International Transport Forum

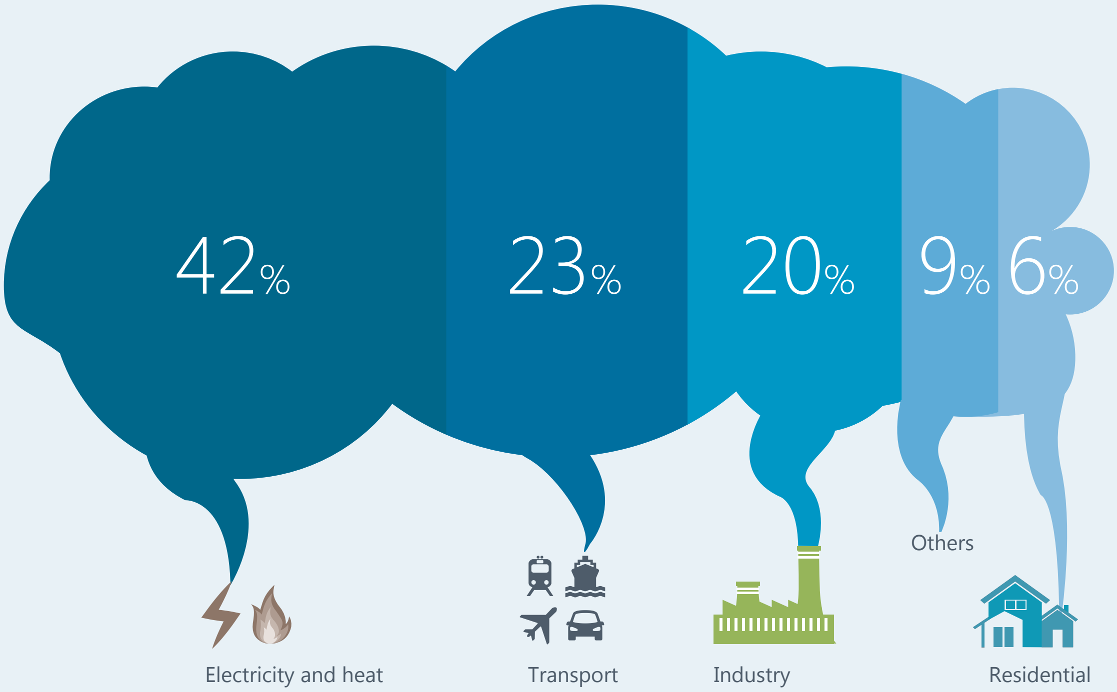
Carbon Valuation for Transport Policy

Towards a More Coherent International Approach

International Transport Forum: Global dialogue for better transport

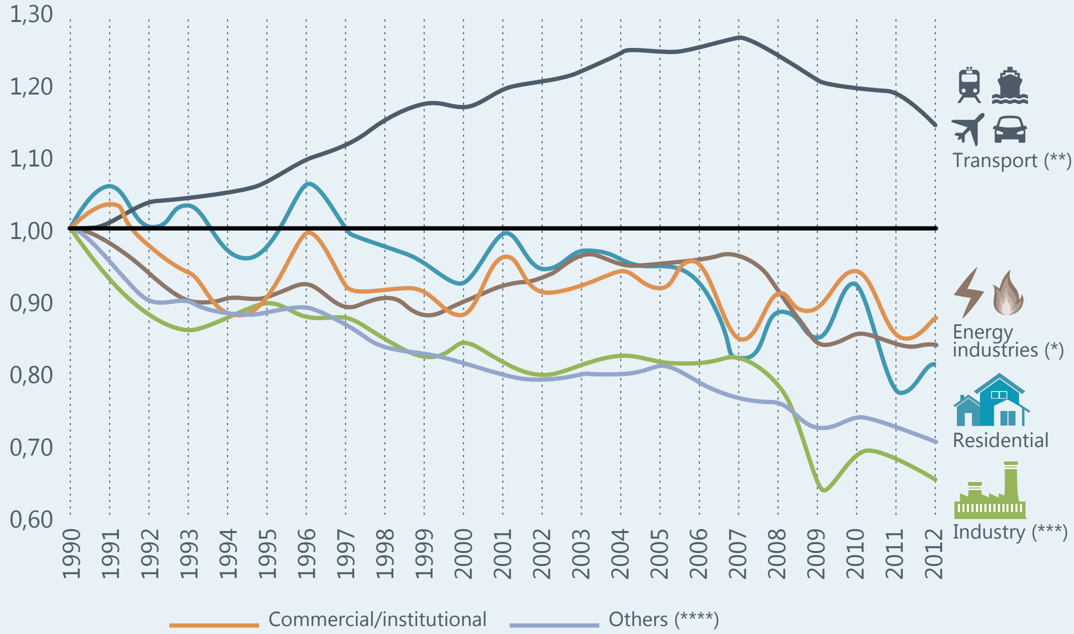
Global CO_2 emission shares

(from fuel combustion, by sector, 2012)



Others includes commercial/public services, agriculture/forestry, fishing, energy industries other electricity and heat generation, and other emissions not specified elsewhere.
Source: IEA (2014)

Greenhouse gas emissions in the European Union 1990-2012



Notes: (*) Excluding LULUCF (Land Use, Land – Use Change and Forestry) emissions and International Bunkers (**) Excluding International Bunkers (international traffic departing from the EU) (***) Emissions from Manufacturing and Construction and Industrial Processes (****) Emissions from Fuel Combustion in Agriculture/Forestry/Fisheries, Other (Not elsewhere specified), Fugitive Emissions from Fuels, Solvent and Other Product Use, Waste, Other. Source: European Commission (2015) "Reducing emissions from transport," http://ec.europa.eu/clima/policies/transport/index_en.htm [Last accessed 3 November 2015]

The issue

Carbon valuation for decision making in transport

Transport is central to the climate change mitigation task. Transport accounts for nearly a quarter of global carbon dioxide (CO_2) emissions from fuel combustion. Between 1990 and 2012, CO_2 emissions from the transport sector increased by 57% globally. They result mainly from road transport: In 2012, the road sector accounted for 75% of all transport emissions. The increase in emissions from road transport was less pronounced than in other transport modes, however: Global road traffic emissions grew by 64% globally over the 1990 to 2012 period, compared to increases of 80% for aviation and 66% in maritime transport.

