Implications of 2DS and 1.5DS for Land Transport Carbon Emissions in 2050

Partnership on Sustainable Low-carbon Transport (SLoCaT)

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Abbreviations

ADB	Asian Development Bank
APA	Ad Hoc Working Group on the Paris Agreement
AR5	Fifth Assessment Report
AR7	Seventh Assessment Report
BAU	Business-as-Usual
COP21	Twenty-first Conference of Parties
CO2	Carbon Dioxide
DDPP	Deep Decarbonisation Pathways Project
ETP	Energy Technology Perspectives
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft fuer Internationale Zusammenarbeit
Gt	Gigatonne (1 billion tonnes)
IEA	International Energy Agency
(I)NDC	(Intended) Nationally-Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
ITDP	Institute for Transportation and Development Policy
ITF	International Transport Forum
LCS	Low-Carbon Scenario
LCV	Light Commercial Vehicles
MCB	Michelin Challenge Bibendum
Mt	Million Tonne (1 million tonnes)
NPS	New Policies Scenario
OECD	Organisation for Economic Co-operation and Development
PLDV	Passenger Light-Duty Vehicles
PPMC	Paris Process on Mobility and Climate
SDG	Sustainable Development Goal
SED	Structured Expert Dialogue
UN Environment	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WEO	World Energy Outlook
WRI	World Resources Institute
1.5DS	1.5 Degree Celsius Scenario
2DS	2 Degree Celsius Scenario

Executive Summary

This report explores land transport emissions trends and mitigation potential relative to the 2-degree Celsius Target (2DS) and 1.5 degree Celsius Target (1.5DS) called for under the Paris Agreement on climate change.[1,2]

The main objective of this assessment is to estimate the magnitude of mitigation possible in the transport sector by 2050, considering low-carbon policies proposed and/or investigated for implementation in 60 individual countries[3] with detailed emissions projections to 2050, which in 2010 accounted for about 89% of global land transport sector emissions about 76% of population, and about 84% of global GDP.[4] The magnitude of emission reduction achieved through the implementation of low-carbon policies is compared with emission reductions in the transport sector consistent with achieving a two-degree Celsius scenario (2DS) target or 1.5DS target, as defined under the Paris Agreement on Climate Change.[5]

This study considers a 2050 timeframe and a 1.5 degree Celsius scenario (1.5DS) target, and is one of the first global meta-analyses of long-term (2050) transport sector emissions by aggregating "bottom-up" country transport CO_2 estimates for 2050. This meta-analysis uses one of the largest existing collections of literature outside the IPCC process, considering insights from many modeling studies[6] Land transport passenger and freight activity is set to double between 2013 to 2050 if no additional low-carbon policies are adopted and implemented[7], and thus a mere evolution of current transport policies will not be sufficient to reach a 2DS or 1.5DS. Limiting climate change to 1.5 degree Celsius means nothing short of de-carbonizing transport around mid-century or soon afterward in the most advanced economies, (2070 in less-developed countries), and thus transformational changes in thinking and behavior, and new approaches to policy, technology and investments are required.

A bottom-up analysis considering additional transport mitigation measures shows potential to approach a 2-degree scenario (if all modeled policies are implemented), but would still fall well short of a 1. 5-degree scenario. It is clear therefore that current policies and measures being considered for individual countries are generally inadequate and more transformational measures are needed. As such, more ambitious transport mitigation measures are needed to reach the 1. 5-degree scenario targeted in the Paris Climate Agreement[8].

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[1] This analysis does not include emissions from aviation and shipping. The 2DS and 1.5DS are described in more detail in Section I.

[2] The SLoCaT Partnership would like to acknowledge the following expert reviewers of the draft analysis: Daniel Bongardt, GIZ; Urda Eichhorst, GIZ; Bert Fabian, UN Environment; Lewis Fulton, UC Davis; Benoit Lefevre, WRI; Jacob Mason, ITDP; Wei-Shiuen Ng, ITF; Jacob Teter, IEA; and Tali Trigg, GIZ

[3] The complete list of studies considered in the analysis is available in Annex III

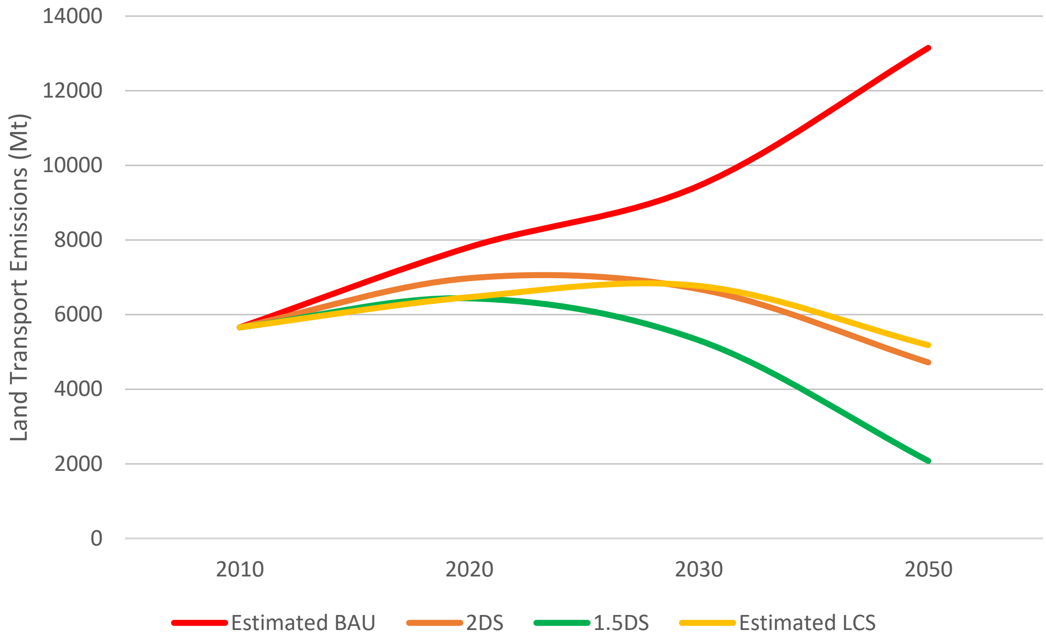
[4] The 60 countries in the study comprise Albania, Argentina, Australia, Bangladesh, Belgium, Bosnia and Herzegovina, Brazil, Brunei Darussalam, Cambodia, Canada, China, Colombia, Croatia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Kosovo, Lao PDR, Latvia, Macedonia, Malaysia, Mauritius, Mexico, Montenegro, Myanmar, Nepal, Netherlands, New Zealand, Nigeria, Norway, Peru, Philippines, Poland, Portugal, Republic of Korea, Romania, Russia, Serbia, Singapore, Slovenia, South Africa, Sweden, Switzerland, Thailand, Turkey, Ukraine, United Kingdom, United States, and Vietnam. The 60 countries are nearly evenly split between OECD (high-income) vs. non-OECD (middle and low income).

[5] The Paris Agreement

[6] See Annex III.

[7] Energy Technology Perspectives 2016

[8] The Paris Agreement



BAU scenario

1. Under a business-as-usual (BAU) scenario, global land transport sector (tank-to-wheel) emissions could grow from 6.3 gigatonnes (Gt) annually in 2013 to 13 Gt by 2050.[9] Assuming that all other sectors follow a BAU scenario, this would result in an increase in the transport share of total economy-wide emissions from 12% to 16% by 2050.[10]
2. From 2010 to 2050, under a BAU scenario, transport sector emissions in non-OECD countries are projected to increase nearly threefold (295%) while transport emissions from OECD countries are projected to increase only slightly (17%).[11]
3. Individual country transport specific modeling efforts, as documented in this report based on a range of country specific reports, tend to project more rapid increases in transport emissions, especially in the period 2030-2050, when compared with global estimates which are often based on national or regional energy-economy and integrated assessment models built on regional growth drivers.[12]

Emission reduction requirements for 2DS and 1.5DS

1. This report develops analysis indicating that applying 2DS and 1.5DS targets for the transport sector could result in emissions of 4.7 Gt and 2 Gt by 2050, respectively, as compared to a 13 Gt projection under BAU.
2. Transport sector emissions need to peak in the first half of the 2020s (or require more intense reductions in case of a delay) in order to stay on track to achieve

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[9] Throughout this report, emissions magnitudes are given in annual and not cumulative terms.
[10] This is based on a dynamic baseline established by individual studies, which generally consider "business-as-usual" (BAU) as no additional new radical implementation of low-carbon policies, and assumes that current emission trends will continue. The IPCC Fourth Assessment Report defines BAU as baseline/reference case assuming that future development trends will follow those of the past and no changes in policies will take place.
[11] It should be noted that non-OECD countries are starting from a very low baseline in 2010 compared to OECD countries.
[12] National modeling numbers can be found in Annex I.

2DS and 1.5DS targets; thus, any delay in scaling-up mitigation efforts will make this transformation nearly impossible to achieve.

(Bottom-up) emission reduction potential

1. By implementing a set of low-carbon transport policies identified in policy and research documents collected in support of this document[13], transport emissions could be reduced to about 5 Gt (roughly 60% below BAU by 2050). This exceeds the mitigation potential estimated by the IPCC Fifth Assessment Report[14] which states *"For the transport sector, a reduction in total CO_2eq emissions of 15–40% could be plausible compared to baseline activity growth in 2050* (*medium evidence, medium agreement*)*".*
2. Both OECD and non-OECD countries show comparable transport mitigation potential by 2050.[15] Thus, transport has considerable potential to contribute towards economy-wide emission reductions by filling policy gaps based on currently identified mitigation measures.[16]
3. Analysis of policy measures identified indicates that passenger transport policies are about three times more likely to be used as a mitigation option when compared with freight policies (based on national studies), although freight accounts for about 40% of global transport emissions[17].
4. "Improve" strategies (e.g. electrification of vehicles) are more widely represented (accounting for about 60% of actions) in national mitigation strategies (including NDCs) when compared to 'Avoid' strategies (e.g. walkable cities) (about 17%) and 'Shift' strategies (e.g. improved public transport) (about 20%) or combinations thereof. Potential reasons behind the bias toward 'Improve' strategies include an assumption of high mitigation potential when compared to "Avoid" and "Shift" strategies, perception of feasibility of implementation, perception of potential job creation, and insufficient consideration of sustainable development co-benefits in climate change policy making.
5. An analysis of 450 low-carbon emission modeling studies[18] indicates that many analysts that have quantified 'Avoid' and 'Shift' strategies arrive at the conclusion that these can have a comparable impact to that of improve strategies.
6. By 2050, implementation of low-carbon transport policies could enable the transport sector to approach a 2DS, with a projected 10% gap (i.e. emission

[13] As considered in the low carbon modelling studies. These studies consider policies for emission modelling based on local priority, cost, co-benefits and mitigation potential, and also include planned transport related measures in NDCs.

[14] IPCC, 2014: Summary for Policymakers. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.),. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[15] This finding is consistent with the findings of IEA ETP 2016: "The potential to reduce GHG emissions in percentage terms is roughly the same in OECD and non-OECD economies (GHG emissions in the 2DS in 2050 are 60% to 70% lower than in both 4DS and 6DS), but the cumulative abatement potential in absolute terms (in million tonnes of CO2 equivalent) is about 60% greater in non-OECD economies than in OECD countries."

[16] This assumes that policies are implemented as visualized in the modeling studies, acknowledging that many of these measures and policies may not be implemented in reality due to many factors. The complete list of studies considered in the analysis is available in Annex III.

[17] IEA Mobility Model, 2015 (counting only tank-to-wheel emissions for land transport). We do not have projections available for 2050. It is acknowledged that a comparison of the number of passenger and freight transport policies does not fully reflect the relative mitigation potential of each of these policy types.

[18] See Annex III.

difference between low carbon scenario and required 2DS scenario) in 2050.[19] However, the emission gap with required reductions for a 1.5DS is projected at roughly 150%.

Preliminary Recommendations

1. Making optimal use of *country-based*, bottom-up assessment of demonstrated mitigation potential is key to ensure that the upcoming efforts by the United Framework Convention on Climate Change (UNFCCC) on convening a facilitative dialogue, conducting a global stocktake and defining low GHG emissions development strategies are indeed *country-specific* and evidence-based while optimizing low-carbon policies in the context of sustainable development.
2. The identification and analysis of country-specific mitigation measures can inform the development of integrated, region-specific policy packages in a global roadmap for the decarbonization of the transport sector. The analytical framework developed in this study can also help to clarify the impact of the implementation of a global roadmap at the country level.
3. A series of “no regret” quick win actions are essential in setting a short-term trajectory (by 2020) to allow the transport sector to maximize mitigation potential in the medium term (by 2050):
    a. Prompting decisions to expand the implementation of solutions that have already proven their efficiency at a smaller scale or with a less ambitious scope.
    b. Halting existing practices and/or regulations that run in directions opposite to what is required to set the global transport sector on a lower-carbon trajectory
    c. Initiating without delay and at relatively low cost, actions or decisions preparatory to full implementation of a global decarbonization roadmap.

[19] This acknowledges a range of uncertainty that could exceed the stated ‘gap’.

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I. Introduction and Study objectives

Transport currently accounts for about 14% of direct economy-wide global anthropogenic greenhouse gas emissions.[20] Demographic, behavioral, business, technology driven trends are driving large increases in transport demand, in a sector currently still more than 90% dependent on fossil fuels.[21] An additional 2.6 billion people are expected to live in cities by 2050,[22] placing further pressure on urban transport systems, and driving strong growth in urban passenger trips and freight deliveries. Because of this growing demand, tank-to-wheel transport emissions could grow by a factor of about 1.5 by 2050 under a BAU scenario. Since transport infrastructure related decisions "lock-in" transport demand for decades to come, public policy in the coming years will determine whether we are set on a course for a high or low-carbon transport future, especially in rapidly motorizing countries.

The Paris Agreement on climate change, in which 195 governments agreed to limit global warming to "'*well below 2°C' above pre-industrial levels, and to aim for a temperature increase of not more than 1.5°C"* provides both a complex challenge and a unique opportunity for transformational global climate action, including in the transport sector.

The main objective of this assessment is to estimate the magnitude of mitigation possible in the transport sector by 2050, considering low-carbon policies proposed and/or investigated for implementation in 60 individual countries with detailed emissions projections to 2050, which in 2010 accounted for about 89% of global land transport sector emissions about 76% of population, and about 84% of global GDP.[23] The magnitude of emission reduction achieved through the implementation of low-carbon policies in these countries, extrapolated to a global scale is the compared with emission reductions in the transport sector consistent with achieving a two-degree Celsius scenario (2DS) target or 1.DS target, as defined under the Paris Agreement on Climate Change.[24] This helps to determine a projected "emission gap" in the transport sector in 2050.

This study is an extension of the 2015 SLoCaT study "Emission Reduction Potential in The Transport Sector by 2030,"[25] with key conclusions of the 2015 study described in *Box 1*.

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[20] SLoCaT (2015). Emission Reduction Potential in the Transport Sector by 2030.
[21] IEA MoMo values indicate 96.5% fossil shares of final energy, and ETP 2015 indicates 93%. See also SLoCaT (2015) Renewable Energy and Transport – Decarbonising Fuel in the Transport Sector.
22 http://www.un.org/en/development/desa/population/publications/pdf/urbanization/WUP2011_Report.pdf
[23] The 60 countries in the study comprise Albania, Argentina, Australia, Bangladesh, Belgium, Bosnia and Herzegovina, Brazil, Brunei Darussalam, Cambodia, Canada, China, Colombia, Croatia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Kosovo, Laos, Latvia, Macedonia, Malaysia, Mauritius, Mexico, Montenegro, Myanmar, Nepal, Netherlands, New Zealand, Nigeria, Norway, Peru, Philippines, Poland, Portugal, Republic of Korea, Romania, Russia, Serbia, Singapore, Slovenia, South Africa, Sweden, Switzerland, Thailand, Turkey, Ukraine, United Kingdom, United States, and Vietnam. The 60 countries are nearly evenly split between OECD (high-income) vs. non-OECD (middle and low income).
[24] The Paris Agreement
[25] Emission Reduction Potential in The Transport Sector by 2030

Box 1: Key Conclusions from SLoCaT 2DS/2030 Study

1. Without low-carbon policy interventions, a continuation of current transport activity trends could lead to a 55% increase in annual transport CO_2 emissions by 2030 when compared with 2010 levels.
2. Most of the projected transport sector emissions growth would be concentrated in developing countries, where transport emissions are projected to grow 2-4 times faster than economy-wide emissions.
3. Low-carbon scenario (LCS) projections show transport emissions growth to 6.2 Gt of annual CO2 emitted by 2030, which corresponds to a decrease of 24% from the BAU scenario.
4. With implementation of low-carbon policies, by 2030 global transport emissions per capita could be restricted to 2010 levels.
5. Mitigation ambition in current NDCs will not be sufficient to put the transport sector on a 2DS track by 2030.

This study extends the previous analysis to a 2050 timeframe and a 1.5 degree Celsius scenario (1.5DS) target, and is one of the first global meta-analyses of long-term (2050) transport sector emissions by aggregating "bottom-up" country transport CO_2 estimates for 2050. This meta-analysis uses one of the largest existing collections of literature outside the IPCC process, considering insights from many business-as-usual and low carbon transport modeling studies[26] Furthermore, most current modeling efforts are based on regional data, while this analysis uses individual emission projections from 60 countries.

Maximizing economy-wide emission reductions will require optimizing mitigation contributions from the transport sector, and this study gives a comprehensive picture of long-term trends in transport emission shares, growth rates, and absolute and per-capita magnitudes among OECD and non-OECD countries, which can serve as a key tool in addressing transport emissions in the context of economy-wide emissions.

