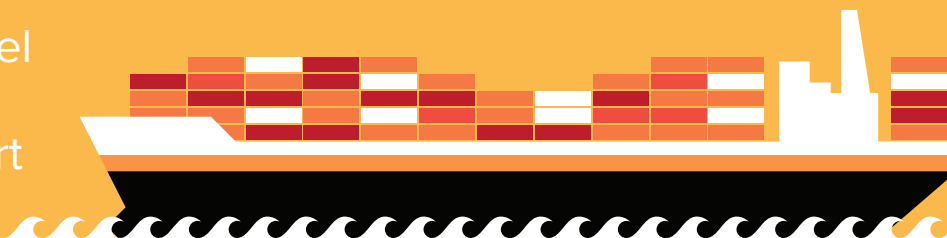




# Climate Change: Implications for Transport



Key Findings from the  
Intergovernmental Panel  
on Climate Change  
Fifth Assessment Report





# The Physical Science of Climate Change

## Rising temperatures:

The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) concludes that climate change is unequivocal, and that human activities, particularly emissions of carbon dioxide, are very likely to be the dominant cause. Changes are observed in all geographical regions: the atmosphere and oceans are warming, the extent and volume of snow and ice are diminishing, sea levels are rising and weather patterns are changing.

## Projections:

Computer models of the climate used by the IPCC indicate that changes will continue under a range of possible greenhouse gas emission scenarios over the 21st century. If emissions continue to rise at the current rate, impacts by the end of this century are projected to include a global average temperature 2.6–4.8 degrees Celsius (°C) higher than present, and sea levels 0.45–0.82 metres higher than present.

To prevent the most severe impacts of climate change, parties to the UN Framework Convention on Climate Change (UNFCCC) agreed a target of keeping the rise in average global temperature since pre-industrial times below 2°C, and to consider lowering the target to 1.5°C in the near future.

The first instalment of AR5 in 2013 (Working Group I on the physical science basis of climate change) concluded that by 2011, we had already emitted about two-thirds of the maximum cumulative amount of carbon dioxide that we can emit if we are to have a better than two-thirds chance of meeting the 2°C target.

## Impact of past emissions:

Even if emissions are stopped immediately, temperatures will remain elevated for centuries due to the effect of greenhouse gases from past human emissions already present in the atmosphere. Limiting temperature rise will require substantial and sustained reductions of greenhouse gas emissions.



# About this document

The Fifth Assessment Report from the Intergovernmental Panel on Climate Change is the most comprehensive and relevant analysis of our changing climate. It provides the scientific fact base that will be used around the world to formulate climate policies in the coming years.

This document is one of a series synthesizing the most pertinent findings of AR5 for specific economic and business sectors. It was born of the belief that transport stakeholders could make more use of AR5, which is long and highly technical, if it were distilled into an accurate, accessible, timely, relevant and readable summary.

Although the information presented here is a 'translation' of the key content relevant to this sector from AR5, this summary report adheres to the rigorous scientific basis of the original source material.

Grateful thanks are extended to all reviewers from both the science and business communities for their time, effort and invaluable feedback on this document.

The basis for information presented in this overview report can be found in the fully-referenced and peer-reviewed IPCC technical and scientific background reports at: [www.ipcc.ch](http://www.ipcc.ch)

**PUBLISHED:**

July 2014

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# Key Findings



1

**Impacts of climate change including more intense droughts and floods, heat waves, thawing permafrost and sea-level rise** could damage transport infrastructure such as roads, railways and ports, requiring extensive adaptation and changes to route planning in some regions.

2

**Transport accounts for about a quarter of global energy-related carbon emissions.** This contribution is rising faster than for any other energy end-use sector. Without aggressive and sustained policy intervention, direct transport carbon emissions could double by 2050.

3

**Cutting carbon emissions from transport is challenging given the continuing growth in demand and the slow turnover of stock and infrastructure as well as, for some modes, the suitability of alternative fuels with an equivalent energy intensity to fossil fuels.** Despite a lack of progress to date, the transition required to dramatically reduce emissions could arise from new technologies, infrastructure and modal shifts, the implementation of stringent policies and behavioural change.

