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Impact of ITS Measures Towards Reaching Emissions Targets

ABSTRACT

This paper studies the impacts of different actions taken to reduce greenhouse gas emissions from transport and logistics and analyses how the effectiveness of these actions has been assessed. The objective is to identify the potential of ITS from an environmental point of view as well as the importance of assessing and evaluating it. The focus of the paper is on intelligent transport systems and services (ITS) and utilisation of information and communications technology (ICT) in road transport. The influence of ITS is typically realised more from being an enhancing tool rather than a complete solution. A literature review provides an overview of the impacts on CO_2 emissions of ITS solutions targeting different problems. The relevance of assessing and evaluating the environmental impacts is analysed by considering the jointly agreed greenhouse gas emissions targets within the European Union. The impact of ITS measures depends on various factors, including population density and climate. As an example of less generalised estimates, assessments for conditions in Finland are presented. Impact evaluation for implemented solutions is important not only for finding the most efficient ways to reduce emissions but also, perhaps more significantly, to find concrete incentives and arguments for authorities, companies and private people to invest in the solutions – namely, saved money and time.

Keywords: ITS, greenhouse gas emissions, ICT, transport, impact evaluation

1 INTRODUCTION

Transport is the second largest source of greenhouse gas (GHG) emissions, just behind energy. Between 1990 and 2011, emissions from road transport have increased by 21%, now producing about 23% of the total CO_2 emissions in the EU (European Environment Agency, 2013). In Finland, transportation has been responsible for 18–20% of the total GHG emissions each year between 2005 and 2010 (Statistics Finland, 2012).

The most significant factor in the amount of emissions from transport is the quantity of traffic. Other components, such as mode of transportation, fuel type, fuel efficiency, route efficiency and idling time, define the amount of emissions per distance travelled. Technical improvements on vehicle efficiency, fuel consumption and fuel efficiency are widely researched and the fuel efficiency of passenger car transport is considered the main reason for CO_2 emission decrease in road transport since 1995 (European Environment Agency, 2011a). Trials and studies have also found replacing gasoline vehicles with electric vehicles to reduce GHG emissions by at least 25–40% (Zulkarnain *et al.*, 2012).

As seen in Figure 1, in 2010, 76.4% of the total inland freight transport in EU-27 was over road and passenger cars accounted for 84.1% of all inland passenger transport (Eurostat, 2013a; Eurostat, 2013b). Being by far the most used mode of transport, road transportation alone accounts for over 70% of all transport GHG emissions in EU-27 (European Commission, 2010).

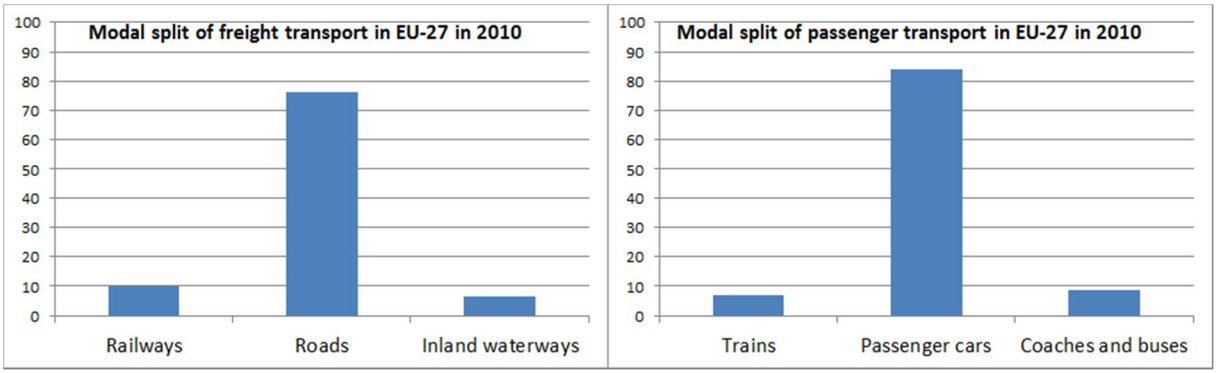


Figure 1: Modal split in freight and passenger transport in EU-27 in 2010.

As well as mode, the type of transport within one mode also plays an important role in determining the amount of emissions, as can be seen in Figure 2. The use of public transportation is highly encouraged as the emissions per person are significantly lower compared to using a personal vehicle. The significantly lower GHG emissions of using public transportation (bus, rail) compared to personal vehicles (European Environmental Agency,

2008a). While technology is improving, even the most efficient cars are barely reaching the emissions per person per kilometre of well-used bus services (for which the technological advances apply to as well).