In summary, this analysis is intended to accomplish the following objectives:

1. Explain the global 2050 IEA 2DS target and a SLoCaT derived 1.5DS target.
2. Project magnitude and growth under a business-as-usual (BAU) scenario[27] (i.e. without additional implementation of low-carbon transport policies) by 2050 in 60 countries, which are subsequently aggregated and extrapolated to provide a global estimate.
3. Investigate the magnitude of mitigation possible if countries implement a series of policies under a low-carbon scenario (LCS) as defined in individual national and regional studies (also summed and scaled up to create a global estimate).
4. Compare how transport emissions (i.e. their magnitudes, shares, and per capita and per-unit GDP intensities) compare among different country typologies (e.g. by OECD versus non-OECD, income level, region).
5. Determine how transport emissions compare to the IEA global 2DS target and the estimated 1.5DS target derived in this study at a global scale.
6. Understand implications of a 1.5DS economy-wide emission target for transport.
7. Assess which low-carbon transport policies are considered in the mitigation studies and how they compare with global NDC commitments.[28]

[26] See Annex III.
[27] The IPCC Fourth Assessment Report defines BAU as baseline/reference case, which assumes that future development trends will follow those of the past and no changes in policies will take place. IPCC, 2007: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp

II. Methodology

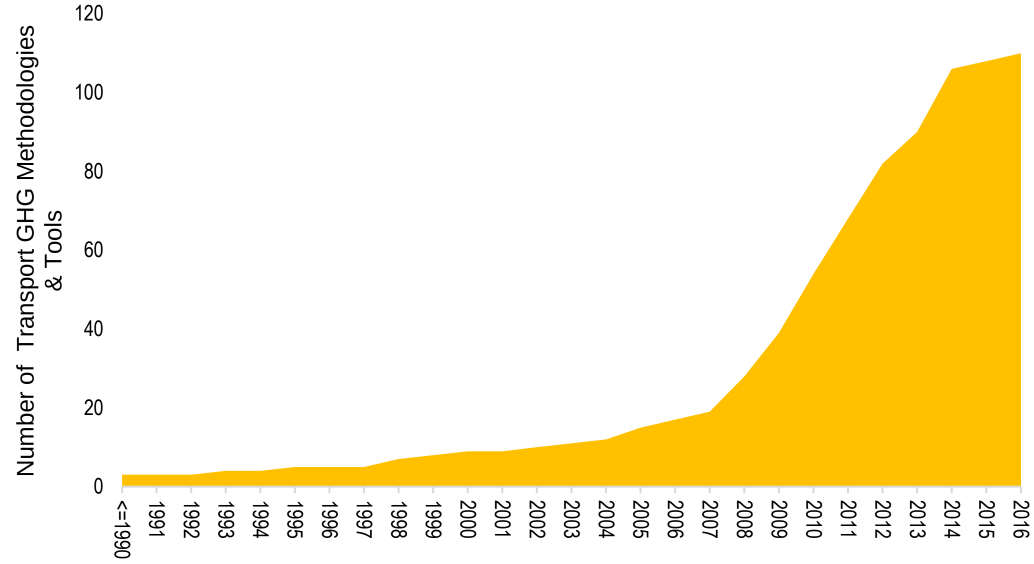
An extensive literature review was carried out by consulting and reviewing about 450 studies to extract detailed bottom-up projections for BAU and LCS scenarios for 2030 and 2050 (see Annex III). Globally only about 60 countries have carried out long-term business-as-usual (BAU) & low-carbon transport (LCS) emission modeling to 2050 (see Box 2). These countries are primarily OECD and middle- to high-income countries. The dominance of high-income countries can be explained by the significant lack of long-term modeling capacity in low- and middle-income countries. Although the 60 countries represent well less than half of the 195 countries that agreed to the Paris Agreement on Climate Change, the 60 countries considered in this analysis accounted for about 89% of global transport sector emissions (not including emissions from the aviation and shipping sectors), about 76% of population, and about 84% of global GDP in 2010[29].

[28] Note that costs are not directly considered in this study, but they are often considered in deriving recommended actions in individual countries based on emissions modelling.
[29] Population and GDP estimates are included in the Annex

Box 2: Bottom-up Transport Emission Modelling

Globally, less than one-third of the countries that have pledged to reduce emissions in Paris have long-term business-as-usual and low-carbon transport emissions modelling. The inavailability and inaccessibility of long-term transport emission projections and low-carbon transport modelling is a cause for concern. Measuring CO2 in transport projects and programs (as well as modelling for broader policies and investments) is essential to enable further country-based action on transport and climate change, through quantification of the potential contribution of low-carbon transport infrastructure and services in comparison to more carbon-intensive investments.

The SLoCaT Partnership has compiled a detailed qualitative assessment of 110 transport greenhouse gas (GHG) emission methodologies and tools (see http://www.ppmc-transport.org/ghg-evaluation-methodologies-assessment/), which cover a wide range of transport subsectors and include both passenger and freight methodologies. The growing number of methodologies, as well as their broad scope, indicate that action on transport and climate change is not held back by the absence of tools to analyse the climate impact of transport interventions. The vast majority of methodologies and tools reviewed are useful for bottom-up modelling, with roughly half useful for national level quantification and available free of charge, suggesting potential for greater low-cost technical assistance in countries lacking adequate transport data and needed capacity.



This analysis is carried out for different typology of countries (i.e. OECD and non-OECD countries, high-, medium- and low-income countries[30] and geographical regions).[31] The aggregated data from individual BAU and LCS projections serve as a building block for the comparison with 2DS and estimated 1.5DS scenarios.

[30] based on economies by per capita GNI in 2012 using World Economic Situation and Prospects categorization and World Bank Country and Lending Groups Categorization
[31] regional classification is in terms of IEA categorization

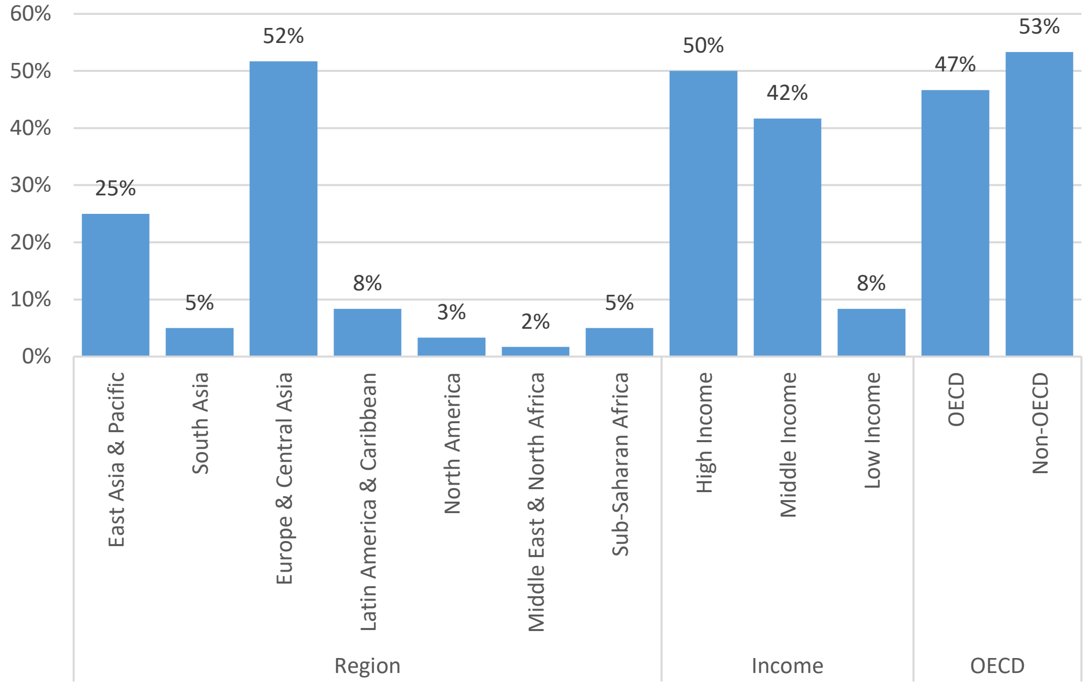


Figure 1 shows the typology of the countries considered in the analysis.

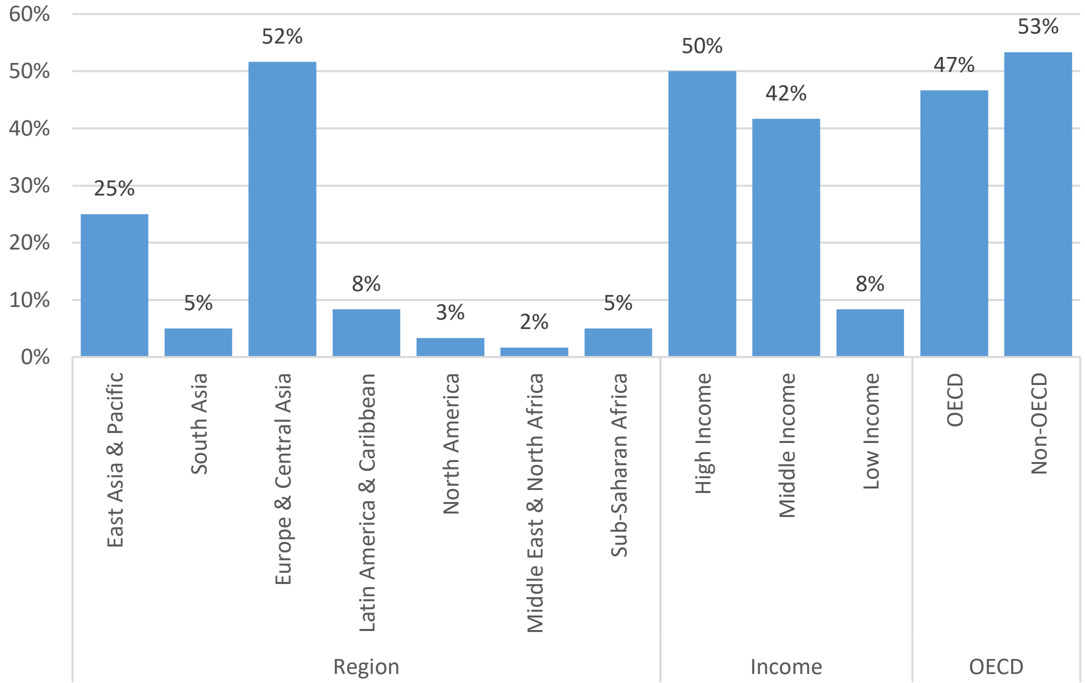


Figure 1 Typology of countries considered in analysis as a percentage of the global total of countries for each category.

The analysis is carried out from 1990 to 2010 (so-called "historic" emissions) and 2010 to 2050 (so-called "future" emissions).[32] The magnitude of emission reduction is compared for

[32] 2010 to 2050 projections are based on a collection of studies carried out in the last decade. These studies already consider significant deviation by 2020 under the low-carbon scenario; thus we consider post-2010 estimates as projections.

with 2DS target (as defined by IEA) and estimated 1.5DS target (as derived by SLoCaT) to determine a projected emissions gap in the transport sector by 2050 (LCS versus 2.5 and 1.5DS. In order to understand the implications of this emissions gap and contribute towards building a roadmap for bridging this gap, a typology analysis of proposed low-carbon mitigation measures is carried out. This typology analysis reveals “policy gaps” (i.e. known but underutilized strategies) and potential steps to address these gaps, which could kick-start the transformation of the transport sector and limit the lock-in effects of a high-carbon business-as-usual (BAU) scenario.

III. Transport Scenarios linked to 2050 2 Degree and 1.5 Degree Celsius Targets

At COP 21 in Paris,[33] 195 countries reached consensus on a landmark agreement to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low-carbon future. The Paris Agreement's focus is to keep a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels (2DS) and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius (1.5DS).[34] The 2DS and 1.5DS scenarios are compared here with business-as-usual growth and a low-carbon scenario where it is assumed that all modeled low-carbon transport policies are implemented.

This report presents four different scenarios and future emission trajectories, which are differentiated mainly by intensity and implementation of low-carbon policies and certain assumptions about future growth, and which are explored in the following sections:

A. 2DS Scenario (IEA-derived)
B. 1.5DS Scenario (SLoCaT-derived)
C. Business-as-usual Growth (BAU)
D. Low-carbon Scenario (LCS)

The cornerstone of this analysis is the comparison of different scenarios with the International Energy Agency (IEA) 2DS related transport sector emissions projections. The IEA 2DS is widely acknowledged as the reference scenario for low-carbon development in the transport sector.

Following the Paris Agreement, which introduced the 1.5DS as a target for international climate policy[35], the discussion on the implications of a 1.5DS has started globally and its pace is accelerating. However, to date there have been few comprehensive attempts to explore the implications of 1.5DS scenario for the transport sector. SLoCaT is therefore proposing an estimated 1.5DS target, recognizing that there is a need to develop a global narrative on sustainable, low-carbon transport that supports short, medium, and long-term action to achieve optimal reductions from the transport sector in support of an economy-wide 1.5DS target. These discussions can be more refined as more scientific findings become available in the future.

A. 2DS Scenario

This IEA-defined scenario considers policies and investments necessary to serve the IPCC-recommended target to limit the rise in long-term average global temperature to 2 °C, i.e. the scenario consistent with limiting the global average temperature rise below 2 °C above pre-industrial levels. For this study, an economy-wide global 2DS scenario is considered from a

[33] The Paris Agreement
[34] UN says Paris Agreement on climate change must aim for long-term environmental stability
[35] A group of 104 vulnerable countries led the initial call for the Paris Agreement to limit warming below 1.5°C. These countries account for about 9% of global greenhouse gas emissions and about 23% of global population in 2010. See http://climateanalytics.org/hot-topics/1-5c-key-facts.html for more details.

range of estimates[36] while a land transport sector-specific 2DS scenario is considered based on the analysis of the IEA Energy Technology Perspectives 2015.[37]

The 2DS is broadly consistent with the World Energy Outlook (WEO) 450 Scenario,[38] which refers to maintaining atmospheric CO2 concentration levels of 450 parts per million. Fundamentally, this scenario is not a future projection but rather a desired outcome based on detailed investigations and it serves as the benchmark for this analysis.

The policy framework assumed in the transport sector underpinning the 2DS scenario for transport includes six main pillars:[39]

1. International sectorial agreements in the passenger light-duty vehicles (PLDV) sector and aviation (both domestic and international), which provide CO_2 emission limits for new cars and aircraft in all countries;[40]
2. Full technology spill-over from PLDVs to light commercial vehicles (LCVs);
3. Improvements in the efficiency of medium- and heavy-duty vehicles to achieve the maximum economic potential by 2040;
4. Alternative fuel support policies;
5. National policies and measures in other segments of the transport sector;[41]
6. Retail fuel prices are kept (through taxation in OECD countries and subsidy removal in non OECD countries) at a level similar to that reached in the New Policies Scenario.[42, 43]

The IEA 2DS scenario sets a target of cutting annual global energy-related CO2 emissions by more than half in 2050 (compared with a 2009 baseline) and ensuring that emissions continue to fall thereafter. Importantly, the 2DS acknowledges that transforming the energy sector (including the transport sector) is vital, but not the sole solution as non-energy sectors (e.g. agriculture, forestry, industrial processes, waste) also need to make significant contribution in support of a 2DS. For the land transport sector, GHG emissions need to be restricted to about 4.7 Gt of annual direct (tank-to-wheel) emissions by 2050[44] or about 17% below 2010 transport sector emission levels (and about 64% below annual emissions in 2050 in the BAU). **Figure 2** shows the required emission reduction trajectory to achieve a 2DS scenario, relative to the transport sector share of economy-wide emissions.

[36] Sixth UN Environment Emissions Gap Report, Effect of current pledges and policies on global temperature by Climate Tracker & Energy system transformations for limiting end-of-century warming to below 1.5 °C

[37] International Energy Agency. 2015. *Energy Technology Perspectives*. Paris. This estimate is corroborated with 2DS estimate by Global calculator developed by UK Government's International Climate Fund and the EU's Climate-KIC & IPCC 5th Assessment database 450 scenario average

[38] 450 Scenario: Method and Policy Framework as discussed in World Energy Outlook-2012, International Energy Agency

[39] It has been argued that the IEA 2DS underestimates the emission reduction potential of the transport sector because of the strong focus on technology related policies in its analysis and limited emphasis on retaining, or expanding the modal share of walking and cycling as well as public transport for passenger transport and expanding the modal share of railways and inland shipping for freight transport. ETP 2016 significantly updates the modeling of Avoid-Shift policies to create a more comprehensive view of mitigation potential.

40 As noted in the Executive Summary, aviation and shipping are not included in this analysis.

[41] This element has been elaborated considerably in the IEA ETP 2016 analysis.

[42] The NPS considers broad policy commitments and plans that have been announced by countries, including national pledges to reduce greenhouse-gas emissions and plans to phase out fossil-energy subsidies.

[43] IEA assume strict and steadily increasing fuel taxes (starting in 2020-2025) on transport fuels, based on their well-to-wheel carbon intensity, in the ETP 2016 2DS.

[44] The IPCC 5th Assessment database 450 scenario average[44] is about 6 Gt by 2050, AR5 Scenario Database. If aviation and shipping are not considered than it is about 4.7 Gt

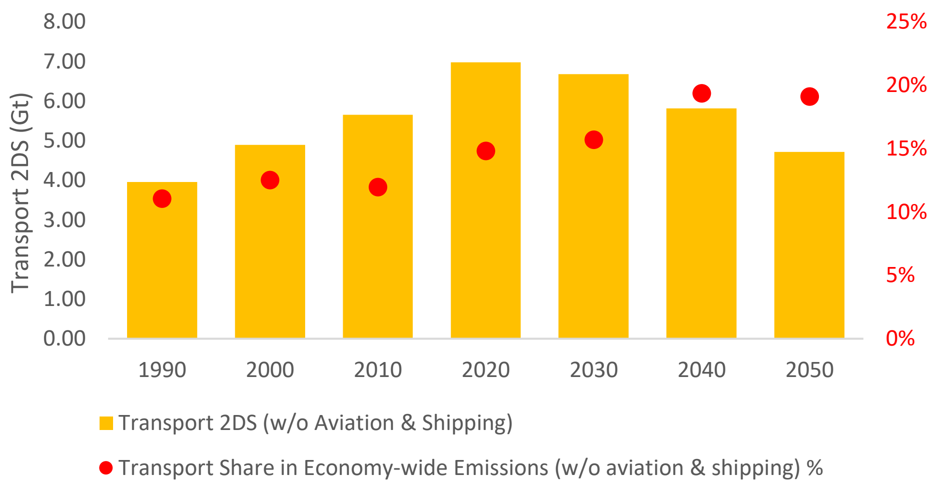


Figure 2 Transport 2DS emissions and its share in economy-wide emissions[45]

This IEA 2DS scenario is more stringent for economy-wide emissions than for transport sector emissions, with 48% reductions below 2010 levels. In 2050, the transport sector emission share of total economy-wide emissions is projected to increase to 25% from a current level of 14%. This indicates that reductions visualized in individual sectors are different based on their magnitude of possible cost implications and potential growth in future demand (see **Figure 3**).

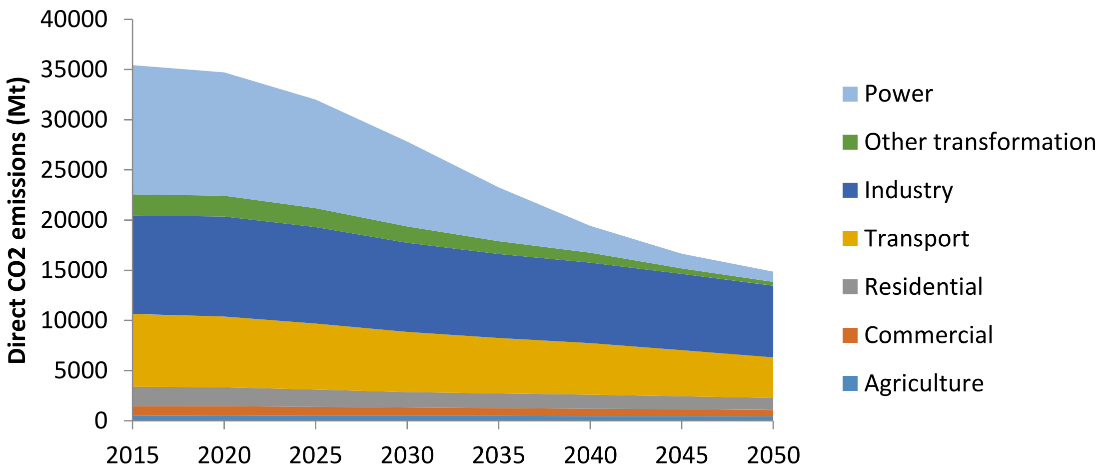


Figure 3 Sector contributions in Energy System Emissions 2DS[46]

These estimates differ slightly from the estimates of the recently launched Deep Decarbonisation Pathways Project (DDPP),[47] which considers a backcasting approach to

[45] International Energy Agency. 2015. *Energy Technology Perspectives*. Paris, economy-wide 2DS setimates are from Sixth UN Eenvironment Emissions Gap Report, Effect of current pledges and policies on global temperature by Climate Tracker & Energy system transformations for limiting end-of-century warming to below 1.5 °C

[46] International Energy Agency. 2015. *Energy Technology Perspectives*. Paris,

[47] The Deep Decarbonization Pathways Project (DDPP): insights and emerging issues. This is a joint project of Sustainable Development Solutions Network (SDSN) and Institute for Sustainable Development and International Relations (IDDRI)

inform the low-carbon transformation envisaged by the Paris Agreement[48] (i.e. 2DS or better). The DDPP estimates that to comply with 2DS by 2050, aggregate energy emissions should be 56% below 2010 levels. For the transport sector in 13 countries, the DDPP estimates backcast reduction to about 24% below 2010 levels by 2050 to contribute toward economy-wide 2DS requirements.

