CISMOB - Cooperative information platform for low carbon and sustainable mobility

ICT towards low carbon and sustainable mobility – a multiscale perspective

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for low carbon and sustainable mobility

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– a multiscale perspective

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https://www.interregeurope.eu/cismob/

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INTRODUCTION

The transport sector has an important contribution to the economy, employment and to the citizens' mobility. However, it is also a major contributor to greenhouse gas (GHG) emissions, representing almost a quarter of Europe's GHG emissions, and air pollution, which reduces air quality in cities with direct effects on public health. In particular, road transport is responsible for almost a fifth of total EU emissions and 73% of emissions from transport (European Commission, 2017).

Intelligent Transport Systems (ITS) is the application of sensing, analysis, control and communications technologies for the management of the transport process to improve safety, mobility and efficiency, increase security and reduce environment impact. The use of ITS tools in transport has brought significant improvement in transport systems performance and it is a key element in reducing carbon footprint, as well as increasing the sustainability on an urban scale. The increasing road transport volumes in the EU are the primary cause of growing congestion and energy consumption, as well as a source of environmental and social problems (Tafidis & Bandeira, 2017). According to EC, ITS can contribute to the main transport policy objectives by reducing environmental impacts and save energy through better demand management. Therefore, the primary goals for urban transport should be the promotion of cleaner cars and fuels and the reduction of road accidents and traffic congestion. ITS tools can have a significant role to a cleaner, safer and more efficient transport system. EC with the ITS Directive (2010/40/EU) gave the necessary legal framework to their member states to accelerate the implementation of smart technologies in transport sector, giving each country freedom to decide their priorities (Urban ITS Expert Group, 2013).

Regarding the mobility sector, there is a clear lack of well-structured policy guidelines that leverage the use of Information and Communication Technologies (ICT), sensing systems and big data to promote a more sustainable use of infrastructures. Specifically, there is still a waste of available resources for estimation real time mobility impacts and an even more obvious inability to use this information to implement sustainable mobility policies. The concept of sustainability in CISMOB concerns not only the carbon footprint but also the local economy and the social dimension, including active transport networks, users and the rest of citizens. Against this background, CISMOB partnership was developed in order to collect new ideas and practical experience.

PROJECT OBJECTIVES

The main goal of the Interregional European Cooperation Project CISMOB is to improve the implementation of regional policies with the ultimate goal of reducing the carbon footprint. This goal can be achieved by promoting the efficient use of urban transport infrastructures through the application and use of ICT. Low carbon essentially means less energy consumption and therefore, a more efficient use of infrastructure. However, this optimization must be performed based on a holistic perspective integrating other environmental externalities (such as noise and other than CO_2 atmospheric pollutants), ensuring equitability, and social cohesion throughout proactively addressing specific local environmental and social vulnerabilities. Subsequently, CISMOB seeks to exchange regional level experiences in developing win-win strategies to achieve common benefits in reducing mobility related carbon footprint. The strategies should be supported by the innovative technology sector, which shall provide tools to increase the promotion of sustainable multimodal urban mobility and mitigate transport related environmental and social impacts. This objective is logically targeted at competent local and regional public authorities. However, universities have a key role by influencing local policy instruments and promoting the collaboration with innovative SMES.

While there are many European strategies and policies for ITS development and pollution reduction, it can be sometimes difficult for countries to translate them into national and regional efficient and harmonized policies. This is where CISMOB can have a major contribution.

The composition of CISMOB partnership was created in order to deepen the relations between regional authorities, universities and stakeholders on a European level, bringing together different regional experiences in the field of smart, low carbon and sustainable mobility management. The partners are: University of Aveiro (PT); Stockholm University (SE), City of Águeda (PT), ITS-Romania (RO), Bucharest-Ilfov Inter-Community Development Association for Public Transport (Bucharest Metropolitan Transport Authority until 31/03/2018) (RO), and Agency of Energy of Extremadura (ES).

The process to drive policy change occurred at different levels over an iterative exchange of expertise programme. This process included a set of learning events, which led to the development of a set of technical documents and action plans for policy improvement. Firstly, a Baseline Assessment Report (BAR) was prepared for evaluating i) how ICT and sensor technology are used in the transportation system and, ii) how carbon footprint and sustainability indicators are considered in the European regions represented by CISMOB partners. BAR identifies Good Practices across the CISMOB Partnership and classify them, namely, in which extent they can be transferred to other Cities and Regions with different scales. This action fosters the knowledge at individual and organizational level (1 and 2). During the first phase of the project timeline, three Building Capacity Workshops (BCW) and three Thematic Seminars were performed. The BCW were organized by local Authorities/Agencies. These events addressed project's outputs and shared each partner's best Practices to partner's staff and key stakeholders. The thematic seminars, organized by universities and ITS non-profit organizations aimed at providing participants with state-of-the-art information (at global level) in the area of capacity building toolkits, ICT and e-governance, as well as to promote social cohesion and urban sustainability (Stockholm University); monitoring and online impacts assessment (University of Aveiro), promoting of intelligent transport systems towards a low carbon mobility (ITS Romania).

It should be highlighted that both the weaknesses and best practices identified in the BAR will influenced the content for these regional events. Conversely, working groups integrating key staff of each partner participated in the development of technical papers pointing out the best practices found in each region, taking also advantage of the scientific, technical and empirical knowledge shared by research institutions and stakeholders.

These actions broaden the level of knowledge acquisition to the third level since regional stakeholders will actively participate in the learning process. CISMOB also supported staff exchange programs. Staff from academic institutions learned experiences in the real world with local authorities. In turn, local authority staff had the opportunity to exchange experiences in other regions as well as to acquire specific skills and techniques in R&D institutions.

The outputs of the exchange of experience process are consolidated in this document entitled "ICT Towards Low Carbon and Sustainable Mobility - a Multiscale Perspective".

This document shares methodologies that can be used in various regions to identify the main negative externalities of the transport sector and potential good practice solutions observed during the interregional cooperation.

The focus of CISMOB is the engagement of pertinent stakeholders (decision and policy makers and all relevant actors, with particular focus on ICT and transport sector) in order to speed up decision making for the advance of policies for implementation of ICT measures in transport and contributing to mitigate transport related impacts in the consortium regions. Table 1 summarizes some stakeholder groups and their main interests.

Table 1 Example of regional stakeholder groups and their interests

Managing authorities *R&D and Technological Platforms, Universities*	Funding and selection of new sustainable mobility projects, Mobility plans (big demand generator), technical expertise
IT companies and transport private sector	Promoting R&D support and dissemination of products (e.g., smart transport apps, car sharing, integrated transit ticket solutions)
Public transport providers and transport authorities	Promoting multimodal information, integrated ticketing systems Increase public transport usage Public tendering of mobility services
Environmental Associations	Ensuring Environmental Sustainability
Institutional, energy and environmental agency, mobility and transport institutions	Ensuring consistency between regional objectives and national legislation


Duidelijk
Aanwezig!
MULTIVIEWS

AGENDA OBJECTIVES

This AGENDA brings together outputs produced by the INTERREG EUROPE CISMOB project, which is a four-year partnership of six organizations from four European Union (EU) member states namely Portugal, Spain, Romania and Sweden (PT, ES, RO, SE).

This Agenda aims at providing regions and decision makers and managing authorities with simple methodological approaches:

- to estimate the transport-related environmental and social impacts of the transport sector on their region;
- to identify and classify regions regarding the penetration of ICT and ITS (Intelligent Transport Systems);
- to predict potential environmental gains of projects focused on sustainable mobility in order to set up ambitious, but realistic targets on regional policy instruments;
- to share a set of good practices identified over the first phase of the project.

This Agenda can be considered as a support tool for regions to develop strategies for reducing the carbon footprint. By assessing estimates of road transport emissions, regions have a more clear perspective on their level of contribution for the GHG emissions. This Agenda is intended to raise awareness among regions on their crucial role to move towards low-carbon and sustainable urban mobility. Good practices highlighted here are expected to contribute to other regions to get inspired on these examples of success, and thus, can adapt and/or replicate them in their own regions.

IMPACTS OF TRANSPORT IN EUROPE

Transport has several impacts on the environment. Emissions contribute to air pollution and climate change, noise causes nuisance and health risks. In addition to these impacts on the environment, transport has also other severe impacts on society.

Road transport is an important source of both greenhouse gases and air pollutants. The conditions are usually worst in areas that generate and attract many trips, such as city centres, shopping areas etc. In some cases, the low level of public transport services or even more the absence of alternative transport modes encourage the use of private vehicles aggravating the situation even more (EEA, 2016).

Despite improvements in vehicle efficiencies over past decades, today the sector is responsible for almost one fifth of Europe's greenhouse gas emissions (EEA, 2016).

One of the main objectives of the European transport strategy in its 2011 White Paper is to build a competitive and resource efficient transport system that will increase mobility. The strategy includes reducing the fossil fuel dependency and the private car usage, by promoting alternative modes of transport.

EU is committed in reducing the environmental impacts of transport in Europe, including its greenhouse gas emissions, and EU’s overall goal is to reduce greenhouse gas emission associated to transport by 80-95% by 2050. In particular, key targets to be reached include reducing average CO_2 emissions of new cars and vans to 95g/km and 147g/km, respectively, by 2020 onwards and oil consumption by 70% by 2050 from 2008 levels (EEA, 2014).

The challenge of sustainable mobility is a worldwide problem, shared by a rising number of countries and regions. This challenge is leading to an increasing global demand for clean products, technologies, and business models focused on green mobility, which presents a huge business opportunity for a competitive EU industry in this sector.

Transport represents almost a quarter of Europe's greenhouse gas emissions and is the main cause of reduced air quality in cities, which poses a serious threat to public health.

Road transport alone is responsible for almost a fifth of total EU emissions and 73 per cent of emissions from transport.

Decisive action on emissions from transport is therefore essential.

highlights

European Strategy for low-emission mobility

With the global shift towards a low-carbon, the Commission's low-emission mobility strategy, adopted in July 2016, aims to ensure Europe stays competitive and able to respond to the increasing mobility needs of people and goods. The strategy integrates a broader set of measures to support Europe's transition to a low-carbon economy and supports jobs, growth, investment and innovation. European Commission guiding principles on strategies to move towards low-carbon mobility state that the main elements should include:

- ability to respond to the increasing mobility needs of people and goods,
- increasing the efficiency of the transport system by making the most of digital technologies, smart pricing and further encouraging the shift to lower emission transport modes,
- speeding-up the deployment of low-emission alternative energy for transport, such as advanced biofuels, electricity, hydrogen and renewable synthetic fuels and removing obstacles to the electrification of transport,
- moving towards zero-emission vehicles. While further improvements to the internal combustion engine will be needed, Europe needs to accelerate the transition towards low- and zero-emission vehicles.

Cities and local authorities are crucial for the delivery of low-carbon mobility strategies, by implementing incentives for low-emission alternative energies and vehicles, encouraging modal shift to active travel (cycling and walking), public transport and/or shared mobility schemes, such as bike, car-sharing and car-pooling, to reduce road congestion and traffic-related pollution.

Emission cuts by Transport Sector

Emissions from transport could be reduced to more than 60% below 1990 levels by 2050. In the short term, most progress can be found in petrol and diesel engines that could still be made more fuel-efficient. In the mid- to long-term, plug-in hybrid and electric cars will allow for steeper emissions reductions. Biofuels will be increasingly used in aviation and road haulage, as not all heavy goods vehicles will run on electricity in future.

EU towards more sustainable and greener mobility

The main challenges for the transport sector in the EU include improvements for multi-modal mobility and shifting towards low-emission mobility.

EU is committed in minimizing the negative effects generated by transport (e.g., accidents, greenhouse gas emissions, air pollution, noise and environmental effects) and has been promoting low-carbon mobility solutions and its impact to economic growth and jobs in the EU.

Efficient transport services and infrastructure are crucial for all regions of the EU.

The EC communications "A European Strategy for Low-Emission Mobility" (adopted in July 2016) and "Europe on the Move" (31 May 2017) present measures with the aim to enable a transition towards low and zero emission mobility. In particular, the areas on which Commission initiatives will focus are:

- digital mobility solutions;
- fair and efficient pricing in transport (which should better reflect negative externalities of transport);
- promotion of multi-modality;
- an effective framework for low emission alternative energy;
- roll-out infrastructure for alternative fuels;
- interoperability and standardisation for electromobility;
- improvements in vehicle testing;
- a post-2020 strategy for all means of road transport, supported by research efforts and investment.

Transport infrastructure quality

Since the global economic crisis, the EU has been suffering from low levels of investment and maintenance in transport, especially in road and rail, infrastructures. This has led to a degradation on the state of roads and consequently, an increase in the risks of accidents, and also an increase of congestion, noise and pollutant emission levels in many EU countries.

Policies should take into account the fact that EU countries have different infrastructure needs. According to (European Commission, 2018), given the regional specificities and differences in transport patterns, a possible indicator to compare the situation among the EU countries is the index of satisfaction with transport infrastructure quality (Figure 1). Figure 1 shows that the overall satisfaction with transport infrastructure is the lowest in the Central and Eastern European countries, (which includes Romania), and the highest for e.g., Spain, Finland, France and the Netherlands. Within the CISMOB partnership regions, Spain and Sweden are quite similar in these four components, with exception for the quality of the railroads, where Spain presents higher levels of satisfaction. In particular, in terms of infrastructure quality of roads, for instance, Portugal belongs to the top 3 along with the Netherlands and France, presenting higher levels of satisfaction when compared to several other countries including Denmark, Germany, Finland, Sweden, UK or Spain.

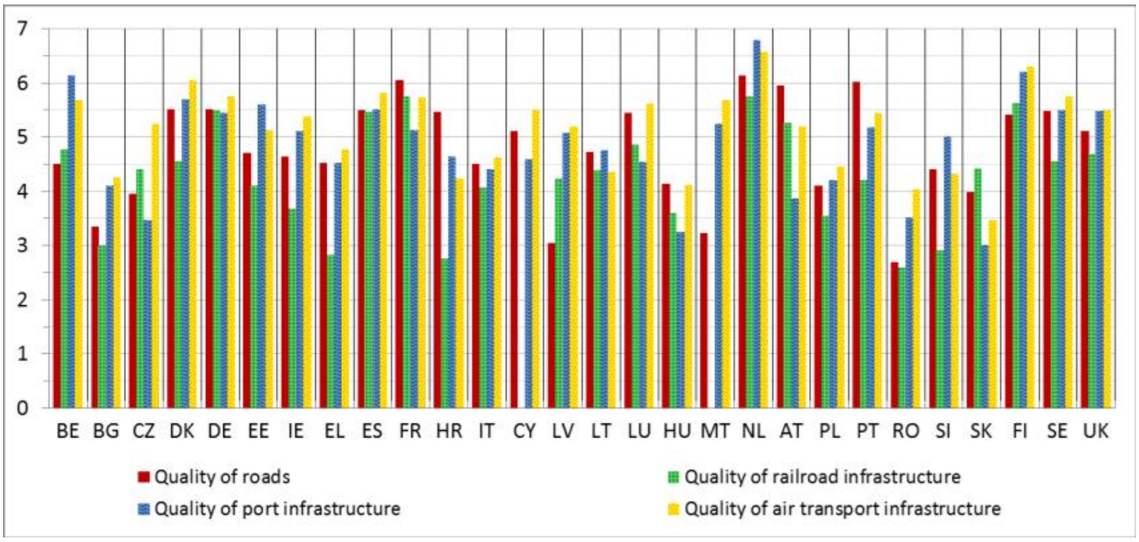


Figure 1 Satisfaction with infrastructure quality (2016-2017)

Source: World Economic Forum, The Global Competitiveness Report database 2016-2017. Scale from 1 [extremely underdeveloped] to 7 [extensive and efficient by international standards]. The countries were ranked on their overall performance on transport infrastructure.

EU has a financial mechanism to support infrastructure networks and the largest part of the funding should be assigned to:

- developing the European rail network (EUR 1.8 billion);
- decarbonising and upgrading road transport and developing intelligent transport systems (EUR 359.2 million);

Portugal and Romania are two of the 15 EU countries that benefit this funding for the period 2014-2020.

highlights

5G CONNECTED BIKE: a new way for data gathering

The world's first 5G connected bike is a project from Urban ICT Arena in Kista, Sweden.

Through the innovative use of information and communication technologies, a bike equipped with sensors to measure, for instance:

- humidity,
- UV radiation,
- noise and air pollution,
- particulates,

can be an important source for collecting traffic-related effects data.

The 5G connected bike coupled with a Raspberry Pi version 3 computer board running Rasbian allows to serve as a rolling wireless LAN access point, HTTP server, data center, Bluetooth device, and Internet of Things platform with the ability to use any number of sensors.

Moreover, incorporating a 4G dongle, it can be used with a 4G network.

Having a bike with sensors allows to collect data right on where vulnerable road users are passing by.

highlights

U-BIKE: a step forward to soft mobility

Universities are workplaces involving many thousands of people and the usage of private car in the campuses is a problem in terms of congestion and pollutant emissions. In an attempt to promote soft mobility habits, U-Bike Portugal is a platform where a bike can be allocated to a member of the academic community.

This good practice aims to:

1. promote the use of electrical and conventional bicycles in academic communities;
2. contribute for the reduction of primary energy consumption;
3. contribute for the reduction of greenhouse gases;
4. modification of the modal split in urban transport, namely the transfer of the motorized individual mode of transport to the cycling mode.

