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Transition to Sustainable Mobility: Pathways, Policies, Co-benefits and Opportunities of Low Carbon Transport Future

(Background Paper for Pre-Event -1)

Final Draft

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Transition to sustainable mobility: Pathways, Policies, Co-benefits and Opportunities of low carbon transport future

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1. Introduction

Transport plays an important role in total global energy demand, yet the structure of the sector and the decarbonisation pathways for it are vastly different to the electricity sector. Transport is the currently second largest and the fastest growing energy end-use sector and accounts for 28% of total final energy demand (IEA, 2012; IEA, 2017). The vast majority (94%) of the energy used in transport comes from fossil fuels, responsible for emissions of 6.9 Gt CO_2-eq of carbon dioxide (CO_2) and other greenhouse gases whose increasing concentration in the atmosphere is a dominant factor in the warming of the climate. The near complete dependency of transport on energy from fossil fuels poses major challenges for the sector, which are severe in certain regions, particularly those related to air pollution, environmental degradation, energy security, economic efficiency and sustainable development. In addition to this, transport is at the heart of many other policy objectives related to road safety, land-use, congestion and access to jobs and opportunities.

Sustainable transport plays a key role in delivering on the Paris Agreement, the Sustainable Development Goals (SDGs) and the New Urban Agenda. While providing essential services to society, it is also an important part of the economy and is at the core of several major sustainability challenges, in particular, climate change, air quality, road safety, energy security, and resource efficiency. In this paper, we describe the various factors and co-benefits for sustainable transition for urban mobility and their linkages between decarbonisation pathways, policy integration and institutional structures, and design and testing of innovations. They are:

- Decarbonisation pathways for urban basic services, in particular, urban mobility;
- Integrated urban transition strategies, with a focus on urban mobility innovation actions;
- Local and national policy packages that are mutually reinforcing;
- Concepts for a concerted, multi-level policy approach that provides a basis for multi-actor coalitions that can enable long-term transitions;
- Living Labs and demonstration actions that test the validity of developed concepts and business models.

This paper identifies the potential for land transport in climate change mitigation actions at the local and national level, opportunities for synergies of sustainable development and climate change objectives, and governance and institutional issues affecting the implementation of measures.

Considering the fact, that there is an enormous potential to reduce transport sector greenhouse gas emissions (GHGs) cost-effectively, already shown by some countries, an explanation beyond the economic and technical feasibility, a political and institutional explanation to the differing progress of countries in this area is required.

Identifying institutional barriers in the uptake of low-carbon transport measures, is not only relevant for industrialised countries, where emissions from this sector need to be reduced drastically and action needs to start now, but also particularly relevant for emerging economies where rapid urbanisation and infrastructure development can result in carbon intensive energy and transport pathways if no immediate action is taken, making a 1.5ºC scenario very unlikely. The analysis presented in this paper explores the policy and governance factors that shows the relationship between the selection of interventions and institutional aspects that affect the implementation of a comprehensive strategy to decarbonise the transport sector.

With regard to CO_2 emissions, transport is the fastest growing sector in emerging economies and the sector that shows the least progress with respect to mitigation in industrialised (OECD, 2017). When looking at the relative success in some countries for example in the shift towards renewable energies, it is puzzling to see that the progress of climate change mitigation in the transport sector, trails well behind other sectors, particularly the electricity sector. This suggests that a different policy approach might be needed for transport that takes into account the complexity of the sector. The analysis of this paper explores pathways and scenarios for the decarbonisation of the transport sector, which helps identifying the main elements of a policy package and implications for a governance approach. A central element in urban mobility transition strategies is the direct link between policy design and institutional structures, which can be tested in innovative Living Labs, where integrated technology and policy solutions combine various local and national policy objectives to support establishing a basis for broad political coalitions for wider sector transitions.

In addition to the tangible environmental benefits and visible strengthening the governance structures, institutional integration and support to innovation, low carbon pathways, incl. sustainable mobility options, will also be economically beneficial for local, sub-national and national governments embracing these solutions.