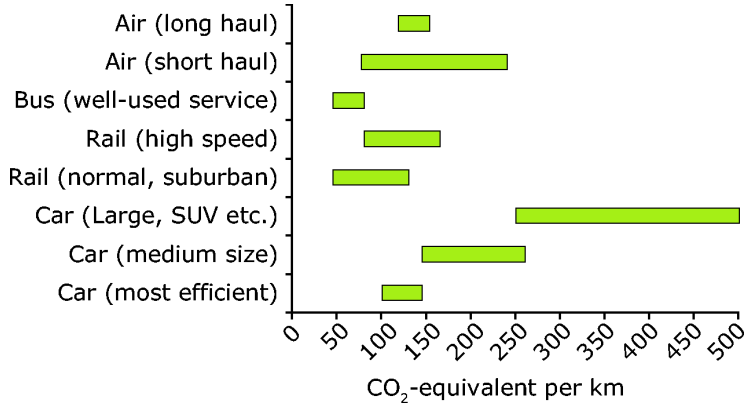


Figure 2: GHG emissions across different modes of transportation. (European Environment Agency, 2008a)

ITS can help change travel behaviour by, for example, making it easier to use public transport. The ITS Action Plan (European Commission, 2008) states that ITS can create clear benefits for transportation in terms of sustainability along with efficiency, safety and security. It mentions electronic toll collection systems, dynamic in-vehicle navigation systems and systems supporting eco-driving as ITS solutions that contribute to the greening of transport.

The White Paper on transportation by the European Commission (2011c) sets goals for a competitive and sustainable transport system. An important one is developing new transport models that make the most of combining the most efficient transport modes to transport large amounts of goods and passengers. The use of ICT is highlighted as a key factor in enabling simpler and more reliable transitions. Shifting transport from roads to other modes will reduce congestion and, therefore, GHG emissions. Intelligent transport and logistics solutions and services can – and are expected to – take advantage of data, such as traffic flow, interruptions and conditions, to provide valuable information in new ways (Ministry of Transport and Communications Finland, 2012).

While the various benefits of ITS systems and services are acknowledged, they are often not quantified and the potential is mainly viewed from the point of view of safety, efficiency and better services. Development and implementation decisions behind ITS solutions can be viewed from one point of view (e.g. safety, efficiency, costs or environment) but often their impacts are beneficial in terms of many aspects (European Commission, 2008). Modern information systems, for example, can be cheaper to implement and maintain than older systems while, at the same time, improving safety and reducing congestion, which reduces emissions and improves efficiency.

Implementation decisions should consider the various benefits that can be gained. Decision makers are careful in remembering to assess negative environmental effects of large transportation projects, but they should also pay attention to the positive opportunities. Similarly as using expected job creation or saved lives in a cost–benefit analysis, emissions reductions should be weighed. Defining a value for reduced emissions is not easy but more importantly, it is impossible if the magnitude of the impact is not assessed.

While different modeling methods are used, assessing the impact of different solutions and scenarios is challenging as different ITS-based strategies can have a complex impact on the whole transport system. However, clear, quantified assessments on the impact of ITS on the energy efficiency and CO_2 emissions of transport is valuable for promoting sustainability (European Commission Ministry of Economy, Trade and Industry, 2009).

In addition to the difficulties of estimating impacts by using models, measuring emissions in the environment before and after implementing a solution will also have various factors affecting the result. As an example, transport GHG emissions increased in the EU by 29% between 1990 and 2009 regardless of vehicle efficiency improvements and implemented measures, while emissions from other sectors fell by 24%. The exception for rising emissions was 2007–2009, generally considered a result of the global recession (Smokers *et al.*, 2012*)*.

Some benefits of ITS systems and services, or decisions supporting their creation, may be realised much further down the road or as side effects. For example, a government providing open data may spark new services that may not directly impact on transport emissions, or even transportation in general, but the users may become sensors that provide floating car data (FCD) which can be further used to develop better, dynamic navigation services that reduce congestion. In this scenario, the government would indirectly have improved transportation efficiency and sustainability while also enabling new business growth.

2 OBJECTIVE AND METHOD

This paper studies the impacts of different actions taken to reduce greenhouse gas emissions from transport and logistics and analyses how the effectiveness of these actions has been assessed. The focus of the paper is on intelligent transport systems and services (ITS) and utilisation of information and communications technology (ICT). Other means of improving environmental friendliness (such as fuel efficiency, alternative energy, aerodynamics, tyre friction, and so on) are excluded. The objective is to identify the potential of ITS from an

environmental point of view as well as the importance of assessing and evaluating it.