4

**Many energy efficiency measures have a positive return on investment.** Examples such as improving aerodynamics and cutting weight of vehicles, and bringing engines up to leading-edge standards, could cut energy consumption by 30–50% by 2030. Some of these measures have a negative lifetime cost.

5

**Efficient, low-carbon transport systems have significant co-benefits,** such as better access to mobility services for the poor, time saving, energy security, and reduced urban pollution which can lead to better health. These benefits can offset most if not all of the mitigation costs. Integrated, far-sighted planning can create resilient low-carbon transport networks, particularly in new urban areas.



Transport relies overwhelmingly on oil, with over 53% of global primary oil consumption in 2010 used to meet 94% of transport energy demand. This makes the transport sector a key area for energy security concerns and a major source of air pollutants such as ozone, nitrous oxides and particulates, as well as carbon dioxide (CO<sub>2</sub>).

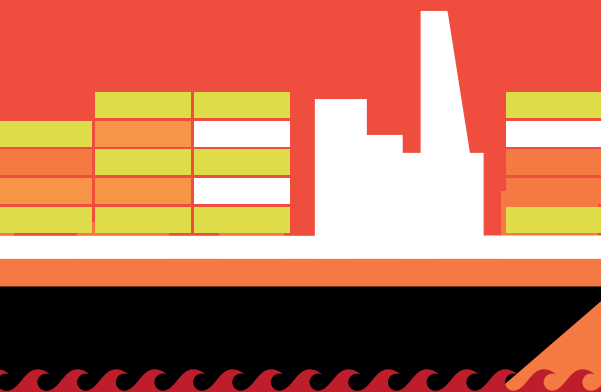
Without sustained action, greenhouse gas (GHG) emissions from transport will continue to rise in line with growth in GDP. However, a number of options for mitigating emissions exist through policy, infrastructure and technology advances - for example through:

- Improving fuel economy and manufacturing standards to support vehicle efficiency
- Using urban planning, technological innovations and education to reduce transport demand
- Using pricing schemes and infrastructure improvements to support modal shifts from private vehicles to mass transit systems, electric vehicles, cycling and walking
- Using incentives to business and appropriate infrastructure investments to further support modal shifts of freight from short- and medium-haul aircraft and road trucks to high-speed rail and coastal shipping.

Barriers to adoption include high upfront costs, slow turnover of stock, and expense associated with transforming or decommissioning existing infrastructure, as well as ingrained social norms and consumer attitudes where vehicle ownership often provides a symbolic meaning of status. While alternatives are becoming available, significant policy intervention will be critical to generalising low-carbon technologies and practices for both passenger and freight transport. This will only be achievable at scale with involvement from the private sector that is more creative, ambitious and collaborative than has been experienced to date.

Adapting to climate change and building in resilience will require higher specifications for existing transport infrastructure and awareness of projected impacts. Companies will benefit from understanding and quantifying risks to infrastructure in order to justify capital investment.

Co-benefits of mitigation can offset some or all of the costs. For example, more affordable and more accessible transport systems will foster productivity and inclusion, thereby improving access to markets, jobs, education, health and other services, providing opportunities to reduce poverty and increase equity. Well-designed and well-managed transport infrastructure is also vital for supporting trade and competitiveness.



# Executive Summary

# Impacts of Climate Change

Climate change impacts will vary between transport modes and their associated infrastructure, with impacts also varying widely between and within regions. Future changes in freight and passenger traffic may reflect the relative sensitivity of different transport modes to extreme weather events and other climate change impacts. For business, this implies a need to assess supply-chain risk and build redundancy and resilience into logistics networks to account for a higher likelihood of disruption.

## Roads

Extreme heat will soften paved roads, requiring resurfacing with more durable materials. Frequent freeze-thaw cycles in cold regions will damage both the base and paved surface. More frequent flooding in some regions will increase the need for maintenance, and for investment in drainage and protection. Unpaved roads are especially vulnerable to intense rainfall. Bridges are exposed to flood events, requiring upgraded design specifications in new construction and retrofitting. It is estimated that adapting bridge infrastructure in the United States will cost USD 140–250 billion over the next 50 years; estimates for Europe are USD 350–500 million per year.

