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Supporting the Development and Implementation of Low Emission Development Strategies in the Transport Sector

APEC Energy Working Group

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1 Project Overview

The transport sector is responsible for about 23% of global energy-related carbon dioxide (CO_2) emissions today.[i] In 2013, urban transport activities accounted for about 40% of energy use.[ii] The transport sector offers considerable potential for achieving low-carbon economic development and energy-efficiency gains by implementing enabling policies, effecting changes in user behavior, and advancing adoption of energy-efficient technologies.

But in the Asia-Pacific Economic Cooperation (APEC) region, CO_2 emissions from fuel combustion are projected to rise about 32% from 2010 to 2035.[iii] Therefore, effectively addressing socio-economic growth while confronting environmental concerns in the transport sector—not only at the national level but also at the regional level—is critically important. Economies will need support as they develop and implement strategies for transitioning to a low-carbon future.

To that end, this project tailored activities to specific APEC economies. The Low Emission Development Strategies Global Partnership (LEDS GP) Transport Group then transferred lesssons learned from these selected economies to other APEC economies and beyond via capacity-building workshops and study tours—moving from problems in common to sustainable solutions in common.

1.1 Project Description and Outputs

This project facilitated dialogue between national and subnational authorities and provided capacity-building support to enable APEC economies to integrate clean-transport activities into their national planning strategies. Support included conducting peer-to-peer workshops, offering technical assistance, and developing training packages to disseminate knowledge.

Our project objectives were to 1) strengthen the capacity of at least three APEC economies via in-person workshops and 2) develop a customized training package and a road map of design instruments for implementing low emission development strategies (LEDS). The goal of this publication is to showcase the project impacts and respective outputs (which are the three workshop summary reports, road map, and training package), present conclusions, and provide a future outlook.

In this project, we focused on cross-scale innovators and early adopters of LEDS—economies with favorable political and economic conditions to influence change—that expressed interest in technical assistance and peer-to-peer and multi-level exchange across various levels of governence. This project was a collaborative effort between LEDS GP Transport Working Group and the APEC economies. Therefore, we worked to ensure that all appropriate stakeholders within the APEC economies were involved in the process, and we codesigned solutions to address any potential critical sustainability challenges.

Cross-fertilization and coordination with other projects were central to the work. The LEDS GP Latin America and Caribbean and Asia regional platforms have knowledge about members' national and regional priorities. With in-kind support, these regional platforms co-led the peer-learning activities and supported the delivery of technical assistance because of the regional perspective they provide on key issues. These collaborations enabled us to design technical content that provided a greater learning experience to APEC-funded participants and other self-funded participants through broader information sharing from these organizations.

In this cross-regional effort, we have identified APEC economies as ideal beneficiaries for our efforts to promote energy-efficient, low-carbon transport policies and technology options. Connecting APEC economies more closely with low-carbon activities in the region will strengthen information exchange and facilitate matchmaking on financing of low-emission development programs and projects to attract investment and promote green growth. With these goals in mind, we provided focused support that yielded the following outputs:

1. **In-person workshops with "early-mover" peer advisors and experts:** Designed to facilitate dialogue between domestic and regional authorities, these workshops focused on a specific APEC economy's situation (Peru, Viet Nam) and supported a specific, customized policy-making process resulting in better integration of the transport sector in elaborating and implementing an ambitious pathway for low-emission transport development. Specifically, Peru was interested in learning about energy-efficient policies that strengthen the transport sector, and Viet Nam was interested in learning about ways to improve the efficiency of its urban transport systems. Our third and last workshop was a "Study Tour" of Singapore with the goal of disseminating Singapore's success and lessons learned to the greater APEC network. In all three workshops, peer-learning and discussion activities fostered active participation of all attendees. The workshops convened local stakeholders as well as decision-makers and peer experts from the region and international experts from within the APEC economies and beyond. Each workshop aimed to increase participants' confidence and capacity to advance the integration of clean-transport measures in national development plans. Annexed at the end of this publication are the agendas of each workshop, which note and acknowledge the multiple collaborators who assisted in making the programs successful. The summary reports of each workshop constitute the main body of this publication.
2. **Road map to design instruments for implementation:** A road map developed for technical staff details how to design and implement energy-efficient transport actions and integrate them as part of long-term development plans. This strategic plan lays out the steps an economy can take to identify its main challenges and opportunities so as to develop a systematic plan of action for achieving its low-emission transport and development goals.
3. **Training package:** The training package is a compilation of tools, good practices, case studies, and other technical resources that provide digestible information for policy makers about planning and implementing energy-efficient, low-carbon transport policies

and measures. We designed the package to achieve three main objectives: 1) promote replication of good approaches across all APEC economies and beyond; 2) facilitate access to curated information and tools for policy makers on low-emission transport policy options; and 3) offer a complete suite of information in different formats—from high-level overviews to detailed information—to answer why, what, and how.

1.2 Key Findings—Challenges and Opportunities

Based on discussions and surveys across all three workshops, we identified nearly a dozen challenges and opportunities to plan and implement low-carbon transportation measures across all participating economies. They are highlighted below (in no specific order):

- Develop and implement policies to regulate and promote electric vehicle (EV) use
- Develop and implement policies that encourage/regulate nonmotorized transportation, intermediate public transportation, and its integration into city planning
- Develop and implement policies that encourage transition to electrification of buses, reform the existing bus sector, and increase efficiency of services by addressing challenges in urban transport
- Increase understanding of stakeholder engagement, cross-sectoral collaboration/coordination (i.e., transport, utilities, and energy and regional/local policy makers)
- Enhance understanding of standards, disposal, recycling, and environmental impact of EV batteries
- Promote greater understanding of charging infrastructure—planning and standards
- Develop capacity to provide support for EV infrastructure and deployment
- Integrate planning and governance, understanding the role of government leadership and policies
- Develop sustainable land management policies and city planning
- Deepen understanding of funding sources (especially mobilizing the private sector), successful incentives (i.e., fees, taxes, rebates)
- Plan and prepare for future economic disruptions (i.e., autonomous vehicles).

Each economy's next steps will be specific to its own priorities, but some general next steps can be ascertained from the list of challenges and opportunities. Several participants have indicated that they see the benefits of the regional collaborations the workshops facilitate and enable while supporting the identification of economy-specific priorities. These participants have the opportunity to continue their engagement via the LEDS GP communities of practice, which are platforms that facilitate ongoing peer-learning and regional/local collaborations. Two communities of practice recently launched in Asia and in Latin America and the Caribbean are focused on the themes of Clean Mobility and Electric Mobility, respectively.

The Asia Clean Mobility Community of Practice held its first online session on June 22, 2018, titled "Enabling a Transition to Electric Mobility in Public Transportation Fleets: Policies and Enabling Environment." Two of the active participants—from the Philippines (APEC economy) and Bhutan (non-APEC economy)—were attendees of the Study Tour in Singapore, indicating that this APEC project has been useful to participants and has facilitated collaboration with this global platform. We will continue to engage APEC participants in future APEC projects, as well as LEDS GP events, as we dive deeper into the topics that interest each economy and the region.

2 Workshop 1 Summary Report: Peru – LEDS LAC Experts' Workshop: Strengthening of the Energy-Efficiency Policies in the Transport Sector

2.1 Overview

Representatives from Argentina, Chile, Colombia, the United States, Malaysia, Mexico, Panama, Peru, and Thailand met in Lima, Peru, on 19–20 September 2017 to discuss, share, and learn about energy-efficiency work being done in each of their economies. The LEDS LAC Experts' Workshop focused on opportunities, challenges, and lessons learned from intersectoral articulation of energy-efficiency policies as well as their assessment in Latin America and information-sharing for the broader Asia-Pacific Economic Cooperation (APEC) region. This workshop was the first of three regional workshops (Peru, September 2017; Viet Nam, December 2017; Singapore, May 2018) that shared best practices on energy-efficiency policies in the transport sector across the APEC region.

Participants provided insight into each of their economies' experience linking energy-efficiency policies across the transportation sector; identifying and prioritizing challenges and incorporating a gender approach into transport policies; providing cross-sectoral articulation for implementing energy-efficiency policies in transport; developing information, measurement, and reporting systems, with a group exercise to define baselines; and considering electrical mobility.

Representatives from various economies presented on each of the topics.

Group discussions following the presentations gave other workshop participants the opportunity to ask questions of the presenters. There were two group exercises: 1) Identifying Risk, Barriers, and Opportunities in the Implementation of an Energy-Efficiency Project, and 2) Defining Baselines, Defining Steps for Project Implementation, Identifying Stakeholders, and Identifying Barriers.

Figure 1. Peru workshop participants

2.2 Workshop Description and Outputs

Linking energy-efficiency policies in transport: Participants shared their experiences on reducing greenhouse gas (GHG) emissions by implementing efficiency policies as prioritized by each economy. Cristina Victoriano from the Ministry of Energy of Chile focused on Chile's implementation of a vehicle energy-efficiency label. Jorge Macias from WRI Mexico presented the process behind implementing Mexico's vehicle energy-efficiency standard.

Key takeaways from the presentations include the following:

- Chile's vehicular energy-efficiency label:

The new edition of the label took effect June 2017 and includes electric and hybrid vehicles. See Chile's consumer portal for vehicular energy-efficiency information.

- Mexico’s vehicle efficiency standard:

The energy-efficiency standard took effect in 2013. The standard defines an average energy-efficiency goal for the automotive industry’s domestic fleet in Mexico.

Summarized in Figure 2 are the risks/barriers associated with implementing EVs (blue) and energy-efficiency standards (green). Each barrier was ranked in terms of the probability of encountering the barrier and the magnitude of the impact that this barrier would have on implementing the project. Two teams decided to consider EV implementation projects; the third team considered energy-efficiency standards.

In the first group exercise following the first round of presentations, participants formed three teams, each comprising representatives from different economies and/or ministries. The goal of this exercise was for participants to identify the greatest risks and barriers to implementing energy-efficiency policies in their economies (each team had two projects to choose from: EV implementation or implementation of energy-efficiency standards). The second group exercise consisted of prioritizing the challenges graphically within an Impact-Probability matrix.

Cross-sectoral articulation for implementing energy-efficiency policies in transport: This part of the workshop consisted of case studies presented by APEC and non-APEC members (given the importance of improving the efficiency of transport in the LAC sector).The goal was to learn from economies that have recently taken successful steps toward reforming their energy-efficiency policies.

APEC Case Study: Thailand’s experience

- The high political commitment from the prime minister at the intersectoral tables made it possible to address the political challenges.
- The first step toward implementation was to help different ministries calculate their potential savings from increased energy efficiency.
- Borwornpong Sunipasa of the Department of Alternative Energy Development and Efficiency of Thailand presented and discussed their experiences, challenges, and opportunities of intersectoral and national-subnational cooperation.

Non-APEC Case Studies:

- Claudia Cuentas of the Ministry of Environment and Sustainable Development of Colombia, Fernando Lia of the Ministry of Energy and Mines of Argentina

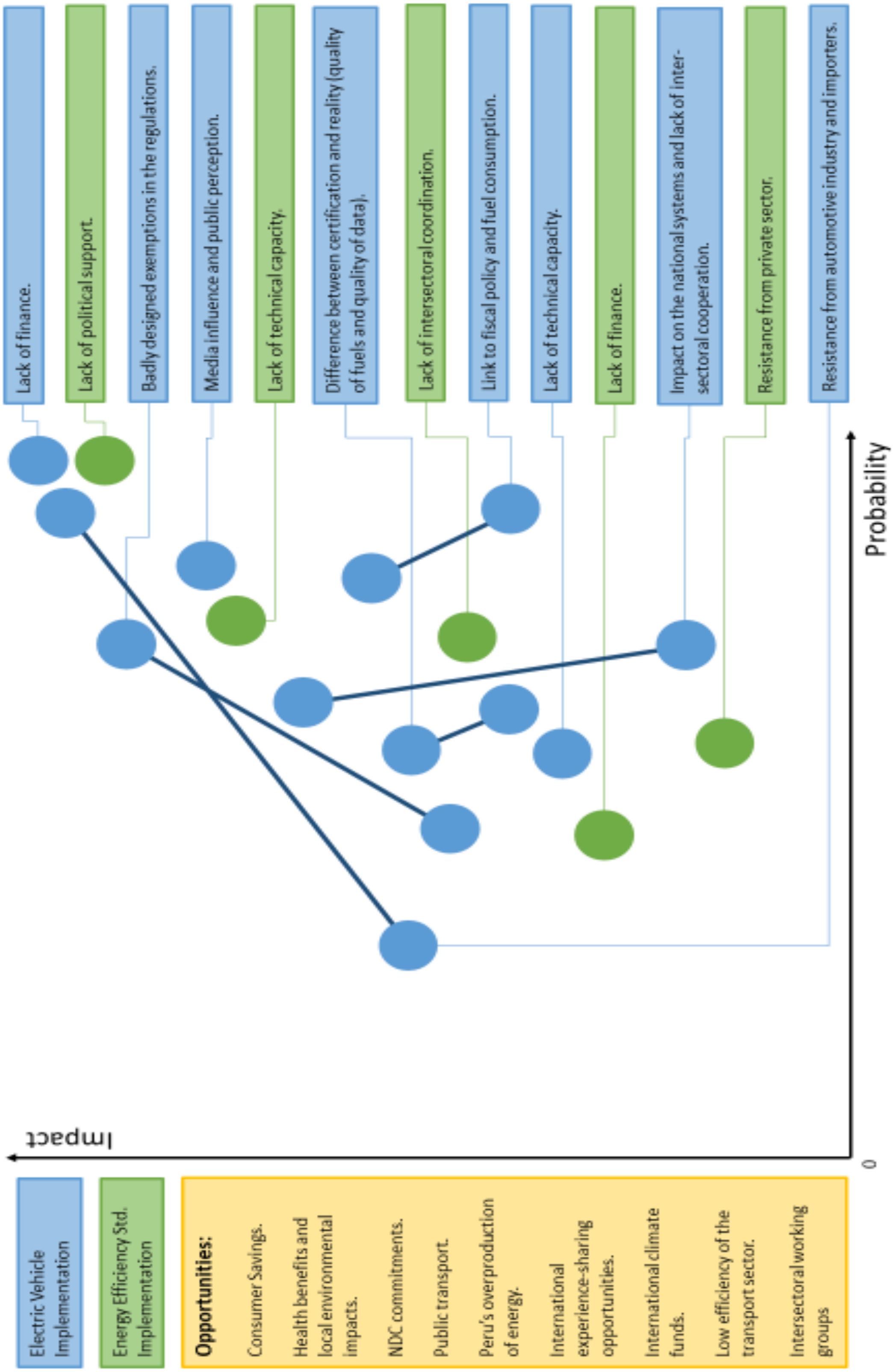

Figure 2. Summary of risks/barriers associated with implementing 1) EVs (blue) and 2) energy-efficiency standards (green). Workshop participants ranked each barrier in terms of probability of encountering the barrier and the magnitude of the impact that barrier would have upon implemention. Two teams decided to consider EV implementation projects, whereas the third team focused on energy-efficiency standards.

Key takeaways from the presentations include the following:

Argentina's experience

- The Under-Secretariat of Energy Efficiency leads the process of energy efficiency in the transport sector.
- To address the lack of interest and priority in other sectors, stakeholders identified common interests and strategic partners.

Colombia's experience

- To address the policy-implementation gap, it is key to design the policy with participation of the different sectors.
- Key elements to success are interaction with the local community and socialization of the projects and goals.

Measurement, reporting, and verification (MRV) systems: This section of the workshop aimed to share lessons learned from implementing, operating, and developing MRV systems in the transport sector. This section was led by Susana Ricaurte, an MRV expert who was heavily involved in developing Bogota's TransMilenio.

Key takeaways from the presentation include the following:

- Emission reductions = Emissions baseline – Emissions leakage – Project emissions. The baseline refers to the situation that would have occurred if the project had not been created, not the historical situation.
- Adequate monitoring must be done with clear and verifiable parameters.
- High-level political commitment to the MRV system is important for its implementation.
- Mechanisms should be developed to connect and regulate the exchange of information.
- Strengthening of financial capacity is required, which can be achieved through agreements with funding agencies.

The second group exercise, which followed a similar format to the previous group exercise, began after Ricaurte's presentation. In the first stage of this exercise, participants defined the necessary steps to implement energy-efficiency policies. The second stage of the exercise consisted of identifying the stakeholders involved in each step. The third stage consisted of identifying the barriers that would arise at each step and with each actor involved. Again, each team had two projects to choose from (EV implementation or implementation of energy-efficiency standards). For this exercise, all teams decided to consider EV implementation projects. Interestingly, although all three teams chose the same topic, the teams outlined the implementation steps, actors involved, and barriers/challenges differently.

Electromobility in the LAC region: Representatives from Mexico, Chile, and Peru discussed their experiences reducing GHG emissions by introducing hybrid and/or EVs into their transportation sector. Eduardo Olivares of SEMARNAT gave an update on Mexico's Hoy No Circula traffic-flow restriction program and presented Mexico's plan to electrify the taxi fleet. Andres Pica of the Ministry of Environment of Chile talked about Chile's "green taxes," Transantiago's new tenders, and the ministry's new Electromobility Strategy. Finally, Daniela Rough of the Ministry of Energy and Mines of Peru presented the economy's TransElectrico NAMAs project.

Figure 3. Several Peru workshop participants taking part in a learning session

Key takeaways from the presentations include the following:

Mexico's electromobility and emissions management

- All new taxis must be hybrids or electric.
- The Hoy No Circula program restricts traffic flow by not allowing the use of certain vehicles for a number of days per week according to their level of emissions (EVs can circulate every day).

Chile's electric mobility

- In September 2014, Chile introduced two green taxes on the sale of new vehicles based on their fuel efficiency.
- Transantiago's new tenders seek to promote cleaner technologies such as hybrid and electric buses.
- The Electromobility Strategy is led by the Ministry of Energy with participation of the Ministry of Transport and the Ministry of Environment (currently in the process of public consultation).

Peru's TransElectrico NAMAs project

- To implement these changes in Peru, the Ministry of Energy and Mines identified several barriers that would require solutions prior to implementation.

Participants suggested two prominent areas needing significant improvement: building infrastructure and technical capacity.

Figure 4. Peru workshop participants during a learning session

Awareness campaigns that disseminate information about new technologies and desired infrastructure changes are needed to get the public on board with their priorities.

Overall, the workshop provided a way to find opportunities for collaboration, learn from cross-sectoral networking experiences, and discuss, share, and exchange information among APEC economies and regional partners with similar experiences. The feedback received was overwhelmingly positive, which stresses the usefulness of workshops and the interest in the topic. Participants expressed interest in continuing these kinds of workshops, having benefitted from the lessons learned, relishing the exchange platform created, and being eager to apply the knowledge acquired.