For this analysis, the 2050 target considered for the land transport sector is about 4.7 Gt, based on the IEA ETP 2015 2DS analysis. In terms of land transport emissions share, this would imply an increase from 12% to 19% in total economy-wide 2DS emissions, and this points to the fact that other sectors in the IEA analysis contribute a larger share of decarbonization efforts by 2050 (though not beyond) in the 2DS scenario when compared to the transport sector.[49]

In such a 2DS scenario, by 2050, the global economy-wide and transport sector emissions per capita would need to be restricted to 2.5 and 0.6 tons/capita respectively (0.5 tons/capita for land transport)[50] (**Figure 4**).

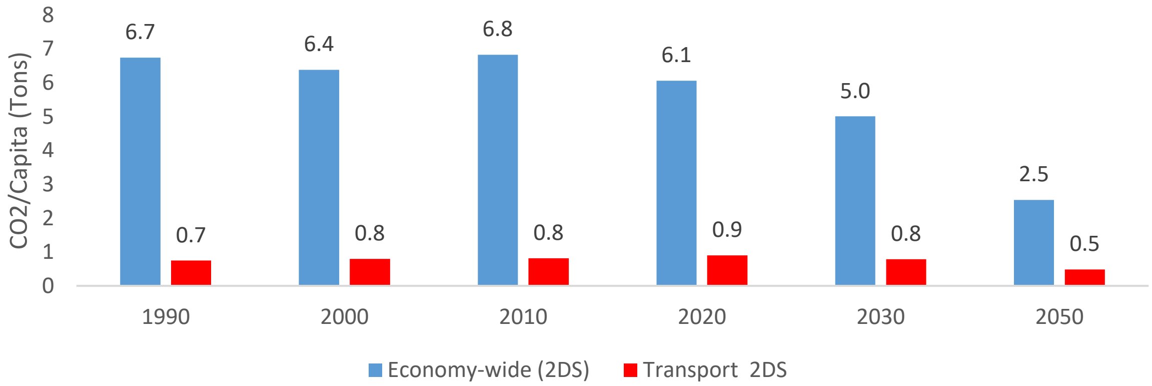


Figure 4 CO2/Capita for Economy-wide & Land Transport Sector[51]

B. 1.5DS Scenario

The IPCC Fifth Assessment Report[52] (AR5) estimated a carbon budget of 1000 GtCO2 to limit global warming to below 2°C.[53] Different studies have utilized this carbon budget concept in different ways to arrive at net global GHG emissions between 2060 and 2075. For

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48 The Deep Decarbonization Pathways Project (DDPP): insights and emerging issues, The DDPP framework has been developed and utilized by a consortium led by The Institute for Sustainable Development and International Relations (IDDRI) and the Sustainable Development Solutions Network (SDSN). It currently consists of scientific research teams from leading research institutions in sixteen of the world's largest greenhouse gas emitting countries.

49 The transport contribution is assumed to be less based on projected cost and mitigation potential relative to other sectors.

50 This assumes a 2050 global population of 9.7 billion. This closely matches with the aspirational goal of 0.5 tons per capita set in VIBAT project - Transport, Climate Change and the City, By Robin Hickman, David Banister

51 International Energy Agency. 2015. *Energy Technology Perspectives*. Paris.

52 https://www.ipcc.ch/report/ar5/

53 In 1.5°C scenarios, the remaining carbon budget for the 21st century is reduced to almost half compared to 2°C scenario i.e. the range of cumulative carbon emissions in 1.5 °C scenarios is 680–895 GtCO2 from 2011 to 2050, and 200–415 GtCO2 from 2011 to 2100. Energy system transformations for limiting end-of-century warming to below 1.5 °C

a 1.5 Degree scenario, most estimates suggest economy-wide net negative CO_2 emissions must be realized by mid-century.[54] However, not all sectors may reach complete decarbonization but only as close to zero as possible and any remaining GHG emissions need to be balanced by using future carbon-negative technologies and energy systems like bioenergy with carbon capture and sequestration.

There have been few comprehensive attempts to explore the implications of 1.5DS scenario for the transport sector. Rogelj et al. (2015)[55] estimated that worldwide CO_2 emissions from energy and industry would have to reach zero around 2050 to st within a 50% chance of returning warming to below 1.5°C by 2100. They estimated the need for an earlier transition to net zero carbon emissions worldwide to achieve a 2DS (when compared with other estimates), to be achieved between 2045 and 2060. For the transport sector they estimated that a 1.5DS would necessitate about 40% to 55% lower reductions than a 2DS scenario.

The UNFCCC's Structured Expert Dialogue (SED)[56] has suggested that in general, *"pathways limiting warming to below 1.5DS by the end of the century are similar to those limiting warming to 2°C, but call for more immediate mitigation action and an additional scaling-up of the challenging features of the 2DS scenarios, such as the scaling-up of CO2 removal technologies and of the full set of low-carbon technologies*". Further it suggests that "*that cost implications would not determine whether or not to pursue the 1.5 °C warming limit*". It has been estimated that 1.5°C and 2°C trajectories have been shown to overlap until the 2020s, and afterward stronger emission reductions are required for 1.5°C.[57]

SLoCaT is proposing a 1.5DS estimated target recognizing that there is a need to develop a global narrative on sustainable, low-carbon transport that supports short-, medium-, and long-term action to achieve optimal reductions from the transport sector in support of 1.5DS economy-wide emission reduction target. These discussions can be refined as more scientific findings become available and aim to help to better define the 1.5DS target for transport. Thus, in this analysis, 1.5 degree and 2 degree scenarios are used as a scoping exercise, or as a means to an end, i.e. to understand the possible mitigation gap in 2050 as compared to business-as-usual and low-carbon transport scenario for the countries and to highlight policy gaps.

To arrive at the 1.5DS target for transport by 2050, we consider:

- The economy-wide emissions for 2DS at 2050 is 24.7 Gt
- The economy-wide emissions for 1.5DS at 2050 is 10.9 Gt
- The economy-wide emission gap (2DS and 1.5DS) in 2050 is 13.8 Gt
- The IEA land transport emissions for 2DS at 2050 is 4.7 Gt
- The expected land transport emission share for 2DS at 2050 is 19%
- We allocate the economy-wide emission gap to transport sector (13.8*19%) i.e. 2.6 Gt and subtract this from 2DS scenario to get 1.5DS (i.e. 4.7 - 2.6 = 2.1 Gt)

Similar calculations can be carried out in 2020 and 2030 to determine 1.5DS estimates for transport sector in 2020, 2030 and 2050.

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54 A situation of net negative emissions is achieved when more GHGs are sequestered or stored than are released into the atmosphere as a result of human activities. http://uneplive.unep.org/media/docs/theme/13/EGR_2015_Technical_Report_final_version.pdf
55 Energy system transformations for limiting end-of-century warming to below 1.5 °C
56 Report on the structured expert dialogue on the 2013–2015 review
57 http://climateanalytics.org/files/feasibility_1o5c_2c.pdf

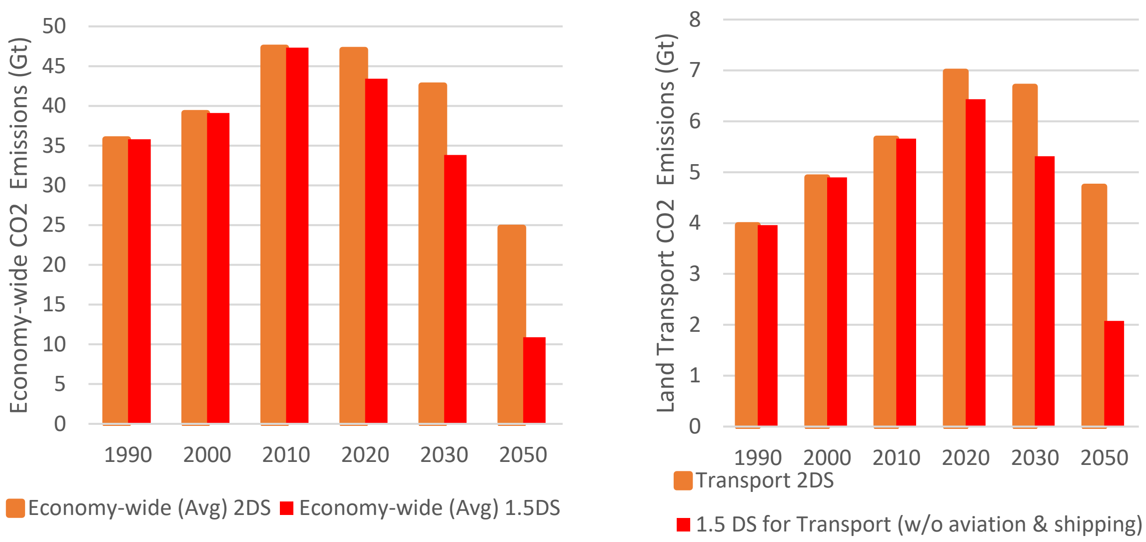

Figure 5 Economy-wide and transport sector 2DS and 1.5DS CO2 emissions

In this study, the SLoCaT estimate of 2.1 Gt of annual transport sector emission by 2050 to achieve a 1.5DS[58] serves as a global benchmark (extrapolated from data for 60 countries) for comparing BAU and low-carbon scenarios and could be further refined as more scientific findings become available in the future. This estimate is not an end in itself, but the beginning of a process of understanding the deep reductions and subsequent sectorial transformations that may be required in the transport sector under a 1.5DS.

By comparing economy-wide emissions for a 1.5DS with a 2DS, the emission gap in 2050 is determined and subsequently this gap is translated to the land transport sector assuming a proportional share in economy-wide emissions in 2DS scenario. As noted earlier, this translates to a land transport emission share of economy-wide emissions to increase from 12% to 19% from 2010 to 2050, which is derived by comparing the two graphs in Figure 5.[59]

This assumption (i.e. translating transport's proportional share of 2DS to 1.5DS) is built on the proposed principle of "sectorial solidarity," which means that the emission gap is distributed to individual sectors based the share of each in total emissions from 2010 to 2050. However, it is also important to realize that not all sectors can provide *additional* potential for maintaining average global temperatures below 1.5°C[60] as they would already be decarbonized to the fullest extent possible under a 2DS (e.g. power sector in **Figure 6**). This means that to meet the 1.5DS, sectors such as transport, industry and buildings may need to bear a higher share of emission reductions (relative to other sectors such as power), and may need to be supported with negative-CO2 emission technologies and systems, such as bioenergy combined with carbon capture and sequestration, or natural sequestration through afforestation.

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[58] Not including aviation and shipping.
[59] Transport share is expected to increase to 19% by 2050 based on the economy-wide emissions gap between the 2DS and 1.5DS trajectories, which is translated to the transport sector using its projected share of 2DS economy-wide emissions. Since transport emissions are growing under a 2DS, we assume that the sector will bear a slightly larger share of emission reductions by 2050.
[60] http://climateanalytics.org/files/feasibility_1o5c_2c.pdf

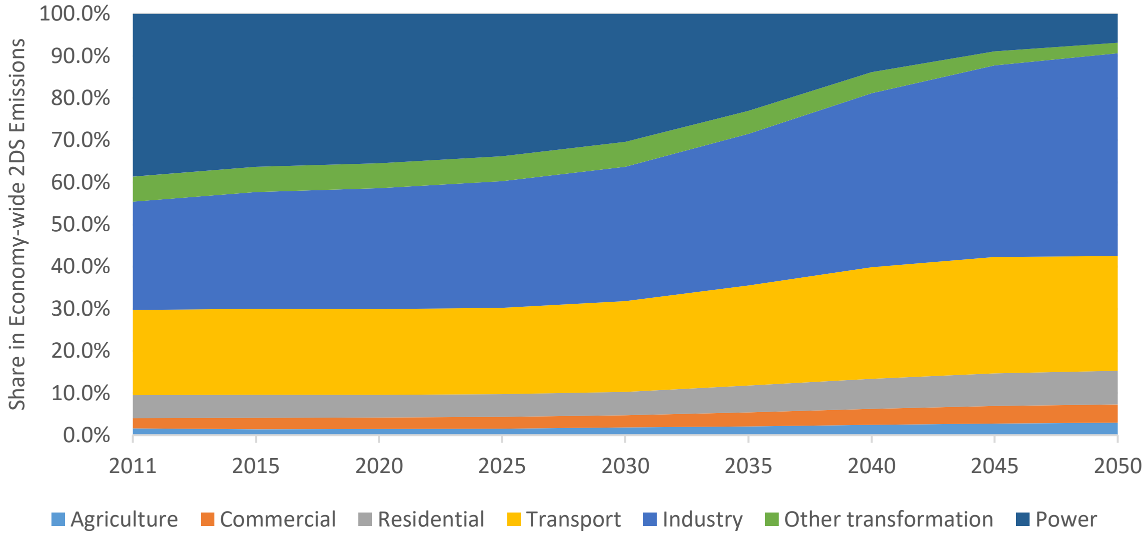

Figure 6 Sectorial Share of Economy-wide Emissions, 2010-2050

In the 2DS scenario, it is generally assumed that all sectors, including the transport sector, need to provide significant contributions based on their capabilities and requirements to bridge economy-wide emission gap; however, different sectors in different countries have different cost-effective approaches for reducing GHG emissions, and allocation of emission reduction targets to different sectors is often based on a combination of factors, such as local priority, cost effectiveness, future magnitude of growth, and co-benefits. Different countries may prioritize different sectors for achieving national emission reductions. However, a 1.5DS changes the equation, as translating a 2DS to a 1.5DS would require the highest possible reduction from the transport and industry sectors, which are expected to contribute to a combined three-quarters of economy-wide emissions by 2050 under a 2DS scenario (as shown at the right edge of **Figure 6**)[61].

The roughly 2 Gt required under the 1.5DS scenario by 2050[62] translates to about 0.2 tons/capita of land transport emissions. Including shipping and aviation, the target could be 2.7 Gt by 2050 (equivalent to 0.28 tons/capita) which is about 55% below a 2DS scenario, and thus close to estimates by Rogelj et al (2015) of 40-55% reductions below a 2DS scenario to achieve a 1.5DS[63]. (**Figure 7**)

[61] Re-defining climate ambition to "Well-below 2C" Background and proposed ETP analysis, International Energy Agency, 2016
[62] As compared to 4.7 Gt required by 2050 to achieve a 2DS.
[63] Energy system transformations for limiting end-of-century warming to below 1.5 °C

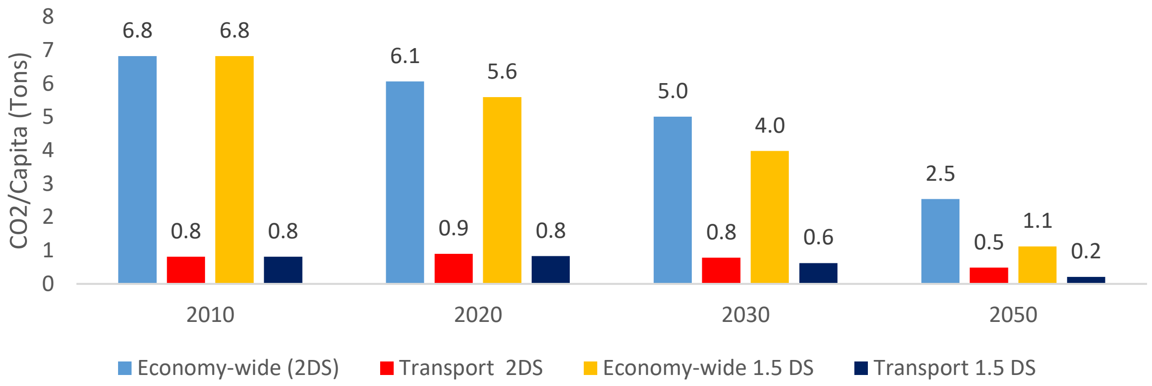

Figure 7: Per-capita emissions under 2DS and 1.5DS

C. Business-as-usual Growth (BAU)

BAU projections forecast emissions on an assumption that no additional low-carbon policy actions are adopted. The projections are estimated assuming continuation of transport sector investments to keep the existing transport capacity operational for full length of analysis (e.g. to include a realistic level of investments and maintenance where necessary, to avoid the transport network deteriorating). This scenario takes into account economic forecasts but does not envisage shifting transport-related investments to more low-carbon modes.

An extensive literature review was carried out by consulting and reviewing more than 450 studies[64] to extract detailed transport sector-related bottom-up projections for BAU for 2030 and 2050. Globally about 60 countries have carried out low-carbon transport emission modeling out to 2050. For each of these 60 countries, emission estimates for BAU from the different studies were compiled to determine average values for 2020, 2030 and 2050. In 2010, collectively these 60 countries constitute about 89% of global transport sector emissions with a total of 5Gt of annual GHG emissions.

By 2050, the bottom-up average BAU projections from 60 countries overshoot the average BAU forecasts of global models[65] (i.e. about 10.8 Gt for 60 countries alone vs. an average global model forecast of 9.3 Gt). This indicates that aggregate individual country land transport specific modeling efforts capture faster transport emissions growth especially in the period 2030-2050 when compared with global estimates which are often based on macro energy-economy and integrated assessment models built on regional growth drivers. This growth is particularly rapid in the 2030 to 2050 period where the global models project transport emission intensity growth will taper off when compared to individual country

[64] The 450 studies are selected from available transport sector BAU projections and mitigation potential estimates derived from modeling efforts by government agencies, development banks, and research organizations. A major limitation of the BAU scenario is that it considers a simple average of the different BAU estimates from individual studies for a country based on a detailed literature review, and we do not differentiate among estimates based on their probable accuracy or based on their assumption of socio-economic factors.
[65] results from several models as reviewed in the Fifth Assessment Report (AR5) of Working Group III of the Intergovernmental Panel on Climate Change (IPCC)[65] and other estimates such as IEA 6DS[65], Global Calculator BAU estimates[65] and ICCT-Roadmap.[65] These estimates predict transport sector emissions to grow from 7.3 Gt in 2013[65] to nearly double by 2050[65] to 14 Gt and about 9.3 Gt depending upon if aviation and shipping emissions are neglected.

forecasts (Figure 8). Regional modeling efforts give more conservative estimates for 2030 to 2050 period when compared with individual country projections, which could be due to varied assumptions and socio-economic forecasts considered in the modeling efforts.