Transport emissions are proving stubborn to reduce. Even jurisdictions that have made effective progress in reducing emissions in other sectors of the economy have had limited success in curtailing CO_2 from transport. In the European Union (EU), for instance, transport emissions increased by 36% between 1990 and 2007, while those in other major sectors decreased 15%. Since 2008, emissions from transport in the EU have begun to fall (in part due to challenging economic conditions) but transport emissions in 2012 were still 20% above 1990 levels.

Global road and rail passenger travel is projected to grow to 2050 by between 120% and 230%, depending on future fuel prices and urban transport policies, according to the International Transport Forum's *Transport Outlook 2015*. Consequently, and taking into account expected technological progress, CO_2 emissions from global surface passenger transport will grow by between 30% and 110%, while growth in world road and rail freight volumes to 2050 ranges from 230% to 420%.

In view of its resilience to decarbonisation efforts and the projected increases in demand for both passenger and freight transport, implementing policies that set transport on a clear decarbonisation pathway are central to the climate change mitigation task.

Valuation of CO_2 emissions is central for good decision making in transport. Cost-Benefit Analysis (CBA) is widely recognised as a useful, even indispensable, tool for making good decisions on which transport projects should be funded and which policies should be pursued. CBA essentially aims to establish which projects and policies offer the best value for money, one of the core criteria for making decisions, notably for the long term.

The core approach of CBA for transport projects and policies is to use the users' willingness to pay as the main measure of the direct benefits from a transport investment or service. Where there are benefits or costs that spill beyond the direct benefit for users affected by the intervention (e.g. more noise associated with new train services), the analysis needs to effectively incorporate values for these further impacts, identifying them clearly in appraisal summary tables to highlight trade-offs for decision makers, and/or by "monetising" each one to allow comparisons using a common metric.

