Climate change and transport

Patrick Jochem and Werner Rothengatter and Wolfgang Schade

Karlsruhe Institute of Technology (KIT), Institute for Industrial Production (IIP)

2016

Patrick Jochem, Werner Rothengatter, Wolfgang Schade 2016

Climate change and transport

In: Transportation Research Part D: Transport and Environment, Volume 45, Pages 1-3, https://doi.org/10.1016/j.trd.2016.03.001

Postprint of the article “Climate change and transport” *In: Transportation Research Part D: Transport and Environment, Volume 45, Pages 1-3*, https://doi.org/10.1016/j.trd.2016.03.001

Climate Change and Transport

Patrick Jochem[1], Werner Rothengatter[2] and Wolfgang Schade[2]

[1] Karlsruhe Institute of Technology (KIT), Institute for Industrial Production (IIP), Chair of Energy Economics, Hertzstr. 16, Building 06.33, D-76187 Karlsruhe, Germany, Jochem@kit.edu,
Tel: +49 721 608 44590, Fax: +49 721 608-44682

[2] M-Five, Frankenstr. 8, D-76137 Karlsruhe, www.m-five.de, wolfgang.schade@m-five.de,
Tel: +49 721 824818 90, Fax: +49 721 824818 91

The transport sector is currently the second largest emitter of carbon dioxide (CO2) emissions, which is the main anthropogenic greenhouse gas (IPCC, 2013). On the global perspective, transport emissions are increasing fast and they might soon catch up with those from the electricity and heat provision sector (IEA, 2015). In 2010 transport generated about 7.0 gigatonnes of direct greenhouse gas emissions. Mainly driven by fast development of emerging economies, transport might double its emissions by 2050 (IEA, 2015). Decarbonising transport is seen as more challenging compared to other sectors (cf. Creutzig et al., 2015).

The fifth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC) indicates that the increase in global average surface temperature is very likely due to the observed raise in anthropogenic greenhouse gas emissions and the target to keep global warming below 2L requires severe efforts by the society (IPCC, 2015). In contradiction, transport has not been in the focus of the political agenda (Creutzig et al., 2015) – mainly because policy makers believe that the economy is strongly dependent on cheap mobility and they fear to annoy their voters. The scientific community should strengthen their proclamation that current societies are still focusing on inefficient and oil dependent mobility technologies. Non-motorised modes, public transport, and electric vehicles might provide competitive and efficient abatement options with further social benefits in the future (Creutzig, 2015; Jochem et al., 2015). Otherwise, the ongoing increase in greenhouse gas emissions from transport will highly probably continue for the next decades, due to the rising global vehicle fleet and increasing volumes in freight transport and aviation.

For this, further political efforts are necessary. The scientific community has been providing numerous recommendations – with little impact on actual policy-making. These policy measures might be classified by the updated Activity– Structure–Intensity–Fuel (A–S–I–F) framework, which includes four main policy leverages of greenhouse gas mitigation: avoid (i.e. reduce number of trips and travel distance), shift (i.e. use fuel-efficient modes), improve (i.e. implement more efficient technologies), and finance (i.e. find ways to finance these actions) (cf. Tiwari et al., 2011). The approach is based on the decomposed drivers of transport emissions – which are simultaneously possible leverages for policy measures:

$$E_{GHG} = \sum_{i\epsilon I} TV_i \cdot eff_i(q) \cdot CI_i(f) \tag{1}$$

The stylised equation states: Transport greenhouse gas emissions (E_{GHG}) equals the sum over the emissions from all traffic modes i ($i \in I$). These emissions depend on their mode-specific traffic volumes (TV_i), the average technology-dependent energy efficiency ($eff_i(q)$), and the average fuel-dependent carbon intensity ($CI_i(f)$). Whereas the avoid (A) leverage focuses on declining the first factor TV_i, the shift (S) leverage changes its composition. Both measures usually require some behavioural changes. The third leverage, improve (I), is usually a technically-based measure, which mainly focuses on improving the energy efficiency of modes and/or reducing the carbon content of the fuels. Finally, the finance (F) leverage considers the missing willingness to invest in projects (e.g. urban public transport) due to limited budget in developing countries and the huge required investments with long pay-back periods in these fields. This F leverage might influence all three factors in the formula – even though its primary focus is on the S leverage.