3 Workshop 2 Summary Report: Viet Nam - LEDS Asia Experts' Workshop: Improving the Efficiency of Urban Transport Projects

3.1 Overview

Representatives from Bangladesh, the Philippines, Papua New Guinea, Thailand, and Viet Nam met in Ho Chi Minh City, Viet Nam, on 4 December 2017 to discuss, share, and learn about operational and energy-efficiency improvements in urban transport projects. The LEDS Asia Experts' Workshop focused on opportunities, challenges, and lessons learned from bus rapid transit (BRT) projects and reform approaches to organizing transport governance in Southeast Asia, as well as discussing how to transition to an electric bus fleet.

The presentations and discussions covered two core topics:

* Bus-sector reforms and service-based contracting

* Business models for buses and the electrification of the public transport fleet.

The 25 workshop participants engaged in intensive discussions about how to spur transport reform, and each provided insight into their economies' experience of linking operational and energy-efficiency policies in transport. For example, Thailand has made great efforts to promote public transport use and combine it with the introduction of 200 new electric buses in cities. The Viet Namese representative reported on solutions to congestion that BRT systems, in particular, can deliver. In Hanoi, a new BRT route has proven successful and may be expanded and complemented with other transport policies.

3.2 Workshop Description and Outputs

Reforming bus operations through service-based contracting and key performance indicators: Christian Mettke of Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) opened the first session by highlighting the connection between urban mobility and public health. Through platforms like the Sustainable Urban Transportation Project (SUTP), GIZ addresses key areas of sustainable transport policy for developing cities. Consolidating public transport is a key precondition needed to make transport more efficient. Addressing challenges in urban transport—such as congestion, pollution, and high external costs—requires modernizing and formalizing public transport services.

However, improving service standards leads to cost increases, which can prohibit new transport initiatives.

Figure 5. Viet Nam workshop participants

In a second presentation, Mr. Kaenzig (ITP/GIZ) discussed franchising bus services and key performance indicators as a way to measure and manage bus-sector reform. He noted that industry and route consolidation offer opportunities for rationalization and subsequent performance evaluation that can increase efficiency and reduce costs and emissions. He drew from case studies in Johannesburg, South Africa; Kaunas, Lithuania; Tiblisi, Georgia; Singapore; and London, UK, where franchising and minimum service standards triggered higher quality and a mode-shift toward public transport.

Different forms of contracts are available to initiate these reforms. Additionally, establishing key performance indicators can set the baseline for improving public transport service over time, e.g., by starting with simpler performance metrics on the percentage of schedule operated and excess wait time. Evaluating these indicators can serve to assess network-wide performance, ensure operator compliance, and increase customer satisfaction and ridership. Kaenzig illustrated the correlation between better data and better bus system performance using several examples from the last decade.

Transitioning to electrification of the public transport fleet: Mr. Escalante (WRI Mexico) reported on low- and zero-emission vehicles and the significance of this transition for public transport operations. Four trends in cities around the world are noteworthy:

- New stakeholders such as utilities are interested in electrification.
- New and available financing mechanisms reduce up-front costs.
- Technological innovations allow for more efficient operations.
- Public funding, guarantees, and incentives help stabilize the business environment.

Escalante described the business scenario for public or private fleets and how to overcome barriers to implementation. To overcome barriers and ensure the delivery of complex investments in hybrid and electric buses, several investment components, funding sources, financial products, and delivery mechanisms may be considered. Research by the [WRI Ross Center for Sustainable Cities] on 25 cities that have successfully deployed EVs provided the pillars of a business model. As an example, Escalante reviewed the status of the Integrated Public Transportation System of the city of Bogota, which introduced more than 500 hybrid electric buses in 2012.

Figure 6. Several Viet Nam workshop

In the first stage of the group exercise that followed the presentation, workshop participants reflected on the business model of transport systems known to them and shared their experience with the group. The goal was for participants to identify the responsibilities of regional and local policy makers in planning electrification of the public transport sector. Recognizing and learning about facilitation and dialogue mechanisms of varying levels of government can help decision makers facilitate project implementation and effective coordination of project-specific support.

During the second stage of the exercise, participants discussed the implications of the business model framework for subnational implementation and concrete steps toward more intergovernmental coordination. Receiving commitments from all agencies has proven crucial in past successful projects.

As a result of the exercise, the participants recognized the complexity of adopting electric buses and the need to involve a variety of stakeholders from across ministries (e.g., Transport, Energy, Utilities) as well as local stakeholders (e.g., city engineers). This insight led them to start thinking about who will be involved once officials make the decision to electrify their public transport fleet.

Overall, the workshop was a great venue to identify opportunities for collaboration; learn from examples of implementation; and discuss, share, and exchange information. Participants expressed interest in continuing these kinds of workshops, having benefitted from the lessons learned, relishing the exchange platform created, and being eager to apply the knowledge acquired.

4 Workshop 3 Summary Report: Singapore - LEDS Community of Practice: MobiliseYourCity Study Tour, Moving Towards Sustainable, Energy-Efficient, Urban Mobility in Emergeing Cities

4.1 Overview

Representatives from Chile, Indonesia, Mexico, the Philippines, Thailand, Viet Nam, the United States, Germany, Bhutan, India, and Sri Lanka convened for a three-day Asia-Pacific Economic Cooperation study tour in Singapore on 7–9 May 2018 to discuss, share, and learn about sustainable, energy-efficient, urban mobility approaches in their emerging cities. The study tour aimed to provide a learning experience for decision makers and senior technical staff involved with planning or policy making for sustainable, energy-efficient urban mobility.

Participants in the Singapore workshop came together from around the APEC region to share the extent of urban mobility in their economies and to learn from the experiences and best practices of Singapore in terms of sustainable, energy-efficient urban transport policies, financing, and governance and management. Key topics included the following:

- Domestic and local institutional set-up toward sustainable urban transport
- Sustainable urban land use and mobility planning
- Financing mechanisms and funding sources of sustainable urban mobility

- Lessons learned on reform projects in Singapore and other APEC economies
- Planning and implementation of new transport technologies.

The workshop included participation from Singapore's public sector (i.e., Land Transportation Authority, Urban Redevelopment Agency). Representatives shared the processes involved in bringing market transformation to fruition from the perspective of Singapore's success. Participants also received an introduction to the private-sector operators of urban mobility in Singapore, which gave them an opportunity to learn more about operations, management, and coordination with the public sector. Additionally, participants had the opportunity to meet and learn from a group of researchers working on the future of urban mobility in Singapore that included electric and autonomous public transport vehicles.

In addition to learning from their peers and the experiences of Singapore, workshop participants received training in the use of a tool to assess the implementation feasibility of an EV fleet.

Participants in this workshop took home best practices from Singapore and peers regarding urban mobility planning, financing, and public transport operations. They engaged in peer-to-peer knowledge exchange and disseminated knowledge and lessons learned from other APEC economies and beyond. The workshop experience encouraged participants to continue to foster the relationships established at the workshop for continued knowledge sharing and possible future collaboration.

4.2 Workshop Description and Outputs

Identifying needs and priorities: Each participant delivered a short presentation on the status of urban mobility in his or her economy. After the presentations, participants were asked to reflect on the priorities and needs to achieve sustainable, energy-efficient urban mobility in their economies in these key strategic areas:

- Policy and regulations
- Institutional arrangements
- Financing
- Capacity development
- Priority measures.

Participants revisited and analyzed these priorities on the last day of the workshop, and it became clear that various challenges existed at different levels. Some economies are looking toward the infrastructure requirements for shared electric mobility. However, others are trying to provide attractive public transport options to change the modal split away from increasing individual motorization. Many participants highlighted the importance of inter-agency coordination but concluded that transport departments alone do not have sufficient leverage to influence the necessary shifts.

This study tour was the final in the series of workshops that began with Peru in September 2017, followed by Viet Nam in December 2017. The convening organizations were the LEDS GP Transport Working Group and GIZ. They designed and conducted this APEC workshop and study tour in the context of the international MobiliseYourCity Partnership and a LEDS Community of Practice, striving to learn and disseminate knowledge on best practices, policy reform, finance tools, and infrastructure to facilitate implementation of sustainable urban mobility.

Figure 7. Singapore workshop participants during a visit to Singapore's Urban Redevelopment Authority

<u>Singapore Authorities—Governing Public Transport and Urban Planning</u>: Eu Jin Toh and Sharon Wong from the Land Transportation Authority led a session on past reforms and the current financing of Singapore's public transport. The focus was on understanding

how Singapore has managed its land resources to provide an efficient road and rail transport network. A 1996 white paper on public transport financing constitutes the original framework for securing quality, affordability, and profitability of service. Infrastructure and capital expenses are fully funded by the government, which at the same time maintains a high degree of regulatory control. Singapore authorities plan to double the rail network from its current length of 180 Km to 360 Km in 2030.

Participants heard from urban planners Claudia Heng and Caroline Seah from the Urban Redevelopment Authority (URA) about Singapore's land-use policies. The scarcity of land in the island state is used as a lever for close coordination and enforcement of policies among the urban planning, housing, and transport sectors. About 80% of the building stock is public housing.

Private-sector engagement: The study tour visited the depot of Tower Transit, one of four bus operators in Singapore. Tower Transit operates about 380 buses split among four different types, and it has been in Singapore for just over 2 years. Tower Transit employees guided the participants through the various workshops and office spaces. At the end, Managing Director Andrew Bujtor presented on the company's approach to providing competitive and reliable services. At the end of his presentation, Bujtor initiated a discussion on how private operators should best invest to prepare for disruptions in the transport sector.

The participants also visited the headquarters of Grab, a Singapore-based transportation network company (TNC) that has grown quickly in Southeast Asia. In a presentation by Grab's public affairs team and in ensuing discussion, the delicate and uncertain challenges ahead for the interplay of public transport and new mobility services became apparent. Recent studies have questioned the environmental and social impact of TNCs, and companies are highlighting their utility as mobility providers.

Figure 8. Study tour participants visiting Grab headquarters in Singapore

Research and tools: The study tour invited several researchers and nonprofit representatives to share their insights on issues and developments in urban transport.

Ann Bernal from Green Freight Asia presented on the consequences and outlooks for sustainably managing logistics and freight operations in booming Asian markets. A research team from TUM CREATE, a Singapore-German research cluster, gave participants insights into their investigations of the ultimate public transport system and presented several options for modular public transit and innovations in operations, design, data analysis, and technology. One of the baseline concepts is to create a coordinated, seamless public transport experience. To make this a reality, Dr. Andreas Rau's research team drew from multiple examples around the world, highlighting the importance of network density and a hierarchical structure for managing transit modes. Further presentations dealt with simulating an electric transport infrastructure for Singapore and design considerations for autonomous vehicles. In the ensuing discussion, participants applied and compared the presented concepts and policy ideas.

Jone Orbea from WRI Mexico presented a technology decision tool that allows life-cycle and cost comparisons of bus fleets. She drew on the experiences of Mexican policy decisions and allowed participants to apply the spreadsheet-based tool to their own situations.

The workshop in Singapore provided a very enriching experience and allowed the participants to gather insights and understand developments in sustainable urban mobility from a variety of perspectives. The Singaporean approach is certainly unique and depends on a high level of government involvement, but Singapore offered many valuable and transferable lessons learned from its integrated planning and governance. Another good practice emphasized by many partners was the open-ended technology approach, together with greater focus on responding to people's actual demands and needs in navigating the city.

Through interactive sessions involving input from participants and moderation by the organizers, the workshop enabled reflection on how to confront current challenges and transfer knowledge and policy approaches. What also became clear was the need for greater coordination of transport departments with other departments on issues of urban mobility and sustainable transport.

Overall, the workshop served as a valuable means to find opportunities for collaboration, learn from cross-sectoral networking experiences, and discuss, share, and exchange information among APEC economies and regional partners with similar experiences. The feedback received was overwhelmingly positive, stressing the usefulness of workshops and interest in the topic. Participants expressed interest in continuing these kinds of workshops, having benefitted from the lessons learned, relishing the exchange platform created, and being eager to apply the knowledge acquired.

5 Conclusions and Future Outlook

The in-person workshops were a primary output of this project and, based on participant responses to an end-of-project survey, have produced significant impacts as workshop learnings are applied address the priorities of participating economies. Examples of impacts include:

- Understanding and using public transportation franchising

- Gaining insight into implementation of a new policy on truck efficiency, called the Green Freight Program
- Applying ideas for implementing fuel economy standards
- Applying ideas for designing a National Electromobility Strategy
- Building international collaborations and relationships.

A training package ("Improving the Operational Efficiency and Energy Efficiency in Public Transport") and a road map ("Report of Fiscal Policies for vehicle fuel economy") was also produced, partly using information derived from these workshops. Both of these were distributed to all participants at the end of the project. The training package drew partly from workshop contents on operational efficiency (Viet Nam), energy efficiency (Peru), and public transport (Singapore), along with additional desktop research. The roadmap is not derived from workshops' contents, but represents desktop research intended to fill a research and a policy gap.

Continuous engagement and participation in peer-to-peer learning through the LEDS GP Communities of Practice will further consolidate and enable these impacts to flourish in the long term.

The next steps and future challenges to be addressed include:

- Developing a deeper understanding of regulation of EVs and batteries, whether applied to public transportation (e.g., buses), intermediate public transportation (e.g., auto-rickshaws), or personal vehicles
- Developing a deeper understanding of the stakeholders involved in scaling up EV deployment and building closer collaborations (e.g., engaging with utiltiies and energy companies)
- Incorporating shared mobility concepts into transportation planning.

The relationships/collaborations built through participation in these workshops, will continue to deepen knowledge sharing and thereby expand the long-term impacts.

[i] IEA (2009) *Transport, Energy and CO_2: Moving Toward Sustainability*. Paris: International Energy Agency.

[ii] IEA (2016) *Energy Technology Perspectives 2016: Executive Summary*. Paris: International Energy Agency

[iii] APERC (2013) *APEC: Energy Demand and Supply Outlook 5th Edition*. Tokyo: Asia Pacific Energy Research Centre.

6 Supporting Information

6.1 Workshop 1 Agenda: Peru

Experts' Workshop

Strengthening of energy efficiency policies in the transport sector

Opportunities, challenges and lessons learned from intersectoral articulation and measurement and reporting systems in Latin America

Place and date

Tuesday 19th and Wednesday 20th September 2019

CAF offices in Lima

Av. Canaval y Moreyra 380, piso 13.

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Sponsors:

Introduction

Under the priority theme of the LEDS LAC platform and the Centro Regional de Colaboración Panamá UNFCCC- CAF on strengthening the transport components of the NDCs, the third thematic workshop on transport issues will be held on September 19 and 20, in the city of Lima, Peru. The workshop focuses on "Strengthening energy efficiency policies in the transport sector" with the objective of addressing the opportunities, challenges and lessons learned from intersectoral coordination and measurement and reporting systems in Latin America.

Organizers and sponsors

The workshop is organized by the LEDS LAC platform with the collaboration of the LEDS GP Transport Task Force (led by WRI) and the UNFCCC-CAF Panama Regional Collaboration Center. It is sponsored by the Asia-Pacific Economic Cooperation Forum (APEC) and the Inter-American Development Bank (IDB).

Methodology

The workshops organized by LEDS LAC built upon the assumption that all participants are experts in the subject and can contribute to the learning of others in the workshop.

The thematic workshops are designed for small groups and are meant to be participatory, with all sections(?) being used to answer questions and help solve the needs of the participants (as identified in anticipation to the event). The help includes everything from the definition of conceptual frameworks, to the use of tools and the identification of specific lessons learned.

It is intended that all the economies represented in the workshop have the opportunity to share their case, having identified the sessions that are of greatest relevance (based on the experiences to be presented). Dialogues are facilitated so to determine key messages which are then systematized in a final document available for sharing.

Themes

This workshop seeks to promote exchanging of experiences, good practices and lessons learned on:

Developments and experiences on GHG emissions reduction projects in the transport sector based on the implementation of policies such as: energy efficiency of vehicles and / or introduction of hybrid or electric vehicles.

The implementation, operation and development of an MRV system (monitoring, reporting and verification) in mitigation projects within the transport sector, and within the framework of the NDCs. More specifically, what can we learn from the experiences of CDM projects?

In a transversal way, what are the challenges and opportunities of intersectoral and subnational articulation in order to achieve the objectives set out in the two previous themes.

Agenda

	Tuesday September 19	**Wednesday September 20**
8:30-9:00	Registration	
9:00-10:30	Topic 1 - **Linking energy efficiency policies in transport and NDCs** Presentation from economies México: Fuel Economy Standard Jorge Macías, WRI México Chile: Vehicle labelling Cristina Victoriano, Ministerio de Energía Discussion	Topic 3 – **Information, measurement and reporting systems** Experiences in CDM projects: What can we learn? Susana Ricaurte, Colombia
10:30-11:00	Coffee Break	Coffee Break
11:00-13:00	Topic 1 – *continued* Group work	Topic 3 – *continued* Group work
13:00-14:30	Lunch	Lunch
14:30-16:00	Topic 2 - **Cross-sectoral articulation for the implementation of energy efficiency policies in transport** Presentation from economies Experiences in Argentina Fernando Lía, Secretaría de Planeamiento Energético Estratégico Experiences in Thailand – Borwornpong Sunipasa, Oficina de Promoción de Eficiencia Energética Discussion	Topic 4 – **Electrical Mobility / Electric Vehicles** Presentation from economies Enabling conditions Advances in México Eduardo Olivares, SEMARNAT Advances in Chile Andrés Pica, Ministerio de Medio Ambiente Advances in Perú Daniella Rough, Ministerio de Energía y Minas
16:00-16:30	Coffee Break	Coffee Break
16:30-17:30	**Incorporating gender topics into transport policies** Presentation and discussion	Group Work **End of workshop**

6.2 Workshop 2 Agenda: Viet Nam

Experts' Workshop

Improving the efficiency of urban transport projects

4 December 2017

Sheraton Saigon Hotel & Towers

88 Dong Khoi, District 1,

Ho Chi Minh City, VN-SG, Viet nam

Followed by the ALP Annual Forum

5-6 December 2017

APEC Asia-Pacific Economic Cooperation

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

LEDS GLOBAL PARTNERSHIP

Sponsors:

Introduction

This event is held under APEC Project: EWG 13 2016A – *Supporting the Development and Implementation of Low-Emission Development Strategies (LEDs) in Transport Sector.* Under the Asia-Pacific Economic Cooperation (APEC) Energy Smart Communities' Initiative (ESCI), this project will facilitate dialogue between domestic and regional authorities and provide technical assistance and capacity-building support to governments to integrate transport into their high level (e.g. domestic planning strategies (i.e. LEDS and NDCs) to promote energy efficient, low carbon transport actions through the approach of conducting peer-to-peer workshops and knowledge sharing.

Organizers and sponsors

This APEC expert's workshop is organized by the LEDS Transport Working Group and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) in coordination with the Asia LEDS Platform (ALP).

Objectives

This workshop is part of a series of trainings that will be spread over three days.