2. Transition pathways

Urban passenger transport plays particularly important role in providing access to urban services, economic opportunities and social participation (Admasu, Balcha, & Getahun, 2016; Angel & Blei, 2016; Bibas, Méjean, & Hamdi-Cherif, 2014). Both private and public transport are projected to increased rapidly, mainly in developing and emerging economies. This reflects the growing travel demand in developing economies, which is a vital component of economic development (Berry, Jouffe, Coulombel, & Guivarch, 2016; Gschwender, Jara-Díaz, & Bravo, 2016; Spyra & Salmhofer, 2016).

The transport sector is currently on track to continue to stay at current levels of greenhouse gas emissions even under very optimistic scenarios (Fulton, Lah, & Cuenot, 2013; Harvey, 2013). Growth in mobility demand for mobility outpaces efficiency gains. Even when taking into consideration a substantial take-up of more efficient vehicles technology and some modal shifts, transport CO_2 emissions in 2050 will still be at 2015 levels of around 7.5 Giga-tonnes of CO_2 (OECD, 2017). If, however, there are now changes to current trends, transport sector greenhouse gas emissions are set to double by 2050 (Sims et al., 2014). Setting the transport sector on a low-carbon development pathway is essential for global climate change mitigation efforts that aim to stabilise global warming at well below 2ºC, which is the internationally agreed target under the United Nations Framework Conventions on Climate Change (UNFCCC). To contribute to this target developed countries will have to rapidly decarbonise their transport sector over the coming decades (-80% by 2050) and developing and emerging countries will have to curb growth (+70% by 2050), which will require substantial policy action (Fulton et al., 2013).

The main message from decarbonisation scenarios is that light-duty vehicle (LDV) travel will need to change rapidly in industrialised countries and shift towards more efficient vehicle technologies and more efficient modes of transport. In industrialised economies a reduction of car travel between 4% to 37% combined with average vehicle fuel efficiency (reduction in energy/km) of between 45 to 56% would be required to achieve the desired reduction of 73 - 80% to be roughly in line with an emission reduction pathway for a 2°C stabilisation scenario as suggested by the IPCC (Fulton et al., 2013; IEA, 2012). In developing and emerging countries, light-vehicle travel per capita has still a potential to grow even under a low-carbon development scenario by around 130 to 350 % if accompanied by fuel efficiency and carbon intensity gains of 40 to 50% (Fulton et al., 2013; IEA, 2012).

Urban passenger transport and surface freight transport need to play a major role in decarbonising the sector, both in managing growth in emerging economies and drastically reduce emissions in industrialised economies, even more so when aiming for a 1.5ºC stabilisation pathway. The mitigation potential of a number of transport sector mitigation measures has been well-established, e.g., shift to public and non-motorised transport and efficiency improvements of internal combustion engines (Kok, Annema, & Van Wee, 2011; Macchion et al., 2014; Sims et al., 2014; Wright & Fulton, 2005). However, a more integrated view that combines technology shifts potential in a balanced perspective to the wider sustainable (urban) development approach of low-carbon mobility options still needs further research (Creutzig, 2016; Saujot & Lefèvre, 2016).

3. Policy integration

Energy and climate change policies for the transport sector require a stable political operating environment to enable long-term investment decisions by industry and consumers (Fais, Sabio, & Strachan, 2016; Lakshmanan, 2011; Spataru, Drummond, Zafeiratou, & Barrett, 2015). Consensus focused governance and institutional structures may be able to provide such a strategic, coherent and stable operating environment. The policy environment, or context in which decisions are made, is as important as the combination of policy decisions and infrastructure investments that make up a low-carbon transport strategy (Justen, Fearnley, Givoni, & Macmillen, 2014). This policy environment includes socio-economic and political aspects of the institutional structures of countries.

Policy interventions in the transport sector, such as fuel and vehicle taxation, are highly visible and politically sensitive. They require a strong political commitment to appear on the policy agenda and to remain in place as they rely on investments that are only cost-effective over the medium to long-term IEA and OECD, 2009; Sims et al., 2014. Developing consensus can be difficult because transport is complex and multifaceted and policy interventions can have unintended consequences (Klenk & Meehan, 2015; Lijphart, 1984; Häussler, Schmid-Petri, Adam, Reber, & Arlt, 2016). Linking and packaging policies is vital to generate synergies and co-benefits between measures, including linking GHG reduction goals with other sustainable development goals, such as increasing energy security, road safety, public health, increasing economic productivity and air pollution, and improving equity and access.