Through the U-Bike platform, one has the possibility of renting one of the 3234 bicycles (2096 electric and 1138 conventional) for a large time period (semester or year).

For instance, in the University of Aveiro (Portugal), 46% of the community uses private car. Within the U-Bike Project, as an incentive, the University of Aveiro provides healthy breakfast and showers for those students which use the bicycle as transport to the campus.

In the Aveiro Region, it is estimated that such bicycles will travel around 2.5millions km along 26 municipalities, which corresponds to saving almost 170tonnes of oil equivalent and a consequent reduction of more than 500tonnes of CO_2 equivalent.

Congestion levels

The main external costs of transport are those linked to greenhouse gas emissions, local air pollution, congestion, capacity bottlenecks, accidents and noise. Traffic congestion on roads not only increases the fuel consumption but consequently leads to increase in carbon dioxide emissions, outdoor air pollution as well as increase in the exposure time of the passengers and vurlnerable road users. For instance, in 2015, in the EU at least 33% of the final energy consumption and 24% of greenhouse gas emissions (which represents 23% more greenhouse gas emissions than in 1990) were derived from transport (European Commission, 2018).

A possible indicator to compare the situation in terms of congestion levels among the EU countries can be derived by measuring the hours spent by cars in road congestion every year (Figure 2). The countries with the highest congestion levels include Malta (more than 75 hours spent in road congestion annually), UK (more than 40 hours), and Romania (more than 30 hours), while the countries with the smallest congestion levels include Finland and Sweden. Portugal presents higher levels of congestion with approximately 28 hours spent in road congestion annually, when compared with Spain (around 25 hours), or Sweden (around 20 hours).

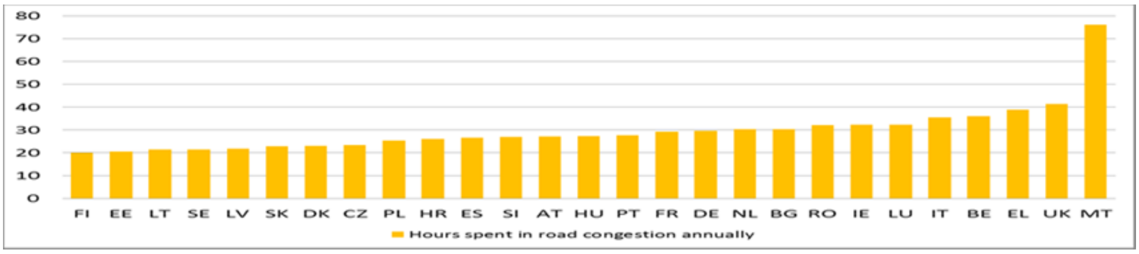


Figure 2 Average annual hours spent in congestion per vehicle (2015)

Data source: European Commission, Joint Research Centre, based on TomTom data. No data available for Cyprus. For methodological reasons, the data for Malta are of limited comparability with the ones for the other countries studied.

There is the need to improve the efficiency in the use of urban transport infrastructure. One possible way is through time-differentiated congestion charging, which have proven to be effective in limiting peak-hour congestion, but currently, its application on EU roads is marginal. Another tool for fostering a more efficient use of roads (not only in terms of congestion, but also in terms of environmental and air pollution and road safety) can be using the full capabilities of available technologies. This is one of the objectives of the CISMOB project: promote innovative ways to reduce carbon footprint and increase sustainability by improving the efficiency in the use of urban transport infrastructure through ICT.

highlights

Improving Public Transport Management

Public transport can be made more efficient by using innovative and ICT systems for public transport management (PTM). For instance, an innovative and complex PTM system was implemented in the city of Timisoara, in Romania, under responsibility of RATT – Societatea Transport Public Timisoara (Timisoara Public Transport Company).

This system involves two major components: integrated e-ticketing and Automatic Vehicle Location by GPS (AVL). The e-ticketing system is implemented with contactless cards, which are easy to use and allow the implementation of a flexible and efficient tariff policy, while providing the possibility to monitor public transport usage and passenger flows. The AVL transmits information from individual vehicles over a digital link via GPRS connection to the Control Centre of RATT.

The most important subsystems of AVL are:

1. fleet management;
2. real-time passenger information on board and in stops;
3. passenger counting;
4. communication network;
5. fuel consumption monitoring.

Thus, RATT is able to managing an integrated PTM system for its fleet of buses, trolley-buses and trams providing real-time information on-board and in stops and e-ticketing.

Timisoara is able to efficiently manage public transport with an investment of around 4Million EUR.

By implementing this type of PTM systems, public transport becomes more efficient, convenient and accessible for everyone.

Alternative fuels

Alternative fuels are another way to reduce the negative impacts of both passenger transport, - private and public - and freight transport in terms of environment- and health- harmful emissions.

In EU, there is being an increasing trend of alternative fuel vehicles, such as electricity, hydrogen fuel cells, natural gas, etc..

Figure 3 shows the share of battery electric vehicles (BEV) and plug-in electric vehicles (PEV) in new passenger car registrations for the year 2016. The Netherlands (around 5%) and Sweden (around 3%) present the highest shares for PEVs, while France and Austria have the highest share of BEVs (both countries present more than 1%). Within the CISMOB partnership regions, Portugal has approximately 0,5% share of PEVs and 0,5% of BEVs, while Spain and Romania have the lowest shares for both PVEs and BEVs (less than 0,25%). According to (European Commission, 2018), it is also possible to see that in most countries there is a clear relationship between the incentives offered and an increase in the number of greener vehicles.

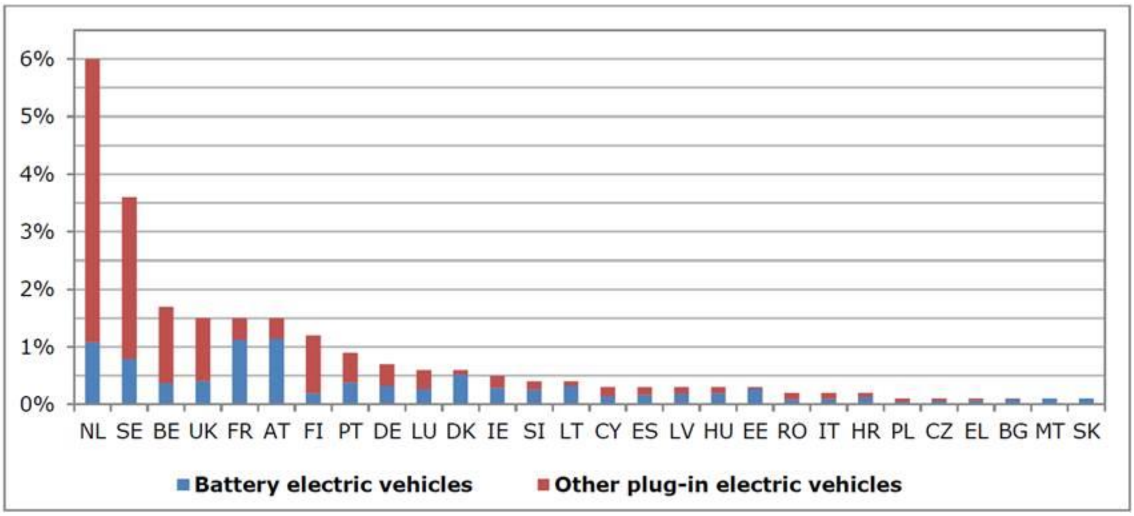


Figure 3 PEV market share in new passenger cars (M1) registrations (2016)

Source: European Alternative Fuels Observatory.

highlights

How crowded is the public transport?

Crowding in public transport is becoming a growing concern as demand grows. Crowding information is related to the level of load capacity of the public transport (e.g., bus, metro, train).

From passenger's perspective, it is expected that experienced crowding leads to increased dissatisfaction, and thus, deteriorating the experience in commuting in this mode of transport and influencing decisions on whether to use public transport in further trips.

In Stockholm, Sweden, in a pilot project, real-time crowding information is displayed to metro users, which enables them to know in real-time the load of the metro, and then, decide which one they will choose to proceed with their trip. During the pilot, it was estimated that 25% of the passengers noticed, understood and considered the provided information useful.

The implementation of this practice consists in having the information in two formats: visual (an overhead screen) and vocal (through speaker system).
The information is collected by an officer stationed in the previous station that will evaluate the metro train load in 3 levels: low, average and high.

The whole system is estimated to require an investment around 3100EUR per month.

Environmental impact

The continuous increase of vehicle fleet along with the development of road transport networks has associated a wide range of externalities. Main types of externalities refer to environmental impact, expressed as degradation of air quality, greenhouse gas emissions, increased threat of global climate change, degradation of water resources, and noise; social impact, expressed as quality of people life, human health, and economic impact, expressed as economic growth. Current development of road transport promotes a growing interest for sustainable and eco-friendly transport worldwide (European Commission, 2018).

However, road transport presents the highest share of CO_2 emissions in the transport sector, and thus, EU countries have to made efforts to mitigate this impact.

Road charging systems on European roads vary in terms of network coverage, charge levels and other conditions, which poses, for instance, administrative burden. Current systems do not necessarily take into account the environmental impact of vehicles. Thus, a more efficient tolling scheme is needed.

Transport fuel taxes can have effects in terms of a more sustainable use of cars and/or alternative fuels. Concerning fuels tax rates, there is a very significant difference across EU countries. However, for almost all EU countries diesel is taxed less than petrol.

The following figure illustrates the share of transport environmental taxes w.r.t. total taxation.

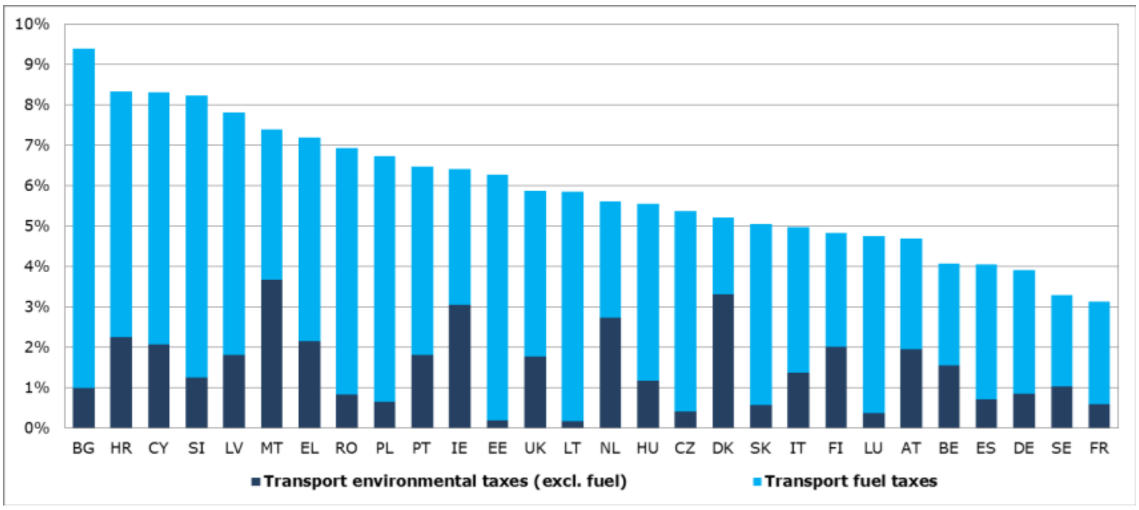


Figure 4 Transport environmental taxes as % of total taxation (2015)

Source: DG TAXUD

Figure 4 shows the transport environmental taxes as % of total taxation for the year 2015. A first observation is that the share of environmental taxes in total transport taxation reflects in general, a small component of the taxation system, meaning that it does not properly address transport externalities. Higher environmental taxes are applied in Malta and Denmark.

Current fuel taxes in the EU vary substantially across member states. An increase in fuel prices can result in a decrease in fuel and transport demand, and greenhouse gas emissions. Fuel taxation is a potential instrument for reducing emissions from transport, representing the best charge structure for internalising climate change related externalities (EEA, 2017b). The European Commission is aiming to achieve fair and efficient pricing of transport, which implies that transport charges should aim to reflect the external costs of transport. However, to date fuel taxation is not generally used to internalise the environmental externalities of transport, possibly because high fuel tax is often politically unviable. However, fuel taxes are not the only way towards fair pricing. For example, charging per kilometre or vehicle regulations could be some effective measures (EEA, 2017b).

Within the CISMOB partnership regions, Romania and Portugal have higher transport taxes, while Spain and Sweden have lower. In terms of the environmental tax component, Romania and Spain have similar lower shares, when compared to Portugal, which has the highest environmental tax component within the CISMOB regions.

Besides taxation and charges such as "user pays" and "polluter pays" principles, according to EC, measures that can address transport negative externalities consist in:

- deploying clean fuels for transport;
- deploying intelligent transport systems;
- setting efficiency standards for vehicles;
- sharing best practices (including eco-driving);
- encouraging the use of collective transport.

These measures are part of the Communications "A European Strategy for Low-Emission Mobility" and "Europe on the Move", where, for instance, new CO_2 standards for cars and vans after 2020 are proposed, as well as an action plan to boost investment in alternative fuel infrastructure and develop a network of fast and interoperable recharging stations.

highlights

Urban ICT Arena: opening new possibilities of digitalization

Urban ICT Arena is an open co-creation arena and testbed in Kista, Sweden.

With Urban ICT Arena, Kista can be regarded as a cluster for the development and demonstration of innovative solutions that benefit society.

Urban ICT Arena was created envisaging a cooperation between industry, academia and public sector and it consists of a massive IT-infrastructure, display window, meeting arena, project place and various projects and project participants.

The overall purpose of Urban ICT Arena is to help develop tomorrow's sustainable cities, boost innovation and secure jobs for the future. In particular, it has three objectives:

- Developing sustainable cities (foster more ICT-based solutions for urban sustainability challenges than there are at present resulting in both greater impact and lower costs),
- Boosting innovation (One aim of Urban ICT Arena is to secure and strengthen the capability to support innovation processes and to support SMEs and start-ups in developing ICT-based products and services.) and
- Securing the jobs of tomorrow (One of the long-term aims of Urban ICT Arena is to advance the region and prepare it for new future demands).

For instance, one of the projects within the Urban ICT Arena is with electric self-driving shuttle buses, which is the first test in Sweden of autonomous vehicles on public roads (Autopiloten Kista). On average, more than 200 people travel on the bus every day. Other project is the 5G NotBoring Connected Bike.

Social impact

The past decades showed evidence linking transport, particularly motorised road transport, with damage to human health as a direct consequence of road accidents and exposure to pollutant and noise emissions (European Commission, 2018). Thus, transport can impact society in terms of heath issues through various ways, including:

- road traffic injuries and deaths,
- noise pollution,
- air pollution.

Road Accidents

Road traffic accidents in the Member States of the EU claim about 26.100 lives and leave more than 1.4 million people injured (around 2900 per day) in 2015. The following figure illustrates the annual number of fatalities, injury accidents and injured people in EU for the period 2016-2015.

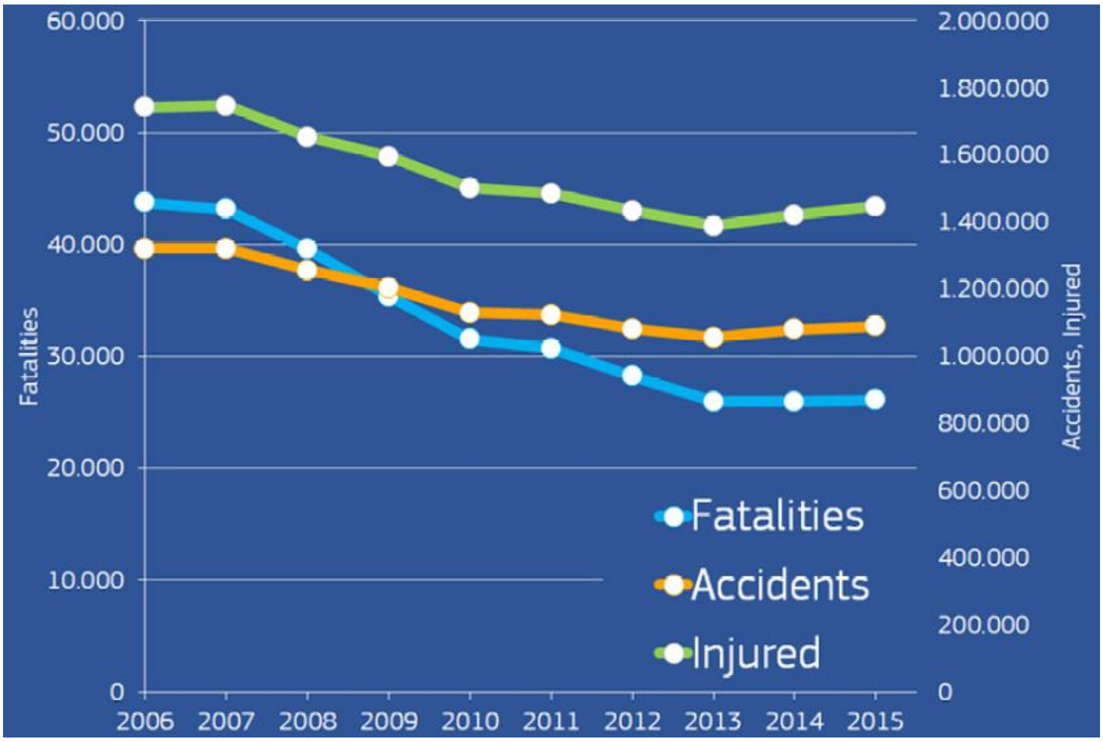


Figure 5 Annual number of fatalities, injury accidents and injured people in EU between 2016-2015

SOURCE: https://ec.europa.eu/transport/road_safety/sites/roadsafety/files/pdf/statistics/dacota/aar2017_infographics.pdf

It can be observed a reduction around 40% in the fatalities in this period, but in terms of injury accidents, the reduction is more slightly, not reaching the level of 20%.