On 4 December, a one-day event tailored to provide capacity building on operational and energy efficiency of urban bus systems. The workshop will include participants sharing experiences on the topic and providing a platform for peer-to-peer knowledge exchange with experts providing inputs to maximize learning and retention.

Following the conclusion of the APEC workshop, attendees will continue the discussions focusing on energy efficient transport at the Asia LEDS Platform Forum (5-6 December).

On 5 December, there will be one session dedicated to continuing the discussion from first day of workshop activities during of the Asia LEDS Platform Forum. Session one will provide an overview of how the activities from the first day fit into development of policies related to low emission development in transport sector and the NDCs.

On 6 December, to complete the series of trainings, Session two will be an interactive training session focusing national urban mobility programmes (NUMPs) as a tool to implement transformational transport actions as part of NDCs.

By attending in the series of trainings, participants will have gained knowledge on the topic by learning from the experiences of their peers and learned new approaches to developing solutions to implementing energy efficient urban transport systems from experts.

Methodology

The workshop as part of the training series is built upon the assumption that all participants are experts in the subject and can contribute to the learning of others in the workshop. The workshop is designed for small groups and are meant to be participatory.

It is intended that all the economies represented in the workshop have the opportunity to share their case, having identified the sessions that are of greatest relevance (based on the experiences to be presented). Dialogues are facilitated so to determine key messages which are then systematized in a final document available for sharing.

Agenda

	Monday, 4 December
8:30-9:00	Registration
9:00 – 9:10	Overview
9:10 – 9:50	Economy Introductions Thailand The Philippines Papua New Guinea Viet Nam
9:50 – 10:00	Discussion
10:00-10:30	Topic 1 – **Key Performance Indicators: Introducing Service Contracts to Bus Services** *Modern bus operations require a strong regulatory framework with clear policy and franchising guidelines but also a formalized (company-based) industry that meets the service requirements set by the Government. The morning session will explore the transition towards the implementation of key performance indicators as a strategy to gradually move towards service contracting in bus services, both preconditions to successful BRT operations. The session will look into basic principles, transition strategies and expected outcomes of such transition, building upon international examples.*
10:30-10:45	Coffee Break
10:45-12:00	Topic 1 – *continued*
12:00-13:30	Lunch
13:30-15:00	Topic 2 – **Transitioning to electrifying public transport fleets** *The afternoon session will present the state of affairs of zero-emission buses around the world and key findings of the research on the topic. Participants will be introduced to an implementation framework and explanation of its components. The framework will help participants identify challenges and opportunities for zero-emission bus implementation by breaking down complex components related to electric bus implementation. This session aims to increase technical understanding of all the building blocks of an electric bus implementation.*
15:00-15:15	Coffee Break
15:15 – 16:15	Topic 2 – *continued*
16:15-17:30	Closing

6.3 Workshop 3 Agenda: Singapore

Community of Practice - Study Tour 2018

MobiliseYourCity – Moving towards sustainable, energy efficient, urban mobility in emerging cities

7-9 May 2018

Hotel Mercure Singapore Bugis

122 Middle Road, Singapore 188973

Singapore

Asia-Pacific Economic Cooperation

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

LEDS Global Partnership

Sponsors:

Mobilise Your City

Asia LEDS Partnership

Introduction

This event is held under APEC Project: EWG 13 2016A – *Supporting the Development and Implementation of Low-Emission Development Strategies (LEDs) in Transport Sector.* Under the Asia-Pacific Economic Cooperation (APEC) Energy Smart Communities' Initiative (ESCI), this project will facilitate dialogue between domestic and regional authorities and provide technical assistance and capacity-building support to governments to integrate transport into their high level (e.g. domestic planning strategies (i.e. LEDS and NDCs) to promote energy efficient, low carbon transport actions through the approach of conducting peer-to-peer workshops and knowledge sharing.

The convening organizations, the Low Emissions Development Strategies Global Partnership (LEDS GP) Transport Working Group (TWG) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), will design and conduct this study tour in the context of the international MobiliseYourCity Partnership and a LEDS Community of Practice striving to learn and disseminate knowledge on best practices, policy reform, finance tools and infrastructure to facilitate implementation of sustainable urban mobility.*

* We would also like to acknowledge funding from the US State Department and the German Government (German Ministry for the Environment, Nature Conversation, and Nuclear Safety (BMU)), which was used for facilitating the organization and implementation of this workshop.

Objectives

Participants learn from the experiences and best practices of Singapore in terms of sustainable urban transport policies, financing and governance & management.

Participants understand the processes involved in bringing market transformation into fruition from the perspective of Singapore' success factors.

Learn from the experiences of Singapore and other participant experiences in regard to sustainable urban mobility incl. urban design and planning, construction, project implementation, and disaster risk reduction.

The participants take home best practices from Singapore and peers in regard to urban mobility planning, financing and public transport operations.

Foster a close working relationship with Singapore agencies and individuals for continued knowledge sharing and possible future collaboration.

Participants engage in peer-to-peer knowledge exchange and disseminate knowledge and lessons learnt from other APEC economies and beyond.

Target Group

The study tour aims to provide a learning experience for political decision makers from the national or local level or senior technical staff. Participants should be responsible for significant planning or policy making in (sustainable) urban mobility.

Key Topics

National and subnational institutional set-up towards sustainable urban transport

Sustainable urban land use and mobility planning

Financing mechanisms and funding sources of sustainable urban mobility

Lessons learnt on reform projects in Singapore and other APEC economies

Planning and implementation of new transport technologies

Methodology

The workshop as part of the training series is built upon the assumption that all participants are experts in the subject and can contribute to the learning of others in the workshop. The workshop is designed for small groups and is meant to be participatory.

It is intended that all the economies represented in the workshop have the opportunity to share their case, having identified the sessions that are of greatest relevance (based on the experiences to be presented). Dialogues are facilitated so to determine key messages which are then systematized in a final document available for sharing.

Agenda

	Monday, 7 May
9:00-9:30 *Hotel Mercure Singapore Bugis 122 Middle Road, Singapore 188973*	Registration Meeting room Queen I & II
9:30-10:00	**Welcome and Overview** *Angela Enriquez (WRI/LEDS), Christian Mettke (GIZ)* Setting the agenda Study tour objectives
10:00-11:30	**Introductions to Urban Mobility Contexts** *Melissa Cruz (GIZ)* Introductions Brief presentations by economies with focus on urban mobility status and challenges
11:30-12:30	**Identification of Priorities and Needs** *Melissa Cruz (GIZ)* Discussion of common priorities and interests Exchange of findings
12:30-13:30	Lunch
13:30-15:30	**Governance and Financing of Public Transport** *Eu Jin Toh (Land Transportation Authority (LTA)* Singapore's early public transport financing principles and regulatory framework Transitioning to new contracting model for buses Transitioning to new rail financing framework Discussion
15:30-17:00	**Smart Urban Freight** *Ann Bernal (Green Freight Asia)* Green freight and smart logistic transportation initiatives Outlook to intelligent transport system applications
17:00-19:00	**Last Mile Connectivity Stroll & Mobility Challenge** *(optional)* Opportunity to explore and connect
19:00-21:00	**Networking Dinner** **(***hosted by GIZ)*

	Tuesday, 8 May
9:00-9:30	**Review Day 1 and Logistics Day 2**
9:30-10:00	Bus transfer to site
10:00-11:30 *Urban Redevelopment Authority, 45 Maxwell Rd, Singapore 069118*	**Planning: Field Visit Urban Redevelopment Authority (URA)** *Daveen Koh, URA* Land Use Planning in Singapore Singapore's planning context Singapore's planning and development system Planning strategies
11:30-12:00	Bus transfer to hotel
12:00-13:00 *Hotel Mercure Singapore Bugis* *122 Middle Road, Singapore 188973*	Lunch
13:00-13:30	Bus transfer to site
13:30-15:30 *CREATE Tower,* *1 College Ave E, Singapore 049374*	**Future Mobility: Field Visit TUMCREATE** *(TUMCREATE)* Overview of research topics of TUMCREATE (AVs, future urban mobility systems etc.) Future of urban mobility Promotion and Regulation of ride sharing/hailing services
15:30-16:00	Bus transfer to site
16:00-18:00 *21 Bulim Drive, Bulim Bus Depot, Singapore 648170*	**Operations: Field Visit Tower Transit** *Diana Mohd Noor (Tower Transit)* Tour of Bulim Bus Depot Tower Transit: history, operational insights, business models of electric buses Q&A
18:00-18:30	Bus transfer to hotel

	Wednesday, 9 May
10:00-10:30	**Review Day 2 and Logistics Day 3**
10:30-12:00 *Hotel Mercure Singapore Bugis 122 Middle Road, Singapore 188973*	**Decision-Making on Fleet Renewal** *Jone Orbea (WRI)* Presentation of tool that provides technical information to support fleet technology decisions Discussion on moving transport from national agenda to local implementation
12:00-13:00	Lunch
13:00-14:30	**Knowledge: LEDS Community of Practice (CoP)** *Sanjini Nanyakkara (NREL/LEDS), Avantika Arjuna (ICLEI/ALP)* LEDS objectives Benefits of CoP for urban mobility stakeholders
14:30-15:00	**Final Reflections** *Christian Mettke (GIZ), Melissa Cruz (GIZ)* Short reflection by participants on Lessons learned Next steps
15:00-15:45	MRT Transfer to site
15:45-18:00 *9 Straits View, Marina One West Tower, Singapore*	**Future Mobility: Field visit to Grab** *(Grab)* Introduction to Grab vision and business Presentation of recent and future applications of Grab Potential of collaboration (regulation, data, planning)
18:00-18:30	MRT Transfer back to hotel
19:00-21:00 *Hotel Mercure Singapore Bugis 122 Middle Road, Singapore 188973*	**Farewell Dinner** **(***hosted by GIZ)*

6.4 Roadmap – Report on Fiscal Policies for Vehicle Fuel Economy

6.4.1 Introduction: The transport sector needs vehicle fuel economy policies

6.4.1.1 The status quo of transport is unsustainable

As economies grow rapidly in Asia and the Pacific, there is a trend towards increased use of motorized vehicles (International Organization of Motor Vehicle Manufacturers (OICA) 2016). The world already has over 1.2 billion vehicles, and this number is expected to double by 2030 under current scenarios (Sims et al. 2014). About 90% of the growth of passenger light-duty vehicles (LDVs, standard 4-wheel private automobiles) is expected to occur in non-OECD economies (Global Fuel Economy Initiative 2016a, 5).

From 2013 to 2040, the total vehicle stock in APEC economies is expected to grow from 663 million to 1.27 billion (APEC 2016, 7), with 453 million new vehicles in China and South-East Asia alone (APEC 2016, 7). In the APEC area, light-duty vehicles (LDVs) account for 73% of final energy consumption in the transport sector; the number of LDVs is expected to grow by an additional 900 million by 2040 (APEC 2017a, 63). Especially in Asian and Pacific cities, more and more people drive more and more vehicles at an astonishing pace. Key factors of this surge are rapid industrialization and urbanization as well as rising income levels (APEC 2016, 13). As reported by the International Council on Clean Transportation, 76% of global vehicles sales take place in APEC member economies (International Council on Clean Transportation 2015, 15).

This development brings various opportunities, but it does not come without challenges. Among the foremost are the anticipated costs from the impacts of climate change. The transport sector's amount and share of greenhouse gas emissions has grown continuously. Carbon emissions are expected to rise steeply under a business-as-usual scenario, and somewhat moderately under an NDC scenario (Silitonga, Atabani, and Mahlia 2012, 1688; Global Fuel Economy Initiative 2017). Among the key tasks for policymakers is to enhance the efficiency of land transport and to address the economic, social, and environmental costs of transport.

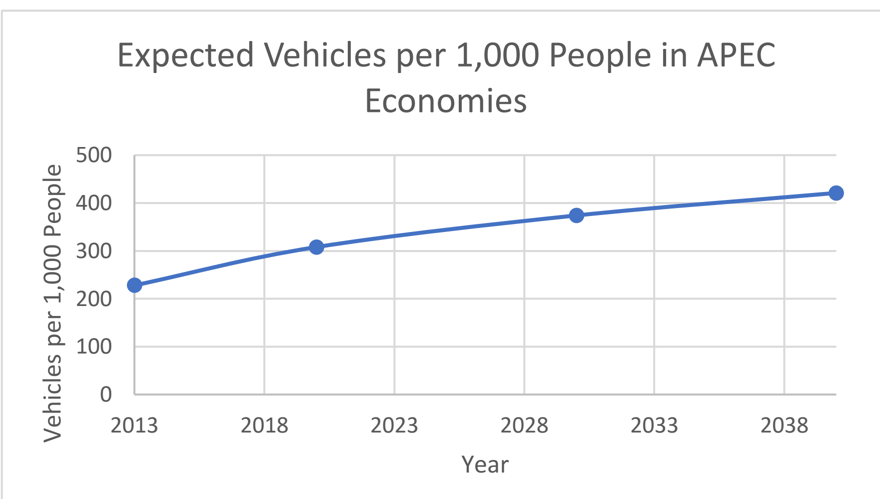

Figure 1: Expected Vehicles per 1,000 People in APEC Economies (APEC 2016)

Energy security and oil prices

APEC economies are net importers of petroleum, and imports are expected to grow under all scenarios (APEC 2016). While energy diversification is also increasing due to higher rates of renewable energy, continued reliance on fossil fuels makes both economies and their consumers sensitive to fluctuations in the international demand and supply of oil and other fuels. Overall, energy self-sufficiency among APEC economies declines as energy imports rise, particularly in South-East Asia (APEC 2016, 179)

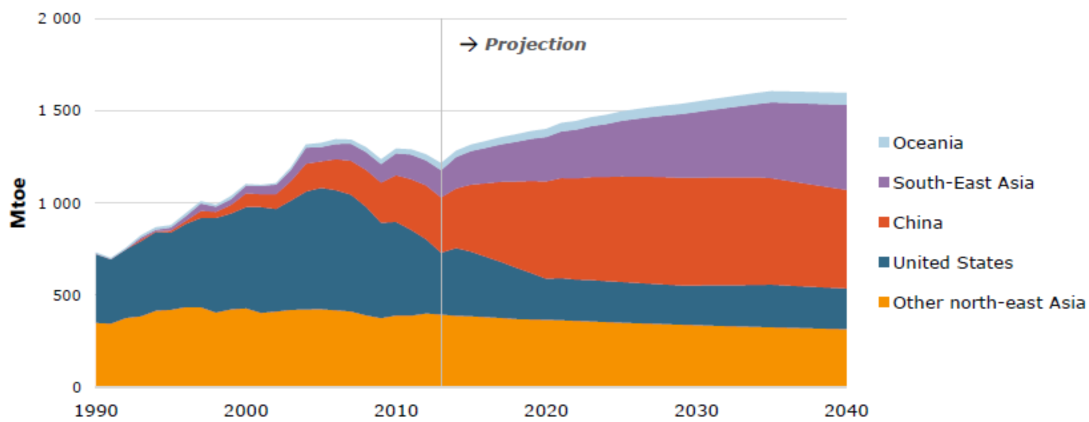

Figure 2: Historical and projected oil imports (APEC 2016, 52)

Road transport currently consumes more than half of the world's petroleum supply, with demand growing particularly for heavy duty vehicles and in non-OECD economies (International Energy Agency 2017a). Among APEC economies, transport accounted for 26% of total energy demand in 2013 (APEC 2016, 99). Scarce oil supplies can severely impact and curtail economic activity, and energy security[1] concerns continue to play a major role in national planning (Asian Development Bank 2009). Curbing the dependence on petroleum can serve the double purpose of buffering supply interruptions and promoting energy efficiency.

Energy security weighs even heavier when it is coupled with concerns about fiscal stability, for example when energy consumption is highly subsidized. APEC economies recently have utilized lower oil prices to successfully implement subsidy reforms (International Energy Agency 2017b). Government fuel subsidies are highly inefficient instruments and can hamper economic liberalization and trade (Global Subsidies Initiative 2009; Van de Graaf and van Asselt 2017). In addition, they are unequally distributed and do overwhelmingly not favor the poor, thereby disqualifying as social assistance (Arze del Granado, Coady, and Gillingham 2012). APEC economies already have successfully reduced their fossil fuel consumption subsidies by 50 percent since 2011 which shows the impact of coordinated commitment and effective pricing strategies (APEC 2017b, 1). Here, fuel economy policies could create significant economic value and generate consumer savings.

[1] Energy security definitions vary, see APEC (2016), page 175.

Air quality, local pollution, and health hazards

Globally, transportation accounts for a larger percentage of urban ambient air pollution from PM2.5 (25%) than any other source (Karagulian et al. 2015). Today, the highest levels of air pollutants are concentrated in developing cities, where transportation often accounts for a disproportionately higher share of PM2.5 than the global average (Karagulian et al. 2015). For reducing health impacts from air pollution, it is important to know the sources contributing to human exposure. This study systematically reviewed and analyzed available source apportionment studies on particulate matter (of diameter of 10 and 2.5 microns, PM10 and PM2.5) performed in cities to estimate typical shares of the sources of pollution by economy and by region. A database with city source apportionment records, estimated with the use of receptor models, was also developed and available at the website of the World Health Organization.

Some of the most impactful air pollutants are particulate matter (PM 2.5 and black carbon), carbon monoxide, nitrogen oxides, sulfur dioxide, ozone, methane, and lead. While phasing out the most severe health hazards, like lead and sulfur, ranks higher on immediate priority when emission standards are still lacking, it is important to address all persistent as well as manageable factors for air pollution (World Health Organization 2016; Organisation for Economic Co-operation and Development (OECD) 2014).

According to the World Health Organization (WHO), 3 million pre-mature deaths in 2012 were associated with outdoor air pollution. Of these, 87% occurred in low- and middle-income economies, with the greatest burden in the WHO Western Pacific and South-East Asia regions (World Health Organization 2016). A more recent study suggests that in the most affected places, more than 25% of deaths are due to pollution. According to the Lancet report, overall air pollution is responsible for an estimated 9 million premature deaths, costing the global economy an equivalent of 6.2% of its economic output (Landrigan et al. 2017).

It is important to note that, as transport should be thought of as a system, improvements in emissions control, fuel quality, and vehicle efficiency are not independent projects, but can go hand in hand. As noted by the UNEP Partnership for Clean Fuels and Vehicles: "A long term strategy that focuses on cleaning the fuels and vehicles in an integrated manner will result in optimal benefits to the economies. For in-use vehicles, effective inspection and maintenance programs will ensure vehicles emit fewer pollutants." (Partnership for Clean Fuels and Vehicles (PCFV)

Climate change and low carbon visions for the transport sector

Transport emissions contribute chiefly to air pollution and climate change and thereby pose a threat to the sustainable development of global economies (Pachauri et al. 2014). Alarmingly, transport sector emissions are growing faster than those from any other sector (Sims et al. 2014). Transport contributes about 23% of global energy-related greenhouse gas emissions, whereof 17% or 73.6% of total transport emissions come from road transport (Sims et al. 2014). In sum, LDVs are responsible for 9% of global emissions (Yang et al. 2017). Exacerbated by accelerating urbanization and rising levels of income, the developing world particularly is impacted by the growth of inefficient vehicles. For example, Asia's share of global CO2 transport emissions is projected to increase to 31% by 2030 and a large share of air pollution in Asia comes from traffic (Asian Development Bank 2017).

