Sustainable development synergies and co-benefits of low-carbon transport measures

EcoMobility Dialogues / Technical Paper

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In brief:

Estimates suggest that urban transport energy consumption could be 40-50% lower compared to the 2010 demand only by using currently available and cost effective measures. But policy-makers and decision-makers are often uninformed about co-benefits of low-carbon transport. Numerous assessment tools may help in providing advice on the wider sustainable development benefits of climate change mitigation measures in the transport sector.

The EcoMobility World Festival 2015

The EcoMobility World Festival 2015 will take place in the CBD of Sandton, Johannesburg – the vibrant heart of South Africa – in the month of October. The Festival will offer a view of cities in the future, with active street life and social inclusivity, served by a sustainable transport system.

As part of the EcoMobility World Festival, the EcoMobility Dialogues aim to encourage local and international dialogue and informed conversations about the future of urban mobility and the need for innovation to meet the needs in developing cities.

The Technical Papers: Contributions to the EcoMobility Dialogues 2015

In the course of preparing the EcoMobility Dialogues 2015 in Johannesburg, South Africa, experts have been asked to prepare and present technical papers on topics that challenge urban mobility today.

Five such technical papers have been compiled:

- Transferring sustainable transport and EcoMobility solutions
- Transport and climate change
- Sustainable development synergies and co-benefits of low-carbon transport measures
- A call to action on green freight in cities
- Soot-free urban bus fleets

The findings and messages of this paper are part of informing local leaders for their debates and provide input to the "Johannesburg Declaration on Climate Smart Cities". They will be further shared within ICLEI's EcoMobility Alliance (www.ecomobility.org) and are made available to a wider audience.

We cordially thank the author of **Sustainable Development Synergies and Co-benefits of Low-carbon Transport Measures** for their enormous work and input and for enriching technical and political debates around how we can generate more livable cities while contributing to a low carbon development.

Further information

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Sustainable development synergies and co-benefits of low-carbon transport measures

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Executive Summary

Low-carbon transport mitigation has the potential of generating synergies with other economic, social and environmental objectives. But when it comes to transport policies, access, economic development, safety, air quality, congestion and other factors are often more important policy objectives than a low-carbon transport sector, in particular at the local level. Based on Avoid-Shift-Improve approaches and case studies from Germany, Colombia, India and Singapore, the author shows that aiming for low-carbon transport does have quantifiable co-benefits in economic, social and environmental terms.

Estimates suggest that urban transport energy consumption could be 40-50% lower compared to the 2010 demand only by using currently available and cost effective measures. Yet, a lack of information prevents authorities from implementing low-carbon transport policies: compared to large-scale transport projects, such as highway construction, small but more sustainable concepts often lack the critical mass to allow for a thorough cost-benefit analysis. Luckily, numerous tools are available for policy-makers and decision-makers to make better informed decisions.

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Low-carbon transport as trigger for sustainable development

This report investigates the synergies that many transportation climate change emission reduction strategies have with other economic, social and environmental objectives, which substantially increase their cost-effectiveness and build political support for their implementation. These consist of emission reduction strategies which reduce total vehicle travel and help create more compact, multi-modal communities, where residents tend to own fewer motor vehicles, drive less and rely more on alternative modes (walking, cycling, public transit, and telecommunications that substitutes for physical travel). Such strategies can help achieve various planning objectives including reduced traffic and parking congestion, public infrastructure and service cost savings, consumer savings and affordability (savings targeting lower-income households), increase safety and security, improve mobility options for non-drivers (and therefore reduced chauffeuring burdens for motorists), and improve public fitness and health, in addition to their pollution emission reductions. Many stakeholders place a high value on these benefits, which creates opportunities for collaboration to support their implementation. This report examines these issues. It explores the linkages between climate change and other planning objectives, and provides guidance on ways to use co-benefits to promote climate change mitigation measures and achieve more sustainable development which optimizes economic, social and environmental objectives.

With regard to the terminology, this paper evolves from using the well established term '*co-benefit*' that describes positive side-effects of climate change mitigation actions, towards using the term "*sustainable development benefits*" to highlight the fact that all environmental, economic and social impacts are equally important from a societal perspective. The paper also explores the risks and uncertainties of some impacts of mitigation measures that may lead to trade-offs and negative side-effects. This aim will help to inform priority-setting for decision makers.

