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RAILWAYS AND GREEN GROWTH

Why investing in railways leads to a better future

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Introduction

After 2008, a new approach regarding sustainable development gained ground: the policies for reducing emissions and the consumption of non-renewable resources represent the opportunity to overcome the causes of a series of concurrent crises: the climate crisis, the economic/financial crisis and the food crisis.

The new approach is focused on the **opportunity** given by policies for climate change mitigation and the responsible use of resources, rather than the costs that those actions can imply.

The **"green growth" approach** completely overturns the alleged incompatibility between economic growth and environment; it makes the promotion of sustainable development an engine of economic growth and an essential instrument to foster economic recovery.

The so-called "green stimulus packages" involving all G20 countries helped creating a new awareness: the opportunity has come to face not only the effects of the crises, but also the root causes. There are many interpretations of what caused the multiple crises, however there is a substantial agreement on the fact that the human race is faced with a **serious distortion in the allocation of capital**: financial, human, technical and natural capital (UNEP 2009, UNCTAD 2010, UNEP 2011).

In this perspective, investments, policies and activities fostering green growth (i.e. fighting climate change, an inefficient and irresponsible use of resources, the contamination of ecosystems, poverty and inequality) produce an essential re-balance of the allocation of capital.

In the green growth framework, the transport sector has a crucial role. It is well known that this sector is an important driver of economic growth and at the same time is one of the major stressors for the environment (due to energy consumption, emissions, harmful effects on ecosystems, etc.) and for the economy and society (e.g. for accidents and congestion). Future projections of the mobility indicators correlated with economic growth, increase of disposable income, population and urbanization show that the transport sector is one of the most strategic sectors for green growth.

To apply the green growth approach in the transport sector means to promote a transition from the current transport system to green transport, defined as a transport system that supports environmental economic and social sustainability (OECD 2011).

From an operational point of view, a green transport approach calls for action and investments that:

- Follow an Avoid/Shift/Improve (ASI) strategy, i.e. reduce the mobility demand and pursue accessibility, shifting on more sustainable modes of transport and improving the efficiency of vehicles;
- Enable the background conditions to reduce the distortions in the resource allocations for the transport market, which cause the prevalence of unsustainable modes.

In this transition towards green transport, **railways are an essential instrument in all the Avoid/Shift/Improve (ASI) lines of action**. Railways have the lowest specific external costs (per passenger and per freight tonne), so they would gain further competitive advantage from the internalization of external costs.

The core business of all the world railways – to transport passengers and freight – is completely in line with the objectives and actions of green transport. Modal shift to rail contributes to the reduction of impacts of the transport sector and to foster economic growth.

There is no question that railways are environmentally friendly: in terms of specific impacts, railways are decidedly better than road and aviation, both for passenger and for freight service.

On the other hand the **systemic effects of a modal shift to rail** are less known. In recent years, several transport scenarios have highlighted the contribution of increasing rail market share in mitigating the environmental impact of the transport sector.

The International Energy Agency (IEA), through its Mobility Model (MoMo), has defined an avoid/shift scenario to 2030 and 2050, where increasing rail market share gives a vital contribution to reaching the objective of containing the global temperature increase to 2°C. The International Transport Forum (ITF), also through MoMo, has dealt with the issue of urban mobility by defining two avoid/shift scenarios (urban land transit development). The conclusion is that such policies would significantly contain the growth of private vehicles in the future, and consequently their emissions.

As for the contribution of a modal shift to rail to economic growth, new observations have recently come to light.

Firstly, the 2008 stimulus packages have demonstrated that, especially during a recession, **the investments on transport infrastructure have positive impacts both for GDP growth (through the so-called fiscal multiplier) and for job recovery**. The limits are rather on the short-term investments in the road sector, an aspect which does not concern eco-efficient infrastructure such as railways.

Many studies highlight that a specific sum invested in railway infrastructure creates more jobs than in road or air transport. **The increase of rail market share offers thus a positive net contribution in job creation**. **The jobs created are also "green jobs"**: compared to other "green" sectors (e.g. renewables, waste management, organic farming), railways are one of the green economy sectors with the highest potential of job creation for a predefined investment amount.

Investments in rail not only foster the increase of GDP and of occupation, but they are considerably less expensive than similar investments in the road sector. The IEA compared two scenarios: business-as-usual (BAU), where the projected growth of infrastructure in emerging economies is aligned with the current state of developed economies, and an Avoid-Shift scenario, featuring a strong shift-to-rail component. The comparison shows that the total investment (including the construction and maintenance of infrastructure and vehicles) for **the Avoid-Shift scenario is lower by 50 trillion dollars**.

The role of cities in the world economy is also a field where railways can deliver significant benefit. Urbanisation will undoubtedly increase, especially in developing countries. To make this an opportunity for growth, urban development has to be symbiotic with the development of public transport. In the large and congested urban areas, railways have an essential role for liveability and productivity.

In conclusion, **green growth represents an extraordinary challenge and opportunity for the railway sector**, especially in emerging economies, where in the next years many important strategic decisions will be made, with impacts on future decades.