Global warming will reduce the fuel and energy efficiency of public and private vehicles by increasing

demand for cooling. It will increase energy consumption in the refrigeration of perishable freight. The more intense rainfall likely in some regions may reduce driving safety, through poorer visibility and worse surface conditions, although less frost and ice will have the opposite effect.

Thawing permafrost is also a systemic threat. Much polar transport infrastructure depends on permafrost for support in winter or all year. The winter ice road season has already decreased from 200 days in the 1970s to 100 days in some areas of Alaska. Large investments may be required to replace winter ice roads by conventional roads. The winter road network is projected to contract by an average 14% across the eight polar nations by 2050.

## Rail

Rail beds are susceptible to increased rainfall, flooding and subsidence, sea-level rise and increased incidence of freeze-thaw cycles. Thawing permafrost may lead to ground settlement, which undermines the stability of railways. Higher temperatures pose a threat to rails through thermal expansion and buckling. Underground electric rail systems (a particular transport feature of cities) are vulnerable to heat waves and flooding. For example, Hurricane Sandy (United States, 2012) flooded eight under-river subway tunnels, severely impacting economic activity.



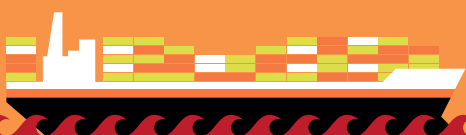


The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) is the most detailed assessment of climate change ever.



## Shipping

More frequent droughts and floods may force businesses to use smaller vessels for inland shipping, for example along the Rhine in Germany or across the Great Lakes in North America, which will raise shipping costs. Some inland waterways are projected to be useable for fewer days each year because of more intermittent water availability. On the ocean, a projected increase in storms in some regions could raise the cost of shipping by forcing ships to take longer routes that are less storm-prone, and may increase maintenance of ships and ports. More frequent delays and cancellations of ferries could result from extreme weather events. However, the Arctic Ocean is projected to become progressively more accessible to shipping in summer as sea-ice extent decreases, with a virtually ice-free ocean likely by mid-century. This will allow routine use of the Northwest Passage, the Northern Sea Route and other routes, and increase maritime access to coasts in northern Canada, Alaska (the United States), Russia and Greenland. However, the increase in shipping through these sensitive ecosystems could lead to an increase in local environmental and climate change impacts.



## Aviation

More storms in some regions may increase the number of weather-related delays and cancellations. Clear-air turbulence is likely to increase in the Atlantic corridor, leading to longer and bumpier trips. More intense heat and rainfall will have similar impacts on airport runways as on roads. Higher temperatures at high-altitude and low-latitude airports may reduce the maximum take-off weight or require investment in longer runways due to less dense air.



## Coastal infrastructure

Roads, rail and airports near the coast will become more vulnerable to flooding and erosion as a result of sea-level rise and extreme weather events, as will ports. Extreme events projected to increase include intense rainfall, high winds and storm surges. Hurricane Katrina in 2005 caused damage estimated at USD 100 million to Mississippi ports, while Sandy in 2012 led the Port of New York to shut down for a week, with losses of USD 50 billion. Globally, the value of all coastal assets (not just transport) exposed to flooding was estimated at 5% of gross domestic product (GDP) in 2005, projected to rise to 9% in 2070.





# Transport Demand on the Rise

Transport accounts for about a quarter of global energy-related carbon emissions. This contribution is rising faster than for any other energy end-use sector. Without aggressive and sustained policy intervention, direct transport carbon emissions could double by 2050.

**Better air traffic management** can reduce CO<sub>2</sub> emissions through more direct routings and flying at optimum altitudes and speed.

Fuel efficiency gains of 40–50% from 2030–2050 can be achieved through improved design.

**Rail**

Increased rainfall, flooding and subsidence, sea-level rise and increased incidence of freeze-thaw cycles undermine the stability of railways.

**Aviation**

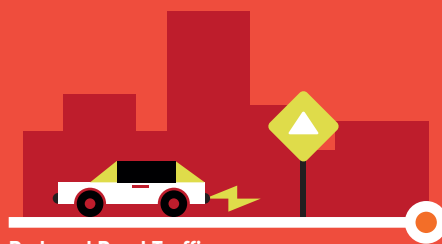
More storms in some regions may increase the number of weather-related delays and cancellations. Higher temperatures at high-altitude and low-latitude airports may reduce the maximum take-off weight or require longer runways due to less dense air.