Parties to the United Nations Framework Convention on Climate Change (UNFCCC) agreed on limiting climate change to a rise below 2 degrees Celsius in 2009, and have subsequently committed to action to reduce national GHG emissions. With this intention, almost every party to the UNFCCC has submitted nationally determined contributions (NDCs) which became relevant with the Paris Agreement entering into force on November 4, 2016. All APEC member economies except for Chinese Taipei are parties to the

UNFCCC and have signed and ratified the Paris Agreement.[2] The Paris Agreement is generally seen as an important framework for ensuring global cooperation and driving low carbon investment. APEC leaders reaffirmed their commitment to the Paris Agreement and to "transparent and effective implementation in order to transition towards a low carbon, climate resilient economy" in the 2016 Leaders' Declaration in Lima, Peru.

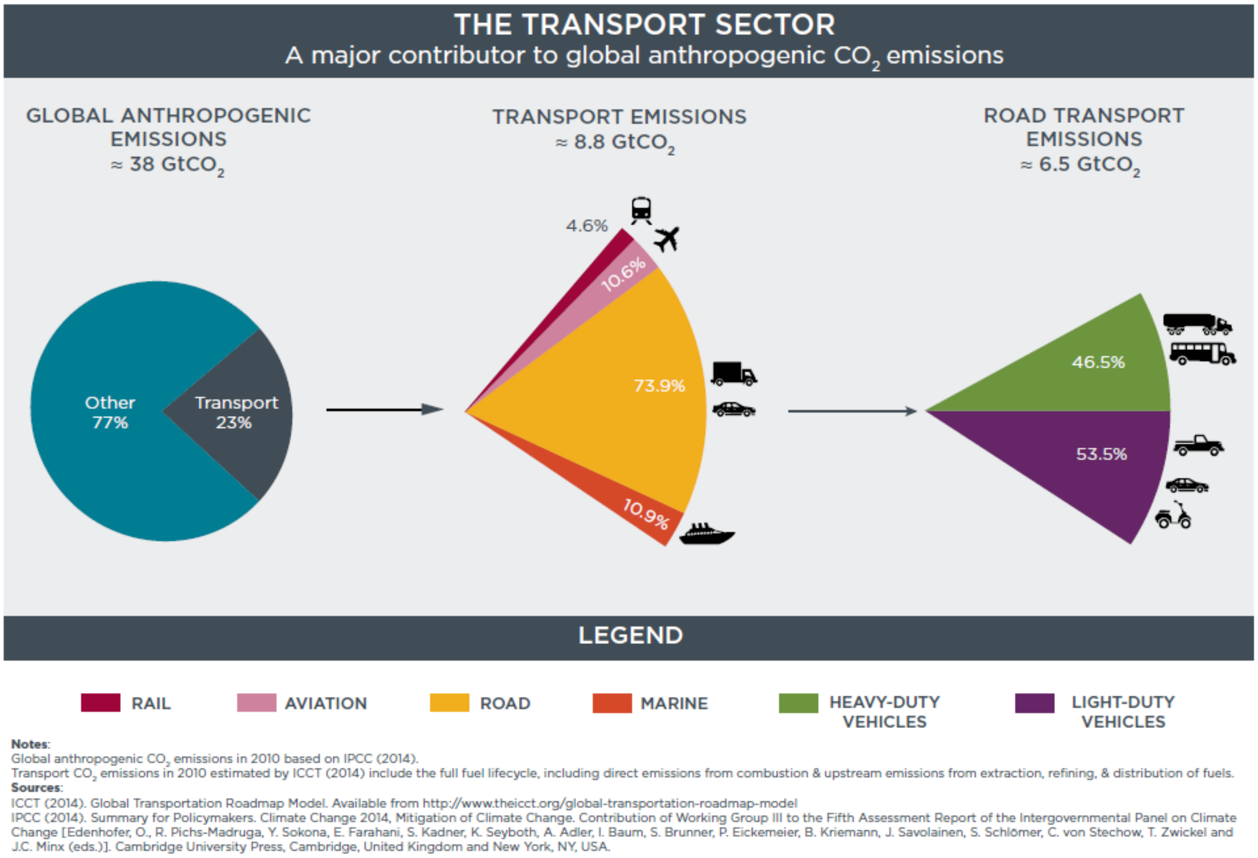

Figure 3: Contributions of passenger vehicles to global CO2 emissions (International Council on Clean Transportation 2014, 6)

Fuel economy policies are highly relevant for achieving the NDCs. However, the global vehicle fuel economy is not improving at a rapid enough pace to meet the 2-degree goal (Cooper, Lefevre, and Li 2016). Consequently, increasing the stringency and scope of fuel economy regulations and pricing schemes are a key action to achieve a global 2-degree target. It stands out that doubling the fuel economy of passenger vehicles would reduce carbon emissions by about 1.5 Gt/year by 2050 (SLoCaT 2016, 45). "Achieving the Global Fuel Economy Initiative (GFEI) target is estimated to account for almost one third of the CO2 reductions necessary to switch individual motorized passenger transport from a 6 degree Celsius (6DS) to a 2DS emission trajectory" (SloCaT 2016, 45).

[2] Chinese Taipei has still published their INDCs and stated its interest in participating in the global climate change process https://www.taiwanembassy.org/nl_nl/post/1411.html

Curiously enough, non-OECD economies have recently been similar or even more ambitious in improving their fuel economy (Global Fuel Economy Initiative 2017). Given that many NDCs of APEC economies fall in the category of "Tighten fuel economy standards for passenger vehicles" (Peet et al. 2016), these actions may be particularly appropriate for implementation. Projections from the latest APEC Energy Supply and Demand Outlook show that, "fuel efficiency improvements deliver most (194 Mtoe) of the savings" (APEC 2016, 100) under an Improved Efficiency Scenario, which has transport energy demand peaking in 2025.[3] In line with the most relevant scenarios, global energy related CO2 emissions have to be reduced by 50% by 2050 to meet the 2-degree scenario (2DS)[4].

Addressing transport problems

Given the above-stated issues regarding energy dependence, the health implications of air pollution, and the implications of (and commitments to abate) climate change, there is a clear need to reform the status quo of the transport sector. Such changes to provide a low-carbon, sustainable urban transport network will require a paradigm shift. To help guide and coordinate strategies, a planning framework can be used to address these transportation issues. In particular, "Avoid-Shift-Improve" is an effective implementation strategy specifically designed for the transport sector:

Avoid: refers to the need to minimize motorized trips. This can be achieved in several ways such as integrated urban planning, transit-oriented development, or changes in land-use. Avoid also encompasses the need to reduce travel time and length.

Shift: refers to a shift in the way the trips are done and to an increased in travel efficiency. Shift can be visualized as a shift from privately own vehicles to public transport or more environmentally friendly modes of transportation.

Improve: focuses on vehicle, fuel efficiency, infrastructure, and technological improvements. It seeks to optimize technologies as to make them more efficient and cleaner.

Efforts to improve vehicle fuel economy generally fall in the "Improve" category of the "Avoid-Shift-Improve" framework. Within the suit of fuel efficient vehicle technologies, electric vehicles, with zero tailpipe emissions and increasing battery affordability, are emerging as an effective and pragmatic option for improving emissions (Bloomberg New Energy Finance 2018). The nascent stages of electric vehicle adoption have started to take root, and it is widely believed that electric vehicle technology will emerge as the leading technology in the global effort to improve fuel economy (Bloomberg New Energy Finance 2018; Egbue and Long 2012; OECD/IEA 2018).

Improving fuel economy has great potential for improving economic prosperity and mobility

[3] Not considered in this scenario are urban planning and demand management solutions as well as a high penetration of alternative fuels.

[4] Note that the 2DS calculates with probability: The two-degree scenario (2DS) plans an emissions trajectory which would result in a 50% chance of limiting average global temperature increase to 2°C.

Efficiency improvements can stop economic losses and spur economic growth. The OECD estimates that road transport accounted for about half of the costs of the health impact of air pollution in OECD economies in 2010; which is most likely higher or comparable for non-OECD members as well. The estimated impact for China and India alone was almost twice as high as for all OECD economies, calculated at USD 1.9 trillion (Organisation for Economic Co-operation and Development (OECD) 2014).

There is wide agreement that "fuel-efficiency improvements are essential for competitiveness in an increasingly global market" (Springer et al. 2014, 11). Research by the New Climate Economy shows that economies can follow a prosperous growth pathway by utilizing efficiency and connectivity to achieve a higher economic output, productive investments in transport and infrastructure, as well as realizing health benefits, and reductions in carbon emissions (Zhao et al. 2016). Therefore, many auto industries accept (and often surpass) tighter fuel economy standards and recognize the benefits for the rate with which they innovate (Nidumolu, Prahalad, and Rangaswami). Researchers also found that "recent changes in US and European standards have both increased the rate of technology adoption and affected the direction of technology adoption" (Klier and Linn 2016).

The demands for sustainable development are urgent and enormous. At the same time, transport systems form the backbone for economic cooperation and prosperity of nations. The crucial question for APEC economies is how they will address the challenges and opportunities of economic growth and prosperity in the 21st century. Among the measures available, fuel economy improvements have very bright prospects to contribute positively to the economy. As a ClimateWorks report notes, the U.S. Environmental Protection Agency already established in 1999 that the quantifiable social benefits of fuel economy policies for passenger vehicles outweigh the additional costs, "on the order of two to five times" (ClimateWorks 2014). This usually comes at a cost of less than 2% of the new car to the consumer.

6.4.1.2 Public policy is key to save fuel and emissions

The goals and types of fuel economy policies

Public policies can influence the fuel economy of land transport in various ways. Fuel economy of vehicles is defined as "the efficiency of the conversion of energy contained in the fuel to mechanical energy at the wheels that drive the vehicle (measured as distance travelled)" (International Energy Agency 2012a, 9). Fuel economy policies influence the characteristics of vehicles in their consumption of fuel, not the quality of the fuel or driving behavior.

The ultimate objective of fuel economy policies is to increase the fuel efficiency of the overall vehicle fleet on the roadway network. To achieve this goal, Anderson et al. (2011) note that there are two chief reasons that governments enact fuel economy standards: (1) to ensure automakers produce more efficient vehicles and shift sales towards more fuel-efficient models, and (2) to allow consumers to better identify and rank the fuel efficiency of different makes and models of vehicles (International Council on Clean Transportation 2015).

Fuel economy policies can generally be distinguished in three categories: (1) normative measures such as standards or import restrictions, (2) economic instruments or incentive measures such as tradable permits, fees, and taxes, and (3) information measures such as labels, and information campaigns. The most common distinction is made between standards and economic instruments. In this publication, special emphasis will be paid to fiscal instruments, which form a subgroup of economic instruments. Fiscal instruments include taxes, fees, and subsidies, and exclude quantity instruments such as permits and quotas.

Among APEC economies, both normative and information measures like fuel economy/CO2 standards and efficiency labels are in place in Australia, Canada, Japan, Korea, China, and the United States. In addition, Chile, Mexico, New Zealand, Singapore, and Chinese Taipei have implemented mandatory fuel efficiency labels (APEC 2016, 40). Development of fuel economy policies is underway in economies such as the Philippines, Singapore, Malaysia, Viet Nam, Indonesia, and Thailand (Silitonga, Atabani, and Mahlia 2012).

1. *Fuel economy* is usually expressed in forms of "specific fuel consumption (Lge/100 km) or fuel economy (MPG or km/Lge)" (Global Fuel Economy Initiative 2016b, 15). The most consistent way of measuring fuel consumption would be by target unit per unit of distance, e.g. l/ 100km (often written as liter of gasoline equivalent (lge)). In accordance with IEA and ICCT reporting, the terms *fuel efficiency* and *fuel intensity* can be used identically with *fuel economy* (International Energy Agency 2012a, 9; International Council on Clean Transportation 2007; Posada, Yang, and Blumberg 2017, 7) (see Box).

The US approach to measure in miles per gallon is not recommendable as it represents a non-linear relationship and users regularly undervalue the value of fuel savings (Transportation Research Board and National Research Council 2010, 39).

2. Carbon emissions are highly correlated with fuel efficiency of vehicles, which is why both can be chosen as a target for policies (International Energy Agency 2012a, 9). As already noted in the 2008 APEC *Survey of Policies and Programs that Promote Fuel-Efficient Transport in APEC Economies*, many policies either address GHG emissions or fuel economy with the implicit understanding that the other target will be impacted indirectly as well (APEC 2008).

Fuel quality also impacts the efficiency and emissions of a vehicle. Diesel engines emit less CO2 than equivalent gasoline engines, although at the expense of more local air pollutants (Brand 2016). The emissions intensity of new vehicles might change with the introduction of more electric and alternatively-fueled vehicles. However, for the moment, all relevant policy studies and scenarios attribute large significance to fuel economy measures that reduce gasoline or diesel consumption (Asian Development Bank 2017; Gallagher and Muehlegger 2011; Global Fuel Economy Initiative 2016b; International Energy Agency 2012b).

3. Passenger vehicles, also characterized as LDVs differ in their classification across regions and economies. With the different vehicle types on the market, some are classified according to their weight, others to their overall size, or footprint, others again due to their power or engine displacement (International Council on Clean Transportation 2017a). Recent methodological updates in fuel economy research allow to compare them consistently (Global Fuel Economy Initiative 2016b, 15).

Another change in methodology comes with the harmonization of fuel economy test cycles to the Worldwide Harmonized Light Vehicles Test Cycles. So far, three test cycles have been applied to measure fuel efficiency: the European NEDC, the US Corporate Average Fuel Economy (CAFE), and the Japanese JC08. "Globally, the changes in methodology result in an increase in average specific fuel consumption of 13%" (Global Fuel Economy Initiative 2016b, 16), which renders the GFEI target of halving global fuel consumption per km of new LDVs by 2030 more difficult than previously assumed.

Policy instrument choice

Academic research on fuel economy policy is now about two decades old (Greene 1998; Portney et al. 2003). Additionally, international institutions and think tanks like the World Resources Institute, the World Bank, the International Energy Agency, and the International Council on Clean Transportation also have produced early policy-oriented publications on international fuel economy policies (Faiz, Weaver, and Walsh 1996; An and Sauer 2004; Schipper 2008; Onoda 2008; International Council on Clean

Transportation 2007). Currently, international efforts are coordinated in the Global Fuel Economy Initiative (GFEI).

Policy instruments differ in their effect in many ways, which can lead to confusion in their classification. For example, labeling policies typically mandate the disclosure and comparison of fuel economy values for vehicles. While this is a standard, it does not by itself have a direct effect on fuel economy, and is therefore characterized as an information measure. This policy rather enables more informed decision-making by buyers, which is expected to lead to fuel savings and emission reductions. Consequently, testing and publishing fuel economy values to develop a fleet-wide baseline analysis is usually one of the first actions that governments undertake. This topic will be explored in more depth in Section 2.

Economic instruments are said to be more cost-efficient, while command-and-control instruments are more commonly implemented by policymakers (Santos et al. 2010). For a relevant overview of the discussion on economic efficiency of vehicle policies, see the recent literature review by Anderson and Sallee (2016).

Comparatively little attention has been paid to the effectiveness of economic instruments versus standards. There is a debate whether standards or economic instruments are easier to implement (measuring/labeling the vehicle fleet is always a prerequisite). ICCT (2010) and IEA (2012a) suggest that it might be easier, especially for developing economies, to implement economic instruments, since they carry a lower budgetary and administrative burden. *"For economies where programs do not already exist, or for vehicle types that have not been regulated, feebates offer a quick and relatively easy way to begin reductions in fuel consumption and CO2"* (International Council on Clean Transportation 2010, 16).

Grey literature has shifted more towards finding the appropriate policy mix, and enabling what is politically feasible for decarbonizing the transport sector (van der Vooren and Brouillat 2015; Yang et al. 2017; Lah 2017). Apart from economic optimality, this discussion increasingly considers revenue-neutrality and political feasibility as important components. A number of impact studies, for example, which econometrically measure the effects of introduced policies, are about one decade old. The research on early fuel economy policies allows deriving best practices and informs successful policy in new contexts (Ryan, Ferreira, and Convery 2009; de Haan, Mueller, and Scholz 2009).

<u>Limitations of fuel economy policies (new vehicles, rebound effect, unintended consequences)</u>

About 80% of new passenger vehicles globally are covered by an emissions or fuel economy regulation (International Council on Clean Transportation 2017a, 1). Fuel economy policies generally concern new vehicles only. This is mostly because the assessment of their characteristics is easier at the point of production and sale than measuring the existing fleet. For example, the Global Fuel Economy Initiative (GFEI) has set a target of halving the fuel consumption per km of new LDVs by 2030 (compared with 2005) (Global Fuel Economy Initiative 2017). However, this means that the fuel economy of the sum of vehicles on the road is worse than the specified values for new vehicles indicate. It is hard to obtain a global number for the share of new vehicles, but based on estimates from the OECD, one could assume that about 10% of the vehicle fleet is new (Gordon 2005; OECD 2009a, 11).

Four-wheel passenger vehicles are more uniform in nature and therefore easier to address. Only China has fuel economy regulations for two- and four-wheelers in place (Yang 2017). While regional contexts differ in their use of vehicle modes, for reasons of comparison (and of higher fuel and emissions impact), we will only compare light-duty passenger vehicles.

A similar limitation is the discrepancy in taxation between private and company cars. In Europe, about 50% of vehicles are owned by incorporated entities with lower tax burdens, which might reduce the impact of consumer-oriented fuel economy policies.[5]

Plotkin noted that, for the US market, between a "30–50% improvement over a 12–15 year period" (Plotkin 2009, 3848) is possible and economically rational. However, large fuel economy improvements have not materialized "mainly because of a shift towards bigger, more powerful vehicles" (International Energy Agency 2012a, 8). This phenomenon of increasing consumer demand for more emitting vehicles is explored by the literature in detail and negates some of the fuel savings of higher fuel economy (Ó Gallachóir et al. 2009; Knittel 2011)

One effect of every energy efficiency improvement is that the use of the tool has become less energy-intensive, thereby incentivizing more frequent use of it, effectively negating the savings. This *rebound effect* also occurs with more efficient vehicles, which allow consumers to travel greater distances at the same fuel consumption. There is some debate in the fuel economy literature and in environmental policy in general about the scope of the rebound effect, while recent analysis suggests only a minor rebound effect of 10-20% is likely (Hymel and Small 2015; Gillingham, Rapson, and Wagner 2016).

Not considered further in this analysis

There are a number of additional policies that are not part of the investigation. While they are traditionally not considered fuel economy policies, they can serve to support fuel efficiency and facilitate the uptake of better fuel economy.