The focus of the paper is on solutions affecting road transport because of its significance and potential compared to other modes. Road transport is by far the most used mode of transport and it accounts for a majority (over 70%) of all transport related emissions (European Commission, 2010). In addition to that, it has a higher number of potential active users of smart systems (i.e. more solutions, such as navigation information, benefit car drivers than passengers on a train, for example).

Relevant emissions reduction target agreements between EU countries and applying to EU countries are viewed as the motivation and strategic goals that drive the greening of transportation. Some states have set their own targets for transport emissions to further guide themselves on how to achieve overall reduction efforts across all sectors. National transport emission targets in Finland are used as an example.

A literature review is done on the impacts of ITS solutions on reducing CO_2 emissions to understand the assessment and evaluation methods and to evaluate the potential of the measures. Solutions for various purposes (e.g. congestion, safety and information) are looked at to see the potential in measures that are not primarily for reducing emissions. The impact of ITS measures depends on various factors, including population density and climate. As an example of less generalised estimates, assessments for conditions in Finland are presented.

3 GREENHOUSE GAS EMISSION REDUCTION TARGETS

In 1992, most of the world's governments signed the UN Framework Convention on Climate Change (UNFCCC) at the Earth Summit in Rio de Janeiro. The Kyoto Protocol became the first legally binding outcome from this declaration in 1997. After EU set out its broad, long-term vision for a sustainable future in 2002, the Kyoto Protocol finally came into force in February 2005. It defined national targets for greenhouse gas emissions. (European Environment Agency, 2005) For the first commitment period, 2008–2012, target for transport sector in Finland was to maintain the emissions at the level of 1990 or below (European Environment Agency, 2002). In addition to the jointy agreed national targets, some states have set themselves their own sector specific objectives to help achieve the overall targets. As an example, Finland has defined passenger car stock emissions for years 2030, 2040 and 2050 (Prime Minister's Office Finland, 2009). A list of transportation sector GHG emissions targets for EU and Finland are presented in an annex.

The White Paper on transportation (European Commission, 2011c) gives the most important overall European transport emissions targets, which are to be reached through more specific targets. The core guiding targets are to reach a transport sector greenhouse gas emissions reduction of 20% (compared to 2008 levels) by year 2030 and a reduction of 60% (compared to 1990 levels) by year 2050. Separate targets guide the achievement the overall goals of the transport sector. As passenger cars represent a major portion of traffic, the targets set for them by the European Commission (2009d) play an important part. As *Figure **3*** shows, the average CO_2 emissions of new cars has decreased continuously since 2000. The progress towards target in 2015 and 2020 is promising. The reported, laboratory testing results of the cars emissiosn are, however, perhaps too optimistic as driving in "normal", real-world conditions can generate significantly higher average emissions (European Environment Agency, 2012).