Electric hybrid drive trains, buses and cars can reduce consumption by 35% compared with conventional engines.

In China, electrification and other measures on train infrastructure from 1975 to 2007 helped reduce CO<sub>2</sub> emission intensity by 87%.

## Co-Benefits

Efficient, low-carbon transport systems have significant co-benefits, such as better access to mobility services for the poor, time saving, energy security, and reduced urban pollution leading to better health. Some studies suggest that the direct and indirect benefits of sustainable transport measures often exceed the cost of their implementation.



**Reduced Road Traffic**

Reduced road traffic and congestion often lead to fewer traffic crashes, less noise and less road damage.



**Health**

Walking and cycling and rapid transit/public transport combined with improved land use can bring great health benefits. Lowering CO<sub>2</sub> emissions could increase emissions of health-damaging small particulates.



## Opportunities & Solutions

The transition required to dramatically reduce greenhouse gas (GHG) emissions needs system-wide strategies that combine new vehicle/fuel technologies, modal change, and stringent sustainable transport policies and profound behaviour change.



**System Infrastructure Efficiency**



**Carbon Intensity of Fuels**



**Energy Efficient Vehicle Performance**



**Demand Reduction**



**System Optimisation**

Port infrastructure may need to be rebuilt to avoid the worst impacts of sea-level rise. Efficiency of new-built vessels can be improved by 5–30%.

For international shipping, combined technical and operational changes can massively reduce energy use.



### Road

Extreme heat will soften paved roads. Unpaved roads and bridges are especially vulnerable to intense rainfall. Frequent freeze-thaw cycles in cold regions will damage both the base and paved surface.

### Shipping

More frequent droughts may force the use of smaller vessels for inland shipping. Some waterways may become less accessible due to decreased water availability. A projected increase in storms in some regions could raise the cost of ocean shipping.

Truck modernisation including increased freight load, along with engine, tyre and vehicle maintenance, can significantly improve fuel economy.



The high-speed 'Shinkansen' commuter train in Japan reduced energy consumption by 40%.



### Energy Security

Cutting carbon emissions is likely to be more challenging than for other sectors given the continuing growth in global demand and scale of change needed. However, doing so will assist with long-term energy security.

### Cost Savings

Many energy efficiency measures have a positive return on investment. Improving aerodynamics and cutting the weight of vehicles and optimising design may have a negative lifetime cost.

### Low-Carbon Cities

Owing to their high concentration of population, economic activity, and motorisation, mega-cities are primary contributors to local and global environmental problems. Low-carbon transport is a long-term sustainability strategy.



# Resilience

As the transport sector will be highly exposed to climate change, it will require extensive adaptation of infrastructure, operations and service provision. It will also be indirectly affected by adaptation and decarbonisation in the other sectors that it serves.

Design of urban form and an associated transport network will play a significant role in the resilience of cities of the future. The development path of infrastructure and settlements also taken by developing countries will have a significant impact on the future scale of transport related emissions and, consequently, total GHG emissions. For this reason, adaptation and mitigation should be approached together.

## Land infrastructure

Resilience of land infrastructure can be improved by for example, increasing the cover thickness and quality of concrete. Adaptation would apply to both existing and new infrastructure. Management of storm and wastewater flow will become key – for example, upgrading the drainage system in Mumbai (India) could reduce economic losses from a 1-in-100 year flood event by as much as 70%. Denser cities should improve transport efficiency, but can leave large populations vulnerable to extreme weather events. Building resilience in the transport sector must therefore be consistent and coherent with wider approaches to climate-smart cities.

