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Industry Agenda

Sustainable Transportation Ecosystem

Addressing sustainability from an integrated systems perspective

April 2012

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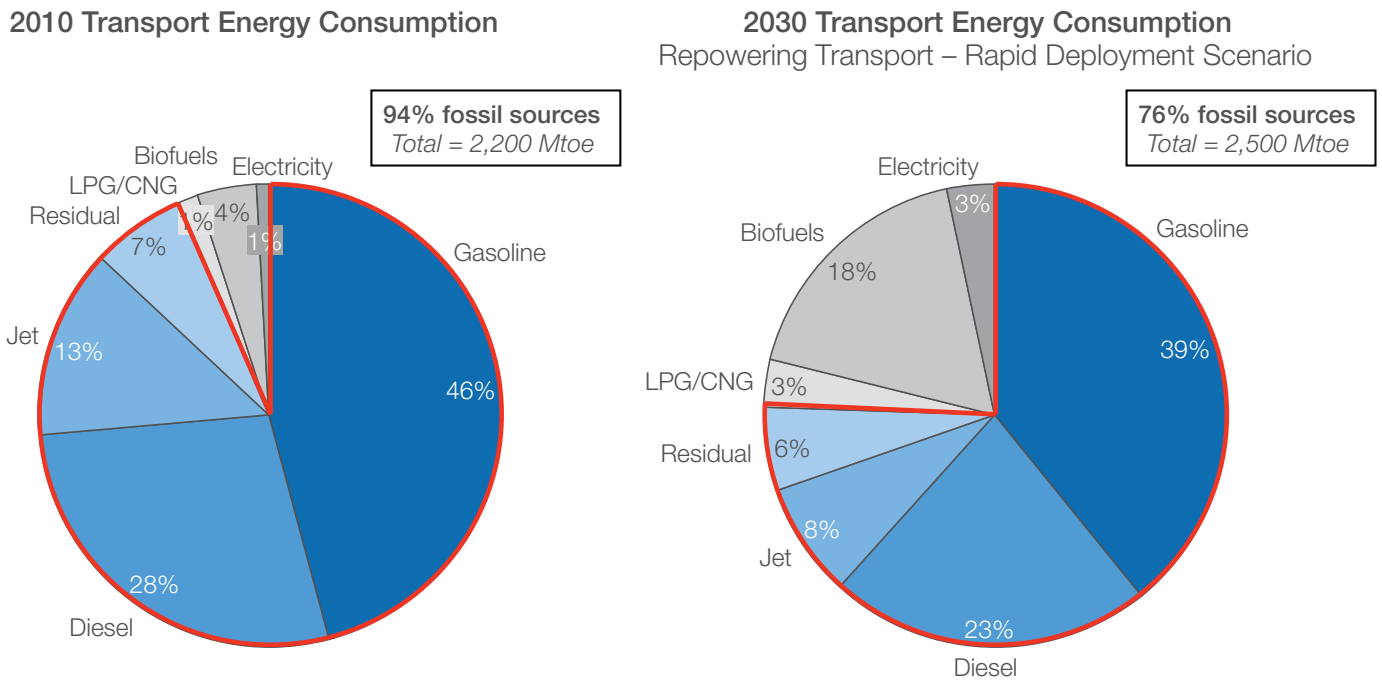
Executive Summary

The transportation sector[1] is currently at a juncture characterized by both great opportunities and challenges. On the one hand, the introduction of new technologies, new players and changing customer behaviours provide the sector with the potential to transform as a system, for new business models to develop, and for the different modes to provide more concrete responses to the challenge of environmental sustainability and carbon emissions reductions in the sector.[2] On the other hand, factors such as the current depressed economic climate, scarcity of resources[3] and system inertia[4] inhibit the industry's ability to respond efficiently to these opportunities, delaying the introduction of technologies that would enable the transportation sector to reach its environmental sustainability and carbon emissions reductions targets and its evolution to an innovative system.

Presently, more than 60% of the 87 million barrels of oil consumed every day power the world's transportation sector, and liquid fossil fuels account for 94% of the energy supply to the sector, as shown in Figure 1. Fossil fuels are expected to remain the primary source of energy in the transportation sector for at least the next two decades: even in the most aggressive scenarios examined in the World Economic Forum's work on Repowering Transport,[5] 76% of the energy supply to the global transportation sector will be provided by fossil sources in 2030. To be successful in meeting the sector's carbon emissions reduction targets and contribute to limiting global warming to less than 2°C, the transportation sector cannot continue to develop under a business-as-usual scenario because it implies a continued strong dependence on oil with a low share of renewable energy.

Figure 1: Transportation energy consumption projections 2010-2030

Source: IEA/SMP, IMO, IATA, Carbon Neutral Skies team analysis, Repowering Transport team analysis



[1] The transportation sector includes air, maritime and land transport for passengers and freight.

[2] While environmental sustainability in transportation encompasses a broad range of topics related to climate change, land use and water access, the project has focused on carbon emissions due to this being the main focus of the transportation sector's and policy-makers' environmental targets.

[3] While scarcity of petroleum resources can be a driver for introduction of more sustainable fuels and transportation technologies, limited availability of resources such as biofeedstock and rare earth metals can be an inhibitor for scaling up new energy sources such as biofuels or technologies such as electric vehicles.

[4] Inertia in the transportation sector is driven by multiple factors, including: stakeholders' focus on optimizing their actions for a particular industry or transportation mode rather than taking a systems view of entire sector; limited access to capital for R&D and infrastructure investments; and industry stakeholders' sunk cost into existing technologies and assets that limits the attractiveness of new investments.

[5] The World Economic Forum analysed the use of energy sources in transportation as part of the Repowering Transport study in February 2011. For the full project report, visit: www.weforum.org/reports/repowering-transport-2011.

The transportation sector has responded to this challenge by actively seeking and implementing solutions to reduce its impact on the environment (see spotlight box on the right). Ambitious carbon emissions reduction targets have been defined both by entire industrial sectors (such as the air and marine transport sectors) and individually by leading companies in the sector.

While this transformation of the transportation sector away from fossil fuels is an important step to reduce carbon emissions and climate change, it also represents a broader opportunity to respond to policy-makers' and the public's calls for increased job creation in the current depressed economic climate.

Transitioning the sector to new sustainable transportation alternatives will require investments in R&D and infrastructure that can lay the foundation for immediate job creation today and sustained economic growth in the future.

Due to the complex nature of the transportation sector, achieving this transformation will require a fundamentally new approach to addressing environmental sustainability and carbon emissions reductions. The network of stakeholders that directly or indirectly influence the sector, shown in Figure 2, span a wide range of constituents that include stakeholders both within and outside the transportation sector. To successfully address the sector's environmental sustainability challenges, the perspectives of all stakeholders in the system must be considered and integrated.

Addressing sustainability from this *integrated systems approach* enables policy-makers and other stakeholders to better assess the complex challenges and multitude of opportunities available to the transportation sector to achieve its targets. It also allows for more effective policies to be implemented that assess the trade-offs between modes and technologies, and enable the whole sector to reach its emissions reduction targets rather than favouring a single mode. Finally, it also brings the potential for risk sharing of investment into new technologies among stakeholders throughout value chains.

This report aims to support the process of establishing an integrated systems approach by providing a framework and recommendations for each stakeholder in the system on how to take action to achieve this goal.

Spotlight: Emissions Reduction Initiatives in Transportation

The individual transport modes in the transportation sector are currently working on a range of initiatives to reduce their greenhouse gas footprint.

In air transport, initiatives are underway to improve aircraft and airport operations, traffic management and aircraft design and materials, as well as early retirement of aircraft and the use of biofuels.

In road transport, work is being done to reduce emissions and improve fuel economy of combustion engines (including downsizing, turbocharging and direct injection), as well as light weighting, improvements to aerodynamics of vehicles, and the introduction of new electric and alternative fuel drivetrains.

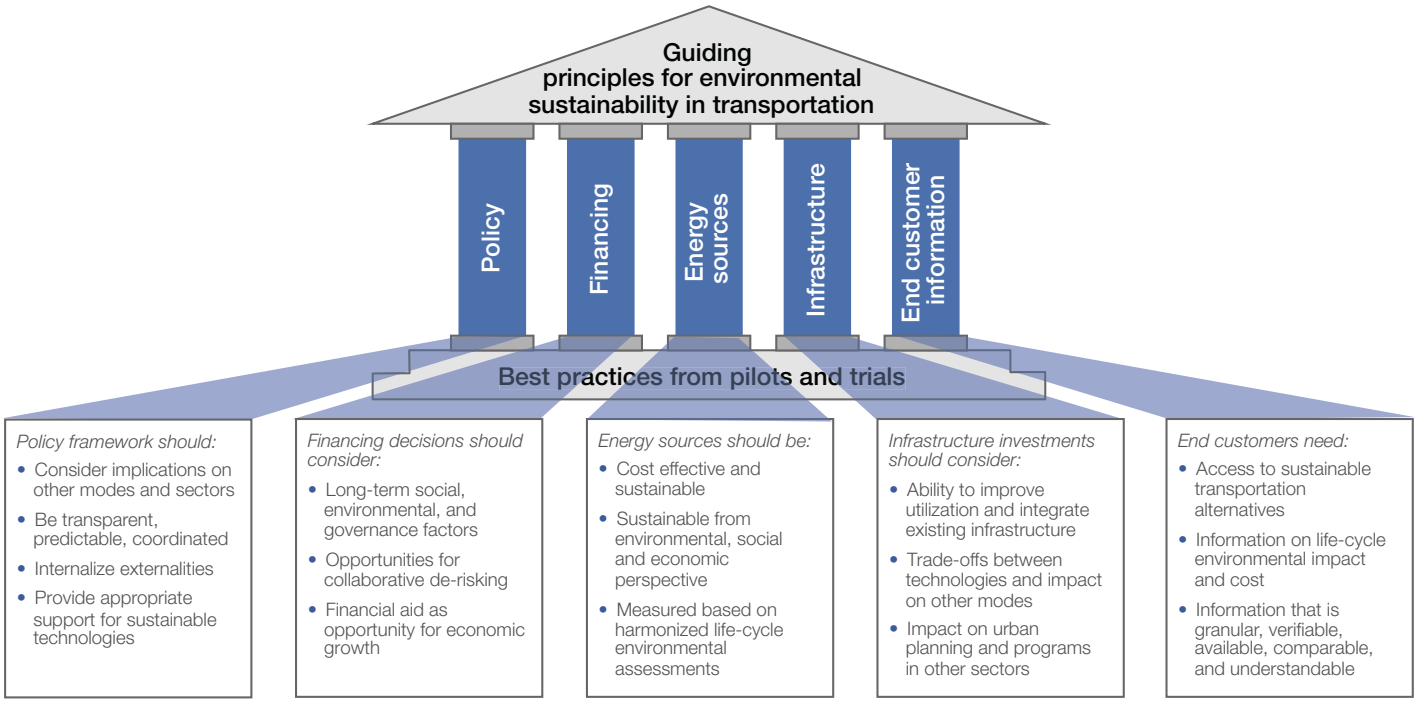
In marine transport, the focus is on increased fuel efficiency through improvements in ship design, operations and machinery, and to introduce more sustainable fuels.

Figure 2: Stakeholders in the transportation system

As part of the framework, the report provides all stakeholders in the transportation system a common set of principles to guide alignment and coordinate actions related to carbon emissions reductions in the sector. This alignment and coordination will allow the sector to realize its potential of growth and positive economic impact while achieving its environmental sustainability targets.

The principles can also be adopted by corporations to provide a framework for sustainable growth that goes beyond Corporate Social Responsibility and touch on all aspects of corporate strategy. These sustainability principles, which are covered in more detail in Chapter 3 of the report, are summarized in Figure 3 below.

Figure 3: Guiding principles for environmental sustainability in transportation



While a diverse range of initiatives[6] can contribute to achieving an environmentally sustainable transportation system, three areas – consignment-level carbon reporting, vehicle electrification and aviation biofuels – have been identified as levers with significant potential for enabling the sector to reduce its carbon emissions.[7] For these three levers, the report outlines a set of concrete recommendations to support scale-up – summarized in Figure 4. These recommendations demonstrate how the implementation of an integrated systems approach to addressing the environmental sustainability challenge for the transportation sector provides an effective and efficient way to coordinate different public and private stakeholders, and develop a more successful framework to accomplish the sector's goals. Ultimately, this would allow the sector to grow while achieving individual environmental targets and effectively: contribute to limiting global warming; provide governments economic returns, jobs creation and a better way to allocate scarce resources; and provide society with transportation solutions capable of meeting the challenges of the 21st century.

[6] The transportation sector is currently assessing or implementing environmental sustainability initiatives across all transport modes, including: improvements to conventional combustion engine vehicles in road transport (e.g. downsizing, turbocharging, direct injection, light weighting, etc.); improvements to aviation fleet, operations and infrastructure in air transport (e.g. aerodynamics, weight, fuel efficiency, air traffic management, fuel management, continuous descent, etc.); improvements to marine fuel efficiency in marine transport (ship design, operations, machinery); and greater use of alternative fuels in all transportation modes and electricity generation.

[7] While the project recognizes that biofuels have an important role to play in road transportation (and are already in use in many geographies), the project has focused on applications of biofuels in aviation due to these being the only alternative fuel option for this industry.

Figure 4: Summary of key recommendations to stakeholders in the transportation system

Policy-makers (e.g. regional, federal, local governments)

System-level transformation

- Analyse sustainable transportation technologies from a systems perspective to understand benefits on energy security, job creation and emission reductions and create a long-term energy plan that integrates all transportation modes
- Phase out fossil fuel support and incentivize sustainable fuel sources and power generation
- Ensure granular, comparable, understandable information on sustainability (e.g. consignment-level emissions and feedstock sustainability) and cost (e.g. total cost of ownership) is available to all users

Vehicle electrification

- Incentivize demand and supply of plug-in electric vehicles through a combination of non-financial (e.g. zero emission zones, taxi lane access, fleet mandates) and financial incentives (purchase subsidies, RD&D funds)
- Ensure electric grid regulation supports cost-efficient and speedy development of a smart electric vehicle charging infrastructure

Aviation biofuels

- Provide financial (e.g. co-financing, tax incentives, loan guarantees, grants) or other support (e.g. sites, involvement of military as large scale pilot user, R&D and production facilities) for aviation biofuels
- Harmonize sustainability criteria and accounting procedures for biofuels in aviation between regions

OEMs and suppliers (e.g. auto OEMs, aircraft OEMs, engine manufacturers, component manufacturers)

System-level transformation

- Identify opportunities to collaborate with players in other parts of the value chain (e.g. policy-makers, financial institutions, academia, energy providers, service providers) to develop and scale up the use sustainable transportation technologies

Vehicle electrification

- Automotive suppliers: Collaborate with key customer groups (e.g. corporate fleets, L&T industry) to understand requirements, and with infrastructure providers to develop alternative mobility and financing solutions

Aviation biofuels

- Aviation suppliers: Support aviation biofuel development and production through aerospace and defence offset agreement investment mechanisms and other strategic investments in local research, design and development

Energy suppliers (e.g. utilities, oil companies, chemical companies)

System-level transformation

- Collaborate with other stakeholders such as policy-makers, financial institutions, suppliers, academia and mobility service providers to support scale-up of sustainable technologies

Vehicle electrification

- Utilities: Assess opportunities to upgrade electric grid and develop new mobility offerings to support mass-market adoption of plug-in electric vehicles, alone or in partnership with start-up players

Aviation biofuels

- Oil/chemical companies: Focus biofuel investments on fuel types appropriate for modes of transport where no other sustainable alternatives exist, such as aviation and marine (e.g. biojet, biodiesel) and collaborate with other stakeholders to ensure sustainable growth opportunities for biofuels are commercialized

Service providers (e.g. airlines, car rental, logistics companies)

System-level transformation

- Collaborate with other service providers to develop integrated, sustainable mobility solutions where emissions can be measured in a reliable and granular way

Vehicle electrification

- Proactively adopt plug-in electric vehicles in operations to help build demand and support technology development

Aviation biofuels

- Collaborate with other stakeholders in the value chain to de-risk investments in biofuels for aviation

End customers (e.g. corporate fleet operators)

System-level transformation

- Actively seek out and demand information on sustainability impact of transportation options from OEMs/service providers

Vehicle electrification

- Assess viability of switching to plug-in electric vehicles, based on a holistic perspective that includes total cost of ownership and lifetime emissions

Aviation biofuels

- Demand and utilize biofuel usage information provided by airlines and transportation providers to make informed choices about use of transportation alternatives

Financial institutions and investors (e.g. corporate, private equity)

System-level transformation

- Incorporate a long-term perspective of environmental, social and governance factors in performance measurement systems, investment criteria and corporate strategy

Vehicle electrification

- Collaborate with stakeholders in the transportation system to develop new financing models and mobility offerings for plug-in electric vehicles for end customers

Aviation biofuels

- Collaborate with stakeholders in the transportation system to de-risk investments in biofuel for aviation through joint financing models

Academia (e.g. universities, research labs)

System-level transformation

- Educate governments, users and industry on sustainability methodology and concepts, management practices for sustainability and macro trends of relevance to transportation

Vehicle electrification

- Support private industry players with development of new and improved battery technologies

Aviation biofuels

- Research new and improved pathways for biojet fuel to drive down cost and expand range of production options

Industry associations

System-level transformation

- Disseminate information across modes and sectors on sustainability topics to raise awareness of transportation as enabler for balanced economic growth and driver of change

Electric vehicles

- Educate consumers about total cost of ownership of vehicles and well-to-wheel emissions

Aviation biofuels

- Support dissemination of best practices for production and use of aviation biofuels with a wide range of stakeholders

NGOs

System-level transformation

- Participate in industry efforts to define a sustainable vision for the transportation sector

Vehicle electrification

- Educate consumers about total cost of ownership of vehicles and well-to-wheel emissions

Aviation biofuels

- Engage in sustainability standards development processes to avoid future disagreement over sustainability claims

Contents

Introduction

The Sustainable Transportation Ecosystem report examines the question of how to develop a more holistic approach to environmental issues facing the global transportation sector. It outlines a framework for how the transportation sector as a whole can achieve environmentally sustainable growth and reach its carbon emissions reduction targets, and how different stakeholders in the system can take action to support this goal.

The report provides an overview of the present key carbon emissions reduction targets for the transportation sector[8] and an integrated, rather than mode-specific, systems approach to achieving these targets. It also provides a set of sustainability principles that are applicable to all stakeholders and transport modes in the transportation system that can support the development of more environmentally sustainable solutions and processes for the transportation sector.

Finally, the report offers specific recommendations for how each stakeholder can take action on three promising levers in the near term – *consignment-level carbon reporting, vehicle electrification and aviation biofuels* – that could significantly reduce emissions and enable environmentally sustainable growth of the transportation system.