Scrappage schemes have played a large economic role as stimuli during the financial recession, inter alia justified on environmental terms. However, the evidence of their effect in improving fuel efficiency is limited (Hsu and Sperling 1994; Jacobsen and Van Benthem 2015; Grigolon, Leheyda, and Verboven 2016).

Infrastructure policy, which incorporates building preferential HOV (high occupancy vehicles) lanes for buses or electric cars, parking restrictions, and other transit-oriented development (TOD) measures have a huge impact on the transport mode share, but less directly on vehicle efficiency improvements (Cervero and Sullivan 2011).

Technology-specific measures (e.g. requirements for providing charging infrastructure for electric vehicles) or government investment in research and development can work in support of more efficient vehicles.

Increased public attention has been paid to monitoring and enforcement of testing protocols following the 2015 Volkswagen scandal, with consequences that point toward more international standardization on emission and consumption values (International Council on Clean Transportation 2017b). This development makes it more difficult for European fuel economy targets to be met, but at the same time has spurred harmonization of global tests and targets (Resources for the Future 2016).

Lastly, the difficulties in selecting the right attributes and targets for measuring fuel economy can lead to unintended consequences and even perverse incentives. Examples for this are the comparatively less stringent CAFE standards for the class of light-duty trucks and sport utility vehicles (SUVs) in the United States, which have enabled the rapid expansion of this vehicle class (Plotkin 2009; Carley et al. 2017;

[5] "Company cars represent half of the entire passenger car fleet in Europe, and their purchase is subsidized. This subsidy has the effect of greatly diminishing the effect of existing fiscal policies, and substantially greater CO2 reduction can be realized if this incentive-distorting subsidy is removed. Both company and private car taxes should be linked to vehicle CO2 performance." (International Council on Clean Transportation 2011, 11)

Yacobucci and Bamberger 2006; International Council on Clean Transportation 2017a). Another example is visible in the (assumed) benefits of lower GHG emissions for diesel vehicles, which have created pathways for large shares of diesel vehicles in the European Union (Leinert et al. 2013).

6.4.2 Policies for vehicle fuel economy: standards, incentives, and information measures

6.4.2.1 Introduction to different policy types

"Most industrialized economies have established programmes to address transportation-related GHG emissions. Fuel economy programmes and GHG emission targets, either mandatory or voluntary, have proven to be among the most cost-effective tools" (An, Earley, and Green-Weiskel 2011, 1)

Both in theory and in practice, there exist many public policies to achieve a more efficient fuel use in the transport sector. In the context of established vehicle policies, there are a number of relevant measures to improve fuel economy.[6] The most common ones can generally be distinguished in three categories: (1) normative measures such as standards or import restrictions, (2) incentive measures such as taxes, fees, or tradable permits, and (3) information measures such as fuel efficiency labels.

The Global Fuel Economy Initiative (GFEI) is a partnership of the International Energy Agency (IEA), United Nations Environment Programme (UNEP), International Transport Forum of the OECD (ITF), International Council on Clean Transportation (ICCT), Institute for Transportation Studies at UC Davis, and the FIA Foundation. Since its establishment in 2009, GFEI has become a global initiative to drive policy processes for increased fuel economy as part of energy efficiency.

The idea of the initiative is to coordinate global fuel economy developments and provide a unified platform for the process of maximizing fuel efficiency and reducing transport emissions. Its members engage in global and regional research and data analysis, provide on-the-ground support for national and regional policy-making, and promote fuel economy through outreach and awareness campaigns to public and private stakeholders. GFEI's targets are to improve worldwide new car fuel economy by 30% by 2020, by 50% by 2030, and by 50% for all vehicles by 2050 (Global Fuel Economy Initiative 2016a).

The GFEI also supports efforts towards significant fuel economy policies in such diverse places like Indonesia, Kenya, Ethiopia, and Chile. An important step prior to the adoption of a policy is the analysis and development of national fuel economy baselines. (https://www.globalfueleconomy.org/about-gfei)

There are five different categories of fuel economy measures identified by the GFEI: regulatory policies, economic instruments, traffic control measures, information, and technology. Viewed holistically, efficiency improvements could happen in every one of four target areas of "Improve vehicles, Improve fuels, Improve driving habits, Optimise infrastructure/systems to reduce congestion and delays" (Global Fuel Economy Initiative 2011). However, the most impactful intervention in the transport sector for now lies in the

[6] No uniform way of categorizing them exists, which can be challenging for policy advisors. On first impression, these definitional issues may seem unimportant and even unnecessarily confusing. They do, however, precede some important considerations on policy choice and consequences, and therefore validate the attempt to establish a comprehensive and systematic understanding.

improvement of fuel economy of vehicles, where existing technology could cut transport emissions in half by 2050 (Global Fuel Economy Initiative 2016a).

For the scope of this analysis, we will only consider regulatory, economic, and informational fuel economy measures, with a special emphasis on economic measures. An exception to the covered vehicle policies are fuel standards or taxes, since they regulate the quality or price of fuel consumed by vehicles, not its application in the vehicle. Since fuel tax policy is very efficient in influencing fuel use and comes close to the idea of a carbon tax, we will include it in the analysis. Fuel taxes and subsidy reform count among the most effective tools to reduce inefficient emissions from vehicles, since they are applicable to all vehicles (not just new vehicles) driving on the roads (Anderson and Sallee 2016).

Both economic and informational instruments receive only secondary treatment in the most recent ICCT publication as "Complementary Vehicle Fuel Economy Policies" (International Council on Clean Transportation 2017a, 24). For that reason, it is useful to start with a brief synopsis of fuel economy standards.

6.4.2.2 Fuel economy standards

Traditionally, standards have been the oldest regulatory measure to promote efficient use of fuels. The US was the first economy to introduce vehicle emission standards with Congress enacting the Corporate Average Fuel Economy (CAFE) standards in 1975. The main aim of the standards was to reduce energy consumption by increasing the fuel economy of vehicles after the oil crisis (Santos et al. 2010, 10). They also serve to make consumer decisions more rational and internalize social costs/reduce GHG emissions (Greene 1998; Plotkin 2009). CAFE standards subsequently improved fuel economy and were increased over the first years, although they saw little increase in stringency until 2009, when the Obama administration introduced more ambitious targets. Overall, the CAFE program can be seen as a success, although a limited one (Greene 1998; Anderson and Sallee 2016; Carley et al. 2017).

Other economies followed the US much later. The European Union settled for voluntary agreements with auto maker associations on CO2 standards for passenger vehicles in 1998. When it became apparent that the industry was not going to achieve the agreed targets, the EU set mandatory standards from 2009 on. Most standards today result in mandatory improvements or tradeoffs for car makers. Japan, China, and South Korea also developed fuel economy standards in 1999, 2004, and 2004 respectively.

In 2017, there were nine economies (Brazil, Canada, China, India, Japan, Mexico, Saudi Arabia, South Korea, and the United States) and the European Union that had established fuel economy or GHG emission standards for LDVs (International Council on Clean Transportation 2017a, 1).

Standards usually come in the form of fleet-wide standards that allow manufacturers to trade of more efficient vehicles against higher consuming ones. Allowing flexible systems (e.g. with tradable credits), encourages early adoption and technology innovation and reduces the cost of compliance for manufacturers (ICCT 2017, 17). In some regions (notably the United States and Europe) attribute-based strategies, with standards based on vehicle weight or size, are being considered in fuel economy policies (An, Earley, and Green-Weiskel 2011).

Frequent criticisms of standards state that they are costlier and that they are not as efficient as taxes, because they induce a "rebound effect" by lowering the cost of driving (Plotkin 2009, 3843–3844). (Research related to fuel efficiency rebound effects is discussed above, in Section 1.2.) However, the program efficiency depends as much on the stringency as on the specific structure a of the program; for example, the different categorization of cars and (light-duty) trucks in the US CAFE standards for a long time was a major market distortion and barrier to improved fuel economy (Fischer, Harrington, and Parry 2007; Killeen and Levinson 2017).

6.4.2.3 Economic instruments

Economic instruments utilize incentives to generate a change in the behavior of individuals, e.g. to purchase more efficient vehicles. These policies, also known as *incentive-based (IB)* or *market-based (MB)* instruments, generally operate better in market economies where supply and demand are strong determinants of prices and quantities of goods and services (Goulder and Parry 2008). The most prominent economic instruments are taxes and quotas in different variations.

Taxes (and other fiscal instruments) apply a price signal to an activity, such as emissions or congestion, and thereby make this behavior costlier to the end-user. There exist various names for the application of tax policies for fuel economy (e.g. vehicle tax incentives promoting higher fuel economy; price-based instruments), but it is most correct to describe them as levies or taxes.[7] Fuel taxation, for example, raises the final price of fuels to include externalities not accounted for in the wholesale price.

In transport, taxes can help consumers appreciate fuel efficiency savings over the full lifecycle of a vehicle. Vehicle taxes commonly are levied either at the point of sale or registration, or recurrently during the ownership and usage of the vehicle (Plotkin 2016). Taxes are most efficient when they constitute non-fixed, ownership charges (International Council on Clean Transportation 2011).

To promote fuel economy, policies that address the characteristics of vehicles are more (GHG-) relevant than those addressing the characteristics of fuels and driving behavior.[8] One example of the former is a vehicle registration tax, which adds a usually one-time fee for the licensing of a new vehicle. On the other side, subsidies for electric vehicles add incentives to the purchase of less-emitting engines.

The IEA and ICCT provide regular updates on standards, but not on incentive instruments. Recently, though, assessments have recommended a combination of tax policy and regulatory measures to stimulate energy efficiency in transportation (Global Fuel Economy Initiative 2016b; Yang et al. 2017). Particularly, differentiated vehicle taxes, feebates, and green vehicle taxes have garnered more prominence over the past decade (Greene et al. 2005; Anderson et al. 2011; Durrmeyer and Samano 2017). They are accompanied by a growing literature on fuel tax reform, consumer behavior, and subsidies for alternative and electric vehicles (Greene et al. 2005; Sterner 2007; Arze del Granado et al. 2012; International Energy Agency 2017b).

Quotas or permits regulate a specific amount of an activity in a location that is permitted and whose violation will be penalized. Allowances function similarly, although they provide transferable permissions. Marketable allowances can be either auctioned off or grandfathered (given out for free) by a government (Santos et al. 2010, 8).

A market regulator can issue a specific number of permits that allows market participants to conduct an activity, including transferring their permits. Permits can be auctioned or grandfathered based on past performance. As Santos et al. (2010) describe, taxes are mostly preferable to permits since they provide a

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[7] Although there are certain differences between the effects of taxes and subsidies on individual behavior and political economy, it is conceptually correct to classify subsidies as negative taxes (Jaffe and Stavins 1995).
[8] Fuel taxes are very relevant to saving fuel, and might even be the more direct instrument to reduce emissions; however, they do not directly influence the decisions of producers and consumers regarding more efficient vehicles (see e.g. Montag 2015; Frondel et al. 2013; Dineen et al 2017).

more certain price signal, have a better fiscal impact, and can be designed better for purpose. Generally, permits do not find wide-ranging application in the transport sector, although transport has been included in various environmental trading systems (Han et al. 2017; Flachsland et al. 2011).

6.4.2.4 Examples of fiscal policies

Fiscal policies exist in a growing number of economies (ICCT 2017a, 24). In 2010, 17 European economies (covering all major car manufacturing economies in western Europe) had installed fiscal policies (International Council on Clean Transportation 2011, 12). Based on OECD classification, there are as many as 46 economies that have vehicle taxes in place.[9]

Taxes and fees for fuel economy thus can be generally grouped in four categories (Dineen, Ryan, and Ó Gallachóir 2017, 3):

- Fuel taxes: Also called a "gas tax," these are taxes levied per unit of fuel sold.
- Purchase and Registration Taxes: Taxes on acquisitions, at the time of purchase of the vehicle: value-added tax (VAT) and registration tax (RT)
- Annual Circulation Taxes/Excise Duties: Taxes on vehicle ownership, such as annual motor taxes, termed here as circulation tax
- Feebates: A combination of purchase fees and rebates, known as feebates.

These four policy types will be explored in more detail in the section below. (Please note that in the section below, *Purchase and Registration Taxes* and *Annual Circulation Taxes/Excise Duties* are both discussed under the umbrella of Differentiated Vehicle taxes.

(1) Fuel taxes

Fuel taxes are a common measure for governments to gain revenue, e.g. to finance transport infrastructure. In the past decade, they have also garnered recognition as the "single most powerful climate policy instrument implemented to date" (Sterner 2007, 3194). Fuel taxes can account for the gap between the private and the social costs of driving by increasing the price of consumed fuel (UNDP 2018; Montag 2015). In contrast to fuel economy standards and other measures intended to raise the efficiency of vehicles, fuel taxes provide incentives to drive less to all drivers. Fuel taxation therefore comes closer to an optimal policy than conventional standards (Parry et al. 2007). Montag (2015, 148) summarizes that, "other policies, such as a car tax, may complement fuel taxes but are not substitutes." This also follows from the theory on externality pricing: "In most cases, a correctly calculated externality tax on the purchase price of a new vehicle is likely to be a small fraction of that purchase price whereas a correctly calculated externality tax at the point of use is likely to be a relatively larger fraction of the price of use. Hence, the latter is likely to have a greater impact on the consumer's decision than the former." (OECD 2009a, 12). For a discussion on the rebound effect, see Section 1.2 and Gillingham et al. (2016).

Recent research has compared the value of taxing fuels versus pricing the efficiency characteristics of cars. Despite the short-term thinking of consumers when buying a car (Greene et al. 2005; Greene, German, and Delucchi 2009), fuel taxes are a more effective instrument than vehicle taxes in reducing emissions

[9] Based on a count from an OECD Database on Environmental Taxation, with revenue in %GDP >0, category defined as "one-off import or sales taxes on transport equipment, recurrent taxes on ownership, registration or road use of motor vehicles, and other transport-related taxes, excluding excise taxes on automotive fuels."

(Grigolon et al. 2017). The reason is consumer heterogeneity in annual mileage – fuel taxes have a bigger impact on those drivers with a higher mileage, thereby curbing emissions more. Fuel taxes are elastic in the long run but quite inelastic in the short run (Sterner 2007), although a higher elasticity is assumed outside of the US (Plotkin 2016). If the goal itself was to increase fuel efficiency of the fleet alone, disregarding aggregate emissions, measures to increase the upfront price of inefficient vehicles like purchase or registration taxes would be better suited.

However, unfortunately some governments also subsidize fuel use with the aim to support other development agendas (Global Subsidies Initiative 2009). Suffice to say that the starting point for increasing fuel taxes to account for externalities is to ensure no adverse fuel subsidies are in place. Where relevant, equity concerns can be addressed through policy design (Jakob et al. 2015; Van de Graaf and van Asselt 2017).

Fuel taxes widely differ across economies (Ley and Boccardo 2010). Many members of the European Union like the Netherlands, the United Kingdom, and Germany have traditionally had high fuel taxation, which has impacted the fuel efficiency of passenger vehicles (Ryan et al. 2009; Frondel and Vance 2013; Santos 2017). However, there is no uniform or coordinated fuel taxation within the EU, and member states have been reluctant to surrender national tax authority despite benefits from a green fiscal policy standpoint (Frondel and Vance 2013). Among non-EU-economies, Hong Kong, China; Brazil; South Korea, and Uganda have relatively high fuel taxes (Ley and Boccardo 2010). India, China, and Indonesia have recently made strides in reducing fuel subsidies (Dartanto 2013; Dansie, Lanteigne, and Overland 2010).

There are both advantages and challenges to introducing higher fuel taxes, the main difficulty being political acceptability (Aldy 2017). The case of British Columbia, the Canadian province that introduced a revenue-neutral carbon tax, has therefore drawn much attention. Here revenues generated from a tax specified based on the carbon intensity on activities were used to reduce income taxes and offset particularly affected sectors (Murray and Rivers 2015). Santos (2017) finds that fuel taxes already work to a varying level as corrective taxes of European road transport externalities. However, externalities from diesel fuel are less accounted for. Besides, fuel taxes in EU member states have effectively decreased since they are not automatically updated for inflation (Transport & Environment 2011). In addition, addressing the full costs of congestion and crashes requires further policies.

(2) Differentiated vehicle taxes

Differentiated vehicle taxes are charges which vary dependent on the characteristics of a vehicle. As opposed to fixed charges, which are applied to vehicles independently of their fuel consumption or emissions (such as sales taxes), differentiated vehicle taxes are non-fixed charges, which can change depending on how “green” a certain vehicle is (International Council on Clean Transportation 2011). Differentiated vehicle taxes often aim to influence the types of vehicles which are purchased (Giblin and McNabola 2009).

In 2010, there were 16 economies with CO2 emissions- or fuel consumption-related taxes on LDVs that were applied at either purchase and registration or annually during the use (OECD 2009b). Most of them were in Europe, where vehicle taxes have been in place prior to mandatory standards (see Figure 4, below). When it was clear that the policy mix did not have the intended effect, the EU additionally introduced emissions standards (Ryan et al. 2009, 365). In the meantime, ownership of LDVs in relationship to their efficiency has become subject to taxation in other parts of the world, like in China, India, South Africa, and Turkey (International Council on Clean Transportation 2017a, 24).

Most of the taxes in place were directly dependent on the CO2 emissions per km of the vehicles driven, with a roughly equal split between upfront and recurring taxes. Differentiated charges are most relevant to fuel economy and emissions efforts. Ideally, there is a continuous rate that correlates the efficiency to the monetary charge applied.

There is sufficient evidence to reasonably claim that direct CO2-based taxation is more effective in lowering emissions and reducing fuel costs than indirect taxation (Dineen et al. 2017). Of particular relevance is that vehicle taxes can be a standalone measure to improve fuel economy: *"Differentiated vehicle taxation was effective even when not coupled with fuel economy standards, especially in markets with lower purchasing power due to low average income levels (the case of South Africa is especially interesting in this respect)."* (Global Fuel Economy Initiative 2016c, 9) Indirect CO2 taxation, e.g. through taxation of vehicle attributes such as engine size or vehicle weight, has a more varied effect (Yang et al. 2017, 14).

As shown by the OECD (2009b), both upfront and recurring taxes vary widely in their effectiveness. For example, Portugal, Norway, and Ireland have quite steeply differentiated taxes that incentivize lower emission vehicles, while the taxes in Canada and Austria do not discriminate among vehicles that differ by 100g CO2 per km. Additionally, tax effects on the relationship between petrol and diesel vehicles can sometimes, as in the case of Ireland, have perverse/unintended outcomes (Leinert et al. 2013).

There seems to exist some disagreement in the literature on whether upfront purchase and registration taxes or annual ownership taxes have a higher efficiency potential (Gerlagh et al. 2016; Brand, Anable, and Tran 2013; Ryan, Ferreira, and Convery 2009; Montag 2015). Many studies investigate the impacts of vehicle taxation schemes (Vance and Mehlin 2009; Gallagher and Muehlegger 2011; Huse and Lucinda 2013; Gerlagh et al. 2016; Malina 2016; Dineen, Ryan, and Ó Gallachóir 2017; Fridstrøm and Østli 2017), without coming to a clear decision between different tax schemes.