## Rail systems

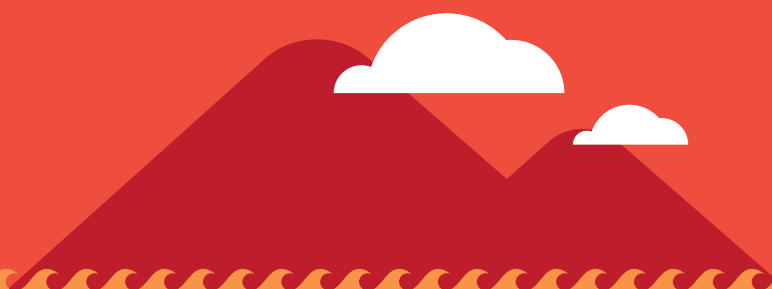
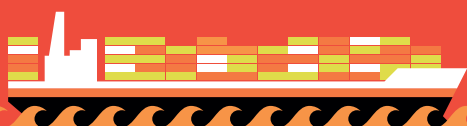
Rail beds are susceptible to increases in precipitation, flooding and subsidence, sea-level rise, extreme events and incidence of freeze-thaw cycles. The complexity of addressing rail infrastructure is increased through differences in design specifications, multiple types of rail and materials used, and uncertainty about the changes in future temperatures. As an example, to adapt to heat waves, underground rail systems could require substantial investment in ventilation. In the UK, USD 290 million has been allocated to increase the capacity of London's underground cooling system.

## Inland waterways

Adaptation options for inland waterways include canalising sections of rivers and increasing use of water management techniques to regulate river depth. Inland flood defences will also be required.

## Coastal adaptation

The global mean sea-level rise is projected to be 0.28–0.98 metres by 2100, although with regional variations and local factors, the local sea-level rise can be higher. This has serious implications for coastal cities, deltas and low-lying states. Adaptation options include conserving or restoring habitats such as dunes, wetlands and deltas, to buffer against storm surges. Such habitats could also sequester carbon. Hard infrastructure adaptation could include strengthening barriers for coastal roads, railways and other infrastructure, or relocating them to higher ground to cope with sea-level rise and extreme weather events. Long-term coastal adaptation could include enhanced sea defences, barriers and coastal barrages.



# Mitigation Potential

Greenhouse gas emissions from the transport sector have more than doubled since 1970, increasing to the equivalent of 7 billion tonnes of carbon dioxide (CO<sub>2</sub>eq) in 2010 and rising at a faster rate than for any other energy end-use sector. Around 80% of the increase is from road vehicles. Light vehicle ownership stands at 1 billion and is projected to double in the next few decades, with two-thirds of the growth in non-OECD countries. Around a tenth of the global population accounts for 80% of total motorised passenger kilometres, indicating that without stringent policy intervention that incentivises low-carbon transport options, economic growth will bring large increases in carbon emissions.

Decoupling transport from GDP growth is possible but will require the development and deployment of appropriate measures, advanced technologies and improved infrastructure. The cost-effectiveness of these opportunities may vary by region and over time. Delivering mitigation actions in the short-term could avoid lock-in effects resulting from the slow turnover of stock (particularly aircraft, trains and ships) and the long-life and sunk costs of infrastructure already in place. When developing low-carbon transport systems, behavioural change and infrastructure investments are often as important as developing more efficient vehicle technologies and using lower carbon fuels.

## Modal shifts

Modal shifts in transport involve shifting passengers and freight to lower-carbon forms of transport, for example from private vehicles to mass transit systems, from cars to bicycles, or from air to rail. Prioritising infrastructure for pedestrians and promoting non-motorised transit options create economic and social co-benefits. Barriers to modal shifts include social norms, existing urban form and the need for new infrastructure with high upfront costs, for example to build electric vehicle charging infrastructure or railways. Such costs may diminish after including co-benefits.

## Demand reduction

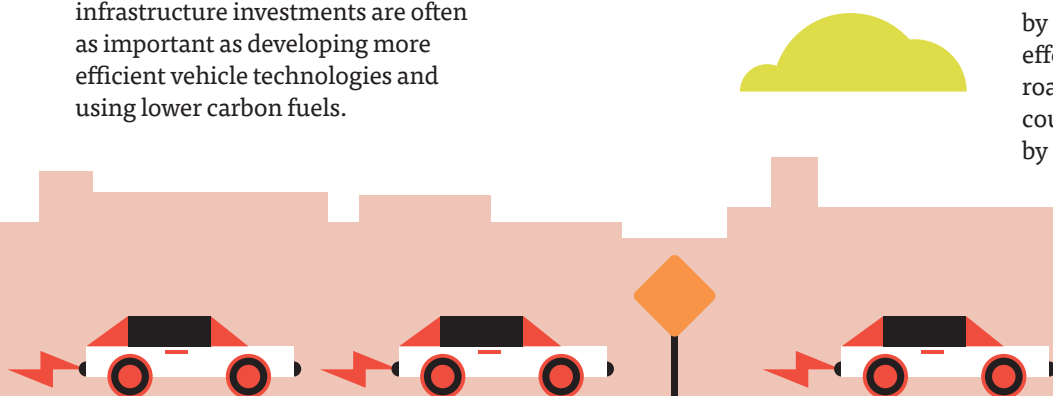
Reducing transport demand can be achieved by mixed zoning and increased density of cities so reducing travel times, through road pricing schemes, by creating local supply chains, and through technological shifts such as internet shopping and video conferencing. If poorly designed, cities can 'lock in' high carbon emissions through urban sprawl and private vehicle dependence.