Structure of the Report

The first chapter of this report is dedicated to the description of the terms “green growth” and “green economy”. The term **“green growth”** was used for the first time in the year 2005, in Seoul, at the Ministerial Conference on Environment and Development (MCED). It is only after 2008 that the term “green growth”, together with “green economy”, became the way to deal with sustainable development issues in a new perspective. The innovation is strictly connected to the phase of crisis, when many of the theoretical and political contributions were made on this topic. Right after the explosion of the subprime mortgages bubble, the entire world started to ask questions on the sustainability of the development model in the light of the multiple crises that humanity was dealing with: the economic crisis of course, but also the energy, food and climate crises. The “green growth” approach overturns the presumed incompatibility between economic growth and environment, and attributes to the promotion of sustainable development a role of driver for growth and economic recovery.

In the framework of green growth, the transport sector is of primary importance. Transport is a key factor of economic growth and at the same time one of the major stressors from an environmental (emissions, energy consumption, harmful effects on ecosystems, etc.) and a socio-economic (accidents, congestion, etc.) point of view. The second chapter describes the so-called **“green transport”**, i.e. a green growth-oriented transport which could fully belong to the “green economy” sector. The chapter deals with the strategy, the policies and the actions that are necessary for a transition towards green transport.

The third chapter tackles the topic of what is the role of railways in green transport and green growth. Railways are already an environmentally friendly mode of transport: this doesn’t mean that there shouldn’t be a commitment for the railway sector to become even more so. To reduce the specific environmental impacts of railways means to improve and conserve one of its main competitive advantages in the transport market, an advantage which is destined to be more and more important in the future. The initial part of this chapter is thus dedicated to summarise what is the “improve” potential of railways. However, railways can contribute in a fundamental way in the transition towards green transport with a continuous increase of its market share, both in passenger and in freight service. The second part of the chapter outlines the role of railways in the “shift” pillar, also in combination with the “avoid” pillar.

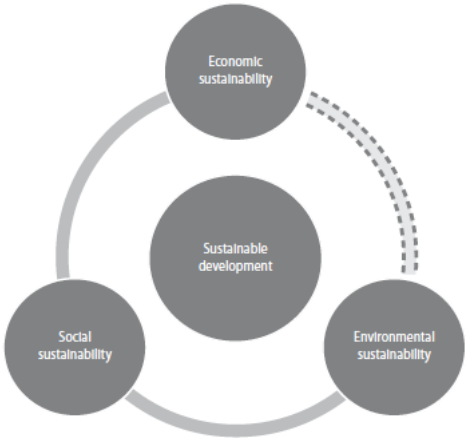
The objective of the fourth chapter is to highlight the multiple impacts of a “modal shift to rail”, both from an environmental and from an economic point of view, in terms of the investments on the transition to green transport that involve railways.

The fifth and last chapter reports **the commitments of the world railway sector taken during the world climate conference of September 2014 in New York.** Those are voluntary commitments on the reduction of energy and carbon intensity in the world railway sector and the “Modal Shift Challenge”, i.e. the commitment to increase the passenger and freight market share of railways. Specific targets have been set for both commitments to 2030 and 2050.

1. Green economy and green growth

Since the UN Conference on Environment and Development (UNCED) in 1992, sustainable development has been the overarching goal of the international community. Green economy policies have been discussed and analysed by economists and academics for several decades but the concepts of **green economy** and **green growth** have only recently gained remarkable international attention. The attention has been intensified by recent prolonged global climate, food and financial crises, and underscored by continued warnings from global scientists that society is in danger of transgressing a number of planetary boundaries or ecological limits. Economic and social sustainability on one hand and social and environmental sustainability on the other hand are largely complementary. Not so with economic and environmental sustainability, as growth has come largely at the expense of the environment. Green growth and green economy aim to ensure that economic and environmental sustainability become compatible and sustain each other.

Fig. 1 The three pillars of sustainable development



Source: World Bank 2012

1.1. Green growth

Green growth is a new model of economic growth, targeting

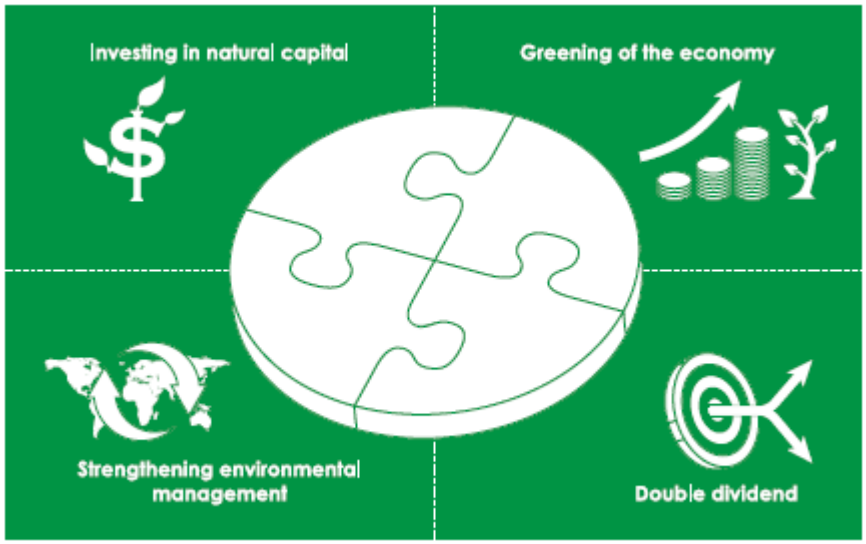
- poverty reduction
- job creation
- social inclusion
- environmental sustainability
- climate change mitigation
- biodiversity loss
- security of access to clean energy and water.