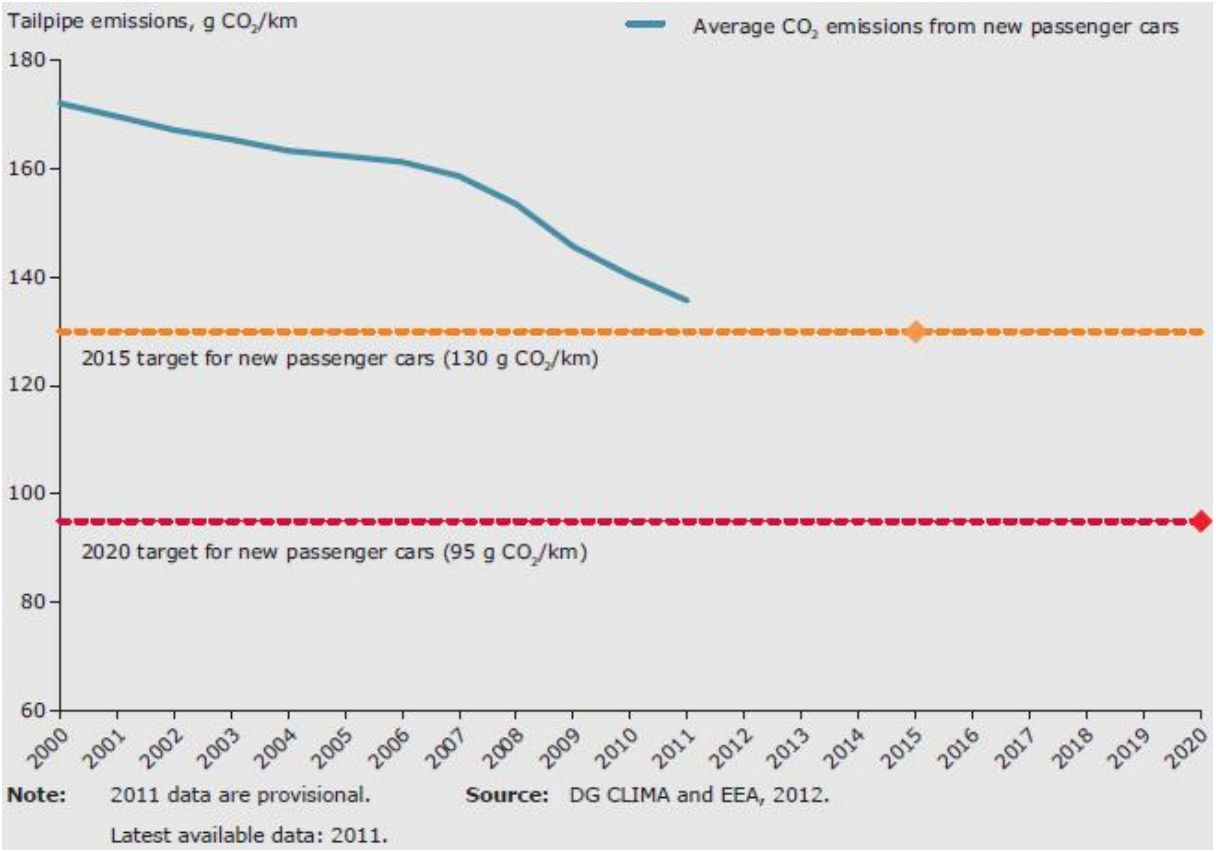


Figure 3: Average emissions for new cars (tailpipe g CO_2/km, EU-27). (European Environment Agency, 2012)

As seen in Figure 4, the current progress over the past few years has been promising and if the current trend would continue, the targets of 2030 and 2050 could be reached. However, the significant trend change in emissions coincides with the economic crisis. Whether the progress continues after the economy starts getting stronger is questionable.