Decision making on transport policy and infrastructure investments is as complex as the sector itself. Rarely will a single measure achieve comprehensive climate change impacts and also generate economic, social and environmental benefits (Creutzig, 2016; Lah, 2015). Many policy and planning decisions have synergistic effects, meaning that their impacts are larger if implemented together. It is therefore generally best to implement and evaluate integrated programs rather than individual strategies (Hüging, Glensor, & Lah, 2014). For example, by itself a public transit improvement may cause minimal reductions in individual motorised travel, and associated benefits such as congestion reductions, consumer savings and reduced pollution emissions. However, the same measure may prove very effective and beneficial if implemented with complementary incentives, such as efficient road and parking pricing, so travellers have an incentive to shift away from individual car travel (Cuenot, Fulton, & Staub, 2012; den Boer, Essen, Brouwer, Pastori, & Moizo, 2011). In fact, the most effective programs tend to include a combination of qualitative improvements to alternative modes (walking, cycling and public transit services), incentives to discourage carbon-intensive modes (e.g. fuel pricing, vehicle fuel efficiency regulation and taxation), and integrated transport and land use planning, which creates more compact, mixed and better connected communities with less need to travel (Figueroa, Lah, Fulton, Mckinnon, & Tiwari, 2014; Sims et al., 2014).

A vital benefit of the combination of measures is the ability of integrated packages to deliver synergies and minimise rebound effects. For example, the introduction of fuel efficiency standards for light duty vehicles may improve the efficiency of the overall fleet, but may also induce additional travel as fuel costs decrease for the individual users (Yang, Mock, German, Bandivadekar, & Lah, 2018). This effect refers to the tendency for total demand for energy decrease less than expected after efficiency improvements are introduced, due to the resultant decrease in the cost of energy services (Sorrell 2010; Gillingham et al. 2013, Lah 2014). Ignoring or underestimating this effect whilst planning policies may lead to inaccurate forecasts and unrealistic expectations of the outcomes, which, in turn, lead to significant errors in the calculations of policies' payback periods (IPCC 2014). The expected rebound effect is around 0-12% for household appliances such as fridges and washing machines and lighting, while it is up to 20% in industrial processes and 12-32% for road transport (IEA 2013). The higher the potential rebound effect and also the wider the range of possible take-back, the greater the uncertainty of a policy's cost effectiveness and its effect upon energy efficiency (Ruzzenenti & Basosi, 2008).

Therefore, an integrated policy approach that creates consensus and coalitions among diverse stakeholders and interests can help to overcome implementation barriers, minimise rebound effects, and motivate people, businesses, and communities (von Stechow et al., 2015). This type of integrated policy approach is especially critical because current GHG reduction measures alone can make important contributions but cannot achieve the levels of reduction needed to shift to a 1.5°C pathway (IPCC 2014). Figure 1 shows that the policy integration is vital to achieving stabilisation pathways that are in line with global climate mitigation targets and they can create the basis for coalition building if the policy objectives of key stakeholders and veto players are taken into account.