## Vehicle efficiency

Light-duty vehicle efficiency improvements of about 25% can be achieved through better aerodynamics, lower resistance tyres and weight reduction. Upgrading average internal combustion engines to leading edge standard, for example through direct injection, can reduce fuel consumption by a further 25%. Many of these gains are available at very low or negative costs. Electric hybrid drive trains, buses and cars can reduce consumption by 35% compared with conventional engines, but at a higher cost.

Similar or slightly lower energy savings can be achieved with heavy-duty vehicles and ships. High potential improvements for aircraft efficiency are projected, but improvement rates may be slowed by long aircraft life.

Freight business operators have a strong incentive to reduce energy intensity since fuel typically accounts for around one third of operating costs in the road freight sector, 40% in shipping and 55% in aviation. However, a so-called 'rebound effect' can undermine some of the benefits of efficiencies, for example if vehicle drivers take advantage of fuel savings by driving more often. Rebound effects can be reduced through road pricing or other schemes that counter the lower travel cost created by efficiency improvements.



## Carbon intensity of fuel

Replacing petrol and diesel with lower-GHG alternatives can reduce transport emissions while continuing to use conventional internal combustion engines and fuelling infrastructure. Alternatives include compressed natural gas (CNG) and biofuels. Biofuels can also be tailored for aviation. However, biofuels do not automatically reduce lifecycle emissions, particularly if their growth destroys forest or other natural carbon stores. Wider concerns involve the effect of biofuel plantations on nature, and rising food prices if biofuel crops replace food crops. The biofuel supply could be increasingly affected by variable weather.

Adoption of battery electric vehicles (BEVs) or hydrogen fuel cell-powered vehicles generate potentially very low fuel emissions if they use electricity from low-carbon sources. All ambitious scenarios for economy-wide mitigation include decarbonisation of power generation. Electric vehicles represent an option to reduce carbon emissions from transport in these scenarios. At present, BEVs generally have a range of only 100 to 200 kilometres, with costly batteries taking more than four hours to recharge, slowing uptake. Hydrogen can be produced from natural gas or from renewable sources by electrolysis or biomass gasification. Both electric and hydrogen vehicles require new refuelling infrastructure, a significant barrier to uptake.

## Policy intervention

Slowing, then stabilising and ultimately cutting global transport sector emissions will require aggressive and sustained policy interventions and concerted action on a number of options:

- For freight, a range of fiscal, regulatory and advisory policies can incentivise businesses to reduce the carbon intensity of their logistical systems
- Fuel economy standards that limit the energy consumption of cars can ensure production of more efficient models

- Pricing schemes such as variable registration taxes can boost adoption of the most efficient vehicles
- Regulation can bring a shift to low-carbon fuels, as seen in California and the European Union
- Biofuel mandates can determine levels of blending in motor fuel
- Taxes on gasoline and diesel, traffic restraint measures and city congestion charging and pricing schemes can help curb transport demand
- Investments that ensure safety can boost a modal shift to cycling and walking, as seen in Denmark and the Netherlands
- Pricing strategies can reduce travel demand by individuals and businesses
- Public investment in fuelling infrastructure, demonstration programmes and the establishment of fuelling and recharging standards can stimulate shifts to hydrogen, CNG and electric vehicles
- Centralised urban planning and public investment can build new mass transit infrastructure
- Strong education policies can help to create behavioural change and social acceptance.