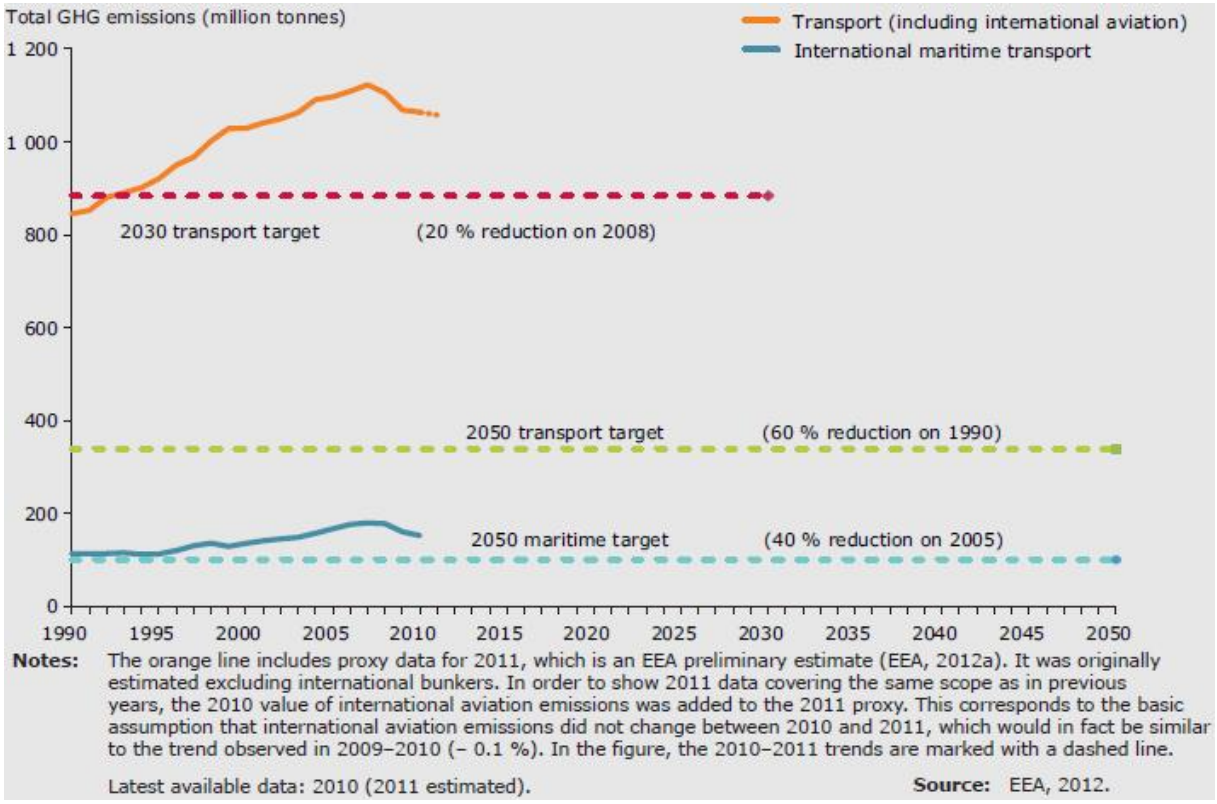


Figure 4: Transport emissions of GHG in EU-27. (European Environment Agency, 2012)

While the progress towards reaching the set targets is promising, although it raises some questions and presents uncertainties, the potential contributions of ITS systems and services are very welcome. ITS does not have a set target for emissions reductions as it covers a range solutions directed at different problems and the effect on emissions is typically difficult to measure. Since there are no clear objectives to reach by ITS measures, investments on other areas with clear indicators may be prioritized.

Financial factors are strong drivers for any decisions, but it is difficult to define monetary values for emissions. The EU Emissions Trading System (EU ETS) is a cornerstone of EU policy combating climate change. The value of emissions allowances traded over EU ETS has, however, varied extremely much throughout its existence making it inefficient. A surplus of allowances has lowered the price so much that the cost no longer incentivizes reducing emissions. (European Commission, 2013)

4 ITS SOLUTIONS AND THEIR IMPACTS

Section 4.1 describes how the impacts of ITS solutions on greenhouse gas emissions are assessed or evaluated. Sections 4.2 and 4.3 describe the assessed and evaluated impacts of various kinds of ITS measures that have been implemented and planned, respectively.

4.1 Evaluating Impacts

Carbon dioxide equivalent (CO_2e) amounts are typically used for evaluating GHG emissions. Measuring the actual emissions is, however, challenging. Therefore, generalised estimates are often used. For example, emission amounts from different modes are mostly based on type average emissions and traffic volumes and a shift from one transport mode to another is indirectly monitored by the mode shares.

Assessment or evaluation is usually performed by utilising models that estimate the impact brought on by changing some variables. Different models are better suited for different cases. Traffic management measures can use emission models based on traffic situation, instantaneous emission models suit advanced driver assistance systems (ADAS) and eco solutions can utilise engine power demand modelling (TNO, 2009). Accurate estimates require sufficient existing data and combined models. For example, changes in congestion and traffic volumes affect travel speeds, which in turn affect the emissions from one vehicle.

The impact of solutions that prevent interruptions can be evaluated by estimating the reduction in congestion and comparing the expected emissions from congestion with those of free flow traffic along the affected distance (TNO, 2009).

4.2 Impact of Implemented Solutions

The main means for reducing transportation GHG emissions are technological advances (e.g. more fuel efficient engines), management of mobility and demand (promoting and incentivizing public transportation, cycling and walking) and improving the flow of traffic (reducing congestion). The benefits of ITS typically fall on the latter two, making it difficult to estimate its impact. Technological improvements are more likely to be directly measurable, whereas mobility management, for example, consists of many contributing factors. Ecological (and economical) driving technique and habits are another common domain improved by ITS.

The impacts of different solutions obviously depend on various factors and surrounding conditions. For example, traffic flow improvements are more efficient in highly congested areas. Table 1 presents evaluated emission impacts of implemented solutions described next.

Table 1. Implemented solutions and evaluated GHG impacts

#	Solution	Evaluated CO_2 Effect
1	Intelligent adaptive speed systems advising driver	35%
2	Adaptive traffic lights	30%
3	Dynamic speed suggestions for approaching traffic lights compared to adaptive cycle time	17%

4	Congestion charging	16%
5	Rigidly enforced speed regulation	15%
6	Integrated traffic and mobility management system to improve traffic flow	15%

A common factor to the evaluations is that they all tend to be estimates based on either models or overall emissions changes. If evaluations are based on measurements under real conditions, which is rare, different factors are not analysed to estimate their individual impact on the overall emissions.