Monetising noise and health impacts of local emissions, safety impacts, and congestion are routine in practice. Standardised approaches are emerging, even at an international level, to model and measure these effects that occur within national borders. However, the global nature of climate change makes it more difficult to capture its effects within the CBA framework. Policy and project decisions are generally taken with a national or sub-national perspective, so it is not obvious how global impacts of any increases or decreases in emissions generated by local projects and policies should be valued. In practice, governments select different approaches to ascribing values to CO_2 emissions within CBAs.

The choices applied in CBAs in the transport sector are critical. They can form the basis for governments' decisions on how to weigh trade-offs between climate change mitigation and other policy objectives. Inappropriate valuation of CO_2 emissions will therefore affect the level of mitigation targeted (and achieved) and would lead to an inappropriate allocation of resources.

The approach

Comparing carbon values and valuation methods

The issues underlying the valuation of CO_2 emissions were explored in two recent studies by the International Transport Forum (ITF) and the OECD. These studies also examine the valuation approaches adopted in selected countries and looked at the actual values used. The OECD surveyed a sample of member countries on their approaches for valuing CO_2 emissions in transport appraisals. Drawing on this survey and the available literature, an ITF Working Group examined the practical and theoretical issues associated with valuing CO_2 emissions (the "carbon value" for short). Three issues were explored in particular:

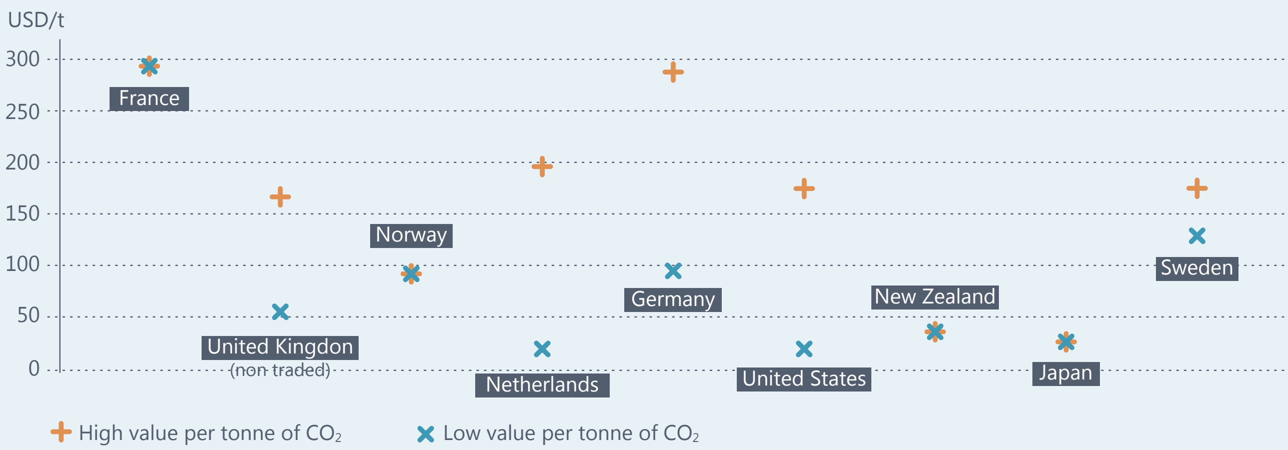
- **Valuation of carbon:** What is the correct approach to valuing the social cost of carbon emissions to be used in CBA? How should the carbon value evolve over time? Should the carbon value be the same across different sectors within a jurisdiction? Should the carbon value be the same across jurisdictions?
- **Climate change-related uncertainty**: How does uncertainty affect the results of traditional CBA? Does the scale of uncertainty associated with some climate change effects require new techniques to better capture it for the CBA?
- **Discounting long-term effects**: Should the discount rate be constant over time? If a declining discount rate schedule is used in project appraisal, how should the schedule be determined?

Unlike local air pollution, the effects of climate change do not depend on where in the world gases are emitted (technical considerations regarding aviation aside). There is a strong case for considering the costs incurred by climate change as shared globally. This view would imply a uniform marginal cost of CO_2 emissions worldwide (at any given point in time).