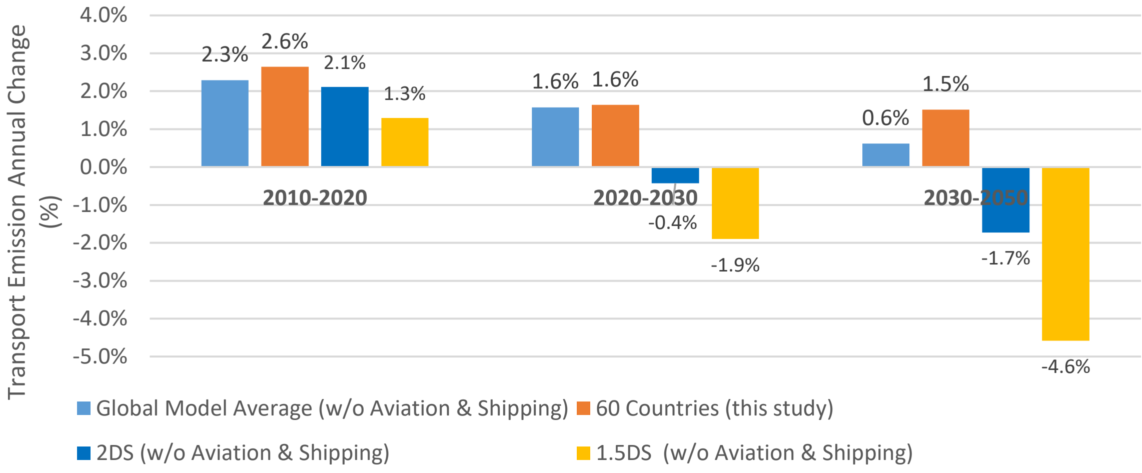

Figure 8 Transport emission annual growth in business-as-usual scenario (vs. 2DS/1.5DS)

In order to understand the global transport emission gap between BAU and the 2DS and 1.5DS targets, insights from 60 countries are expanded to 193 countries (i.e. from 89% to 100% of global emissions) by extrapolating BAU growth rates for OECD and non-OECD countries. If the global transport sector trajectory followed the same path as depicted by the 60 countries considered in this study, annual transport sector emissions would increase to 13 Gt by 2050.

If the global economy-wide CO2 emissions under a 1.5DS are to become net zero between 2045 and 2060, a rapid transformation of the transport sector in the post-2030 period will be required (i.e. an average 4.6% annual reduction in transport emissions to decrease from 5.3Gt in 2030 to 2.1Gt in 2050). Any delay in scaling-up mitigation efforts in the period up to 2030 will make this transformation nearly impossible to achieve.

Insights from the 60 countries considered reveals that most of the BAU transport emission growth is projected to take place in non-OECD countries. From 2010 to 2050, OECD countries considered in the analysis grow by only 16% while non-OECD countries are projected to increase nearly three-fold under a BAU scenario (or roughly 18 times the rate of OECD countries).

Figure 9 shows that the majority of projected land transport emissions growth is concentrated in the developing countries (non-OECD, middle and low income), and compares rates of growth in the 2010-2030 vs. 2030-2050 periods.

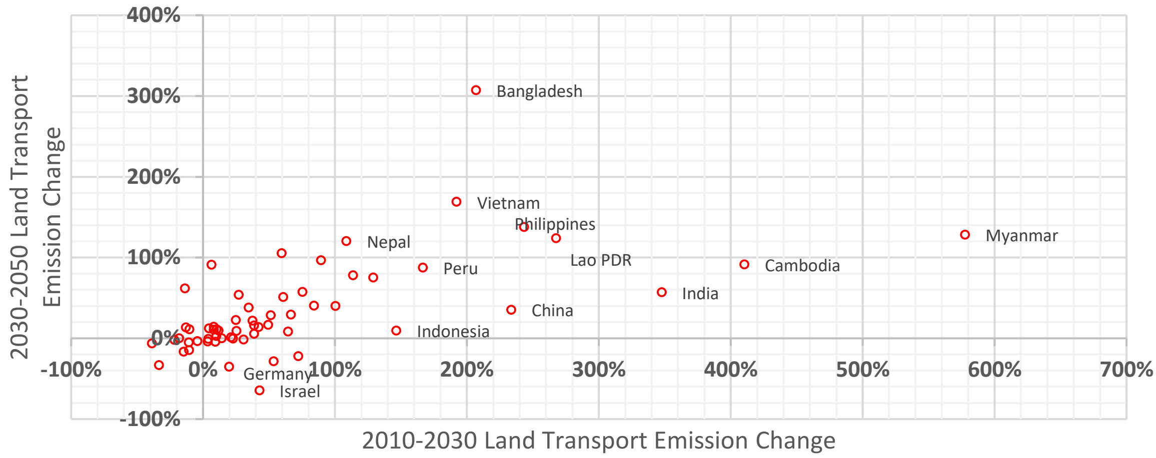

Figure 9 Change in annual transport emissions between 2030 and 2050 under BAU

Based on data availability for 2050, the 10 countries where the emissions are projected to grow most from 2010 to 2050 are Myanmar, Bangladesh, Cambodia, Lao PDR, Philippines, Viet Nam, India, Peru, Nepal and China. By contrast, countries where the absolute BAU emissions in 2050 are projected to be lower than 2010 are Mauritius, Israel, Serbia, Switzerland, Japan, Kosovo, Germany, Finland, France, Italy, Croatia and Sweden. The reduction is due to many factors, including projections of socio-economic, demographic and implementation of existing low-carbon transport policies.

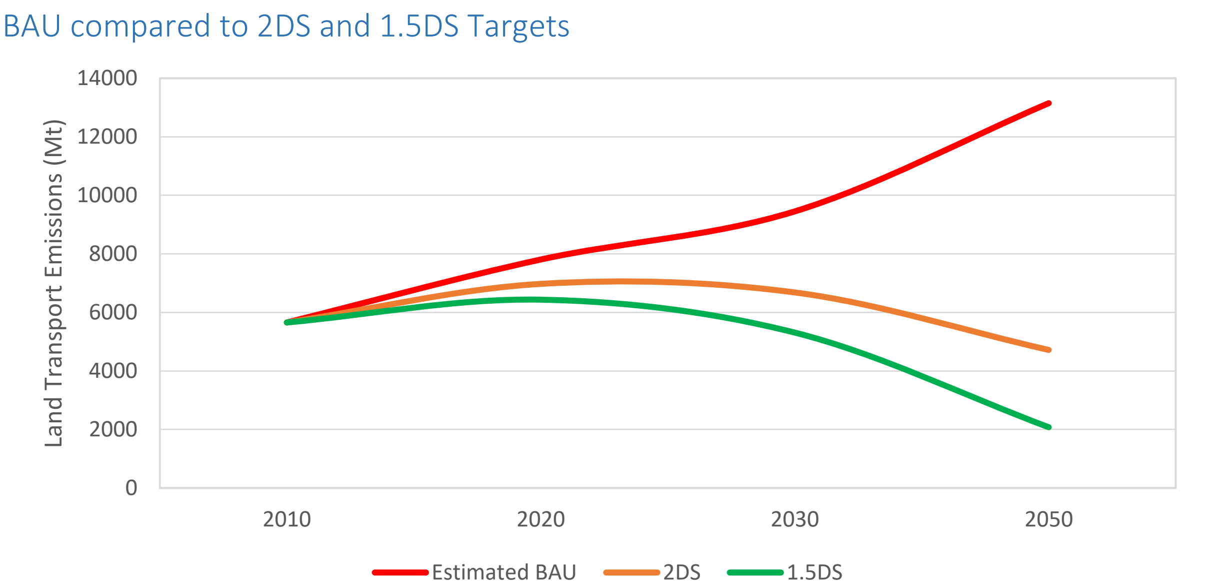

Figure 10 shows the emission gap, comparing aggregated emissions in the BAU scenario with 2DS and 1.5DS targets. In 2030, projected annual BAU emissions exceed 2DS and 1.5DS projections by about 29% and 44%, respectively,[66] and by 2050, BAU annual emissions exceed those in the 2DS and 1.5DS projections by 64% and 84%, respectively (with 60 countries extrapolated to a global scale).

[66] In 2030, the emission gap was found to be 41% in 2015 SLoCaT study Emission Reduction Potential in The Transport Sector by 2030, for 2DS

Lack of progress to date in reducing the rate of growth of global transport emissions to realize peaking transport emissions by the first half of the 2020s as a means of achieving a 2DS/1.5DS translates to a need for deeper emission reduction requirements in the middle and longer term, making it more difficult to achieve 2DS or 1.5DS target in the transport sector, under the previously-defined scenario.[67] Thus, a massive shift from unsustainable to sustainable transport will require 'quick win' actions in the transport sector focused on shifting investments in infrastructure at both country and city levels in the 2020s.

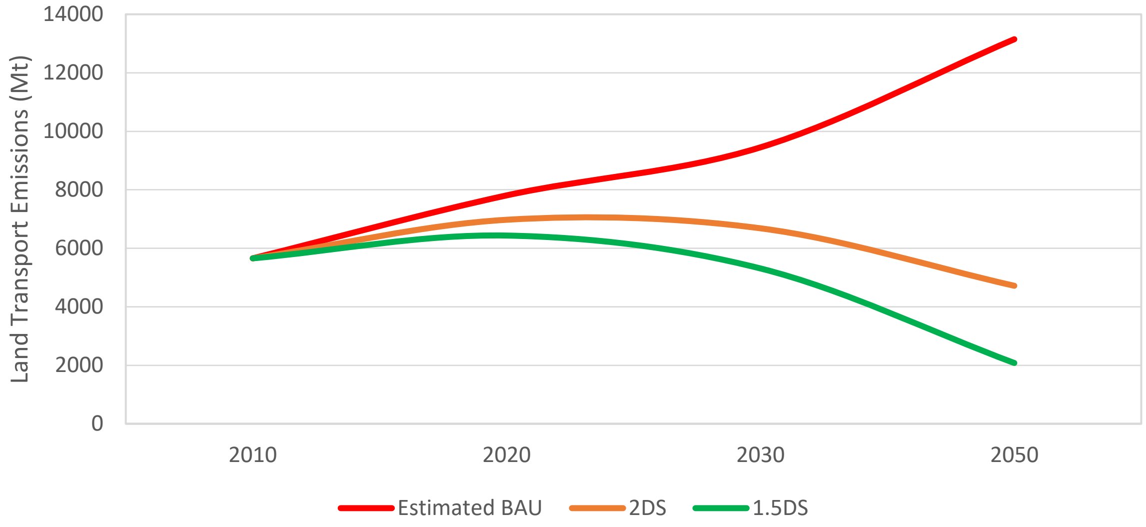

Figure 10 Transport emission gap (BAU with 2DS & 1.5DS)

It is important to note the divergent trends of transport CO2/capita and transport CO2/GDP (**Figure 11**). Transport CO2/capita in developed economies has stabilized to some extent, while in developing economies it is projected to increase rapidly over the next decades. In comparison, transport CO2/GDP (i.e. 'emission intensity') shows a sharp decline over time in both developing and developed economies, even without implementation of additional low-carbon transport policies.

These trends indicate a projected decoupling of transport emissions with respect to GDP (i.e. where transport emission growth is lower than economic growth). This could be mainly due to impact of existing transport policies in OECD countries and changes in economic structure in many non-OECD countries (i.e. a shift from industrial to service-oriented economies generates higher GDP per unit transport activity). While about 4% of NDCs (including those from China and India)[68] consider transport emission intensity reduction targets, these do not necessarily lead to insights for transport or other sectors[69].

[67] Hypothetically, a later peak in transport sector emissions could also potentially be compensated by mitigation actions in other sectors, or with a steeper reduction within the transport sector over time. In practice, however, each of these alternate scenarios is likely to be difficult to achieve.
[68] http://unfccc.int/resource/docs/2016/cop22/eng/02.pdf
[69] Emission intensity targets at an economy-wide scope do not provide good insights into emission trends, as they are measured relative to GDP growth and thus a higher intensity of GDP growth might reduce emission intensity even when transport CO2 emissions are growing. For example, from 1990 to 2010, transport emission intensity decreased by about 70% in non-OECD countries while transport CO2 increased by about 90%.

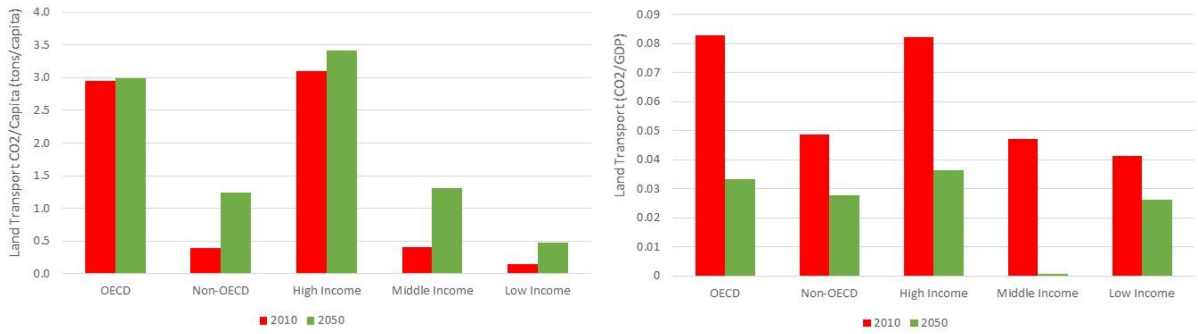

Figure 11 BAU Intensity: Land Transport CO2/Capita (left) and Land Transport CO2/GDP (right)

Under a BAU scenario, the transport share in economy-wide emissions could increase from 14% in 2010 to 22% by 2050 (or about 16% by 2050 for land transport). However, there is significant variation in transport emission shares based on income levels. Generally, as a country becomes richer, the transport share of economy-wide emissions increases, reflecting the fact that transport sector carbon intensity grows relative to other sectors, most likely due to increases in private motor vehicle use. In 2010, the average transport share in total economy-wide emissions in low, middle, and high income countries analyzed in this report were 3%, 8%, and 22%, respectively, and national transport emissions shares ranged from a low of 2.4% (Myanmar) to a high of 36.3% (Montenegro).[70]

Also important is the energy mix in countries (e.g. if hydro or nuclear account for a high share of power generation, then transport is likely to have a higher share of emissions). Since the phasing in of renewables will not happen at same pace across the world, this will also influence the relative share of transport emissions relative to total emissions. In any case, developing countries with low transport share of economy-wide emissions are projected to grow quickly, resulting in increases in the global transport share of total emissions in future.

D. Low-carbon Scenario (LCS)

The Low-carbon Scenario (LCS) considers significant additional policy measures and investments in low-carbon modes, which allows the transport sector to deviate from the BAU emission trajectory. Low-carbon measures include a combination of 'Avoid' strategies, which reduce the need to travel (e.g. transport demand management); 'Shift' strategies, which move transport trips to more efficient modes (e.g. public transport improvements); and 'Improve' strategies, which increase the efficiency of existing trips (e.g. fuel economy standards). This scenario may include different policy options either in combination or in isolation as determined based on several factors such as local priorities, costs, marginal abatement cost curves, and co-benefits.

[70] Emission Reduction Potential in The Transport Sector by 2030

An extensive literature review was carried out by consulting and reviewing more than 450 studies[71] to extract detailed bottom-up projections for BAU and low-carbon scenario for 2030 and 2050. Globally about 60 countries have carried out "long-term" low-carbon transport emission modeling (i.e. for 2050), which account for a subset of the 450+ studies referenced above. Attempts were made to identify at least two to three low-carbon studies per country for the 60 countries that have carried out low-carbon transport emission modeling for 2050. The LCS projections were first combined as a simple average by country and then in an aggregated manner.[72]

Trends in Policy Measures

Based on the typology analysis of the policies and measures modeled, it was found that three times more passenger transport mitigation policies have been considered compared with freight transport policies, which are often neglected in mitigation assessment studies (**Figure 12**). However, freight consumes about 40% of transport energy demand, and in many developing countries its share of energy use exceeds passenger transport energy demand.[73] Global Fuel Economy Initiative has quantified that road freight vehicles need to contribute about 50% of transport emissions reductions necessary to switch from a 6DS to 2DS scenario.[74]

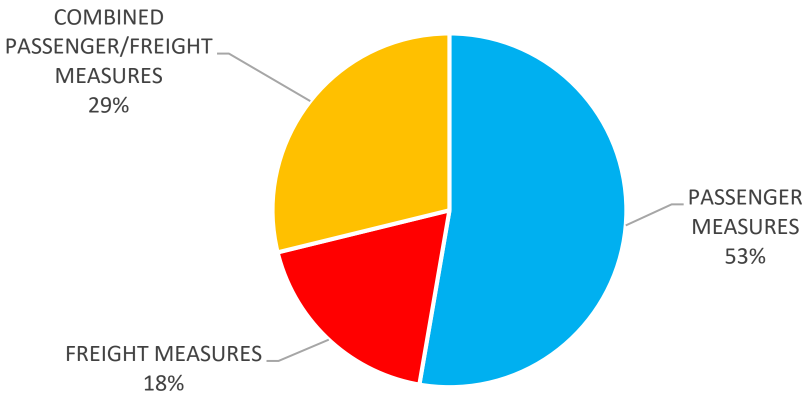

Figure 12 Modes considered in Mitigation Measures (LCS Scenario)

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[71] The 450 studies are selected from available transport sector BAU projections and mitigation potential estimates derived from modeling efforts by government agencies, development banks, and research organizations. A major limitation of the BAU scenario is that it considers a simple average of the different BAU estimates from individual studies for a country based on a detailed literature review, and we do not differentiate among estimates based on their probable accuracy or based on their assumption of socio-economic factors.
See Annex III for a list of studies.

[72] It is important to note that for each particular country, LCS projections from different studies and sources can vary significantly due to a number of factors (e.g. methodology, socio-economic projections, type and source of data, and differing intensity, timeline and magnitude of policies modelled).

[73] http://www.iea.org/publications/freepublications/publication/Tracking_Clean_Energy_Progress_2015.pdf

[74] GFEI: Fuel Economy State of the World 2016 Time for global action

Figure 13 compares the dominance of passenger transport mode and "improve" strategies in both OECD and non-OECD mitigation assessments (i.e. excerpted from the 450 studies considered). However, there are few subtle changes among different types of countries. For example, fiscal instruments are more preferred in the OECD countries while mode shift-related policies are more prevalent in non-OECD countries. Also, OECD countries tend to utilize "policy-packages" rather than modeling individual policies.

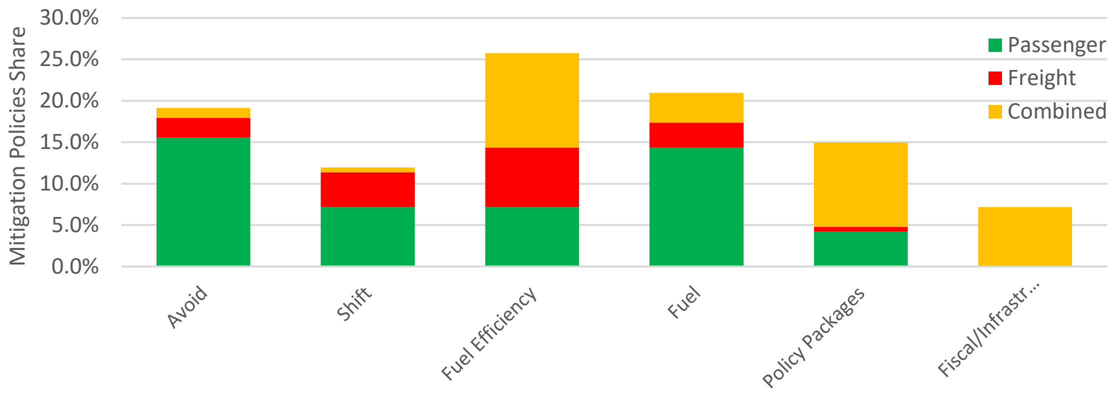

Figure 13 Typology of Policies & Measures in Mitigation Studies

Figure 14 shows a broad snapshot of policies and measures being assessed in current transport modeling literature (i.e. excerpted from the 450 studies considered), and establishes that there is a high dominance of 'Improve' strategies (61%) when compared to 'Avoid' and 'Shift' strategies[75].