4.2.1 Intelligent Adaptive Speed Systems Advising Driver. A programme called "Ecodrive" in the Netherlands in 2004 found eco-driving training to reduce fuel consumption by 4.2–4.5% (European Environment Agency, 2008b). Studies have estimated CO_2 emission reductions of 34.9% for typical passenger vehicles by using intelligent adaptive speed systems that advise the driver (Servin *et al.*, 2006).

Just providing bus drivers with simple, clear information about current speed in relation to speed limits was found to reduce speeding and result in up to 10% reduction in their fuel consumption (Sihvola *et al.*, 2012).

4.2.2 Adaptive Traffic Lights. Intelligent traffic lights (or approaching traffic lights intelligently) to create a "green wave" can reduce a vehicle's emissions by reducing the amount of stops and accelerations (Dobre *et al.*, 2012). Studies have shown that the adaptive traffic lights can reduce CO_2 emissions by up to almost 30%, although results vary greatly based on the location, time of day, and amount of traffic (Hutton *et al.*, 2010).

4.2.3 Dynamic Speed Suggestions for Approaching traffic lights compared to adaptive cycle time. A dynamically adjusting speed suggestion system (dynamic road signs or an in-car display) for hitting traffic lights when they are green is implemented on some roads in the Netherlands (Ministry of Infrastructure and the Environment the Netherlands, 2011). The system gives the end-user speed advice based on the time of day, car in front, place in queue, place on the road and possible congestion at an upcoming intersection. Carbon dioxide emissions were found to be reduced by 17% compared to vehicle-adaptive cycle time controllers in a limited number of emission measurements (DTV Consultants, 2009).

4.2.4 Congestion Charging. Paying to drive in a defined zone – can reduce congestion and encourage the use of bicycles in urban areas. Transport for London have estimated an impact of 16% CO_2 emission reductions resulting from changes in the amount and flow of traffic due to the introduction of a charged central zone in London, UK (Transport for London, 2007).

4.2.5 Rigidly Enforced Speed Regulation. In the UK, traffic management solutions, under the term "Managed Motorways", includes using variable speed limits to smooth the flow of traffic as well as using the hard shoulder of some highways as an extra lane during busy times (UK Department for Transport, 2011). The result is a steadier stream of traffic with less stopping, improving traffic flow and safety and reducing congestion and air pollution. Even non-dynamic, but rigidly enforced, speed regulations were estimated to result in CO_2 reductions of 15% in Rotterdam, the Netherlands (Kroon, 2005).

4.2.6 Integrated Traffic and Mobility Management System to Improve Traffic Flow. In Rome, Italy, an integrated Traffic Control Centre (TMC) monitors, manages and controls urban traffic through several subsystems to improve traffic flow. The ITS system includes functions such as mobility management, traffic light regulation, traffic flow monitoring, user information via variable message signs, restricted traffic area access monitoring, video surveillance, monitoring and communicating parking spaces, and providing traffic information. Along with reduced travelling times and accidents, the amount of emissions have fallen by 15% in areas managed by the TMC (National ITS Report: Italy, 2011).

With efficient incident management (i.e. detecting and reporting accidents), significant congestion reductions (up to 30%) are possible. Initial estimates claim a reduction of 5% in vehicle hours lost for eCall alone (Ministry of Infrastructure and the Environment the Netherlands, 2011).

4.3 Estimated Impact of Proposed Solutions

The Netherlands Organisation for Applied Scientific Research, TNO, used various methods and models (cf. 4.1) to evaluate a number of ITS-based measures for their CO_2 reduction potential (TNO, 2009). They found scaling of the measures to be the most important factor. While, for example, congestion charging may be effective locally, it is applicable in fewer situations than solutions that require little infrastructure and management, such as improved eco-driving. Table 2 lists their estimates for the solutions' potential within EU-27.

Table 2. Potential CO_2 impact of ITS-based solutions in EU-27 estimated by TNO (2009)

Solution	Potential CO_2 Effect
Eco-driving coaching	15%
Eco-driver assistance	10%
Pay-As-You-Drive	7%
Platooning	6%
(Adaptive) cruise control	3%

Solution	Potential CO_2 Effect
Fuel-efficient route choice	2%
Dynamic traffic light synchronisation	2%
Automatic engine shutdown	2%
Trip-departure planning (freight)	2%
Tyre pressure indicator	1%
Congestion charging	0.5%
Slot management	0.05%
Lane keeping	0.008%
Emergency braking	0.007%

Kompfner and Reinhardt (2008) estimate that the next generation of driver coaching systems combining Vehicle-to-Infrastructure (V2I) communication systems to support drivers and fleet managers to improve fuel efficiency can have an even higher fuel saving potential of 20%, while existing systems could result in 10–12% fuel savings.