In practice, different countries apply different values to carbon. The variation in the values applied in CBA is wide, and there are even variations across industry sectors within a single country. Several countries recommend the application of "low" and "high" values in transport CBA to test a range of scenarios.

Carbon values

used in transport project appraisal in 2030 by selected OECD member countries



Notes: All carbon values were first inflated to 2013 prices in domestic currency using GDP deflators and then converted to USD using PPP conversion factors. GDP deflators and PPP data are sourced from OECD Statistics. A conversion factor of 3.67 is used to convert tC to tCO_2 (for Japan).

Source: OECD survey of monetary carbon values in selected member countries.

The insights

Differences in the valuation approach affect mitigation policy

Part of the discrepancy across the monetary values that countries apply in appraisal reflects different methods used in valuation of CO_2 emissions. Four approaches are generally applied:

1. Damage cost estimate (the "social cost" of carbon)

2. Abatement cost estimate based on an emissions target

3. Abatement cost estimate based on current mitigation policies

4. Market price of carbon under a tax or emission trading scheme.

Theoretically, the damage cost approach is the most appropriate for assessing the economic effects of CO_2 emissions. Damage costs can be estimated using sophisticated integrated climate-economy models covering impacts on both natural and social systems. However, the models used to estimate damage costs are complex and subject to significant uncertainty.

The three other approaches to deriving carbon values can be used to substitute for damage cost estimates but they will yield different results when national approaches to emissions reduction are not fully consistent with assumptions in integrated global climate change assessment models. A first inconsistency arises given that each country or group of countries has different carbon budgets established through global negotiations (rather than a single budget applied through a global emissions trading system for example).

Beyond the multi-lateral strategic issues, there are other reasons why alternative valuation approaches will diverge from global damage cost estimates. The value of carbon derived from abatement cost approaches varies with the policy options selected in the emissions mitigation strategy adopted and with the CO_2 emission target chosen. For example, the use of poorly designed policies such as mandating the use of biofuels with volumetric targets will result in extremely high cost per tonne of CO_2 abated.

Carbon prices derived from current emissions trading markets or from CO_2 taxes can also diverge greatly from damage costs. The price of carbon on emissions trading markets is strongly influenced by decisions on the total number of emission allowances issued and by the exemptions accorded to specific sectors of the economy. Unless the quota for allowances is determined by damage cost modelling it will have little or no relation to marginal climate change impacts.

Today's markets reflect this divergence rather than the potential for trading to drive efficiency in the mitigation measures taken. A survey of some of the trading schemes operating today found a range of between USD 2 and USD 14 per tonne of CO_2, which is much lower than values used in transport appraisals. Carbon tax levels tend to be even more arbitrarily set, more on the basis of political acceptability than optimal abatement strategies.

Regardless of the approach used, for efficiency a common carbon value should be assigned for national investment and mitigation policy appraisal in all sectors within the same jurisdiction. According to the OECD survey, some countries have not established a standardised practice, so different carbon values are sometimes used by different sectors within the same jurisdiction. Since the policy actions in one sector can often affect the outcomes of other sectors, the use of inconsistent carbon values across sectors can hinder assessment and effectiveness of climate change policies.

Addressing risk and uncertainty

Compounding the methodological differences among countries is the challenge of dealing with cause-and-effect relations that are not perfectly understood and cannot be forecast with precision. Even the

Putting a price on carbon

Strengths and weaknesses of alternative approaches to carbon valuation

Strengths		Weaknesses
- Global consistency - Appropriate measure of damage - Accounts for feedback	**Damage cost estimate** (the "social cost" of carbon)	- Complex model with uncertainties - Equity concerns in aggregating effects across countries
- Simple to understand (cost to the economy or government) - Easy to implement if mitigation policies have been costed	**Abatement cost** estimate based on current mitigation policies	- Does not represent damage costs - Limited by national abatement choices, which may be inefficient or may change - Value varies across countries
- Simple to understand (cost to the economy or government) - Easy to implement if abatement cost curve has been estimated already	**Abatement cost** estimate based on emission target	- Does not represent damage costs - Limited by national policy choices - Need to estimate abatement cost curve - Value varies across countries
- Reflects efficient mitigation measures if global emission trading scheme covered all emissions	**Market price** under a tax or trading scheme	- Dependent on prior abatement cost estimate - No global trading scheme in place - Many exclusions from national trading schemes - Carbon taxes often set at an arbitrary level - Value varies across countries