The concept has its origins in the Asia and Pacific Region when the green growth approach was firstly adopted by the Fifth Ministerial Conference on Environment and Development (MCED) in March 2005 in Seoul, with the aim of harmonising economic growth with environmental sustainability. After the OECD declaration in June 2009, the OECD has become a major proponent of green growth and supports efforts of countries to implement green growth.

In the aftermath of the 2008 financial crisis, this approach has evolved as a way out of economic doldrums when all G20 countries have adopted green stimulus packages with public investments and incentives aimed at environmental protection.

A number of other international organisations, think tanks and academics have also turned their attention to green growth, including the World Bank which attaches considerable interest in helping emerging economies to "leapfrog" over the industrialization patterns of the developed world, and avoid the trap of "growing first, cleaning up later". According to the World Bank, green growth can help developing countries to achieve their economic, environmental and social objectives.

Fig. 2 Effects of Green Growth



Source: UNESCAP 2012

There are several definitions for green growth; the list below includes definitions by key international actors involved in green growth.

UNESCAP: *growth that emphasizes environmentally sustainable economic progress to foster low-carbon, socially inclusive development. (UNESCAP/ADB/UNEP 2012)*

OECD: *fostering economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies. (OECD 2011a)*

WORLD BANK: *growth that is efficient in its use of natural resources, clean in that it minimizes pollution and environmental impacts, and resilient in that it accounts for natural hazards and the role of environmental management and natural capital in preventing physical disasters. (World Bank 2012)*

GGGI, Global Green Growth Institute: *green growth is the new revolutionary development paradigm that sustains economic growth while at the same time ensuring climatic and environmental sustainability. It focuses on addressing the root causes of these challenges while ensuring the creation of the necessary channels for resource distribution and access to basic commodities for the impoverished. (GGGI 2012)*

According to the OECD, a green growth policy framework will differ from country to country, depending on economic conditions and local environmental, institutional and development phases. However, in all cases the green growth policy framework must:

- integrate the natural resource base into the same dynamics and decisions that drive growth;
- develop ways of creating economic payoffs which more fully reflect the value of the natural resource base of the economy;
- focus on mutually reinforcing aspects of economic and environmental policy.

This includes changing payoffs through:

- Pricing pollution and natural resource use
- Removing perverse subsidies
- Ensuring regulatory standards focused on outcomes.

The change of payoffs in the economy also needs to address inertia, the risks of technology lock-in, and the roles of innovation, infrastructure and institutions in enabling change.

1.2. Green economy

The term *green economy* appears for the first time in 1989 as the title of a report commissioned by the Government of the United Kingdom: Blueprint for a Green Economy (Pearce 1989). In 2008, the term was revived in the context of the financial crisis and global recession, when UNEP outlined the idea of *green stimulus packages* as a tool of economic recovery efforts (Barbier 2009, UNEP 2011). UNEP identified specific areas where large-scale public investment could kick-start a *green economy* with multiple objectives:

- economic recovery
- poverty eradication
- reduced carbon emissions and ecosystem degradation.

UNEP defines a green economy as one that results in "improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" (UNEP 2010). In its simplest expression, "a green economy is low-carbon, resource efficient and socially inclusive".

The UNEP approach has established a new setting: policies to reduce emissions and consumption of non-renewable resources represent a tool to overcome and remove the causes of a series of multiple global crises facing humanity (climate, biodiversity, fuel, food, water, and after 2008, the global financial system).

The causes of these crises vary, but at a fundamental level they all share a common feature: the gross misallocation of capital.

The new approach focuses on the opportunity represented by the policies of combating climate change and the responsible use of resources, rather than on the costs that these actions may involve and their attribution. In a green economy, growth in income and employment can be generated by strategic public and private investments that reduce greenhouse gas emissions, improve resource efficiency and reduce loss of biodiversity.

Fig. 3 The main sectors of green economy

Source: UNEP 2011

Reversing the economic pattern of unsustainable development to unlock the productive and employment potential of a green economy requires three important steps:

- ensuring that markets and policies incorporate the full costs and benefits of environmental impacts;

- implementing effective and appropriate information, incentives, institutions, investments and infrastructure to guarantee the role of policy in controlling excessive environmental degradation;
- assessing and monitoring the potential long-term impacts of continuing environmental degradation, land conversion and global climate change on the health and stability of ecosystems.

However, a green economy cannot be focused exclusively on eliminating environmental problems and scarcity. It must also address the concerns of sustainable development with intergenerational equity and eradicating poverty. In sum, UNEP states that "moving towards a green economy must become a strategic economic policy agenda for achieving sustainable development".