Smart logistics – efficiency improvements in transport and storage – are estimated to have the potential for 225 $MtCO_2e$ worth of fuel, electricity and heating savings in 2020 in Europe, and 1.2 $GtCO_2e$ globally (The Climate Group, 2008). Using ICT to optimise logistics could, then, globally result in emission reductions of 16% in transport and 27% in storage. ICT could improve efficiency in a number of ways, such as improved transport network design, seamless and centralised distribution networks and flexible management systems for delivery services.

4.4 Regional Differences

Because the driving conditions and traffic levels can differ significantly from one place to another, the emission reduction potential of solutions also varies. Table 3 presents an example of expert estimates for emission reduction potential of ITS-based solutions in typical Finnish conditions by Kulmala & Schirokoff (2009).

Table 3. Potential CO_2 impact of ITS-based solutions in Finnish conditions (Kulmala & Schirokoff, 2009)

Solution	Potential CO_2 Effect
Congestion charging	10 – 20%
Management of interruptions	5 – 15%
Management of transport equipment	3 – 6%
Traffic light advantage for public transportation	1 – 3%
Information on alternative ways to travel	1 – 2%
Roadside warnings	0.5 – 3%
Fluency reporting	0.5 – 2%

Compared to the TNO estimates presented in Table 2 in section 4.3, the effects of congestion charging and interruption management are much higher in the estimates for Finnish

conditions. If initial congestion levels are lower, a smaller traffic reduction can improve the flow more. Weather conditions (typically snow in this case) affect the amount of interruptions, which, in turn, affect emission savings potential of avoiding and clearing interruptions.

5 CONCLUSIONS

This paper set out to understand the environmental impact of ITS solutions created to answer different problems (e.g. congestion, safety, efficiency) and the importance of assessing and evaluating those impacts.

There is little accurately measured data available about the impacts of ITS solutions on carbon dioxide emissions, mainly because identifying the effects of a particular solution from a dynamic environment is challenging. While direct measurements would be more concrete, different analysis models and expert estimates provide valuable insight to the benefits. Based on these estimates, the potential of utilising ICT in a variety of ways for improving transportation efficiency and eco-friendliness seem clear.

ITS-based solutions often have an indirect impact on the environment by affecting the behaviour of people. For example, increasing the favourability of public transportation by providing better information and services around it. Even when mode changes do not occur, ITS can still have a significant impact by guiding people with more efficient and ecological route options (e.g. dynamic navigation) and driving behaviour (e.g. advanced cruise control and speed suggestions). More direct ways to utilise ITS to achieve emissions reductions are by enforcing limits and guidance (e.g. financial reward or charging based on behaviour).

Impact evaluation for implemented solutions is important not only for finding the most efficient ways to reduce emissions but also, perhaps more significantly, to find concrete incentives and arguments for authorities, companies and private people to invest in the solutions – namely, saved money and time. Since policies such as emissions reductions might investment decisions, environmental effect evaluation results can support and be used as arguments in favor of those decisions. The EU emissions targets seem achievable at the moment, but changes, such as economic growth, may hinder the progress. ITS can provide a strong impact and support the achieving of the set goals.

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ANNEXES

Annex I – Greenhouse Gas Emission Targets

Table 4. European and Finnish GHG emission targets and the respective EEA TERM indicators