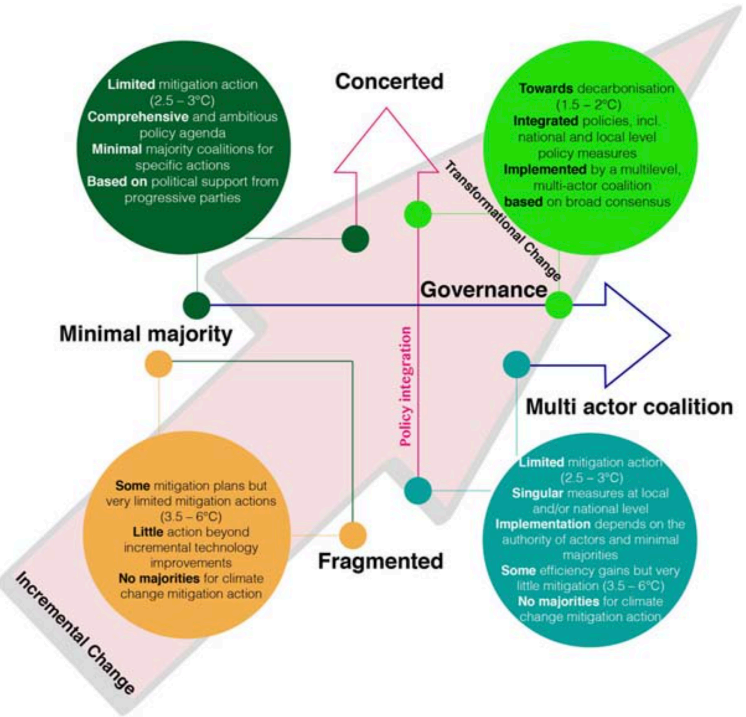

Figure 1: Policy integration and governance framework

4. Costs and benefits of transitioning to sustainable mobility

There is the general assumption that the transformation towards sustainability in the transport sector will be very costly. While the shifts towards more sustainable mobility infrastructures, services, and vehicle technologies will need innovation and investments, the overall benefits and savings far outweigh the costs. A sustainable mobility future would only require a fraction of the costs and resources compared to a business as usual scenario in the global transport sector.

Several international assessments have analysed the technological potential and effort required to decarbonise the transport sector (Figueroa et al., 2014; Fulton et al., 2013; IPCC, 2014). These analyses show that, moving on to a stabilisation pathway that is consistent with global climate change targets, transport needs to decarbonise substantially over the coming decades and almost entirely in industrialised countries by the middle of this century (OECD, 2017). Taking this path will unlock direct and indirect benefits that outweigh the costs, with savings of between US$ 50 trillion and US$ 100 in trillion in fuel savings, reduced vehicle purchases, needed infrastructure and fuel costs. The additional co-benefits and synergies generated by sustainable mobility, such as improved safety and air quality and reduced travel time make an even stronger case for the shift towards low-carbon transport. The contribution of countries to the global decarbonisation efforts of the (land-) transport sector is reflected in the scenarios that show travel demand, technology deployment and policy interventions and their effect on different scenarios.

From a climate change perspective vehicle technology and fuel switch options provide the biggest mitigation potential (Kahn Ribeiro & Figueroa, 2012), but this does not fully reflect a broader sustainable mobility perspective. A broader multimodal approach that manages growth in travel demand and modal split may yield important benefits in air quality, traffic congestion, safety and overall societal mobility may trigger substantially higher socio-economic co-benefits and may also be more cost effective (Van Vuuren et al., 2015).

A recent analysis of the University of California, Davis and the Urban Electric Mobility Initiative (UEMI) shows that transition towards sustainable, low-carbon and resource efficient mobility can save over US$6 trillion globally every year, by giving preference to public transport, walking and cycling (Figure 2).