Figure 6 shows the share of fatalities by road type in the EU for the year 2015. A closer look on the type of road permits to conclude that in EU, in 2015, more than half of the fatalities occurred in rural roads.

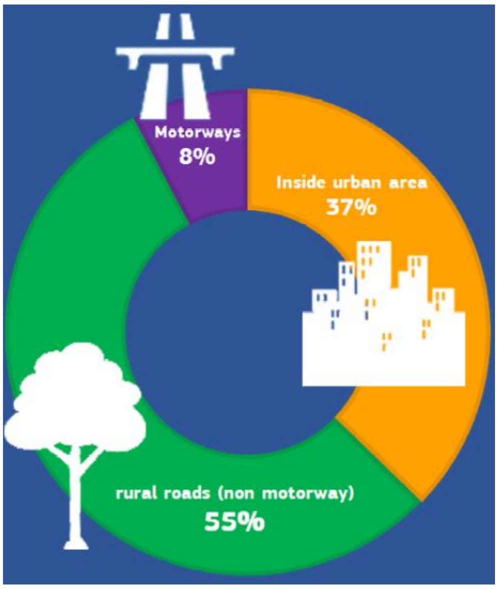


Figure 6 Share of fatalities by road type in the EU for the year 2015

SOURCE: https://ec.europa.eu/transport/road_safety/sites/roadsafety/files/pdf/statistics/dacota/aar2017_infographics.pdf

Road traffic noise

The impacts of exposure to high levels of environmental noise include annoyance, stress reactions, sleep disturbance, poor mental health and well-being, as well as negative effects on the cardiovascular and metabolic system (World Health Organization, 2011), (European Commission, 2015). Environmental noise causes approximately 16 600 premature deaths in Europe each year, with almost 32 million adults suffering from annoyance and over 13 million suffering sleep disturbance. The WHO has identified noise as the second most significant environmental cause of ill health in western Europe, the first being air pollution.

Noise pollution is a major environmental health problem in Europe, and road traffic i sone of the most contributors. However, railways, air traffic and industry are also important sources of noise.

The following figures show the estimated number of people in Europe who are exposed to levels of environmental noise that are above noise indicator levels. Here, Lden represents the Long-term average indicator designed to assess annoyance and defined by the Environmental Noise Directive (END), it refers to an annual average day, evening and night period of exposure with an evening weighting of 5 dB(A) and a night weighting of 10 dB(A); Lnight is the Long-term average indicator defined by the END and designed to assess sleep disturbance and it refers to an annual average night period of exposure.

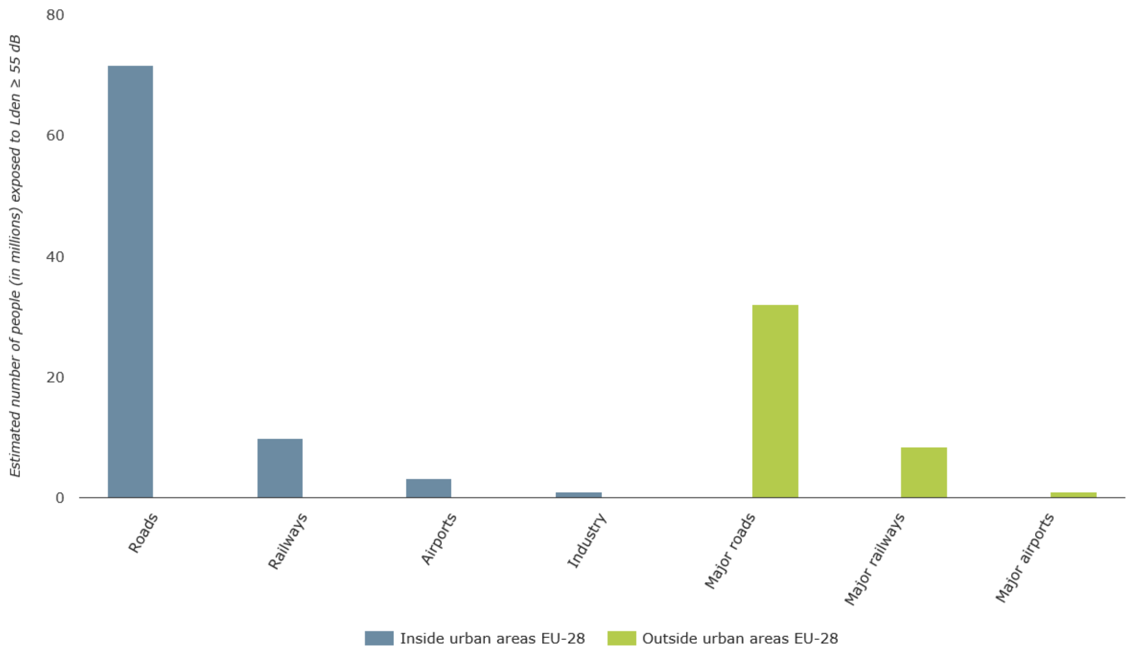


Figure 7 Number of people exposed to average day-evening-night noise levels in EU-28 (Lden) ≥ 55 dB

SOURCE: "Population exposure to environmental noise"
https://www.eea.europa.eu/downloads/5c9bbb02e71247e586deb718c858e9cb/1532009381/assessment-2.pdf

It is estimated that approximately 104 million people in the EU-28 are exposed to high Lden noise levels (annual average day, evening and night exposure to noise) from road traffic, which is also an importante source of noise at night-time with almost 60 million people exposed to high noise levels.

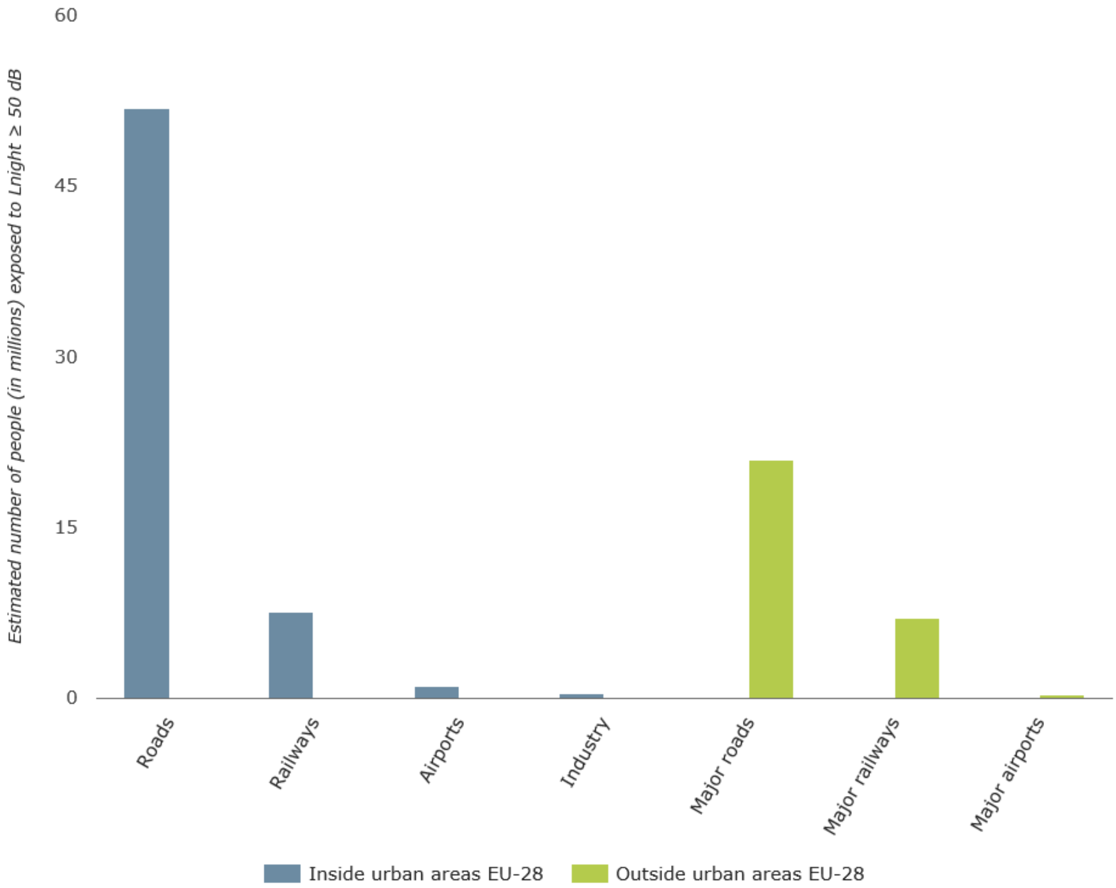


Figure 8 Number of people exposed to night-time noise in EU-28 (Lnight) ≥ 50 dB

Road traffic air pollution

Vehicle emissions from burning petrol and diesel include particulate matter (PM10 and PM2.5), and nitrogen dioxide, carbon monoxide and other gases. Exposure to particulate matter can lead to chronic respiratory and cardiovascular diseases, some cancers and low birthweight, while Nitrogen dioxide is associated with acute respiratory effects such as asthma symptoms, especially in children (Beelen, R.; Rasschou-Nielsen, O.; Staffogia, M.; Andersen, 2014; Hoek, G.; Krishnan, R.M.; Beelen, R.; Peters, 2013; Jacquemin, B.; Sunyer, J.; Forsberg, B.; Aguilera, 2009; Pedersen, M.; Giorgis-Allemand, L.; Bernard, C.; Aguilera, 2013; Stafoggia, M.; Cesaroni, G.; Peters, A.; Andersen, 2014).

The transport sector is a very important source of greenhouse gases within the EU and the largest contributor to NO_X emissions, accounting for 46% of total EU-28 emissions in 2014. For certain pollutants, such as NO_X and CO_2, there is a wide gap between official emission measurements and the average real-world driving emissions, since emissions in real-life driving conditions are often higher, especially for diesel vehicles, than those measured during the approval test.

Transport also contributed to 13% and 15% of total PM10 and PM2.5 primary emissions, respectively, in the EU-28 in 2014.

In 2014, about 16% of the EU-28 urban population was exposed to PM10 above the EU daily limit value (i.e., 50 µg/m3 not to be exceeded on more than 35 days per calendar year, for short-term exposure). Regarding PM2.5 exposure, about 8 % of the EU-28 urban population was exposed to levels above the target value set by the Ambient Air Quality Directive (EU, 2008) to be 25 µg/m3 annual mean.

The following figure shows the 3-year averaged concentrations from measurements at all urban and suburban background stations. This 3-year running mean of PM2.5 concentrations is calculated as the average over all operational urban or suburban background stations within a Member State in the period 2012–2014.

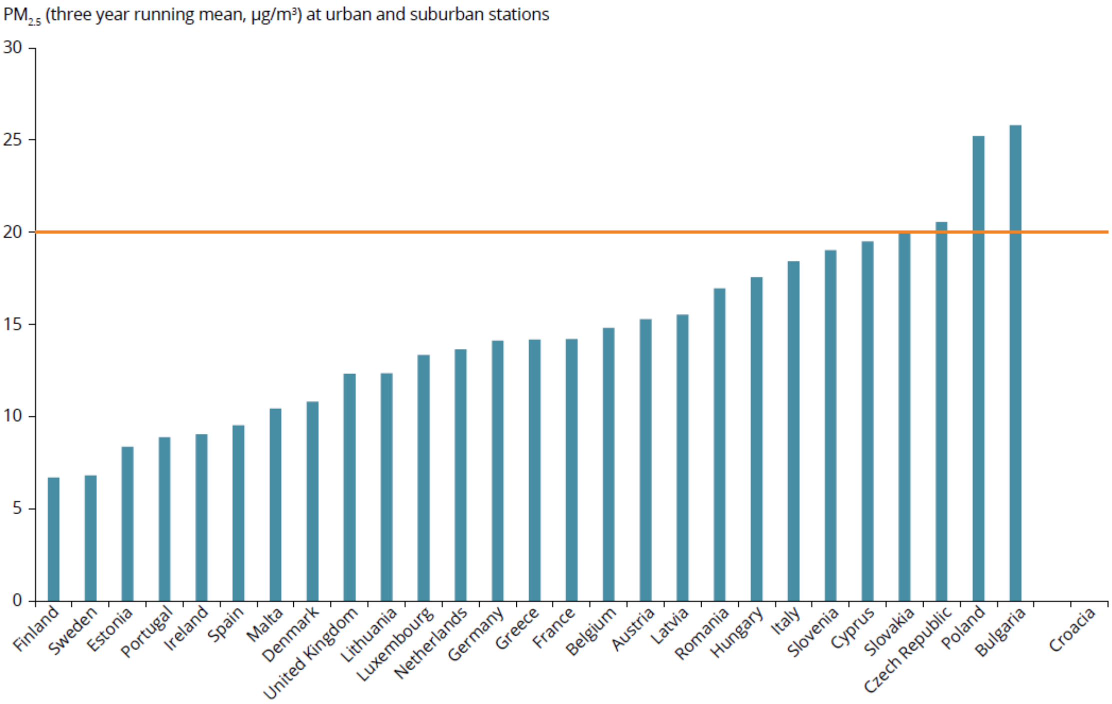


Figure 9 Urban and suburban background PM2.5 concentrations presented as 3-year averages in the EU-28 (2012–2014), as an approximation of the average exposure indicator

SOURCE: air quality report

It can be observed that the average urban concentrations in 2012–2014 were above 20 µg/m3, which is the legally binding level for exposure concentration.

From Figure 9, the results for CISMOB Partnership Regions show Sweden, followed by Portugal and Spain present average values below 10, while Romania levels are rather close to 17 µg/m3.

highlights

Solar powered e-paper display for real-time public transport information

Promoting the use of public transport may help in decreasing traffic congestion and air pollution in urban areas. Moreover, providing reliable and real-time updated information to public transport users is important to making users able to manage their personal mobility.

For instance, in the city of Coimbra, Portugal, the Municipality applied for funding for the project "Informação em tempo real" (Real Time Information), in order to be able to implement real time information panels for public transport.

SMTUC - Serviços Municipalizados de Transportes Urbanos de Coimbra (Urban Transport Municipal Services of Coimbra) are responsible for providing real-time public transport information displayed in several bus stops through solar powered e-papers, which allow energy savings. There is a total of 32 panels, being 5 of them indoor panels specially conceived to provide real time public transport information on the surroundings of buildings such as hospital, school, commercial or transport interfaces.

The panels consist in a solar powered e-paper technology that shows in real time the waiting time until the next buses, and their respective line.
The buses have installed a GPS that communicates with a platform real time location. An open data platform will also be implemented.

It is estimated that each solar powered e-paper panel costs around 3.500EUR.

General overview

Bearing in mind the current situation of transport in EU, this means that the current transport system might not be sustainable and needs to be adjusted. Promoting a shift to low emission mobility and addressing negative externalities is one the main objectives of the EC.

Adjustment of infrastructure to new mobility patterns (e.g., alternative fuels) require new investments and a different approach to the (re-)design of networks. Despite a good provision of infrastructures, there exist European countries with high levels of road congestion. This situation reinforces the need of an efficient and sustainable transport system that requires integration of different modes of transport, including equipment for traffic management and innovative technologies, and appropriate pricing for the use of infrastructure.

ICT tools play a key role in minimizing transport-related externalities. Digital technologies play a crucial role for creating a multimodal transport system. Cooperative intelligent transport systems (C-ITS) allow road users and traffic managers to share information and use it to coordinate their actions. The deployment of intelligent transport systems for road and its interface with other modes varies across Europe.

There is a strong commitment of all EU countries in the deployment of intelligent transport systems for road and its interface with other modes. In this light, EC is committed in reducing CO_2 emissions, congestion and air pollution to improve the quality of life of European citizens and to reach the goals set by the Paris Agreement. Multimodality can have an important role in reducing such transport externalities. Thus, EC set the year 2018 to be the “Year of Multimodality” and the EC is promoting the importance of multimodality for the EU transport system, by proposing a set of legislative and policy initiatives. In particular, the key thematic areas include:

- Digitalisation with focus on digital corridor information systems and multimodal travel information and ticketing;
- The use of economic incentives to promote multimodality;
- Support to multimodal infrastructure and innovation, physical and digital;
- The promotion of 'active mobility' integrated with other modes in particular, in an urban and smart cities context.

highlights

Trafiklab: Providing Public Transport Information

Trafiklab is an open data platform providing access to data on public transport in Sweden, making data and information available to every potential user. Trafiklab platform gathers multiple data information about transports in Sweden and make it available, so that users can develop and share smartphone app's. There exist many different API's (Application Programming Interfaces which make it possible for developers to use routines or data that is outside their code), among which one can point: 1) ResRobot - Trip Planner (public transport schedules in Sweden and their geographic location); 2) Traffic State SL 2 / Trafikverket open API (traffic conditions); 3) SL (Storstockholms Lokaltrafik AB) Real Time Information (real time information on buses, subways, commuter trains, local trains and boats in Stockholm).
The main goals of this good practice are: 1) Make all traffic data in Sweden available; 2) Share APIs to foster transportation sector entrepreneurship; 3) Share to the population all the apps created; 4) - Increase the usage of public transport. Trafiklab functions as a socio-technical value-creating mechanism, primarily for third-party developers. There are however, some challenges in creating a public transport open data platform since it requires to engage public transport companies regarding innovation and open data benefits, and collaboration and common priorities among a wide range of stakeholders.
Nowadays, most travelers have access to a mobile device with an internet connection, which allows instant access to information about delays and keep their personalized timetable updated regarding public transport. The public transport open data platform enables that public transport can be used more efficiently by its users and attract new users. Political willingness to work with open data is crucial and enables transparency and diffusion of public transport information.