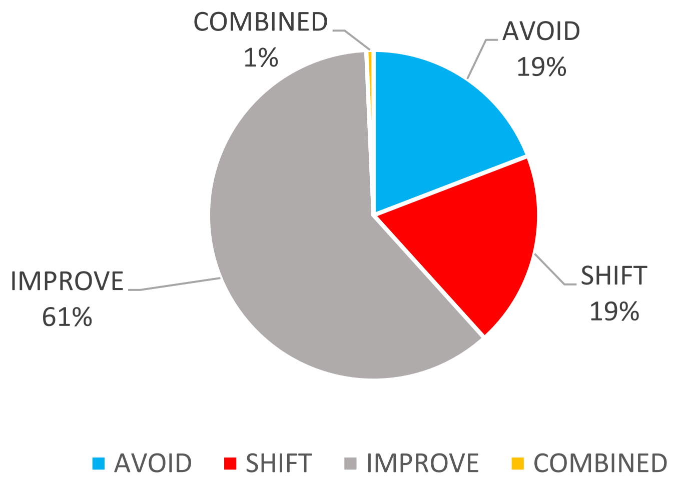

Figure 14 Policies & Measures considered in Mitigation Studies

[75] When policy packages are further delineated into avoid-shift-improve strategies where possible.

This trend is also visible in the formal climate policy-context, as the majority of mitigation measures (about 63% of nearly 307 proposed mitigation measures) proposed in NDCs represent 'Improve' strategies (**Figure 15**)[76].

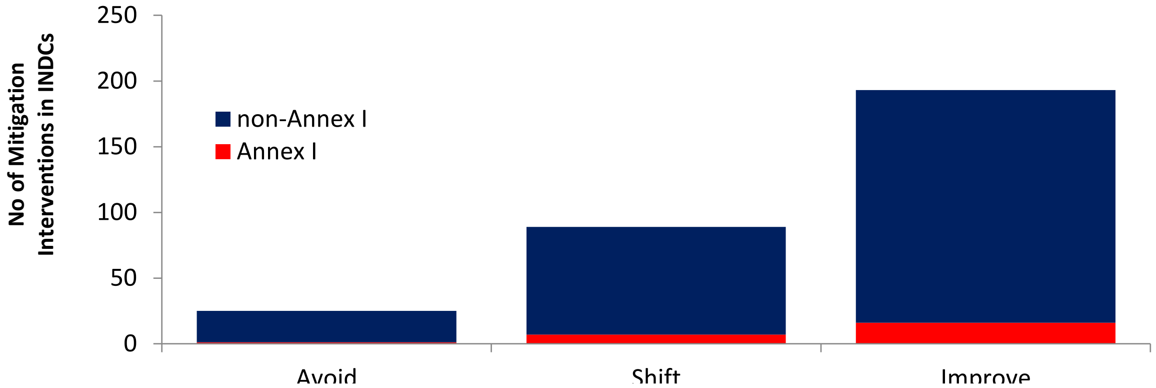

Figure 15 Mitigation Measures in NDCs

Potential reasons behind the high proliferation of 'Improve' strategies (e.g. electrification of vehicles) include an assumption of high mitigation potential when compared to "Avoid" and "Shift" strategies (e.g. walkable cities, improved public transport), perception of feasibility of implementation, perception of potential job creation, and insufficient consideration of sustainable development co-benefits in climate change policy making.

For example, IEA's 2015 Energy Technology Perspectives states that policies on Avoid and Shift can be assumed to reduce global transport energy consumption and emissions by 15% or more by the middle of this century in a stringent mitigation case[77]. IEA[78] has estimated that, total passenger activity can increase from 54 trillion passenger kilometers (2015) to 100 trillion passenger kilometers in the 2040s and freight activity could increase from 108 trillion ton-km in 2015 to 167 trillion ton-km in 2050. In the OECD countries the 2DS projection sees a 17% reduction in light-duty vehicle travel per capita between 2010 and 2050, while in the developing and emerging countries, light-vehicle travel per capita triples in 2DS case.[79]

McKinsey, in 2009, in its multi-sectorial global assessment concluded that behavioral change constitutes only about 8% of total mitigation by 2030. In the ITF Global Urban Passenger Model[80], between 79% and 89% of total emission reductions in 2050 were due to changes in technology, i.e. a switch to alternative fuel and advanced vehicle technologies, depending on the policy scenarios.[81]

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[76] Nationally-Determined Contributions (NDCs) Offer Opportunities for Ambitious Action on Transport and Climate Change (Updated). Note that this speaks to the number of proposed interventions, but not their relative mitigation impact.
[77] IEA, Energy Technology Perspectives 2015 - Mobilising Innovation to Accelerate Climate Action,
[78] IEA Energy Technology Perspectives 2016 – Towards Sustainable Urban Energy Systems
[79] Transport Pathways for Light Duty Vehicles: Towards a 2° Scenario
[80] ITF, International Transport Forum Transport Outlook 2017 (in press)
[81] Pathways to a low-carbon economy: Version 2 of the global greenhouse gas abatement cost curve

Yet, recent estimates from ITDP and UC Davis[82] indicate that by improving and expanding policies and investments on public transportation, walking and cycling, urban passenger transport emissions could be reduced 40% by 2050, which is equivalent to about 13% of global transport GHG emissions. Further, taking sub-national modeling approach can also help delineate Avoid and Shift effects due to increased urban density and better land-use planning, in contrast to broader policies driven by GHG/capita at national levels.

At a more general level, the analysis of low-carbon modeling studies indicates that many analysts that have quantified avoid and shift strategies arrive at the conclusion that these can have a comparable impact to that of improve strategies (**Figure 16**). This demonstrates that Avoid is potentially as important as Shift, which in turn is as important as Improve oriented measures. The effectiveness of each type of policy in reducing emissions also depends on existing policies and measures, as well as current transport demand and behavior.

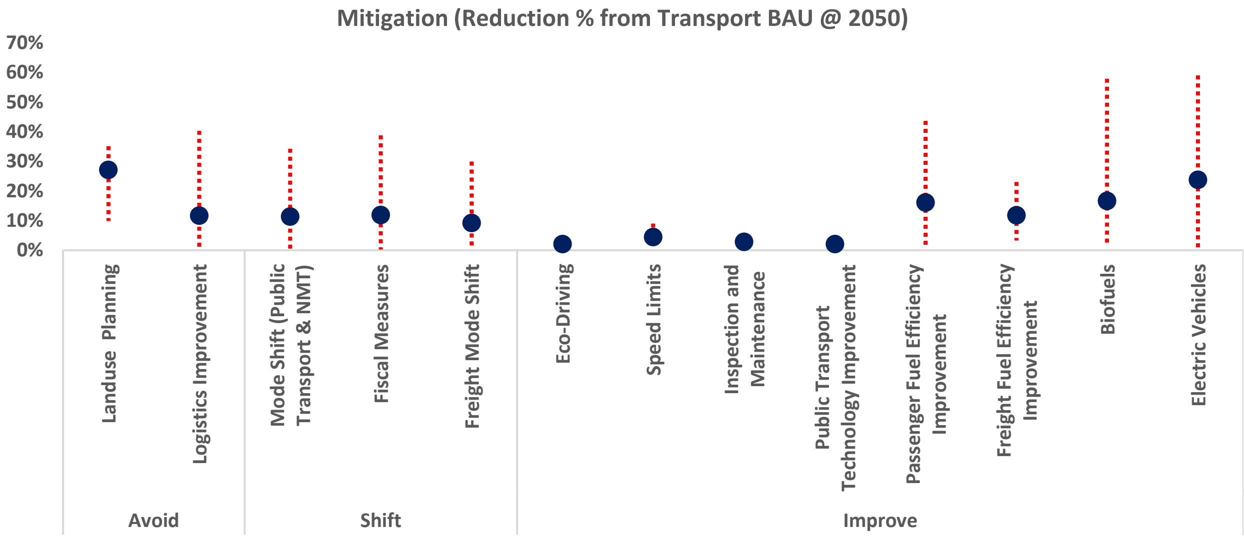

Figure 16 Mitigation Impacts of Individual Policies from Transport BAU (at 2050)[83]

This figure further implies that there is a large variation in mitigation impact, due to a number of factors such as magnitude and intensity of measure considered, market segment considered, socio-economic characteristics, modes considered, assumptions in travel activity, mode share, existing transport infrastructure and services provided, price elasticity of transport demand, fuel intensity and carbon intensity of fuels. For example, fuel efficiency improvement could be carried by simple eco-driving or increasing or decreasing speed flow, by improving vehicle maintenance or by scrapping old vehicles or by implementing fuel economy standards.

Further, these instruments could be applied for a particular mode or across all modes or could be carried out only in urban areas or across all regions within a country with different intensity. The resulting impact will vary and will also influence other factors linked to fuel consumption. For example, increased fuel efficiency may lead to more travel demand and

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[82] A Global High Shift Scenario: Impacts And Potential For More Public Transport, Walking, And Cycling With Lower Car Use, By Michael A. Replogle, Institute for Transportation and Development Policy & Lewis M. Fulton, University of California, Davis

[83] SLoCaT Partnership analysis

may also prevent to some extent mode shift to public transit resulting in reduced mitigation impact as driving becomes cheaper.[84]

The Paris Agreement on Climate Change "aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty" (emphasis added) and thus mitigation strategies should be considered based on their contribution to wider sustainable development goals and not solely based on their "mitigation impact".[85] This is especially relevant for the developing countries where travel demand is set to multiply in the coming decades. It is these countries that suffer the largest problems in terms of road safety, air pollution and congestion and which have the largest interest in transport policies that combine the reduction of transport emissions with other developmental objectives.

Improve strategies aimed at reduction of greenhouse gas emissions can have important effects on air pollution (through e.g. introduction of electric vehicles) but these do not address other developmental concerns like road safety and congestion. Avoid and Shift strategies do have the potential to address multiple developmental concerns (especially in a context where the transport sector is still rapidly growing). Furthermore, Avoid and Shift strategies tend to accrue significant cost savings (as compared to Improve strategies), through such factors as reduced health care costs due to increased physical activity; decreased traffic accidents; and increased productivity due to reduced driving time.

Clearly, avoid and shift policies are especially relevant in context of deep decarbonization in non-OECD economies, as these countries have not yet fully "locked in" to high emission trajectories with high investments into carbon-intensive infrastructure.

For radical transformation, a wide array of low-carbon policies needs be implemented to avoid unnecessary motorized trips (and to reduce the lengths of such trips), shift motorized trips to low-carbon modes, and improve the efficiency of motorized trips. Low-carbon strategies for the transport sector should, in order to maximize impact ideally be a balanced combination of 'Avoid-Shift-Improve' strategies applicable to both passenger and freight movement, in order to achieve both carbon reductions and development co-benefits. Avoid and Shift strategies must form the foundation of decarbonization policy especially in developing countries: passenger vehicle ownership in OECD countries is projected to increase by about 10% from 2010 to 2050, while in non-OECD countries, the projected increase is about 300%[86].

E. Combined analysis

By implementing low-carbon transport policies that were identified in the mitigation potential assessment studies, transport emissions could be reduced by an estimated 28% by 2030[87]

[84] The ranges reflected in chart are intended to avoid the additive (i.e. "double counting") impact of these policies.
[85] While from a pure climate change mitigation perspective vehicle efficiency and low-carbon fuels may provide the biggest potential, this does not fully reflect a broader sustainable transport perspective. See Transport Pathways for Light Duty Vehicles: Towards a 2° Scenario
[86] International Energy Agency. 2015. *Energy Technology Perspectives*. Paris.
[87] The 2015 SLoCaT study "Emission Reduction Potential in The Transport Sector by 2030" projected mitigation potential to be 24% in 2030.

and 62% by 2050 (**Figure 17**)[88]. The LCS emissions in this study represent a bottom-up scenario reflecting local development needs and priorities. The scenario is then aggregated using low carbon measures considered for implementation in individual countries based on an analysis of combined costs, co-benefits and multi-criteria assessments.

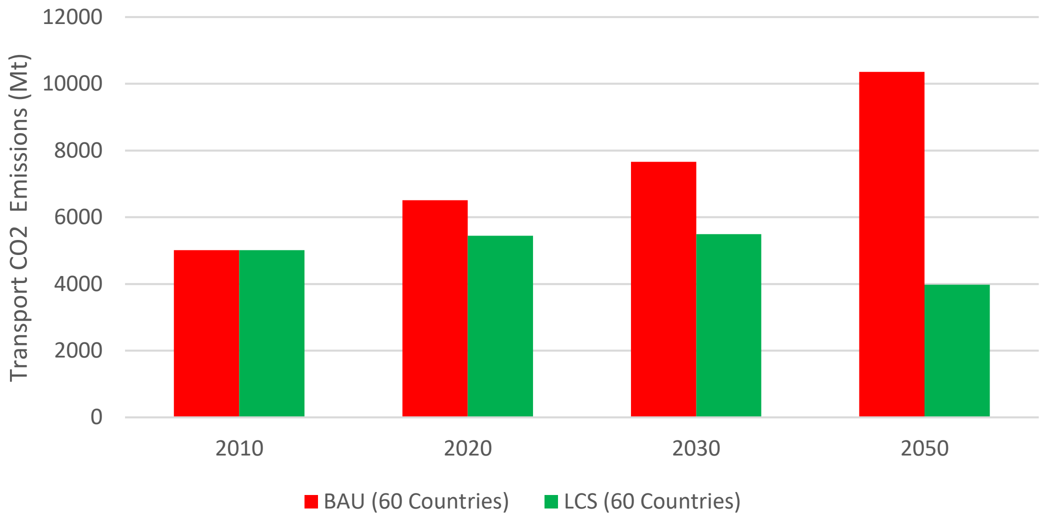

Figure 17 Transport CO2 Emissions in Low-carbon Scenario

It is significant, to note that the mitigation potential assessed (i.e. 62% by 2050) well exceeds the potential estimated by the IPCC fifth assessment report[89] which suggested *"For the transport sector, a reduction in total CO2eq emissions of 15–40% could be plausible compared to baseline activity growth in 2050* (*medium evidence, medium agreement)".*

The growth in land transport emissions could be reduced from a total of 13 Gt to about 5 Gt by 2050. **Figure 18** shows the emission gap between low-carbon scenario with 2DS and 1.5DS scenario. By 2050, the emission gap of LCS (estimated) with 2DS and 1.5DS scenarios is 10% and 149% respectively. If all countries were to aggressively implement low-carbon transport policies being considered and modeled, the transport sector could bridge the 10% emission gap and reach 2DS targets; however, a 1.5DS target appears much more elusive and it is clear that additional ambition is required.

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[88] In order to understand the emission gap at the global level, the LCS growth rates for OECD and Non-OECD countries are applied to countries without bottom-up data to get a global LCS projections and to compare with 2DS and 1.5DS scenarios. This assumes that other countries are able to implement similar policies as considered in countries analysed in this study

[89] IPCC, 2014: Summary for Policymakers. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

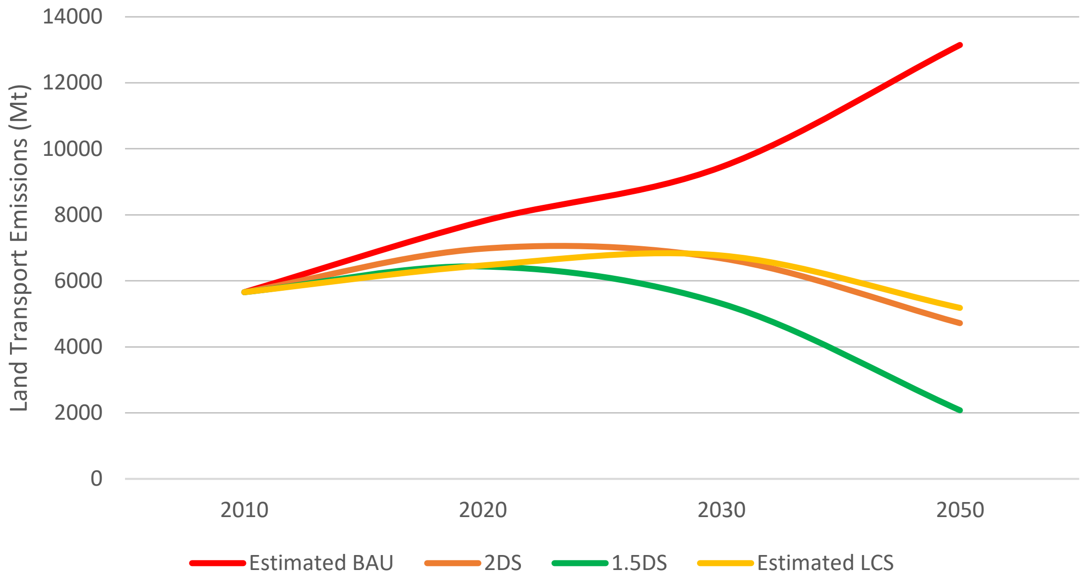

Figure 18 Transport emission gap under LCS

Figure 19 compares projected country transport emission growth under both BAU and LCS. For example, India can reduce projected BAU growth of 600% to about 150%, with low-carbon policies. In addition, the majority of OECD countries go below 0% in LCS from 2010 to 2050 resulting in a decrease in absolute emissions through the adoption of low-carbon policies.

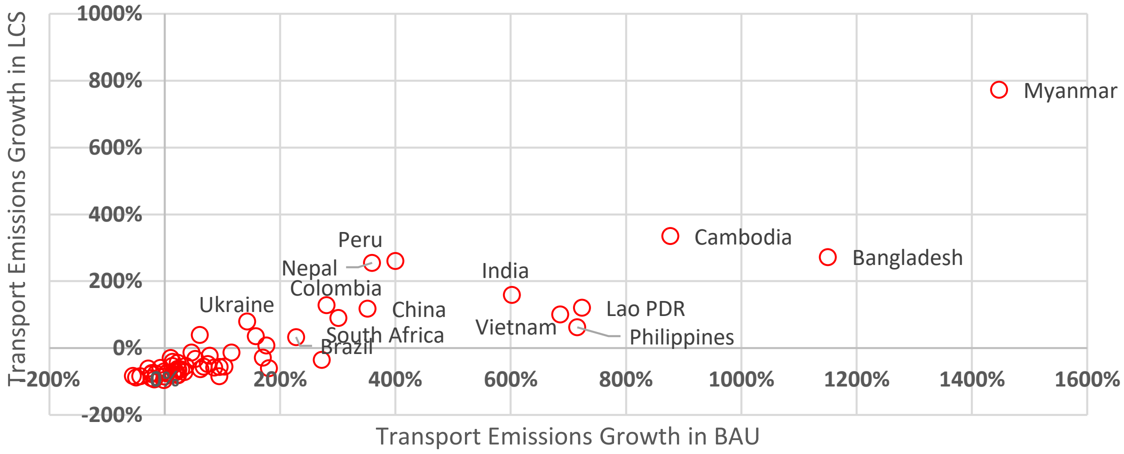

Figure 19 Transport CO2 emissions change to 2050 under BAU vs. LCS

However, even by 2050, 17 countries[90] out of 60 countries considered in our analysis would not have peaked their transport emissions by 2050 even with the implementation of low-carbon transport policies being planned or even considered. Thus, considering the observed aggregate high emission gap with 1.5DS scenario, it is clear that current policies and measures being considered by individual countries are in several cases inadequate and more transformational measures are needed.