1.3. Similarities and differences between green growth and green economy

The distinctions among the concepts of green economy and green growth have started to overlap and the two terms are now being used almost interchangeably. A main driver behind the development of these concepts has been the move towards a more integrated and holistic approach to incorporating environment and development in economic decision making, policy and planning.

The terms green economy and green growth imply a strong focus on the intersection between environment and the economy. According to the three dimensions of sustainable development many of the definitions of these terms from recent publications incorporate a social emphasis too.

Table 1 Characteristics of Green Economy and Green Growth

	GREEN ECONOMY	GREEN GROWTH
SOCIAL	• human well-being • social equity • socially inclusive • reduced inequalities • better quality of life • social development • equitable access • addressing needs of women and youth	• well-being, socially inclusive, access to basic commodities for the impoverished • meeting demands for food production, transport, construction, housing and energy
ECONOMIC	• growth in income and employment • public and private investments • resilient economy • Economic growth • New economic activity	• economic growth and development • technology and innovation • environmentally sustainable economic progress • more resilient • sustained economic growth • driver for economic growth • new growth engines • green technology • new job opportunities • qualitative growth rather than simply increasing GDP • job creation or GDP growth
ENVIRONMENTAL	• Reducing environmental risks and ecological scarcities • low carbon • resource efficient • reduce carbon emissions and pollution • enhance energy and resource efficiency; • prevent loss of biodiversity and ecosystem services • within ecological limits of the planet • environmental responsibility • finite carrying capacity	• Protection and maintenance of natural assets and environmental services • provision of resources and services • low carbon • using fewer resources and generating fewer emissions • resource efficient • cleaner • climatic and environmental sustainability • energy and resource efficient; • minimises pollution and environmental impacts • resilient to hazards • harmony between the economy and the environment • environmental protection • reduce GHG

Source: United Nations – A guidebook to the green economy

Many definitions of green economy include a reference to ecological limits or planetary boundaries, while definitions of green growth do not include this reference. A difference between the two concepts can be traced in the fact that green growth is more a "bottom-up" approach of greening products, processes, services, technologies and supply chains, compared with the "top-down" approach of green economy which involves strategic, macro-economic policies addressing systemic challenges.

Overall, the various definitions of green growth and green economy are generally consistent, both having sustainable development as their ultimate objective and being a means to reconcile the economic and environmental pillars, without ignoring social aspects.

2. Green transport

2.1. Green transport: definition, actions and policies

UNEP defines *green transport* as one that "supports environmental sustainability through e.g. the protection of the global climate, ecosystems, public health and natural resources. It also supports the other pillars of sustainable development, namely economic (affordable, fair and efficient transport that supports a sustainable competitive economy as well as balanced regional development and the creation of decent jobs) and social (e.g. allowing the basic access and development needs of individuals, companies and society to be met safely and in a manner consistent with human and ecosystem health, and promoting poverty reduction and equity within and between successive generations)."[1]

Green transport is hereby defined as a transport system that supports environmental, economic and social sustainability (OECD 2011). Green transport represents at the same time the goal and the actions and investments needed to achieve this goal.

Fig. 4 Green transport as a goal

Source: UNEP 2011

To become green, the transport sector is faced with the overall demand for transport activity (for both passenger and freight) growing rapidly, especially in developing countries, and increasingly motorised. **The global vehicle fleet to 2050 is set to multiply three times in Asia, up to five or six times in China and India, and worldwide three o fourfold**. Technological improvements such as fuel-efficient vehicles and alternative power sources since today have not been rapid enough to offset the impacts of this growth (in term of number of vehicles and amount of travel).

The extrapolation of these trends from the past and their projection onto the future shows serious social, environmental and economic damage. There will be unsustainable impacts on environment, society and economy, including energy consumption and greenhouse gas emissions (GHG), resource depletion and land grab, degradation of human health (through air pollution, noise, vibration, etc.), reduction in human security (because of traffic accidents), loss of biodiversity, congestion (and associated losses in the productivity of urban areas), reduction of accessibility and severance of communities.

[1] UNEP, 2011, Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication, www.unep.org/greeneconomy

2.2. Avoid/Shift/Improve Strategy

The current transport system largely depends on vehicles running on fossil fuels, which has social impacts, and causes environmental and economic unsustainability. In order to overcome the failures of the current system, a genuine and precise change to the current model is needed. This would enable necessary action to be taken to ensure that the mobility of people and goods becomes socially inclusive, and uses resources efficiently, with the lowest environmental impact.

With this in mind, a consistent, thorough, and complete intervention strategy should be followed, consisting of three main pillars:

• Promote accessibility and reduce the need for mobility (Avoid / Reduce)

• Use more sustainable modes of transport (Shift)

• Technologically enhance all vehicles, ensuring higher efficiency, with lower emissions (Improve).

This strategy, endorsed by EEA and UNEP is also known by the initials ASI, from (A)void, (S)hift, (I)mprove.