Of course, every situation is unique, with its own priorities and perspectives. As a result, it is important to tailor this analysis to reflect the needs and resources of each particular situation, and to communicate these concepts in ways that effectively resonate with different stakeholders and interest groups.

1. Sustainable development benefits for key climate change mitigation measures

This section outlines and reviews some key policy and infrastructure measures that provide synergies between climate change mitigation and other sustainable development objectives.

Sustainable development synergies and co-benefits of climate change mitigation measures

Low-carbon transport has the potential to help achieve various economic, social and environmental policy objectives, and so provides far more total benefits, and more opportunities for building political support, than policies that are justified for climate change reduction alone. Only a few studies have actually examined the combined costs to society of factors like reducing congestion, air pollution, accidents, and noise. One example is for Beijing where the cost of these factors combined was assessed to be between 7.5% to 15% of GDP annually (Creutzig and He, 2009).

Energy security is a key policy objective on the national level and transport plays a major role in this due to its almost complete dependence on petroleum products. This makes the sector and its users vulnerable to increasing and volatile oil prices, which directly affects disposable incomes. Low-carbon transport has the potential to improve not only the energy security of a country, but also to reduce the exposure to high oil prices of individuals and businesses (Leiby 2007; Shakya and Shrestha 2011). By providing choices of different modes and costs of transport, low-carbon mobility also improves the **access** to transport services, in particular to low-income groups, but also to businesses (Banister 2011; Boschmann 2011; Sietchiping, Permezel, and Ngomsi 2012).

Congestion is a major issue in many urban areas and creates substantial economic cost. For example, it accounts for around 1.2% of GDP as measured in the UK (Goodwin 2004); 3.4% in Dakar, Senegal and 4% in Manila, Philippines (Carisma and Lowder 2007); 3.3% to 5.3% in Beijing, China (Creutzig and He 2009); 1% to 6% in Bangkok, Thailand (World Bank 2002) and up to 10% in Lima, Peru (Kunieda and Gauthier 2007). Re-allocating space from roads and parking to more people centred-activities can significantly improve the **quality of live** in cities. Improved **reliability** of travel times for both people and freight can also contribute substantially the attractiveness of cities and the **ease of doing businesses**.

Air quality is another major issue to which low-carbon transport can make a positive contribution by reducing vehicle engine emissions such as sulphur oxides (SOx), nitrous oxides (NOx), carbon monoxide (CO), hydrocarbons (HC), volatile organic compounds (VOC), toxic metals, and particulate matter (PM), the finer particles of which can cause cardiovascular, pulmonary and respiratory diseases. Lack of active personal mobility has also been linked to obesity and a number of chronic diseases (WHO 2008). Vital from a synergies perspective is to motivate people to travel actively by walking and cycling without exposing them to air pollution.

Health benefits of non-motorized transport (NMT) by cycling and walking significantly outweigh the risks due to pollution inhalation (Rabl and de Nazelle 2012; Rojas-Rueda et al. 2011). While some strategies to modal shifts will have a direct climate change mitigation co-benefit, others such as the introduction of environmental zones may cause trade-offs, which will be discussed later.

Road safety is also a major transport policy objective at the local and national level that needs to be addressed in integrated climate change mitigation strategies aiming for a high level of co-benefits. Road accidents killed around 1.27 million in 2011, over 90% in low-income countries. In addition, between 20 to 50 million people suffer serious injuries annually (WHO 2011).

Energy security, transport access and affordability, air quality, health and safety are all powerful policy objectives that need to be taken into account when designing integrated climate change mitigation strategies and Nationally Appropriate Mitigation Actions (NAMAs) that are geared towards a high level of synergies and co-benefits. The IPCC (2014) pointed out that an integrated approach that addresses transport activity, structure, intensity and fuels is required for a transition towards a 2°C stabilisation pathway as well as generating sustainable development benefits (Table 1).

Different types of policies and programs tend to have different impacts and benefits. Strategies that reduce total motor vehicle travel, by creating more compact, multimodal communities, and providing incentives for travellers to shift from automobile to more resource-efficient modes (walking, cycling, ridesharing, public transit, telecommunications that substitute for physical travel, and delivery services) tend to provide the greatest total benefits, reflecting the many costs, including both internal and external costs, of motor vehicle travel and the road and parking facilities they require. Improving motor vehicle fuel efficiency and shifting to alternative fuels provides fewer co-benefits.

