary, EN – National Road, ER – Regional Road. Source: InIR, (2009)

The majority of the IP's have motorway characteristics, but there are also motorways which are not IP's. At the beginning of 2008 were in operation 2 613 km of motorways and 690 km more were planned. Since 1990 (303 km of motorways) until 2005 (2.341 km) there was an average annual growth of 14.6% in the motorway extension. After building the last 690 km of motorways Portugal will reach an average density of 35 motorway km/1 000 km^2 of area. This value will be similar to the current figures for Germany, Switzerland or Denmark.

2.2 Model of organization and management of the National Road Network

The organization and management of the Portuguese National Road Network (NRN) has evolved along the last decades to face the new challenges emerging in the road sector. In 2007 the government created a public institute designated Instituto de Infra-estrutura Rodoviária, IP (InIR, which means Institute of Road Infrastructure). Now InIR is the public institute having the main responsibilities for the supervision and regulation of the entire National road sector.

Until 2007 EP - Estradas de Portugal, SA was the public institution historically responsible for the construction, operation and maintenance of the national road (except, since the seventies, in the case of motorway concessions that were emerging). Simultaneously the EP also had some regulatory power over private concessions. This was the organizational model for decades (excluding some changes essayed in the nineties which were abandoned).

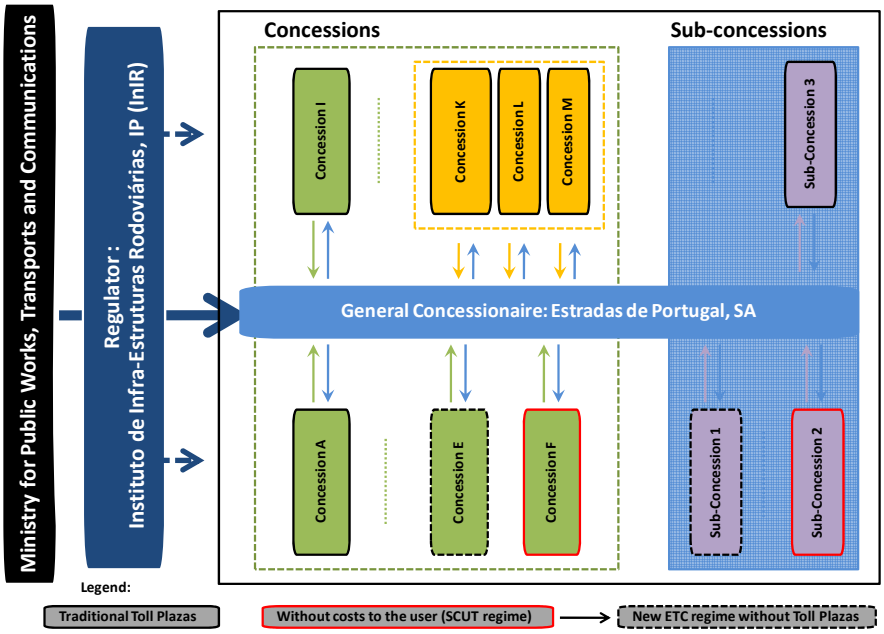

Figure 2: Qualitative model of the National Road Network

Since the change that occurred in 2007 in the regulatory framework, the EP was transformed into a private company with all of its capital held by the State. Now the EP is the general concessionaire of the majority of the NRN. It is a special case with a concession period of 75 years. The EP also has specific functions in the relationship between the regulator (InIR) and the other concessions. These are differentiated according to their relational model. During the nineties the concession contracts were made directly with the State and are known as the "concessions". Currently, most of the new concessions are contracted by the EP. The contracts of these concessions are contracts of sub-concession of the EP network, not directly involving the state. These contracts are known as the “sub-concessions”. However, the EP in the future will always have intermediary functions between all the concessionaires and the regulator (InIR). The qualitative framework is shown in Figure 2.

2.3 The Concessions

The road concessions began in the seventies with the granting of 390 km to BRISA, the first motorway concession in Portugal. During the nineties two other concessions were granted: the Tagus River Crossing (the two bridges) and the “Concessão Oeste”, with an overall length of 200 km. After the approval of the plan PRN200 in 1998, there was a huge boom in building new motorways. In 1999 the Portuguese government has launched seven new motorway concessions without costs for users. These motorways have a shadow toll that is paid by the State to the concessionaire, through the government budget. This shadow toll regime is called the SCUT regime. The SCUT motorways represent an extension on 928 km and one third of the total length of road concessions at date. Until 2007 four more concessions where launched: “Litoral Centro”, “Norte”, “Douro Litoral” and “Grande Lisboa”. A complete list of the three types of existing concessions is included.

Table 2: Road concessions – current situation

Date of first Contract	Name	Type	Situation	Total km
1972	Brisa	Concession	Opened	1 092
1994	Travessias do Tejo	Concession	Opened	24
1998	Oeste	Concession	Opened	170
1999	SCUT Beira Interior	Concession	Opened	178
1999	Norte	Concession	Opened	170
2000	SCUT Interior Norte	SCUT Concession	Opened	156
2000	SCUT Costa de Prata	SCUT Concession	Opened	105
2000	SCUT Algarve	SCUT Concession	Opened	129
2001	SCUT Beiras Litoral e Alta	SCUT Concession	Opened	173
2001	SCUT do Norte Litoral	SCUT Concession	Opened	116
2002	SCUT Grande Porto	SCUT Concession	Opened	72
2004	Litoral Centro	Concession	Opened	93
2007	Douro Litoral	Concession	Opened	129
2007	Grande Lisboa	Concession	Opened	25
2009	AE Transmontana	EP Sub-concession	Awarded	186
2008	Baixo Alentejo	EP Sub-concession	Awarded	344
2008	Douro Interior	EP Sub-concession	Awarded	272
2008	Túnel do Marão	Concession	Awarded	30
2009	Algarve Litoral	EP Sub-concession	Awarded	273
2009	Baixo Tejo	EP Sub-concession	Awarded	68
2009	Litoral Oeste	EP Sub-concession	Awarded	109
2010	Pinhal Interior	EP Sub-concession	Awarded	369
-	AE Centro	EP Sub-concession	Biding	567
-	Alto Alentejo	EP Sub-concession	To be launched	139
Until 2007	**Several**	**Concessions**	**Opened**	**1 881**
2000-04	**Several**	**SCUT Concession**	**Opened**	**751**
2009-10	**Several**	**EP Sub-concessions**	**Various**	**2 327**
		TOTAL		**4 989**