TRAFIKLAB

A closer look at the Transport Sector within the CISMOB Partnership

Modal Split for Passenger Transport

All countries within the CISMOB partnership record a high use of passenger cars (European Commission, 2018). In 2015, car trips represented more than 80% of the passenger-kilometres travelled for Portugal and Sweden, which are both above the EU average. Romania presents the lowest. Regarding the use of buses and coaches, Portugal records a lower use along with Sweden than the EU average, while Spain and Romania present higher shares. Despite the importance of rail transport, its share in the modal split in Spain, Portugal and Romania is still low comparing to the EU average, while Sweden records higher use of railways. In terms of use of tram and metro, Portugal presents the lowest, while Romania records a high use, representing more than two times more than the EU average.

Table 2 Modal split for passenger transport in 2015

	Passenger cars	Buses and coaches	Railways	Tram and metro
ES	79.9	11.7	6.6	1.8
PT	88.5	6.3	4.1	1.1
RO	74.8	14.5	4.3	6.3
SE	81.7	7.2	9.3	1.8
EU-28	81.3	9.4	7.6	1.8

(%-shares based on passenger-kilometres)

Evolution of Alternative fuels in Road Transport

All countries within the CISMOB partnership present very different BEV, PHEV and CNG shares (European Commission, 2018). A first observation we can make is that the shares in Sweden are by far higher than the remaining countries. All these countries present a significant growth trend in the share of PHEVs, more evident in 2015-2016. The share of alternative-fuelled cars in total sales in Spain is smaller than in Portugal or Sweden. With respect to Portugal and Romania, the number of electric charging points has been increasing and well as the number of alternative-fuelled cars is increasing. However, the number of new passenger cars using alternative fuels remains below 1% of the overall fleet. In case of Romania, the number of alternative-fuelled cars is rather small.

An evident point is that CNG cars, which share recorded approximately 0,40%, are no longer being registered.

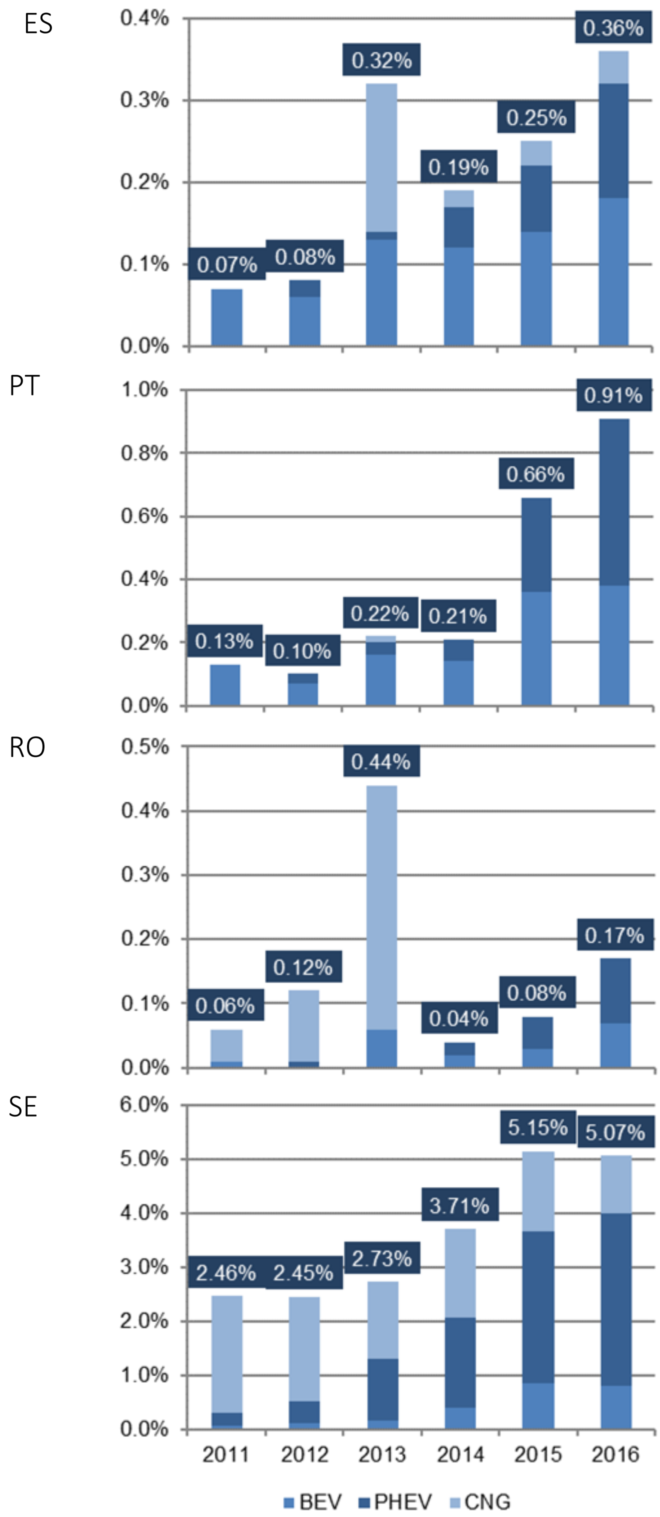


Figure 10 Alternative fuel passenger cars market share for the period 2011-2016

SOURCE: EUROPEAN ALTERNATIVE FUELS OBSERVATORY (BEV = battery electric vehicle; PHEV = plug-in hybrid electric vehicle; CNG = compressed natural gas).

Competitiveness Performance

The Global Competitiveness Index (GCI) (Schwab, 2017) tracks the performance of 137 countries on several pillars of competitiveness. The idea behind this index is to provide a multidimensional measure of economic/innovation development to help decision makers understand the complex nature of the development challenge; to design better policies, and to take action to economic progress. Different pillars and subpillars are considered; for instance, it encompasses perspectives in terms of innovation, quality of infrastructures, technological readiness and a more complex issue such as diversion of public funds.

The Global Competitiveness Report (Schwab, 2017) provides a ranking for each one of the 137 countries. The report defines "competitiveness as the set of institutions, policies, and factors that determine the level of productivity of an economy, which in turn sets the level of prosperity that the economy can achieve". The GCI establishes a common framework to measure the ability to provide sustained economic growth and well-being, allowing decision makers to monitor their annual progress presenting an index that is a position from 1-137, being the rank of the country compared to the rest of the world.

The following table presents the rankings of GCI 2017–2018 for Spain, Portugal, Romania and Sweden.

Table 3 Global Competitiveness Index 2017-2018 for the countries within the CISMOB Partnership

	Rank/137			
Index Component	ES	PT	RO	SE
Global Competitiveness Index	34	42	68	7
Diversion of public funds	96	46	91	13
Quality of overall infrastructure	18	13	103	15
Quality of roads	16	8	120	18
Quality of railroad infrastructure	11	31	73	21
Technological readiness	28	26	51	5
Capacity for innovation	49	39	109	4

The results provided in this table suggest Sweden outperforms other countries, with GCI equals to 7, while Romania presents compelling results.

Spain is at position 34, followed by Portugal at 42. Romania is practically in the middle of the ranking. Regarding subpillars "Diversion of public funds" and "Capacity for innovation", Sweden and Portugal present the best results, being at the top 50 and 40, respectively. Spain presents a compelling result in terms of "Diversion of public funds".

It can be observed that Portugal has better quality of overall infrastructures, followed by Sweden. In particular, Portugal has very good quality of roads, while Spain presents better results in terms of railroads. In terms of "Technological readiness", Spain and Portugal are practically at the same level, while Sweden is at the top 5, along with "Capacity for innovation" subpillar.

The following figure shows the competitiveness performance of CISMOB Partnership Regions in terms of scores.

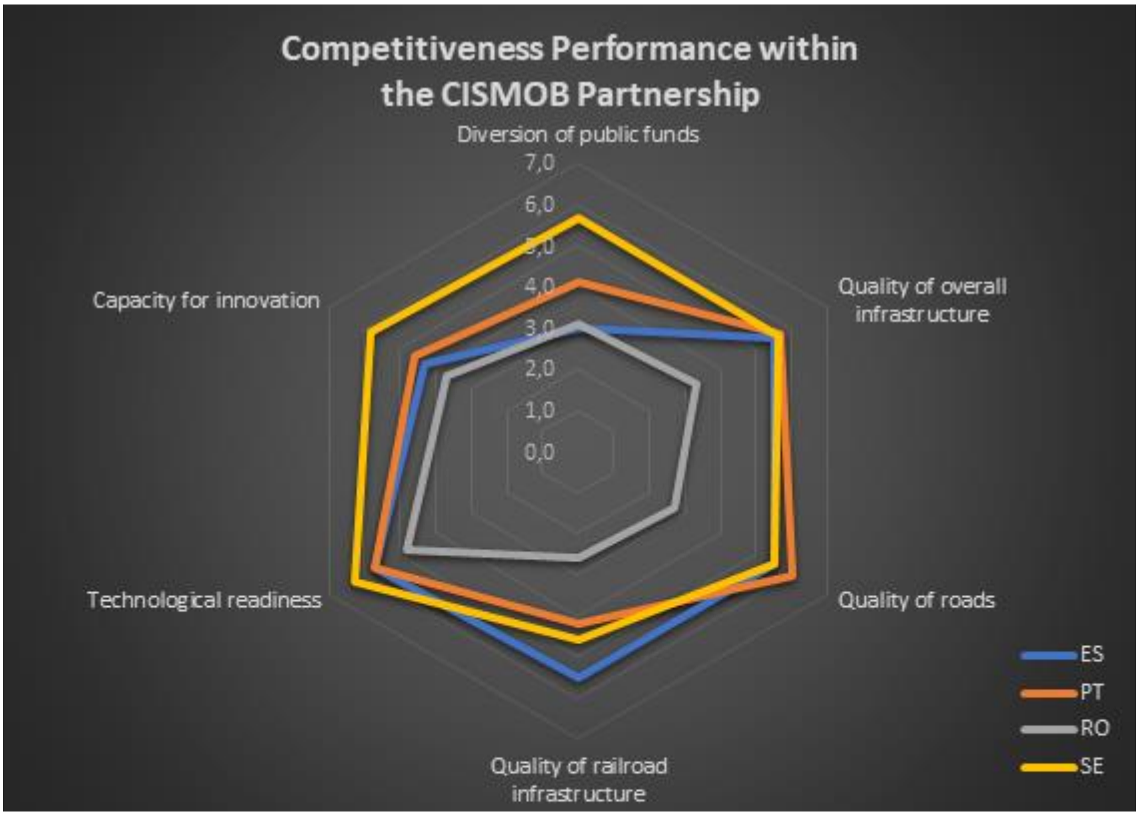


Figure 11 Competitiveness performance of CISMOB Partnership Regions in terms of scores

SOURCE: (Schwab, 2017)

Using a scale from 1 to 7, the final score for each subpillar is more informative for policymakers as a guide to action. In essence, the score may be a better indication of the direction of change, allowing to policymakers understand the drivers of competitiveness and then, evaluate, adjust, or develop strategies and policies accordingly.

There are evident differences within the CISMOB partnership. The first observation we can make is that Romania is by far the country that is falling behind others in all subpillars of competitiveness. On the other hand, Sweden presents high-level results, recording in practically all subpillars a level of 5 or more. Comparing the scores for Portugal and Spain, it can be observed that Portugal outperforms Spain in all the analysed subpillars, except for the quality of railroads. In fact, these scores allow one to conclude that Spain has better quality of railroads than other of these countries. In case of "technological readiness", higher scores are reported for Sweden, followed by Portugal and Spain with very similar levels. Concerning the level of technological readiness, Romania presents a good score, while for the remaining subpillars the levels remain relatively low.

highlights

Fully integrated innovative electric mobility model

Electric mobility has playing a crucial role to move towards low carbon mobility solutions.

Portugal is one of the first countries in the world to have an integrated policy for electric mobility and a charging network for Electric Vehicles with national coverage.

The MOBI.E electric mobility model is a fully integrated and totally interoperable system, multi-retailer and multi-operator.

In practice, it is a national electric mobility system that allows any individual the access to any provider of electricity in any charging point explored by any service operator.

This ensures transparency, low entry barriers and competition along the value chain, and runs under a business and service model that takes advantage on the growing importance of electricity produced with basis on renewable energy.

Charging systems such as MOBI.E allows an open access, fully interoperable system, able to integrate different players of the service value chain. MOBI.E enables the integration of several electric mobility electricity retailers and charging service operators into one single system, thus stimulating competition.

The central management system, with a dedicated layer for full compatibility, makes it possible to integrate any charging equipment from any manufacturer and to connect to multiple systems from third parties.

Hence, MOBI.E allows any user to charge any vehicle in any location without any worries for technical compatibility, by using a single subscription service and authentication mechanism. At the same time, it allows full transparency for all stakeholders and the generation of multiple market-based opportunities with different business models.

There are available three types of charging stations:

1. normal (3,7 kWh, 6-8 hours for 100% of the battery capacity);
2. semi-fast (22 kWh, 1 hour for 80% of the battery capacity) and
3. fast (20-30 minutes for 80% of the battery capacity).

MOBI.E consists in a network composed by 600 charging stations in Portugal, initially the charge had no costs, but a tariff is now being tested.

The MOBI.E system relies on a comprehensive IT management platform that interconnects all stakeholders around a well defined service value chain, through the integration of all information, energy and financial fluxes, ensuring transparency, service integration, competition and reinforced management capability for all stakeholders. Some of the system's main features include:

1. Real-time monitoring of charging points, including charging status and vacancy information
2. Remote monitoring of the charging process
3. Web-based multi-platform access: PC, PDA, cell phone
4. Integrated invoicing with supplementary services: Parking, public transports, domestic electricity, personal and business accounts.

Since its implementation, it is estimated:

- almost 5.5 thousand users,
- more than 4GWh of energy consumed,
- almost 500 thousand chargings
- avoiding around 2.7ton of CO_2 emissions.

ITS TOWARDS MORE EFFICIENT AND SUSTAINABLE MOBILITY

CISMOB main vision is to take full advantage of ICT to improve the efficiency in the use of urban transport infrastructure. During the first phase of the project, partners were able to learn good practices of sustainable management of urban transport taking advantage of ICT.

Intelligent Transport Systems (ITS) applications help cities to achieve policy goals with regard to accessibility, livability and safety. New advances in technology have increased the possibilities of using ITS and traffic management in urban environments.

Specifically, ITS are applications of advanced sensor, computer electronics and communication technologies which, without embodying intelligence as such, aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and ‘smarter’ use of transport networks. ITS applications include telematics and all types of communications in vehicles, between vehicles (e.g., vehicle-to-vehicle), and between vehicles and fixed locations (e.g., vehicle-to-infrastructure) (Eline & Teije, 2015).

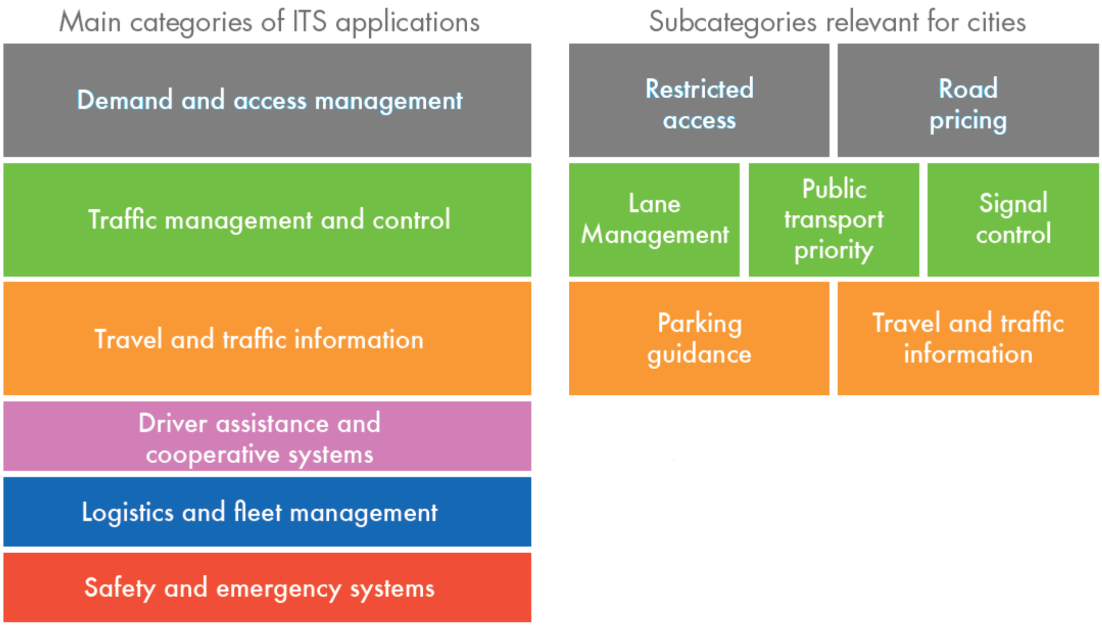


Figure 12 ITS categories and subcategories

SOURCE: CIVITAS WIKI consortium civ_pol-not6_its_web (Eline & Teije, 2015)

Managing urban traffic can be considered a challenge, especially in an era where cities are expected to grow, leading to an increase in traffic demand. Figure 13 illustrates the reasons why it is complex to deploy ITS in urban areas. In particular, these characteristics are key factors when selecting measures.