Table 1 A high-level overview of mitigation strategies and their potential economic, social and environmental co-benefits (based on IPCC, 2014)

Level	Approach	Sustainable development benefits (and risks for trade-offs)		
		Economic	**Social**	**Environmental**
Activity	***Avoid*** Reduce total vehicle travel by reduced trip distances e.g. by developing more compact, mixed communities and telework.	Reduced traffic and parking congestion (6,7). Road and parking cost savings Consumer savings Energy security (1,2). More efficient freight distribution (14). Reduced stormwater management costs	Improved access and mobility, particularly for non-drivers, which improves their economic opportunities and productivity (9) Affordability (savings for lower-income households) Accident reductions	Ecosystem and health benefits due to reduced local air pollution (20). Reduced land consumption (7, 9). Potential risk of damage to vulnerable ecosystems from shifts to new and shorter routes (15,16).
	Shift to low-	Improved productivity due to reduced urban	More equitable mobility access and safety,	Ecosystem and health benefits due to reduced local

Structure	carbon transport modes, such as public transport, walking and cycling	congestion and travel times across all modes (6,7). Improved energy security (1,2).	particularly in developing countries (8). Reduced accident rates from improved walking and cycling conditions, and shifts from automobile to public transit (7,11). Total accidents can increase if extra safety measures for cyclists are not introduced (22). Reduced exposure to air pollution (7). Health benefits from shifts to active transport modes (7,12).	air pollution (20).
Intensity	***Improve*** the efficiency of the vehicle fleet and use	Reduced transport costs for businesses (4,5). Improved energy security (1,2).	Reduced fuel cost (1,2). Health benefits due to reduced urban air pollution (20).	Ecosystem and biodiversity benefits due to reduced urban air pollution (20).
Fuels	***Improve*** the carbon content of fuels and energy carriers	Some measures may reduce the costs for businesses; others may increase (4). Improved energy security (reduction of oil dependency) (1,2). Reduce trade imbalance for oil-importing countries (3).	Lower exposure to oil price volatility risks (1,2). Electric and fuel cell powered vehicles give air quality improvements (13,20) and noise reduction (10) Potential increase in accidents due to electric vehicles (2-wheelers, cars, buses, trucks) being silent at low speeds (24). CNG and biofuels have mixed health benefits (19,20). A shift to diesel can improve efficiency, but tends to increase air pollution human health damages (23).	Electric and fuel cell vehicles Air quality improvements (13,20). Biofuels: Potential adverse effects on biodiversity, water and nitrification (24). Potential issues associated with sustainable supply of biofuels (21). Unsustainable mining of resources for technologies e.g. batteries and fuel cell (17,18).

References: 1: (Greene 2010); 2: (Costantini et al. 2007); 3:(Kaufmann, R.K., Dees, S., Karadeloglou, P., Sánchez 2004); 4: (Boschmann 2011); 5: (Sietchiping, Permezel, and Ngomsi 2012); 6: (Cuenot, Fulton, and Staub 2012, Lah 2014); 7: (Creutzig, Mühlhoff, and Römer 2012); 8: (David Banister 2008); 9: (D. Banister 2008; Geurs and van Wee 2004); 10: (Creutzig and He 2009); 11: (Tiwari and Jain 2012); 12: (Rojas-Rueda et al. 2011); 13: (Sathaye et al. 2011); 14: (Olsson and Woxenius 2012); 15: (Garneau et al. 2009); 16: (Wassmann 2011); 17: Eliseeva and Bünzli 2011; 18: Massari and Ruberti 2013; 19: (Takeshita 2012); 20: (Kahn Ribeiro et al. 2012). 21: (IEA 2011b), 22: (Woodcock et al. 2009) , 23: (Schipper and Fulton 2012), 24: (Sims et al. 2014,)