The question is partly what instrument will have a higher effect on the consumer – an upfront tax that counters myopic discounting or a recurring tax that encourages switching to a more efficient vehicle sooner. Tax rates per ton of CO2 over the (estimated) lifetime of a vehicle are higher for recurrent than for upfront taxes (OECD 2009b, 14), which would speak to their higher potential for fuel economy. Some early researchers indicated a higher impact for annual circulation taxes (Ryan et al. 2009; Santos et al. 2010). But realistically applying a discount rate reduces the value of recurrent taxes to a small difference to upfront taxes. Speaking in favor of upfront taxes, they present a higher potential for internalization, which would make upfront registration taxes more effective than that annual circulation taxes (Gerlagh et al. 2016, 106).

<u>Purchase & registration taxes</u>

The impact of registration taxes on average vehicle emissions is not significant when economy-specific characteristics are considered (Ryan et al. 2009; Santos et al. 2010, 29). To further complicate the picture, there might be fine-grained differences whether a tax is levied at purchase point through sales or by the customer at point of registration. Evaluations of sales tax waivers and other tax policies indicate that higher, fuel economy-dependent purchase fees or feebates may steer consumers more effectively towards efficient vehicles than higher fees at the point of registration (Gallagher and Muehlegger 2011).

<u>Circulation taxes / excise duties</u>

Circulation or road taxes, also known as excise duties, are taxes which are paid on a continuous basis (usually annually or monthly). These taxes are often paid in conjuncture with annual registration fees, and are traditionally justified as a tax on vehicles to utilize a public road (Gass, Schmidt, and Schmid 2011).

While the concept of taxing for the privilege of using a vehicle on a public right-of-way is not new, circulation taxes are increasingly being weighted by emissions and fuel efficiency standards in some economies (Ajanovic and Haas 2016; Malina 2016). For example, Malina (2016) finds that at least 13 economies Europe now levy an adjustable circulation tax which is dependent on vehicle efficiency characteristics – mainly based on CO2 emissions, but also commonly on factors such as engine size, vehicle weight, and fuel type.

Example from the Netherlands:

The Netherlands provide a positive example of an economy that has focused its tax policies towards more efficient vehicles since 2010. Previously a fixed percentage of the purchase price, the vehicle registration tax now proportionately reflects the CO2 emissions of a new vehicle. Similarly, a higher annual circulation tax applies to high-emitting vehicles, while zero or low emission vehicles are exempt. Additionally, there exist incentives to stimulate a quicker adoption of hybrid and electric cars (Smit 2016).

The Netherlands provide a case where fuel economy and emissions intensity of vehicles was worse-than-average in comparison to European neighbors, but saw the biggest improvement due to CO2-differentiated taxes (Dineen et al. 2017).

Country	Name of tax	One-off or recurrent	CO_2 or fuel efficiency	Comments
Austria	Vehicle registration tax	One-off	Fuel eff.	Flat rate for diesel (petrol) vehicles using more than 10 (11) litres per 100 km.
Canada	Green Levy	One-off	Fuel eff.	Gradually increasing taxes for vehicles with low fuel efficiency. Until 31.12.08: Also bonuses for vehicles with high fuel efficiency.
Denmark	Passenger car fuel consumption tax	Recurrent	Fuel eff.	Different, progressive, rates for petrol- and diesel-driven cars
Finland	Car tax – passenger cars	One-off	CO_2	Tax as % of retail value: (0.1 * gram CO_2 per km)+4
France	Tax on vehicle registration for high CO_2 emitters	One-off	CO_2	Bonus – malus system
Germany	Motor Vehicle Tax	Recurrent	CO_2	2€ per gram CO_2 per km, above 120 gram per km (until 2011).
Ireland	Vehicle Registration Tax	One-off	CO_2	Same, progressive rates for all car categories
Ireland	Motor Vehicle Tax	Recurrent	CO_2	Same, progressive rates for all car categories
Luxembourg	Motor Vehicle Tax	Recurrent	CO_2	Different, progressive, rates for petrol- and diesel-driven cars
Netherlands	Car registration tax	One-off	CO_2	Information is lacking in our database.
Norway	Motor vehicle registration tax	One-off	CO_2	Same, progressive rates for all car categories
Portugal	Excise tax on motor vehicles	One-off	CO_2	Different, progressive, rates for petrol-, diesel-, LPG- and hybrid-driven cars
Portugal	Motor vehicle circulation tax	Recurrent	CO_2	Same, progressive rates for all car categories
Spain	Tax on vehicle registration	One-off	CO_2	Same, progressive rates for all car categories
Sweden	Motor Vehicle Tax	Recurrent	CO_2	Different, fixed rates for petrol- and diesel-driven cars
United Kingdom	Vehicle excise duty	Recurrent	CO_2	Different, progressive, rates for petrol- and diesel-driven cars

Figure 4: European examples of differentiated vehicle taxes (OECD 2009b, 6)

	VAT	Tax Scheme		Subsidy
		One-time	Annual	One-time
Austria	20%	• Registration tax based on fuel consumption. **EVs** have deductions.	• Circulation tax based on engine power. **EVs** are exempted. • [Company car] Income tax based on price.	
Denmark	25%	• Registration fee mostly based on vehicle price. **EVs weighing less than 2000 kg are exempted.**	• Annual circulation tax based on fuel consumption. **BEVs** weighing < 2000 kg are exempted. • [Company car] Income tax based on price.	
France	19.6%	• Registration tax based on engine power. **EVs** are exempted.	• [Company car] Income tax based on CO_2 emission. **BEVs** and some **PHEVs** are exempted.	• Up to EUR 7,000 for **EVs**.
Germany	19%		• Circulation tax based on engine displacement and CO_2 emission. **EVs** are exempted for 10 years. • [Company car] Income tax based on price. **EVs** have deductions.	
Netherlands	21%	• Registration tax based on the CO_2 emission level of the vehicle. **BEVs** and most **PHEVs** are exempted.	• Circulation tax based on the vehicle weight, fuel type, and CO_2 emission. **BEVs** and most **PHEVs** are exempted. • [Company car] Income tax for cars emitting more than 50 g/km CO_2 of 25% of the vehicle's cata-logue value in 2013. **BEVs** and some **PHEVs** are exempted.	
Sweden	25%		• Road tax based on CO_2 emission. **EVs** are ex-empted. • [Company car] Income tax partially based on vehi-cle price. **EVs** are exempted 40%.	• Up to about EUR 4,600 based on price difference for **EVs**.
United Kingdom	20%	• First year excise duty based on the CO_2 emis-sion and vehicle price. **BEVs** and some **PHEVs** are exempted.	• Excise duty from second year of purchase based on the CO_2 emission and vehicle price. **BEVs** and some **PHEVs** are exempted. • [Company car] Income tax based on CO_2 emission and price. **BEVs** are exempted.	• Up to EUR 5,900 for **BEVs** and some **PHEVs**.
Norway	25% **BEVs** exempted	• Registration tax based on vehicle weight, en-gine power, nitrogen oxide emissions and CO_2 emissions. **BEVs** are exempted.	• Circulation tax about EUR 350.	
China	17%	• Acquisition tax (10%). • Excise tax based on vehicle engine displace-ment and price.	• Vehicle and vessels fee based on engine dis-placement and price. **EVs** are exempted.	• Up to EUR 7,200 for **EVs**.
Japan	5%	• Acquisition tax based on engine displacement and vehicle price. **EVs** are exempted.	• Tonnage tax based on vehicle weight. **EVs** are exempted. • Automobile tax based on engine displacement. **EVs** are exempted 50%	• Up to about EUR 6,500 based on price difference for **EVs**.
United States	7.3% [a] (8.4%)	• Registration fee around EUR 33. • Gas-guzzler tax for very fuel-inefficient vehicles.		• Up to about EUR 5,500 based on battery capacity (federal). • About EUR 1,800 for **BEVs** and EUR 1,100 for **PHEVs** (California).

(a) It is sales-weighted average of states average combined vehicle sales tax rate.
(b) Source: Drenkard, 2013, NADA, 2013.
BAV: Battery-**electric vehicle**, EV: **Electric vehicle**, **PHV**: Plug-in hybrid **electric vehicle**.

Figure 5: Global schemes of differentiated vehicle taxes https://www.cesifo-group.de/ifoHome/facts/DICE/Infrastructure/Transportation/General-Transport-Policy/overview-vehicle-taxation-scheme/fileBinary/Overview-vehicle-taxation-schemes.pdf

(3) Feebates

Feebates are a combination between fees for less efficiency and rebates, or discounts, for the purchase of more efficient vehicles. "The basic idea of a feebate is simple. Buyers of inefficient vehicles are levied a surcharge (the "fee"), while buyers of efficient vehicles are awarded a rebate (the "bate")." (RMI 2010 blog). The ICCT 2010 report defines feebates as a, "program that imposes a fee on vehicles that perform worse than a specified benchmark and awards a rebate to vehicles that perform better than the specified benchmark" (International Council on Clean Transportation 2010, 8).

Feebates aim at correcting market failures and providing incentives for both the reduction of inefficient and the accelerated adoption of efficient vehicles. While feebates can make consumer decisions more rational by pricing, the largest impact of a feebate system is a longer-term manufacturer response (International Council on Clean Transportation 2010, 38). However, feebates can be beneficial for consumers and producers alike, e.g. providing better consumer information, encouraging more innovation, saving fuel and money, and reducing environmental impact (Greene et al. 2005; D'Haultfœuille, Givord, and Boutin 2014).

Feebates, if designed properly, can have a high impact and provide additional price signals (Greene et al 2005; Santos et al 2010, 20). In contrast to a tax, the feebate incorporates a visible incentive to the consumer for purchasing the more efficient vehicle, rendering an overall more effective price signal and efficient GHG mitigation approach. However, many considerations relevant to differentiated vehicle taxes also apply to feebates.

Feebates require prior analysis and clear labeling of fuel economy classes to determine where to set the pivot point, as a marker between the bonus and the malus vehicles receive. This classification can be independent of vehicle size and do not need to discriminate against certain vehicle classes (RMI 2010 blog). As with vehicle taxes, discontinuities and step functions always reduce the effectiveness of a feebate system, but might be easier to introduce initially (see e.g. France and Singapore) (International Council on Clean Transportation 2010, 38).

According to the ICCT, there are five features of a good feebate design (International Council on Clean Transportation 2010, 38):

Continuous incentive: a slightly more efficient vehicle looks slightly better from a financial perspective, even beyond a required minimum standard

Informing consumer decision-making upfront: more life-time costs are made visible at buying point

Technology-neutral price signal: no matter what kind of brand or fuel type, the feebate does not discriminate

Dynamically improving pivot point: ambitions and rate rise over time, and formerly incentivized vehicles get penalized after a while[10]

Long-term, few revisions: the overall structure remains stable and allows for planning

Detailed research on feebate systems exist for France, Norway, Denmark, Singapore, and the US state of California. *"For economies where programs do not already exist, or for vehicle types that have not been regulated, feebates offer a quick and relatively easy way to begin reductions in fuel consumption and CO2" (International Council on Clean Transportation 2010, 16).*

Initial reviews of this fairly recent policy show a promising impact: "[…] car purchase feebate policies are shown to be the most effective in accelerating low carbon technology uptake, reducing life cycle greenhouse gas emissions and, if designed carefully and adjusted over time, can avoid overburdening consumers with ever more taxation whilst ensuring revenue neutrality. […] in order to achieve the transition to a low carbon transport system governments should focus on designing incentive schemes with strong up-front price signals that reward 'low carbon' and penalize 'high carbon'" (Brand, Anable, and Tran 2013, 146).

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[10] "A "benchmark" (also known as a pivot point) defines who pays and who receives benefits by setting a level of fuel economy or emissions (e.g. in gCO2/km). A "rate" determines the marginal costs and benefits (usually priced in cost per g/CO2). Depending on the choice of benchmark, feebates can produce revenue, be revenue neutral or be a net subsidy to cleaner, fuel efficient car purchases."
https://www.globalfueleconomy.org/transport/gfei/autotool/approaches/economic_instruments/fee_bate.asp

Example from France:

Various economies have implemented feebate programs, although none have met all these design criteria. Out of the European examples, the French feebate system is often deemed the most effective one. In 2008, fleet-wide emissions intensity was reduced by 9 gCO2/km, equivalent to a marginal CO2 cost rate of US$29 per gCO2/km (International Council on Clean Transportation 2011, 22).

The feebate program in France, also known as the “bonus/malus" policy, was launched in 2008. This policy directly aimed to influence consumer decisions, with a scheme of taxes and rebates which varied depending on the CO2 emissions of new cars. To navigate political barriers, the feebate policy was initially designed to be revenue-neutral, with the amount of revenue collected by the fees matching the amount of subsidies dispersed through the rebates. Originally, rebates ranged from 200 to 1,000 Euros for low-emission vehicles (defined as emitting less than 130 g/km) and fees ranged from 200 to 2,600 Euros for high-emission vehicles (defined as emitting more than 160 g/km). The feebate chiefly affected the consumer side of the automobile industry, since the feebate was paid or received only once, at the time of sale of a vehicle, and covered all new vehicles (including those purchased or manufactured abroad) (Zifei Yang 2018; Durrmeyer and Samano 2017).

Since the French feebate policy was established in 2008, (as well as other standards within France and across the EU), the French vehicle fleet average CO2 emissions have steadily declined. While this result is promising, lower average CO2 emissions made it increasingly difficult for the feebate system to stay revenue neutral, since cleaner vehicle averages meant less fees were collected and more rebates were provided. The policy did include a stepwise fee structure to account for cleaner future emission norms, however this function did not adequately maintain parity between the feebate system and emission trends. To address this issue, in 2017, a continuous function was introduced to dictate the emissions standards to set the fees for the policy. This continuous fee structure allows for a constant impetus to increase vehicle efficiency, as opposed to the incremental incentives provided under the stepwise model (Zifei Yang 2018). Comparative analysis suggests that the French feebate program could be further improved by instituting higher fees (as in Ireland), in addition to a continuous fee structure (International Council on Clean Transportation 2010; Brand, Anable, and Tran 2013; Durrmeyer and Samano 2017; Rivers and Schaufele 2017)

Example from Singapore:

The city-state of Singapore introduced a feebate under the name of the Carbon Emissions-Based Vehicle Scheme (CEVS) to encourage the purchasing of more fuel-efficient vehicles. Vehicles emitting 135g CO2 per kilometer will receive a rebate on their registration fee, while vehicles with emissions beyond 185g CO2/km will be charged an additional fee. The monetary incentive ranges from $5,000 to $30,000 (Singaporean dollars, roughly equivalent USD $3,750 to $15,000) (GFEI 2018).

More stringent rules (up to 50% higher rate) applies to taxis in order to induce a shift to low-carbon fleets for vehicles with more kilometers travelled. Diesel vehicles are excluded from the feebate benefits due to the high emittance of fine particular matter (GFEI 2018).

The CEVS was in place from January 2013 until June 2017. The CEVS has now been succeeded by the Vehicular Emissions Scheme (VES), which also covers other pollutants (hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NOx) and particulate matter (PM)). The feebate will be determined by the worst-performing pollutant to encourage low emission vehicle selection. The reform is accompanied by a re-designed fuel economy label that includes better consumer information (Singapore Land Transport Authority 2017).

6.4.3 Lessons learned from national experiences & application potential for APEC

The existing literature and international experiences offer a wealth of knowledge which can help guide APEC economies and cities in their endeavors to improve vehicle fuel economy. While there is a constant need to conduct more research and to reevaluate case studies, the existing literature can provide valuable insight on how to create and improve fiscal policies. Below are some of the key lessons learned from the international experiences with fiscal fuel economy policies.

6.4.3.1 An imperfect policy is usually better than no policy

The first step towards improving fuel economy and lowing emissions through fiscal policies is simply to establish some sort of fiscal policy. Policy makers that have no experience or history with fuel economy policies need to overcome their tendency to take inaction in the face of uncertainty. One way for a government to spur the creation of policies is to test and publish fuel economy values to develop a fleet-wide baseline analysis.

Initial policies are essential and act as building blocks for future improvements. Programs to address fuel emissions and fuel economy have shown to be important and cost-effective ways to improve sustainability (An, Earley, and Green-Weiskel 2011; An and Sauer 2004; International Council on Clean Transportation 2017a) Therefore, it is important for governments to establish polices, even if there are imperfect.

Even if a fiscal policy is unable to achieve its desired sustainability targets at its inception, it can provide valuable experience for creating strong future policy. Many of the most publicized and successful case studies often faced adversity and challenges. The feebate system in France, for example, needed to completely overhaul its fee structure to stay relevant and financially viable (Varun Sivaram 2013; Zifei Yang 2018). Likewise, the CAFE standards in the United States initially created a perverse incentive for manufactures to expand their production of light-duty trucks and sports utility vehicles (Plotkin 2009; Carley et al. 2017; Yacobucci and Bamberger 2006). Despite these challenges, both of these case studies implemented changes (to varying degrees of effectiveness) to address the problems they faced. The success of a program to address fuel emissions and/or fuel economy often lies not in its creation, but in its ability to adapt to identified issues.

6.4.3.2 Tax policies may be easier to implement than other public policies

For policy makers and economies at the nascent stages of their fiscal policy endeavor, one lesson to consider is that it might be most feasible for new economies to begin with CO2-based taxation of vehicles, beginning with new and currently-used vehicles. In accordance with most observations, “the introduction and enforcement of taxation schemes is generally easier than compared to the enforcement of vehicle CO2 emission standards.” (Yang et al. 2017, 14), and the lowest threshold for effective fuel economy measures should be chosen. Unlike emission standards, taxes can help consumers appreciate fuel efficiency savings over the full lifecycle of a vehicle, especially when they constitute direct, non-fixed, ownership charges (International Council on Clean Transportation 2011). This is especially true for economies without domestic car industries, where standards are difficult to enact since all automobiles are imported. For these so called "technology taker" economies, tax incentives can generate a shift towards importing only the more efficient vehicles. Taxes are also mostly preferable to permits, since taxes provide a more certain price signal, have a better fiscal impact, and can be designed better for purpose (Han et al. 2017; Flachsland et al. 2011).

Within the realm of tax policy options, feebates may be one of the best initial options for economies starting a program to address fuel economy and emission issues. *"For economies where programs do not already exist, or for vehicle types that have not been regulated, feebates offer a quick and relatively easy way to begin reductions in fuel consumption and CO2" (International Council on Clean Transportation 2010, 16).* Unlike other tax methods, a feebate incorporates a visible incentive to the consumer for purchasing the more efficient vehicle, providing an overall more effective price signal and efficient GHG mitigation approach. Examples of feebate programs in France and Singapore demonstrate that feebates can target consumers directly, by primarily affecting the demand side of the vehicle market (Durrmeyer and Samano 2017).