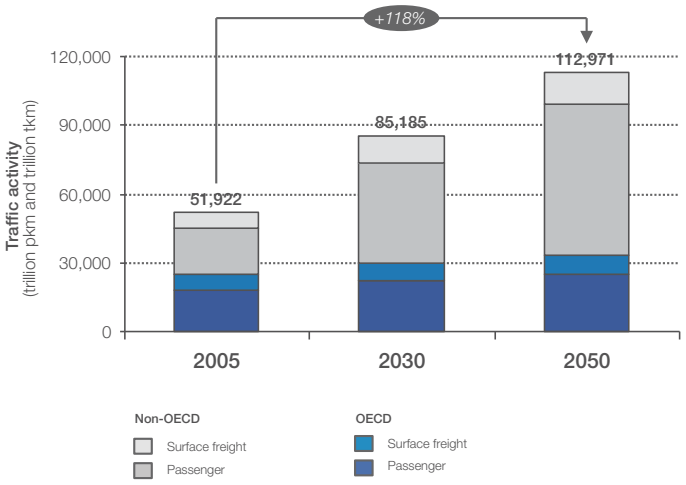
[8] Where available, sustainability targets are given for an entire sector (e.g. ICAO targets set for the aviation industry), or in cases where sector targets are not available, individual company targets of leading companies in the industry (e.g. sustainability targets of leading automotive OEMs).

The Potential of an Integrated Systems Approach for Sustainable Transportation

The global demand for mobility of people and goods is projected to increase dramatically over the coming decades, driven primarily by economic and population growth. According to a baseline scenario developed by the International Energy Agency (IEA), global ground passenger and freight traffic in OECD and non-OECD regions is projected to increase by 118% from 2005 to 2050; the majority will come from increases in non-OECD regions, as shown in Figure 5.[9]

Figure 5: Global ground passenger and freight traffic forecasts 2005-2050[10]

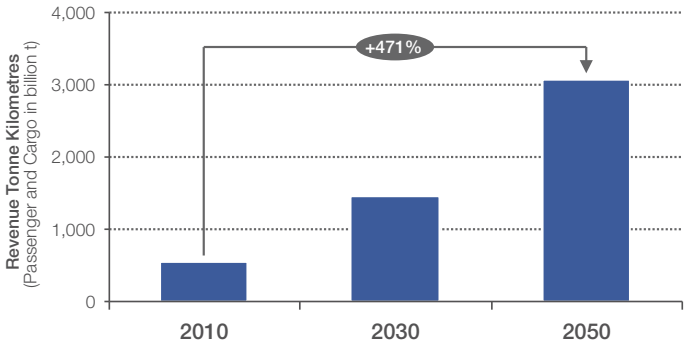
Source: International Energy Agency: Transport, Energy and CO_2 2009



The global air transport sector forecasts a strong increase in demand, with projections from the World Economic Forum report *Policies & Partnerships for a Sustainable Aviation*[11] showing growth in passenger and freight revenue tonne kilometres of 471% from 2010 to 2050, as illustrated in Figure 6.

Figure 6: Global air passenger and freight traffic forecasts 2010-2050

Source: World Economic Forum analysis; ICAO; Airbus



[9] International Energy Agency: Transport, Energy and CO_2, 2009.

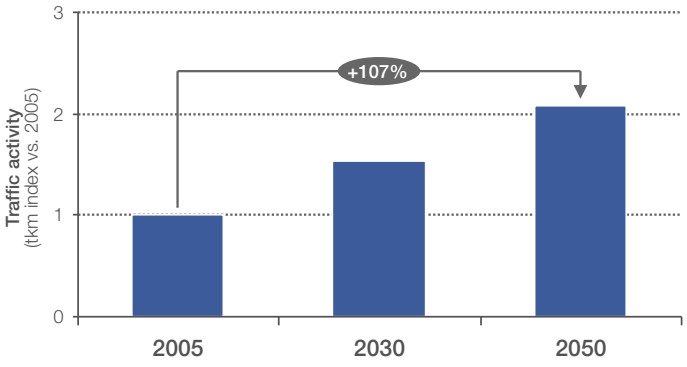
[10] The IEA has developed several scenarios for future development of energy use in transportation. The Baseline scenario reflects current and expected future trends in the absence of new policies. The High Baseline scenario considers the possibility of higher growth rates in car ownership, aviation and freight travel than the Baseline scenario. The BLUE Shift scenario is based on achieving the maximum CO_2 reduction in transport by 2050 using measures costing up to US$ 200 per tonne, with specific focus on modal shifts to cut energy use and CO_2 emissions.

[11] For the full report, please see: http://www.weforum.org/reports/policies-and-collaborative-partnership-sustainable-aviation.

Marine transport is also projected to grow strongly over the next few decades. The baseline scenario developed by the IEA show increases in freight volumes of 107% by 2050 versus a 2005 baseline, as illustrated in Figure 7.

Figure 7: Global marine freight transport forecasts 2005-2050[12]

Source: International Energy Agency: Transport, Energy and CO_2 2009

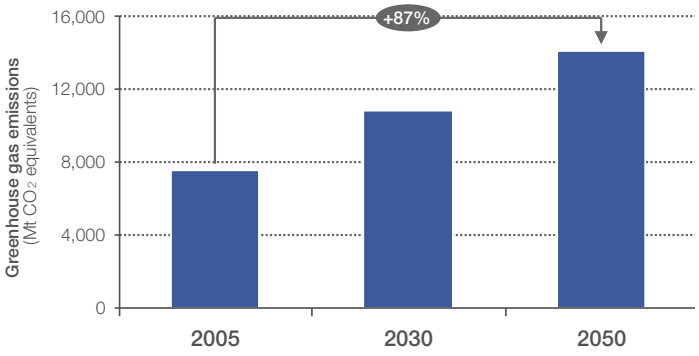


As a fundamental enabler for mobility and economic growth, transportation will play a key role in future social and economic development. However, several challenges remain to the development of a sustainable and competitive transportation system.

First, the growth in demand for mobility is driving increased demand of transportation fuels. The transportation sector currently represents 23% of global greenhouse gas emissions[13] and the IEA projects that emissions from transportation could increase by 87%[14] by 2050 if current and future expected trends continue and new policies are not put in place to counter these trends, as illustrated in Figure 8.

Figure 8: Global greenhouse gas emissions from transportation 2005-2050, as projected by the IEA's baseline scenario[15]

Source: International Energy Agency: Transport, Energy and CO_2 2009



[12] The IEA BLUE Map scenario is based on achieving the maximum CO2 reduction in transport by 2050 using measures costing up to US$ 200 per tonne, with specific focus on strong improvements in efficiency and introduction of advanced technologies and fuels.

[13] According to the IEA, transportation accounted for 23% of energy-related greenhouse gases in 2005.

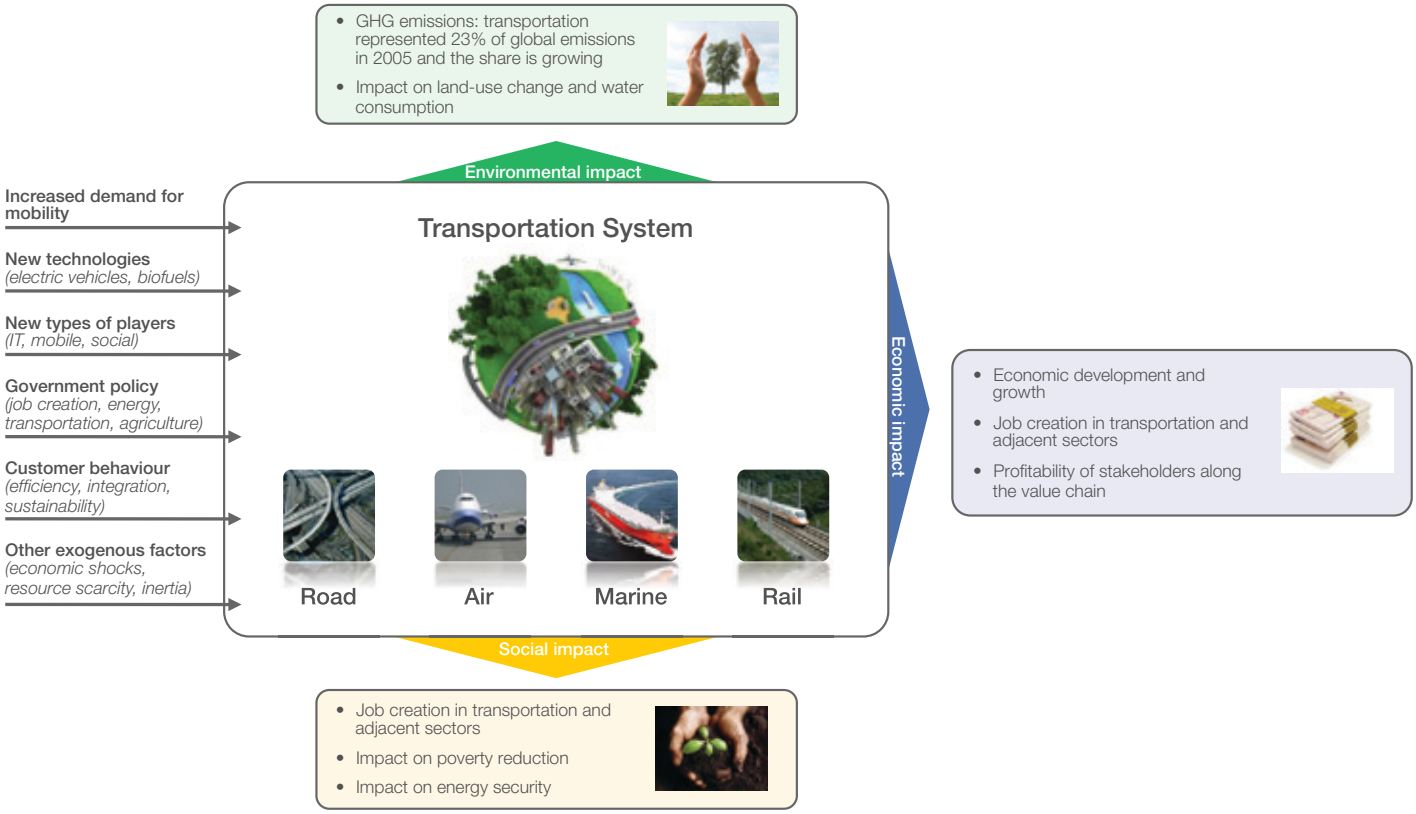
[14] The IEA projects that overall energy-related emissions would roughly double in a Baseline scenario, keeping transportation's share of global emissions roughly unchanged from current levels.

[15] The IEA BLUE scenarios are based on achieving the maximum CO2 reduction in transport by 2050 through a combination of modal shifts ("Shifts"), energy efficiency improvements ("Efficiency") and use of alternative technologies and fuels.

Second, the transportation system itself is becoming more complex, with new technologies being introduced,[16] stakeholders from across the value chain developing and shaping new solutions,[17] and supply chains becoming more complex and international.[18] Third, external factors such as economic shocks, scarcity of resources (e.g. rare earth metals and bioresources), and inertia among providers and consumers of energy[19], are limiting the adoption of new alternative technologies.[20]

On the other hand, the transformation of the transportation sector away from fossil fuels also represents an opportunity to respond to policy-makers' and the public's calls for increased job creation in the current depressed economic climate. Transitioning the sector to new sustainable transportation alternatives will require investments in both R&D and critical transportation infrastructure that can lay the foundation for immediate job creation today and sustained economic growth in the future. If a successful partnership between the transportation industry and other stakeholders can be established to release capital for investments in the transformation of the transportation system overall, a win-win opportunity can be created that advances the agenda of both the sector and society in general. An overview of these challenges and opportunities is illustrated in Figure 9 below.

Figure 9: Challenges and opportunities in the transportation system



[16] For example, the use of smartphones to plan and reserve travel and location-based social networks.

[17] For example, customers demanding more efficient and integrated offerings and transportation providers offering mobility on demand solutions in collaboration with vehicle suppliers and infrastructure providers.

[18] For example, increasing freight transport intensity of the global economy and increasing proportion of global GDP crossing international frontiers.

[19] Inertia in the transportation sector is driven by multiple factors, including: stakeholders' focus on optimizing their actions for a particular industry or transportation mode rather than taking a systems view of entire sector; limited access to capital for research and development and infrastructure investments; and industry stakeholders' sunk cost into existing technologies and assets that limits the attractiveness of new investments.

[20] While scarcity of petroleum resources can be a driver for the introduction of more sustainable fuels and transportation technologies, limited availability of resources such as biofeedstock and rare earth metals can be an inhibitor for scaling up of, for example, biofuels and electric vehicles. An additional challenge to the introduction of sustainable alternatives is the low cost of traditional established transportation fuels and means of transportation that use these, due to assets already being amortized or externalities not being fully reflected in prices.

In a complex and interrelated world, addressing the challenge of reducing carbon emissions from an entire sector should be approached by taking an integrated systems view of the global transportation system. As mobility becomes ever more intermodal, international and interconnected with other sectors, decisions need to be made with a view that goes beyond isolated modes or regions to maximize the potential of carbon emissions reductions and scarce resources. As an example, nowhere is this more apparent than in the case of biofuels, which is critically linked with other modes, regions and sectors (see spotlight box below).

Spotlight: The Need for an Integrated Systems Approach on Biofuels

Experiences with the use of biofuels in the road and air transport sectors illustrate the need for an integrated systems approach to sustainability in transportation.

The use of biofuels such as ethanol and biodiesel for light-duty vehicles can provide a substantial reduction in emissions relative to fossil fuels. However, the allocation of scarce bioresources to these vehicles impacts the availability of biofuels for air, marine and heavy duty road transport where no other sustainable fuel alternatives are available.

Criteria for what is considered a sustainable biofuel also vary between regions, creating challenges for airlines that wish to be recognized for use of biofuels on international flights.

Biofuels are also closely linked to policy and developments in other sectors, most notably agriculture and energy. The relative cost and availability of biofuels are, for example, critically linked to crop prices and volumes, as well as fossil fuel prices.

Another example of the need for a holistic approach is for improving coordination of personal and freight movement. This can take several forms: on the “last mile”, particularly within urban areas the substitution of car shopping trips by van deliveries to the home; the allocation of road and rail infrastructure between passenger and freight traffic; and the combination of freight and passengers on the same vehicles, particularly in rural areas.

As a result, the transportation industry and governments will need to adopt a more systematic and integrated approach to address the growing need for mobility, integrate new stakeholders and technologies, and allocate resources in an optimal way to deliver sustainable solutions. Tackled in the right way, these challenges can become powerful opportunities for environmental, social and economic development.

An Integrated Approach to Meeting Sustainability Targets in Transportation

From the broadest perspective, sustainability in transportation encompasses a wide range of environmental, social and economic aspects that are closely interlinked, as reflected in the project's definition of sustainability in transportation below. To meet the environmental challenges facing the transportation sector today and in the future – and unlock the sector's opportunities for positive social and economic development – the transportation sector will need to transform as a system. This transformation, especially as it pertains to reducing the carbon emissions of the sector, requires coordination and collaboration with stakeholders both within and outside of the sector and hence necessitates a multistakeholder approach. The project has therefore focused on addressing the environmental sustainability challenge of the industry.

Spotlight: Defining Sustainability in Transportation

The project's definition of sustainable mobility follows the one used by the World Business Council for Sustainable Development (WBCSD) for the Mobility Project 2030.

Sustainability mobility meets the needs of society to move freely, gain access, communicate, trade and establish relationships without sacrificing other essential human or ecological requirements today or in the future, specifically:

1. Preserve the natural environment: The environment should not be degraded by transport-related activity
2. Meet the travel needs of the population: People need reliability and choice of modes in an integrated system
3. Support a good economy: Transport needs to support an economy that improves the well-being of all people
4. Minimize infrastructure costs: Transport systems need to be planned so that infrastructure and services can be funded in the long term, and that best use is made of investments
5. Maintain energy security: Transport can play a significant role in helping to decouple support of a good economy from increasing demand for fossil fuels
6. Ensure long-term viability of the transport system: Transport infrastructure and services must be continuously maintained work together as an integrated system

Several ambitious targets for reducing carbon emissions of the overall transportation sector have been proposed by international organizations and governments (see spotlight box below). In cases where no industry targets are available, individual companies have defined their own targets. A selection of industry and company-specific targets is outlined in Figure 10.

Spotlight: Environmental Sustainability Targets for the Transportation Sector

The European Union has outlined a plan for emissions reductions in the European transportation sector in

the 2050 timeframe to limit greenhouse gas warming increases to less than 2°C. While deeper cuts can be achieved in other sectors, transport will need to reduce its emissions by 60% in this timeframe. To reach this long-term target, the transport sector should reduce its emissions by 20% below 2008 levels by 2030. Recognition is made of the global nature of the maritime and aviation sectors and the need to avoid imposing excessive burdens on EU operations that could compromise the EU role as a global transportation hub.

The International Energy Agency (IEA) has defined several scenarios for how emissions from transportation can be reduced on a global basis. The BLUE Map scenario forms the foundation of the IEA's studies and indicates a reduction of emissions from passenger and freight mobility of 40% relative to 2005 levels by 2050 through efficiency improvements and use of alternative fuels. OECD regions achieve far bigger reductions than non-OECD regions while India and China show increases compared to 2005 levels.

The World Business Council for Sustainable Development (WBCSD) has outlined a comprehensive vision for the future of sustainable business in its Vision 2050 report. Emissions from mobility are here reduced in line with IEA projections of 30-40% by 2050 through efficiency improvements and alternative fuels.

Figure 10: Selected sector targets for environmental sustainability in transportation

Aviation

International Civil Aviation Organization
ICAO and the Environment

- States and relevant organizations will work through ICAO to achieve a global annual average fuel efficiency improvement of 2% per annum until 2020 and an aspirational global fuel efficiency improvement rate of 2% per annum from 2021 to 2050
- ICAO and its member States with relevant organizations will work together to strive to achieve a collective medium-term global aspirational goal of keeping the global net carbon emissions from international aviation from 2020 at the same level
- ICAO and its member States affirm that addressing GHG emissions from international aviation requires the active engagement and cooperation of States and industry and have noted the collective commitments announced by Airports Council International (ACI), Civil Air Navigation Services Organization (CANSO), International Air Transport Association (IATA) and International Coordinating Council of Aerospace Industries Associations (ICCAIA) on behalf of the international air transport industry to: continuously improve CO_2 efficiency by an average of 1.5% per annum from 2009 until 2020; to achieve carbon neutral growth from 2020; reduce carbon emissions by 50% by 2050 compared to 2005 levels.