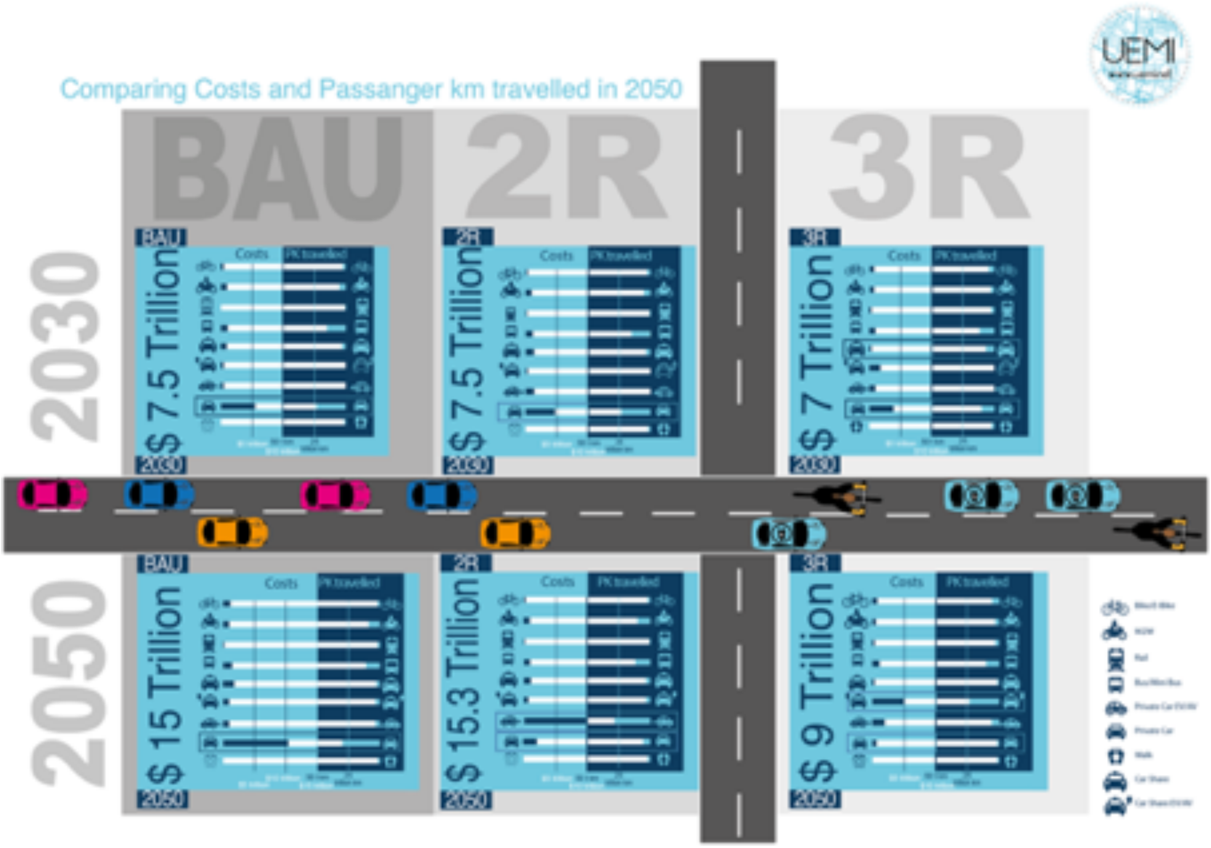

Figure 2: Cost comparison of transition pathways

The massive savings from reduced costs for vehicles and fuels far outweigh the estimated 1.5 trillion US$ that are needed in investments for efficient and accessible public transport systems.

The transformation of the transport sector is driven by several levels of intervention that shape, not just the vehicle technology, but also mobility patterns and urban form:

Accessibility is a key sustainable development goal. Providing high quality public transport services and walking and cycling infrastructure is a core part of accessibility for all. To enable this, densification characterised by compact city development can help with mixed use, poly-centric structures and short travel distances, and overall increase access to goods and services.

Sharing should include pooling and public transport feeder systems as well as access to shared cars and ride hailing services. Pricing system should be harmonised across these services and encourage the use of the most efficient options.

Efficiency and Electrification: With regard to efficiency, downsizing drastically vehicle size and power is vital and highly cost-effective along with improvements of the internal combustion engines itself. This is countering the trend of the last decades towards bigger, faster and more powerful cars, which has eradicated almost all efficiency gains in powertrain technologies. Similarly, electrification should focus on the most viable end resource efficient types of vehicles (small) and vehicle usage (public or shared). The use of renewable energy in powering e-mobility increases the emission reduction potential.

As mentioned earlier, air quality, road safety, energy efficiency, access to mobility services and other factors that are considered to be co-benefits of sustainable urban development measures from a climate change perspective are in fact the driving factors for policy intervention, in particular on the local level (Goodwin, 2005)Hultkrantz et al., 2006; Jacobsen, 2003; Rojas-Rueda et al., 2011. There is a direct link between energy security and climate change mitigation actions that focus on fuel switch options, to biofuels and electrification (Shakya & Shrestha, 2011; Leiby, 2007; Jewell, Cherp, & Riahi, 2014) and demand side measures, such as resource and fuel efficiency and compact urban design (Cherp et al., 2012; Leung, 2011; Cherp et al., 2012; Leung, 2011; Sovacool & Brown, 2010)(. These city level strategies are also likely to improve access and contribute to productivity and social inclusion (Banister, 2008; Miranda & Rodrigues da Silva, 2012), provide better access to jobs, markets and social services (Banister, 2011; Boschmann, 2011; Sietchiping, Permezel, & Ngomsi, 2012). Improved access is a major objective in the New Urban Agenda as it provides opportunities for employment, education and other basic needs (Misselwitz, Overmeyer, & Polinna, 2016).