Although the majority of policies will focus on reducing CO<sub>2</sub> emissions, transport also contributes to climate change in other ways. Mitigating the climate impact of transport therefore has a wider meaning than just reducing CO<sub>2</sub> emissions. Black carbon (soot) from diesel and heavy oil burning, nitrogen oxides, carbon monoxide, methane, fluorinated gases (F-gases) and aerosols all have warming or cooling effects. Policies aimed at reducing air pollution can either lead to a net increase in warming (for example by reducing sulphate aerosols) or a net cooling (for example by reducing black carbon). Black carbon emissions from Arctic shipping are a particular concern as soot deposits on ice and snow can increase local warming. There is strong evidence that reducing black carbon emissions could provide an important short-term strategy to mitigate atmospheric concentrations of pollutants that contribute to global warming.



# Regional Perspectives

Projected annual CO<sub>2</sub> emission growth rates for 2002–2030 range from 1.3% for the OECD nations to 3.6% for developing countries. The potential for reducing these growth rates varies widely across countries and regions, as do the policies and measures required to achieve a reduction. Improved vehicle efficiency and low-carbon fuels could offset much of the growth in non-OECD carbon emissions by 2030. To facilitate the development of sustainable transport systems, eight multilateral development banks have pledged to invest USD 175 billion over the next ten years. Funding for sustainable transport could in large part be derived by redirecting resources from unsustainable transport and fossil fuel subsidies, and by using revenues from a carbon or gasoline tax. Non-OECD business actors comprise a greater proportion of state-owned enterprises, whose influence points may be different from the privatised transport companies of OECD countries.

## Asia

Transport infrastructure in the Low Elevation Coastal Zone (LECZ) is highly exposed to climate impacts such as sea-level rise, storm surges and typhoons. Three of the world's five most populated cities (Tokyo, Delhi, Shanghai) are located in high flood-risk areas.

About two-thirds of the USD 8 trillion needed for infrastructure investment in Asia and the Pacific between 2010 and 2020 will support new development, which creates opportunities for producing resilient, low-carbon transport networks if considered in the planning stage.

## Europe

Severe road accidents are projected to fall by mid-century due to fewer frosts and progress in vehicle technology and emergency systems. Rail systems will experience less ice and snow-related disruption, but may see a rise in heat-related buckling.

In some Western European cities, a combination of public transit and cycling infrastructure, pricing, and land-use measures is projected to lead to notable co-benefits. These co-benefits include energy security, savings from fuel spending, reduced congestion, fewer accidents, and increased public health from more physical activity, lower air pollution and less noise-related stress. Such examples will provide demonstrations for urban planners in other regions.

## North America

It is estimated that a 1-metre rise in relative sea level projected for the US Gulf Coast region between Alabama and Houston over the next 50 to 100 years would permanently flood a third of roads and put more than 70% of ports at risk. A theoretical 7-metre storm surge in the region would threaten more than half of major highways, almost half the total length of rail tracks, 29 airports, and virtually all ports.

An increase of 1–1.5°C in global mean temperature could increase the costs of keeping paved and unpaved roads in the United States in service by, respectively, USD 2 to 3 billion per year by 2050.



# Conclusion

Climate adaptation and mitigation for the transport sector poses complex challenges for policy makers, business actors and civil society due to perceived and real trade-offs between upfront costs and longer term benefits. This sector will also be indirectly affected by the adaptation and decarbonisation of the other sectors that it serves. There is no doubt that policies aimed at meeting the agreed target of keeping global warming since pre-industrial times below 2°C would have major implications for all elements of the transport sector in the short and medium term.

Despite a lack of significant and consistent progress, AR5 concludes that the emission reduction potential in the transport sector is larger, and comes at lower cost, than stated in its previous assessment in 2007. There are positive indications that pricing and other stringent policy options are in some places being implemented alongside new technologies. There are signs that:

- Light-duty vehicle ownership has peaked in some OECD countries
- Uptake of electric vehicles and mass transit systems has increased
- There is renewed interest in compressed and liquefied natural gas and in biofuels
- There is greater awareness of the co-benefits of urban planning that promotes walking and cycling.