Automotive

Volkswagen Group/Toyota Motor Corp.
WBCSD Vision 2050

- Environmental impacts substantially reduced: in line with IEA scenarios, **CO_2 emissions are reduced by some 30-40%**
- **GHG intensity of light duty vehicles reduced by 80%** through downsizing, lighter weight, more efficient drivetrains and low-carbon fuels
- Alternative drivetrains like HEV, PHEV, BEV and fuel cell vehicles, and energy carriers such as electricity or hydrogen produced from low-carbon sources increasingly dominate, enabling ever-increasing well-to-wheel efficiency. **As 2050 nears, alternative drivetrains and hybrids dominate sales**

Renault-Nissan Alliance
Nissan Green Program 2016 Targets

- Create zero emission society utilizing EVs and their derivative technologies with partners
- Develop EV charge and discharge system and information network
- Leading fuel efficiency: **35% fuel economy improvement compared with 2005 on a corporate average** for all Nissan vehicles sold in Japan, China, Europe and the United States
- Introduce 4 EVs including Nissan LEAF; introduce Fuel Cell Electric Vehicle (FCEV) into market; take global leadership in supplying batteries for electric-drive

Marine

International Maritime Organization
IMO and the Environment

- The 2009 GHG Study identifies a significant potential for reduction of GHG emissions through technical and operational measures to improve the energy efficiency of ships. Together, if implemented, these measures could increase efficiency and **reduce the emissions rate by 25% to 75% below the current levels**. Many of these measures appear to be cost-effective.
- In July 2011, IMO adopted a new chapter to MARPOL Annex VI that includes package of mandatory technical and operational measures to reduce GHG emissions from international shipping, with the aim of **improving the energy efficiency for new ships** through improved design and propulsion technologies and for all ships, both new and existing, primarily through **improved operational practices**. The measures are expected to come into force on 1 January 2013.

AP Moller-Maersk
Maersk Line Environmental Targets and Activities

- Reduce CO_2 emissions by 25% from 2007 to 2020 based on the Clean Cargo Working Group CO_2 methodology (based on the GHG Protocol supply chain guidelines and IMO guidelines). At the end of 2012 CO_2 emissions were reduced by 15.6 % compared to 2007 numbers,
- Introduced the world's most energy efficient container vessels per container transported (The Triple-E vessels) which will reduce CO_2 emissions by 50% compared to an average container vessel on the Asia-Europe trade lane
- Introduced slow steaming in the container shipping industry which reduces CO_2 emissions by approximately 10%
- Testing biofuels and collaborating with other industry players on developing sustainable biofuels tailored for shipping

Service Providers

International Association of Public Transport
Sustainability Charter

- Reduce **pollutant emissions to air**
- Reduce energy consumption, implement efficiency measures and increase the use of renewable energy to **reduce GHG emissions**
- Reduce **noise and vibration** by promoting the use of quieter travel modes and vehicles, reduce the noise generated by vehicle use and control the levels of transport noise sensitive location

TNT
Corporate Responsibility Report

- The impact of our operational activities on the environment is one of the key drivers of our corporate responsibility strategy. We seek to limit the impact with respect to:
- The use of natural resources in our operational activities
- Climate change by greenhouse gas emissions – 40% CO_2 efficiency improvement by 2020
- Human health by exposure to noise and air pollution

The CO_2 emissions reduction targets announced to date by companies and the sector are ambitious and highlight the need for cross-sector collaboration and government participation to introduce the required technology and infrastructure, and to modify service provider and customer behaviours.

Presently, the transportation sector, policy-makers and other stakeholders, such as environmental organizations, have been individually working to develop perspectives on how to reduce carbon emissions in transportation. However, few have taken an integrated approach and the majority of the work has been confined to isolated modes or stakeholders. Those who have tried to take an integrated approach have not collaborated with all stakeholders in the transportation system to establish a common vision, direction and targets.[21]

The Sustainable Transportation Ecosystem report proactively responded to this need for architecting a new vision by bringing together many of the key stakeholders of the transportation system and committing to working together – across modes, regions and stages of the value chain – to play their role in meeting the challenge.

Each member of this project has therefore taken a holistic view to addressing how the sector as a whole can reduce its carbon emissions. They have also considered the implications of the introduction of policies, technologies and shifts in consumer behaviours, and ensured that actions that affect the entire system are not simply for the benefit of a single mode or stakeholder.

To execute this approach, all stakeholders identified a set of fundamental sustainability principles that would need to be applied across the transportation sector.

[21] International organizations and industry associations and bodies have focused on individual transport modes and have generally not utilized a multistakeholder approach. However, the World Energy Council's work on transport scenarios for 2050 is one example of such an integrated approach.

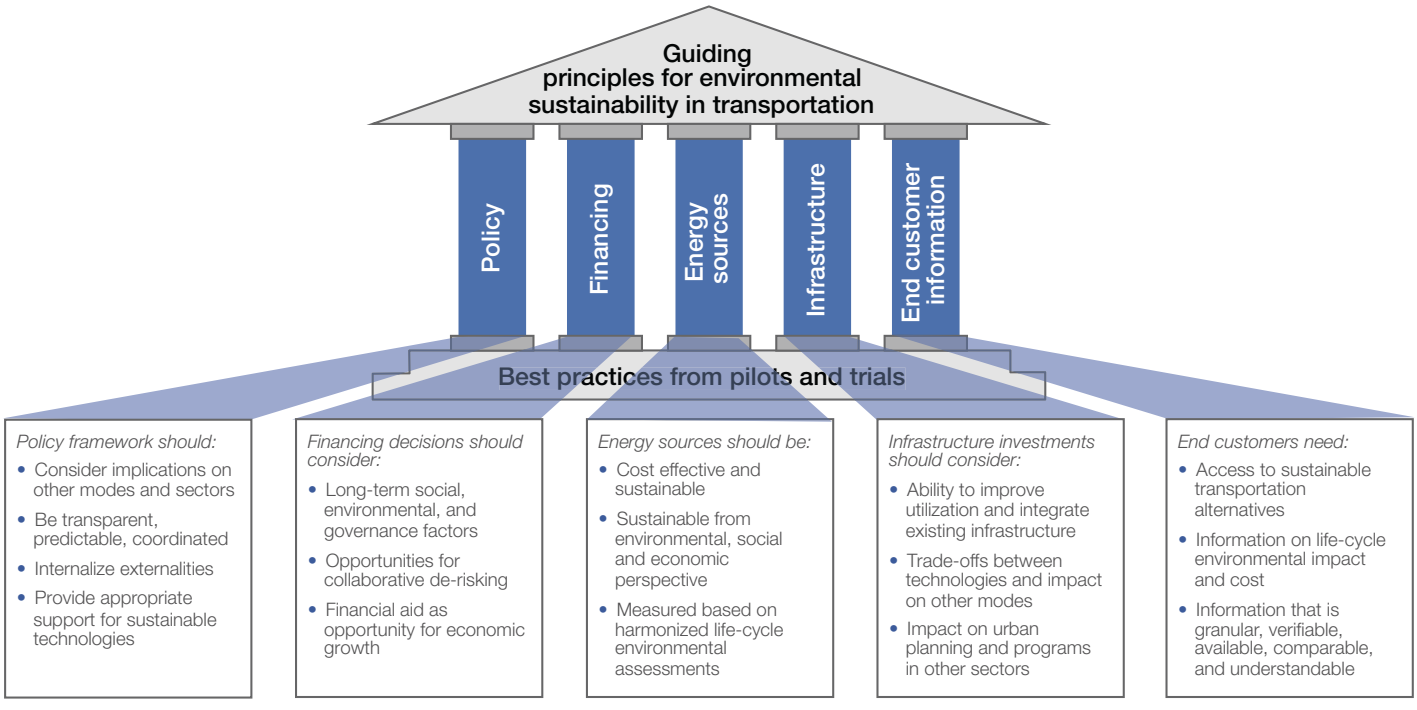
Guiding Principles for Driving Sustainability in Transportation

A transformation of the complex and interlinked transportation system requires a high level of coordination and collaboration between stakeholders. To realize the systemic change required to reduce the carbon emissions of the sector, it is necessary to establish a common set of guidelines or *principles* for how the specific challenges of each stakeholder should be addressed.

Leading companies in the transportation system have already taken steps to address the environmental sustainability challenge through adoption of new technologies and practices. Based on these experiences, the project identified key success criteria and best practices for achieving a sustainable transportation system through a number of workshops and interviews conducted over an eight-month period with numerous transportation stakeholders. These stakeholders included airlines, logistics providers, vehicle, aircraft and component suppliers, utilities, oil companies, chemicals and biofuel providers, financial investors and multilateral banks, and industry organizations.

From these best practices, a task force identified a set of generally applicable guiding principles for achieving environmental sustainability in the transportation sector that have broad applicability across technologies, modes and regions. The principles, as illustrated in Figure 11, were grouped into five broad areas: *policy, financing, energy sources, infrastructure and customer information.*

Figure 11: Guiding principles for an integrated view to environmental sustainability in transportation



Details

Policy

Sustainability Principles

Policies should be transparent, predictable, stable and coordinated on a global or regional basis whenever feasible

Policies for transportation should be formulated under the guise of a holistic transportation policy plan for the country, region, etc. in order to consider all implications of specific policies on different transportation modes

The sustainability of transportation options should be reflected in the price to end customers. To the extent that market prices do not reflect this, policies should be put in place to address this externality (imbalance)

Transport technologies that have superior sustainability performance but suffer from high cost at low scale or lack of enabling infrastructure should be supported through policy for a limited, defined period of time

Application Examples

- Singapore's government has developed a Land Transport Masterplan that guides the development of its entire land transport sector over a period of 10 to 15 years, ensuring transparency, predictability and stability for consumers and businesses
- Because sustainability criteria for biofuels in aviation are not coordinated between regions, the use of these fuels may not be recognized for emissions credits and taxations on international flights
- China instituted fuel economy standards for light-duty vehicles in 2005, outlining a progressive strengthening in standards by 2009 at the same time. Due to the predictable nature of the policy, many manufacturers opted to implement the stricter requirements ahead of time

- Ethanol and biodiesel mandates and incentives in the road transport sector where alternatives such as electrification are available, impacts the availability of biofuels in other modes, such as air and marine, where no alternatives are available
- The European Union has developed a long-term transportation policy plan that integrates multiple transport modes and other sectors such as energy, however, additional global coordination is still needed (especially for aviation and marine sectors)

- Taxation and subsidy arrangements for fossil fuels, which fail to take in the external social and environmental costs, give fossil fuels an unfair advantage. Taxing carbon emissions to reflect the social and environmental costs can help level the playing field and shift demand towards low-emissions technologies
- The introduction of a carbon tax on fossil fuels in Sweden in the 1990s have reduced the country's emissions by 20%, increased the use of alternative energy sources, including bioenergy, and made the country one of the leading nations in environmental improvements

- Electric vehicles are expensive to produce at low volumes, limiting uptake from customers and interest from automotive OEMs to continue to produce these vehicles
- Aviation biofuels are currently not available at commercial level scale due to lack of production facilities, resulting in very high prices for these fuels and limited ability for airlines to utilize these fuels

Financing

Sustainability Principles

Application Examples

Investments should be made with a long-term view that considers the value creation and risk reduction potential of environmental, social and corporate governance factors

- A diversification of energy sources for transportation (e.g. oil, natural gas, biofuels, wind/solar electricity) reduces supply interruption risk and allows for potential diversification of changes to input prices. These benefits should be priced into portfolio investment and financing decisions for sustainable transportation technologies

All public and private stakeholders in the transportation system should work together to develop business models and financing arrangements which de-risk investments in sustainable transportation technologies

- The aviation alternative fuels organization CAAFI has collaborated with the US DOE, USDA and US Navy to create a US$ 510 million financing mechanism for development of aviation biofuel production facilities on a cost-sharing basis that will benefit both the military and commercial aviation
- Electric vehicle manufacturer Renault has decided to decouple the battery from the vehicle from an ownership perspective and rent the battery to the end customer rather than selling it. This reduces the up-front cost for customers and reduces residual value risk

Financial aid for developing countries should aim to combine economic development with sustainability and job creation opportunities in sectors such as transportation, energy and agriculture

- The Mexican airport authority, ASA, and Spanish aviation research company SENASA, have collaborated to support underdeveloped rural regions through growth of sustainable aviation fuels, driving significant economic growth and supporting the development of local supply chains for fuels that can reduce emissions

Energy sources

Sustainability Principles

Application Examples

Sustainable alternative energy sources that are cost effective for transportation need to be developed and adopted by stakeholders in the transportation system

- The transportation sector can learn from other sectors' innovative use of sustainable energy sources. The IT sector has been proactive in adopting alternative energy sources for powering and cooling data centers in order to de-carbonize the sector. By integrating on-site wind generation in construction of data centres, power can be provided at low cost to the operator and optionally fed back into the grid when power demand is low for additional revenue generation

Energy sources must be sustainable from an environmental, social, and economic perspective as well as support job creation and contribute to security of supply

- Biofuels that follow robust sustainability requirements and have competitive cost versus conventional fuels offer a solution for the aviation, marine and road transport sectors to reduce their environmental footprint. Biofuels can also provide economic benefits to parts of the world that have large amounts of marginal or unviable land for food crops, but are suitable for growing second-generation biofuel crops. Many of these countries are developing nations that could benefit greatly from a new industry such as sustainable biofuels. Many countries, among them Thailand, Mexico and Spain, now see biofuels as a key enabler for poverty reduction and job creation in rural areas

Environmental sustainability of energy sources needs to be guided by life-cycle assessments that are internationally harmonized

- The production of some biofuels can be highly energy intensive or lead to indirect land use change impacts and the choice of feedstock can have a significant impact on the net emissions reductions achievable. Use of such biofuels should only be considered when the total net impact on emissions is positive when comparing to fossil fuels across the entire life cycle
- Railways and electric vehicles powered by high-carbon intensity electricity may have higher well-to-wheel emissions than highly efficient combustion engine alternatives, illustrating the need for integration of transportation policy with energy policy (power generation)

Infrastructure

Sustainability Principles

Application Examples

Opportunities to evaluate re-utilization of and integration with existing infrastructure should be analysed and identified to reduce infrastructure investment cost

- Drop-in biofuels for aviation can be fed into the same infrastructure as conventional fuel, minimizing the incremental investment required in airport infrastructure, planes and engines
- Charging of electric vehicles in homes, corporate parking facilities and parking garages can in many cases utilize existing outlets (e.g. for block heaters), depending on local electricity regulation and technical specifications

The trade-offs between infrastructure investments for different transportation technologies and the impact on other transportation modes should be considered to maximize the value of investments

- Linking road, rail, airport and port infrastructure together ensures that passengers and goods can be easily shifted to other modes . Many airports are now integrated with train stations, for example in Germany and France where Lufthansa, TGVAir and DB have collaborated to create new multi-modal hubs
- In development of national transport plans, total infrastructure costs must be compared for e.g. rail/road/air transport to ensure cost-efficient investments

Investment planning should be integrated with infrastructure programmes of other sectors and overall policy planning in other sectors (e.g. urban planning, energy, agriculture, commerce)

- To ensure successful scale-up of plug-in electric vehicles, investments in charging infrastructure for vehicles must be coordinated with electric grid transmission and distribution investments and renewable energy investments
- To ensure sufficient bioresources are available for production of sustainable biofuels in aviation, investments in biofuel-related infrastructure at airports and fuel depots need to be coordinated with agricultural policy planning
- To minimize overall investment cost, rail infrastructure investments need to be coordinated with urban planning and agricultural/landscape

End customer information

Sustainability Principles

Application Examples

End customers should be provided access to sustainable transportation alternatives that compare favorably with non-sustainable options

- Providing mobility as a service rather than a vehicle as an asset can provide added convenience to customers and overcome cost challenges related to high acquisition cost of new technologies. Examples of these new business models include the mobility-on-demand initiative Autolib in Paris and car2go across Europe and North America
- In France, SNCF and Air France have collaborated to offer customers the option to book journeys involving a combination of rail and air transport in a seamless offering

End customers should be provided information on life-cycle emissions and life-time costs of the available transportation options

- Many vehicle buyers, especially consumers, are not able to compare the total cost of ownership of options, putting plug-in electric vehicles at a disadvantage due to high acquisition cost
- All users of freight and express services (including e.g. businesses shipping goods to customers and consumers ordering articles online) need clear information on the carbon impact of their choices
- The transportation sector should look to the system of energy efficiency ratings for home appliances in Europe and assess whether a similar system could be adopted for life-cycle emissions of transportation options

Sustainability and cost information should be granular, verifiable, easily available, easily comparable and easily understandable

- The wide range of systems and processes available for consignment-level information on carbon emissions of shipments need to be harmonized so that customers can easily compare transportation options from different providers or using different transportation modes
- Many travel booking engines and websites now offer customers a breakdown of the carbon emissions associated with their travels and allows them to choose alternative means of travel or offset their emissions

Recommendations for Realizing Sustainability in Transportation

Reducing the transportation system carbon emissions – while ensuring that it can achieve sustainable growth of the transportation system to deliver both economic value to nations and social value to citizens – is a complex challenge. To drive the development of a transportation sector that is environmentally, socially and economically sustainable, all stakeholders in the transportation system must take a systemic view to the sustainability challenges, understand the relationships and dependencies between their own activities and of others, and collaborate to develop new business models and technologies. This will require modification or the introduction of new policies, practices and processes affecting all stakeholders. What is needed is a transformation of the transportation system.

To accelerate this transformation, other than the adoption of the sustainability principles outlined, a diverse range of improvements contributing to realizing environmental sustainable growth of the transportation sector have been identified. Of these, three have been highlighted by the task force as levers with significant potential for the sector: *consignment-level carbon reporting, vehicle electrification and aviation biofuels.*

For each of these specific levers, recommendations on how to accelerate their implementation are provided for each stakeholder. It should be noted that consignment-level carbon reporting focuses on a system-level transformation of the transportation industry that cuts across multiple modes, while the other two, vehicle electrification and aviation biofuels, are examples of potentially game-changing technologies for individual modes that can help address specific sustainability challenges in road and air transport.

Enabling the System-level Transformation

A set of key actions need to be taken to initiate the system-level transformation towards a more sustainable transportation system. These actions are not specific to any one technology, sector or mode, but form the foundation of reducing carbon emissions of the transport sector and address issues across policy, financing, energy sources, infrastructure, and end customers & information.