Table 2 ASI Strategy

Avoid/reduce	Shift	Improve
Reduce/avoid transport demand	Modal shift towards less polluting modes	Improvement on efficiency of mode and vehicle
Efficiency of the system	Efficiency of the trip	Efficiency of vehicle

The *Avoid/Reduce* policies are aimed to the reduction of transport demand, without depressing the economic growth, limiting exchanges or hindering the free circulation of people or goods.

Passenger transport demand can be reduced, for example, through the *virtualisation* of people's movements (e.g. telecommuting, on-line shopping) or through efficient and effective urban planning: increasing the density of cities, placing the main urban functions close to public transport corridors and hubs (e.g. railway stations), avoiding urban sprawl. The same objective in freight transport can be reached by developing a more efficient *geography* of production and commerce, for instance by opening new routes that would reduce the travel distance of goods.

The reduction of vehicle traffic is also part of the Avoid/Reduce pillar. All efficiency actions designed to reduce the movement of vehicles, such as the increase of load factors, have the effect of cutting the impacts of mobility. This action can be applied both to the passenger sector (e.g. with car-pooling and car sharing) and to the freight sector (with activities such as packaging design, reduction of empty trips, larger vehicles, optimisation of logistic chains).

The *Shift* pillar aspires to reduce the impacts of passenger and freight mobility by promoting the adoption of transport modes with lower specific impact. The objective is to reduce the impact of that part of transport demand which cannot be avoided or reduced, and therefore has to be satisfied through the use of more sustainable modes which offer a comparable travel performance.

It is well-known that cars, trucks and planes are transport modes with a higher specific impact than railways, buses and metro. These modes in turn have a higher impact than non-motorised transport, such as travelling by foot or by bicycle. Every one of those modes of transportation with a lower impact is more efficient in specific segments of the transport market, and it is in those segments that it has to maintain or increase its market share by exploiting its competitive advantage.

The measures encompassed by the *Improve* pillar are targeted to the improvement of the *efficiency of transport vehicles*. The goal is to reduce the impact of the part of transport demand that cannot be effectively avoided, reduced or transferred on more sustainable modes: the vehicles have to be continuously more efficient, more secure and generate less emissions.

The technological innovation has a large role in this pillar, as it can act in the field of engines, fuels and on other vehicle components. For example in private cars – the largest source of atmospheric emissions in the passenger transport sector – it is possible to intervene by reducing emissions and specific consumption of traditional engines (*fuel economy*), by using alternative fuels or biofuels, or through the electrification of vehicles. There are also other possibilities of action on vehicles, such as the reduction of weights, the improvement of aerodynamics, the reduction of friction, etc.

2.3. Enabling conditions

The ASI strategy requires adequate investments and needs to be supported by appropriate policy options:

- Reforms of the structure of taxes and charges with a view to pricing negative environmental externalities of transport (e.g. via road pricing, carbon tax, eco-taxation, subsidies for greener transport)
- Setting the right financial conditions and economic incentives
- Other policies such as planning, regulations and standards and information provision and other approaches to address transport market failures, measurement issues and behavioural biases
- Providing the right environment for private finance (e.g. fast-tracked and simplified planning approval for new projects) to give clear signals to support private investment;
- Conditions for assuring the right policy framework for greening transport infrastructure provision and fleets;
- Smart land use;
- Innovation policies, ensuring technology transfer and access;
- Strengthening institutions and capacity.

3. Green transport and railways

Once the meaning of "green transport" is established, the question is: which role can it play and which contribution can the railway sector give to it? Since the enabling conditions belong to the policy sphere, the role of railways has to be outlined within the three pillars of the ASI strategy, identifying for each line of action which can be the role played by railways.

3.1. ASI strategy and railways

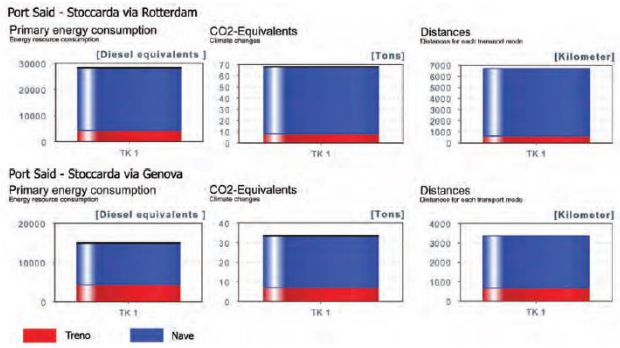
3.1.1. Avoid/Reduce

In the *Avoid/Reduce* pillar, railways as a sector and as a mode of transport, do not appear to play a direct role in transport reduction.

However, as seen earlier, one of the factors in the reduction of transport demand is the decrease of travelling distances. In long-distance freight transport, supporting world trade, this objective can be reached through the **creation of new rail corridors shorter than the corresponding sea routes**. Such a measure can contribute to the global reduction of the impacts of mobility, and create an opportunity for the countries traversed by the new railway corridors to increase the accessibility of their markets to the sea and vice-versa. Examples of this are the Trans-Asian Railway network or the North-South freight railway corridors in Europe, that can intercept part of the maritime traffic crossing the oceans or the straits.