Source: authors, based on InIR, (2009)

2.4 The tolling system

Only the national motorways and the two Tagus river bridges are tolled. Expressways (like some IC's) and other high quality national roads are not tolled. Each concession has its own tolling regime defined under the initial contractual conditions and upgraded yearly on the base of the domestic price index. The structure of tariffs set for the concessions is similar and set to achieve the goals of cost recovery for infrastructure

Via Verde, developed by BRISA is the first Portuguese electronic toll collection system (ETC). In 1995, Portugal became the first country to apply a single, universal system to all tolls in the country (the Via Verde). The system can also be used in parking facilities and gas stations. Via Verde was adopted by all road concessionaires and was used extensively by all users as the unique available solution, until 2010. At the beginning of 2010 there were almost 2.4 million ETC subscribers. This represents the biggest coverage rate in Europe, regarding either the population (22%), or vehicles (near 50%). In 2010 some SCUT motorways (with shadow toll) began to be transformed in toll motorways. Because these motorways don't have toll plazas, users are required to purchase an on-board unit (OBU) to pay the electronic toll and continue traveling on the motorway. It is expected that the majority of the SCUT motorways will be converted in future into motorways with electronic toll and without physical facilities for toll collection.

Recently, the law was changed and in May 2009 the government formed the SIEV. It is the public company that holds the concession to operate and manage the new system for the electronic identification of vehicles in Portugal. The role of Via Verde has changed from a natural monopoly to be a toll collection operator, subject to competiveness. Due to the

recent changes there is already a second authorized entity, which is CTT, the Portuguese mail company that is already operating in the motorways having the new electronic toll system.

From 2010 on, there will be two types of electronic devices: the electronic detection devices (only Via Verde for the moment) and the new device for electronic identification (also known as the “electronic plate”). Both systems are interoperable.

Currently, there are four different kinds of toll collection regimes:

- No tolling at all (some motorway stretches near cities, and with other specificities);
- Traditional tolling system with toll plazas and the concessionaire collecting directly, or using an electronic device (OBU) from Via Verde.
- Shadow tolls without costs for the users (SCUT): Motorways without toll plazas - the concessionaire receives a fee from the State for each passing vehicle and/or, sometimes, a payment for availability (sub-concessions, via the EP general concessionaire).
- The new electronic tolling system without toll plazas and with several electronic toll collection concessionaires (ETCC) playing in the market (at the moment, only Via Verde and CTT). This is the new system applied to the ex-SCUT motorways that are being transformed in tolled motorways paid by the users – the system began to operate on the 1st November 2010.

3 PORTUGUESE CARBON FOOTPRINT

Portugal as Member-Sate of the European Union (EU) is committed within all the global agreements in which the Union is involved and leading part. This is the case of Global Warming. The major target of these agreements is the mitigation of all the physic, economic and social impacts motivated by the Greenhouse Gases Emissions (GHGE), of which, Carbon is undoubtedly the most known. Scientists have predicted those effects long time ago as a side effect of the exponential increase of the GHGE produced in the past two centuries. Finally, at the end of the last century the World has found the necessary conditions for a global (and political) approach of the problem. In 2005, and after a very long path of discussions and disagreements, finally the Kyoto Protocol entered into force (on February 16, 2005).

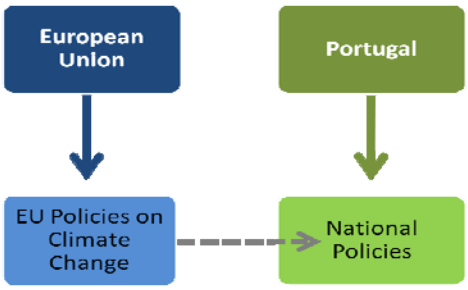

Figure 3: Climate change policy framework

The world has finally reached a global commitment to reducing GHGE into the atmosphere, especially the most common gas, CO_2. The sensible issue of the Protocol is setting binding targets for the 37 industrialized countries and the European Community for reducing the GHGE over the period of 2008-2012. This represents a new paradigm for the World, which implies several economic and political risks, but that is also a global opportunity. Not only represents a sustainability opportunity, but also an economic and

technologic window at global scale which might be very important for the XXI Century – the century where fossil energy will decline and energy is needed to be reinvented!

Kyoto's represents for the industrialized countries a global commitment of five per cent reduction of GHGE in the period of 2008-2012, having 1990 emissions as baseline. In particular, represents to the EU a challenger commitment of an eight per cent reduction on the same period, regarding also 1990 values.

European countries have different industrialization levels and represent different shares of the GHGE at EU level. Taking into account that different 'historical responsibilities', some European countries like Germany or France face important reductions of the GHGE for the 2008-2012 period. Other countries, like Portugal, which in 1990 had still a comparatively low motorization and were not as industrialized as other EU countries, also had the chance to increase their share of GHGE up to 1990 levels. Portugal could increase its share of GHGE by 27%, compared to 1990 levels.