Recommendations

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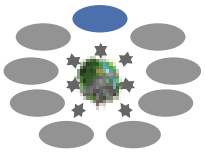
<tr>
<td> 
Policy-makers</td>
<td>Apply a holistic approach to use of energy sources in transportation

- Develop a long-term energy policy plan that integrates all transportation modes. Ensure that all transport policy measures and investments are implemented in accordance with this policy plan to create market stability for all stakeholders

- Phase out financial support, including incentives and favourable taxation, for all fossil-based fuels for transportation

- Phase out existing biofuel incentives in those transport modes where fuel alternatives exist (e.g. ethanol and biodiesel for passenger cars where plug-in electric vehicles are an option) and incentivize the development and use of sustainable fuel sources, especially for those transport modes where no viable sustainable alternatives exist (e.g. sustainable biofuels in aviation, marine, heavy trucking)

- Incentivize low-carbon energy generation to reduce carbon emissions and strengthen life-cycle emissions benefits of electrification, e.g. through renewable portfolio standards and feed-in tariffs

Encourage sustainable behaviours among end customers

- Encourage manufacturers and service providers to provide granular, verifiable and easily available, comparable and understandable information on the carbon footprint of their products and/or services and support the dissemination of this information through, for example, advisory schemes

- Encourage more efficient utilization of road transport vehicles through, for example, public transportation, car sharing and mobility on demand solutions</td>
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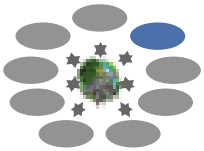
<tr>
<td> 
Suppliers
(e.g. vehicles, aircraft, components)</td>
<td>Collaborate with stakeholders to scale up use of sustainable transportation alternatives

- Identify opportunities to collaborate with players in other parts of the value chain (e.g. policy-makers, financial institutions, academia, energy providers, service providers) to develop and scale up the use sustainable transportation technologies

- Encourage the analysis of environmental, social and governance factors that may have a financial impact on investments and incorporate these into the development of corporate strategy and technology roadmap</td>
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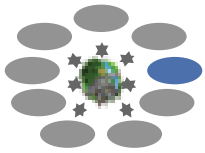
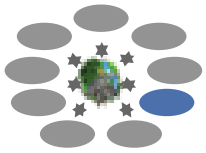
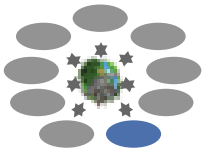
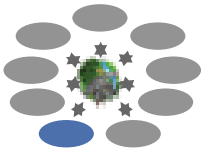
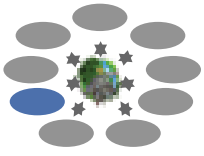
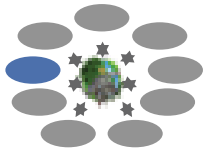
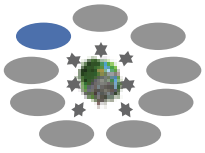
 **Energy Providers**	Collaborate with stakeholders to scale up use of sustainable transportation alternatives - Identify opportunities to collaborate with other players such as policy-makers, financial institutions, suppliers, academia and mobility service providers to support scale-up efforts of sustainable technologies - Collaborate with policy-makers and transport industry to identify mechanisms that would render alternative energy sources more cost efficient
 **Service Providers** (e.g. airlines, logistics providers, infrastructure providers)	Provide transparency on sustainability of transportation adoption - Create a neutral platform to allow companies to exchange carbon data in a transparent and consistent way and identify the gaps that need to be addressed - Harmonize practices within existing carbon reporting schemes, especially related to default CO2 emission factors, emission allocations (route specific, local network, country or global average), and use of subcontractor/supplier data in emissions calculations Be a driver for introduction of sustainable transportation alternatives - Collaborate with other service providers to develop integrated, sustainable mobility solutions, e.g. through integration of air, rail and road transport modes - Proactively adopt new sustainable transportation technologies to help build large-scale demand and support market development for these technologies
 **End Customers**	Be a driver for introduction of sustainable transportation alternatives - Proactively assess viability of switching to more sustainable transportation options, based on a holistic perspective that includes total cost of ownership and lifetime environmental impact, including modal shifts, vehicle sharing, improvement of equipment utilization and lifestyle changes
 **Financial Institutions and Corporate Investors**	Assess the full potential of sustainable transportation investments - Develop performance measurement systems for in-house and external fund managers that balance fostering a long-term perspective with short-term accountability - Encourage the analysis of environmental, social and governance (ESG) factors that may have a financial impact on investments and incorporate these into the development of corporate strategy and technology roadmap - Modify incentives for corporate executives towards superior long-term performance, for example, by including ESG factors as indirect financial performance criteria - Integrate ESG risks and opportunities fully into the process of developing corporate strategy - Create structured, regular dialogue on ESG issues between senior management and investors - Collaboratively explore mechanisms to create stability in financing markets with policy-makers and stakeholders from the transportation and other sectors
 **Academia**	Push the research envelope and educate the market – Explore innovative collaboration modes with different stakeholders in the transportation ecosystem to accelerate the development of new technologies or scale up of technologies – Analyse macro-level trends in transportation and adjacent sectors such as energy and agriculture, and develop assessment of policy impact for government – Support the development of management practices and decision support tools to enable private and public players to incorporate environmental, social and governance factors in decision-making – Provide a neutral third-party benchmarking role to industry and government studies

 **Industry Associations**	Be a hub for information sharing among stakeholders - Continue to disseminate information on industry progress in sustainability initiatives - Provide training on sustainability topics for policy-makers and executives from transportation and related sectors to bridge information gaps - Collaborate within the industry to develop a common understanding of how to reach a sustainable transportation system and disseminate recommendations to policy-makers - Raise awareness of sustainability in transportation as enabler for balanced economic growth and position industry as driver of change ("part of the solution rather than the problem") - Increase dialogue and cooperation among industry associations of the different transport modes - Encourage the participation of a wide range of perspectives (including e.g. NGOs) in defining a sustainable transportation industry vision
 **NGOs**	Be a constructive sounding board for the industry - Engage in sustainability standards development processes to avoid future disagreement over sustainability claims - Participate in industry efforts to define a sustainable transportation vision

In addition to the recommended actions covering all modes of transport and areas of the value chain, there are a wide range of specific measures to be taken to drive the transformation to a sustainable transportation system. One critical area where change is needed to enable this transformation is in the area of end customers and information. Transparent, accurate and granular information about the sustainability impact of different transportation options is critical to enable users and end customers to make more informed choices about use of these options and help accelerate the transformation.

In the logistics and transport sector, efforts have already been made to provide consignment-level (per shipment) information of carbon emissions of shipments and allocate it along the value chain. Many of the tools and systems that have been developed are complementary. However logistics companies and their end customers still struggle to efficiently collect, process and report carbon footprint data in a widely accepted form. Greater transparency and harmonization of these efforts (across countries, industries, commodity groups, transport modes and level of statistical granularity) is critical to improve the quality and uptake of reporting and to help users make more sustainable decisions.

The logistics sector is actively working to create a neutral platform to allow companies to exchange carbon data in a transparent and consistent way and identify the gaps that need to be addressed, and to harmonize practices within existing carbon reporting schemes. As part of this effort, a rigorous mapping of existing consignment carbon reporting initiatives has been developed by the project[22] and set of specific recommendations have been developed for how the industry can move towards greater harmonization and improve access to information for end customers. An illustrative example of how carbon information could be reported to end customers is shown in Figure 12.

[22] This ongoing work is being disseminated through the Consignment Carbon website at http://consignmentcarbon.org, where a link can be found to the interactive database of carbon reporting initiatives. It is expected that there will be increased focus on consignment-level carbon reporting when the new generic ISO 14067 standard on quantification and communication of carbon footprint of products/services is released in 2013.The standard can become an important reporting driver when buyers in various sectors are requesting standardized carbon footprint information from their suppliers, logistics providers included.

Figure 12: Illustrative example of consignment-level carbon emissions report

Consignment-level GHG emissions report (illustrative)

Service provided description

- Transporting of 10,000 consignments from customer facility in Seoul to customer facility in San Francisco
- Activities including in emissions reporting include: Intermodal operations, sea freight shipping and Repackaging of all consignments and road freight

Reporting parameters

Calculation method	*Averaging - 1 year*
Associated indirect activities reported	*Upstream fuel emissions*
	Embedded Lifecycle emissions in packaging
Emissions from subcontractors	*Included in calculations Reported using secondary*

Emissions reported

Direct	**18,500 kg CO_2e**
	10,000 kg CO_2e

Total emissions per consignment

2.85 kg CO_2e / consignment

Reporting standards followed

GHG Protocol - Product and Supply Chain Protocol	**Fully Compliant**
Logistics and Transport Industry Specific Reporting Guidelines	**Fully Compliant**

Plug-in Electric Vehicles in Road Transport[23]

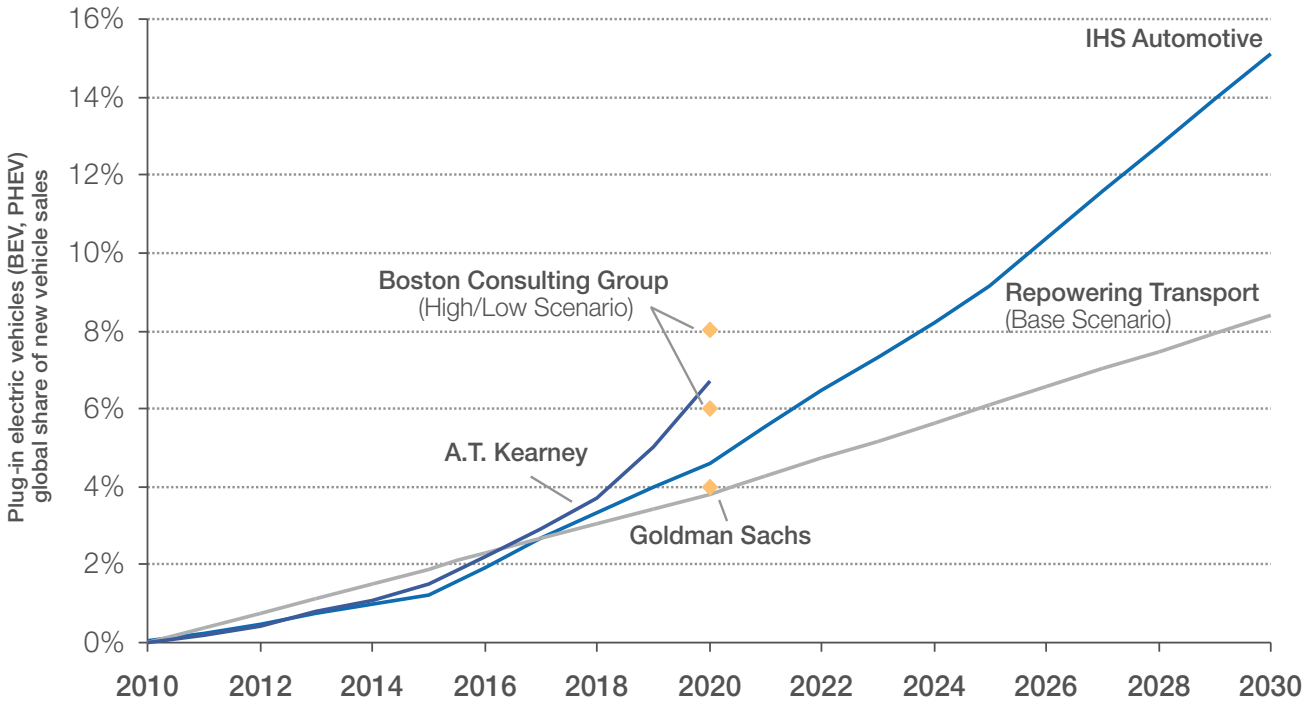
Electric drive-trains are highly efficient and provide significant reductions in emissions[24] relative to fossil fuels when low-carbon electricity is used. With increasing penetration of renewable electricity generation and continuous improvements in battery technology, electrification represents one of the most promising pathways to reduce the carbon emissions of light duty vehicles in the near term. Projections by industry players and market research firms indicate plug-in electric vehicles (battery electric vehicles (BEV), plug-in hybrid vehicles (PHEV) and range extender vehicles[25] combined) at 4-8% of new sales by 2020 and 8-15% by 2030, as shown in Figure 13.

[23] Plug-in electric vehicles (battery electric vehicles, plug-in hybrid and range extender vehicles) were analysed as part of the World Economic Forum's Repowering Transport initiative.

[24] Emissions reductions provided by plug-in electric vehicles include carbon dioxide (CO_2), nitrogen oxides (NO_x), sulfur oxides, particulate matter (PM), carbon monoxide (CO) and volatile hydrocarbons.

[25] A battery electric vehicle (BEV) is powered exclusively by an electric drivetrain and battery; a plug-in hybrid electric vehicle is powered by a combination of an electric drivetrain and a combustion engine drivetrain and contains both a battery and a fossil fuel tank; a range-extender vehicle is exclusively powered by an electric drivetrain and battery, but contains an auxiliary fossil-fuel generator and fuel tank that recharges the battery when the state of charge is low.

Figure 13: Global plug-in electric vehicle (BEV, PHEV) penetration forecasts

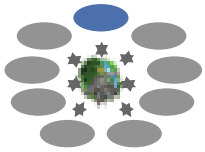


Source: IHS Automotive (2011); World Economic Forum (January 2011); A.T. Kearney (March 2011); Boston Consulting Group (July 2011); Goldman Sachs (July 2010)

Recommendations

To rapidly scale up the use of plug-in electric vehicles, a number of actions have been identified as important by the sector. Broadly, the goal of these recommendations is to address hurdles that face all stakeholders in enabling the large-scale deployment of plug-in electric vehicles and related infrastructure. Mainly, these recommendations aim to:

- Strengthen the business case for adoption of vehicles by consumers and fleet customers, and for supply of vehicles by automotive OEMs and suppliers
- Ensure the electric power grid supports scale up of plug-in electric vehicles from a technical and regulatory standpoint
- Accelerate adoption of vehicles through innovative business models and financing models



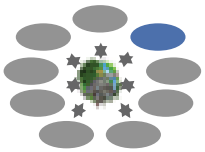
Policy-makers

Actively push and incentivize adoption of plug-in electric vehicles

- Incentivize demand for plug-in electric vehicles through a combination of non-financial incentives (e.g. zero-emission zones, bus/taxi lane access) and financial incentives that apply to a broad range of use cases (both private and fleet users, both leasing and cash purchases)
- Incentivize supply of plug-in electric vehicles through financial incentives (e.g. grants, loan guarantees, loans) to automotive OEMs and suppliers focused on research, development and design, and manufacturing
- Incentivize and play a leading role by mandating government fleets to be early adopters of new, sustainable alternatives (e.g. plug-in electric vehicles) and allow for most efficient use of vehicles through utilization management programmes that allow fleets to reduce the overall number of vehicles required
- Educate consumers about fuel consumption measures (e.g. miles per gallon equivalent) and total cost of ownership of vehicles, especially as it pertains to plug-in electric vehicles, and ensure that fuel consumption and cost information is harmonized and effectively communicated to end customers
- Explore joint procurement models between public and private fleet buyers to drive down acquisition cost through volume bundling

Ensure grid infrastructure and regulation supports uptake of plug-in electric vehicles

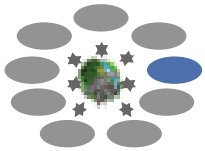
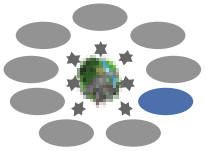
- Review electric grid regulation with utilities and other infrastructure providers to ensure cost efficient and speedy deployment of a smart electric vehicle charging infrastructure (e.g. grid connection, siting, metering, electricity sales provisioning, roaming) that does not limit adoption of plug-in electric vehicles (e.g. penalizing early adopters of large number of electric vehicles through excessive grid tariffs)
- Ensure regulation supports cost efficient and speedy deployment of plug-in electric vehicle charging infrastructure for both slow/trickle charge, as well as for solutions to recharge en-route (e.g. battery swapping, fast charging)
- Encourage utilities and infrastructure operators strengthen existing power grid distribution infrastructure and expand public charging infrastructure for plug-in electric vehicles
- Encourage and support automotive OEMs and infrastructure providers to accelerate and expand standardization interfaces (e.g. for plug-in electric vehicles and charge points)

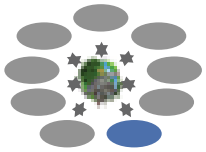
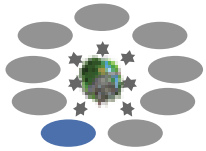
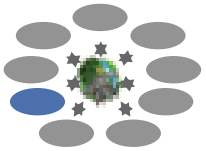
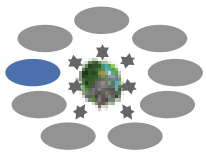
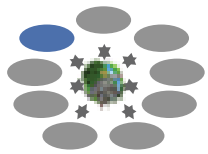


OEMs and Suppliers
(e.g. vehicles, components)

Automotive OEMs and Suppliers: Support the market with vehicles

- Accelerate development of alternative powertrains, especially plug-in electric vehicles for appropriate vehicle/customer segments. These segments are characterized by:
  1. Driving patterns are well-defined and required range is limited
  2. Up-front cost is minimized or hidden to the end customer
  3. Where introduction of plug-in electric vehicles provides additional cost savings to strengthen the business case (examples of such segments are urban deliveries, corporate fleets replacing use of taxis, urban transit applications for rental cars and taxi fleets)
- Collaborate with key customer groups (e.g. corporate and government fleets, logistics & transport and rental car providers) to identify additional functional/technical requirements for plug-in electric vehicles based on first usage experience

	- Collaborate with transportation and infrastructure providers (including both established and start-up players) to develop alternative mobility and financing solutions that make adoption of plug-in electric vehicles more attractive for end customers - Collaborate with industry partners on glider concept[26] to provide plug-in electric options to niche end customers/special vehicle segments - Support further collaboration with industry peers, utilities and governing bodies to standardize connectors and interfaces for vehicles and charge points Automotive OEMs (only): Educate end customers about Total Cost of Ownership (TCO) - Educate end customers about total cost of ownership of vehicles, including plug-in electric vehicles [26] Vehicles produced by an automotive OEM without powertrain, typically sold to partners that install alternative powertrain options and sell vehicles to end customers.
 **Energy Providers**	Ensure grid infrastructure supports large-scale deployment - Identify local bottleneck areas in distribution/last mile infrastructure and proactively upgrade grid to support electric vehicle deployment - Develop commercial offerings to support mass-market adoption of plug-in electric vehicles among customer base - Collaboratively foster and encourage start-up players to develop and launch new mobility models - Support further collaboration with industry peers, automotive OEMs and governing bodies to standardize connectors and interfaces for vehicles and charge points
 **Service Providers**	Fleet operators (e.g. logistics, rental car fleets, corporate fleets): Generate demand for vehicles - Analyse driving patterns of existing fleet to determine potential to migrate to plug-in electric vehicles - Proactively pilot plug-in electric vehicles in existing fleet to help support market development and familiarize end customers with electric vehicles - Collaborate with automotive OEMs on operational testing and share key functional and technical requirements for plug-in electric vehicles - Clearly communicate demand for cleaner vehicles towards automotive OEMs in procurement processes and support development and innovation by committing to long-term, high-volume demand of vehicles (e.g. through buying consortia) - Cooperate with infrastructure providers to overcome customer concerns/limitations (e.g. next charging station, information on charging etc.) - Cooperate with utilities to identify limitations/hot spots in electric grid and ensure adequate level of public infrastructure availability - Cooperate with cities and other government bodies to increase the penetration of plug-in electric vehicles in cities