An example of a potential Avoid/Reduce action can be taken from a research published by the Sustainable Development Foundation on the Genoa-Rotterdam freight corridor (Susdef 2012). Up until now, many ships have chosen to use the Suez canal, instead of docking in Genoa and saving 4 to 6 days of navigation, due to a series of infrastructural deficits regarding the Genoese crossroads causing an uncertainty in times, and to the problematic intermodality between maritime and rail transport. Instead, freighters prefer to cross the stretch of Gibraltar and unload in North Range ports and from there transfer loads by rail.

Fig. 5 Comparison of pollutant emissions for a load of 1000 tonnes transported between Port Said and Stuttgart via Genoa and Rotterdam



Source: Susdef elaboration with EcoTransIT World tool

Guaranteeing an effective transfer of loads by rail in Italian ports, therefore encouraging modal shift by rail, would involve around 3 500 less kilometres travelled by the cargo. This route reduction would result in the following environmental advantages: 47 630 MJ in consumption of primary energy (PEC), 3.4 tonnes of CO_2, 3.5 tonnes of CO_{2eq}, 77 kg of nitrogen oxide (NOx), 4.08 kg of non-methane hydrocarbon (NMHC), 44.4 kg of sulphur dioxide (SO_2), 6.36 kg of particulate matter (PM_{10}).

A further measure of transport demand saving through the reduction of the travel distance has been activated by the Transit-Oriented Development (TOD), in particular in emerging economies, that has the goal of reversing car-dependent urbanization. The World Bank's "Transforming Cities with Transit: Transit and Land-Use Integration for Sustainable Urban Development" (World Bank 2013) concluded that compact, mixed-use, pedestrian-friendly development **organized around a mass transit station** is one of the most

effective strategic initiatives to address the negative effects of motorization. Master plans from the past decades of global good practice cities clearly identified rail transit systems as the backbone of urban development. IPCC estimates that over the medium-term (up to 2030) to long-term (2050 and beyond), urban (re)development and new infrastructure, linked with land use policies, could evolve to possibly reduce GHG intensity by 20-50% below 2010 baseline by 2050, through more compact and integrated transit, improved cycling infrastructure, and walking-oriented urban planning.

Rail stations as important nodal points both in city centres and in local urban towns also serve wider social functions, by offering accessibility to a comprehensive and wide range of services, such as post offices or shopping facilities. Reducing local trips for intercity and international passengers is one of the main functions of rail stations: due to their usually central location, compared to airports, rail allows its clients to reduce the needs of urban and local transport once the main trip of the door-to-door chain has finished.

3.1.2. Shift

It is well known that railways, compared to other competing transport systems, are extremely environmentally friendly, resource efficient and socially inclusive. Rail is often quoted as one of the most sustainable means of transportation. In the Shift line of action, the role of railways is essential. On a sustainability level, the real challenge of green transport is to expand the market share of railways. Unlike other competing sectors, the mission of the railway companies and in general of the rail sector as a whole (transporting goods and people) coincides with one of the main lines of action of green transport.

But it is necessary to make an important clarification: this condition is met **in the event that the market shares of the railways will increase to the detriment of road and air transport.** Only in this condition an expanding railway market share achieves the goal of reducing the impact of transport.

The demand concerned by this kind of shift is only the demand that it is not possible to reduce or to avoid without depressing economic growth, limit commercial exchanges or prevent the free movement of goods and people (i.e. by applying Avoid/Reduce measures).

The term “modal shift” is tied to the evolution in the organisation of transport in developed countries, where road and air transport have been continuously growing their share. The modal restructuring implies in this case a “shift” from less sustainable modes to more sustainable modes such as railway. In several other countries and regions, however, the modal share is already favourable to rail. What is happening there today is in fact a shift towards less sustainable transport modes. In this context, the term “modal shift” can be misleading if it is intended to be a shift towards rail. The meaning of the ASI strategy here is to stop the modal shift to less sustainable modes, or in other words “maintain” the modal share of rail when an increased demand for mobility arises. This is also the perspective for those developing countries in which railways currently have a very limited role or none at all, such as in many African countries.

There are technical and economic constraints – always in evolution – that determine the market segments in which railways can be competitive with other less sustainable modes such as cars, light and heavy-duty vehicles and aviation. The necessary condition for the train to be preferred to modal alternatives is that railways are able to offer a competitive product/service **on a specific market segment[2].**

Currently, with reference to the experiences collected in different geographic areas and railway systems, the greater potential of railways can be seen mainly in some market segments where the train has the technical means and competitive advantages to gain significant market shares with other modes of transport. The outcome of this competition, in case the railway prevails, determines a potential reduction of the impacts of transport.

[2] One of the more significant segmentations is based on the optimal range of the different transport modes. The optimal range is intended as the range that can be served best by a specific mode of transport in terms of efficiency and effectiveness. The efficiency integrates in the range the optimal use of the “value of time”.

Rail can potentially serve very well the great volumes of traffic **centred in the metropolitan cities**, coming and going from the suburbs and the outskirts of the city. The car congestion of the roadways entering the city is a competitive advantage for rail: many successful examples of commuter trains can be taken from European, North American and Asian cities. An urban development tightly connected to the railway system is a great opportunity for railways and for the liveability of large cities.