6.4.3.3 Fuel taxes may be the most effective policy measure

While *feebates* may be easy to implement for economies who are commencing on their fuel economy and emission programs, many case studies and literature have concluded that *fuel taxes* are the most effective fiscal policy. Fuel taxes, dubbed the "single most powerful climate policy instrument implemented to date" (Sterner 2007, 3194), are often viewed as the tax measure with the most impact on emission reductions (Grigolon, Reynaert, and Verboven 2017; Sterner 2007). Although *fuel emissions* and *fuel consumption* are not synonymous terms, fuel taxes provide incentives to drive less to all drivers, which provides a positive outcome for all consumption- and emission-related transportation goals. Fuel taxes are also effective tools because they are applicable to all vehicles (not just new vehicles) driving on the roads (Anderson and Sallee 2016). Fuel taxation therefore comes closer to an optimal policy than other conventional standards and taxes (Parry, Walls, and Harrington 2007). Fuel taxes are also simple to implement from a technical perspective (although perhaps not for a political perspective, as discussed in the next section), since these taxes do not require detailed knowledge of the sustainability characteristics of the vehicle fleet.

Although fuel taxes may be difficult to implement due to economic and political (see section below) factors, there are actions even the most intransigent economies can take to work towards the implementation of fuel taxes. In many economies, fuels are subsidized in an attempt to spur development. While there is evidence that low fuel prices can facilitate economic development, particularly as it relates to trade (Hummels 2007), other literature demonstrates that fuel subsidies are highly inefficient instruments which can hamper economic liberalization and trade (Global Subsidies Initiative 2009; Van de Graaf and van Asselt 2017). Perhaps most importantly, fuel subsidies greatly diminish the efficacy of existing fuel- and emissions-related fiscal policies, and substantially greater CO2 reduction can be realized if incentive-distorting subsidies are removed (International Council on Clean Transportation 2011). Additionally, sustainability efforts themselves, may provide a source of economic growth (Springer et al. 2014). Therefore, one major way economies can work towards improving their sustainability policies is to reduce and/or eliminate fuel subsidies.

6.4.3.4 Policies need to be politically feasible

Effective policies require political support, since a policy is only as good as its ability to be implemented. A proposed fuel tax, for example, may be an ideal way to curb emissions, but it may be vulnerable to political opposition, both by other sectors or government as well as public motorists (Aldy 2017). Not only can political opposition to a new policy stall its implementation, it may also exacerbate public mistrust towards future policy endeavors (Owens 2000). Regardless of the types of fiscal attempts made by a economy to increase transportation sustainability, the political implications, both from internal branches of the government and the general population, need to be considered in the planning process.

The most *impactful* policies are often the most *disruptive* policies. Therefore, decisionmakers may find themselves in a dilemma, where the actions which are the most effective are also the actions which are the least popular. Some literature has attempted to determine the appropriate policy mix, by enabling what is politically feasible for decarbonizing the transport sector (van der Vooren and Brouillat 2015; Yang et al. 2017; Lah 2017). It is important for policymakers to acknowledge and consider the tradeoff between *effective* and *admissible* fiscal actions when deciding which policies to promote.

One way to help make a policy politically acceptable may be to make that policy revenue-neutral, with new taxes offset by new subsidies or tax cuts. Since revenue-neutral policies promote new sustainability practices without influencing the net tax burden, such policies have the potential to improve general economic growth more than standard fiscal policies (Murray and Rivers 2015). Revenue-neutral programs may also gain popularity because they can directly and financially benefit the general population in a visible way. For example, the proceeds of the carbon tax in British Colombia were used to reduce income taxes, and this program has witnessed a steady increase of public support (Murray and Rivers 2015). Revenue-neutrality was also key to the political success of the feebate program in France (Zifei Yang 2018; Varun Sivaram 2013). While political acceptance is contingent upon a variety of factors, revenue-neutrality may help placate some of the major political barriers that policies may face.

6.4.4 Conclusion

Current trends in the transport industry must change if economies wish to achieve their national climate objectives and if the international community wishes to limit climate change impacts to 2 degrees Celsius. Vehicle use is increasing around the world, particularly in APEC economies. As APEC economies grow, inefficient vehicles exacerbate negative trends related to green-house gas emissions, public health issues, and energy security.

Given the large and increasing stake that the transportation sector has in many sustainability-related issues, the “greening” of transportation has tremendous potential to benefit populations in every APEC economy (as well as other economies around the world). Public policy programs are essential in this effort, since fuel economy policies represent the organized effort to increase the overall efficiency of the vehicle fleet on the roadway network. Therefore, a key task for policymakers is to enhance the efficiency of land transport and to address the economic, social, and environmental cost of transport.

Decisionmakers have a large vocabulary of policies to consider when shaping sustainability programs for their economies. This roadmap highlights several specific fiscal policies which may prove most advantageous to APEC member states who are attempting to create or strengthen their fuel economy policies. The appropriate fiscal tools to enact will depend on the specific characteristics and the culture of political acceptability within a given economy. Ultimately, fiscal policy measures should be at the heart of a robust national policy program, which also consists of a mix of fuel economy standards, incentives, and informational measures.

6.4.5 References

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6.5 Training Package: Improving the Operational Efficiency and Energy Efficiency in Public Transport

6.5.1 Introduction: Getting transport right as a system

Across the world, transport experts are wondering how to “future-proof” their sector ahead of large challenges. High on the agenda stands the goal of building better cities, but also reducing global greenhouse gas emissions, expanding access to opportunities for citizens (such as jobs, education, health services, etc.) via better mobility, making transport more inclusive, and improving the efficiency of vehicles and systems.

At the same time, new mobility services and electric vehicles are disrupting the way transport is organized in unprecedented ways.[iv] This means many challenges are coming the way of urban planners, decision-makers, entrepreneurs, and governments. Getting transport ready for the 21st century and avoiding mistakes of the past (like urban sprawl, induced traffic demand, or segregated access to mobility) will be crucial.[v]

Generally, transport is best thought of as a system, not just a toolbox. Electrifying the means of transportation will produce certain benefits but might leave transport systems as unsustainable as they sometimes are. Consequently, the disruption and development will have to go beyond improving cars to shifting to more efficient transport systems. Fortunately, innovations in sustainable transport have spread rapidly and exponentially in past decades (see Figure 1).

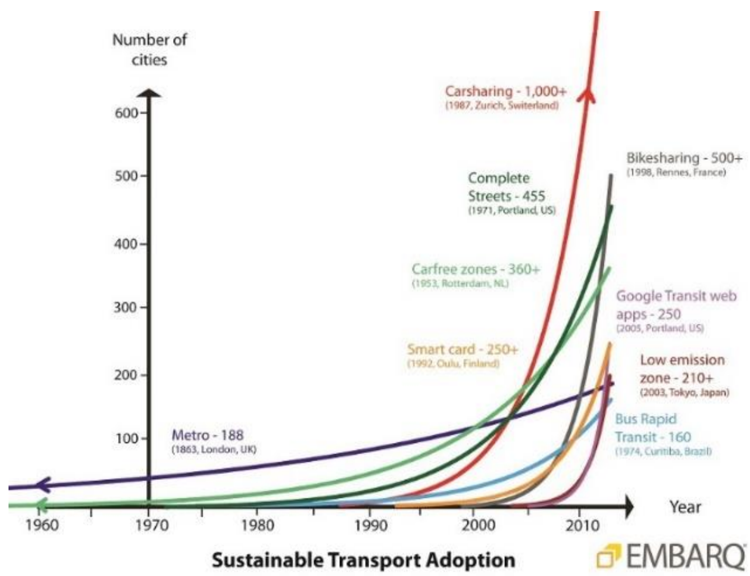

Figure 1: We have seen a rapid spread of sustainable

Public transport plays an integral role in this undertaking. According to UN-Habitat, “Public transport is defined as a shared passenger transport service that is available to the public. It includes cars, buses, trolleys, trams, trains, subways, and ferries that are shared by strangers without prior arrangement.”[vi] The success of public transport, however, also depends on complementary considerations and policies in road safety, non-motorized mobility, urban planning, and governance, to name just a few. Ideally, public transport should be able to provide an integrated mobility system.

In the following sections, we will explore the topics of energy efficiency and efficient operations in detail.

> Getting familiar with the global context of urban transport
>
> Take a look at the publication Changing Course in Urban Transport by the by the Asian Development Bank and GIZ. It provides an interesting and illustrative introduction to today’s challenges and options for urban mobility. Public transport such as formalized bus services and Bus Rapid Transit (BRT), metro or commuter rail are required to make mass mobility in growing cities a reality.

6.5.2 The Avoid-Shift-Improve framework is the clearest and most effective conceptual framework for addressing transport policy

Watch: The "Avoid, Shift, Improve" Strategy (12 mins)

Much of human mobility is dependent on the infrastructure as well as the use and performance of available modes of transport. A comprehensive framework that strives for sustainability in transport sector is the Avoid-Shift-Improve (A-S-I) approach, which aims to simultaneously encourage higher system, trip and vehicle efficiency.[vii]

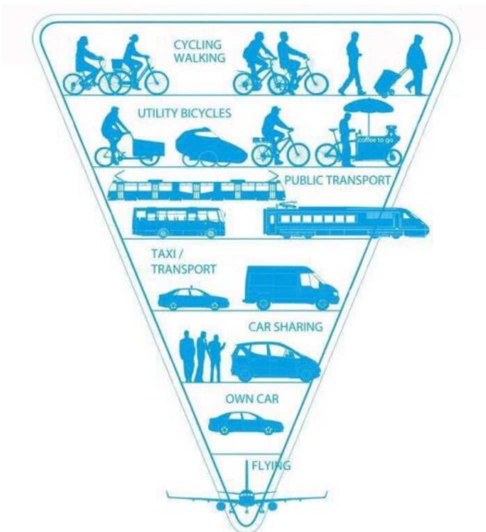

Figure 2: A visual example of Shift actions consistent with the A-S-I framework demonstrated by the Sustainable Transport Pyramid (Source: *SUTP/TUMI*)

"Avoid" refers to minimizing motorized trips through changes in land use by creating compact and less-sprawling cities. "Shift" refers to tilting the modal split toward more public transport and non-motorized travel. "Improve" focuses on technological advances to reduce emissions, such as improving fuel quality and vehicle electrification. Most relevantly, shifting mobility services from less efficient uses to more efficient uses is the idea of public transport.

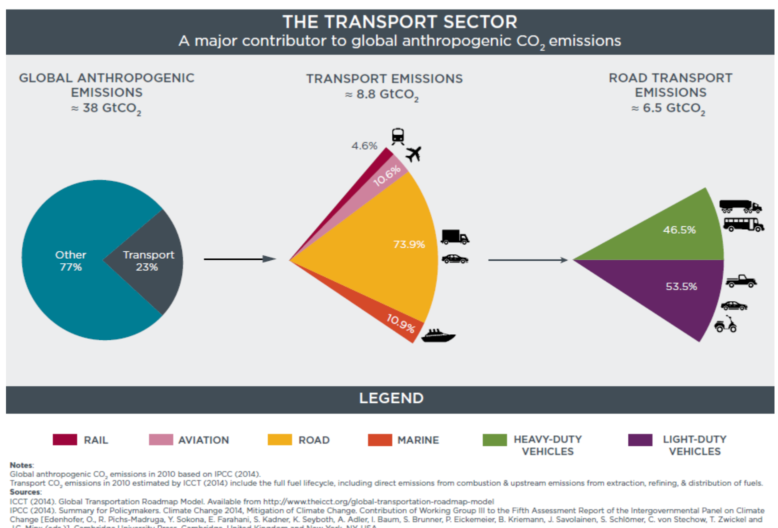

Figure 3: Contributions of passenger vehicles to global CO_2 emissions (Source: International Council on Clean Transportation 2014, 6)

The A-S-I framework is an important concept to make sustainable mobility equitable, efficient, safe and green. Changing the course of transport towards more efficiency is urgent. Currently the environmental impacts of the transport sector are wide-ranging. The sector is responsible for 23 percent of energy-related greenhouse gas (GHG) emissions worldwide, increasing at a faster rate than any other sector. Additionally, 73.6% of transport emissions and 17% of global emissions come from road transport.[viii] These global trends are especially true for the Global South, where annual growth in transport sector emissions is increasing at an average of 4.8 percent. [ix]

The Partnership on Sustainable Low Carbon Transport (SLoCaT) has recognized 20 "Quick Wins on Transport, Sustainable Development and Climate Change" actions which can be implemented immediately before 2020 that would contribute to reducing GHG emissions and making progress on the Sustainable Development Goals (SDGs) within an A-S-I framework (Peet et al. 2016).

LEDS TWG Toolkit:

The Low Emissions Development Strategies Global Partnership (LEDS GP) convenes experts and practitioners to facilitate learning and cooperation for climate change mitigation, adaptation, and sustainable development. Enabling mass mobility through public transport is a cornerstone of low emissions development.

The LEDS GP Transport Working Group (TWG) has devised an online database of transport policies for cleaner and more efficient transport. It features over 350 tools, classified into Avoid - Shift – Improve, that can be used for implementation. The TWG also published a series of briefs outlining the social and environmental dimensions of sustainable transport policy. Each publication presents two case studies highlighting how action in the transport sector can lead to many co-benefits for people and the planet.[1]

6.5.3 The economic case for improving public transport is strong

To achieve sustainable development, cities and economies need to shift their current course toward a growth pathway of compact urban growth, connected infrastructure, and coordinated governance (also known as the 3Cs model).[x] From the urban mobility perspective, evidences have shown that higher public transport maturity is highly correlated with higher city competitiveness, quality of life, and productivity.[xi] Through forward-looking decisions and implementation of new programs, economies will be able to realize the multiple benefits of sustainable transport.

If designed and planned properly, public transport systems can provide mass mobility in the most cost-effective manner. This is best done in dense urban contexts where economies of scale enable high system efficiency. Again, long-term policies that consider the Avoid-Shift-Improve framework and begin with Avoid measures like transit-oriented development (TOD) yield greatest benefits. Public transport also can contribute to fostering overall social cohesion in denser cities.[xii]

While the specific costs of public transport vary in each case, projects overall make economic sense when factors are considered comprehensively.[xiii] Per capita costs of public transport infrastructure projects are often lower or equal than private transport projects.[xiv] The International Energy Agency (IEA) estimated in 2013 that by simply shifting infrastructure expenditures from private transport to public transport, costs over the next 30 years could be reduced by US$20 trillion while contributing to climate targets.[xv] This would carry the additional benefit of creating more and more long-term jobs, roughly about three times as many as through funding road infrastructure for car use.[xvi] At the same time, investments in improved public transport systems also significantly reduce congestion-related costs resulting from time savings.[xvii]

Improving the efficiency of public transport also contributes to social and environmental goals. Of the numerous co-benefits, perhaps the most important ones are the improvements in public health due to reduced air pollution and improved road safety as well as the reduction of greenhouse gas emissions due to lowering vehicle-kilometers travelled (VKT) and consolidation and replacement of the fleet with cleaner vehicles.[xviii] Research on air quality of buses has shown that technologies have to be viewed in their in-system use, and that context-specific factors matter.[xix]

Usually, achieving operational efficiency and energy efficiency goals goes hand in hand. As the International Council on Clean Transportation notes: "For all regions analyzed, expanding public transit systems will only bring significant health benefits if coupled with regulations that assure improvement in bus emission controls. More broadly, integrated policies aiming to mitigate both climate and health impacts work best."[xx] The topic of increasing energy efficiency and switching to cleaner vehicle fleets will be explored further in section 5.

UITP advocacy paper:

The International Association of Public Transport (UITP) has created the advocacy paper "Public Transport: Creating Green Jobs and Stimulating Inclusive Growth" which elaborates how public transport benefits the economy, various stakeholders, and the environment. Among others, it offers overview guidance on how to professionalize and promote the work of public transport operators. Particularly impressive is the listing of impacts of investment on the creation of local jobs. For example, case studies show a five-fold return on investment and one to three additionally induced jobs for public transport. If you are interested in training provided by UITP, please see here.

6.5.4 We can encourage the shift to public transport by creating efficient and reliable systems

At the 2018 Transforming Transportation event, the Mayor of Bogota (Colombia), Enrique Penalosa, asked why a citizen using public transport should have a slower commute than a private vehicle owner. [xxi] He also once eloquently stated that, "an advanced city is not a place where the poor move about in cars, rather it's where even the rich use public transportation."[xxii]

Ideally, public transport, which can be a great equalizer for citizens from different walks of life, should significantly contribute to or wholly provide an integrated mobility system. Despite its high potential for enabling mass transit, public transport has in recent decades lost popularity due to the spread of individually owned vehicles and due to perceived and real deficiencies in providing services for passengers safely and conveniently. Moreover, in terms of governance, there can be multiple competing policies among different planning and transportation departments that are only partially reconcilable, thereby resulting in lack of offering the public with comprehensive sustainable transport options.

Overcoming these conflicts requires comprehensive reforms by governments, operators, intermediaries, and the public. The common goal would be to boost ridership of public transport systems while mitigating negative social, economic, and environmental effects.

Comparing Public Transport Modes: Operations and Emissions

Based on the urban context, population density and characteristics of activities in the region, cities are often required to formulate and design multi-modal transport systems—which include walking, biking, and public transit—to be able to satisfy the various travel needs of its citizens, and to avoid excluding its most vulnerable citizens. Thus, the purpose of comparing different public transport modes is not to identify "the best" transit mode, but to better understand the nuances of the modes so that government officials can make an informed decision when selecting a suitable system, especially when they are fiscally limited.

In academia, there is an ongoing debate and research on the conditions and impacts of various transport modes.[xxiii] "Comparing the effects obtained by 86 transit systems around the world including Bus Rapid Transit (BRT), Light Rail Transit (LRT), metro, and heavy-rail transit systems"[xxiv] shows that metro and BRT systems can generate similar results in terms of travel time savings and value creation. To a large extent, this depends on the capacity and average occupancy of mass transit systems (as well as the range or diversity of these values). Good research has been done for BRT systems but could be improved for comparisons across public transport.[xxv]

The type of public transport system the city governments can actually implement would be greatly contingent upon the city's financial, technical, and institutional capacities. For many cities in the Global South, while officials often have lavish ambition to build light rails and metros for the image of their cities, larger infrastructure projects usually mean longer completion time with greater expenses. Therefore, when choosing transport modes, cities need to carefully examine the long-term financing mechanisms and financial sustainability for the appropriate mega-projects.