To evaluate these impacts, it is important to understand the various steps between particular policy and planning decisions, their impacts on transport conditions and development patterns, their effect on how and how much people travel, and resulting economic, social and environmental impacts. Many policy and planning decisions have synergistic effect – their impacts are larger if implemented together – so it is generally best to implement and evaluate integrated programs rather than individual strategies. For example, by itself a public transit improvement may cause minimal reductions in automobile travel, and associated benefits such as congestion reductions, consumer savings and reduced pollution emissions. However, those same transit improvements may prove very effective and beneficial if implemented with complementary incentives, such as efficient road and parking pricing, so travellers have both push and pull incentives to shift from automobile to transit. In fact, the most effective programs tend to include a combination of improvements to alternative modes (walking, cycling, ridesharing and public transit services), incentives (efficient road, parking and fuel pricing; commute trip reduction and mobility management marketing programs; road space reallocation to favour resource-efficient modes), plus "smart growth" land use development policies which help create more compact, mixed and better connected communities.

Table 2 Steps between policy or planning decisions and their ultimate economic, social and environmental impacts

Policy or Planning Decision (infrastructure investment, zoning, fuel taxes, road and parking fees, etc.) ↓ **Transport Conditions and Land Use Development Patterns** (road and parking supply and price, location and type of development, etc.) ↓ **Travel Behavior** (amount of walking, cycling, public transit and automobile travel) ↓ ↓ **Economic, Social and Environmental Costs** (consumer costs, public service costs, crashes, pollution emissions, physical fitness, etc.)

There may be several steps between a policy or planning decision, their impacts on transport system and land use development, effects on travel behavior, and their ultimate economic, social and environmental impacts.

Examples and case-studies

This section will explore some specific examples where sustainable development benefits have been assessed and will summaries their findings. This will provide some relevant insights that can be used by decision makers and advisors as reference points for future NAMA projects.

TransMilenio in Bogota, Colombia

Bogotá's TransMilenio bus rapid transit (BRT) system is one of the most successful BRTs moving up to 36,000 passengers per hour in each direction. The implementation of TransMilenio was supported by a number of additional measures that formed an integrated package, which helped explain the high level of benefits across a number of policy areas. As well as nearly 1 million tCO_2 saved annually, the system created substantial travel time savings, reduced operating cost for the bus company, and fewer crashes and injuries on two of the system's main corridors (Bocarejo et. al. 2012). Air quality improved substantially in the city since implementation with emission reductions of 43% in SO_2 emissions, 18% in NOx, and a 12% in PM (Turner et. al. 2012). Road fatalities were reduced by over 80% and average travel times by 30% (Carrigan et al. 2013).

Congestion charging in Singapore

A congestion charging system was introduced in 1975 in Singapore, which boosted public transport patronage almost immediately and led to a 45% reduction in traffic, a 25% decrease in road site accidents, and average travel speeds increasing from about 20 km/h to over 30 km/h (OECD & ECMT 2007). The system has been constantly upgraded and a number of supporting measures introduced. This led to public transport having a modal share of over 60% in daily traffic, an increase of nearly 20% (Ang 1990). The success of the system in improving infrastructure capacity, safety and air quality and reducing travel demand, fuel use and greenhouse gas emissions inspired the congestion charge systems in London and Stockholm and plans for similar systems in a number of other cities (Prud'homme & Bocarejo 2005).

Eco-tax and vehicle tax in Germany

Germany has implemented a number of relevant measures in recent years that combine fuel and vehicle taxation to improve the efficiency of the vehicle fleet, reduce frequency of journeys and influence modal choice. The following sections explore briefly the key policies that shape Germany's vehicle fleet and use. As part of the Ecological Tax Reform ('Ökosteuer' discussedbelow) petrol and diesel prices increased from 1999 to 2003 by EUR 0.0307 per litre and year (totalling an increase of EUR 0.1534 /l as of 2003). This internalized a part of the external costs and increased energy efficiency in the transport sector. By 2012 the energy tax on transport fuels was EUR 0.6545 /l on petrol, EUR 0.4704 /l on diesel and EUR 0.18 /kg on CNG and LNG (BMF 2012).

Since January 2009, the motor-vehicle tax (annual circulation tax) includes a CO_2 based calculation but only applied to automobiles newly registered since then. It takes account of typical CO_2 emissions for vehicles and has lower rates for automobiles that have especially low emissions. Additional to a taxation based on the engine size, there is a CO_2 tax of EUR 2.0/g CO_2 above 95 g. It was estimated that the implementation of the CO2 based motor-vehicle taxation will lead to GHG emission reduction of about 3 Mt CO_2-eq per year by 2020. A key feature of fiscal policy measures is the ability to generate funds that directly contribute to other (non-environment related) objectives.