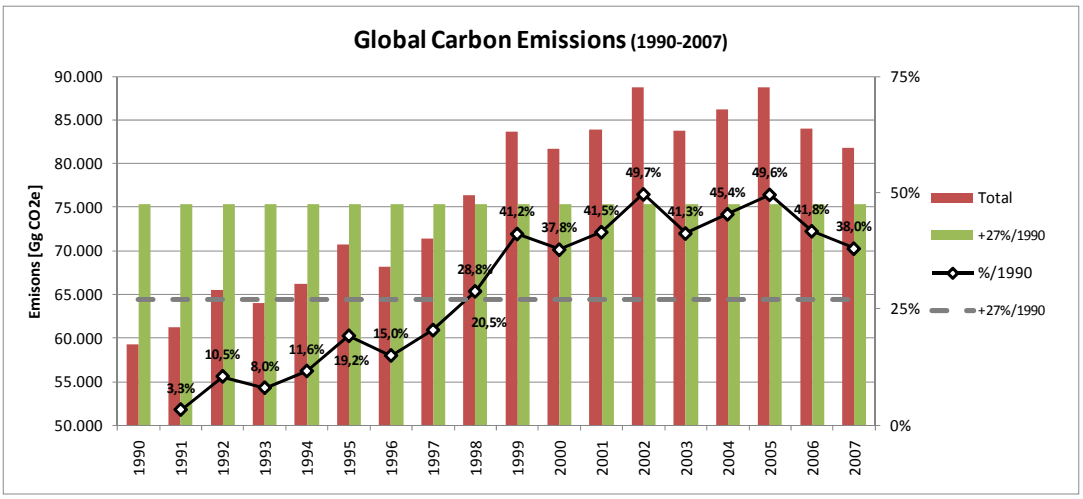

Figure 4: Evolution of the Portuguese GHG emissions in pre-Kyoto period
Source: authors, adapted from "CumprirQuioto.pt", (2010a).

In 1998, the year after the adoption of the Kyoto Protocol (on December 11, 1997), the Portuguese GHGE were already 28.8% above 1990 baseline (the grey dot line in the picture marks Portugal target +27%/1990). On the following years emissions grow further (in 1999 jumped to 41.2%) and in 2010 the value is still 33.6% above the base line. The whole evolution of the Portuguese GHGE from 1990 up to 2007 (until just before the Kyoto's adoption) is depicted in Figure 4.

In spite of the reductions achieved since 2005, the year that the Protocol entered into force (on February 16) Portugal is still producing more GHGE than it should. Since that date (and even earlier), the Portuguese Environmental Agency (APA) have been preparing the ground and taking measures to mitigate and reduce the overall GHGE. The policy strategy, as shown in Figure 5, is supported by three major policy tools.

The first one is the National Climate Change Programme (PNAC). This programme is in continuity with the European Climate Change Programme and all the major mitigation measures taken in all the responsible sectors of activity. The other tools correspond to the national implementation of other Kyoto mechanisms. The second applies only to major fixed Carbon sources (heavy industry and similar). The third tool, the Portuguese Carbon Fund (FPC), began operating in 2006 and is a trading mechanism allowing the investment

on national and external projects which represent reductions on GHGE. These reductions can be incorporated in the Portuguese overall balance equation of CO_2e. The creation of the FPC has already implied an investment of 138.64 M€ during 2008 and 2009 to help reducing the CO_2e deficit.

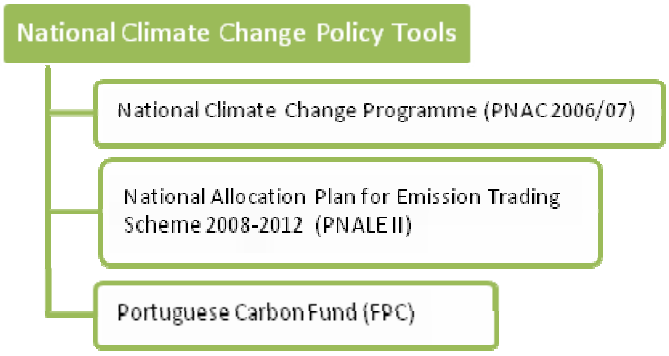

Figure 5: Portuguese Climate Change policy tools

Kyoto Protocol implies for 2008-2012 a reduction of the GHG overall emissions to 1990 +27%, meaning that Portugal is allowed to emit in this period of five years a total of 381.95 Mt CO_2e. This represents an average value of 76.39 MtCO_2e per year. The last up to date figures are for 2008, published in the "2010 Assessment Report on Climate Change Policies in Portugal" (values in the first column, from “CumprirQuioto.pt”, 2010). The values for 2009-2012 represent predictions based on the evolution of macroeconomic variables like: the GDP, demography, technologic standards, predicted evolutions in the energy field, and so.

As can be seen the assessment of the whole period implies a total deviation of 12.07 M€, corresponding to a percentage of 3.4% from Kyoto’s target. Part of that deviation has already been covered by the FPC in 2009 and 2010 (5.27 M€). The rest may be recovered by the effective reductions to be achieved between 2009 and 2012, and/or using the carbon fund (FPC).

Table 3: Compliance with the Kyoto Protocol (Assessment Framework)

	Year					
	2008[(1)]	2009	2010	2011	2012	Σ2008-12
Assigned Amount	76.39	76.39	76.39	76.39	76.39	381.95
Estimated National Emissions of GHG	78.38	79.14	79.14	79.14	79.14	394.92
Deviation from the Assigned Amount - total	1.99	2.75	2.75	2.75	2.75	12.97
- %	2.61%	3.59%	3.59%	3.59%	3.59%	3.4
Portuguese Carbon Fund: units of compliance received	0	2.29	2.98	0	0	5.27

Notes: all values (except percentage) in Mt CO_2e.