most sophisticated and theoretically appropriate approach to carbon valuation (damage cost) is subject to high uncertainty over the potential effects of increasing CO_2 concentration in the atmosphere. There are also significant uncertainties in the potential socio-economic responses to changes in the climate. So, while the models that estimate likely impacts on the climate and resulting damage costs have greatly improved, these models still have limitations.

To address uncertainty in long-term climate effects in transport appraisal, it is first necessary to distinguish between risk, i.e. unknown outcomes that can be characterised by an objective probability distribution, and unquantifiable uncertainty or "Knightian" uncertainty (following 20th century economist, Frank Knight).

Quantifiable risks in the cause-effect relationships of the climate system and economy can be dealt with by incorporating the probability distribution of climate events in cost-benefit and related analyses. In its simplest form, this can be done through the application of qualitative descriptions of possible outcomes, or testing the sensitivity of results to a number of likely parameter values. More sophisticated approaches include the application of probability-weighted scenarios.

Climate sensitivity provides an example of the role that risk and uncertainty play in developing a damage cost estimate for the value of carbon emissions. Climate sensitivity is defined as the average surface warming that would result from a doubling of the atmospheric concentration of CO_2. Every climate model reflects unknown outcomes in physical relationships using a probability distribution that quantifies the risks that a doubling in CO_2 concentrations will lead to a 2, 3, 4, 5 or 6 degree Celsius temperature increase. Across climate models, a wide range of probabilities is assigned to these outcomes. Confidence that these probabilities are accurate is clearly low. In other words, they reflect Knightian uncertainty as much as quantifiable risk.

A key uncertainty in climate policy relates to the occurrence of catastrophic events with a low probability of occurrence but a high potential of severe damages. The magnitude of damages and their probabilities are unknown and may be largely unknowable. It is therefore inappropriate to apply standard statistical approaches to try and incorporate these effects in CBA. The better approach is to employ non-standard techniques to supplement or inform the core quantified CBA. This could be done by carrying out an uncertainty assessment, which should be similar to sensitivity testing or scenario analysis but would include the application of less likely sensitivity tests and scenarios. Presenting a separate uncertainty analysis to decision makers should assist in making better policy and investment decisions.

Carbon values now and for the future

Countries differ not just in how they estimate the value of carbon, but also in how they consider the value of carbon will evolve over time. Governments in some countries, the have adopted carbon values that increase over time, others have not. Two elements are relevant in the incorporation of the time element of climate impacts in CBA.

First, there is consensus among scientists and policy makers that carbon values will increase over time, at least conceptually. This is because the impact of the emission of an extra tonne of CO_2 will increase as the concentration of CO_2 in the atmosphere increases.

The second factor is the way that future impacts are discounted to present values, i.e. the social discount rate. Individuals exhibit a pure time preference. (Though, of course, the level of CO_2 concentration is affected by mitigation efforts to slow down the rate at which CO_2 accumulates). This depends on how individuals view their enjoyment of consumption over time, preferring overall consumption today over equivalent consumption in the future. This is reflected in CBA by applying society's rate of time preference as a discount rate (the "social discount rate").

In traditional CBA frameworks, impacts that may occur in the distant future are typically excluded from the analysis. This is based on the view that once such future values are discounted back to present values they will be close to zero. However, this may not be appropriate for assessing climate change effects as climate change policy is very much concerned with potential changes in the distant future. Such potential impacts can be emphasised in CBA by using a very low discount rate or a declining discount rate.

Future carbon values

By country, in USD 2013 value per tonne of CO_2

Source: ITF calculations based on OECD survey of selected member countries

There are two main approaches to determining discount rates for impacts affecting future generations. The prescriptive approach assumes that society's "pure" preference between consumption today and in, say, 50 years, is a policy parameter that can be set to balance the welfare of current and future generations. The descriptive approach assumes that the discount rate should be inferred from observations of market behaviour such as the pricing of long-term financial assets.