Rail can potentially play a key role serving the **intercity passenger traffic** competing with airlines. High-Speed Rail is definitely the most effective means of transport when travel time is lower than 2 hours, but when train travel time is between 2 and 4 hours it can still be competitive. With the commercial speed of HSR continuously growing, the optimum distance now reaches 1 000 km. A notable example is China, which has shown a fast development of its high-speed rail system: there, the optimum distance goes up to 1 500 km in the case of Beijing to Shanghai.

Railway can potentially gain market share at the expense of cars even for smaller distances, with or without HSR service. This also depends on certain factors, e.g. the geographic characteristics of a country, the travel time difference between rail and car, the train schedules and the density of train stations. There are countries such as Switzerland, Germany or Japan[3], where well-performing Intercity services on some routes engender modal shares for rail well above the modal shares for road. There is a very strong correlation between the rail vs. road modal split and the travel time needed for each mode: thus, only fast railway networks with frequent connections can compete with road transport. All this is possible on some conditions, e.g. a high population density with an equally high density of railway offer and demand.

Railway freight traffic is a strategic transport system. In the freight sector, it can be observed that countries with an extended and homogeneous territory are more favourable to railway freight transport, while countries or regions which are smaller or fragmented by internal geographic barriers are less auspicious of railways as a means to transport freight. Railway transport is extremely efficient to transport raw materials for industrial activity (e.g. steel, chemicals, automotive) and for container traffic, tightly integrated with naval and road freight. The main feature of freight rail is to operate on long distances: the challenge for the whole railway sector is to reduce the distance in which rail transport is effective, and gain market shares in commercial sectors which are not using railway transport yet, or very little. All this is possible, and demonstrated by several success stories, through technological and organizational improvements that increase efficiency, security and reliability of transport.

According to IEA, if growth in global truck travel between 2010 and 2050 could be cut by half from the projected 70% and shifted to expanded rail systems, about a 20% reduction in fuel demand and CO_2 could be achieved, with only about a fifth of these savings being offset by increased rail energy use.

The potential for shifting freight to greener modes is difficult in urban areas. Even if city logistics systems are almost entirely reliant on road vehicles, intra-urban rail freight movements are possible. Within cities, the concept of modal split between passenger and freight movement can be related to the interaction between land development and transport.

3.1.3. Improve

Even if railways contribute with a very low share to the energy consumption (2.2%) and to the CO_2 emissions (3.3%) of the world transport sector, improving vehicle efficiency is one of the most important goals of railways.

Railways can improve their energy intensity by undertaking technical/organisational and systemic strategies. The main factors that can have an impact on railways energy intensity can be differentiated between those related to supply and those related to demand.

[3] All the countries mentioned have a high per-capita income, extremely developed networks of roads and highways, and rates of penetration for private cars much higher than the world average.

Table 3 Energy intensity reduction strategies

Supply factors	Demand factors
Traction concepts and energy sources	Space utilisation
Mass reduction	Load factor
Areodynamic and friction	Reduction empty trips
Reducing conversion lossess	Flexible trains
Regenerative braking and energy storage	Marketing strategies to increase demand
Reducing energy consumption for confort function	
Energy efficient driving	
Procurement strategies	
Awareness of personal and incentives	

Source: UIC EVENT

The supply-side factors, in summary, are connected to new technologies and technology improvements. A typical example of energy efficiency is the modification of the *traction concept*: from diesel to electric, as it once went from steam to diesel. Given a technology, it is also possible to improve its use, for instance with "intelligent driving" which can be put in practice both through training of the drivers and through an efficient planning of the schedule.

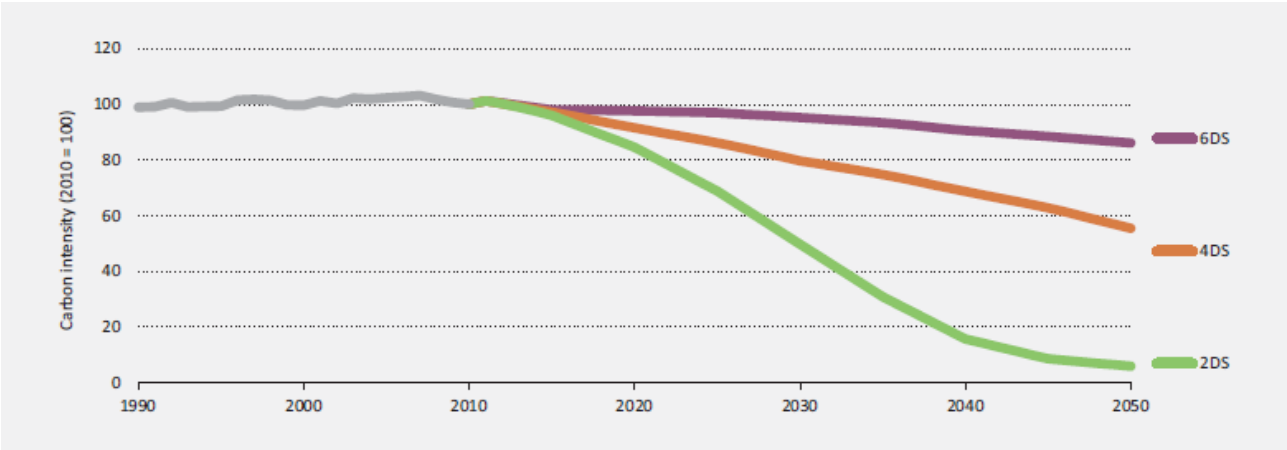
The demand-side factors act on the denominator of energy intensity: when more passengers and freight are transported with the same amount of energy consumption, the intensity decreases. Consequently the demand-side strategies are concentrated on increasing the load factor of trains. This objective can be reached by reducing the offer of trains with the same amount of passengers transported (e.g. trains with more capacity or with a more flexible composition) or by increasing the amount of passenger/freight transported with the service already in place. The increase of passengers and freight transported can be a direct consequence of the increase of market share of railways by modal shift.