[90] Argentina, Bangladesh, Brazil, Cambodia, China, Colombia, India, Laos, Myanmar, Nepal, Peru, Philippines, Romania, South Africa, Thailand, Ukraine, Vietnam

By 2050, under the LCS scenario, transport CO2/capita reaches the 2DS limits of 0.5 (0.48) tons/capita; however, the 1.5DS requirement is about 0.2 tons/capita[91] (Figure 20). Under the LCS, while the OECD countries are able to reduce transport emissions from 3 tons/capita to 1 ton/capita by 2050, non-OECD countries limit the growth in transport CO2/capita from 1.2 tons/capita to 0.5 tons/capita.

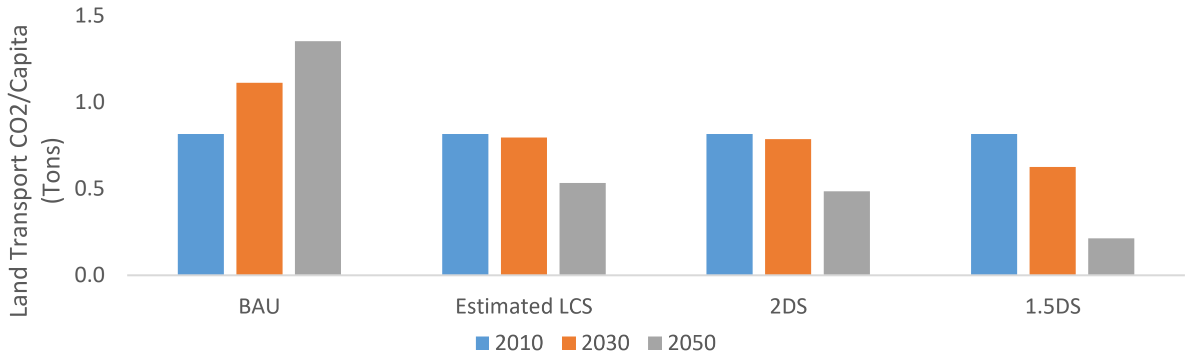

Figure 20 Transport CO2 per Capita (BAU, 2DS, 1.5DS & LCS)

It is also notable that there is not a great difference in mitigation potential at 2050 under LCS among different typology of countries (e.g. OECD and non-OECD countries show mitigation potential of 65% and 59% by 2050, respectively, assuming sufficient financing/investment capacity) (Figure 21).

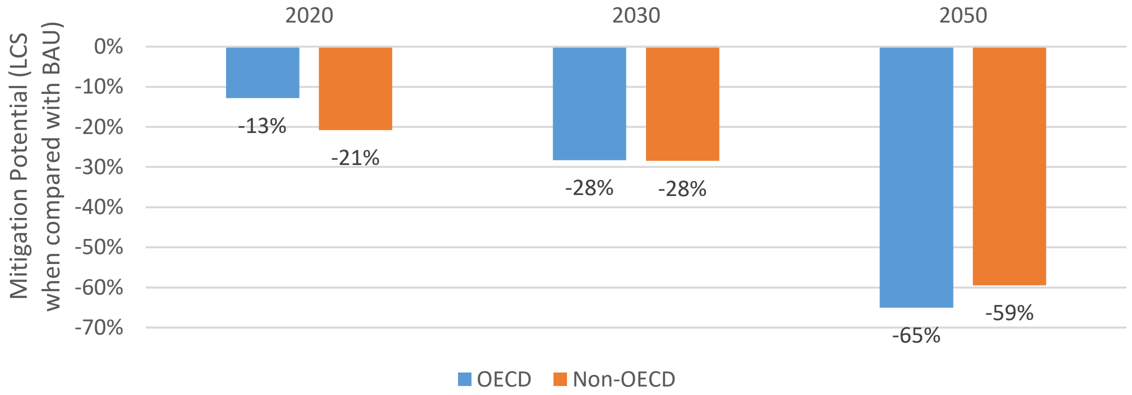

Figure 21: 2050 mitigation potential in non-OECD countries

91 Without aviation and shipping.

IV. Making use of bottom-up mitigation assessments to accelerate transformative change in the transport sector

The bottom up approach to the assessment of mitigation potential in the transport sector that underpins this report can help the planning of accelerated transformative action in the transport sector in support of 2DS or better target. Two primary means of achieving this target in practice are: (a) the forthcoming revision of nationally-determined contributions (NDCs) and the formulation of low greenhouse gas emission strategies under the Paris Agreement, and (b) the emerging transport sector Global Road Map and Quick Wins under development by the Paris Process on Mobility and Climate (PPMC).

A. NDC 2.0 and low greenhouse gas development strategy concept under Paris Agreement

The mitigation contribution that each individual country has elected to contribute toward global climate targets are known as nationally determined contributions (NDCs). Article 3 of the Paris Agreement requires them to be "ambitious", "represent a progression over time" and set "with the view to achieving the purpose of this Agreement". The contributions are to be reported every five years and are to be registered by the UNFCCC Secretariat. Each further iteration should be more ambitious than the previous one, known as the principle of 'progression'. Countries can cooperate and pool their NDCs[92].

Among 160 NDCs representing 187 countries that were submitted as of August 1, 2016, 75% explicitly identify the transport sector as a mitigation source, and more than 63% of NDCs propose transport sector specific mitigation measures. In addition, 9% of NDCs include a transport sector emission reduction target, and 12% of NDCs include assessments of country-level transport mitigation potential.

Transport related actions in the NDCs are heavily skewed towards passenger transport, which is included in 91% of NDCs identifying specific transport modes. Among these, urban transport measures are mentioned in 74% of NDCs, and heavy rail and inland waterway are also well represented, while strategies such as high-speed rail (2%), aviation (5%) and walking and cycling (14%) have received relatively less attention (**Figure 22**).[93]

[92] Articles 3, 4(9), 9(3), Paris Agreement (2015)
[93] Nationally-Determined Contributions (NDCs) Offer Opportunities for Ambitious Action on Transport and Climate Change (Updated)

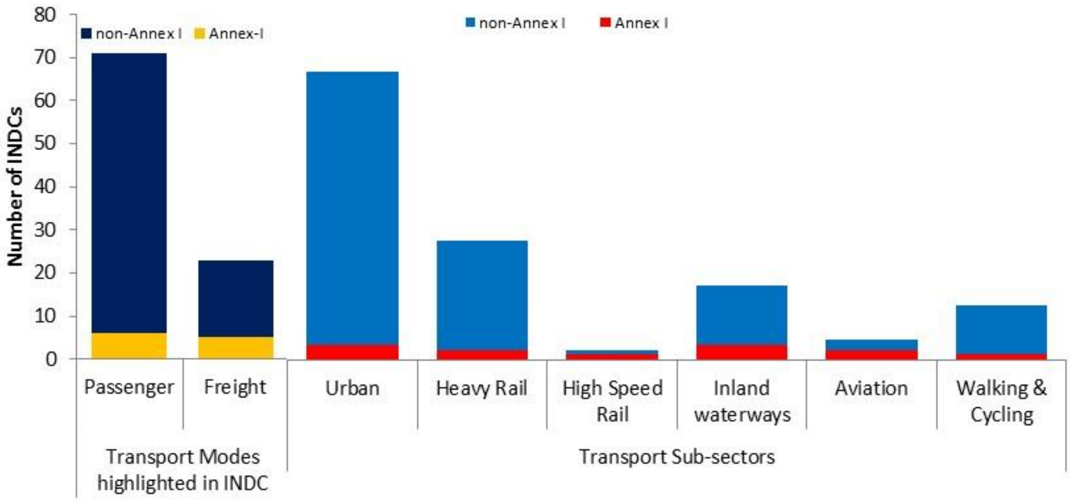

Figure 22: Share Of Transport Mitigation Measures in NDCs by Mode and Subsector

The Paris Agreement does not foresee substantive strengthening of NDCs for the 2020-2025 period, which would be needed to achieve the required peak in transport emissions during the same period to maintain a 2DS or 1.5DS trajectory (as previously discussed in this report). Recent assessments by a range of international bodies have concluded that current NDCs will not be sufficient to achieve a 2DS, despite broad consensus that ambition levels in current NDCs are on a projected course for a 2.7 degree Celsius increase. A SLoCaT assessment of current NDCs confirms that ambition level of the NDCs also falls far short of what is required.[94]

It is essential that transport components in the revised NDCs are informed by the targets and strategies described in this study through an aggressive implementation of a low-carbon scenario in countries across the income spectrum. In this context it is key that the Ad Hoc Working Group on the Paris Agreement (APA) emphasizes the importance of considering bottom-up mitigation assessments in the development of further guidance to assist Parties in submitting their future NDCs, which are to be re-submitted by 2019 (with earlier action encouraged).[95]

Much work must be done to decide both on the inputs that will be used to monitor progress toward the Paris Agreement's goals, and the outputs that will inform Parties' future actions. Countries will take initial stock of their collective efforts in 2018, through a "facilitative dialogue," and starting in 2023 hold a global stocktake of efforts to reach the goals every five years (see Box 3 for further explanation).

The **Facilitative Dialogue** that is going to take place in 2018 is a process to review the first NDCs and shape how future global stocktakes can be shaped. It intends to assess the progress on the implementation of technology, finance and capacity-building support to developing country Parties and the mitigation efforts by all Parties (according to Decision 1/CP.19, paragraphs 3 and 4). For more information, see http://unfccc.int/cooperation_and_support/financial_mechanism/items/9985.php

The **Global Stocktake** is intended to take place every 5 years in order to measure and review the global progress towards achieving the goals of the Paris Agreement. Based on the result, Parties can adjust their mitigation actions and increase ambition levels. For more information, see the following links:

94 Nationally-Determined Contributions (NDCs) Offer Opportunities for Ambitious Action on Transport and Climate Change (Updated)
95 http://www.wri.org/sites/default/files/Post-Paris_Key_Areas_final_revised_v2_FINAL_FOR_BLOG.png

- https://unfccc.int/files/meetings/bonn_oct_2015/application/pdf/art.10_sog_23102015.pdf
- http://www.wri.org/blog/2016/05/insider-4-key-questions-design-global-stocktake

Additional UNFCCC terminology is provided in a glossary of key terms at http://www.ppmc-transport.org/cop22-negotiations/

Box 3: UNFCCC Terminology

This global stocktaking will use the latest reports of the IPCC as inputs, and so the Panel also agreed in April 2016 to consider by 2018 how best to align the work of the IPCC during the development of its Seventh Assessment Report (AR7) with the needs of the global stocktake.[96] Additionally, Parties are invited to communicate their “mid-century long-term low GHG emissions development strategies,” or “long-term strategies” by 2020.

Making full and optimal use of country based, bottom-up, assessment of demonstrated mitigation potential is key to ensure that the upcoming efforts on facilitative dialogue, global stocktake and long-term low GHG emission development strategies are country specific and are evidence based, while optimizing low-carbon policies in the context of sustainable development. In this context, it is crucial to also consider carbon reduction co-benefits and address any potential conflicts between NDCs and SDGs, to ensure that climate and development goals complement each other to the greatest possible extent.

Implications for COP21 decision elements

IPCC 1.5 Study – global stocktake

The IPCC was invited by the COP21 to work on a special report about the impacts of global warming of 1.5 degree Celsius above pre-industrial levels. The report is going to show the related global greenhouse gas emission pathways and the findings can be used for a roadmap to decarbonize transport. The report is due to be released in 2018.

This study demonstrates that the IPCC may be underestimating projected aggregate emissions in the transport sector as well as underestimating emissions reduction potential (as noted in AR5). The current study, based on a bottom-up approach, offers the possibility to create a more structured approach, and has the potential to inform the forthcoming IPCC 1.5DS study.

NDC 2.0 and GHG emission studies

A 1.5DS has the positive potential to raise mitigation ambition in forthcoming iterations of NDCs, but it also poses the possible pitfall of pushing the dialogue disproportionately in the direction of technology-oriented solutions. Furthermore, the combination of rapid motorization and transport infrastructure investment in many developing countries, coupled with ongoing policy gaps that keep these investments from moving in a more sustainable direction, highlight the need for a more structured approach.

Thus it is very important to highlight the necessity of creating a coherent global transport roadmap, and of defining and implementing a set of quick wins to rapidly set emissions on trajectory consistent with a goal of full decarbonization soon after 2050. Finally, it is essential

[96] https://ipcc.ch/news_and_events/pdf/160422_%20IPCC_HLEE_statement_final.pdf

to focus on short- and medium-term transport actions that have the potential to yield sustainable development co-benefits (in addition to carbon emission reductions) and to provide significant cost savings to society. These outcomes are necessary to achieve the broader goals of the global climate and development agenda, once again conspiring against a purely technological approach to transport sector improvements.

B. Development of Global Decarbonization Road Map and Quick Wins

To guide the transformation towards a better than 2DS in the transport sector, there is a need for a broad consensus on a comprehensive global roadmap that links policy, investment and behavior, as well as technology in a coordinated manner. The aim of such a roadmap is to put transport on to a path to decarbonization early in the second half of the century. The transformation of the transport sector will be greatly aided by implementing a series of "quick-win" actions to kick-start progress toward a longer-term shift.[97]

Since early 2016, the PPMC, composed of Michelin Challenge Bibendum (MCB) and SLoCaT, have been advocating and developing a comprehensive global roadmap for decarbonizing the transport sector.[98] The global roadmap process aims to build multi-stakeholder support for a realistic, strategic macro-vision of the transformations necessary over the next 40 to 60 years, in order to drive effective early transformative action for transport (by state and non-state actors) in a coordinated, determined, and powerful way.

The global roadmap, will focus on identifying a balanced package of measures necessary, which will take into account the main sustainable transport paradigm: combining *Avoid* (i.e. reduce unnecessary travel) *and Shift* (i.e. shift movement of goods and people to the most efficient modes) with *Improve* (i.e. improve environmental performance of fuels and engines) actions in the short term in all regions of the world, while taking into account the potential of new, shared mobility solutions and supportive enabling institutional and financial mechanisms. The aim is to ensure that *all* the necessary policies *and* technologies are included in a single comprehensive, development sensitive, transport roadmap that integrates regional specifics. This will include a certain amount of prioritization of actions based on an assessment of mitigation potential, but will also take into account cost effectiveness, broader sustainable development impacts, and political acceptability.

The actions proposed in the roadmap will be global in nature but the manner in which they are deployed will be dependent on local circumstances, and thus the roadmap must be flexible enough to reflect different conditions in more-developed countries, emerging countries, and least-developed countries. The regional differentiation of the global roadmap will take into account the specific circumstances of developed countries (mostly OECD member states), transitional, and least developed countries (mostly developing countries with a specific focus on Africa, Asia and Latin-America and the Caribbean).

A successful development of a common global roadmap for the transport sector will require close coordination with other sectors, at global, national and local levels. The growing importance of non-traditional fuels like electricity, and in the future possibly hydrogen, calls for close coordination with the energy sector. A better linkage of transport planning with urban planning and changes in land use, resulting in more compact cities, is key in lowering the need for transport among the rapidly growing urban population in the world. A combination of government regulations and transport pricing policies will also be necessary.

As a first step it will be important to firmly establish the specific needs for regional and global 'transformational changes'. The next step will be to clearly describe what an efficient 2050 - 2070 transport system should look like in various national and regional contexts; this in effect becomes the 'destination' of the roadmap. This work will clarify and guide implementation of

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97 http://www.ppmc-transport.org/global-road-map-2/

98 http://www.ppmc-transport.org/global-road-map/

Paris Agreement on Climate Change, as well as the 2030 Sustainable Development Agenda for the transport, to limit climate change to 1.5DS and support sustainable development.

Achieving the targets of the global roadmap in the long-term requires a course of immediate bold and ambitious actions that will kick-start the transformation of the transport sector in the desired roadmap directions, and limit the lock-in effects of a high-carbon BAU scenario. It is in this spirit that SLoCaT/PPMC have proposed a number of transport "quick win" actions for implementation at scale in the pre-2020 period, to build a foundation for the global roadmap.[99]

These pre-2020 actions span policy, regulatory and operational solutions for both human mobility and freight movement, thus providing a balanced toolbox to ramp up needed actions across transport themes and modes, and structuring efforts in three directions:

- Prompting decisions to expand the implementation of solutions which have already proven their efficiency at a smaller scale or with a less ambitious scope (e.g. bike sharing)
- Halting existing practices and/or regulations that run in directions opposite to what is required to set the global transport sector on a lower-carbon trajectory (e.g. fossil fuel subsidies)
- Initiating without delay and at relatively low cost, actions or decisions preparatory to full implementation of a global decarbonization roadmap (e.g. carbon pricing)

Quick wins are not stand-alone solutions; they are essentially pre-2020 steps towards the implementation of the de-carbonization roadmap. Therefore, implementing a full-blown transformation will require scaling up proven no-regret actions without delay, with some of the ensuing benefits arriving pre-2020 and others post-2020.

The identification and analysis of country specific mitigation measures can inform the development of interrelated, region specific, policy packages in a global roadmap for the decarbonization of the transport sector. The analytical framework developed in this study can also help to clarify the impact of the implementation of a global roadmap at the country level.

The analytical framework used in this report has been helpful in assessing the impact of a series of Quick Wins identified by the SLoCaT Partnership.

Together, the global road on decarbonizing transport and the Quick Wins on Transport, Sustainable Development and Climate Change can help to inform global, regional and national policy on transport and climate change and thereby optimize emission reductions in the transport sector.

[99] http://www.ppmc-transport.org/quick-wins-on-transport-sustainable-development-and-climate-change/

V. Conclusions and Recommendations

Understanding the implications of 2DS and 1.5DS for the transport sector

The above 2050 analysis carried out with aggregated insights from more than 450 studies and insights from 60 countries (Annex III), has yielded a number of key findings as related to BAU scenarios, 2DS and 1.5DS requirements, and (bottom-up) emission reduction potential:

BAU scenario

1. Under a business-as-usual (BAU) scenario, global land transport sector (tank-to-wheel) emissions could grow from 6.3 gigatonnes (Gt) annually in 2013 to 13 Gt by 2050.[100] Assuming that all other sectors follow a BAU scenario, this would result in an increase in the transport share of total economy-wide emissions from 12% to 16% by 2050.[101]
2. From 2010 to 2050, under a BAU scenario, transport sector emissions in non-OECD countries are projected to increase nearly threefold (295%) while transport emissions from OECD countries are projected to increase only slightly (17%).[102]
3. Individual country transport specific modeling efforts, as documented in this report based on a range of country specific reports, tend to project more rapid increases in transport emissions, especially in the period 2030-2050, when compared with global estimates which are often based on national or regional energy-economy and integrated assessment models built on regional growth drivers.[103]

Emission reduction requirements for 2DS and 1.5DS

1. This report develops analysis indicating that applying 2DS and 1.5DS targets for the transport sector could result in emissions of 4.7 Gt and 2 Gt by 2050, respectively, as compared to a 13 Gt projection under BAU.
2. Transport sector emissions need to peak in the first half of the 2020s (or require more intense reductions in case of a delay) in order to stay on track to achieve 2DS and 1.5DS targets; thus, any delay in scaling-up mitigation efforts will make this transformation nearly impossible to achieve.