In a traditional transport CBA, the discount rate is usually assumed to be constant over time. Having a constant discount rate means individuals (and generations) are time-consistent and that their later preferences confirm earlier preferences. However, a range of academic literature has argued that when future discount rates are uncertain, then the effective (or "certainty-equivalent") discount rate must decline over time. Against this argument, other researchers have attempted to incorporate project-specific risks as well as Knightian uncertainty in the calculation of the appropriate discount rate. On balance, it is not clear from the current state of research, whether the flat or declining discount rate is appropriate in the appraisal of initiatives that will have major climate implications.

Currently, different countries apply different discount rates in CBAs, ranging from 1% to 8% per annum in the sample of OECD countries surveyed, with methodological differences explaining much of the difference in level. Of the countries surveyed, the United Kingdom and Norway adjust the discount rate for the risk associated with long-term effects across time by adopting a declining schedule, while the Netherlands, Germany and the United States adopt a lower but constant discount rate.

The effects of the carbon value's time profile and the discount rate can be considered together to give an indication of how strongly differences in emissions will feature in transport CBAs – particularly where emission impacts are produced later in the future. For example, in present value terms, a tonne of CO_2 saved by a project in 2050 would be valued between USD 2, in New Zealand transport appraisal, and USD 300, in German transport appraisal.

In practice, the divergence of global carbon values will mean that initiatives to reduce the carbon intensity of transport in New Zealand would tend to perform less well in a CBA than in Germany, where carbon reduction benefits would be given a large value.

Without a unified approach in each country's CBA guidelines, including in the transport sector, governments are likely to each make different and sub-optimal decisions about projects that affect national emissions. Consequently, some governments may overinvest in climate change mitigation, some may underinvest, and, most likely, the total amount of mitigation will be too little to stay within the globally agreed CO_2 concentration targets.

There are several useful analytical approaches to the valuation and the incorporation of CO_2 emissions into CBA applied in OECD member countries. While at this stage, there is no single number or approach that is perfect, there is a strong case for countries to work towards a common approach to valuation.

Further reading

OECD/ITF,
Adapting Transport Policy to Climate Change: Carbon Valuation, Risk and Uncertainty,
OECD Publishing, Paris, 2015

OECD/ITF,
ITF Transport Outlook 2015,
OECD Publishing, Paris,2015

International Energy Agency,
CO_2 Emissions from Fuel Combustion
Paris, 2014

"Monetary Carbon Values in Policy Appraisal: An Overview of Current Practice and Key Issues", OECD Environment Working Papers, 92, Paris, 2015

"Improving the Practice of Cost Benefit Analysis in Transport", ITF Discussion Paper, Paris, 2011

About the International Transport Forum

Who we are
The International Transport Forum at the OECD is an intergovernmental organisation with 57 member countries. It acts as a think tank for transport policy and organises the Annual Summit of transport ministers. ITF is the only global body that covers all transport modes. The ITF is administratively integrated with the OECD, yet politically autonomous.

What we do
The ITF works for transport policies that improve peoples' lives. Our mission is to foster a deeper understanding of the role of transport in economic growth, environmental sustainability and social inclusion and to raise the public profile of transport policy.

How we do it
The ITF organises global dialogue for better transport. We act as a platform for discussion and pre-negotiation of policy issues across all transport modes. We analyse trends, share knowledge and promote exchange among transport decision-makers and civil society. The ITF's Annual Summit is the world's largest gathering of transport ministers and the leading global platform for dialogue on transport policy.