ITS and traffic management approaches can lead to positive effects on the experience of travelling, in particular with significant impacts in terms of reducing travel times, air pollution and fuel consumption, and increasing road safety. For instance, real time information on eco-friendly modes of transport such as walking, cycling and public transport, can influence change to more sustainable modes, whilst optimizing control settings of traffic signals can reduce fuel consumption and emission of pollutants.

EC with the ITS Directive (2010/40/EU) gave the necessary legal framework to their member states to accelerate the implementation of smart technologies in transport sector, giving the freedom to each country to decide their priorities (Urban ITS Expert Group, 2013). Available ITS tools vary in technologies applied, from basic management systems such as car navigation and traffic signal control systems to more advanced applications that enables the use of real-time data and involve various technologies, such as: software and sensor technologies, wireless communications, computing technologies; floating car data/floating cellular data and sensing technologies (Yen & Lyoen, 2012).

Figure 13 Important characteristics of urban traffic

SOURCE: CIVITAS WIKI consortium civ_pol-not6_its_web (Eline & Teije, 2015)

In essence, the idea of using ITS applications is to minimise road traffic-related environmental impacts and improve road safety, being a key element in reducing carbon footprint, as well as increasing the sustainability on an urban scale. This can be achieved by considering:

- Optimal use of road traffic and travel data,
- Network efficiency and minimise congestion,
- Enhance modal integration.

The following table presents insights that can be used to help in the initial selection of ITS and traffic management measures to meet local conditions of mobility characteristics, challenges and policy goals (Marsili et al., 2017).

Table 4 ITS and traffic management measures deployment and benefit KPIs

Deployment KPIs	description	definition	calculation
Automated speed detection/ Information gathering infrastructures / equipment	Length and % of road network type covered	Road based on ITS infrastructures/equipment (sensors, cameras, FCD) enabling speed detection, and traffic, weather and emissions monitoring. Data collected can be used for traffic measures and information services.	KPI = (kilometres of road network type equipped with information gathering infrastructures / total kilometres of same road network type) x 100
Dynamic Public Transport Traveller Information	% of road / transport network type covered Or Number and % of urban, inter-urban and/or rural public transport stops	Information on up-to-date estimates of public transport services such as arrival time, delays or cancellations. It can also include information on multimodal interchanges nodes. Such information can be displayed on public transport stops through variable message signs or via apps.	KPI = (kilometres of transport network type with provision of dynamic travel information Services / total kilometres of same transport network type) x 100 KPI = (number of transport nodes with provision of dynamic travel information Services / total number of same transport nodes) x 100

Real-time Traffic condition and (Dynamic) Travel Time Information	Length and % of road / transport network type covered by services on traffic and travel information	Current traffic information on network provided to road users and traffic managers through communication channels. It can include information on accidents, road works, congestion hotspots, travel times / delays. This predictive or real-time information could be provided on-trip and pre-trip (Dynamic travel information) using different information channels. It can include information on disruptions, travel times / delays, vehicles positioning, accessibility of nodes and vehicles.	KPI = (kilometres of road network type with provision of real-time traffic information Services / total kilometres of same road network type) x 100
Adaptive Traffic Control or Prioritisation	Number and % of signal controlled road intersections with adaptive traffic control or prioritisation	Road intersections with ITS technologies for controlling junction flow are able to adapt to traffic levels or prioritise certain movements and vehicle fleets/type of users.	
Forecast and Real Time Event Information	Length and % of road network covered or impacted by Forecast (pre-trip) and Real Time (on-trip) Event Information	Real time information on both expected (e.g., road works, traffic jams, closures) and unexpected (e.g., incidents, accidents, sudden adverse weather), events to road users. It should provide information with pre-trip and on-trip warnings to drivers.	
Incident detection and management	Length and % of road network type covered or impacted	Road with ITS infrastructure (cameras, sensors, FCD) to detect incidents (e.g., accidents, congestion) on a section of road network that can be used to trigger actions to manage the incident by implementation of a planned and coordinated set of actions and resources to handle an incident safely and quickly restoring normal traffic conditions.	KPI = (kilometres of road network type equipped with ITS to detect incident / total kilometres of same road network type) x 100

Traffic management and control measures	% of road network type covered	Road based ITS enabling management and control of traffic movements. It can include variable speed limits, as well as parking management, vehicles / fleet prioritisation.	KPI = (kilometres of road network type covered by traffic management and traffic control measures / total kilometres of same road network type) x 100
Cooperative-ITS services and applications	% of road network type covered	Road based ITS infrastructure enabling services/applications using infrastructure-to-vehicle or vehicle-to-infrastrucure communication.	KPI = (kilometres of road network type covered by C-ITS Services or applications / total kilometres of same road network type) x 100
Co-Modal Traveller Information	Length and % of road network covered with information co-modal services	Co-modal information of different modes/means of transport (multi-modal) and/or the combination of different modes/means of transport within the same route (inter-modal). It requires data from different transport modes (road, rail, water transport, walking, cycling)	
Benefit KPIs	description	definition	calculation
Change in traffic-CO_2 emissions	% change in annual traffic CO_2 emissions on routes/areas where ITS has been implemented or improved	Annually amount of CO_2 emitted collectively by road vehicles on a route or an area, which is estimated based on traffic flows and speeds coupled with assumptions regarding fuel consumption and/or average vehicle efficiency per kilometre for the different vehicle types. The area within which the change in CO_2 emissions is calculated should be long enough to be representative.	KPI = ((traffic CO_2 emissions before ITS implementation or improvement – traffic CO_2 emissions after implementation or improvement) / traffic CO_2 emissions before ITS implementation or improvement) x 100 Emissions are measured in metric tons CO_2 equivalent

Change in travel time	% change in peak period travel time along routes/areas where ITS has been implemented or improved.	Travel time during the hour with the highest traffic flow on a week day can be used in an aggregated average for estimation of consolidated results at road network level. The area within which the change in travel time is calculated should be long enough to be representative.	KPI = ((travel time before ITS implementation or improvement – travel time after ITS implementation or improvement) / travel time before ITS implementation or improvement) x 100
Change in Traffic Flow	Change in traffic flow measured at specific locations of the road network due to implementation of ITS systems.	Traffic flow can be measured typically between key junctions and at a given period of time, typically in the period with the highest flow during a weekday (peak period).	Absolute and % difference for Corresponding timeframes before and after ITS implementation

highlights

Open data platform for public transport

Public transport open data involves cooperation between different entities and public transport operators, which may experience many challenges.

Besides, for providing meaningful information on public transport services to users requires gathering the different information in a single platform.

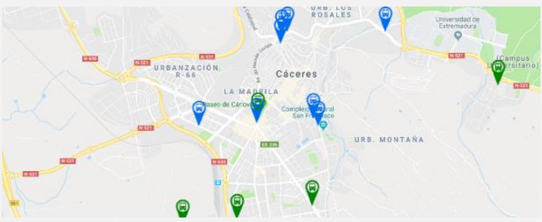
For instance, in Cáceres, Spain, there is implemented an open data service on public transport information with details on stops, lines, schedules and real time bus location.

The goal of this project was to provide all citizens and tourists of Cáceres with information in real-time on city buses and by using such data, it can be used to create smartphone applications.

Some apps allow to inform users on traffic jams and special events, reducing thus, travel time and associated pollutant emissions.

This open data platform costs around 20 thousand EUR per year.

It is important to raise awareness among local public transport operators in order to them make information available in open data format.



ASSESSING ENVIRONMENTAL AND ECONOMIC FACTORS

European Union has been regulating the vehicle emissions by introducing several Euro standards. Despite many technological developments, road transport sector is one of the most important contributors of Europe's total emissions. National car fleet composition in terms of age, engine technology and fuel consumption can have significant impacts on emissions (Beser Hugosson, Algers, Habibi, & Sundbergh, 2016). In fact, 75% of Europe's total road transport emissions are from passenger cars (FONTARAS, ZACHAROF, & CIUFFO, 2017). Transport sector remains a very important source of carbon dioxide (CO_2) emissions within the EU, being the largest contributor to nitrogen oxides (NOx) emissions and also significantly contributing to the total of particulate matter (PM) and total non-methane volatile organic compounds (NMVOCs) emissions (EEA, 2017a).

The Impact Pathway Approach to estimate monetary values of emission

According to (Korzhenevych, A., Dehnen, N., Bröcker, J., Holtkamp, M., Meier, H., Gibson, G., Varma, A. Cox, 2014), "the existing literature for efficient pricing mainly recommends a bottom-up approach following the Impact Pathway Approach (IPA) methodology".

IPA is one of the most important outcomes of the EU's External Costs of Energy and is often used to estimate monetary values of the negative external cost of emissions, being one of the most reliable instruments for quantifying the negative environmental cost of emissions.

Figure 14 shows the five steps included in the IPA framework.

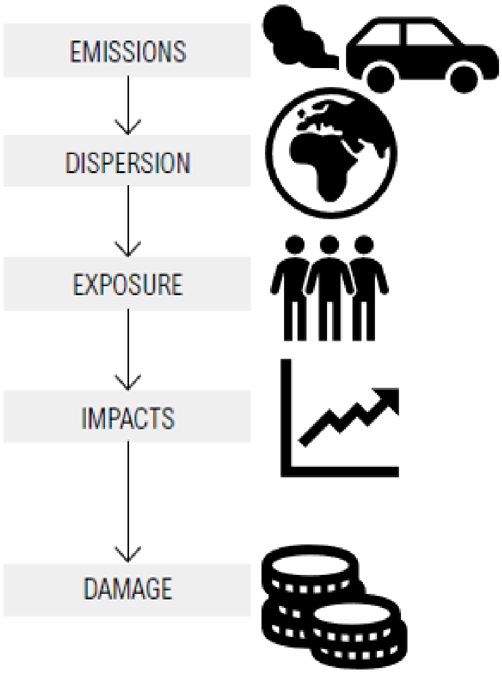


Figure 14 IPA framework: 1) emissions; 2) dispersion; 3) exposure; 4) impacts; and 5) damage

Such steps can be outlined as follows:

Step 1 Emission: Identify emission sources; estimate the amount of pollutants through applying transport emission model or emission factors. The amount is usually presented in pollutant mass (e.g., kilogram of CO_2).

Step 2 Dispersion: Simulate pathway of pollutant dispersion around emission sources through air pollutant monitoring and applying atmospheric dispersion models. The scenario of pollutant dispersion is difficult to build; the data accessibility is low. The level of air pollution dispersion is often expressed in concentration (e.g., µg/m3).

Step 3 Exposure: The impacts of transport air pollutant emissions are highly location-specific and depend on many factors, such as local traffic conditions. The exposure assessment therefore relates to the population and the ecosystem being exposed to the air pollutant emissions. Spatially detailed information (e.g., in the GIS) on population density and the geographical distribution of the ecosystem must be available to allow proper assessment.

Step 4 Impacts: The impacts caused by emissions are determined by applying so-called exposure-response functions that relate changes in human health and other environmental damages to unit changes in ambient concentrations of pollutants. These exposure-response relations are based on epidemiological studies. The relationship is often expressed in equations, such as "increased PM2.5 emissions (µg/m3) => cases of asthma".

Step 5 Damage (Cost): The impact of the emissions on humans and the ecosystem can be evaluated and transformed into monetary values. This step is often based on valuation studies assessing, such as the willingness to pay (WTP) for reduced health risks. This is the external cost that we will here express in the form of EUR.

Methodological approaches to estimate road transport emissions

Methodological choice for individual source categories is important in managing overall inventory quality. Emissions can be estimated at different levels of complexity. A tier represents a level of methodological complexity. Higher tiered methods are generally considered to be more accurate (European Environmental Agency - EEA, 2013). The following diagram presents a simple procedure to support the decision on which methodology is appropriate to be applied to estimate exhaust emissions derived from road transport.

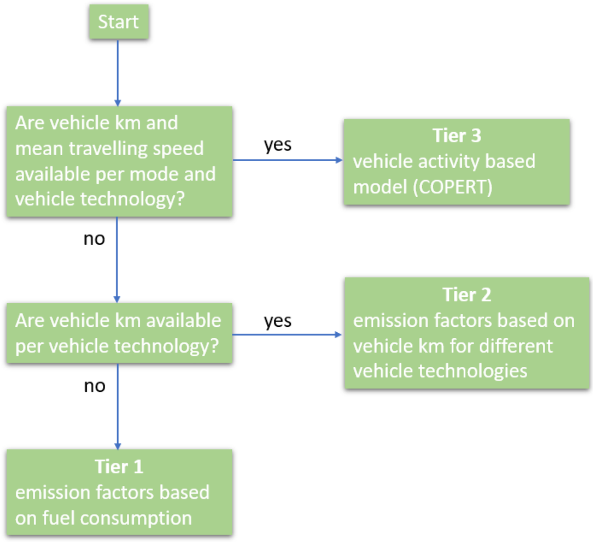


Figure 15 Decision tree for exhaust emissions from road transport

Exhaust emissions estimated using the Tier 1 approach are derived using the following expression:

$$E_i = \sum_j \sum_m FC_{j,m} EF_{i,j,m}$$

where E_i is the emission of pollutant i (g), $FC_{j,m}$ is the fuel consumption of vehicle category j using fuel m (kg), and $EF_{i,j,m}$ is the fuel consumption-specific emission factor of pollutant i for vehicle category j and fuel m (g/kg).

Tier 1 approach requires relevant fuel (gasoline, diesel, LPG and natural gas) statistics, i.e. the volumes (or weights) of fuel sold for road transport use, and for each type of fuel used. This methodology also requires that the fuel sales are disaggregated according to the four vehicle categories (passenger cars, light-duty vehicles, heavy-duty vehicles, and motorcycles/mopeds).

Exhaust emissions can be estimated using the Tier 2 approach by means of the expression:

$$E_{i,j} = \sum_k N_{j,k} M_{j,k} EF_{i,j,k}$$

where $E_{i,j}$ is the emission of pollutant i per vehicle of category j (g/vkm), $N_{j,k}$ is the number of vehicles in nation's fleet of category j and technology k, $M_{j,k}$ is the average annual distance driven per vehicle of category j and technology k (km/veh) and $EF_{i,j,k}$ is the technology-specific emission factor of pollutant i for vehicle category j and technology k (g/vkm).

Tier 2 approach considers the fuel used by different vehicle categories and their emission standards. The vehicle categories to be considered under the Tier 2 approach are passenger cars, light-duty vehicles, heavy-duty vehicles, and motorcycles and mopeds. Information on the number of vehicles and the annual mileage per technology (or the number of vehicle-km per technology) is needed.

Using the Tier 3 approach, exhaust emissions estimates results from a combination of technical and activity data. This type of methodology is more detailed than Tiers 1 and 2. Total emissions from road transport are derived as the sum of hot emissions (when the engine is at its normal operating temperature) and cold-start emissions (emissions during transient thermal engine operation.

$$E_{total} = E_{hot} + E_{cold}$$

where E_{total} is the total emissions of any pollutant (g), E_{hot} represents emissions during stabilised (hot) engine operation (g) and E_{cold} represents emissions during transient thermal engine operation - cold start (g).

Since vehicle emissions dependent on the engine operation conditions, it is expected a distinct emission performance under urban, rural and highway driving.

$$E_{total} = E_{urban} + E_{rural} + E_{highway}$$

where E_i, with $i = \{urban, rural, highway\}$, is the total emissions of any pollutant at driving mode i (g).

Total emissions are calculated by combining activity data for each vehicle category with appropriate emission factors. The emission factors vary according to the input data (driving situations, climatic conditions). Moreover, the Tier 3 methodologies also uses information on fuel consumption and fuel specification.

The following diagram presents the basic methodology behind the Tier 3 approach.

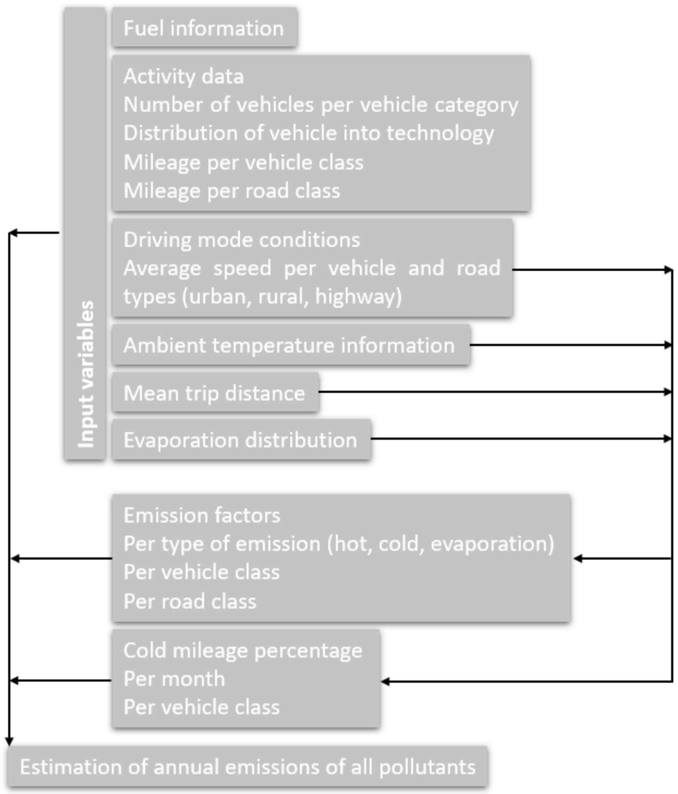


Figure 16 Basic framework for a Tier 3 approach

This methodology is incorporated into the software tool COPERT (COmputer Programme to calculate Emissions from Road Transport), which is widely used as a reference vehicle emission model in Europe (Emisia SA, 2017).