The combination of various policy objectives that can be addressed by an integrated multi-level policy and governance approach provides a solid basis for durable polices that can have long-lasting impacts. Climate change, better air quality, noise prevention, safety, energy security and productivity are key policy objectives for policy makers at the local and national level, even though to varying degrees (De Hartog, Boogaard, Nijland, & Hoek, 2010; Jewell et al., 2014; Rabl & De Nazelle, 2012; Tiwari & Jain, 2012). While this creates substantial opportunities for benefits across these policy areas, it also creates a highly complex policy environment with a large number of actors and stakeholders. Table 1 provides an overview of the required policy intervention and their potential impact and cobenefits, which gives a first indication of the key policy actors involved and with that the potential veto players (Lah, 2017).

Table 1: Summary of Sustainable Urban Mobility Actions and Potential Benefits

Low-Carbon Urban Mobility Actions	Emission reduction potential	Co-benefits and synergies	Potential veto players
Activity (reduction and management: short distances, compact cities and mixed use)	Potential to reduce energy consumption by 10% - 30%	Reduced travel times; improved air quality, public health, safety and more equitable access	Urban planing department, mayor, transport department
Structure (shift to more energy-efficient modes)	Potential for energy efficiency gains varies greatly, but, e.g. BRT can deliver up to 30% reductions at a cost of $1 - $27 million/km	Reduced urban congestion and more equitable access	Mayor, transport department, public transport authority

Intensity (vehicle fuel efficiency)	Efficiency improvement of 40% - 60% by 2020 feasible at low or negative costs	Improved energy security, productivity, and affordability	Treasury/ Finance Ministry, Transport ministry (national)
Fuel (switch to electricity, hydrogen, compressed natural gas, biofuels and other fuels)	Changing the structure of the energy consumption but not necessarily overall demand	Diversification of the fuels used contributes to climate, air quality and/or energy security objectives	

Adapted and expanded from (Sims et al., 2014); (Figueroa, Lah, Fulton, Mckinnon, & Tiwari, 2014); (Lah, 2017)

5. Living labs and demonstration actions

To enable transformative change towards sustainable urban mobility it is vital to go beyond a mere technical perspective on vehicle technologies and take a systemic approach. The Living Lab concept outlined in this paper addresses e-mobility innovation as a component of an intermodal concept that assists in the wider transition towards sustainable urban mobility. Testing innovative urban e-mobility solutions at different Technology readiness levels (TRL) and in different environments can enable replication and can contribute to a supportive political, legal, economic and fiscal landscape An integral part of effective Living Lab approach is the facilitation of close cooperation between local, regional and national decision-makers, operators, industry and businesses to develop innovative e-mobility solutions that not only fit into the local context but also are scalable and replicable (Voytenko, Mccormick, Evans, & Schliwa, 2016). The Living Lab approach outlined here considers mobility as a socio-technical system that consists of technologies, regulations, institutional settings, the economic system, interests, influence and power structures, behavioural patterns, and social norms. It considers that e-mobility should be integrated with existing transport services and networks in the frame of sustainable urban mobility planning tailored to the specific local economic, technological, social, political and environmental context. The integration of e-mobility innovations into the wider frameworks of Sustainable Urban Mobility Plans (SUMPs), local air quality plans and National Urban Mobility Programmes as well as business operations and industry development strategies are vital objectives of this approach.

6. Conclusion

The transition to sustainable mobility has the potential to unlock trillions of dollars in cost savings or more sustainable travel patterns, along with substantial co-benefits that help transforming cities into more liveable, environmentally friendly and economically efficient centres. Segregated policy interventions in this sector can have unintended consequences, positive and negative as they rarely only affect one objective, for example, air quality measures may affect fuel efficiency negatively or biofuels may have land-use change implications.

Linking and packaging policies are therefore vital to generate synergies and co-benefits between measures. This provides a basis for coalitions that can align different veto players. While some analysis on policy integration has been carried out, e.g. (Justen et al., 2014; Givoni, 2014), the linkages between policy packaging, co-benefits and coalitions have not been assessed for climate change mitigation strategies in a specific sector yet.

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