(Bottom-up) emission reduction potential

1. By implementing a set of low-carbon transport policies identified in policy and research documents collected in support of this document[104], transport emissions could be reduced to about 5 Gt (roughly 60% below BAU by 2050). This exceeds

[100] Throughout this report, emissions magnitudes are given in annual and not cumulative terms.
[101] This is based on a dynamic baseline established by individual studies, which generally consider "business-as-usual" (BAU) as no additional new radical implementation of low-carbon policies, and assumes that current emission trends will continue. The IPCC Fourth Assessment Report defines BAU as a baseline/reference case, assuming that future development trends will follow those of the past and no changes in policies will take place.
[102] It should be noted that non-OECD countries are starting from a very low baseline in 2010 compared to OECD countries.
[103] National modeling numbers can be found in Annex I.
[104] As considered in the low carbon modelling studies. These studies consider policies for emission modelling based on local priority, cost, co-benefits and mitigation potential, and also include planned transport related measures in NDCs.

the mitigation potential estimated by the IPCC Fifth Assessment Report[105] which states *"For the transport sector, a reduction in total CO_2eq emissions of 15–40% could be plausible compared to baseline activity growth in 2050* (*medium evidence, medium agreement*)*".*

2. Both OECD and non-OECD countries show comparable transport mitigation potential by 2050.[106] Thus, transport has considerable potential to contribute towards economy-wide emission reductions by filling policy gaps based on currently identified mitigation measures.[107]
3. Analysis of policy measures identified indicates that passenger transport policies are about three times more likely to be used as a mitigation option when compared with freight policies (based on national studies), although freight accounts for about 40% of global transport emissions[108].
4. "Improve" strategies (e.g. electrification of vehicles) are more widely represented (accounting for about 60% of actions) in national mitigation strategies (including NDCs) when compared to 'Avoid' strategies (e.g. walkable cities) (about 17%) and 'Shift' strategies (e.g. improved public transport) (about 20%) or combinations thereof. Potential reasons behind the bias toward 'Improve' strategies include an assumption of high mitigation potential when compared to "Avoid" and "Shift" strategies, perception of feasibility of implementation, perception of potential job creation, and insufficient consideration of sustainable development co-benefits in climate change policy making.
5. An analysis of 450 low-carbon emission modeling studies[109] indicates that many analysts that have quantified 'Avoid' and 'Shift' strategies arrive at the conclusion that these can have a comparable impact to that of improve strategies.
6. By 2050, implementation of low-carbon transport policies could enable the transport sector to approach a 2DS, with a projected 10% gap (i.e. emission difference between low carbon scenario and required 2DS scenario) in 2050.[110] However, the emission gap with required reductions for a 1.5DS is projected at roughly 150%.

In sum, a bottom-up analysis considering additional transport mitigation measures shows potential to approach a 2-degree scenario (if all modeled policies are implemented), but would still fall well short of a 1.5-degree scenario. It is clear therefore that current policies and measures being considered for individual countries are generally inadequate and more transformational measures are needed. As such, more ambitious transport mitigation

[105] IPCC, 2014: Summary for Policymakers. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.),. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
[106] This finding is consistent with the findings of IEA ETP 2016: "The potential to reduce GHG emissions in percentage terms is roughly the same in OECD and non-OECD economies (GHG emissions in the 2DS in 2050 are 60% to 70% lower than in both 4DS and 6DS), but the cumulative abatement potential in absolute terms (in million tonnes of CO2 equivalent) is about 60% greater in non-OECD economies than in OECD countries."
[107] This assumes that policies are implemented as visualized in the modeling studies, acknowledging that many of these measures and policies may not be implemented in reality due to many factors. The complete list of studies considered in the analysis is available in Annex III.
[108] IEA Mobility Model, 2015 (counting only tank-to-wheel emissions for land transport). We do not have projections available for 2050. It is acknowledged that a comparison of the number of passenger and freight transport policies does not fully reflect the relative mitigation potential of each of these policy types.
[109] See Annex III.
[110] This acknowledges a range of uncertainty that could exceed the stated 'gap'.

measures are needed to reach the 1.5-degree scenario targeted in the Paris Climate Agreement[111].

Considering a high emission gap with proposed 1.5DS scenario, it is important to understand the typology of low-carbon mitigation measures being proposed for understanding the mitigation potential and recommended for implementation by several groups. It is also important to emphasize that all sectors needs to contribute and 1.5 degrees would mean that pushing the envelope in all sectors, including transport.

Preliminary Recommendations

1. Making optimal use of *country-based*, bottom-up assessment of demonstrated mitigation potential is key to ensure that the upcoming efforts by the United Framework Convention on Climate Change (UNFCCC) on facilitative dialogue, global stock taking and long-term low GHG emissions development strategies are indeed *country-specific* and evidence-based while optimizing low-carbon policies in the context of sustainable development.
2. The identification and analysis of country-specific mitigation measures can inform the development of integrated, region-specific policy packages in a global roadmap for the decarbonization of the transport sector. The analytical framework developed in this study can also help to clarify the impact of the implementation of a global roadmap at the country level.
3. A series of “no regret” quick win actions are essential in setting a short-term trajectory (by 2020) to allow the transport sector to maximize mitigation potential in the medium term (by 2050):
    a. Prompting decisions to expand the implementation of solutions that have already proven their efficiency at a smaller scale or with a less ambitious scope.
    b. Halting existing practices and/or regulations that run in directions opposite to what is required to set the global transport sector on a lower-carbon trajectory
    c. Initiating without delay and at relatively low cost, actions or decisions preparatory to full implementation of a global decarbonization roadmap.

Strategies to improve quantification of transport GHG emissions

As noted, the “2 Gt by 2050” estimate in this study is not an end in itself, but the beginning of a process of understanding deep reductions which may be required within the transport sector under a 1.5DS. We acknowledge a number of shortcomings in the overall analysis (based in part on data limitations), which include the following:

- Assumption in assigning transport share for 2DS and 1.5DS relative to BAU
- Incomplete country coverage (due to inconsistent data availability)
- Inconsistency in analysis of policy scenarios (due to uneven data distribution)
- No urban/rural split for data on transport emissions per GDP/capita, which has implications for other assumptions and results

[111] The Paris Agreement

A relevant initiative to address data limitations is being led by the Asian Development Bank (ADB), which is close to prototyping a transportation model that can be calibrated by individual countries in a common framework. ADB's user-friendly and policy-oriented approach is currently being tested on a number of ADB member countries, and may be suitable for a wide range of country planning efforts. All of these approaches will be improved through interaction and knowledge sharing with national experts.

In order to improve upon this analysis in future iterations, we propose to take the following steps to contribute toward the research agenda for the sustainable transport community:

- Collaborate within global processes to improve scope and quality of transport data collection
- Identify ways to improve the analysis methodology (e.g. better policy impact assessment tools)
- Consider likelihood of transformative developments (e.g. rapid scale up of electrification/renewable energy, other disruptive technologies)
- Consider actions to be taken beyond 2050, to inform nearer term actions
- Develop baseline indicators considering existing studies. These indicators will help monitor and evaluate the impact of subsequent mitigation actions.

Annex I: Estimates on Transport CO2 Emissions

	Transport CO2 (Mt)			Transport CO2 (Mt): BAU (avg)			Transport CO2 (Mt): Low-carbon (avg)		
	1990	2000	2010	2020	2030	2050	2020	2030	2050
Albania	0.7	1.45	2.2421053	3	3	4	2	2	1
Argentina	28	40	41	54	72	114	52	55	44
Australia	61	73	84	101	115	140	92	85	37
Bangladesh	2	3	8.4	12	26	105	8	13	31
Belgium	21	25	27	24	24	27	21	18	4
Bosnia and Herzegovina	2.17	2.07	5.6010797	7	7	7	4	3	1
Brazil	81	121	166	204	265	544	190	175	221
Brunei Darussalam	0.55	0.8	1.564	2	2	3	1	0	0.25
Cambodia	1	1	2	6	10	19	5	5	8
Canada	139	170	187	223	252	347	180	143	78
China	136	263	514	1337	1714	2320	1012	1217	1118
Colombia	14	20	22	34	46	82	32	40	49
Croatia	4	5	6	6	6	6	5	5	2
Denmark	11	12	13	14	14	16	13	12	5
Estonia	2	2	2	3	3	3	2	2	1
Finland	12.8	12.8	13.4	13.0	11.0	11.0	10.6	9.4	0.9
France	122	141	134	132	119	113	119	101	31
Germany	165	183	155	196	186	120	143	119	40
Greece	15	19	22	23	25	27	19	18	9
Hungary	8	12	12	17	18	13	15	13	8
Iceland	0.62	0.67	0.90	1	1	2	1	1	1
India	87	98	161	384	723	1134	308	556	419
Indonesia	35	65	106	158	261	286	113	207	76
Ireland	5	11	12	14	16	17	13	14	10
Israel	8	13	12	15	17	6	13	10	1
Italy	103	122	119	120	114	110	107	95	49
Japan	216	264	228	210	204	174	180	144	52
Kosovo		0.57	4.3018076	6	3	3	4	1	0
Laos	1	0	1	4	5	11	3	4	3
Latvia	3	2	3	3	4	4	3	3	1
Macedonia	0.76	0.98	2.7368497	3	3	3	2	1	1
Malaysia	14.04	30.94	42	65	70	91	57	48	36.3
Mauritius	0.44	0.75	0.9	1	1	0	1	0	0
Mexico	95	109	166	220	286	223	200	190	48
Montenegro			1.2778626	2	1	2	1	1	0
Myanmar	1	2	2	8	15	35	7	11	20
Nepal	1	2	2	3	5	10	3	4	8
Netherlands	26	33	35	38	36	36	30	25	9
New Zealand	9	12	14	17	18	27	16	15	6
Nigeria	11.64	21.66	46.629116	67	88	174	35	32	30
Norway	9.93	11.93	14	18	18	<u>18</u>	14	8	<u>5</u>
Peru	7.06	9.61	16.666667	28	44	83	24	34	60.058
Philippines	13	26	21	44	72	171	35	47	34

	Transport CO2 (Mt)			Transport CO2 (Mt): BAU (avg)			Transport CO2 (Mt): Low-carbon (avg)		
Poland	20	28	48	50	58	59	47	50	27
Portugal	10	19	19	20	21	21	17	16	11
Republic of Korea	43.26	77.72	105.88498	120	132	162	86	74	72
Romania	12	9	14	19	20	23	17	17	20
Russia	342	153	228	223	243	465	191	199	103
Serbia	4.42	2.3	18.281984	22	11	11	16	6	3
Singapore	4	6	7	10	10	11	8	6	3
Slovenia	3	4	5	6	6	6	5	5	1
South Africa	29	36	48	80	109	191	72	68	91
Sweden	19.77	21.27	21.5	19	19	21	17	13	1
Switzerland	15	16	16	17	14	12	16	12	6
Thailand	28	44	55	77	102	143	56	78	75
Turkey	27.76	34.8	44.01	85	88	124	75	47	18
Ukraine	91	35	40	45	64	97	33	38	72
United Kingdom	122	127	121	127	132	126	111	73	32
US	1492	1830	1764	1701	1614	1992	1528	1243	820
Vietnam	4	12	32	56	93	250	53	59	64

Annex II: Estimates on GDP and Population

	Gross domestic product based on purchasing-power-parity (PPP) per capita GDP						Population (In Thousands)					
	1990	2000	2010	2020	2030	2050	1990	2000	2010	2020	2030	2050
Albania	2847	4184	9386	15033	24488	64973	3281	3122	2902	2935	2954	2710
Argentina	7213	11830	19228	25705	33229	55527	32730	37057	41223	45517	49365	55445
Australia	18730	28769	41489	54645	72763	129014	17097	19107	22163	25598	28482	33496
Bangladesh	848	1361	2592	5194	8460	22448	105983	131281	151617	170467	186460	202209
Belgium	19715	29315	40122	48777	60000	90785	9978	10268	10930	11634	12019	12527
Bosnia and Herzegovina		5141	9017	13747	22392	59412	4527	3793	3835	3758	3584	3069
Brazil	6826	9108	14340	16576	21243	34888	150393	175786	198614	215997	228663	238270
Brunei Darussalam	55924	66767	79303	108685	177036	469729	257	331	393	450	496	546
Cambodia	694	1084	2462	4932	8034	21317	9009	12198	14364	16809	18991	22545
Canada	20302	29723	39844	52034	63255	93481	27662	30702	34126	37600	40390	44136
China	969	2888	9157	20190	28717	58096	1154606	1269975	1340969	1402848	1415545	1348056
Colombia	4876	6621	10806	16942	25239	56011	34272	40404	45918	50229	53175	54927
Croatia		12444	19454	26686	40198	91211	4776	4428	4316	4162	3977	3554
Denmark	21272	32716	41726	53574	65241	96751	5140	5338	5551	5776	6003	6299
Estonia		12091	21724	36504	57983	146295	1565	1399	1332	1295	1243	1129
Finland	18542	27404	38741	46556	56619	83744	4987	5176	5368	5585	5706	5752
France	19662	28515	37284	47200	57438	85060	56943	59387	62961	65720	68007	71137
Germany	20648	29549	40118	53805	59722	73580	78958	81896	80435	80392	79294	74513
Greece	13859	20312	28962	32234	40446	63682	10132	10954	11178	10825	10480	9705
Hungary	10968	14200	21877	32326	39108	57241	10385	10224	10015	9685	9275	8318
Iceland	18864	27137	38508	55440	67628	100634	255	281	318	342	364	389
India	1165	2019	4445	9060	14758	39158	870602	1053481	1230985	1388859	1527658	1705333
Indonesia	2880	4647	8433	14842	23301	57430	181437	211540	241613	271857	295482	322237
Ireland	13920	31892	44088	68740	84322	126885	3563	3842	4617	4874	5204	5789
Israel	12836	20727	29064	39014	51511	89799	4499	6014	7420	8718	9998	12610
Italy	20017	28602	35071	40161	48155	69234	57008	57147	59588	59741	59100	56513
Japan	19114	25520	33853	43173	48184	60017	122249	125715	127320	125039	120127	107411
Kosovo							1862	1700	1775	1811	1829	1829
Laos	1030	1793	3719	7510	12233	32459	4248	5343	6261	7398	8489	10172
Latvia		8861	17833	33031	53804	142758	2664	2371	2091	1919	1806	1593
Macedonia		7145	11564	18127	29527	78345	1996	2012	2062	2088	2078	1938

	Gross domestic product based on purchasing-power-parity (PPP) per capita GDP						Population (In Thousands)					
Malaysia	6762	12789	20336	33272	53485	138210	18211	23421	28120	32374	36107	40725
Mauritius	4844	8848	15283	25750	41944	111289	1056	1185	1248	1291	1310	1249
Mexico	8261	11775	15054	20605	28254	53124	85609	102809	118618	134837	148133	163754
Montenegro		7779	13562	20377	33191	88067	615	614	622	626	618	574
Myanmar		1199	3679	8399	13681	36299	42007	47670	51733	56242	60242	63575
Nepal	794	1240	1959	2978	4359	9339	18742	23740	26876	30184	33104	36159
Netherlands	20962	33244	44839	58211	71880	109602	14915	15894	16632	17185	17605	17602
New Zealand	14935	21814	31267	42378	53618	85833	3398	3858	4369	4730	5103	5607
Nigeria	1631	2351	5128	6879	8652	13686	95617	122877	159425	206831	262599	398508
Norway	27967	46489	61520	76403	93051	138022	4240	4492	4891	5494	5945	6658
Peru	3416	5302	9620	14749	21272	44247	21827	25915	29374	33317	36855	41899
Philippines	2635	3401	5550	9704	15807	41940	61947	77932	93039	108436	123575	148260
Poland	6568	11629	21082	34302	39741	53342	38195	38486	38575	38407	37207	33136
Portugal	12783	20460	26497	32104	39624	60360	9890	10279	10585	10161	9845	9216
Republic of Korea	7519	16452	29825	45052	56070	86848	42972	46206	49090	51251	52519	50593
Romania	7355	8010	16719	27214	44329	117619	23489	22128	20299	18848	17639	15207
Russia		11154	22632	28496	34388	50080	147569	146401	143158	142898	138652	128599
Serbia		6165	12110	17259	26875	65161	9518	9463	9059	8674	8281	7331
Singapore	22179	40950	70598	100309	137727	259642	3016	3918	5079	6007	6418	6681
Slovenia		17980	28055	36620	51491	101806	2007	1989	2052	2075	2054	1942
South Africa	6406	7718	11842	14441	20977	44263	36793	44897	51622	56669	60034	65540
Sweden	19891	29257	42022	56031	69261	105827	8559	8872	9382	10120	10766	11881
Switzerland	30142	38803	52980	66700	84916	137634	6674	7166	7831	8654	9223	10019
Thailand	4264	7358	13181	20284	31826	78350	56583	62693	66692	68581	68250	62452
Turkey	7111	10199	16193	25213	35274	69043	53995	63240	72310	82256	87717	95819
Ukraine		3976	7712	10127	13690	25022	51370	48746	45647	43679	40892	35117
United Kingdom	17245	26135	35797	48100	60741	96865	57110	58867	62717	66700	70113	75361
US	23914	36433	48310	65161	80514	122923	252848	282896	309876	333546	355765	388865
Vietnam	952	2058	4396	8422	13719	36401	68210	80286	88358	98157	105220	112783

Annex III: Reference for Economy-wide and Transport CO2 Emissions

	Country	Study
1	Afghanistan	The Intended Nationally Determined Contribution of the Afghanistan under the UNFCCC
2	Albania	The Intended Nationally Determined Contribution of the Albania under the UNFCCC
3	Albania	2050 SEE Carbon Calculator
4	Algeria	The Intended Nationally Determined Contribution of the Algeria under the UNFCCC
5	Andorra	The Intended Nationally Determined Contribution of the Andorra under the UNFCCC
6	Angola	The Intended Nationally Determined Contribution of the Angola under the UNFCCC
7	Antigua and Barbuda	The Intended Nationally Determined Contribution of the Antigua and Barbuda under the UNFCCC
8	Argentina	CLIMACAP Project
9	Argentina	Economics of Green House Gas Limitations
10	Argentina	Second Comunicación Nacional de la República Argentina a la Convención Marco de las Naciones Unidas sobre Cambio Climático
11	Argentina	The Intended Nationally Determined Contribution of the Argentina under the UNFCCC
12	Armenia	The Intended Nationally Determined Contribution of the Armenia under the UNFCCC
13	Armenia	Third National Communication on Climate Change
14	ASEAN	The Study for Long-Term Transport Action Plan for ASEAN (LPA Project), 2014, Institution for Transport Policy Study (ITPS)
15	ASEAN	APEC Energy Demand and Supply Outlook – 5th edition
16	Asia	ADB & DFID “Energy Efficiency and Climate Change considerations for on road transport in Asia" 2006
17	Asia	Economics of Reducing Greenhouse Gas Emissions in South Asia - Options and Costs
18	Asia	Lee Schipper et al. "Transport and Carbon Dioxide Emissions: Forecasts, Options Analysis, and Evaluation", ADB
19	Australia	Australia’s emissions outlook
20	Australia	Australia’s Sixth National Communication on Climate Change
21	Australia	Beyond the limits Australia in a 1.5-2°C world
22	Australia	Estimating the Emission Reduction Potential of Australian Transport
23	Australia	The Intended Nationally Determined Contribution of the Australia under the UNFCCC
24	Austria	Austria's Sixth National Communication
25	Austria	First Biennial Report
26	Azerbaijan	The Intended Nationally Determined Contribution of the Azerbaijan under the UNFCCC
27	Bahamas	The Intended Nationally Determined Contribution of the Bahamas under the UNFCCC
28	Bahrain	The Intended Nationally Determined Contribution of the Bahrain under the UNFCCC
29	Bangladesh	Bangladesh's second National Communication
30	Bangladesh	Bangladesh 2050 Pathways
31	Bangladesh	Low-Carbon Society Development towards 2025 in Bangladesh
32	Bangladesh	The Intended Nationally Determined Contribution of the Bangladesh under the UNFCCC