For a proper analysis of pollutant emissions, associated with road transport traffic, the computer software COPERT 4 can be easily used. The software was developed to perform evaluations of air pollutant and greenhouse gas emissions specific to road transport. It estimates emissions of all regulated air pollutants (CO, NO_X, VOC, PM) produced by different vehicle categories, and CO_2 emissions based on fuel consumption. The following figure illustrates the input variables in COPERT.

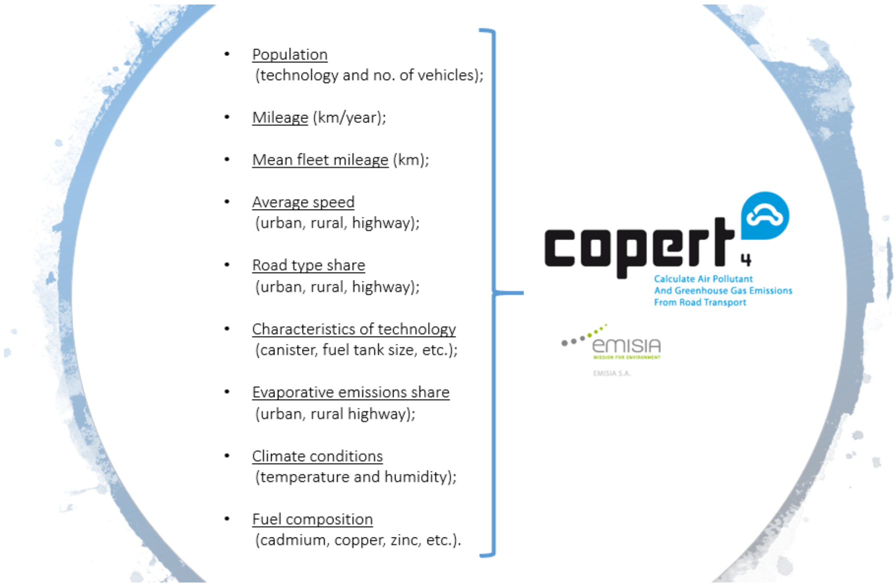


Figure 17 Input variables in COPERT

Methodological approaches to estimate road transport emission costs

Internalising the external costs of transport has been an important issue for policy development for many years in Europe. The final report for the European Commission - DG MOVE "Update of the Handbook on External Costs of Transport" (Korzhenevych, A., Dehnen, N., Bröcker, J., Holtkamp, M., Meier, H., Gibson, G., Varma, A. Cox, 2014) provides information on how to generate external cost values for different external cost categories, as a basis for the definition of internalisation policies such as efficient pricing schemes, including air pollution and climate change.

The impacts associated to the road traffic pollutant emissions can be monetized following the Impact Pathway Methodology. Each pollutant has a specific cost to society (Table 5), and given an amount of pollutant emissions, one can estimate based on the country characteristics by using a top-down methodology where average national data is used (Korzhenevych, A., Dehnen, N., Bröcker, J., Holtkamp, M., Meier, H., Gibson, G., Varma, A. Cox, 2014).

Damage costs of CO_2 are generally set to 90EUR per tonne for all countries and due to its adverse health effects, damage costs of PM are differentiated regarding the area and for PM costs estimation, the percentage of vehicle km by road type should be considered.

Table 5 Updated damage costs in € per tonne (2010)

	NOx	NMVOC	PM2.5 (exhaust and non-exhaust)			
Country	All areas	All areas	Urban	Suburban	Interurban	Motorway
Austria	17 285	2 025	215 079	67 839	37 766	37 766
Belgium	10 927	3 228	207 647	60 407	34 788	34 788
Bulgaria	14 454	756	212 875	65 635	34 862	34 862
Croatia	15 149	1 819	208 779	61 539	31 649	31 649
Cyprus	6 465	1 122	198 440	51 200	25 040	25 040
Czech Republic	15 788	1 648	215 667	68 427	43 028	43 028
Germany	17 039	1 858	220 461	73 221	48 583	48 583
Denmark	6 703	1 531	188 000	40 760	13 275	13 275
Estonia	5 221	1 115	197 188	49 948	15 359	15 359
Spain	4 964	1 135	195 252	48 012	14 429	14 429
Finland	3 328	781	191 237	43 997	8 292	8 292
France	13 052	1 695	211 795	64 555	33 303	33 303
Greece	3 851	854	197 845	50 605	19 329	19 329
Hungary	19 580	1 569	221 881	74 641	47 205	47 205
Ireland	5 688	1 398	194 660	47 420	16 512	16 512
Italy	10 824	1 242	197 361	50 121	24 562	24 562
Lithuania	10 790	1 511	202 775	55 535	23 068	23 068
Luxembourg	18 612	3 506	218 548	71 308	45 688	45 688
Latvia	8 109	1 499	200 878	53 638	19 528	19 528
Malta	1 983	1 007	98 132	NA	NA	NA
Netherlands	11 574	2 755	195 592	48 352	29 456	29 456
Poland	13 434	1 678	221 455	74 215	47 491	47 491
Portugal	1 957	1 048	196 335	49 095	18 371	18 371
Romania	22 893	1 796	231 620	84 380	56 405	56 405
Sweden	5 247	974	197 450	50 210	14 578	14 578
Slovenia	16 067	1 975	214 910	67 670	39 633	39 633
Slovakia	21 491	1 709	226 510	79 270	54 030	54 030
United Kingdom	6 576	1 780	194 751	47 511	14 026	14 026
EU	10 640	1 566	270 178	70 258	28 108	28 108

SOURCE:(Korzhenevych, A., Dehnen, N., Bröcker, J., Holtkamp, M., Meier, H., Gibson, G., Varma, A. Cox, 2014)
http://ec.europa.eu/transport/themes/sustainable/studies/doc/2014-handbook-external-costs-transport.pdf

Relative share of difference in emissions and traffic-related environment costs of CISMOB countries in average emissions in EU 28comparison with EU 28 Average

In terms of pollutant emissions, under the current adopted policies, the declining trend in emissions verified since 2005 is expected to continue until 2030, but it is expected that the cost of air pollution from road transport will remain high, due to congestion and an expected growing demand for transport.

The following figure gives us an insight of current situation of CISMOB Partnership Regions (latest available data - 2014) in terms of road transport-related pollutant emissions and associated costs.

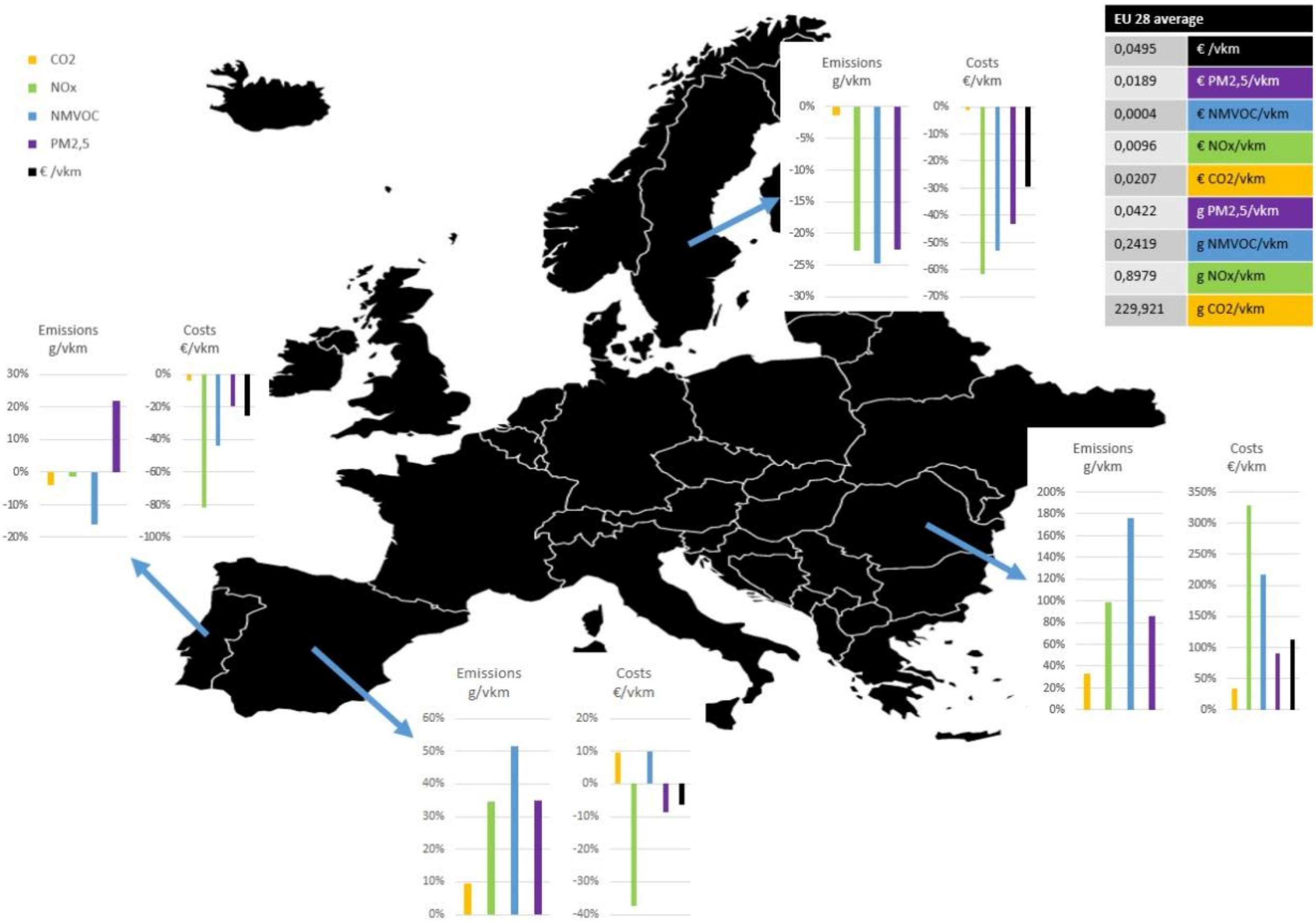


Figure 18 Relative share of difference in emissions and traffic-related environment costs of CISMOB countries in average emissions in EU 28 comparison with EU 28 Average

For the calculation of the total emissions COPERT 4 v11.4 emission calculation tool was used, while the total emission costs per km of each pollutant were calculated based on updated values of damage costs (€ per tonne, 2010) based on the Impact Pathway Approach (IPA) described in (Korzhenevych, A., Dehnen, N., Bröcker, J., Holtkamp, M., Meier, H., Gibson, G., Varma, A. Cox, 2014).

A first observation is that Sweden has by far lower emissions than the remaing countries, while Spain and Romania present higher levels comparing to EU-28 average. In case of Spain, a possible reason may be due to the large size of the national vehicle fleet, while in case of Romania, these results can be justified by possibly presence of older vehicles in roads. Romania also presente compelling results, since its total emissions of NO_X and PM2.5 are almost the double when comparing to EU-28 average and presents approximately 180% more in NMVOCs. Comparing to EU-28 average, Portugal presents around 20% more emissions for PM2.5.

Regarding the relative share of emission costs, Sweden and Portugal present lower costs than EU-28 average for all pollutants. In particular, Portugal presents 80% costs concerning NO_X.

GOOD PRACTICES ON LOW CARBON AND SUSTAINABLE MOBILITY

During the 1st phase of the CISMOB Project, partners sought to bring together efforts to get involved in CISMOB activities related to exchange and share of experience. In particular, the staff exchange meetings were crucial for deep analysis of each CISMOB Region, highlighting differences, weaknesses, opportunities, strengths and threats regarding possible solutions to drive policy change towards more sustainable mobility schemes and decarbonisation strategies by using ICT. All the regional and interregional cooperation permit to identify, share and transfer methodologies, processes and good practices in improving, developing and implementing low-carbon policy measures among the regions. Several staff exchange meetings were carried out and many good practices from partners' countries were identified. Most of them are reported in the following table.

Table 6 Best practices identified between partners countries

Good practice	Description	Scope (local, regional, national)	Country
Trafiklab - Together we create the future of public transport	Trafiklab is a community for open traffic data, made to inspire and foster transport entrepreneurship	Local, Rural, Urban, Metropolitan areas, Regional, National.	Sweden
Not Boring 5G Bike	World's first 5G connected bike	Urban/regional	Sweden
U-BIKE PORTUGAL – rental bicycles for the academic community	U-BIKE project aims to promote soft mobility (in particular, cycling) among the academic community of Portugal	Urban	Portugal
Timisoara Public Transport Management System - PTMS	RATT manages an integrated PTM system for its fleet of buses, trolley-buses and trams providing real-time information on-board and in stops and e-ticketing	Urban, Metropolitan areas	Romania
Real-time crowding information –positive impacts on metro trains	Real-time crowding information consists in providing passengers with information on the load of the metro trains.	Urban, Metropolitan areas	Sweden
MOBI.E - electric charge stations	MOBI.E electric mobility model is a fully integrated and interoperable system, multi-retailer and multi-operator. Network is composed of charging stations for electric vehicles located in spaces of public access.	National - International	Portugal
Solar powered E-paper technology screens for real time public transport information	Solar powered E-paper screens give real time information about public transport in Coimbra.	Local, Urban, Metropolitan areas	Portugal
Opendata Cáceres	Open data platform about public transportation serving the Cáceres population	Local, Urban, Metropolitan áreas, Regional and National	Spain

Urban ICT Arena - An open ICTs and co-creation arena and testbed	Urban ICT Arena is an open ICTs and co-creation arena and testbed in an urban environment developing, testing and showcasing possibilities for digitalization.	Regional	Sweden
RESPLUS – Sweden's largest ticket cooperation	It is a smart ticketing system that includes combined tickets for all long-distance train traffic, regional and local trains, trams and the underground as well as a broad selection of both commercial bus and boat transport	National	Sweden
Via Verde	Electronic fee collection	National	Portugal
Destineo	Journey planner	Regional	France
Transport for London	Journey planner	Local	United Kingdom
E-ticket	Card that combines travel and social services (smart ticketing)	Local	Latvia
OV-Chipkaart	Contactless smart card system used for all public transport in Netherlands (smart ticketing)	National	Netherlands
Mobib-pass	Smart card that can be used to access public transport and hire bicycles (smart ticketing)	Local	Belgium
Navigo	Multimodal smart card for public transport in Paris (smart ticketing)	Local	France
T:card	Smart card that can be used to access buses, trams and regional coaches (smart ticketing)	Regional	Norway
ATI - Saluzzo	Comprehensive public transport system combining electronic ticketing system with Automatic Vehicle Location (AVL) system, managing effectively over 400 buses	Local	Italy
Part for Truro	Dedicated park and ride service for city center visitors. Buses equipped with AVL systems providing passengers the exact time of their arrival	Local	United Kingdom

Sabimos	Travel information system using AVL technologies with traffic intersection priority system, providing real-time information about trains, regional and city buses to travelers and transport companies	Local	Netherlands
AutoPass	Uses electronic radio transmitters, allowing road tolls collection automatically from cars	National	Norway
Milano Area C	A combined Low Emission Zone and urban road charging scheme, where vehicles entering the Area are detected by a system of 43 electronic gates equipped with Automatic Number Plate Recognition technology	Local	Italy
Stockholm Congestion Charge	Payment is allowed by direct debit triggered by the recognition of the on-board electronic tag that is loaned to drivers	Local	Sweden
SFPark	Smart parking: sensors and wireless communication technologies provide real time information on available parking spots	Local	San Francisco, United States
Swansea Project	Project aimed to develop a working traffic emissions forecast model (Nowcaster) that would have the ability to estimate air quality conditions in advance, contributing in a more efficient traffic management control	Local	United Kingdom
Leicester Area Traffic Control Centre	Deploys 13 pollution monitors as traffic management tool	Local	United Kingdom
AID system	Automatic Incident Detection, improved the traffic flow and reduced travel time by detecting immediately stopped or slow driving vehicles inside the tunnel and larger objects on the pavement	Local	Denmark

Vélib	Smart bike-sharing system with over 23.600 bikes and almost 1.800 stations. The system is easily accessible as bike stations are found every 300 meters and you can buy tickets online of at any station	Local	France
Bicing	Highly accessible bike sharing service and an important part of the public transport system in the city of Barcelona with around 6.000 bikes, 400 stations every 300 m and the possibility of using also electric bikes	Local	Spain

ICT towards low carbon and sustainable mobility
A multiscale perspective

PROMOTING CO_2 REDUCTIONS AND ICT PENETRATION IN POLICY INSTRUMENTS

This section is divided into three main subsections. The first is devoted to analyzing how decarbonization targets (CO_2 impacts) of new projects are currently evaluated by ERDF Policy Instruments of CISMOB regions that have specific calls related to sustainable mobility. Moreover, the analysis takes also into consideration current methods to promote ICT penetration and intermodality. In the second part, we provide an approach to estimate project impacts in a more realistic way. Finally, a set of different potential measures would be evaluated under these criteria.