 **End Customers**	Be a driver for introduction of plug-in electric vehicles - Push OEMs for transparency of "total cost of ownership" for all alternative technologies - Communicate required need for charging infrastructure and push energy providers to offer appropriate solutions - Address to local policy-makers the need for support of the early adopters of sustainable technology alternatives
 **Financial Institutions**	Provide innovative solutions to the financing issue - Collaborate with players in the plug-in electric vehicle value chain (e.g. vehicles, infrastructure, mobility services) to develop new financing models for vehicles (e.g. battery leasing) - Build in-house capabilities and knowledge around electric vehicles and battery technologies to insure development of attractive market offerings (e.g. with either appropriate residual value calculations or new innovative offerings overcoming the uncertainty of the residual value)
 **Academia and Research Institutes**	Educate all stakeholders in the transportation system - Identify opportunities to collaborate with players in other parts of the value chain (e.g. policy-makers, financial institutions, suppliers, energy providers, service providers) to develop and push commercialization of sustainable transportation technologies - Educate industries and support them with a strategic/long-term view of the potential of sustainable technologies - Educate governments and end customers (especially end customers) about well-to-wheel emissions and total cost of ownership methodology - Support private industry players with development of new and improved battery technologies to further enhance the applicability and attractiveness of electric transportation - Invest in research and development to further advance technologies that are more sustainable, or identify new alternatives
 **Industry Associations**  **NGOs**	Be a hub for information sharing among stakeholders - Support advocacy and awareness of plug-in electric vehicles and bring together relevant stakeholders to ensure collaboration - Educate consumers about total cost of ownership of vehicles, including plug-in electric vehicles - Initiate and support cross-business partnerships to facilitate the propagation of plug-in electric vehicles, e.g. through buying consortia

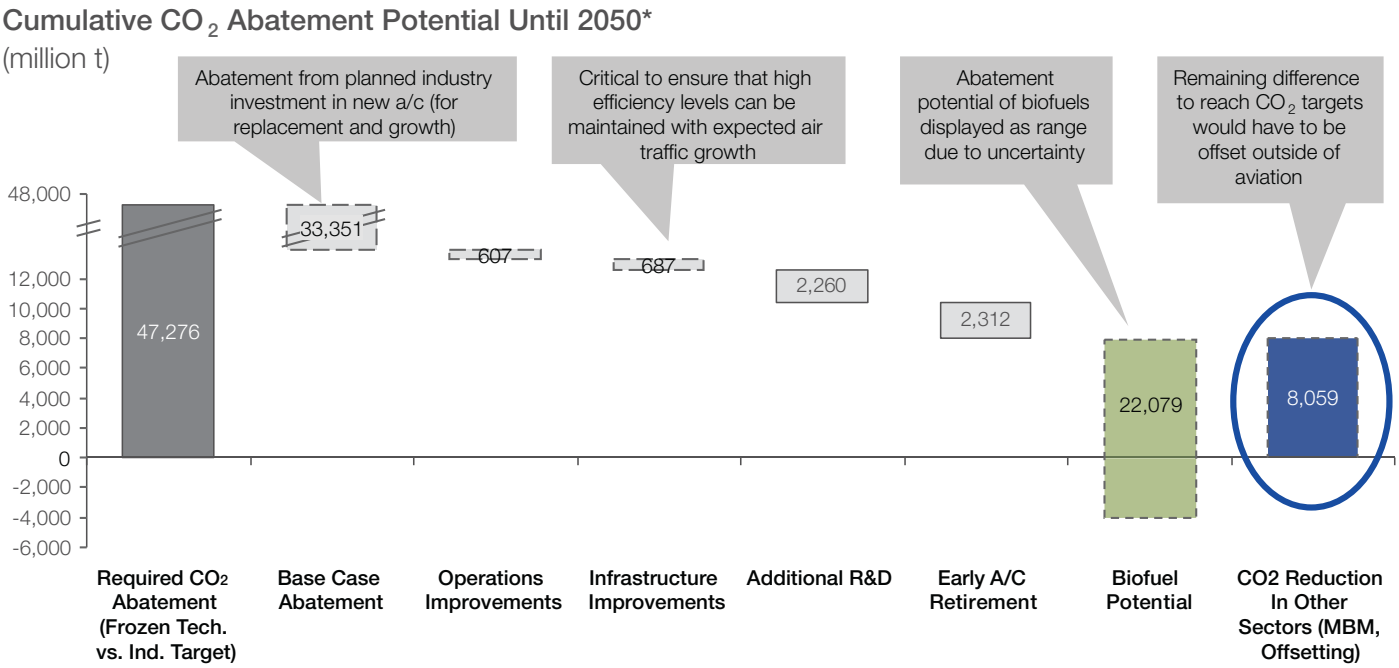
Biofuels in Air Transport[27]

Sustainable, second-generation biofuels with low life-cycle emissions (e.g. from algae, energy crops such as jatropha, camelina and salicornia, sugar cane, forestry waste, urban and industrial waste, etc.) constitute one of the most promising levers for CO_2 abatement for the air transport sector. This is especially true for the aviation industry where technology (such as engines and fuelling infrastructure) is highly standardized and compatible, and distribution points highly concentrated.

As illustrated in Figure 14, improvements to operations and infrastructure, additional R&D and early aircraft retirement can only meet a portion of the emissions reductions needs for the industry,[28] and highlights that biofuels remain the critical lever to achieve the targets.[29]

Figure 14: Carbon emission reduction levers in aviation[30]

Source: World Economic Forum/Booz analysis based on ICAO, FESG, Industry forecasts



* Required CO_2 abatement calculated based on gap between projected CO_2 emissions from Base Case and agreed industry target; Carbon neutral growth assumed from 2020 until 2049 at 2020 CO_2 emission level for calculation of required cumulative CO_2 abatement.

Second-generation biofuels that comply with robust international sustainability guidelines (such as those laid out by the Roundtable on Sustainable Biofuels) are being developed and have already been successfully adopted on a demonstration scale.[31] To date, more than 1,000 commercial flights have taken place since certification of biofuels, proving their technical feasibility. However, despite the numerous successful test flights, a number of challenges still exist to scale up of commercial aviation biofuels (see spotlight box below for further details). To overcome these challenges, a concerted effort by all value-chain players, particularly policy-makers and the financial sector, will need to be made to scale up the production of second-generation biofuels and enable the industry to utilize this fuel commercially.

[27] Biofuels for aviation were analysed as part of the World Economic Forum's Policies and Collaborative Partnership for Sustainable Aviation initiative.

[28] Other emission reductions levers (operations improvements, infrastructure improvements, additional R&D and early R&D retirement) will only provide about 40% of the required reduction beyond planned industry investment in new aircraft.

[29] While alternative energy sources (e.g. hydrogen, photovoltaic) have been assessed by the aviation industry for commercial aviation, these technologies are at the concept stage and not likely to be commercialized within the next decades for commercial aviation purposes.

[30] To meet industry goals, several abatement measures can be employed: accelerated or improved R&D to reduce introductory time or improve fuel efficiency of new aircraft; early aircraft retirement to take old inefficient a/c out of market; biofuels as substitute for jet fuel; operations improvements for optimized flight operations/ weight reduction; infrastructure Improvements for improved ATM, airspace design and air routes; ETS, offsetting as economical measures outside sector; and limit growth/demand.

[31] Current ASTM specifications for sustainable alternative aviation fuels allows for a blend of up to 50% alternative fuel content; industry is continuously working to increase this drop-in rate to 100%.

Spotlight: Scaling Up the Use of Biofuels in Aviation

The two fundamental issues faced by aviation biofuels are scale and breadth of uses. The scale issue arises because even for biofuels already certified, unit costs – at 1.5 to 3 times the cost of fossils-based fuels – are still too high to incentivize airlines to commit to significant take-up. The breadth of uses raises the question of where biofuels will take off – in aviation, in other modes of transportation, in higher value-added applications (e.g. bio-chemicals).

These two issues reverberate across most stages of the value chain, creating a "chicken and egg" problem that makes it impossible to create the right environment for fast development without a collaborative approach.
Starting with the end user, airlines have proven to be active sponsors in the early development of biofuels, but are not ready to bring their commitment to the next level (i.e. guaranteed uptakes). With fuel accounting for a quarter to one-third of their operating costs, no individual airline can afford the risk of a significant fuel cost disadvantage versus its competitors.

Even though the supply curve of fossils-based fuel points to a long term rise in kerosene costs, while scale in alternative fuels should gradually bring biofuel cost down, history shows that geopolitical events can push oil prices down as well as up for sustained periods of time; long enough to cause significant damage to an airline that would have committed too aggressively to biofuels.

- Distribution, from refineries to pipelines (or other modes of transport) to airport storage and hydrant systems, is often controlled, at least partially, by oil companies. The attractiveness of "dropping-in" biofuels varies depending on the supply-demand balance and economics of their refineries upstream. When controlled by state-related organizations (e.g. Mexico), these infrastructures can be an effective promoter of aviation biofuels as they represent substantial end use scale. Their decisions impact all airlines equally (i.e. limited competitive distortion).

- Biofuel refiners need scale to produce at fuel-competitive costs. While the economics of some technologies (particularly based on vegetable crops) are relatively well understood, others (e.g. waste, algae) will need more time and development to stabilize. Refiners also face alternatives in terms of end use – aviation versus other applications. Lack of certainty on both is restraining the availability of funding for biofuel refinery investments.

- Raw material costs are also driven by scale. Farming's primary role is to supply the food chain. While in some instances agricultural land can be used between food crop cycles to grow second generation crops, the use of land marginal or unsuitable for food crops provides great opportunity for second-generation biofuels. With refining costs very much driven by scale, and transportation costs a significant cost component for delivered raw material, sizable agricultural operations are required that will need substantial upfront costs in land preparation, water availability, access infrastructure, etc. Reliable end customer markets in biofuel are needed to justify these investments.

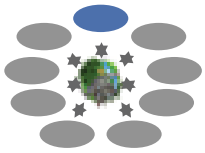
- R&D is needed at crop productivity as well as conversion levels. Privately-funded research is facing uncertainty in terms of both size and timing of the "prize". When will there be sufficient demand for biofuels? Is aviation the right application to bet on, or will some other application dominate?

- Investors, including large industrial and agricultural companies, financial markets, venture capitalists, etc., face the same uncertainty as direct value chain participants regarding scale and end use uncertainty.

Recommendations

To rapidly scale up production of aviation biofuel, a number of actions have been identified as important by the sector. Broadly, the goal of these recommendations is to address hurdles that face all stakeholders in enabling the large-scale, common production and usage of aviation biofuels. Mainly, these recommendations aim at:

- Incentivizing initial scale-up of the aviation biofuel value chain for ensuring cost-effect production and use
- Establishing risk-sharing mechanisms for scale-up across the aviation biofuel value chain
- Leveraging aviation biofuel development as an economic development lever
- Ensuring consistent and stable volume of production and demand for aviation biofuels



Policy-makers

Understand the opportunity in biofuels for aviation

- Involve a wide range of government departments and all relevant stakeholders to assess and understand benefits of aviation biofuels on national energy security policy through diversity of supply (feedstock development), potential for job creation (through technology development) and economic development, overall reaching of national emission reductions targets feedstock development
- Collaborate with governments and key stakeholders in the value chain in other countries to share and adopt best practices on development and adoption of aviation biofuels and support opportunities for large-scale pilots on use of biofuels in aviation

Spotlight: Opportunities of Aviation Biofuels in Mexico/Spain

The Mexican airport authority ASA and Spanish research group SENASA collaborated with their respective transport secretariats on assessing the opportunities of aviation biofuel production in underdeveloped areas of Mexico and Spain. The group identified common interests in the areas of emissions reductions, sustainable agricultural production, energy dependency reduction, development of rural areas and job creation. In Spain, the group found that each 100 hectares of land used for camelina production for aviation biofuels generated 1.5 direct jobs and 0.7 indirect jobs.

Enable cost-effective adoption of biofuels by airlines

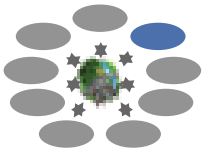
- Harmonize expeditiously biofuel sustainability criteria between regions, especially as it relates to market-based measures, to ensure use of biofuels on international flights are recognized both at origin and destination
- Collaborate with the aviation industry to ensure accounting procedures for use of biofuels are practical and cost-effective, e.g. basing taxation/credits on low-carbon biofuel content purchased rather than consumed
- Harmonize operational fuel handling and distribution to ensure consistent, high-quality fuel
- Incentivize oil and chemical companies to focus biofuel investments on fuel types appropriate for modes of transport where no other sustainable alternatives exist, such as aviation and marine (e.g. bio jet, biodiesel)

Strengthen the business case for use of biofuels by airlines

- Provide financial support (e.g. co-financing, tax incentives, loan guarantees, grants) or other support (e.g. sites, involvement of military as large scale pilot user, R&D and production facilities for aviation biofuels) that ensures a viable business case for stakeholders today and a move towards full private sector financing in the future
- Accelerate global certification of new production processes for aviation biofuels
- Consider directing a portion of least developed country aid programmes towards development of large-scale biofuel raw material production
- Consider global (distortion-free) agreement on biofuel penetration in aviation

Spotlight: Collaborative Financing of Aviation Biofuels in the United States

The US aviation industry, through the alternative fuels advocacy organization CAAFI, collaborated with the US Navy and US Department of Agriculture to make available US$ 510 million in funds to provide cost-sharing financing for aviation biofuels production facilities for military applications. The development of biofuel production facilities for military applications is expected to drive increased availability and cost reductions also for commercial aviation applications



Suppliers
(e.g. aircraft, components, engine OEMs, full system components)

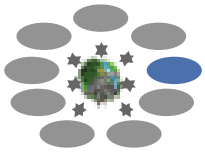
Aircraft manufacturers: Support the entire value chain

- Support aviation biofuel development and production through aerospace and defence offset agreement investment mechanisms and other strategic investments in local research, design and development based on an objective assessment of the merits of technologies and companies
- Collaborate with government, airlines, energy players, agricultural sector and academia to ensure local economic growth opportunities for aviation biofuel production with limited environmental impact mature to the commercialization stage

Spotlight: Collaborative Action for Commercialization

A broad range of stakeholders, including the EU, Airbus, Air France/KLM, BA, Lufthansa, Choren, Neste Oil, UOP and the Biomass Technology Group are collaborating to commercialize biofuels in Europe, with specific focus on:

- Facilitating the development of standards for drop-in biofuels and their certification for use in commercial aircrafts
- Working together with the full supply chain to further develop worldwide accepted sustainability certification frameworks
- Agreeing on biofuel take-off arrangements over a defined period of time and at a reasonable cost
- Promoting appropriate public and private actions to ensure the market uptake of paraffinic biofuels by the aviation sector
- Establishing financing structures to facilitate the realization of 2G biofuel projects
- Accelerating targeted research and innovation for advanced biofuel technologies, and especially algae
- Taking concrete actions to inform the European citizen of the benefits of replacing kerosene by certified sustainable biofuels



Energy Providers

Oil/chemical companies: Strengthen involvement in biofuels for aviation

- Focus biofuel investments on fuel types appropriate for modes of transport where no other sustainable alternatives exist, such as aviation and marine (e.g. biojet, biodiesel)
- Biofuel use should continue to be in line with sustainability criteria[32]
- Collaborate with government, aviation and agricultural sector and academia to ensure local economic growth opportunities for aviation biofuel production with limited environmental impact mature to the commercialization stage

Spotlight: Aviation Biofuels in Thailand

Thai Airways worked with Thai energy company PTT Public Company to provide aviation biofuel for the first passenger biofuels flight in Asia on 22 December 2011, operated by Thai Airways between Bangkok and Chang Mai. PTT Public Company collaborated with the Dutch biofuel agent Sky NRG to source the 50/50% blended biofuel

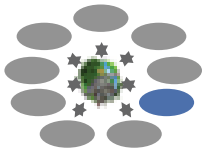
Feedstock suppliers: Monitor and adhere to sustainability criteria

- Closely monitor developments in sustainability standards and ensure adherence to these standards
- Collaborate with governments, aviation, energy sector and academia to ensure local economic growth opportunities for aviation biofuel production with limited environmental impact mature to the commercialization stage

Spotlight: Flexible Biorefineries for Aviation Biofuels

As part of the World Economic Forum's work with the aviation and chemicals industries, the two industries came together in a joint session to explore opportunities for development of biofuels for aviation through flexible biorefineries, which can accept and produce a wide range of feedstock and end products and easily be adapted to changes in demand

[32] e.g. sustainability criteria set forth by the Roundtable on Sustainable Biofuels (http://rsb.epfl.ch).



Service Providers
(e.g. airlines, logistics providers)

Airlines: Continue to be the catalyst for change

- Collaborate with stakeholders in the value chain (e.g. biofuel suppliers, policy-makers, financial institutions) to share investments risk in aviation biofuels (e.g. off-take agreements for biofuel production, financing mechanisms for biofuels)
- Biofuel use should continue to be in line with sustainability criteria
- Collaborate with government, energy players, agricultural sector and academia to ensure local economic growth opportunities for aviation biofuel production with limited environmental impact mature to the commercialization stage
- Ensure large solid and large-scale demand for biofuels (e.g. through the integration of demand in buying consortia)
- Study industry-wide (i.e. non-competition distorting) alternatives available to local, state and regional governments to share the risk of biofuel use

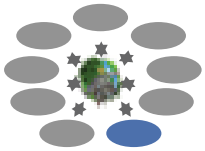
Spotlight: Aviation Biofuel Pilot Flights

A wide range of pilot initiatives have been conducted by the aviation industry to test the technical feasibility of biofuels. The Sustainable Transportation Ecosystem database lists 30 major pilot initiatives conducted in every region of the world. See Appendix for complete details of all projects.

In Germany, Lufthansa has tested the long-term impacts of biofuels on aircraft engines through a six-month trial of a 50/50 jet fuel mix on a dedicated A321 flying the Hamburg-Frankfurt-Hamburg sector. Results will be published in March.

In the United Kingdom, British Airways is developing a biofuel plant with Solena, which will convert London municipal waste into aviation biofuels for use in BA flights operating out of London City Airport.

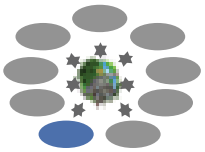
In China, Air China, Boeing and PetroChina are collaborating on feedstock harvesting and processing, establishment of refining capacity for commercial production from jatropha, and the development of the infrastructure to store, deliver and dispense biofuels.