International Transport Forum

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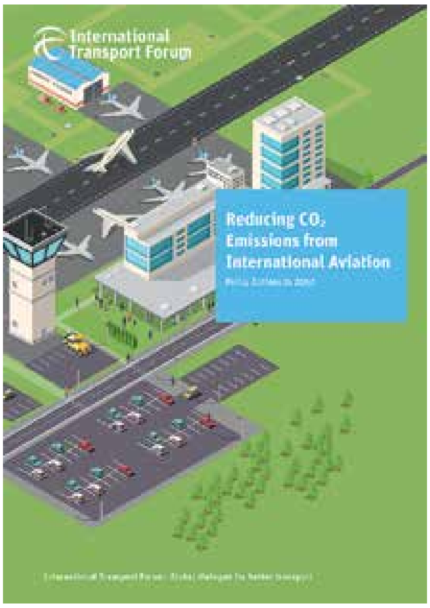
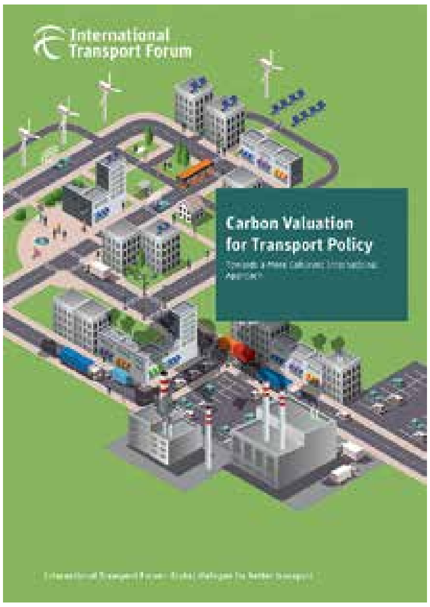
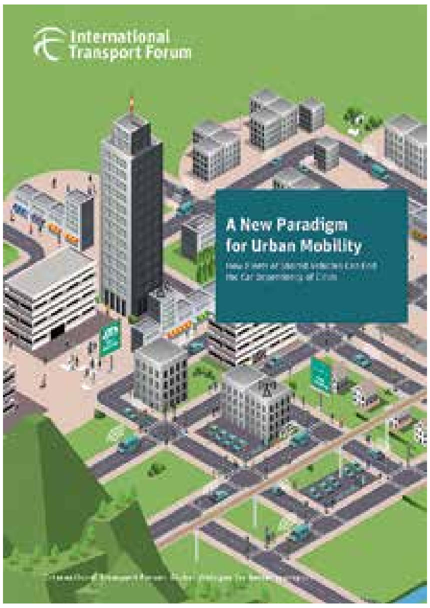
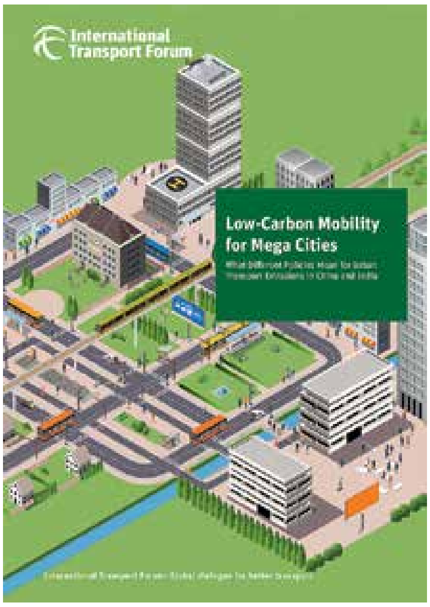
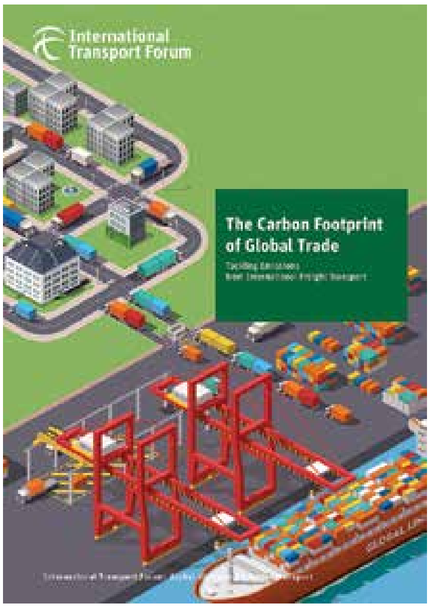
PAPERS ON TRANSPORT POLICY YOU SHOULD READ FOR COP21











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