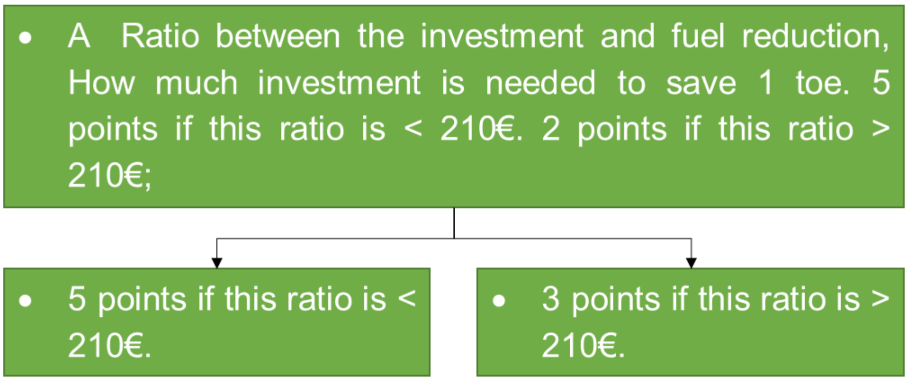
How the merit of a Project is evaluated

CENTRO 2020

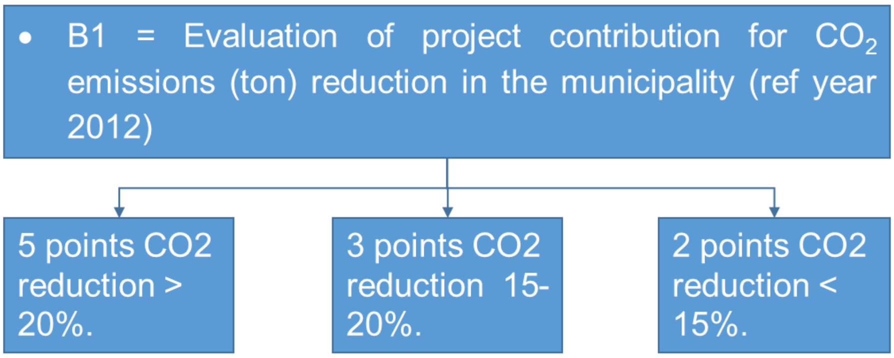
The merit of a project for CENTRO 2020 (CENTRO2020, n.d.) is evaluated through an expression depending on the project typology:

Typology	Expression (merit)
Construction of pedestrian and cyclist paths	MERIT = 0,20 A + 0,25 B1 + 0,15 B2 + 0,10 B3 + 0,10 B4.1 + 0,2 C
Intelligent Transport Systems implementation	MERIT = 0,20 A + 0,25 B1 + 0,10 B2 + 0,10 B3 + 0,15 B4.2 + 0,2 C
Public transport	MERIT = 0,20 A + 0,25 B1 + 0,15 B2 + 0,10 B3 + 0,10 B4.3 + 0,2 C

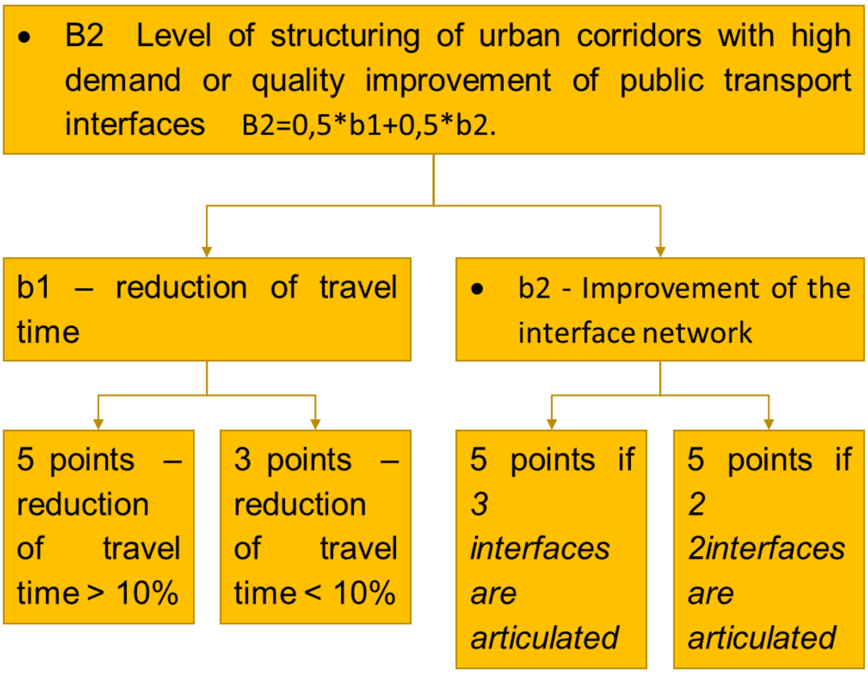
An important criterion indirectly related to carbon emissions is the economic rationality. In OP Centro 2020 the economic rationality of the actions being evaluated is assessed through the ratio between investment and consumption (toe) resulting from the implementation of the project operation.



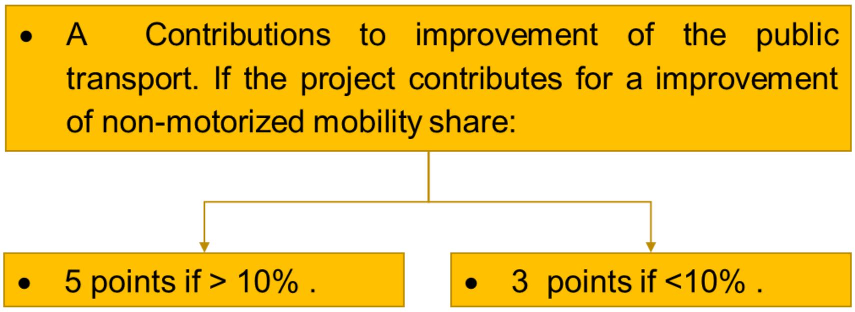
Contribution of the actions planned in the operation to the goals set in the outcome indicators defined for the Investment Priority, assessed through the potential of reduction of greenhouse gases as evidenced by the following method:



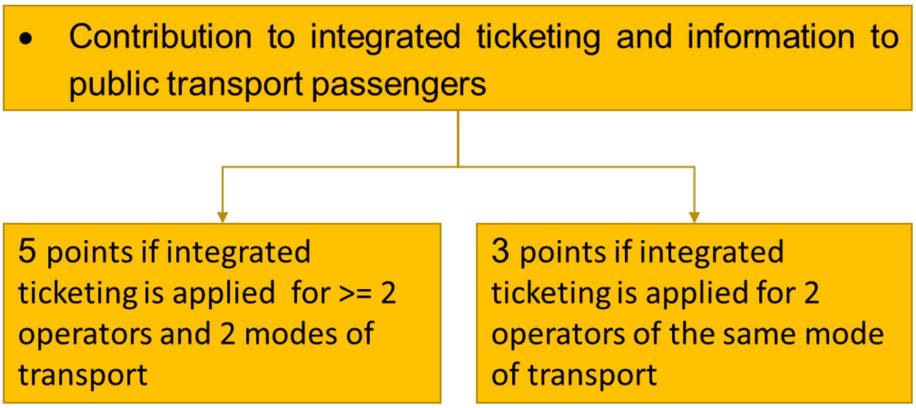
Promotion of intermodality and quality improvement of public transport is valued according the following criteria:



The contribution for the reinforcement of collective public passenger transport and integration in all modes, is assessed in terms of potential increase in the share of non-motorized mobility, namely public passenger transport and soft modes according to the following method:



For Intelligent Transport Systems:



- A = Ratio between the investment and fuel reduction, basically how much investment is needed to save 1 toe. 5 points if this ratio is < 210€. 2 points if this ratio > 210€;
- B1 = Evaluation of CO_2 reduction. 5 points if the project contributes to a CO_2 reduction (ton) above 20%. 3 points if the project contributes to a CO_2 reduction between 20% and 15%. 2 points if the projects contribute to a CO_2 reduction below 15%. The reference year is 2012.
- B2 = Level of structuring of urban corridors with high demand or quality improvement of public transport interfaces, calculated by: B2=0,5*b1+0,5*b2. Where b1= reduction of time (travel, waiting), 5 points if a reduction above 10%, 3 points if below 10%; b2= Improvement of the interface network, 5 points if three interfaces are articulated (bicycle path, roads and railroads), 3 points if two interfaces are articulated (bicycle path, roads and/or railroads).
- B3 = Inhabitants. 5 points if the project is implemented in a county with more than 60.000 inhab. 3 points if the project is implemented in a county with a population between 45.000 and 60.000 inhab. 2 points when the project is implemented in a county with less than 45.000 inhab.
- B4.2 = Contribution to integrated ticketing and information to public transport passengers. 5 points if integrated ticketing for at least 2 operators and 2 modes of transport (roads and railroads). 3 points if integrated ticketing for 2 operators of the same mode of transport (roads or railroads).
- C = Geographical coverage of the operation. 5 points when between two or more counties. 3 points if within a county. 2 points if local.

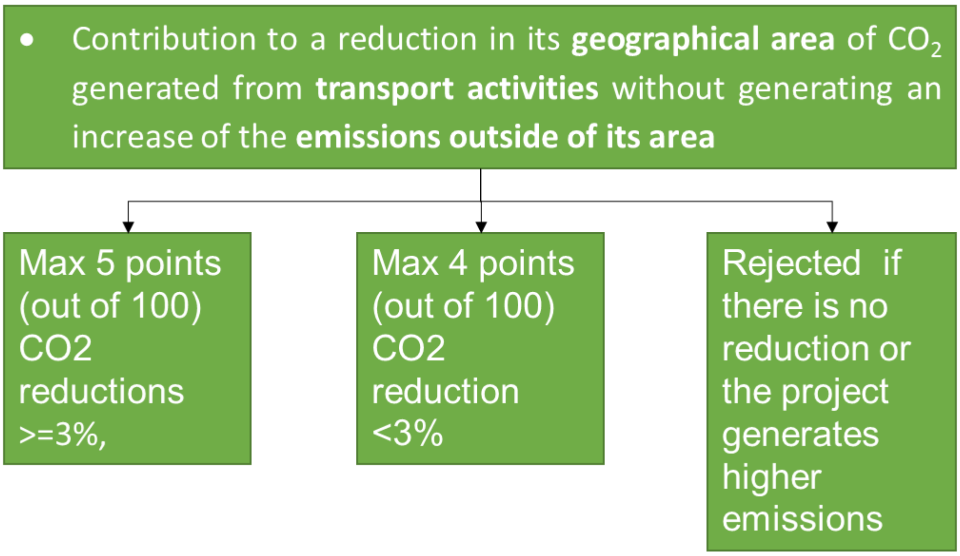
For public transport:

- A = Ratio between the investment and fuel reduction, basically how much investment is needed to save 1 tep. 5 points if this ratio is < 210€. 2 points if this ratio > 210€;
- B1 = Evaluation of CO_2 reduction. 5 points if the project contributes to a CO_2 reduction (ton) above 20%. 3 points if the project contributes to a CO_2 reduction between 20% and 15%. 2 points if the projects contribute to a CO_2 reduction below 15%. The reference year is 2012.
- B2 = Level of structuring of urban corridors with high demand or quality improvement of public transport interfaces, calculated by: B2=0,5*b1+0,5*b2. Where b1= reduction of time (travel, waiting), 5 points if a reduction above 10%, 3 points if below 10%; b2= Improvement of the interface network, 5 points if three interfaces are articulated (bicycle path, roads and railroads), 3 points if two interfaces are articulated (bicycle path, roads and/or railroads).

- B3 = Inhabitants. 5 points if the project is implemented in a county with more than 60.000 inhab. 3 points if the project is implemented in a county with a population between 45.000 and 60.000 inhab. 2 points when the project is implemented in a county with less than 45.000 inhab.
- B4.3 = Contributions to improvement of the public transport. 5 points if the project contributes for a reduction of non-motorized mobility above 10%. 3 points if the project contributes for a reduction of non-motorized mobility below 10%.
- C = Geographical coverage of the operation. 5 points when between two or more counties. 3 points if within a county. 2 points if local.

ROMANIA 2020

Operational Programme Romania 2020 uses a multi-criteria grid for technical and financial assessment of the projects submitted for financing under Specific Objective 4.1 of OPR, the one that targets CO_2 reduction. Regarding CO_2 emissions, the scoring is:



The reduction of CO_2 is to be estimated based on the comparison between "do nothing scenario" and "implement project scenario" in the first year of implementation.

The project proposals are provided with and have to use an Excel tool that allows to estimate CO_2 emissions based on traffic data. In the evaluation grid one can also get a maximum of 2 points (out of 100) if the data from the traffic study are sound are properly input into the Excel tool.


HUNGER?
BURGER KING

Estimating Project Impacts and Comparison grid evaluation framework of Policy Intruments

In order to promote a low carbon economy in the transport sector, regional Policy Instruments should set ambitious targets related to CO_2 emission savings. However, they must be realistic regarding the actual capability of individual projects to contribute directly to carbon reductions. By evaluating projects of different scales observed during interregional cooperation we will observe how CO_2 reductions would be valued in different Policy Intruments equivalent of Operational Programmes.

The objective of this chapter is not to provide accurate figures associated with the implementation of sustainable mobility actions, but rather a realistic approximation of the order of magnitude of investments and potential carbon reductions, in order to support the definition of ambitious but achievable targets in policy intruments. The three measures addressed in this document are inspired in GPs identified among the regions involved in the CISMOB Project.

Metropolitan areas – Congestion charging system

In first scenario, we examine the potential implementation of a congestion charging system in the region of Bucharest - Ilfov. Bucharest is one of the most congested cities in the world, with drivers in the Romanian capital expecting to spend an average of 57 minutes of extra travel due to traffic anytime of the day (TomTom, 2017). In this case, we assume impact would be similar to the Congestion Charging System of Stockholm in terms of reduction in carbon dioxide emissions. Both regions have almost the same population (Eurostat, 2016) and number of registered vehicles (INSSE, 2017; SCS, 2017), (Emisia SA, 2017). Furthermore, the expected effect (14% reduction in carbon dioxide emissions and 2-3% in county region) is an acceptable value, as we have already mentioned above.

Based on Stockholm example, Table 7 explores potential impacts of applying similar measures in the city of Bucharest. Obviously, the success of this measure, among other factors, will be dependent on local pricing policies, controlled zone perimeter and offer of alternative modes.

Table 7 Estimation of potential impacts of implementing a congestion charging system in a metropolitan area

Parameters	Value	Unit
CO_2 transport related emissions - baseline scenario[1]	3 384 821	ton
Estimated CO_2 emissions (all sectors – assuming transport represents 25%)	13 539 284	ton
CO_2 emissins savings inside coordon toll	14	%
Realtive CO_2 emissins savings in the municipality	3	%
CO_2 transport related emissions savings	101 545	ton
Relative CO_2 emissions savings considering all sectors	0,75	%
Investment[2]	309	MEUR
Annual TOE savings	33 400	ton
Initial Investment per TOE saved per year	9 251	EUR/toe
Initial Investment per TOE saved over 10 years	925	EUR/toe

[1] https://www.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1508324219.pdf
[2] https://www.c40.org/case_studies/stockholm-to-introduce-congestion-charge-trial-cut-co2-by-14-traffic-by-25

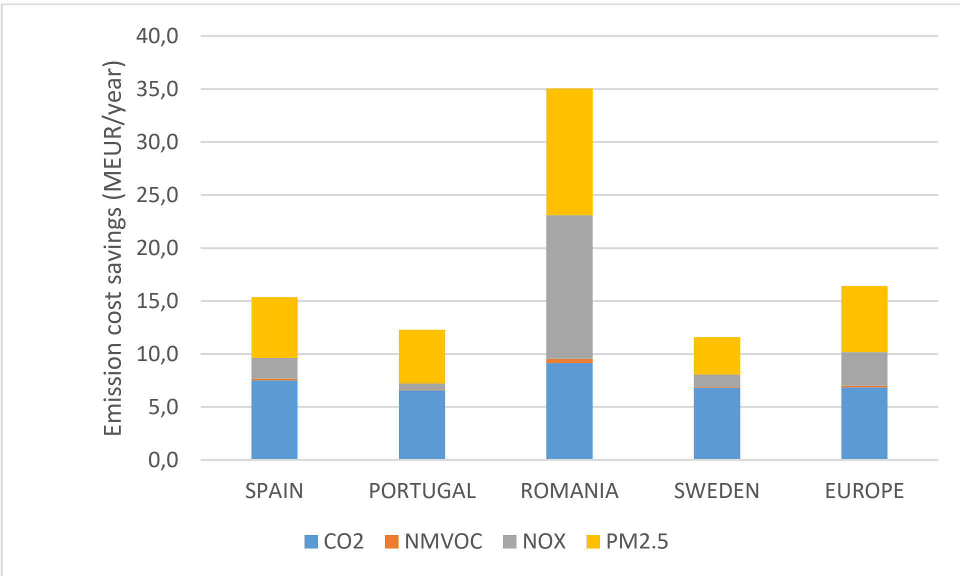


Figure 19 Example of annual external cost savings (in Million EUR) related to emissions due to the reduction of traffic caused by a congestion charching system (traffic fleet and activity data (EMISIA, 2014)

Figure 19 explains to what extent this measure (assuming similar traffic reductions) would contribute to reducing the economic costs related to emissions in different countries of the consortium CISMOB and Europe 28.