(1) Estimations based on the Portuguese National Inventory Report on Greenhouse Gases, 1990-2008 (Costa Pereira et al., 2010). The other estimates use probabilistic projection scenarios. Source: “CumprirQuioto.pt”, 2010.

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Knowing that the transport sector has substantial responsibilities in the problem we must analyse in detail the behaviour of the sector and, in particular, of the road system. We will try to find answer to the following questions:

- What is the GHGE quota of the transport sector in Portugal?
- How is it evolving?
- How are the 'Roads' contributing to the Global Warming problem/solutions?"
- Can this contribution be improved? And How? What directions to follow?

The transport sector stands for approximately one quarter of GHGE in Portugal - precisely 24.6% (2008 data reported in 2010). The evolution of these emissions was indeed impressive, almost doubling from 1990 to 2000. Fortunately, as can be seen, in the last decade there was stabilization with tendency to a smooth reducing.

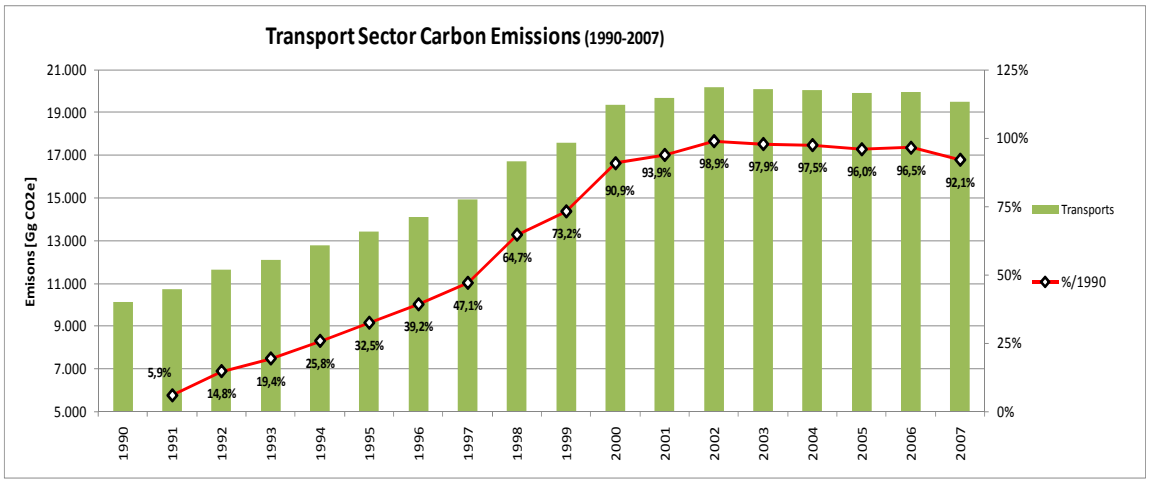


Figure 6: Evolution of the transport sector GHGE in the pre-Kyoto period
Source: authors, adapted from "CumprirQuioto.pt", (2010a)

According to the Portuguese National Inventory Report on Greenhouse Gases for the period of 1990-2008 (Costa Pereira et al., 2010, pg 3-109) the GHGE exhaust of the road system were estimated at about 18.6 Mt CO_2e in 2008. This represents an increase of 97.6% when compared with the 9.4 Mt CO_2e, estimated for 1990. The share of the road system currently represents approximately 95% of the GHGE of transports, which is indeed a key indicator to have in attention.

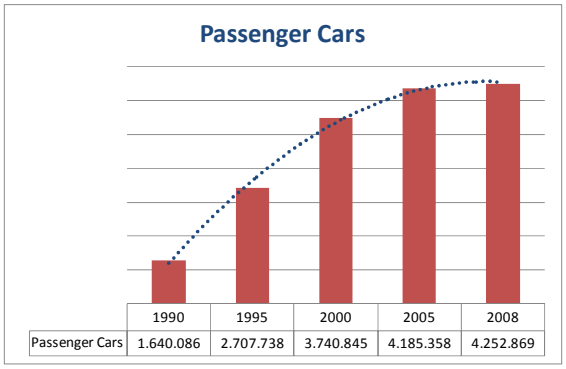
3.1 Mitigation in the transport sector

In face of the substantial impact of GHGE from the transport sector, in particular from the road system, we must understand the causes and circumstances and define mitigation measures and tools for the immediate and the long run.

Portugal had in the last two decades a specific development path which somehow is different from other major European countries. The country had to make a very important effort to recover from its lower patterns of development and achieve levels similar to those of Europe. This implied the construction of hundreds kilometers (started in the '90s and still not completed) of new high quality roads (motorways and trunk roads – IP's and IC's). This way the country benefited from a wide shortening of regional travel time and a substantial improve in accessibilities, both regional and urban.

The simultaneous development on road accessibilities together with the generalized improvement of the purchasing power of families that occurred in the '90s implied an

explosion on private cars acquisition and consequently a huge increase in mobility patterns. This growth led to a motorization rate of 415 veh/1 000hab in 2008 (IMTT, 2007).



	1990	1995	2000	2005	2008
Passenger Cars	1.640.086	2.707.738	3.740.845	4.185.358	4.252.869

Figure 7: Growth of passenger cars fleet
Source: authors based on Costa Pereira et al., (2010, pg 3-123) data.