This approach oversimplifies, however, the transport system, which is highly complex and nonlinear. E.g., individual pol-icy measures in isolation have a limited impact and the effect of different combined policy measures is not necessarily additively. Usually, the greatest impact is achieved when a sustained combination of coherent policy measures is pursued, taking advantage of their multiplicative beneficial effects. Otherwise, the impacts of a mix of policy measures could even level out. This makes a holistic system approach to greenhouse gas mitigation policies for transport necessary.

Further aspects should be considered in order to achieve the ambitious greenhouse gas emission reduction targets in the transport sector. Some of these stylised facts are: (1) Very low-carbon (or ''carbon-free") transport technologies are a pre-requisite for a long-term decarbonised, sustainable transport system. Public and non-motorised modes for urban areas are highly effective in this regard. (2) Vehicle ownership and transport volumes (i.e. vehicle kilometre travelled, VKT) per capita in developing countries are low and are going to increase rapidly with economic growth. Therefore, a leap-frogging strategy for clean technologies and multi-modal mobility is highly necessary. Here, electric vehicles (combined with renewable electricity generation) and services enhancing multi-modal mobility might be the key. (3) A significant increase in demand for freight transport (mainly maritime and road-based) as well as aviation seems unavoidable. Today, no simple solution for a substantial change in these modes appear on the horizon. (4) Fossil fuel extraction and use, in particular in many developing countries, is highly subsidised, either directly or indirectly by the society bearing the external cost of harming health and environment. Getting the prices right, including all externalities of fossil fuel provision and its burning, would still be one of the major policy changes to be implemented to shift mobility towards low-carbon solutions. In the case of freight transport, a major change of the spatial patterns of manufacturing and logistics would be necessary, combined with a modal shift to rail and ship on main runs paired with more efficient milk runs for sourcing and delivery. Aviation is presently widely exempted from taxation and internalisation of external costs, which leads to low costs of energy. This does not create incentives to improve efforts to improve fuel efficiency in aviation.

In October 2014, we took the fifth Assessment Report by the IPCC as motivation to organise an international workshop on different aspects of greenhouse gas mitigation in the transport sector. The workshop was initiated by the Special Interest Group (SIG) ''Transport and the Environment" (formerly SIG 11, now SIG F2) of the World Conference on Transport Research Society (WCTRS). The focus of the symposium was on discussing current research fields and scientific methods in order to find effective and efficient mitigation solutions for the transport sector. The 25 contributions from distinguished experts from all over the world contained policy or social options as well as technological innovations.

In this special issue nine papers were selected, which represent the main contribution of this workshop.

The first section is on road transport. Christian Thies, Karsten Kieckhäfer, and Thomas Stefan Spengler analyse different market introduction strategies of car manufacturers for alternative powertrains in long-range passenger cars under competition as one alternative to significantly reduce CO_2 emissions from road passenger transport. This is a relevant topic because a supply of alternatively propelled vehicles and their market success is pivotal for zero emission vehicles in road transport. The analysis is based on a comprehensive system dynamics model, which considers two competing manufacturers each introducing plug-in hybrids and fuel cell electric vehicles in the German market. The results indicate that greater competition is more successful regarding higher market shares of alternatively powered vehicles.

In this special issue nine papers were selected, which represent the main contribution of this workshop.

Kees van Goeverden, Bart van Arem, and Rob van Nes shed some light on the rather unknown volumes of long-distance travelling by Western Europeans and the corresponding greenhouse gas emissions. They base their analysis mainly on data of the DATELINE project. The estimated total greenhouse gas emissions of long-distance travelling amount to about 520 mega-tons, which is about 50% of all passenger transport emissions. This is alarming because long-distance travelling, particularly by air, is expected to grow more than proportionately.

Maria Vittoria Corazza, Umberto Guida, Antonio Musso, and Michele Tozzi are focusing on the environmental impact from the fast growing market share of bus transport in Europe. They develop innovative solutions including more comfort-able buses, advanced operations based on intelligent transport systems and new engines designed to save fuel and to enhance electrification for a sustainable future European bus system.

The second focus on non-motorised transport in urban areas starts with the contribution by Linus Mattauch, Monica Ridgway, and Felix Creutzig focusing on the necessity to consider individual behavioural mobility patterns in transport modelling and policy design. These individual behaviours are currently hardly considered in current policy designs. They base their analysis on a highly interdisciplinary approach. Their main finding is that transport demand modelling should consider behavioural effects explicitly due to their interaction with preference formation, health benefits (e.g. from additional activity due to non-motorised transport), happiness and status symbols of individuals.