End Customers

Make informed choices about transportation alternatives

- Demand and utilize biofuel usage information provided by airlines and transportation providers to make informed choices about use of transportation alternatives



Financial Institutions

Private financial institutions: Work to resolve the financing issue

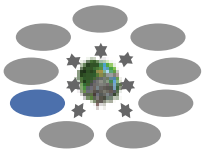
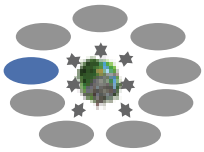
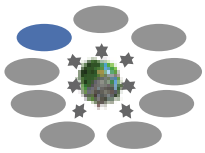
- Collaborate with players across the biojet fuel supply chain (feedstock providers, biofuel producers, oil companies, into-plane providers, airlines) to de-risk investments in aviation biofuel production

Private financial institutions: Work to resolve the financing issue

- Support early phase financing of feedstock and biofuel production in collaboration with stakeholders in the aviation industry

Spotlight: Sustainable Aviation Biofuel Production in Brazil

The Inter-American Development Bank collaborated with Boeing and Embraer to finance a sustainability analysis of renewable jet fuel from sugar cane in Brazil, based on the production process of Amyris. The study assessed the environmental and market conditions associated with production and use of the biofuels and will be independently reviewed by the WWF when the study is completed in early 2012. The study will be an important step in assessing the sugarcane-to-jet pathway for biofuels which will allow further diversification of input sources.

 **Academia**	Push the research envelope - Continue to research new pathways and improvements to existing pathways for biojet fuel to drive down cost and expand range of production options for aviation biofuels
 **Industry Association and Standards Bodies**	Be a hub for information sharing among stakeholders – Continue to support dissemination of best practices for production and use of aviation biofuels with a wide range of stakeholders, including policy-makers (covering transportation, energy, agriculture, defence, urban planning, commerce, trade, etc.), academia, financial institutions, end customers, oil companies and chemical companies
 **NGOs**	Be a constructive sounding board for the industry – Engage in sustainability standards development processes for aviation biofuels to avoid future disagreement over sustainability claims

Conclusions

Having outlined an approach and concrete steps for how the transportation system can collaboratively address the sustainability challenges ahead, the question remains: Where does the industry go from here?

There are promising signs that the transportation sector is gradually moving towards an integrated approach in the marketplace; new multi-modal offerings and integration of offerings that previously were separate are now becoming available.

In Switzerland, for example, the Swiss transport concept integrates air travel through Swiss International Air Lines with public transport and rail offerings from SBB, the national train network. In France, Air France and SNCF, the country's state-owned railway company, are collaborating on integrating air and rail to form a seamless offering to end customer. From the end customer perspective, this is a net win – end customers are increasingly looking for a way to get from point A to point B that is simple and effortless, integrated, cost-effective and offers a low impact on the environment.

Conversely, inter-modal and integrated offerings also allow service providers to deliver a more compelling product to end customers and enable them to address environmental sustainability from a system perspective by moving end customers to lower carbon intensity options.

The developments in the transportation industry are in many ways similar to what happened in the telecommunications and media sectors in the 1990s where a convergence of new technologies and media – such as fixed and mobile voice, fixed and mobile Internet, and TV services – enabled completely new customer offerings and strong growth opportunities for businesses. Similarly, the transportation sector appears to be at an inflection point today where new transportation technologies (e.g. electric vehicles or aviation biofuels) are maturing, information technology allows for increased efficiency and transparency (e.g. prevalence of smartphones) and new mobility models (e.g. on-demand mobility) enable new paradigms to be realized. As these offerings and solutions mature, players in the transportation system will increasingly be able to address sustainability from a holistic system perspective.

In light of macro-developments in the transportation system discussed above, the broad agreement of the sustainability principles and recommendations in this report by a wide range of leading transportation players points to a promising pathway for sustainability in transportation. As the industry continues to address sustainability going forward, key next steps for players will be to not only implement the recommended actions for the transformation of the transportation system and for vehicle electrification and aviation biofuels outlined in this report, but also to apply the sustainability principles to new challenges (e.g. promoting the use of lower carbon intensity transport modes, increasing vehicle utilization).

A critical milestone will be to enhance and reinforce existing alliances that have been formed around sustainability efforts, such as vehicle electrification and aviation biofuels, on a national, regional and international level and move towards implementation of the respective solutions. With this integrated view to sustainability in transportation, the industry has a unique opportunity not only to address the challenges ahead, but also to seize new opportunities at a critical moment.

We, as the industry players that have contributed to this report, stand ready to take on the challenges that lie ahead of us. Collaboration will be essential if we are to be successful, and we challenge everyone to engage with us on this journey.

Appendix

These appendices outline recent and current activities within the areas of aviation biofuels and vehicle electrification, and point towards best practices from different regions of the world that can be leveraged in geographies where the enabling environment for sustainable transportation alternatives is currently developing.

Current State of Biofuels for Aviation

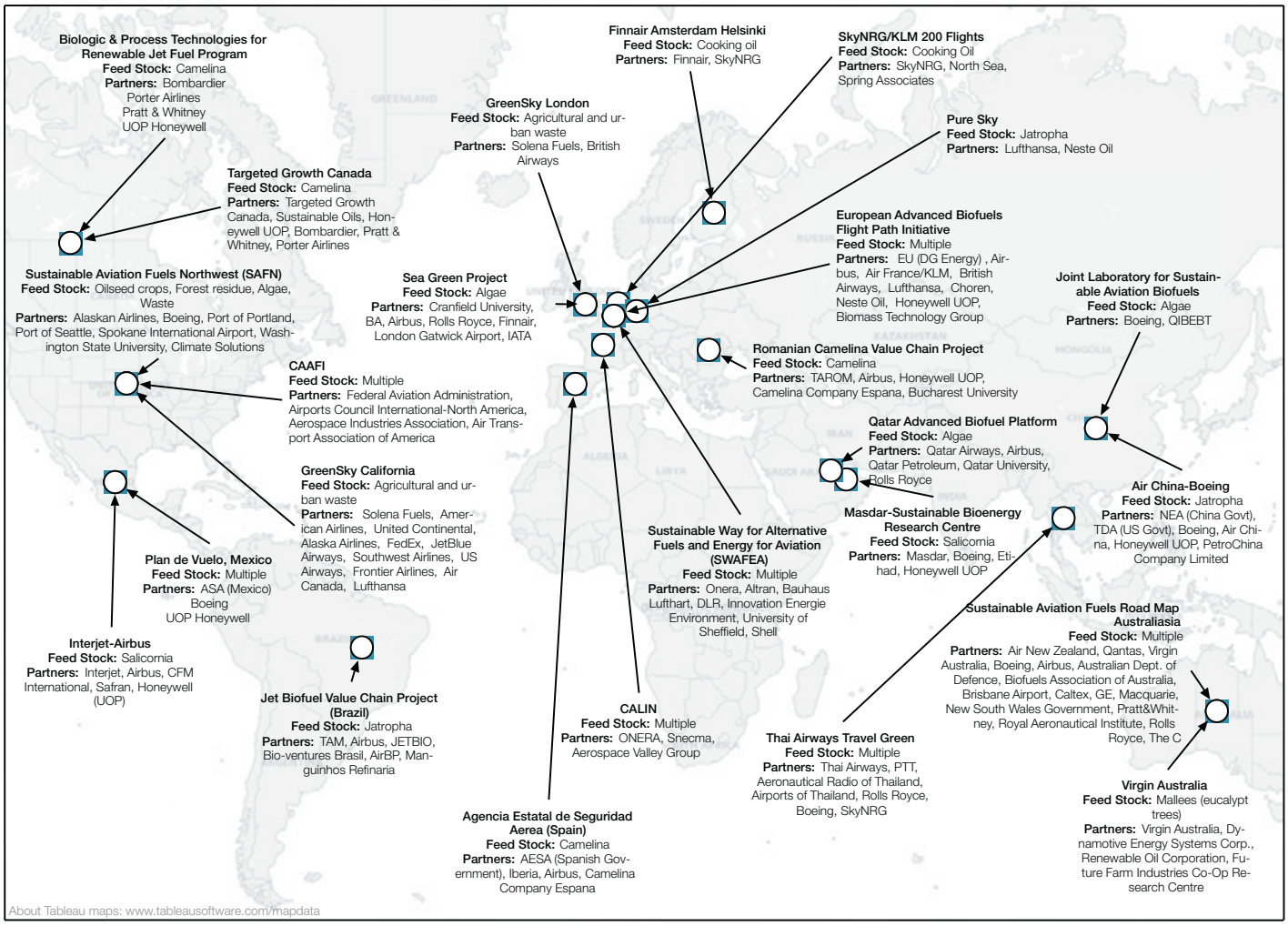
Existing Aviation Biofuel Initiatives

The project has catalogued a number of initiatives related to aviation biofuels, including groups working to facilitate the introduction of biofuels in aviation (e.g. SWAFEA in the European Union, ABRABA in Brazil); action groups driven by airlines to develop sustainable aviation fuels (e.g. the Masdar Sustainable Bioenergy Research Centre headed by Etihad, Boeing, Honeywell UOP and the Masdar Institute); and pilot projects for use of biofuels on commercial flights (e.g. Lufthansa's Pure Sky initiative, British Airways' GreenSky London initiative and ASA's Plan de Vuelo initiative in Mexico).

The complete list of initiatives will be posted online following the publication of this report. The ICAO also publishes a list of initiatives related to biofuels in aviation on their website.[33] Figure 15 illustrates a limited selection of pilot projects that have been conducted by the aviation industry in recent years.

[33] See http://www.icao.int/environmental-protection/Pages/GlobalFramework.aspx.

Figure 15: Selected aviation biofuel pilot projects (non-exhaustive)



Supporting Environment for Biofuels in Aviation

The following pages outline the state of the enabling environment for aviation biofuels in 10 regions of the world, covering North America, South America, Europe, Africa, Asia and Australia. The information may be used to prioritize policy initiatives and pilot projects on a regional basis and assess best practices from regions that have already put in place an enabling environment for the commercialization of these fuels.

	United States	Brazil
Available feedstock • Types of feedstock available (that have favourable growth conditions/ high availability)	• Oilseeds, e.g. lipids, camelina, canola, rapeseed • Agricultural/urban waste • Forest residue • Algae (1) • Cooking oil (1)	• Soybean stalks and leaves • Corn stalks and stems • Forest residue • Sugar cane (tops and bagasse) • Jatropha
Feedstock scalability • Amount of land available for feedstock production • Feedstock growing season and growth conditions	• Agriculture a major industry, net exporter of food • World's largest producer of biofuels, almost entirely first generation • Projected 54 to 348 Mha available for bioenergy production in 2050 • Wide-scale intercropping of wheat and camelina possible	• 264 Mha total agricultural area today • Agriculture provides 34% of GDP, 37% of jobs, 43% of national exports • Major land areas dedicated to biofuel production of sugar cane and oil palm
Refinery capacity and competence • Number of existing and planned biorefineries • Fossil fuel refinery industry presence	• World's largest producer of biofuels, significant competence on biofuels • Future direction of refining capacity uncertain – today being scaled down, but strong government incentives for biojet production may grow bio-refinery scale	• Major technology hub due to strong first generation biofuel position, one of the global leaders in development of biofuels
Infrastructure access • Ownership structure of airports and fuel supply infrastructure • Level of regulation of airports and fuel supply infrastructure	• Commercial airports typically operated by government airport/port authorities	• Airports representing 97% of traffic state owned by Infraero • Government owns 64% of Petrobras • Rail & port network in poor condition, majority of domestic transport by truck
Biofuels know-how • History of existing biofuel initiatives, especially within aviation • Strength of biofuel technology industry and research facilities	• Strong bioenergy technology environment, especially along the West Coast • Aviation seen as an important biofuel customer	• Brazil second largest producer of biofuels worldwide (34% global share), majority ethanol from sugar cane • Second-generation biofuel processes (e.g. alcohol-to-jet, direct sugar to jet) underdevelopment
Political biofuel support • Aviation biofuel ambitions • Aviation biofuel legislation • Aviation's importance to economy	• RFS2 regulation (volume mandate strongly incentivizing biofuel production, biojet can in principle be included) • RFS2 regulation facilitates biofuel or feedstock imports • Government recently announced US$ 510 million in funds to provide cost sharing financing for aviation biofuels production facilities for military applications • Other support programmes (e.g. Farm-to-Fly) by US Department of Agriculture • Strong relationship and cooperation between airlines, government (especially defence department), and organizations such as CAAFI	• Historically funded biofuel production capacity and subsidies for usage, leader in biofuel policy • By 2013, 5% ethanol blend will be mandatory for vehicles • No policies for second gen fuels or aviation biofuels yet adopted • Bilateral agreement between US and Brazil on sustainable aviation fuels • Intends to introduce a biodiesel blend mandate diverting feedstock away from biojet production • Little interaction between government and private sector
Political stability and expediency • Risk of political and social unrest • Political red tape • Efficiency of political processes	• From a relative perspective, stable financial/political environment • Economic downturn a major concern, polarized congress has shown little ability to act • Energy security motivates more strongly than environment	• World Bank ranks Brazil 121 out of 175 countries for foreign investment, due to tax rates, macroeconomic instability, policy uncertainty and cost of financing
Availability of financing • Availability of support mechanisms (e.g. CDM funds, World Bank and regional development banks) • Presence of finance industry (e.g. private equity, venture), especially with focus on clean tech/biofuels	• Availability of financing has been a challenge to date • Government recently announced US$ 510 million in funds to provide cost sharing financing for aviation biofuels production facilities for military applications • US a major hub for clean tech investment community	• IDB, Boeing and Embraer funding sustainability analysis on production of aviation biofuels from sugar cane in Brazil • No government funds for R&D in second-generation biofuels

(1) Available in multiple geographies

	Mexico	EU (France, Italy, Spain, Germany, UK)
Available feedstock • Types of feedstock available (that have favourable growth conditions/ high availability)	• Jatropha • Castor • Salicornia • Sugar cane • Corn stalk and stems • Agave	• Camelina • Agricultural/urban waste • Algae (1) • Rapeseed • Lignocellulose, e.g. forest residues • Cooking oil (1)
Feedstock scalability • Amount of land available for feedstock production • Feedstock growing season and growth conditions	• Agriculture a major employer, but a decreasing share of GDP • Only sugar cane production in surplus, other sectors cannot satisfy demand • Feedstock availability major restriction	• 47.8 Mha available land area for production of energy crops projected to be available in EU27 by 2030 • Highest potential in Poland, Romania, Spain, France, Germany (>3 Mha)
Refinery capacity and competence • Number of existing and planned biorefineries • Fossil fuel refinery industry presence	• Highly developed oil, gas and petrochemical industries • Net exporter of oil, but imports 40% of gasoline due to lack of refineries. Government keen to provide investment for refineries • Top-level universities and agricultural and technological institutions present	• Strong automotive biofuel refinery capacity that is not easily converted for biojet • Netherlands a major global refinery and supply hub for jet fuel • Other refineries: Finland (Neste), planned in UK (Solena), Germany (Choren) etc.
Infrastructure access • Ownership structure of airports and fuel supply infrastructure • Level of regulation of airports and fuel supply infrastructure	• PEMEX is 100% state owned • The ASA government agency operates 18 airports and 61 fuel stations • Road network in poor condition in certain areas of the country	• Airports typically fully or partly owned by government (e.g. BAA, Fraport) but operated by private players • CEPS pipeline provides fuel supply infrastructure to BE, FR, NL, LU, DE
Biofuels know-how • History of existing biofuel initiatives, especially within aviation • Strength of biofuel technology industry and research facilities	• No large-scale production of first-generation biofuels today • Strong activities to enter the aviation biofuels market (Plan de Vuelo project) • Significant fossil fuel and chemical competence through oil, gas and petrochemical industry	• Very strong automotive biofuel experience • Several European airlines pushing biofuel initiatives in advance of ETS for aviation sector • Key players in biojet are SkyNRG, Neste Oil
Political biofuel support • Aviation biofuel ambitions • Aviation biofuel legislation • Aviation's importance to economy	• No current blending targets or financial support for vehicles • Boeing, ASA, Ministry of Comm. And Transport, UOP working to identify opportunities for aviation biofuels • Subsidies for jatropha plantations	• EU set target of 10% of renewable energy in transportation sector by 2020 • EU ETS expanded to aviation sector from 2012 • Environmental concerns a key driver • R&D funding, e.g. EIBI, NER300 • Biofuels FlightPath project (aim: 2 Mt/year by 2020) • Number of member states have failed to include reference to biojet in their transposition of the RED (no economic support). Little consensus on requirements, hard for airlines to follow • Biodiesel blend mandates lower feedstock availability for biojet
Political stability and expediency • Risk of political and social unrest • Political red tape • Efficiency of political processes	• World Bank ranks Mexico as 54 out of 175 countries for ease of doing business • Stability and security concerns due to outbreaks of violence in certain areas	• From a relative (global) perspective, stable financial/political environment • Economic downturn a major concern, especially in selected countries
Availability of financing • Availability of support mechanisms (e.g. CDM funds, World Bank and regional development banks) • Presence of finance industry (e.g. private equity, venture), especially with focus on clean tech/biofuels	• Mexico's membership in NAFTA allows for export opportunities and easier supply of foreign capital • Significant agricultural government support ($6 bn. in '07) to sugar cane producers could be reduced if biofuels added value to residues	• Investors invited through Biofuels Flightpath project

(1) Available in multiple geographies

	Mozambique	South Africa
Available feedstock •Types of feedstock available (that have favourable growth conditions/ high availability)	• Jatropha	• Jatropha, but controversy regarding environmental impact • Maringa • Sugar cane • Forestry residues
Feedstock scalability •Amount of land available for feedstock production •Feedstock growing season and growth conditions	• More than 80% of population engaged in small-scale agricultural production, but lack of infrastructure, commercial networks and financing • Majority of land uncultivated today, large potential for growth in the future	• Large commercial farming sector • Net exporter of agricultural products • Due to aridity of land, only 13.5% of land can be used for crop production • Already utilizes most crops and residues, biofuels would compete
Refinery capacity and competence •Number of existing and planned biorefineries •Fossil fuel refinery industry presence	• New investments into oil refineries considered in recent years, but little activity prior to this	• Develops synthetic fuels (28% of domestic use) through CTL and GTL refineries using FT processes
Infrastructure access •Ownership structure of airports and fuel supply infrastructure •Level of regulation of airports and fuel supply infrastructure	• Major gas and oil exploration activities, but exclusively conducted by international oil companies • Not a major fuel supplier or airport hub	• Government not a major shareholder in SASOL (holds 13% through government pension fund) • Airports Company SA owns 10 major airports, ACSA majority controlled by government
Biofuels know-how •History of existing biofuel initiatives, especially within aviation •Strength of biofuel technology industry and research facilities	• Investments by foreign players such as Sun Biofuels (UK), but little domestic competence	• Historically used sugar cane-derived bioethanol for road transport, but little use today • Considering scaling up of corn-based ethanol due to high oil prices
Political biofuel support •Aviation biofuel ambitions •Aviation biofuel legislation •Aviation's importance to economy	• Growth of jatropha strongly supported by government, but controversy due to concerns of impact to land use and food supply	• South African Biofuel Strategy from 2007 set a 5-year target of 2% biofuel of liquid fuel consumption • Biofuel considered primarily for rural development purposes
Political stability and expediency •Risk of political and social unrest •Political red tape •Efficiency of political processes	• World Bank ranks Mozambique in the 40% percentile for political stability and government effectiveness	• Stable political and investment environment • Well managed and regulated banking sector and sound economic fundamentals
Availability of financing •Availability of support mechanisms (e.g. CDM funds, World Bank and regional development banks) •Presence of finance industry (e.g. private equity, venture), especially with focus on clean tech/biofuels	• No specific programmes identified	• Biofuels a potential job creator through rural farming sector, may drive government funding