In addition to GHG (CO_2), local pollutants such as NO_X and PM have a very significant impact. These numbers suggest these factors should be taken into account in the evaluation of sustainable mobility projects.

Medium-sized city – Real time information for public transport

Real-time information for public transport (RTIPT) is increasingly distributed directly to passengers via signage at stops, stations or through web-enabled or mobile devices.

A main contribution frequently mentioned is the efficiency improvement via the reduction in perceived waiting times for buses. There is a complex relationship between transit information and transit use, but 2% is a frequent reported value related to the impacts of real-time information on transit use (ridership increase) (Brakewood & Watkins, 2018) .

Having as inspiration the platform for real time information for public transport in the medium-sized city of Coimbra, in Centro Region of Portugal, Table X provides an estimate of impacts the implementation of this measure. It should be noted that the presented values result from merely applying an approximate approach based on average values reported in the literature and assumptions of the authors.

Table 8 Assumptions for estimating impacts of RTIPT in a medium-sized city

Real Time Information platform for public Transport	Value	Unit
Passagner.km.ano	47 780 000	Passenger.km/year
Increase in risdership due to project implementation	2	%
Increase in risdership motivated by new demand and transfer from soft modes	50	%
Increase in risdership from private vehicles	50	%
Avoided distance travelled per year in private vehicles	477 800	km/year
Avoided distance travelled per year in Diesel Cars	286 680	km/year
Avoided distance travelled per year in Gasoline Cars	191 120	km/year

Table 9 Estimation of expected emissions and energy savings due to avoided trips in private vehicles due to RTIPT in a medium-sized city

Expected emissions and energy savings	Avoided trips in private vehicles			
	Diesel	Gasoline	Total	Unit
Fuel Consumption	6	8		(l/100 km)
Avoided distance travelled per year	286 680	191 120	477 800	(km/year)
Avoided fuel consumption per year	**17 201**	**15 290**	32 490	(l/year)
Fuel density	0,83	0,72		(kg/l)
Avoided fuel consumption per year	14,2	11,0	25	(ton/year)
Tonne oil equivalent conversion factor	1,045	1,14		
Avoided tonne of oil equivalent per year	**15**	**13**	27	(toe/year)
Conversion factor	3,0982	2,8973		(ton CO_2/toe)
Avoided CO_2 emission	46	36	83	(ton/year)

Table 10 Key perfomance indicators of RTIPT

Key perfomance indicators	Value	Unit
CO_2 transport related emissions - baseline scenario[1]	192 607,0446	ton
Estimated CO_2 emissions (all sectors – assuming transport represents 25%)	770 428,1784	ton
Investment	488 000	EUR
Investment per toe saved per year	**17 766**	**EUR**
Investment per toe saved over 10 years	1777	EUR
Realtive CO_2 emissins savings in the municipality	0,01	%
Relative CO_2 transport related emissions savings	0,04	%

Figure 20 Real time information schedules on an outdoor e-paper technology and solar energy panel

Small town – Electric-bikes sharing system

As another example, we will explore the potential relative impact of implementing a small-scale project of electric bicycles similar to the existing one in the city of Águeda, Portugal. Annual emissions can be estimated based on different methodologies, such as explained in the section Methodological approaches to estimate road transport emissions.

Bike share's effectiveness is dependent on whether it replaces car use. An implicit assumption that associates bike share use with car use reduction has emerged, despite evidence showing that only a minority of bike share journeys are substituting private vehicle trips (ranging from 2% in London to 21% in Brisbane) (Fishman, Washington, & Haworth, 2014).

Due to the lack of information on the substitution mode in the case of electric bikes sharing systems, we will assume this value will be substantially higher considering the possibility of making greater distances. We also assume implementation of these systems in small communities where public transport offer is limited; it is plausible to assume 50% of trips taken on e-bikes are substituting a private car mode.

Table 11 describes the study assumptions and provide an estimate of impacts the implementation of this measure. It should be noted that the presented values are merely an approximate estimate based on average values reported in the literature and assumptions of the authors.

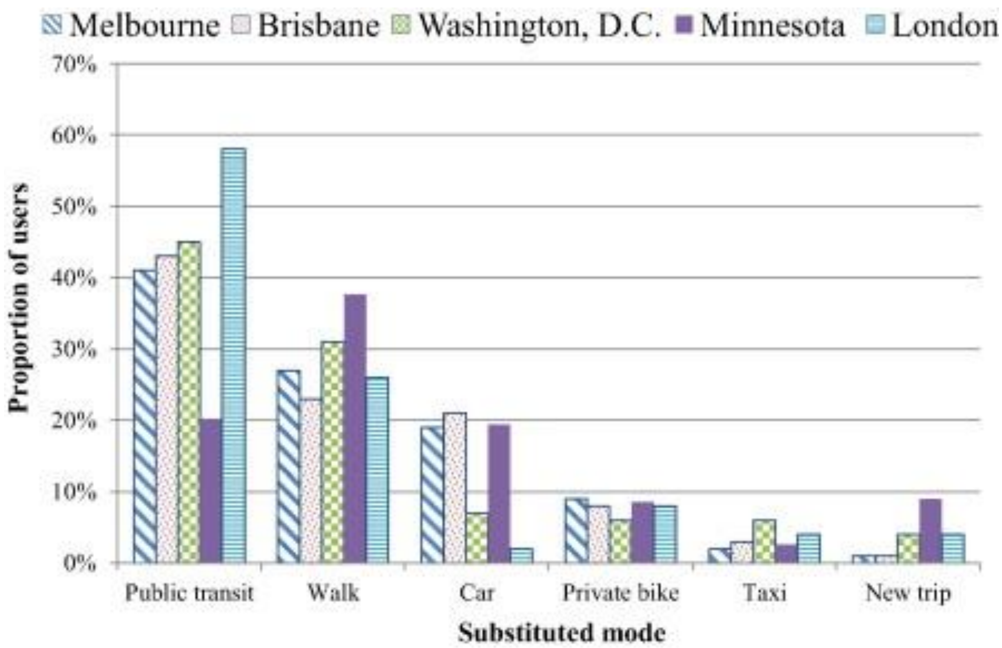


Figure 21 Mode substitution in selected cities (Bike share' s impact on car use: Evidence from the United States, Great Britain, and Australia) SOURCE: (Fishman et al., 2014).

Table 11 Assumptions for estimating impacts of a e-bike sharing system in in a small-sized city

E-bike sharing system - Assumptions	Value	Units
E-bike fleet distance travelled	10	#
Annual Distance travelled per bike	1 500	km/year
Annual Distance travelled	15 000	km/ year
Distance travelled per KWh consumed	160	km/kWh
Annual KWh consumed	93,75	kW.h
CO_2 emissions por kWh	0,187	kg/kW.h
Annual CO_2 emissions of bike sharing system	17,5	kg
Factor related to new demand and transfer from public transport and soft modes	0,5	
Factor related to modal transfer from private vehicles	0,5	
Avoided distance travelled per year (km/year)	7 500	km/year
Avoided distance travelled per year in Diesel Cars (km/year)	4 500	km/year
Avoided distance travelled per year Gasoline Cars (km/year)	3 000	km/year

Table 12 Estimation of expected emissions and energy savings due to an implementation of e-bike sharing system in in a small-sized city

Expected emissions and energy savings	Avoid trips in private vehicles			
	Diesel	Gasoline	Total	Units
Fuel Consumption	6	8		(l/100 km)
Avoided distance travelled per year	4 500	3 000	7 500	(km/year)
Avoided fuel consumption per year	**270**	**240**	510	(L/year)
Fuel density	0,83	0,72		(kg/l)
Avoided fuel consumption per year	0,2241	0,1728	0	(ton/year)
Tonne oil equivalent conversion factor	1,045	1,14		
Avoided tonne of oil equivalent per year	**0,234**	**0,197**	0,431	(toe/year)
Conversion factor	3,0982	2,8973		(ton CO_2/toe)
Avoided CO_2 emission	0,726	0,571	1,296	(ton/year)

Table 13 Key perfomance indicators releted to an implementation of a small e-bike sharing system

Key perfomance indicators	Value	Unit
CO_2 transport related emissions - baseline scenario[1]	68 808	ton
Estimated CO_2 emissions (all sectors – assuming transport represents 25%)	275 232	ton
Investment	15 000	EUR
Investment per toe saved per year	**11 571**	**EUR**
Investment per toe saved over 10 years	1 157	EUR
Realtive CO_2 emissins savings in the municipality	0,0005	%
Relative CO_2 transport related emissions savings	0,0019	%

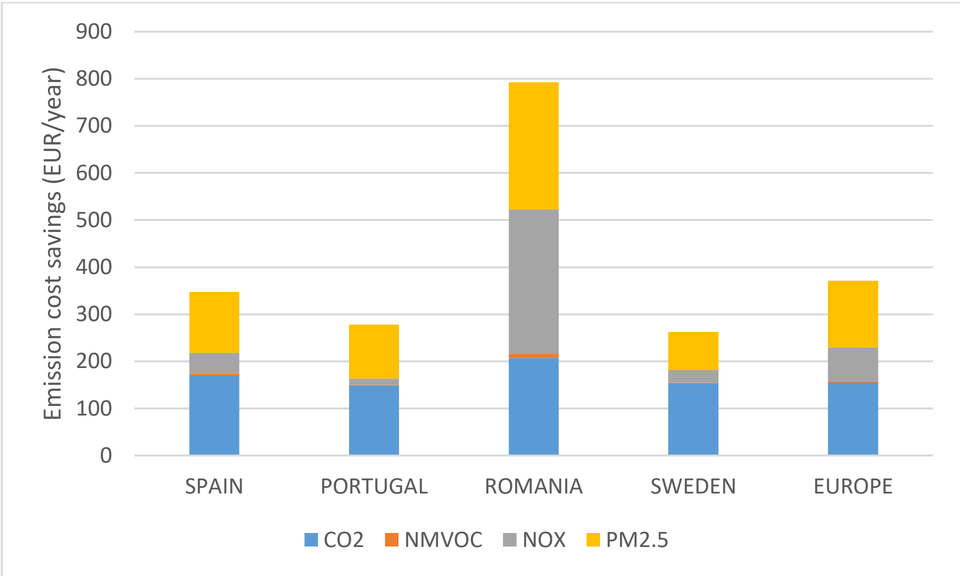


Figure 22 Example of annual external costs savings related to emissions due to the reduction of traffic motivated by a e-bike sharing system (traffic fleet and activity data (EMISIA, 2014))

Figure 22 aims to provide an estimate of the order of magnitude of environmental gains due to the reduction of traffic and consequent economic costs associated with the negative externalities of emissions in different regions.

The costs of noise, congestion/travel time, infrastructure detection and occupation of urban space must also be added. In this way, CO_2 emissions, although relevant, are only a small fraction of the negative externalities of the transport sector.

FINAL NOTES

Improving Policy Instruments – lessons from Interregional cooperation

ICT tools play a key role in minimizing transport-related externalities. For instance, digital technologies are an essential tool for creating a multimodal transport system. Cooperative intelligent transport systems (C-ITS) allow road users and traffic managers to share information and use it to coordinate their actions. Regional and national policy instruments should be adopted to promote a fully integrated intermodal approach between all transport services regardless of the geographic location of the beginning and end of each trip.

The examples analized in this AGENDA have demonstrated that even large-scale projects such as the implementation of a congestion charing system in a metropolitan araa was able to minimize tons of CO_2 emissions per year, however these values are relatively low when compared to the project evaluation framework expectations, in particular regarding to CO_2 reductions. This is particulary evident in CENTRO 2020 when the assessment gird is based on scoring projects for CO_2 reduction limits taking into accout the following reduction thesholds: higher than 20%, between 15 and 20% and less than 15%.

While it may be argued that is positive to set ambitious targets related to CO_2 emissions reductions, the definition of unrealistic thresholds in evaluating projects has the following risks:

- Promoters can see such goals as unattainable and neglect CO_2 emissions as a real objective of the project;
- Promoters may tend to overestimate potential reductions based on unrealistic assumptions;
- Too ambitious and unfounded expectations can be created in relation to the operational programme ability to foster a low carbon economy in the transport sector;
- The budget allocated to intelligent transport systems can be undervalued.

However, it has also been observed that, in addition to CO_2, other impacts resulting from the decrease in the use of individual transport are also very importante. In this way, projects can be valued by taking a more holistic view of their benefits including other factors such as noise reduction, increased safety and improved air quality (mainly NOx and PM2.5). The relative costs associated with emissions of these pollutants to the various countries of the CISMOB and EU28 consortium can be important auxiliary tools to improve the way projects are being evaluated.

It is also important to value the capacity of each indivual project to establish positive synergies with other projects. Thus, capacity for integration and interoperability with other projects (or measures already implemented) can be another factor for the summative evaluation gird of assemennt project evalaution.

Potential solutions

Information and Communication Technologies can play a significant role in the construction of the new and future smart cities (Papa et al., 2017). Some potential solutions regarding the usage of ICT have been described:

- Multimodal Journey Planners:

Consists in a platform that allows the user to plan their journey door-to-door taking in account all the modes of transportation available. (for example, Trafiken in Sweden). Relevant information can be found here and here.

- In-Vehicle Information Systems:

Gives important information such as navigational and traffic information to the driver without disturbing him, through, for example, in-built systems in the vehicle (here).

- Smart Ticketing:

Smart ticketing consists in an electronic ticketing scheme that can easily be used through smart cards of mobile phones here.

- Real-time Passenger Information

Real-time passenger information can be given through devices (smartphone apps, panels, ...) that give to passengers' valuable information (like how many time is left until the next bus arrives, how many seats are available, ...) about public transport.

- Mobility as a servise

Encompasses registration, routing, booking and invoicing for several transport modes (public transport, taxis, station-based and free-floating car-sharing). ICT should support passagners the possibility to tailor their individual needs.

- Automatic Vehicle Location

A device that is able to give the geographic location of a vehicle in real-time.

- Electronic Fee Collection

Aims to reduce the delay time when paying a toll thus reducing congestion and the emission of pollutants. Consists in an electronic device that charges automatically the respective toll.

- Smart Parking

Informs the passengers how many slots are available and where they are through for example a smartphone app

- Traffic Signal Control

One of the first electronic devices to be implemented worldwide in the cities, can be used to make a smooth management of traffic.

- Pollution Monitors

Real-time data about vehicles emissions. Can be used to reorganize traffic in order to decrease air pollution.

- Automatic Incident Detection

Real-time information about road accidents. May improve safety and traffic flow.

- Cooperative Vehicle Systems

This system enables the interaction between vehicles, is regarded has the main direction of the future ITS.

- Automated Vehicles

Automated vehicles have the potential to change the present and future of transportation. Taking advantage of the numerous ITS devices and applications, automated vehicles could be used to mitigate road accidents, emissions, travel time and congestion.

- Bicycle Sharing Schemes

Bicycles can be used has an alternative to the usual and more polluting modes of transport like passenger cars for daily commuters. Bicycle sharing schemes aims to fill this gap by making available bicycles to anyone that wishes to perform short-medium trips inside a city.

Transition to low carbon mobility - conclusion

Transport systems guide our mobility and provide access to jobs, education, and social interactions, which are fundamental to human development (Philp & Taylor, 2017).

Most cities suffer from air pollution which is mainly caused by emissions from private vehicles. There is evidence of increased health effects linked to proximity to roads. Transition to low carbon mobility will benefit environment and improve air quality related to passenger mobility, which will allow to avoid premature deaths and preventing several health issues, such as lung cancers, chronic bronchitis and asthma. Moreover, availability of new technologies and powertrains present opportunities to improve the competitiveness of the industry. City development plan should integrate transport planning with safety, social inclusivity, reduced air pollution, and carbon dioxide emissions. A sustainable low carbon transport sector is essential for building better and cleaner cities and, therefore plays a key role in implementing the Paris Agreement on Climate Change as well as the achievement of the 2030 Development Agenda of the Sustainable Development Goals. Changing the way urban and transport planning is undertaken is very important, thus, an efficient strategy for reducing transport-related carbon emissions involves innovation, influence and investment, and policy interventions impacts should be analysed in detail.

- Planning
  Inclusion of low carbon mobility issues and climate change considerations in urban transport policy measures.

- Promoting holistic approaches
  Provide a framework of indicators to assess and inform the costs and benefits of environmentally effectiveness of different mobility solutions.

- Promoting low carbon mobility solutions
  Prioritize shifts to sustainable transport modes and reduce environmental impacts;
  Provision of financing and incentive mechanisms;
  Low carbon mobility policies directed at achieving widespread behavior change;
  Investment for new technology deployment or development and its application.

- Investment in grids and charging stations
  Sufficient publicly accessible charging infrastructure.

The above points are key enablers for the accelerated uptake of low-carbon mobility. Good planning practices with political will and institutional capability will allow low-carbon mobility to become a reality (Philp & Taylor, 2017). Tools for informed decision making, including modeling, measurement, visualization, and especially assessment, are fundamental for a transition to low carbon mobility.

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