The paper by Salvatore Caprì, Matteo Ignaccolo, Giuseppe Inturri, and Michela Le Pira Green is focussing on how to con-sider climate change mitigation options for planning tools of walking networks in cities. They apply an integrated approach combining transport and land-use planning concepts in order to identify actions oriented to increase resilience with respect to extreme weather conditions. The approach is tested in an Italian case study.

Steffen Lohrey and Felix Creutzig hypothesise the existence of an optimal 'Sustainability Window' of urban form. In the context of the fast rising population of mega cities, this is a very relevant analysis. They apply a theoretical approach supplemented by empirical analysis and indicate how main urban environmental challenges are influenced by the urban trans-port system and the urban form. The authors conclude that only a combination of transport policies, infrastructure investments and progressive public finance enables the development of cities that perform well in several sustainability dimensions. Finally they even indicate an ''optimal" population density for cities and a minimum modal split of ''environ-mental modes".

The third focus is on two dedicated modes, namely aviation and waterborne transport. Janina Scheelhaase, Katrin Dahlmann, Martin Jung, Hermann Keimel, Hendrik Nieße, Robert Sausen, Martin Schaefer, and Florian Wolters give interesting insights from the AviClim research project and suggest how aviation's full climate impact should be addressed from an economic point of view. Their interdisciplinary modelling approach includes both long-lived CO2 and short-lived non-CO2 effects and is therefore a significant contribution to the research society in this field. Their results advise a global emissions trading scheme for both CO2 and non-CO2 emissions.

This analysis was supported by a second paper on aviation by Parth Vaishnava, Annie Petsonk, Rafael Alberto Grillo Avila, M. Granger Morgan, and Paul S. Fischbeck. They analysed mechanisms to guarantee carbon–neutral growth in international aviation, as suggested by the International Civil Aviation Organization (ICAO). The current proposal by the ICAO was hypothetically applied to empirical flights of more than 100 airlines. There results show that the impact on the airlines is very heterogeneous. Hence, the authors develop an alternative approach.

Finally, Christa Sys, Thierry Vanelslander, Mathias Adriaenssens, and Ive Van Rillaer give an interdisciplinary overview on the challenges in introducing an international emission regulation in sea transport. This is not only relevant with respect to the future growth of waterborne freight transport, but also due to the severe local air emissions of sulphur dioxide and particulate matter. The authors focus on deepseashipping and present the general economic impact from introducing Emission Control Areas as well as the resulting competition between (European) seaports.

All in all, the selection of papers shows the variety of topics discussed during the workshop and the holistic perspective the SIG F2 is taking. However, concepts for developing countries and for freight transport remained underrepresented. Some learning from the workshop was shared in a session dedicated to the mitigation potential of electric vehicles during the United Nations Framework Convention on Climate Change (UNFCCC) 21st Conference of the Parties (COP21) in Paris. Hence, our scientific contribution was presented to relevant stakeholders and policy-makers

References

Creutzig, F. (2015), Evolving Narratives of Low-Carbon Futures in Transportation, *Transport Reviews*, doi: 10.1080/01441647.2015.1079277.

Creutzig, F., 2015. Evolving narratives of low-carbon futures in transportation. Transp. Rev. http://dx.doi.org/10.1080/01441647.2015.1079277.

Creutzig, F., Jochem, P., Edelenbosch, O.Y., Mattauch, L., Vuuren, D.P.v., McCollum, D., Minx, J., 2015. Transport – a roadblock to climate change mitigation? Science (Policy Forum) 350 (6263), 911–912.

IEA (International Energy Agency), 2015. World Energy Outlook 2015. Paris.

IPCC (Intergovernmental Panel on Climate Change), 2013. Climate Change 2013 – The Physical Science Basis. Cambridge.

IPCC (Intergovernmental Panel on Climate Change), 2015. Climate Change 2014 – Mitigation of Climate Change. Cambridge.

Jochem, P., Babrowski, S., Fichtner, W., 2015. Assessing CO_2 emissions of electric vehicles in Germany in 2030. Transport. Res. A: Policy Pract. 78, 68–83.http://dx.doi.org/10.1016/j.tra.2015.05.007.

Tiwari, R., Cervero, R., Schipper, Lee, 2011. Driving CO_2 reduction by integrating transport and urban design strategies. Cities 28 (5), 394–405.