Metro in Delhi and Bangalore

High capacity public transport systems are a vital step towards a sustainable, efficient and livable city. Metro systems are currently being developed in a number of cities to create a backbone for efficient public transport systems. Compared to BRT systems MRT systems require higher investments, but usually also come with higher capacities and frequencies. The MRT systems in Delhi and Bangalore have been assessed for their potential to contribute to a number of objectives. The Bangalore Metro Rail Corporation estimated the combined benefits of the Bangalore Metro Rail to amount to Rs11,550 million (EUR150M) of which traffic decongestion was estimated to contribute 33%, savings in travel time 28%, reductions in accidents 7.6%, reduced fuel consumption 24% and the reduction in local air pollution 5.8% (TERI/WBCSD 2009). The metro in Delhi was estimated to lead to an overall reduction of 2.3% (about 115 ktCO_2-eq.) in CO_2 emissions in the initial phase, with the potential of reductions up to 10% (463 ktCO_2-eq) if full ridership could be achieved. At the lower end of the scenario the reduction in air pollution was estimated to amount to lower emissions of NOx

(1143t to 2887t), PM (163t to 325t), CO (6545t to 13,089t) and HC (1951t to 3902t), thereby making a substantial contribution to local air quality.

Health benefits of active modes

The Health Economic Assessment Tool (HEAT) focuses on cycling. HEAT evaluates the financial returns of investments in cycling infrastructure through reduced mortality due to increased physical activity from walking and cycling. In the Czech Republic, 2% of respondents within a HEAT study in Pilsen would take up regular cycling and therefore increased annual mortality savings by €882,000. In Estonia, infrastructure improvements would create a new cycling route encouraging people to begin regular cycling. Consequently, avoidable deaths would be reduced by 0.17 per year. With the country-specific VOSL of € 1,430,000, a current average annual benefit would amount to €12,000 per year. The University of Auckland, New Zealand, estimated on the basis of HEAT, the benefits from 1000 additional adult cyclists commuting regularly in the city. In result, a 17.5% lower mortality was estimated, saving NZD 765,000, annually (Dora, et al., 2011).

Overview of sustainable development impacts

Assessments of specific impacts and combinations within the transport sector tend to have different levels of depth and use different methodologies, hence constraining any comparability across results. Nonetheless, some illustrative examples are provided (Table 2).

Table 2, Climate change mitigation measures, their CO2 emission reduction potential, and their contribution to other sustainable development objectives for the transport sector.

Strategy	Good practice cities/projects	CO_2 emission reduction	Sustainable development benefits (and risks for trade-offs)		
			Economic	Social	Environmental
Avoid					
Road user charging	Road charge in Peking: RMB 1 /km (4)		Social costs : reduction: RMB 11 billion / year	Travel time reductions: RMB 1.2 mio.	
Avoid motorized trips	Trans-Jogja bus system, between 2010-2024 (6)	1.3 Mt CO2			Avoids 3362 t PM10, 61,288 t CO, 10,645 t NOx, 1423 t SO2
Shift					
MRT	Metro in Delhi (3)		Value of air-pollution reduction (2011-2012): ~EUR 92 Mio.; Rate of return: 1.4%	Time Savings: ~EUR 80,000	Vehicles reduction in 2020: 381,006 cars, 2,521,685 2-wheelers, 17,374 buses
BRT	Trans Milenio Bogotá (2)		Rationalised bus system, 32% commuting times reduction, Increases employment	Access for disabled and poor, 90% lower accidents in BRT corridors	Air quality improvements
BRT	Trans Milenio Bogotá (7)		Monetarization of present benefits (2012): USD 3,759 Mio,	Fewer accidents: USD 288 Mio., Reduced travel times: USD 1,830 Mio.	Avoided CO2: USD 108 Mio.,
BRT	Metrobús Line 3 Mexico City (7)		Monetarization of present benefits (2012): USD 194	Fewer accidents: USD 23 Mio., Reduced travel times: USD 141	Avoided CO2: USD 5 Mio.