	United Arab Emirates	Qatar
Available feedstock • Types of feedstock available (that have favourable growth conditions/ high availability)	• Salicornia • Algae (1)	• Algae (1)
Feedstock scalability • Amount of land available for feedstock production • Feedstock growing season and growth conditions	• Lack of arable land, locust swarms, limited water supplies limits crops production • Main potential: algae and salicornia, which can be grown with saltwater	• High temperatures, lack of water and fertile soil limits agricultural production • Main potential from non-crops sources such as algae
Refinery capacity and competence • Number of existing and planned biorefineries • Fossil fuel refinery industry presence	• Major petroleum and natural gas hub, with significant fossil refinery presence • Recent efforts on biofuel related to salicornia and algae, but otherwise little biofuels experience	• Major petroleum and natural gas hub, with significant fossil refinery presence, GtL production including for aviation • SASOL and Qatar Petroleum collaborating on GTL production • Recent efforts on biofuel related to algae, but otherwise little biofuels experience
Infrastructure access • Ownership structure of airports and fuel supply infrastructure • Level of regulation of airports and fuel supply infrastructure	• Dubai and Abu Dhabi major regional and global transportation hubs • State-owned ADNOC is a major oil player in the region and globally	• Doha a major regional transportation hub, operated by Qatar Civil Aviation Authority • Qatar Petroleum a major oil player in the region and globally
Biofuels know-how • History of existing biofuel initiatives, especially within aviation • Strength of biofuel technology industry and research facilities	• Little experience with biofuels development historically • Recently aviation biofuels efforts driven by Etihad	• Little experience with biofuels development historically • Strong know-how on GtL, with the perspective to use the same process for BtL • Recently aviation biofuels efforts driven by Qatar Airways
Political biofuel support • Aviation biofuel ambitions • Aviation biofuel legislation • Aviation's importance to economy	• No observed support programmes for biofuel from political sector	• No observed support programmes for biofuel from political sector
Political stability and expediency • Risk of political and social unrest • Political red tape • Efficiency of political processes	• UAE ranks highly on the World Bank's assessment of political stability and government effectiveness	• Qatar ranks highly on the World Bank's assessment of political stability and government effectiveness
Availability of financing • Availability of support mechanisms (e.g. CDM funds, World Bank and regional development banks) • Presence of finance industry (e.g. private equity, venture), especially with focus on clean tech/biofuels	• Strong investment potential	• Strong investments by Qatar's industry (and Shell) into GtL, with the perspective to further develop into BtL

(1) Available in multiple geographies

	China	ASEAN (Singapore, Malaysia, Thailand)
Available feedstock • Types of feedstock available (that have favourable growth conditions/ high availability)	• Rice straw/husks • Corn stalk, stems, and cobs • Wheat straw • Logging residues • Oil crops, e.g. jatropha	• Crude palm oil (biodiesel) • Waste animal fat • Cooking oil (1) • Sugar cane
Feedstock scalability • Amount of land available for feedstock production • Feedstock growing season and growth conditions	• 553 Mha total agricultural area today • Largely small-scale farm operations • China projected to have large potential for biofuels production from dedicated energy crops, depending on availability of land • Chinese farming companies purchasing land and crops in Africa for food security purposes	• Thailand the second largest producer of biofuels in Asia • Malaysia a major provider of palm oil for biodiesel, however, feedstock is not considered sustainable • Roundtable for Sustainable Palm Oil (RSPO) and biogas capture from palm oil processing wastes initiatives underway to make palm oil a more sustainable feedstock option
Refinery capacity and competence • Number of existing and planned biorefineries • Fossil fuel refinery industry presence	• Five state-certified fuel ethanol production plants today	• Singapore a major hub for fossil refinery and distribution; recent developments around bio-refineries (e.g. Neste Oil NExBTL refinery usable for aviation) • Petronas a major oil player in the region
Infrastructure access • Ownership structure of airports and fuel supply infrastructure • Level of regulation of airports and fuel supply infrastructure	• Massive transportation infrastructure investments in recent years • State-owned PetroChina one of the world's largest oil players • Several global and regional airport hubs for personal and freight	• Singapore: one single airport, controlled by government • All of SIN, BKK, KUL major regional and global transportation hubs (in particular SIN) • Excellent port infrastructure in SIN
Biofuels know-how • History of existing biofuel initiatives, especially within aviation • Strength of biofuel technology industry and research facilities	• Started bioethanol production in 2000 • Largest producer of biofuels in Asia, with focus on biodiesel • Large experience with first gen biofuel production, skilled technicians for second -generation plants could be provided	• Petrochemical industry very strong in both Singapore and Malaysia, major fuel players (e.g. Petronas) • Large biodiesel production in Singapore, palm oil supplied from Malaysia and Indonesia • Biodiesel a key industry for Malaysia
Political biofuel support • Aviation biofuel ambitions • Aviation biofuel legislation • Aviation's importance to economy	• Historically, supported investments for construction of bioethanol plants • Biofuel blending mandate in place • Second-generation biofuels identified as important, but no clear support policies	• Various support measures for first gen bioethanol in Thailand, plans to support second gen biofuels from seaweed, jatropha, cellulose, biomass • Strong focus on energy projects in Thailand • Aerospace and aerospace technology a key industry in Singapore • Generally there is a need to educate the governments about importance of biofuels for aviation
Political stability and expediency • Risk of political and social unrest • Political red tape • Efficiency of political processes	• Biofuel production investments are subject to government approval • Political processes slow to initiate but powerful once effected • Protection of intellectual property a concern for emerging technologies	• Thailand: business regulations very highly regarded by World Bank • Singapore: highly stable and open to foreign investments • Regional cooperation between ASEAN members
Availability of financing • Availability of support mechanisms (e.g. CDM funds, World Bank and regional development banks) • Presence of finance industry (e.g. private equity, venture), especially with focus on clean tech/biofuels	• China has received significant financing through the World Bank and CDM to date	• Singapore provides investment through sovereign wealth fund and development mechanisms to promising industries of strategic importance

(1) Available in multiple geographies

	Australia	India
Available feedstock • Types of feedstock available (that have favourable growth conditions/ high availability)	• Sugar Cane • Grains and short rotation crops • Oilseeds • Urban waste, Agricultural and Forest residues • Algae (1)	• Wheat, rice and sugar cane account for 65% of total agricultural residue/waste • Bagasse and rice husk, by-products from sugar and rice mills respectively, may – at least in theory – be used in their entirety as they are not recovered from the field • Other potential crops include: sugarcane tops, leaves, wheat stalks and husks, banana plant and leaves, maize stalks and cobs, cotton stalks, husks, algae and bollshell • Forecast suggests that between 125m and 183m tonnes of biomass residues will be available annually in India for next-generation ethanol conversion by 2020, without changing today's agricultural land-use patterns or cultivating new energy crops
Feedstock scalability • Amount of land available for feedstock production; Feedstock growing season and growth conditions	• Agriculture a major industry; Australia is a net exporter of food • Australia has a large area (in excess of 17 million hectares) of arable land currently under cultivation, although large parts of it can be prone to drought • Seasons vary in different parts of the country and for different crops • Significant areas of land and water that is suitable for algae growth	• Agriculture employs half of population indirect and directly • 11% of agriculture land, three crops produced, a lot of land available • 400,000 hectares of land, marginal lands, not dominantly fertile lands • Only a third of India's agricultural land is currently irrigated with a preference going to cash crops such as sugarcane. Most of its other food crops are primarily nourished via rainfall • Agricultural yields in India have been low due to manual farming and poorly developed harvesting techniques
Refinery capacity and competence • Number of existing and planned biorefineries • Fossil fuel refinery industry presence	• Refining capacity for new Green Crude streams is reliant on existing petroleum refining facilities • Most existing petroleum refiner marketers buy product, but have no ownership stakes • Leading independent retailer recently acquired one of the ethanol production facilities • Three ethanol facilities currently operating at full capacity (360 ML) with expansions planned • Five small biodiesel facilities operating but most at well below capacity (around 50 ML production per annum compared with capacity of 265 ML)	• Currently there are no next-generation ethanol manufacturing facilities operating in India, but first handful of next-generation ethanol manufacturing facilities expected to come online by 2014 • 600 sugar mills, 131 have ethanol manufacturing units • 189 distilleries (there could be more, but this is the minimum number) manufacturing ethanol • 2.26 billion of ethanol in 2008, production fell in 2009 due to high sugar cane prices, generally use molasses
Infrastructure access • Ownership structure of airports and fuel supply infrastructure; Level of regulation of airports and fuel supply infrastructure	• Airports privately owned. Major airports supplied by pipelines owned by petroleum refiner marketers, which are also partners in joint user hydrant installations (JUHIs) • Oil company fuel suppliers own majority of infrastructure and have very limited participation in biofuels industry development	• Four airports which have been built, currently owned by private developers, other airports are managed by Airport Authority of India (public entity) • Fuel generally transported through airports, also railways • India's road transport sector is growing; however, transporting the fuel within and across state borders is a barrier due to various taxes and regulations and needs streamlining • Oil companies directly negotiate fuel prices with airlines
Biofuels know-how • History of existing biofuel initiatives, especially within aviation; Strength of biofuel technology industry and research facilities	• Variety of early generation biofuels initiatives, with varied results. • Some research areas in advanced biofuels but limited industry investment and R&D • Licella, Mackay and other, smaller scale biofuels demonstration facilities • Limited airline engagement with biofuels, but assisted by Boeing industry involvement	• Currently, no legislation with mandates for blending in biofuels for aviation , but there are some for service transport • King Fisher Airlines is working to develop alternative jet fuels and has partnered with Vienna University to research and develop fuel. There has been no significant progress due to the airline's economic troubles. Despite a lack of progress, there is a huge interest among airlines in biojet fuel as a way to reduce fuel prices and carbon taxes that are levied in major airline hubs (e.g. the EU) • There are a few policies in place, but a lack of policy implementation and no clear long-term mandates or penalties to ensure successful execution
Political biofuel support • Aviation biofuel ambitions • Aviation biofuel legislation • Aviation's importance to economy	• Government currently developing an Alternative Transport Fuels Strategy • Biofuels are excise free for land transport use with a review to take place in 2021. No similar "excise free" status for domestic sustainable aviation fuels. • Government funding for biofuels development has been small compared with US and Europe. • US$ 15 million Second Generation Biofuels Research and Development Programme • US$ 20 Australian Biofuels Research Institute and availability of further funding through new programmes • State biofuels mandate in New South Wales and under consideration in Queensland • Carbon trading regime will apply to aviation	• Ministry of New & Renewable Energy established a National Policy on Biofuels, which mandated the blending of 10% ethanol with gasoline for 2008 for 20 states and four Union Territories • The Indian government regulates the price of most petroleum products but recently allowed gasoline prices to fluctuate at market rates. • Currently, there is no policy mechanism incentivizing farmers to collect and deliver biomass residue to a next-generation ethanol plant.
Political stability and expediency • Risk of political and social unrest • Political red tape • Efficiency of political processes	• Stable financial and political environment. Strong environmental protection legislation and regions • Government in solid fiscal position with low unemployment and inflation • Both sides of politics support biofuels excise regime which passed Parliament in June 2011 • Strong planning and environmental protection regulation at state and local levels	• India does not have a strong track record of fulfilling its biofuel blending ambitions. • no clear mandates or other policies demanding next-generation ethanol consumption in India. • Society of Indian Auto Manufacturers has agreed that 5% is acceptable for domestic vehicles, but cautions against 10% or higher blends. • Currently the biggest consumers of ethanol are the beverage and chemical industries. There will be growing competition over the available ethanol as the oil industry starts blending higher volumes of biofuels. • Competing demand between industries, big hindrance in implementing concrete policies • Lack of implementation due to shortage of fuels, production inconsistent between years • Indian government rolled back biofuels blending targets, should have been 10% but struggling to get 5%
Availability of financing • Availability of support mechanisms (e.g. CDM funds, World Bank and regional development banks) Presence of finance industry (e.g. private equity, venture), especially with focus on clean tech/biofuels	• Availability of financing a significant challenge • $100 million Renewable Energy Venture Capital Fund • Government has announced the $10 billion Clean Energy Finance Corporation as part of the Clean Energy Future package (Basis of Carbon Tax which moves to a carbon pricing regime)	• The Indian government's success in introducing ethanol blending has been erratic in the past decade, and it does not set a good long-term precedent for potential biofuel investors. • Difficult for project developers to secure financing. Investors' lack of familiarity with the technology means projects are vulnerable to very steep lending rates, which places a considerable burden on a technology in the developmental stage. • Indian Renewable Energy Development Agency gives minor financial support to specific projects and schemes for generating electricity and /or energy through new and renewable sources and conserving energy through energy efficiency (interest rates are extremely high, 12.75%) • Funding also available from the Asian Development Bank, commercial and foreign banks • Venture capital and private equity investments were more than 100,000,000 for renewable energy project for 2010. Funding for 2011 is expected to exceed that amount.

Current State of Light Vehicle Electrification

High Potential Application Areas for Road Electrification

In a previous World Economic Forum initiative, Repowering Transport, plug-in electric vehicles (BEV, PHEV and range extenders) were assessed to be a high-potential technology for achieving sustainability and advance the move towards alternative energy sources in the road transport sector:

- Significantly lower lifecycle emissions (depending on electricity mix)
- No tailpipe emissions (improving local air quality)
- Lower total cost of ownership
- Reduced noise
- Higher energy efficiency

Electric vehicles are projected to be an important factor of the future road transport landscape. The question, therefore, is how fast will they be adopted by users? The main obstacles to rapid adoption in mainstream customer segments are:

- High upfront cost, despite favourable total cost of ownership (TCO)
- Challenging to finance due to limited experience with technology (e.g. lithium-ion batteries)
- Limited electric range for longer trips (unless fast charging/ battery swapping in place)
- Limited vehicle supply and model selection (especially in an initial phase)
- Limited access to charging infrastructure (for certain user segments)

Electric vehicles may be adopted first by specific user segments where the use case aligns well with the strengths of BEVs and PHEVs:

- Applications with well-defined driving patterns and limited range
- Applications where the introduction of EVs provide additional cost savings to strengthen the business case
- Applications where up-front cost is minimized or hidden to the user

This project would like to share a selection of high-potential use cases to highlight application areas where electric vehicles can provide a sustainable solution to road transport challenges from three perspectives: environmental (carbon emissions), economic (profitable business case) and social (quality of life, governance, job creation). The use cases will also highlight success factors for further scale up of electric vehicles, to inform players in the ecosystem of what types of partnerships and regulatory environment is needed to succeed.

To ensure relevance and applicability, the use cases were selected based on four criteria:

- A use case where electric vehicles provide a clearly favourable business case compared to a mainstream consumer application
- A use case where range and other limitations of electric vehicles are not relevant
- A use case that is applicable to a non-insignificant niche of the market
- A use case that integrates multiple areas of the ecosystem, especially with respect to the grid (smart charging)

Best Practices from Recent and Current Initiatives

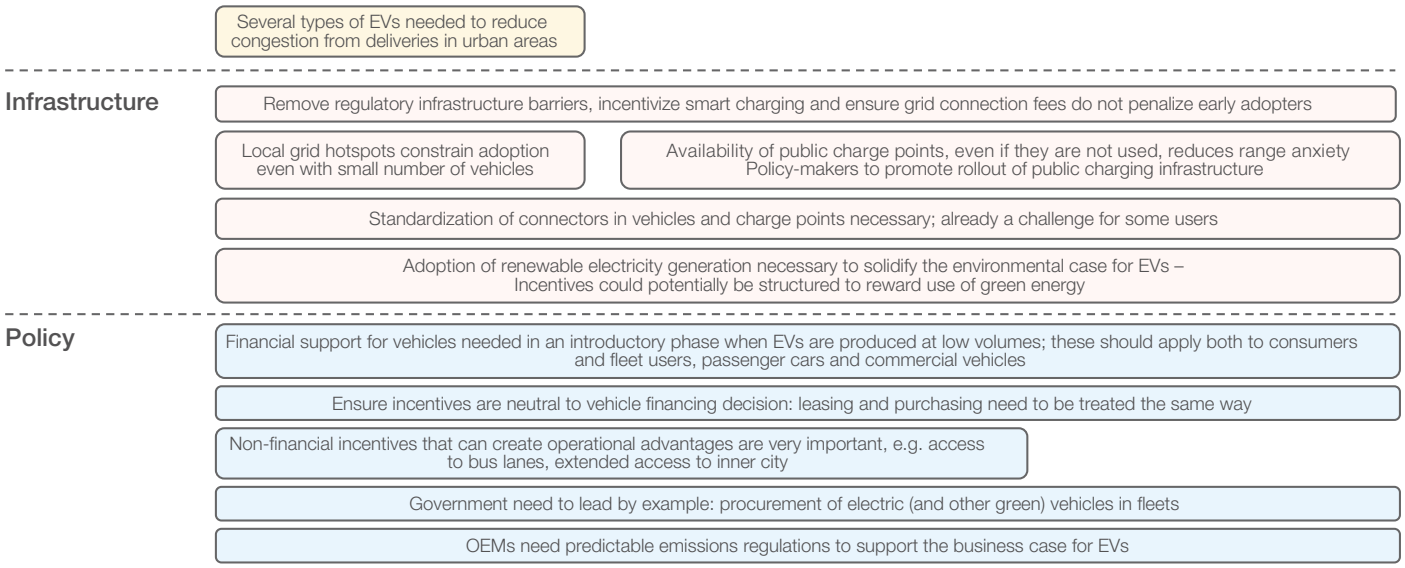
Based on the application criteria outlined above, the project focused on a selection of initiatives conducted by the project's task force, which could help identify best practices and challenges that need to be addressed. The project focused on three main application areas or use cases:

- Urban delivery applications
- Corporate fleet applications
- Consumer applications

Theses application areas, outlined below, were studied through six case studies conducted by players from across the value chain and covering a wide range of geographies:

Company	Location(s)	Application Area / Use Case
UPS	London	Urban delivery applications
TNT	United Kingdom, the Netherlands, France, Italy, Turkey, China, Hong Kong	Urban delivery applications
Bulgarian Electric Vehicle Association	Bulgaria	Urban delivery applications
Better Place	Israel, Denmark, San Francisco, Amsterdam, Australia	Consumer applications Corporate fleet applications
ZEM	Scandinavia and Germany	Corporate fleet applications
Audi	Munich	Consumer applications Corporate fleet applications

Key Success Criteria for Scale-up by Application Area



UPS – United Kingdom
Urban Deliveries
February 2008 – Ongoing

Description of initiative	User behaviour and requirements	- 20 battery electric vans in operation in the United Kingdom provided by Modec - Vans are deployed on a regular schedule for pickups and deliveries, from 8.00 to 18.00 daily - Routes are dense with typically 80 stops; typical range of 50-60 km per day
	Charging infrastructure	- Charge points are 400V 3 phase systems - Vehicles charged overnight in UPS' parking premises - Charge points installed by UPS
	Central/local government support	- EVs in general are well supported by the government: zero congestion charge, zero road charge, and do not require annual Ministry of Transport test. - Passenger cars receive £5,000 in acquisition cost support, however, no such scheme for commercial vehicles
	Vehicle maintenance and reliability	- UPS maintains its own vehicles, including most maintenance for EVs - Vehicles typically come with a one-year warranty and a three-year powertrain warranty
	Economics	- Electric commercial vehicles cost substantially more than an equivalent combustion engine vehicle
Lessons learned/ Success factors for scale-up	User behaviour and requirements	- Generally the vehicles work fine and UPS' drivers have a favourable opinion of them
	Charging infrastructure	- Even with a low number of vehicles (about 20), the slow charging process is an issue with the grid not being able to handle simultaneous charging with the current infrastructure; upgrading the grid would require tens to hundreds of thousands of pounds in costs for UPS - There is a need for governments to step forward and provide support to upgrade the local grid or provide distributed power generations such as PV arrays
	Central/local government support	- Acquisition cost subsidies should be expanded also to commercial vehicles - Increased city operating lane access for EVs (e.g. bus lanes) or other expanded access to inner cities would help support the business case for urban delivery usage - EVs can play a key role in improving local air quality and reduce CO_2 emissions; EVs can also support to some extent the reduction of noise in cities
	Vehicle maintenance and reliability	- From a maintenance perspective, the EV removes some of the complexity of the ICE engine - Consistent and rigorous quality is a challenge with vehicles from start-up OEMs, especially with reliability of batteries - Have not encountered problems with cold-weather performance to date
	Economics	- From a total cost of ownership perspective, EVs are not favourable at this time due to the extremely high acquisition cost and lack of public incentives - EVs will play part of the future solution for commercial urban deliveries, but other technologies such as biomethane, natural gas and hybrid hydraulic diesels will also be needed to fill all the needs for logistics providers

TNT – UK/Netherlands/France/Switzerland/Italy/Turkey/Hong Kong/China
Urban Deliveries
May 2007 – Ongoing

Description of initiative	User behaviour and requirements	- TNT has ~85 electric delivery vans in operation globally - Electric vehicles travel 80-120 km per day on average, returning to depot at night for recharging - Payload is typically an issue with EVs due to weight of batteries, however, the light weight of goods means that vehicles usually load out on volume before weight
	Charging infrastructure	- Vehicles charged through household plugs or 3 phase 400V connectors overnight - EVs need to be parked close to charge points (in some cases indoors), limiting flexibility of where to park the vehicles; this may become a challenge with high number of EVs
	Central/local government support	- In Europe, financial support was not available at time of purchase but is now becoming available - In Hong Kong, financial support schemes are generous, leading to a very favourable TCO for EVs versus ICEs - In China, several beneficial support schemes exist in the 20 focus cities for EVs, as - as financial incentives through the "10 Cities 1,000 Vehicles" programme. - In Shanghai, freight vehicles are not allowed in the inner city, but EVs are exempted. Additionally, freight permits are unlimited for EVs but limited for other vehicles. In Beijing, license plates are typically limited but not for EVs, and government builds new charge points as needed
	Vehicle maintenance and reliability	- Maintenance is typically provided by OEM or agent of OEM; smaller start-up OEMs do not have extensive networks and can take a long time to service EVs - A factory warranty on vehicles of 2-3 years is typical and a warranty on batteries based on number of charge cycles. Additional warranties are needed on other EV drivetrain elements (besides the battery) that can go wrong
	Economics	- Depreciation is very high on EVs; financing companies currently assume residual value close to zero. Secondary value of used battery has not yet been proven - In many countries, the total cost of ownership is higher for EVs than for ICEs
Lessons learned/ Success factors for scale-up	User behaviour and requirements	- Urban deliveries for express companies are well suited to use of EVs due to short distances (<150km), highly predictable distances (varies within 5 km per day) and plenty of time to recharge overnight - From a functional standpoint, would prefer larger vehicles with higher range (~150km) - Established OEMs not offering commercial vehicles of a suitable size/price; logistics providers often required to go to start-up OEMs that have quality issues or are financially unstable. To scale up the use of EVs in urban deliveries, more solid offerings from large OEMs are needed
	Charging infrastructure	- As number of vehicles in use increase beyond the single digits, there is typically a need for upgrading of electric infrastructure. The costs charged to the user of the vehicles associated with this is on the order of €10,000, which is a major barrier to large-scale penetration - Standardization of plugs: wide variety makes it challenging to utilize all public charge points
	Central/local government support	- Long-term acquisition cost subsidies are likely not sustainable; governments need to look at non-financial incentives such as favourable access to inner cities or use of bus lanes. - A stronger business case could be created for EVs if commercial vehicles were limited to access shopping streets only for certain hours but an exception made for EVs
	Vehicle maintenance and reliability	- Maintenance and reliability risks associated with working with smaller start-up OEMs are higher than for large, established OEMs - Reliability of Zebra batteries has not been satisfactory with challenges related to charging batteries in a low state of charge
	Economics	- Logistics companies such as TNT are willing to invest in a small number of EVs in an initial phase even though they are not cost competitive, however, to scale up to tens of thousands of vehicles the business case has to be neutral - As a rule of thumb, if the price of an EV is less than 2.5 times that of a similar conventional vehicle, the business case can reach breakeven after 5 years; high fuel prices also support the business case - In Europe the total cost of ownership for an EV is typically about 40% higher than for an ICE vehicle, although gradually improving. In China the TCO is either neutral or sometimes lower than ICE due to strong incentives

Bulgarian EV Association (BAEPS)/Cities of Sofia, Plovdiv and Varna – Bulgaria
Urban Deliveries
March 2012 – March 2015

Description of initiative	User behaviour and requirements	- Piloting use of commercial electric vehicles, e.g. Renault Kangoo, for urban deliveries in Sofia, Plovdiv and Varna in partnership with local delivery companies - Target is to deploy 600 to 1,000 vehicles over a three-year period and thereby build the rationale for OEMs to establish service centres for EVs in Bulgaria - Planned routes cover deliveries between 100-140 km per day, requiring fast charging at one to two loading points where delivery routes of multiple companies intersect
	Charging infrastructure	- A combination of slow charging overnight and one to two fast chargers (10-15 minute charge time) will be utilized
	Central/local government support	- The cities will provide public charging and parking facilities for the EVs - For each public user the government provides to the trial, the Bulgarian EV Association will match with four private users - Ultimate goal is to reduce Bulgaria's energy resource dependency on oil; currently 90% of oil is imported from Russia
	Vehicle maintenance and reliability	- Based on the experience from other initiatives, the programme expects that maintenance of EVs will be less than ICEs due to the simpler construction
	Economics	- Expected acquisition cost of commercial electric vehicle is ~€24,000 compared to €12,000 for an ICE version - Expected lifetime of vehicles is five years; residual value estimated at €6,000 - Despite double the acquisition cost for an EV, the TCO is expected to be comparable with ICE
Lessons learned/ Success factors for scale-up	User behaviour and requirements	- The key factor that limits the speed and scale of the project today is availability of vehicles from established OEMs - The project has needed to compromise on some of the vehicle parameters like size and payload in order to find suppliers that can provide vehicles
	Charging infrastructure	- Overnight charging of vehicles (expected 15 vehicles at most for an individual company) is not expected to be a challenge from a grid perspective - Infrastructure is not seen as a challenge to scale up today and the available capacity of electricity in the grid is sufficient. The project has already worked with utilities as partners to overcome potential grid power supply challenges
	Central/local government support	- A key initiative for governments is to provide a good example of early adoption of EVs. A strengthening of public procurement processes will be necessary to drive this as public procurement processes currently focus mostly on acquisition cost and place little emphasis on TCO - The entire ecosystem around the electric vehicle needs to be considered in order to drive a successful penetration, including training of emergency personnel about, for example, the risk of high-voltage cables
	Vehicle maintenance and reliability	- With increased penetration of electric vehicles, it is expected that mechanics will increasingly need to be trained on maintenance and repairs to electric drivetrains
	Economics	- The TCO for electric vehicles is favourable, however, availability is the limiting factor and there is a need to encourage new OEMs to play in this market and help drive supply of new vehicles

Better Place – Israel/Denmark
Mass Market Applications
January 2012 – Ongoing

Description of initiative	User behaviour and requirements	- Better Place plans to support a number of vehicles; the first car will be the Renault Fluence Z.E. with switchable battery - Main focus segment for initial deployment is high distance drivers
	Charging infrastructure	- Charging will happen through a combination of slow (trickle) charging (max 16 Amps, Mennekes connectors) and battery switch stations - Magnetic ID card will identify users at battery switch stations and charge points - Slow charging will happen at consumer's houses, shared parking facilities, consumer's work places and in public areas. Battery switch stations will primarily be located at easily accessible locations with high traffic density for long distance trips, but overall ensuring a full coverage of the country
	Central/local government support	- Primary means of support from governments is coming from incentives to purchase electric vehicles and favourable tax policies for EVs - Funding for infrastructure is private and managed by Better Place
	Vehicle maintenance and reliability	- Maintenance for vehicles and infrastructure will be provided through cooperation with Renault and the companies deploying the infrastructure
	Economics	- In Denmark the Renault Fluence ZE will cost 205,000 Danish kroner. For comparison, the Renault Fluence 1.5dCi costs 370,000 Danish kroner - In Israel, the Renault Fluence ZE is also cheaper than equivalent gasoline cars with similar performance (1.8/2.0 l) and equipment - The New European Driving Cycle test suggests that the Renault Fluence Z.E. consumes 7.7 km/kWh; however real consumption is higher and depends on usage, but on average 6.5km/kWh is feasible
Lessons learned/ Success factors for scale-up	User behaviour and requirements	- User reception to vehicles is expected to be favourable due to no range limitations, added convenience, and lower cost of purchase and operation
	Charging infrastructure	- Challenges to date related to deployment of infrastructure have been permitting for charging infrastructure (charge points and battery switch stations), regulation around connections and metering for charge points - Governments and industry should focus on adopting standards for battery switch stations; guaranteeing interoperability of charging infrastructure; and removing regulatory barriers for the deployment of charge points and battery switch stations
	Central/local government support	- In order to drive uptake of electric vehicles, policy-makers should remove regulatory barriers for the deployment of charge points and battery switch stations. This includes a review of connection and metering rules - Currently, some governments have no incentive schemes in place for the purchase of EVs or do not tax gasoline; these markets will be less attractive to deploy EV charging infrastructure compared to countries that have such policies in place
	Vehicle maintenance and reliability	- Insufficient experience has been built to give a thorough analysis of the maintenance needs of the vehicles. However, considering the strong reduction of moving parts in the vehicle and the lack of an oil and cooling system, the expectation is that the maintenance needs and costs will be significantly lower
	Economics	- In Israel, the projected operating cost savings for a Better Place EV will be 17% versus an ICE, assuming an annual drive distance 20,000 km - In Denmark, projected savings are estimated at 20% compared to the operating costs of an equivalent ICE car

Audi – Munich
Fleet Applications
August 2011 – April 2012

Description of initiative	User behaviour and requirements	- Audi will pilot the use of a small fleet of 20 electric range extended Audi A1 vehicles - Drivers have been selected to expose the project to a range of different driving patterns, polled from a wide range of customer segments - Audi has already conducted a reference study using ICE vehicles and is now commencing tests using range-extended vehicles
	Charging infrastructure	- Installation and service of 200 charging stations by the Munich municipal utility company - Driving distances are relatively well defined, e.g. local commuting between home and work
	Central/local government support	- Audi is collaborating with the Technical University of Munich for the evaluation of mobility behaviour
	Vehicle maintenance and reliability	- Not applicable
	Economics	- Not applicable
Lessons learned/ Success factors for scale-up	User behaviour and requirements	- No results available at time of publication
	Charging infrastructure	- Charging at home and at the work place are the primary charging areas, therefore a lack of public infrastructure is not expected to be a critical barrier to adoption. Additionally public charging infrastructure installations seem not to be the best solution in terms of a business case for those who invest: The cost per charge point are very high compared to the possible return - Accounting and billing is a challenge for the deployment of public charging infrastructure as there are many solutions in play and no standards. This could either be driven by a local utility or by the government/municipality
	Central/local government support	- To support the development of a robust plug-in electric vehicle market there is a need for reliable pathways for electrification and predictability around e.g. emissions regulation - A firm understanding for auto industry around, for example, zero emissions regulations, would bring clarity around the fact that electrification is needed
	Vehicle maintenance and reliability	- No results available at time of publication
	Economics	- Given the current prices of components and batteries, the total cost of ownership is not expected to be lower for a range extended electric vehicle and could potentially be worse than for an ICE vehicle (as is the case for the EV version of the smart vehicle) - A discussion is currently ongoing around zero-emission zones in major cities for the future and additional clarity on the outcome of these processes would help provide stability for automotive OEMs to introduce more electric vehicles - Incentives for EVs should ensure that green energy is utilized to provide a strong case for the deployment of these vehicles

ZEM/Move About – Norway/Sweden/Denmark/Germany

Corporate Car Sharing

December 2008 – March 2012

Description of initiative	User behaviour and requirements	- ZEM – the Zero Emission Mobility Alliance – backed the world's first corporate electric vehicle "Mobility-on-Demand" initiative in 2008 at DNV. The operator Move About has since then worked with multiple private and public organizations on promoting the use of EVs with various user groups; ZEM does continuous battery monitoring to increase residual value - Electric vehicles utilized include the Think City, Nissan Leaf, Peugeot iOn and Citroen C-Zero - Employees share easy access to fleets of EVs on their job (around 200 users per 5 vehicles), book trips via their corporate internet or smartphones and unlock the vehicle using an RFID card - Statoil, KPMG or Statkraft in Norway use this EV mobility-on-demand service within the city (15-20 km per trip, 2-3 trips per car per day), replacing the use of taxis for business purposes - IKEA in Denmark sponsors the vehicles through advertising and make them available to the public, allowing at the same time people who do not have a car to drive to IKEA and shop - Akero municipality in Sweden has provided EVs to municipality employees during office hours and to residents after office hours, sharing revenues with Move About - EON in Germany has explored uses of EVs for trips between corporate office locations - Hertz has entered into strategic partnership with Move About to roll out this "zero hassle – zero emission" model to their corporate customers across Europe
	Charging infrastructure	- Charging has primarily been level 1 charging, but together with ZEM and DNV will test level 2 and 3 during 2012 - Charge points have been installed next to the main entrance of corporate office to provide convenience for users - Public charge points have been installed, paid for by the city governments in Norway, or co-sponsored by city-wide programmes, such as in Germany and Denmark
	Central/local government support	- Financial incentives for EV purchases in the form of reduced taxes are present in Norway and Denmark, while Germany and Sweden focus on supporting research and demo projects - Non-financial Incentives (like driving in the bus lane, no tolls/congestion charges) and building free charging infrastructure are very effective. Norway has the strongest incentives (No VAT, bus lane driving, free charging and reserved parking) and has the world's highest EV density per capita - For the pilot programmes in Copenhagen, the municipality arranged for prime charge locations; in Sweden, local municipalities entered into partnerships with utilities to promote shared EV use
	Vehicle maintenance and reliability	- Maintenance cost compared favourably with ICE vehicles due to simpler drivetrain, lack of need for oil changes and dependability of electric motors - Vehicle reliability has been higher with the bigger OEMs (e.g. Nissan and Peugeot vs. Think) Reliability is a key metric for corporations that want a service they do not need to worry about
	Economics	- Move About charged a monthly all-inclusive fee for vehicles, 24/7 maintenance and services, cleaning, tire shift, in car software, corporate branding and setting up and running a corporate-branded website for employees to book in the order of ~€1,100 per month/vehicle or 30 users - Use of Mobility-on-Demand model often reduces corporate fleet size needed to provide access availability demanded by over 30%, and lowers taxi expenses substantially
Lessons learned/ success factors for scale-up	User behaviour and requirements	- Range has not been a problem with users in practice, despite initial concern prior to use of EVs - In winter conditions, lithium-ion batteries have experienced range reduction and start-up problems; this has not been a problem with sodium batteries - Heavy snow has been a challenge for cars with small wheel size and for extended heater use - Availability of vehicles from established OEMs was initially key to increased market penetration
	Charging infrastructure	- Level 1 charging has been sufficient with current utilization levels (2.5 trips per day). Insufficient grid capacity due to charging of high number of vehicles has not been a problem to date - In certain cases, cables were too easy to remove; this was solved by requiring charge point to be locked to charge - Beneficial psychological effect of having some fast charge points available, even if not utilized
	Central/local government support	- Financial incentives play an important role and with more favourable corporate tax exemptions for EVs could help drive EV uptake - In certain regions (e.g. Norway), leasing and purchasing of vehicles do not benefit from the same level of tax benefits, limiting the types of innovative models that can be utilized for EVs - Mobility-on-demand solutions, especially with EVs, are likely to become more popular in Europe when cities raise inner-city traffic restrictions, and when new accounting rules - Deployment of charge points by government can help overcome initial range anxiety with users
	Vehicle maintenance and reliability	- Think EVs have experienced problems with PCUs failing; no problems with new batteries to date - Charge points have been able to withstand snow, rain and cold winter weather - Need for additional vehicles from established OEMs with broader size and range
	Economics	- Total cost of use for end users using corporate car sharing service have been lower than using a taxi (approximately €8 per hour of driving) - Cost can further be reduced through advertising on the vehicles (revenue split with user/ customer)

Glossary of Terms

ATM	Air Traffic Management
BEV	Battery electric vehicle
ESG	Environmental, social, governance
ICAO	International Civil Aviation Organization
IEA	International Energy Agency
OECD	Organization for Economic Cooperation and Development
OEM	Original equipment manufacturer
PHEV	Plug-in hybrid electric vehicle
Plug-in electric vehicles	Battery electric vehicle, plug-in hybrid vehicle or range-extender vehicle
TCO	Total Cost of Ownership

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