There is a strong tendency for car purchasing stabilization. We can take the risk to predict a round figure for motorization of about 450 veh/1 000hab for the near years. But one must not neglect that the European average level of motorization is higher and is not reducing. At medium term it is predictable that the Portuguese motorization rate will tend for figures around 550 or even 600 veh/1 000hab.

It is uncertain whether road mobility will grow in the same way as motorization or if it will decline. This will depend on the efficiency of accessibility and mobility patterns in the future. In particularly, it will depend on the increase of quality for public transport and/or also on the shifting in land use. The last change should mean at least a strong reduction in average travel distances in urban areas - a new paradigm of green mobility is actually necessary for the decade to come.

The cross-problem of recovering the structural delays described and the simultaneous need for strong commitments in relation to GHGE implied a reality in which the share of the road system GHGE has grown substantially in the past and currently represents one of the most challenger environmental responsibilities for Portugal and also one of the most important commitments for the transport sector.

Fortunately, we can observe that the situation has become stable in the last years and is now beginning to overturn. Several issues help to promote changes, including those with an overall negative impact, like the last international crisis. But we must highlight the effective role of the several national authorities and institutions responsible for the transport and energy sectors in Portugal. The Portuguese government promoted the National Climate Change Programme lead by the Portuguese Environmental Agency (a public agency), which was first implemented on 2004 and have already two upgrades (PNAC 2006/07). This programme is a central policy tool on the mitigation of climate change and implied already a significant reduction on emissions volume (as Figures 6 and 8 shows).

Many public and private actors participate actively in the development of several sectorial measures. A short list with the number of transport related measures divided by five categories is presented in Table 4. The proposed measures are differentiated into two groups. Those included in the Reference Scenario (MRt) (adopted in 2005) and the additional measures (MAt) defined during the 2006 revision of the PNAC package

(including one additional measure in 2007). These measures were provided to reinforce the guaranties that the GHGE reduction targets are properly met.

Table 4: Categorization of transport sector Policies & Measures

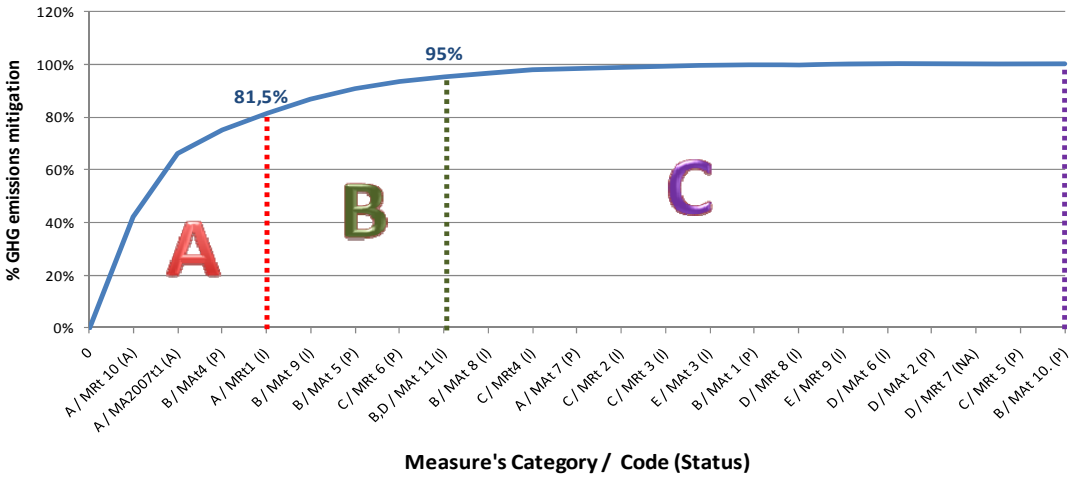
Category	Description	Number of P&M	Expected annual average GHG reduction (Kt CO_2e/year)	Weight of PNAC P&M for Transports
A	Motor and fuel improvements	4	1 997	73.1%
B	PT Services supply	6.5	563	20.6%
C	PT Infrastructure supply	5	136	5.0%
D	Vehicle/Fleet renewal	4.5	26	0.9%
E	Demand Management	2	8	0.3%

Notes: One of the measures implies both extra service supply and fleet renewal. It was divided by half between categories A and D. Source: authors, based on APA, (2010).

A total of 22 P&M were designed for mitigation in transports, allowing a predicted average annual reduction of at least 2 730 Kt CO_2e/year (at least, because 3 measures are not yet quantified).

As can be observed in Table 4, “Motor and fuel improvements” have a preponderant weight on the overall expected reductions due to transport GHGE mitigation. On the other extreme, “Vehicle/Fleet renewal” and “Demand Management” measures have a near zero impact.

To have a better understanding of the relevance of the 22 measures, an ABC analysis was conducted. The measures representing the first 80% and 95% were ordered and identified. The measures are also identified by their categories (A, B, C, D and E in Table 4) and by a status label regarding implementation ((A), (I), (P), (NA) – see Figure 8 notes) - there are still several measures not implemented.



Notes: status: A = adopted, I = implemented, P = planned and NA = info not available

Figure 8: ABC analysis of the Policies and Measures proposed

Source: authors, based on APA, (2010).

The ‘main’ A group is composed of four measures, from which three fall in the “Motor and fuel improvements” category and are already adopted (A) or implemented (I). The third

measure in the ranking depends on the improvement of public transport services in the Metropolitan Area of Lisbon and is not implemented yet.

The complete list of the major A+B Transport P&M is presented in Table 5. The full implementation of all transport P&M would have a strong impact on the reduction of GHGE. The effective reduction of 2 327.6 Kt CO_2e/year is already very significant. Hopefully, this reduction will allow a real decrease in the results of the latest scenarios produced by APA (in 2007) for 2010, which would imply a growth of transports emissions in 110% regarding 1990.