			Mio.	Mio.	
BRT	BRT Cebu, feasible benefits over 20 years(10)	1.19 Mt CO2	Fuel saving: USD 587 mio., Emissions reduction: USD 34 mio.	Time saving: 357 mio. hours, Reduction 960 fatalities, 14407 injuries	Reduced PM 232 t, NOx 1779 t, BC 109 t
BRT	BRT Line C-5 Manila (11)	Reduced CO2 /year:: ~ EUR 60,000	Vehicle operating cost savings: ~EUR 2.7 mio.	Time savings per year: ~ EUR 24 mio., Reduced loss of traffic accidents: ~ EUR 940,000	Reduced air pollution: NOx ~ EUR 1,100, PM ~ EUR 880
BRT	BRT Bangkok	Reduced CO2 /year: ~ 2.3 mio. EUR	Vehicle operating cost savings: ~ EUR 128 mio.	Time savings per year: ~ EUR 78 mio.; Reduced loss of traffic accidents: ~ EUR 34 mio.	Reduced air pollution: NOx ~ 10,000 EUR, PM ~ 300 EUR ,
NMT	Walking and Cycling in Copenhagen: Cycle-friendly city (1)	Overall GHG emission reductions not quantified	Faster transport, Green jobs (650 full time in Copenhagen)	Increased physical activity, Reduced health impacts: 5.51 DDK/km (annually 2 billion DDK), reduced road accidents	Zero air pollutants, Less noise pollution
Improve					
Fuel efficiency standards	Use EURO II norm in Delhi (3)		Rs Mio 40,37 (~EUR 500,000) / year		
Vehicle replacement	Old buses with new ones (EURO IV) with ratio 2:1 in Trans-Jogja (6)	17874 t CO2 /year			Reduction of 123 t NOx /year, 2 t PM10/ year
Heavy duty vehicle efficiency	Improved heavy duty trucks in Guangdong Province, China (8)	37.9 t /year /truck due to better tyres and aerodynamics			NOx: 0.239 tons, PM: 0.016 tons reduction /year /truck
Vehicle switch	Shengyang Public Transport: Switch from old diesel bus to CNG, new diesel bus and hybrid/electric bus (9)	Medium to high potential for CO2 savings (no overall quantification)			Increase in CO2 and SO2 emissions if switch to hybrid/electric bus; decrease of emissions if switch to CNG, new diesel bus
Improved bike facilities	Bike infrastructure in University Novi Sad, Serbia (12)	Reduction of 1,845.9 kg CO2 per year	Income of ~ EUR 400 through advertisement on the bike parking infrastructure	Supporting long-term behaviour	
Mixed approaches					
Sustainable Low carbon transport storyline	Indian Transport Sector (5)	CO2 Avoidance: ~1000Mt CO2 until 2050			Avoidance of an increase in PM levels

1: Copenhagen Bicycle Account (2010) 2: CDM Project Co-benefits in Bogotá, Colombia (2010) 3: Social Cost-Benefit Analysis of Delhi Metro (Murty, Dhalvala & Singh, 2006) 4: Creutzig & He (2009) Climate change mitigation and co-benefits of feasible transport demand policies in Beijing 5: Dhar & Shukla (2015) Low carbon scenarios for transport in India:Co-benefits analysis 6: Dirgahayani (2013) Environmental co-benefits of public transportation improvement initiative: the case

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Strength and weaknesses of current appraisal methodologies

There is a large potential in cost-effective sustainable urban mobility that is yet unexploited. Estimates suggest that urban transport energy consumption could be 40-50% lower compared to the 2010 demand only by using currently available and cost effective measures (Eads 2010; IEA 2014; ITF 2013). Even though the technological potential would allow substantial efficiency gains, greenhouse gas emissions reductions, improved air quality and energy security (Leiby 2007; Mazzi and Dowlatabadi 2007). Considering the cost-effectiveness and the potential for co-benefits, it is hard to understand why energy efficiency in the transport sector continues to lag behind its potential.

One factor that affects the uptake of low-carbon transport measures is the lack of information about the wider socio-economic benefits of sustainable transport measures. Compared to large-scale transport projects, such as highway construction, small but more sustainable concepts often lack the critical mass to allow for a thorough cost-benefit analysis. This section provides a short overview of impact impact assessment methodologies and their ability to assess the potential impact of sustainable urban mobility measures sufficiently enough to determine its value from a wider societal perspective. A discussion is included on the ability to incorporate sustainable development objectives of methodologies such as cost-benefit analysis, multi-criteria analysis and marginal abatement cost curves.