	Country	Study
33	Barbados	The Intended Nationally Determined Contribution of the Barbados under the UNFCCC
34	Barbados	UN Environment, Green Economy Scoping Study
35	Belarus	Belarus Sixth National Communication
36	Belarus	First Biennial Report
37	Belarus	The Intended Nationally Determined Contribution of the Belarus under the UNFCCC
38	Belgium	Belgium Sixth National Communication
39	Belgium	Belgian 2050 Pathways Calculator
40	Belgium	First Biennial Report
41	Belgium	Pathways to World Class Energy efficiency in Belgium
42	Belgium	Scenarios for a Low-carbon Belgium by 2050
43	Belize	The Intended Nationally Determined Contribution of the Belize under the UNFCCC
44	Benin	The Intended Nationally Determined Contribution of the Benin under the UNFCCC
45	Bhutan	The Intended Nationally Determined Contribution of the Bhutan under the UNFCCC
46	Bolivia	The Intended Nationally Determined Contribution of the Bolivia under the UNFCCC
47	Bosnia and Herzegovina	The Intended Nationally Determined Contribution of the Bosnia and Herzegovina under the UNFCCC
48	Bosnia and Herzegovina	2050 SEE Carbon Calculator
49	Botswana	The Intended Nationally Determined Contribution of the Botswana under the UNFCCC
50	Brazil	Brazil Low-carbon Country Case Study
51	Brazil	Brazil's Second National Communication
52	Brazil	Pathways for a Low-carbon Economy for Brazil
53	Brazil	The Intended Nationally Determined Contribution of the Brazil under the UNFCCC
54	Brunei Darussalam	The Intended Nationally Determined Contribution of the Brunei Darussalam under the UNFCCC
55	Bulgaria	Bulgaria sixth National Communication
56	Bulgaria	First Biennial Report
57	Burkina Faso	The Intended Nationally Determined Contribution of the Burkina Faso under the UNFCCC
58	Burundi	The Intended Nationally Determined Contribution of the Burundi under the UNFCCC
59	Cabo Verde	The Intended Nationally Determined Contribution of the Cabo Verde under the UNFCCC
60	Cambodia	Cambodia's First National Communication
61	Cambodia	The Intended Nationally Determined Contribution of the Cambodia under the UNFCCC
62	Cameroon	The Intended Nationally Determined Contribution of the Cameroon under the UNFCCC
63	Canada	Achieving 2050: A Carbon Pricing Policy for Canada
64	Canada	Canada’s Sixth National Report on Climate Change
65	Canada	Getting to 2050: Canada’s Transition to a Low-emission Future
66	Canada	The Intended Nationally Determined Contribution of the Canada under the UNFCCC
67	Central African Republic	The Intended Nationally Determined Contribution of the Central African Republic under the UNFCCC
68	Chad	The Intended Nationally Determined Contribution of the Chad under the UNFCCC
69	Chile	Chile Second National Communication
70	Chile	Greenhouse Gas Emissions in the Transport Sector 2000-2020: Case Study for Chile

	Country	Study
71	Chile	PMR Market Readiness Proposal In Chile: Activity 4: Study On The Chilean National Situation
72	Chile	Programas de transporte: integrando los impactos del Cambio Climático
73	Chile	ForFITS Model - Assessing Future CO2 Emissions
74	Chile	The Intended Nationally Determined Contribution of the Chile under the UNFCCC
75	China	Oil consumption and CO2 emissions in China's road transport: current status, future trends, and policy implications
76	China	The role of biofuels in China's transport sector in carbon mitigation scenarios
77	China	Projection of Chinese Motor Vehicle Growth, Oil Demand, and CO 2 Emissions through 2050
78	China	China 2050 Pathways
79	China	Second National Communication on Climate Change of The People's Republic of China
80	China	The Intended Nationally Determined Contribution of the China under the UNFCCC
81	Colombia	Colombia Second National Communication
82	Colombia	CTF Colombia
83	Colombia	Plan De Acción Sectorial De Mitigación (Pas) Sector Transporte
84	Colombia	The Intended Nationally Determined Contribution of the Colombia under the UNFCCC
85	Colombia	Colombia 2050 Calculator
86	Comoros	The Intended Nationally Determined Contribution of the Comoros under the UNFCCC
87	Congo	The Intended Nationally Determined Contribution of the Congo under the UNFCCC
88	Cook Islands	The Intended Nationally Determined Contribution of the Cook Island under the UNFCCC
89	Costa Rica	Costa Rica Market Readiness Proposal (MRP) Partnership for Market Readiness
90	Costa Rica	The Intended Nationally Determined Contribution of the Costa Rica under the UNFCCC
91	Costa Rica	Third National Communication of Costa Rica
92	Croatia	Croatia Sixth National Communication
93	Croatia	First Biennial Report
94	Croatia	Possible development of the Croatian energy sector by 2050 in the view of carbon dioxide emission reductions
95	Croatia	2050 SEE Carbon Calculator
96	Cuba	The Intended Nationally Determined Contribution of the Cuba under the UNFCCC
97	Cyprus	Cyprus Sixth National Communication
98	Cyprus	First Biennial Report
99	Czech republic	Czech Sixth National Communication
100	Czech republic	First Biennial Report
101	D.R. Congo	The Intended Nationally Determined Contribution of the D.R. Congo under the UNFCCC
102	Denmark	Danish Greenhouse Gas Reduction Scenarios for 2020 and 2050
103	Denmark	Denmark Sixth National Communication
104	Denmark	First Biennial Report
105	Djibouti	The Intended Nationally Determined Contribution of the Djibouti under the UNFCCC
106	Dominica	The Intended Nationally Determined Contribution of the Dominica under the UNFCCC
107	Dominican Republic	Second National Communication on Climate Change of Dominican Republic
108	Dominican Republic	The Intended Nationally Determined Contribution of the Dominican Republic under the UNFCCC

	Country	Study
109	Ecuador	The Intended Nationally Determined Contribution of the Ecuador under the UNFCCC
110	El Salvador	The Intended Nationally Determined Contribution of the El Salvador under the UNFCCC
111	Equatorial Guinea	The Intended Nationally Determined Contribution of the Equatorial Guinea under the UNFCCC
112	Eritrea	The Intended Nationally Determined Contribution of the Eritrea under the UNFCCC
113	Estonia	Long-term energy scenarios for Estonia, Scenarios for 2030 and 2050
114	Estonia	Estonia's opportunities to move Competitive Low-carbon in the direction of the economy in 2050
115	Estonia	Estonia's Sixth National Communication
116	Estonia	First Biennial Report
117	Ethiopia	The Intended Nationally Determined Contribution of the Ethiopia under the UNFCCC
118	Ethiopia	Ethiopia climate resilient green economy strategy
119	European Union	European Gas Forum, "Reducing Transport CO2 Emissions in the EU Transport Sector 2050", 2012
120	European Union	EU Sixth National Communication
121	European Union	EEA greenhouse gas - data viewer
122	European Union	European Commission, "Energy Roadmap 2050", 2011
123	European Union	Greenhouse gas emission trends and projections in Europe 2011 - Tracking progress towards Kyoto and 2020 targets
124	European Union	A policy framework for climate and energy in the period from 2020 up to 2030
125	European Union	Ian Skinner (AEA Associate) Huib van Essen (CE Delft) Richard Smokers (TNO) Nikolas Hill (AEA) "EU Transport GHG: Routes to 2050? - Towards the decarbonization of the EU's transport sector by 2050", 2010
126	European Union	Long-term outlook of energy use and CO2 emissions from transport in Central and Eastern Europe
127	European Union	Road to 2030: how EU vehicle efficiency standards help member states meet climate targets
128	European Union	The Intended Nationally Determined Contribution of the European Union under the UNFCCC
129	European Union	Wolfgang Schade, Nicki Helfrich & Anja Peters, "A Transport Scenario for Europe Until 2050 in a 2-Degree World",2010
130	European Union	EU Transport GHG: Routes to 2050
131	Finland	Finland's sixth national communication
132	Finland	First Biennial Report
133	Finland	Impact Assessment of the EU's 2030 climate and energy policies for Finland
134	Finland	Low-carbon Finland 2050
135	France	First Biennial Report
136	France	Frances Sixth National Communication
137	France	Markal-Times assessment of long term CO2 emissions targets for France
138	France	Pathways 2020-2050 Towards a low-carbon economy in France
139	Gabon	Gabon Second communication of Gabon on climate change to the UNFCCC
140	Gabon	The Intended Nationally Determined Contribution of the Gabon under the UNFCCC
141	Gambia	The Intended Nationally Determined Contribution of the Gambia under the UNFCCC
142	Georgia	The Intended Nationally Determined Contribution of the Georgia under the UNFCCC
143	Germany	First Biennial Report

	Country	Study
144	Germany	Germany's Sixth National Communication
145	Ghana	The Intended Nationally Determined Contribution of the Ghana under the UNFCCC
146	Global	"Pathways to Deep Decarbonization", Sustainable Development Solutions Network (SDSN) and Institute for Sustainable Development and International Relations (IDDRI)
147	Global	"World Energy Outlook 2008", IEA
148	Global	"World Energy Outlook 2012", IEA
149	Global	E. Kriegler, M. Tavoni, T. Aboumahboub, G. Luderer, K. Calvin, G. De Maere, V. Krey, K. Riahi, H. Rosler, M. Schaeffer, D. van Vuuren (2013): What does the 2C target imply for a global climate agreement in 2020? The LIMITS study on Durban Platform scenarios, *Climate Change Economics* 4(4), doi: 10.1142/S2010007813400083
150	Global	Energy Technology Perspectives 2015,IEA
151	Global	Global transportation energy and climate roadmap, 2012, ICCT
152	Global	International Monetary Fund, World Economic Outlook Database, April 2016
153	Global	State of Clean Transport Policy 2014
154	Global	IEA Energy Technology Perspectives 2016 – Towards Sustainable Urban Energy Systems
155	Global	Energy system transformations for limiting end-of-century warming to below 1.5 °C
156	Global	Renewable energy and transport: decarbonizing fuel in the transport
157	Global	Transport Pathways for Light Duty Vehicles: Towards a 2° Scenario
158	Global	Implications of long-term scenarios for medium-term targets (2050)
159	Global	Tracking Clean Energy Progress 2015
160	Global	The Prospect for Modal Shifts in Passenger Transport Worldwide and Impacts on Energy Use and CO2
161	Global	The Road Ahead: How Do We Move To Cleaner Car Fleets?
162	Global	Fuel Economy State of the World 2016 Time for global action
163	Global	The Global Calculator
164	Global	Pathways to a low-carbon economy: Version 2 of the global greenhouse gas abatement cost curve
165	Global	Michael A. Replogle and Lew Fulton, "A Global High Shift Scenario: Impacts And Potential For More Public Transport, Walking, And Cycling With Lower Car Use", ITDP & UC Davis
166	Global	Feasibility of limiting warming to 1.5 and 2°C
167	Global	Report on the structured expert dialogue on the 2013–2015 review
168	Global	What Would a Global Warming Increase of 1.5 Degrees Be Like?
169	Global	National post-2020 greenhouse gas targets and diversity-aware leadership
170	Global	IPCC, 2014: Summary for Policymakers. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change
171	Global	The PBL Climate Pledge INDC tool, 2015, PBL Netherlands Environmental Assessment Agency
172	Global	The Paris Agreement
173	Global	The Pledge Pipeline, UN Environment DTU, 2015
174	Global	Trends in global CO2 emissions; 2014 Report - EDGAR, EC-JRC and PBL Netherlands Environmental Assessment Agency
175	Global	UN Environment 2013. The Emissions Gap Report 2014. United Nations Environment Programme, Nairobi
176	Global	UN Environment 2015. The Sixth Emissions Gap Report 2015. United Nations Environment Programme (UN Environment), Nairobi
177	Global	UNFCCC 2015, Synthesis report on the aggregate effect of INDCs

	Country	Study
178	Global	UNFCCC National Inventory Submissions for Annex I countries, National Communications for Annex I & non-Annex I countries, Biennial Reports (Annex I) & Biennial Update Reports (non-Annex I)
179	Global	UNFCCC, "Intended Nationally Determined Contributions (INDCs)"
180	Global	United Nations, Department of Economic and Social Affairs, Population Division (2014). World Urbanization Prospects: The 2014 Revision, CD-ROM Edition.
181	Global	World Energy Outlook Special Report 2015: Energy and Climate Change, 2015, IEA
182	Global	WRI, CAIT 2.0. 2015. CAIT Projections Beta. Washington, DC: World Resources Institute
183	Greece	A Low-carbon Vision for Greece in 2050
184	Greece	First Biennial Report
185	Greece	Greece Sixth National Communication
186	Greece	The Greek Energy System in 2050 GHG mitigation options
187	Greece	A low-carbon vision for Greece in 2050.
188	Grenada	The Intended Nationally Determined Contribution of the Grenada under the UNFCCC
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191	Guinea Bissau	The Intended Nationally Determined Contribution of the Guinea Bissau under the UNFCCC
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193	Guyana	The Intended Nationally Determined Contribution of the Guyana under the UNFCCC
194	Haiti	The Intended Nationally Determined Contribution of the Haiti under the UNFCCC
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201	Iceland	Life Cycle Assessment of Scenarios for the Icelandic Vehicle Fleet
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220	Ireland	First Biennial Report
221	Ireland	Ireland sixth National communication
222	Ireland	Ireland's Greenhouse Gas Emission Projections 2012-2030
223	Israel	Greenhouse gas abatement potential in Israel
224	Israel	Greenhouse Gas Emission Reductions Action Plan for the State of Israel
225	Israel	Israel second National Communication
226	Israel	The Intended Nationally Determined Contribution of the Israel under the UNFCCC
227	Italy	First Biennial Report
228	Italy	Italy Sixth national Communication
229	Italy	Strategies and technologies for a low-carbon energy system: the Italian case
230	Ivory Coast	The Intended Nationally Determined Contribution of the Ivory Coast under the UNFCCC
231	Jamaica	Jamaica's second national communication
232	Jamaica	The Intended Nationally Determined Contribution of the Jamaica under the UNFCCC
233	Japan	CASA-2030
234	Japan	Japan 2050 Low-carbon navigator
235	Japan	Japan Roadmaps towards Low-Carbon Societies (LCSs)
236	Japan	Japan's sixth Communication to the UNFCCC
237	Japan	The Intended Nationally Determined Contribution of the Japan under the UNFCCC
238	Jordan	The Intended Nationally Determined Contribution of the Jordan under the UNFCCC
239	Kazakhstan	First Biennial Report
240	Kazakhstan	Kazakhstan Sixth National Communication
241	Kazakhstan	The Intended Nationally Determined Contribution of the Kazakhstan under the UNFCCC
242	Kenya	The Intended Nationally Determined Contribution of the Kenya under the UNFCCC
243	Kenya	Kenya's Climate Change Action Plan: Mitigation
244	Kiribati	The Intended Nationally Determined Contribution of the Kiribati under the UNFCCC
245	Kosovo	2050 SEE Carbon Calculator
246	Kuwait	The Intended Nationally Determined Contribution of the Kuwait under the UNFCCC
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257	Liberia	The Intended Nationally Determined Contribution of the Liberia under the UNFCCC
258	Liechtenstein	First Biennial Report
259	Liechtenstein	Liechtenstein's Sixth National Communication
260	Liechtenstein	The Intended Nationally Determined Contribution of the Liechtenstein under the UNFCCC
261	Lithuania	First Biennial Report
262	Lithuania	Lithuanian Climate Change Management Policy
263	Lithuania	Lithuania's Sixth National Communication
264	Luxembourg	First Biennial Report
265	Luxembourg	Luxembourg's Sixth National Communication
266	Macedonia	The Intended Nationally Determined Contribution of the Macedonia under the UNFCCC
267	Macedonia	Assessment of climate change mitigation potential of the Macedonian transport sector
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278	Marshall Islands	The Intended Nationally Determined Contribution of the Marshall Islands under the UNFCCC
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291	Monaco	First Biennial Report
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294	Mongolia	The Intended Nationally Determined Contribution of the Mongolia under the UNFCCC
295	Montenegro	The Intended Nationally Determined Contribution of the Montenegro under the UNFCCC
296	Montenegro	2050 SEE Carbon Calculator
297	Morocco	The Intended Nationally Determined Contribution of the Morocco under the UNFCCC
298	Mozambique	The Intended Nationally Determined Contribution of the Mozambique under the UNFCCC
299	Myanmar	The Intended Nationally Determined Contribution of the Myanmar under the UNFCCC
300	Namibia	The Intended Nationally Determined Contribution of the Namibia under the UNFCCC
301	Nauru	The Intended Nationally Determined Contribution of the Nauru under the UNFCCC
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316	New Zealand	The Intended Nationally Determined Contribution of the New Zealand under the UNFCCC
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325	Norway	Norway's Sixth National Communication
326	Norway	The Intended Nationally Determined Contribution of the Norway under the UNFCCC
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332	Paraguay	The Intended Nationally Determined Contribution of the Paraguay under the UNFCCC
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360	Russia	Russian Sixth National Communication
361	Russia	A SUSTAINABLE RUSSIA ENERGY OUTLOOK
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363	Saint Kitts and Nevis	The Intended Nationally Determined Contribution of the Saint Kitts and Nevis under the UNFCCC
364	Saint Lucia	The Intended Nationally Determined Contribution of the Saint Lucia under the UNFCCC

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365	Saint Vincent and Grenadines	The Intended Nationally Determined Contribution of the Saint Vincent and Grenadines under the UNFCCC
366	Samoa	The Intended Nationally Determined Contribution of the Samoa under the UNFCCC
367	San Marino	The Intended Nationally Determined Contribution of the San Marino under the UNFCCC
368	Sao Tome and Principe	The Intended Nationally Determined Contribution of the Sao Tome and Principe under the UNFCCC
369	Senegal	The Intended Nationally Determined Contribution of the Senegal under the UNFCCC
370	Serbia	2050 SEE Carbon Calculator
371	Seychelles	The Intended Nationally Determined Contribution of the Seychelles under the UNFCCC
372	Sierra Leone	The Intended Nationally Determined Contribution of the Sierra Leone under the UNFCCC
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379	Slovenia	First Biennial Report
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382	Somalia	The Intended Nationally Determined Contribution of Somalia under the UNFCCC
383	South Africa	First Biennial Report
384	South Africa	Long Term Mitigation Scenarios for South Africa and Climate Change Policy Response
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386	South Africa	The South Africa 2050 Calculator
387	South Africa	The Intended Nationally Determined Contribution of the South Africa under the UNFCCC
388	South Sudan	The Intended Nationally Determined Contribution of the South Sudan under the UNFCCC
389	Spain	Spain - Sixth National Communication
390	Sri Lanka	The Intended Nationally Determined Contribution of the Sri Lanka under the UNFCCC
391	Swaziland	The Intended Nationally Determined Contribution of the Swaziland under the UNFCCC
392	Sweden	First Biennial Report
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401	Tajikistan	The Intended Nationally Determined Contribution of the Tajikistan under the UNFCCC
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411	Tonga	The Intended Nationally Determined Contribution of the Tonga under the UNFCCC
412	Trinidad and Tobago	The Intended Nationally Determined Contribution of the Trinidad and Tobago under the UNFCCC
413	Tunisia	The Intended Nationally Determined Contribution of the Tunisia under the UNFCCC
414	Turkey	The Intended Nationally Determined Contribution of the Turkey under the UNFCCC
415	Turkmenistan	The Intended Nationally Determined Contribution of the Turkmenistan under the UNFCCC
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425	Ukraine	First Biennial Report
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