A detailed analysis of measure by category allows a better understanding of the actual potential of each one. Category A, related with motor efficiency and fuels composition was indeed the one with the upmost effectiveness. But this fact can also entail the loss of future gains for this category, because technologies have evolutionary timings and limits. On the other hand, in spite of the real difficulty of having gains in fields like “Demand Management”, it is also truth that there is still a strong potential for reduction in this category. Certainly, this will imply new and innovative policies (eventually within the framework of a new mobility paradigm), which have to allow substantial changes on demand behavior.

As described, Portugal has a very good chance to meet Kyoto commitments for the period between 2008 and 2012. The authorities made several efforts in the last decade. There is a whole framework policy, institutions and measures specifically appointed to the compliance of the targets accepted. The less promising economic period the nation is suffering will also contribute to lower GHGE. So, we can preview with some trust that the deviation of 2% or 3% still subsisting in predictions certainly will be absorbed by the Portuguese Carbon Fund (PCF) and the use of the mechanisms predicted by the Kyoto Protocol.

Table 5: Major A+B Policies & Measures for the transport sector

Designation of P&M	Objective and/or affected activity	GHG	Type of instrument	Imple-mentation Status	Imple-menting Bodies	Expected annual GHG reduction (Kt CO_2e/year)
MRt10. Biofuels Directive (Replaced by MA2007t1)	Reduction in the consumption of fuels responsible for the emission of GHG through the promotion of the use of biofuels in the transport sub-sector (2%-2005; 5.75%-2010)	CO2 CH4 N2O	Regulatory and Economic (concession of subsidies to investment and proper tariffs for biofuels)	Adopted	MEID	1 149
(1)MA2007t1 replacing MRt10. Biofuels Directive	Biofuels Directive– increase of the 5.75% goal to 10% in 2010 regarding biofuels incorporation tax in the road fuels	CO2 CH4 N2O	Economic (concession of subsidies to investment and proper tariffs for biofuels)	Adopted	MEID	655
MAt4. Metropolitan Authority of Lisbon Transports	Modal transfer of 5% (pkm/pkm) by 2010	CO2 CH4 N2O	Regulatory and Economic (change in the supply of public transport)	Planed	MOPTC	245.4
MRt1. Auto-Oil Program: Monitoring of the Agre-ement with Automobile Manufacturers Associations	Reduction of the carbon intensity of light passenger vehicles transport, with increasingly restrictive consumption (and CO2 emissions) standards, to reach the 120 g CO2e/km target by 2010	CO2 CH4 N2O	Voluntary Agreement	Imple-mented	MFAP	175
MAt9. Motorways of the Sea	Transfer of 20% of international road freight traffic to maritime transport	CO2 CH4 N2O	Economic (change in the supply of freight transport)	Imple-mented	MOPTC	150
MAt5. Metropolitan Authority of Oporto Transports	Modal transfer of 5% (pkm/pkm) by 2010	CO2 CH4 N2O	Regulatory and Economic (change in the supply of public transport)	Planed	MOPTC	101.5
MRt6. Improve services provided by CP (reduction in travel time) between Lisbon-Oporto; Lisbon-Castelo Branco; Lisbon-Algarve	Promotion of modal transfer, and consequent reduction in carbon intensity of the global transport activity through supply changes (reduction in travel time) between Lisbon-Oporto; Lisbon-Castelo Branco and Lisbon-Algarve, and consequent increase in the competitiveness of the railway system	CO2 CH4 N2O	Economic (increase in the supply of public transport)	Planed	MOPTC	78
MAt11. Restructuring of supply of CP (national railway) service	Renovation of trains and changes at the supply level (schedules and frequency of services, new connections/services, etc.) so as to capture 261x106 tkm of the road transport mode.	CO2 CH4 N2O	Economic	Imple-mented	MOPTC	44.4

Notes: (1) – the value of 655 kt CO2e/year is additional to the value achieved with measure MRt10. The measure Mat11 is divided between categories B and D. Source: APA, (2010).

The great challenge is the Future, namely the pos-2012 commitments, already being negotiated for the second period of reduction of the GHGE. The numbers 'on the table' appoint to reductions between 20 and 30 percent. This possibly means, for Portugal, the return to 1990 emission levels. The challenge to meet this objective will indeed represent a unique national effort for all.

The first question arising is: to what extend will motor and fuel improvements allow further emission reductions? Can the reduction patterns achieved with Kyoto commitments be repeated again? What will be the second and third best alternatives to improve reductions? How can emerging technologies help improving those reductions? What will be the role of land use and how it will link to transport GHGE (and potential reductions)? Which are the legal and juridical aspects related with supply and demand needed to allow more effective Carbon gains?

The answers to all these questions are fundamental to prepare the next stage related to the Portuguese transport sector and in particular the road system for the next generation of the Carbon mitigation world commitments.

4 ROAD USER COSTS AND THE FUTURE OPTIMIZATION OF GHGE

Before analyze the potential solutions for the optimization of the road GHGE we must quantify the overall economic impact of Global Warming and it relative weight in face of the other externalities and social costs and benefits for the society.

4.1 Current Social Costs

A brief presentation of the current (2008 data) social costs and benefits computed for the Portuguese road system will be done. These values were calculated within the framework of CNIR, the new national accounting model. CNIR was developed by an external consultancy for InIR and is prepared to address all external and internal accounting balances and to produce analysis of the overall financial and costing aspects regarding road assets and agents (users, operators and other). CNIR account was designed to help InIR to answer all the major questions related with costs, regulation and with the financial transferences between all the relevant agents, including the analysis of the external costs and the quantification of costs and benefits for the society.