To make informed decisions about transport infrastructure and policy options, local authorities with limited resources need clear guidance on costs, benefits and overall impacts. There is often insufficient knowledge of the costs and benefits of low-carbon transport measures which can affect the take-up of those measures. Socio-economic benefits of low-carbon transport measures may be underestimated and this uncertainty may be perceived as a risk since it can lead to decisions in favour of more traditional and often unsustainable transport infrastructures. Classic cost-benefit analysis (CBA) is a well-established methodology for infrastructure appraisal. However, since it requires substantial efforts with regard to data and analysis CBAs are usually only carried out for large-scale infrastructure measures such as road or rail construction projects. CBA has often been criticised for failing to incorporate important sustainable development objectives (Jacoby and Minten 2009).

One of the main advantages of CBA is its ability to describe the costs and benefits of a measure in a single cost-benefit ratio (CBR). As such CBA becomes a very useful tool for decision-making based on economic efficiency. However, CBA usually fails to properly incorporate all relevant environmental, social and economic benefits as not all of them can easily be monetised. As it is highly challenging to properly measure social factors such as quality of life, these issues are usually neglected in CBAs.

Another disadvantage of CBA is the extensive data requirements and relative complexity. The lack of transparency and acknowledgements of interactions of policy objectives and distributional effects is another element that affects the reliability of CBA as a decision making tool. As an additional guidance tool for decision making processes multi-criteria analysis (MCA) can be useful. It allows the incorporation of qualitative evidence as opposed to CBA which can only process quantitative data (Beria, Maltese, and Mariotti 2012). Hence factors in decision making processes that may be harder to measure but are equally important can be included.

Tools to assess sustainable development benefits

A number of tools can help guide decision making processes for sustainable transport policies and infrastructures. These apply some of the approaches from traditional appraisal methodologies, but with lower data requirements and with a specific focus to highlight the ability of measures to contribute to sustainable development. The following section provides a short description of a selection of such tools that can help assess some of the co-benefits of sustainable urban mobility measures.

Developed by an EU- funded project, the TIDE impact assessment tool for urban transport innovations aims to combine the advantages of the quantitative and qualitative evidence to assess the impact of urban mobility measures. The methodology was designed to assess small-scale innovative projects. The TIDE handbook provides eight key steps from the project description, to the identification, analysis and testing of key performance indicators, to the visualisation and communication of the results. TIDE is Excel spreadsheet based and requires a number of standard input data, but also provides reference data based on other assessments such as HEATCO. The TIDE handbook provides steps to generate an impact assessment, which is a mixture of traditional CBA and MCA.

Another tool, specifically developed for the assessment of sustainable development benefits is the UNDP NAMA SD Tool. To assess the direct and indirect CO_2 emission reduction potential the Transportation Emissions Evaluation Model for Projects (TEEMP) is a useful and relatively easy to use spreadsheet based tool, which also highlights some linkages to other sustainable development benefits, but does not provide proper assessments of those. The Rapid Assessment Tool, by UN-Habitat and ITDP builds on the TEEMP tool, aiming to add some further analysis on the wider costs, benefits and overall impacts of possible transport measures.An overview of existing tools is provided (Table 3) that can help assess economic, social and environmental benefits of low-carbon transport policies, technologies and infrastructures.

Table 1: A comparison of tools available to help assess economic, social and environmental benefits of low-carbon transport policies, technologies and infrastructures, and their climate and sustainable development objectives.