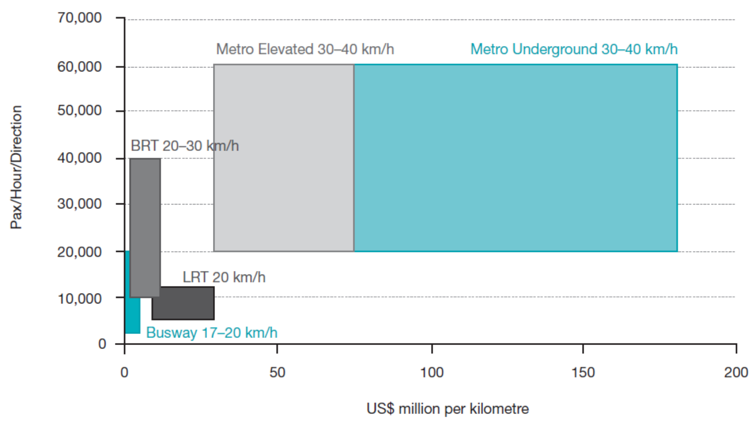

Figure 4: Initial Cost vs. Capacity and Speed of Different Transport Modes (Source: Hidalgo, 2007)

The lifecycle emissions of different modes also depend on many factors, and sometimes public transport can be less efficient, especially outside of dense areas.[xxvi] However, in general, public transport with average occupancy tends to be at least twice as efficient as private vehicle use, based on their energy intensity and absolute consumption.[xxvii] Passenger vehicles are overall quite inefficient in their use of energy since only a fraction is actually used to achieve mobility as a result of idling, engine losses and transmission losses, etc.[xxviii]

The environmental impact of public transport also depends on the technology choices: There is evidence that though there may be operational differences between hybrids, electrics and internal combustion vehicles, they are all viable technologies (Cordeiro, Schipper, and Noriega 2008). However, a common recommendation is for testing and piloting of new technologies until operators are more familiar with them. Also, many bus systems now have a mix of technologies to suit different operational needs, and planning for the mix of technologies should be part of system planning.

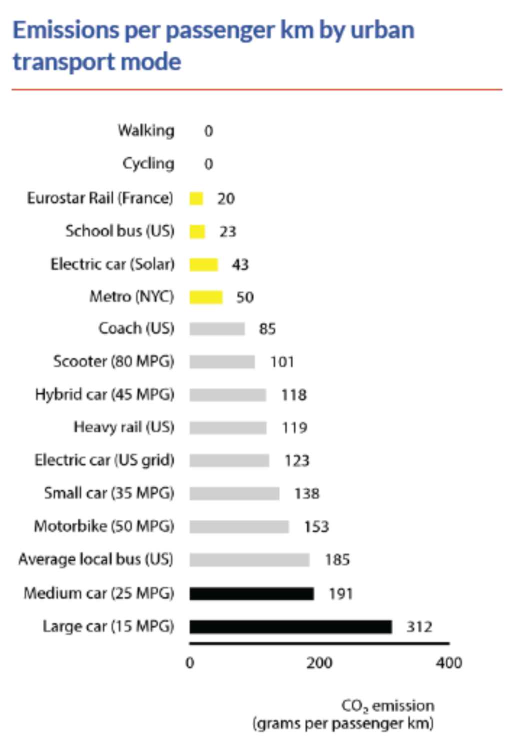

Figure 5: Illustrates the energy intensity of different transport modes and the carbon intensity of their fuels (Source: Rode and Floater 2014, 9).

Bus Systems Improvement for Operation Efficiency

Buses serve as the most common example for public transport, especially in the developing world. In many cities of the Global South, the status quo of the surface transport is often characterized by:

1. Informal operations/Paratransit
2. A fragmented industry
3. Poor service standards – old vehicles, minimal maintenance, uncomfortable, lack of timetable, disjointed network
4. On-street competition
5. Undesirable ‘externalities’

(Source: GIZ Transfer, Presentation Robin Kaenzig, December 2017, Ho Chi Minh City)

Governments around the world have used various means to improve the operation of bus systems in the city—ranging from deploying softer improvement techniques such as bus fleet renewals and bus reorganization, to full-scale replacement of the existing systems with a brand-new system. To date, these global public transport improvement and reform projects have varying degrees of success, though no clear pathway, which can placate *all* involved stakeholders (officials, operators, passengers, etc.) and be sustainable in a longer timeframe (10-20 years), has emerged—perhaps, as a result of changes in political, financial, and demographic aspects over the years.

Nevertheless, one common approach to improve operation efficiency many city governments in the developing world have pursued, albeit with its advantages and disadvantages, is by introducing bus rapid transit (BRT) system as a catalytic project. Pioneered in 1974 in Curitiba, Brazil, the concept of BRT has proliferated from Latin American cities to the global stage, especially in places where there are no historic light rail and metro structures in place.[xxix]

Attractive to planners and policymakers are the social benefits of BRT systems and the significantly lower capital expenses than with rail systems. In comparison to a Metro system, a BRT system can be over 100 times less expensive. Some sources even proclaim, “there is little doubt that BRT in developing cities will be profitable.”[xxx] In an evaluation of 13 BRT systems by the World Resources Institute’s (WRI) transport center EMBARQ it was evident that “capital costs and bus operating costs were the most significant portion of project costs in the cities.”[xxxi]

(GIZ-SUTP 2004) or Meakin 2004: *Training Course: Bus Regulation and Planning – Bus Sector Reform*

BRT research and EMBARQ:

To learn more about how to create successful BRT projects, please see the EMBARQ-WRI report Modernizing Public Transportation or this video on the social, environmental and economic impacts of BRT. Founded in 2002 with the help of Shell Foundation, EMBARQ is now part of WRI Ross Center for Sustainable Cities, focusing on sustainable urban mobility as part of WRI's broader sustainable cities program. EMBARQ has over 15 years of experience making sustainable transport a reality in cities, through continuous on-the-ground presence in Brazil, China, India, Mexico, Turkey, and the United States. Please also refer to Dr. Dario Hidalgo’s research.

To provide metro-like service at the surface, BRT systems strive to achieve four elements or attributes—fast, low waits, comfort, and reliable—by improving operation efficiency. One of the scenarios/frameworks to achieve desirable attributes through operational features is summarized below.

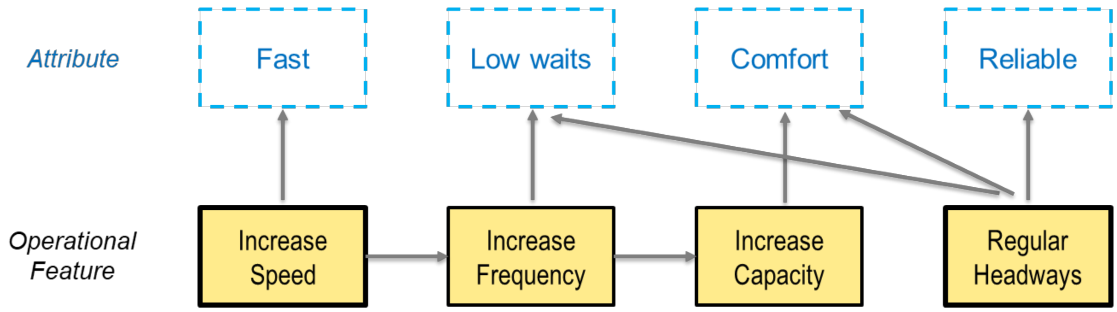

Figure 6: Influence Diagram: Desirable attributes in a BRT system and factors to achieve them (Source: Muñoz 2015)

- To have a *fast* transport service, the increase in *operating speed* is needed.
- To *reduce waiting time*, vehicles need to provide *frequent and regular* (same headway) services.
- To ensure *comfortable system* for a given demand level, *increase in passenger capacity* is needed.
- To have a *more reliable service*, *regular headways*, which often mean low headways through increase in frequency and capacity, are needed.

It is of paramount importance to note that there can be tradeoffs between operation efficiency and accessibility. For example, access to bus station might be reduced when the system favors speed and frequency for high ridership and decreases the number of stops.[xxxii]

6.5.5 Improving the energy efficiency of public transport yields crucial co-benefits (energy efficiency)

Ultimately, energy efficiency in transport relates back to the Avoid-Shift-Improve framework which aims to improve system efficiency, travel efficiency, and vehicle efficiency. Including the several co-benefits of transport, this allows to get a general understanding of the energy efficiency of different transport modes. Co-benefits of improving the emissions quality of public transport fleets include higher economic development, higher quality of life, better energy security and fewer negative externalities.[xxxiii]
Efficiency improvements can also spur economic growth since "fuel-efficiency improvements are essential for competitiveness in an increasingly global market."[xxxiv]

Below, we provided three approaches to improve energy efficiency: (1) Bus route reorganization; (2) Air quality standards and policy, and (3) electrification of bus fleets.

Bus Route Reorganization

Given the impact on vehicle-km, bus reorganization appears to have larger impacts than just replacing a fraction of the bus fleet with cleaner technology. An analysis of the case of Queretaro, Mexico (Cordeiro, Schipper and Noriega 2008), shows how the expected reduction in vehicle-km resulting from bus route reorganization has the largest potential impact on emissions reduction, yielding a 64% reduction of yearly emissions. Adding a BRT corridor also provides additional reduction in GHG emissions. This goes to show that only applying different vehicle and fuel technologies for the BRT corridor, such as low Sulphur diesel, CNG and hybrid buses, provide comparatively small emissions reductions.

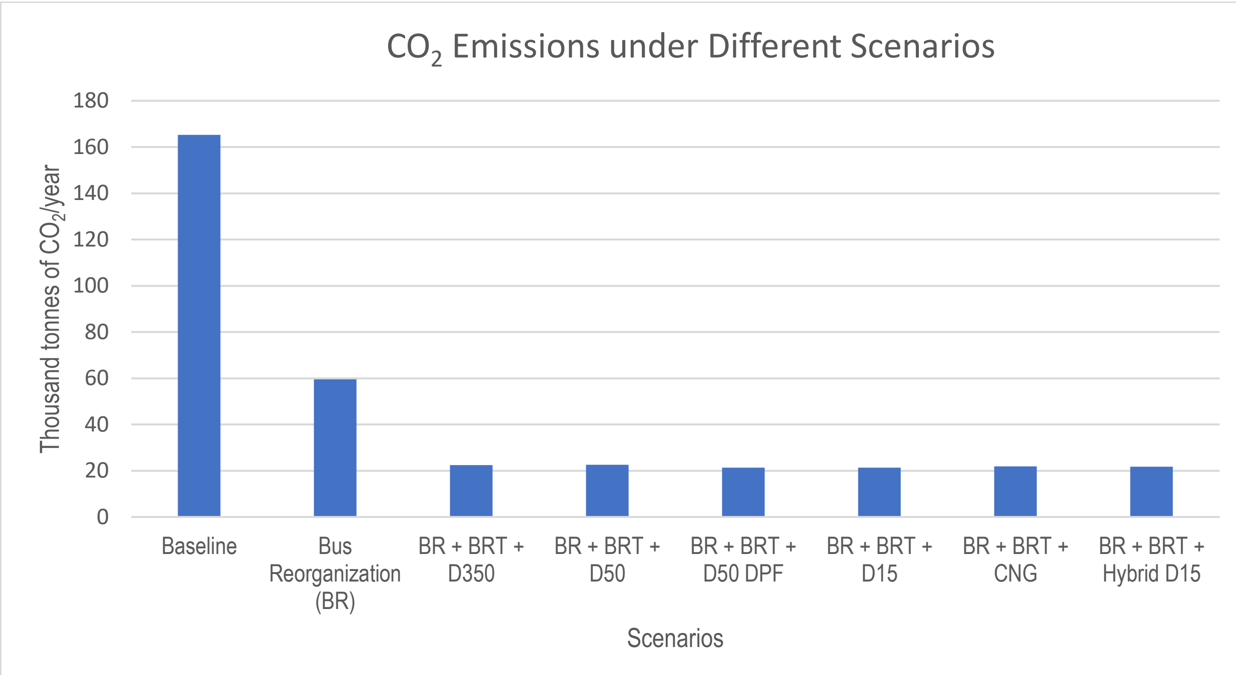

Figure 7: CO_2 Emissions of Bus System Formalization and BRT Implementation in Queretaro (Source: Cordeiro, Schipper, and Noriega 2008)

In general, bus route reorganization is a process combining several measures. Measures can include a mixture of institutional, design and capital investment, and operational actions in the system, such as modifications in the regulatory regime for service provision, removing duplication of routes, adjusting frequency of buses, and improving routing, among other. Bus reorganization can be enhanced if packaged with other measures that will facilitate service integration, such as incorporating branding, infrastructure, traffic control technology and user information systems.

Air Quality Standards & Policy

Energy efficiency of vehicles can be improved through standards and legislation for minimum performance, through incentives and support schemes towards improved design, or the promotion of voluntary measures, awareness campaigns and behavior changes.[xxxv] The average age of the fleet also influences the vehicle efficiency, which is why scrapping incentive programs can be useful.[xxxvi]

Electric Vehicles

The rapid spread of electric vehicles makes the topic of electric mobility particularly popular among policy makers and entrepreneurs. The worldwide shift to electric vehicles will most likely have wide-reaching consequences for policy and technology. With their rapid diffusion and uptake, electric vehicles will pose a challenge for policymakers to keep suit and manage the disruption. The Global Fuel Economy Initiative (GFEI) has proposed reaching a 100 million electric vehicles by 2030, while acknowledging that the path towards this ambitious target is difficult and uncertain (Global Fuel Economy Initiative 2017). There are several barriers standing in the way of a quicker and more widespread uptake of electric vehicles such as a lack of charging infrastructure and customer awareness, long charging times, and expensive (though decreasingly so) batteries.[xxxvii] Storage and charging technologies are the central focus of innovation activities, which have led to significant improvement in size, weight, battery capacity and overall cost. Battery costs have fallen from US$1000/kWh in 2008 to US$400/kWh in 2013.[xxxviii]

It is clear that electric vehicles will soon become a regular component of the global fleet. This is especially true for electric buses, who can make an even heavier dent on air pollution, GHG emissions, and congestion. Multiple cities are leading these efforts worldwide. Shenzhen, for example, built the world's first and largest 100 percent electric bus fleet.[xxxix] This development must go hand in hand with decarbonizing the electricity sector.[xl]

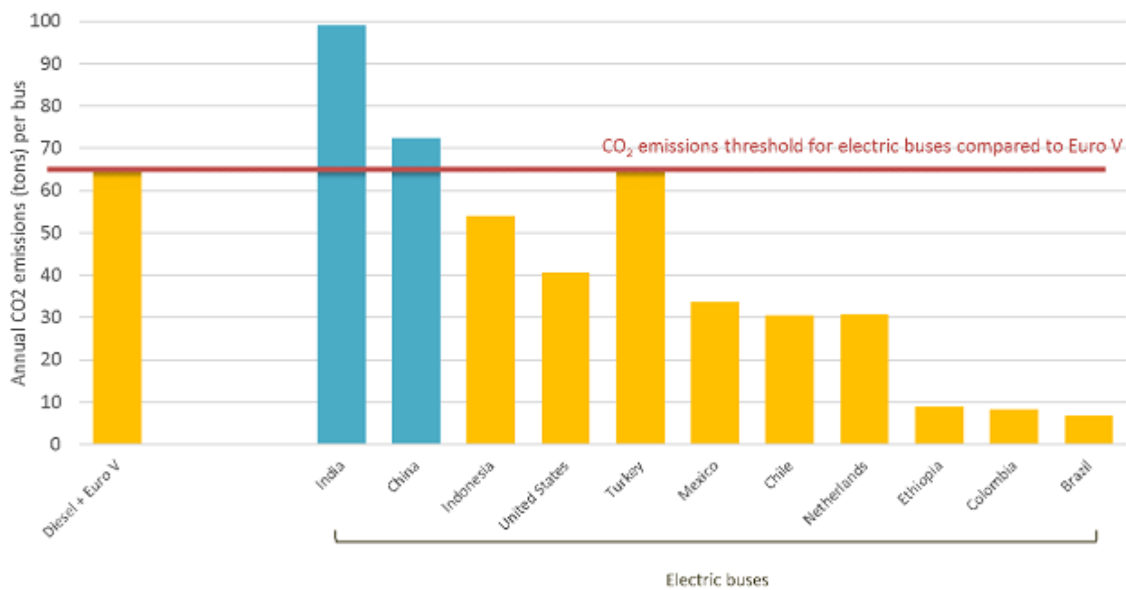

Figure 8: Carbon dioxide emissions from a Euro V bus (tailpipe) compared to an electric bus (upstream) in multiple economies (Source: TheCityFix, Castellanos and Orjuela)

To spur efficiency improvements and support the transition to electric vehicles, fuel economy and air quality standards can help prepare the path for innovation.[xli] Researchers found that, "recent changes in US and European standards have both increased the rate of technology adoption and affected the direction of technology adoption."[xlii]

Sustainable Urban Transport Project

Since 2003, the Sustainable Urban Transport Project (SUTP) by GIZ has generated a variety of publications to assist cities achieve their sustainable transport goals. Of special interest are the SUTP Sourcebook Modules, a comprehensive knowledge series on many aspects of urban transport, as well as their Readings Lists on various topics.

Spotlight: The 2012 Sourcebook Module 5h, Urban Transport and Energy Efficiency, defines and elaborates on energy efficiency actions for local and national policymakers. It features explanatory frameworks and 15 case studies from around the world.

If interested in more visual resources, consider the YouTube channel of the SUTP project.

6.5.6 Conclusion: Operational and energy efficiency will make cities sustainable and prosperous

There are many reasons to encourage a stronger shift to public transport systems. Only efficient mass transit will be able to allow a growing number of people to live in sustainable cities of the future. Shared traveling is necessary to use limited space and resources in the most efficient way. For this to happen, there are numerous components to consider, from urban planning to financing and fleet technology.

A clean and functioning public transport fleet also depend on how new and emerging trends in the transport sector will develop. The UITP has identified four trends in 2017: new mobility services, reorganization of the public transport market, shifts to low-carbon or zero-carbon vehicles, and the rise of two-wheelers.[xliii] All these changes simultaneously pose challenges and opportunities to the organization of public transport. What stays the same is that public transport services will continue to form the backbone of people-centered mobility. Transport planners and researchers need to employ all the tools available to make efficient mobility a reality for the 21st century.

Additional Resources

- Bus Rapid Transit in China: A Comparison of Design Features with International Standards
- The Economic and Social Benefits of Low-Carbon Cities: A Systematic Review of the Evidence
- How did Shenzhen, China Build World's Largest Electric Bus Fleet?
- Shared Mobility Principles for Livable Cities
- Transport Initiatives Proposed in the Context of An Action Agenda on Transport and Climate Change
- Don't Drive Here – Manila (Video)
- LTA Singapore: A People-centered Land Transport System (Video)
- TfL's Dave Wetzel on Why London's Congestion Charging System Took Off (Video)
- Three Revolutions in Urban Transportation (Video)
- Transportation in the City – Options for Urban Mobility – Hong Kong MTR (Video)
- Transportation in the City – Options for Urban Mobility – Trains vs. Buses: The Rise of BRT (Video)
- What is low-carbon development and why is it important? (Video)
- Why buses represent democracy in action? (Video)

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