The CNIR account was built using a bottom-up approach. Table 6 shows the costs and benefits generated by the road system on the rest of the society (excluding, as acting part, the agents of the road system). By 'road system' we mean all the motorways, highways and in general all the roads in the National Road Network (NRN), which is the network regulated by InIR. The costs and benefits related to municipal roads and the urban network are excluded. We must also emphasize that the figures (costs and benefits) represent accounting flows and there is no direct cause/effect between them.

The first conclusion to be taken is that at 2008 there was a benefit/cost ratio of 2.31. In other words, for each 100 Euros of externalities produced by the road users (including accidents and subsidies), they paid (the group of the road users) a compensation of 231 Euros also. From this financial return, 132 Euros were paid only with the road taxes and the rest was paid with VAT and the general taxes.

Table 6: Costs and Benefits generated by the road system on the rest of the society

Costs (10^6€)			Benefits (10^6€)		
Description	**Value**	**Weight**	**Description**	**Value**	**Weight**
Environmental Costs	**1 220**		**Value Added Tax (VAT)**	**1 770**	
Air Pollution	427		VAT on Tolls	148	
• LDV	231	22.6%	• LDV	125	
• HDV	197		• HDV	23	40.5%
Global Warming	502		VAT on Operational Costs (fuel, ...)	918	
• LDV	311	26.5%	VAT on Fuel taxes (ISP, ISV and CSR)	613	
• HDV	191		VAT on other services	91	
Noise	291				
• LDV	140	15.4%	**Road Taxes**	**2 488**	
• HDV	151		ISP (tax on fuel)	1 773	
			ISV (tax on vehicle acquisition)	642	56.9%
Accidents	**663**		IUC (circulation tax)	73	
• Slight injuries	122				
• Serious injuries	136	35.1%	**General Taxes**	**115**	
• Fatalities	405		IRC (tax on corporate income)	103	2.6%
			Various taxes	12	
Subsidies and other payments	**7**	0.4%			
Total Costs for the Society	**1 891**	**100%**	**Total Benefits for the Society**	**4 372**	**100%**

Notes: LDV – Light Duty Vehicles, HDV – Heavy Duty Vehicles.
All values are in resource costs. Costs and benefits in million Euros (M€), at 2008 prices
Source: authors, adapted from CNIR (InIR, 2010).

Additionally, and it is not presented in the table, road users pay a fuel tax called CSR. This is an earmarking tax from which 99% goes to the budget of EP, the general road concessionaire, to face all building and maintenance expenses from the NRN network. The global value of CSR for 2008 was 576.6 M€.

The Portuguese road system (NRN) generated a Global Warming cost of 502 M€ over the society. This represented 26.5% of the overall costs incurred. However, in accounting terms, we can verify that the GHGE from the road system are already internalized by the fuel tax (which is the correct mechanism). So we can't say that the road's Carbon is in fact an externality, because it is already internalized in accounting terms. In spite of that, and taking in attention the decisive role of the road system, it can continue contributing to the reduction of all externalities and specifically the GHGE.

4.2 Qualitative analysis of the impacts of the road system over GHGE

The quantification of costs and benefits generated by the road system on the rest of the society and the overall social costs balance can give valuable insights about how to solve the problems related with the externalities. But, it is possible to go further and try to understand to what extend is the road system responsible for the present situation. The understanding of the present responsibilities allows having a better understanding of what directions to follow in the future.

In other words: to what extension did the continuous development of the National Road Network, accordingly to the PRN2000, and consequently how the construction of hundreds kilometers of new motorways aggravate or alleviate the GHGE? Another question can also be added to the first one. To what extension do the increase in motorization and the spread of urban mobility contribute to GHGE? Or, by the end, which share of the problem is up to each one?

Is out of the scope of this report to produce an extensive analysis and give immediate answers of these complex questions. But, as can be found on the beginning of the report (section two), the major impact of road and motorways improvements occurred only after 1998, when the implementation of the PRN2000 began. During that period (from 1998 on, as Figure 4 shows) the GHGE from transports began a stabile period, until 2007, and after that, hopefully, began to decrease (in the last years).

On the other hand, Figure 7 shows the growth of passenger cars fleet in Portugal. It is known that vehicle fleets in general have grown substantially and passenger cars have grown sharply, more than doubling (+130 %) in the nineties. On contrary, on the decade 2000-2010 the growth has been reduced substantially (13% until 2008 for passenger cars and less than 10% for the global vehicle fleet).

The increase of GHGE from the transport sector was about 73% for the '90s and by the contrary, the values never grew more than 4% (comparing with 2000) for the decade of 2000-2010. In 2007 transports were responsible for the emissions of 19 500 Mt CO_2e, almost the same as in 2000 (19 370 Mt CO_2e). For the whole period, road transport represented more or less the same, very substantial, value of approximately 95%, or, in absolute values, about 18 720 Mt CO_2e in 2007 (APA, 2010).

Finally, we note that there is a strong adherence between the growth of motorization in the nineties and the increase of GHGE (73%), even if in the nineties the construction of new motorways and concessions was reduced only to 200 km (including the new bridge over the Tagus River).

On the contrary, on the period between 2000 and 2010 there were general improvements (in IC's and EN's) and a huge increase in motorways construction, with concessions to grow throughout the country. This includes almost 1 000 km of motorways without costs for the users (in the SCUT regime). Remarkably, there was no evident growth of GHGE, in spite of the small growth of the motorization and the huge growth of the extension and quality of the road network during that period.