#	Greenhouse gas emission target	Target year	Mode	EU or Finnish	TERM Indicator
1	GHG emissions in transport sector:			EU	TERM 002
	-20% compared to 2008	2030			
	-60% compared to 1990	2050			
2	Major urban centre city logistics to be CO_2-free	2030		EU	
3	Renewable energy share of 10% in transport in each state	2020		EU	TERM 031
4	Share of conventionally fuelled cars in urban transport:		Roads	EU	TERM 034
	50%	2030			
	100%	2050			
5	Long distance (>300 km) road freight modal shift to rail/water:		Roads	EU	TERM 013a/b
	30% shift	2030			
	50% shift	2050			
6	Road transport fuel life-cycle GHG emissions to be reduced by 6–10% (compared to 2010 fossil fuels) by fuel suppliers	2020	Roads	EU	TERM 031
7	Type-approval emission average; new passenger cars (percentage of each manufacturer's new cars accounted):		Roads	EU	TERM 027 and
	130 g CO_2/km (65%)	2012			TERM 034
	130 g CO_2/km (75%)	2013			
	130 g CO_2/km (80%)	2014			
	130 g CO_2/km (100%)	2015–			
	95 g CO_2/km (100%)	2020			
8	Type-approval emission average; new light commercial vehicles (percentage of each manufacturer's new vehicles accounted):		Roads	EU	TERM 027 and
	175 g CO_2/km (70%)	2014			TERM 034
	175 g CO_2/km (75%)	2015			
	175 g CO_2/km (80%)	2016			
	175 g CO_2/km (100%)	2017–			
	147 g CO_2/km (70%)	2020			
9	Transport efficiency – load factors:		Roads	EU	
	65%	2015			
	75%	2020			
	85%	2025			
10	Carbon emissions from transport and logistics:		Roads	EU	
	230 million tonnes	2015			
	200 million tonnes	2020			
	162 million tonnes	2025			
11	Long-distance truck efficiency (incl. fuels) (compared to 2011):		Roads	EU	
	+ 20% tonne-km/g CO_2	2015			
	+ 45% tonne-km/g CO_2	2020			
	+ 60% tonne-km/g CO_2	2025			
12	Medium-distance passenger transport mostly by rail	2050	Railways	EU	TERM 012a/b
13	Reduction of 40% in CO_2 emissions of maritime bunker fuels in the EU (compared to 2005)	2050	Waterways	EU	TERM 002
14	Improved efficiency for new maritime ships. Reduction factor compared to Energy Efficiency Design Index (EEDI) reference line (lower for smaller ships, cf. the source):		Waterways	EU	
	10	2015			
	15–20	2020			
	30	2025			

15	Share of 40% for low carbon sustainable fuels in aviation	2050	Aviation	EU	TERM 031
16	CO_2 emission cap (under the EU Emission Trading Scheme (EU ETS)) compared to the average in 2004–2006:		Aviation	EU	
	97%	2012			
	95%	–2020			
17	Cap on CO_2 emissions: Carbon-neutral growth	2020	Aviation	EU	
18	Average annual fuel efficiency improvement of 1.5% (from 2009)	2020	Aviation	EU	
19	CO_2 emissions reduced by 50% compared to 2005	2050	Aviation	EU	
20	Fuel consumption and CO_2 emissions reduced by 50% per passenger kilometre (compared to 2000)	2020	Aviation	EU	
21	Maintain transport emissions at 1990 levels or below	2012		Finnish	
22	Reduction of 16% compared to 2005	2020		Finnish	
23	11.4 million tonnes emissions maximum (15% less than in 2005)	2020		Finnish	
24	Passenger car stock emissions at or below:		Roads	Finnish	
	80–90 g CO_2/km	2030			
	50–60 g CO_2/km	2040			
	20–30 g CO_2/km	2050			

Row	**Source**
1, 2, 4, 5, 12, 13, 15, 21	[1] (European Commission, 2011c)
3	[2] (European Commission, 2009b)
6	[3] (European Commission, 2009c)
7	[4] (European Commission, 2009d)
8	[5] (European Commission, 2011b)
9, 10, 11	[6] (European Commission, 2011a)
14	[7] (International Maritime Organization, 2011)
16	[8] (International Emissions Trading Association, 2012)
17, 18, 19	[9] (International Air Transport Association, 2009)
20	[10] (Advisory Council for Aeronautics Research in Europe, 2001)
21	[11] (European Environment Agency, 2002)
22	[12] (European Commission, 2009a)
23	[13] (Ministry of Transport and Communications Finland, 2009)
23	[14] (Finnish Government, 2008)
24	[15] (Prime Minister's Office Finland, 2009)

Table 5. TERM Core Set of Indicators (European Environment Agency, 2012)

TERM 01	Transport final energy consumption by mode
TERM 02	Transport emissions of greenhouse gases
TERM 03	Transport emissions of air pollutants
TERM 04	Exceedances of air quality objectives due to traffic
TERM 05	Exposure to and annoyance by traffic noise
TERM 12a/b	Passenger transport volume and modal split
TERM 13a/b	Freight transport volume and modal split
TERM 20	Real change in transport prices by mode
TERM 21	Fuel prices and taxes
TERM 27	Energy efficiency and specific CO_2 emissions
TERM 31	Uptake of cleaner and alternative fuels
TERM 34	Proportion of vehicle fleet meeting certain emission standards