			Sustainable development benefits		
Tool and link	**Data needs**	**CO2 emissions**	**Economic**	**Social**	**Environmental**
NAMA SD Tool (UNDP)	√√		√√	√√	√√
Co-Benefits calculator for Transport Projects (IGES)	√		√	√	√
Health Impact Assessment (HIA) in Transport Planning (CDC)	√√√		√√√		
The Co-benefits Evaluation Tool for the Urban Transport Sector (UNU-IAS)	√√	√√	√	√√	√
Health economic assessment tool (HEAT) for cycling and walking (WHO)	√√√			√√	
Harmonised European Approaches for Transport Costing and Project Assessment (HEATCO)	√√√	√√√	√√√	√√√	√√
Transport Emissions Evaluation Model (TEEMP) Clean Air Asia / ITDP	√√	√√√			
Rapid-Assessment Tool (UN-Habitat)	√	√√	√√	√√	√√
CIVITAS cba tool (ELTIS)	√	√	√√	√√	√
JOAQUIN (EC)	√√√	√√√	√√√	√√√	√√√
TIDE Impact Assessment Tool (TIDE)	√√	√√√	√√√	√√√	√√√

Level of coverage of CO2 or SD benefits and data needs: high √√√, medium √√, low √, not covered -

Sustainable development benefits as drivers for policy action

It is often claimed that transport is the hardest sector to decarbonise (ECMT 2007; IEA 2011). However, some countries have managed to curb emissions in this sector, at least to some extent. While it is acknowledged that current measures in most, if not all, countries will not be sufficient to bring transport onto a 2°C pathway.

The recent IPCC Assessment Report clearly states that while emissions reductions can be achieved through several means, such as modal shift, efficiency gains and reduced transport activity, only an integrated approach can achieve the levels of reduction needed to shift to a 2°C pathway. Significant cuts in overall travel and substantial modal shifts would be needed to make up for slightly reduced fuel efficiency improvement in OECD countries, and similarly, that travel demand growth would need to be curbed significantly if reasonable efficiency gains are not continued in developing countries (Fulton et al. 2013). While in developing and emerging countries will be more on maintaining the currently still high share of low-carbon transport modes, fuel efficiency will play an important role to facilitate the growth in travel demand and still making a contribution to global climate change mitigation efforts.

Energy security, safety, health, economic productivity, climate change, local pollution and the aim to attract people and businesses are some of the key drivers for implementing effective policies to reduce transport energy consumption. Each of these drivers is relevant enough to create momentum for policy action. The nature of integrated sustainable, low-carbon transport policies is that it addresses several objectives simultaneously, which generates synergies and helps creating coalitions.

Building coalitions for sustainable transport and climate change mitigation

Vital for the success of long-term policy and infrastructure decisions is support from key political players, stakeholders and the wider public. A societal perspective and the incorporation of sustainable development objectives is a vital step in forging coalitions and getting public support. Policy and infrastructure measures and the combination thereof are an important element in generating sustainable development benefits with low-carbon transport as they provide the content of a low-carbon transport strategy. But vital for the success of the take-up and implementation of measures is the policy environment – the context in which decisions are made (Justen et al. 2014). This context includes not only socio-economic, but also political aspects, taking into account the institutional structures of countries. The combination of policies and policy objectives can help building coalitions, but can also increase the risk of the failure of the package if one measure faces strong opposition, which, however, can be overcome if the process is managed carefully (Sørensen et al. 2014). A vital element of success is the involvement at an early stage of potential veto players and the incorporation of their policy objectives in the agenda setting (Tsebelis and Garrett 1996).

Conclusion and recommendations

Considering that there are great sustainable development benefits to be gained from low-carbon transport policies and infrastructures the uptake of relevant measures is still far lower than the potential. Shifting to a low-carbon development pathway requires substantial efforts for the transport sector. One could argue, however, that a number of measures are no-regret options, which reduce not only CO_2, but also improve air quality, access, energy security and increase economic productivity. Applying a broader sustainable development approach and aiming to integrate relevant policy objectives may help getting support from relevant stakeholders and strengthen the socio-economic case for the shift towards a low-carbon mobility pathway. In that regard a number of steps may help structure the thinking and strategic planning to shepherd a low-carbon transport measure through the process:

1. Reach out to relevant stakeholders
2. Identify the agenda setter
3. Identify the Veto-player
4. Find partners to support you and develop coalitions
5. Use the potential for co-benefits to address objectives of key players
6. Initiate public participation
7. Prepare or the worst
8. Have a plan-B ready
9. Keep up the momentum
10. Wait for the window of opportunity or even better: create it!

Successful strategies need to be integrated across policy areas, regions and levels of government. One way of incorporating objectives of key players and include them in the process is to set-up a cross-cutting working group (first in the department and then across departments and then across levels or government and including key business and civil society players).

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