4.3 The future optimization of GHGE from the Road

Using CNIR results we can assume the road system production of about 44 400 10^6 vkm for LDV and 7 050 10^6 vkm for HDV vehicles, summing a total of 51 450 10^6 vkm produced in 2008. The estimates produced by Azevedo (2008) for the national road mobility (including all urban roads) vary between 86 500 10^6 vkm and 91 000 10^6 vkm in 2006. Assuming the higher estimate and a growing rate of 2% per year (from 2006 to 2008) we can compare the results obtained in CNIR for the National Road Network with Azevedo's disaggregated model for the whole road mobility.

First, we have to estimate the general production for 2008. The value is about 95 000 10^6 vkm (based on Azevedo's results). This means the vkm production on the NRN road system (in CNIR accounts) represents about 54% of the overall mobility. Assuming the rough assumption that the GHGE rates are uniformly distributed over urban and interurban traffic, this means one can allocate 10 140 Mt CO_2e to the national road system. This implies an average equivalent vehicle with an emission rate of 197 gCO_2e/vkm for the NRN network.

Considering for Portugal an average Carbon market price with a value of 14.3 €/tCO_2e ("SENDE – The Exchange of CO2", 2010) and using the emission rate above we obtain a

market price of 2.93 €/1000normalized-vkm. This value is 3.3 times lower the average resource costs for Global Warming used for CNIR (InIR, 2010 based on own computations for LDV and on Maibach M. et al., 2008 for HDV). The figures have a different nature. The first is a price and represents the market price for mitigation (at a specific scale for Kyoto's consumption quotas) and the second represents the 'resource cost' of the scarce resource, including all future costs.

While this 'price' situation exists the incentives for the reduction of traveled distances are not attractive. It is more profitable for the State to continue charging the fuel tax and eventually to manage a partially reimburse of it using, for instances, the Portuguese Carbon Fund. To the user the situation is neutral because he doesn't have s an active role on the Carbon transactions.

The future world commitments of the pos-Kyoto will indeed make much more pressure over the international Carbon markets and prices will grow up in the next years (as also petroleum will). Having that scenario as framework it is probable that carbon market prices will get near the real resource costs. When that will happen then the road sector must be prepared to take more efficient measures. The starting point can be the definition of the right pricing signals given to the agents of the system. The Portuguese government began recently (on 2007) some changes related with the ISV tax (the vehicle acquisition tax). Further the German example of taxing HDV accordingly to Euro fuel efficiency is also a very good example and a good starting point.

5 CONCLUSIONS AND FUTURE PERSPECTIVES

As the numbers show, the development of road facilities is not on the current critical path for the demotion of GHGE from the transport system. On the other hand, the users of the National Roads Network already pay their Carbon costs at 'resource cost' value and additionally give an important net contribution for the society.

Evidences have also shown that improvements to the road system do not necessarily imply growing of emissions. Probably this is because even if there is a growth on mobility patterns due to the improvement between regions or cities, there is also a truly efficiency improvement (less traveled kilometers and in better roads) in the trips of the users already in the system.

There are strong evidences revealing motorization as one of the main drivers for the growth of emissions. Motorization will still continue to increase on the next decade. But it will increase at modest rates and vehicle and fleet substitution will have a fundamental role. It is necessary that the rate of fleet renewal have a stronger impact over emissions than the increase in car ownership.

The ABC analysis made shows that the mitigation policies and measures (P&M) with real impact are mainly related with fuel and motor efficiency (73% of the predicted reductions). As can be seen, the second group of measures with impact on carbon reduction is the improvement of the PT Services (20.6%). Demand Management and Fleet Renewal groups of P&M are not significant when compared with the overall 22 measures. Of the 22 proposed measures only one is directly related with the road system. This measure implies the reduction of motorways speeds implying also a reduction of the carbon intensity of road transport. The expected target is the reduction of the average speed on the motorways at about 6 km/h. The expected effect in GHGE is reduced (0.6 Mt CO_2e).

It is very likely that Portugal can fully realize the Kyoto targets, even using the Portuguese Carbon Fund. A second conclusion must be taken. If a new pos-Kyoto commitment must be assumed, and implies a reduction of 20% or even 30% of GHGE until 2020, then Portugal must have an even more proficient attitude about the subject. This will certainly imply a strong reduction on the GHGE from the transport sector and we must be prepared for that.

This means that know is the right moment to take the right decisions and make the right choices. One of those choices will be the Demand Management. This area of P&M seems to be fundamental because there is no need for substantial investments and financing (unlike Fleet Renewal, or Infrastructure Supply). Probably, the arena must be more focused over urban and metropolitan areas. This is because a substantial part of the population lives there. We must not forget also that congestion costs are larger than benefits in urban areas, implying an inefficient situation and a need for an overturn. The focus of those changes can be based on measures, like the promotion of:

- High Occupancy Vehicle (HOV) Lanes in urban motorways and expressways;
- Ramp Metering in some arterial expressways;
- Car and van sharing/pooling (probably with companies supporting);
- Global parking policies for the whole urban and metropolitan areas, allowing better park&ride opportunities and intermodality;
- Road pricing in city centers;
- Mobility credits;
- And of course, continuous improvements in Public Transport systems

All the policies above imply the regulation of technical or economic (or both) issues

Ending, it is commonly known that transport demand is a derived demand. So, it is a demand dependent of our main demand of activities like sleep, work and go to school or to the cinema. If the overall sprawl of the urban activities continues to grow indefinitely, the enforcement of the measures above will always have a reduced impact. The merge of transport policies and measures with adequate land use policies, restrictive planning of activities and other organizational signals will give the opportunity to the real estate market and transport systems to continue to grow, but at a sustained way.

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