If a collective commitment to redesigning low-carbon transport systems and demand management can be harnessed, there are major opportunities to implement ambitious mitigation measures that enhance the adaptive capacity of the industry as well as enable the realisation of significant co-benefits to society. Given an expected doubling in the global urban area this century – and the fact that most of the world’s urban space is not yet built – recognition of opportunities to make sustainable urban transport planning decisions at the outset of new developments must be prioritised, in order to create resilient, climate-smart cities. Such decisions can build in resilience to projected climate impacts such as sea-level rise, flooding and extreme weather. Inside and outside urban centres, increasingly serious climate impacts will create an ongoing need for adaptation to changed conditions, which implies additional investment.

For companies, there is a need to develop strategies for efficiency, modal shift and acceleration of the development and deployment of low-carbon fuels/vehicles in global logistics networks. These strategies will entail new partnerships with government and civil society as well as collaboration with industry peers and customers to advance policy solutions and identify funding mechanisms that can bridge the gap between up-front capital requirements and longer term benefits.

# Glossary

## ADAPTATION

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The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In natural systems, human intervention may facilitate adjustment to expected climate and its effects.

## BIOFUEL

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A fuel generally in liquid form, produced from organic matter or combustible oils produced by living or recently living plants.

## BIOMASS

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The total mass of living organisms in a given area or volume. The term is also used to denote solid biofuels.

## CLIMATE CHANGE

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Any significant change in climate that persists for an extended period, typically decades or longer.

## CLIMATE IMPACT

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The effects of climate change on natural and human systems.

## CO-BENEFIT

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The positive effect that a policy or measure aimed at one objective might have on other objectives.

## DECARBONISATION

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The process by which countries or other entities aim to achieve a low-carbon economy, or by which individuals aim to reduce their carbon emissions.

## EMERGING ECONOMIES

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Economies in the low- to middle-income category that are advancing rapidly and are integrating with global capital and product markets.

## ENERGY SECURITY

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Maintaining an adequate, stable, and predictable energy supply.

## GREENHOUSE GAS

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A gas in the atmosphere, of natural and human origin, that absorbs and emits thermal infrared radiation. Water vapour, carbon dioxide, nitrous oxide, methane and ozone are the main greenhouse gases in the Earth's atmosphere. Their net impact is to trap heat within the climate system.

## LIGHT-DUTY VEHICLE

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A passenger car or passenger car derivative capable of seating 12 passengers or fewer.

## LOCK-IN

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Occurs when a market is stuck with a standard even though participants would be better off with an alternative.

## MITIGATION

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A human intervention to reduce the sources or enhance the sinks of greenhouse gases.

## MODAL SHIFT

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A change between modes of transport, usually encompassing an increase in the proportion of trips made using sustainable modes.

## OECD COUNTRY

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The Organisation for Economic Co-operation and Development is an international economic body of 34 countries to stimulate economic progress and world trade. Includes many of the world's most advanced countries, but also emerging countries like Mexico, Chile and Turkey.

## PROJECTION

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A potential future evolution of a quantity or set of quantities, often computed by a model. Projections involve assumptions that may or may not be realized, and are therefore subject to substantial uncertainty; they are not predictions.

## RESILIENCE

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The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure.

*“Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.”*

IPCC, 2013

**Disclaimer:**

This publication has been developed and released by the European Climate Foundation (ECF), the Business for Social Responsibility (BSR) and the University of Cambridge's Judge Business School (CJBS) and the Institute for Sustainability Leadership (CISL).

This project was initiated and financed by ECF and endorsed by CJBS and CISL.

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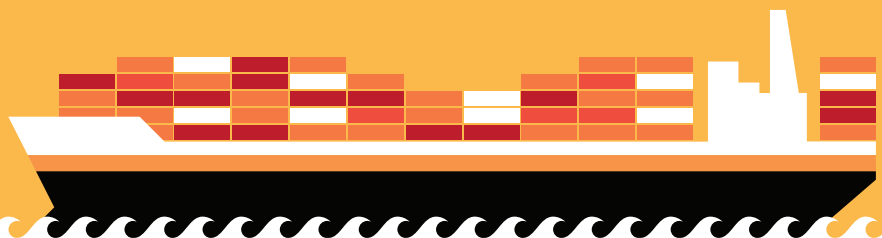


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