Increase and expansion of high speed rail can lead – in absolute terms – to higher total energy consumption. Nevertheless, worldwide experience confirms that High-Speed trains have a lower energy intensity compared to Intercity and regional trains. That is because in HSR service there is a higher load factor, better planning of the schedule and more efficient rolling stock[4].

One of the crucial factors for the reduction of energy consumption is the process of electrification of world railways that is in continuous expansion. The electrification of railway transport can have a double impact on carbon intensity: it increases the energy efficiency and it can be matched with the reduction of the emission factor of electricity which can potentially go all the way down to zero if the electricity is entirely produced with renewable sources.

[4] For example, the high-speed 'Shinkansen' train in Japan gained a 40% reduction of energy consumption by optimising the length and shape of the lead nose, reducing weight, and by using efficient power electronics.

Fig. 6 Carbon Intensity of the Electricity Generation Sector



Source: IEA ETP 2014

According to the IEA 2DS scenario, in 2050 the electricity will be significantly decarbonised, reaching a world average emission factor of 37 gCO_2/kWh. This would be a reduction of more than 90% compared to the emission factor of 529 gCO_2/kWh estimated for 2013 (see Fig. 6).

3.2. Enabling conditions affecting railway

As explained before, the railway sector is in measure to intervene widely on the ASI strategy deployment and on its own performance. An increase in productivity, for instance, can encourage a price competition on certain segments of the transport market and promote the choice of rail. Similarly, the introduction of a new product can have positive effects on the rail modal share: e.g. the high-speed rail, which has often conquered a significant portion of market share from aviation.

These are necessary and decisive actions that, however, have to be done in conjunction with investments in infrastructure which are essential for the development of the transport service. The investments in rail infrastructure, due to their high costs, often have to be connected to the adoption of specific transport policies by public institutions. It is often believed that the investments on rail are always new lines and rail corridors needing huge expenses. In fact, **the investments needed to increase the efficiency and effectiveness of rail transport can also be smaller: e.g. the reduction of bottlenecks, the modernization of signalling systems, the increase of axial loads and loading gauge in some strategic sections of the network.** The investments can also be on building or improving the inter-modal nodes dedicated both to freight (ports, logistic centres) and to passenger traffic (stations, parking facilities, connections with public transport).

The investments in railway networks have also to be evaluated in relation with the investments made on the competing modes. Governments and the various institutions involved often declare that they want a transition to green transport, but they systematically allocate major investments on other less sustainable modes of transport through the construction of roads, highways, airports or through subsidies and various types of support policies. Such investments on vehicle stock, road infrastructure, and fuel-supply infrastructure influence future use and can lock-in emission paths for decades because of economies of scale. The life span of this infrastructure ranges from 50 to more than 100 years. This range makes the current development of infrastructure critical to the modal shift opportunities of the future.

The modal shift is influenced also by demand-side factors such as the generalised perceived cost of travel, the disposable income, the underlying needs of travel and the subjective expectations connected to socio-cultural factors. In the generalized cost of travel factor, for instance, there is a key role played by the accounting of external or hidden costs. Without a mechanism to internalize the external costs, the choices of consumers are made in a transport market that doesn't work correctly and hampers railways.

Removing subsidies to fossil fuels is crucial to greening transport and shifting to railway. IMF estimates that subsidies for fossil fuels reached $480 billion in 2011 (0.7 percent of the global GDP or 2 percent of total government revenues). Subsidies to road and aviation are much wider than just fuel subsidies and involve many other sectors (pricing policies, e.g network charges and parking fees, etc.).

A recent study of **external costs of transport** in Europe examines intermodal comparisons. It calculates the costs that could be avoided by means of shifting from one mode to another with a lower external impact. When considering the charts below it becomes clear that average external costs for road transport are more than four times higher than rail for freight and more than six times higher for passenger services (excluding congestion). The study calls for changes to transport policy, to introduce a consistent, fair policy framework for external costs.

Fig. 7 Average external costs 2008 for EU-27: passenger transport (excluding congestion & motorcycles and mopeds)

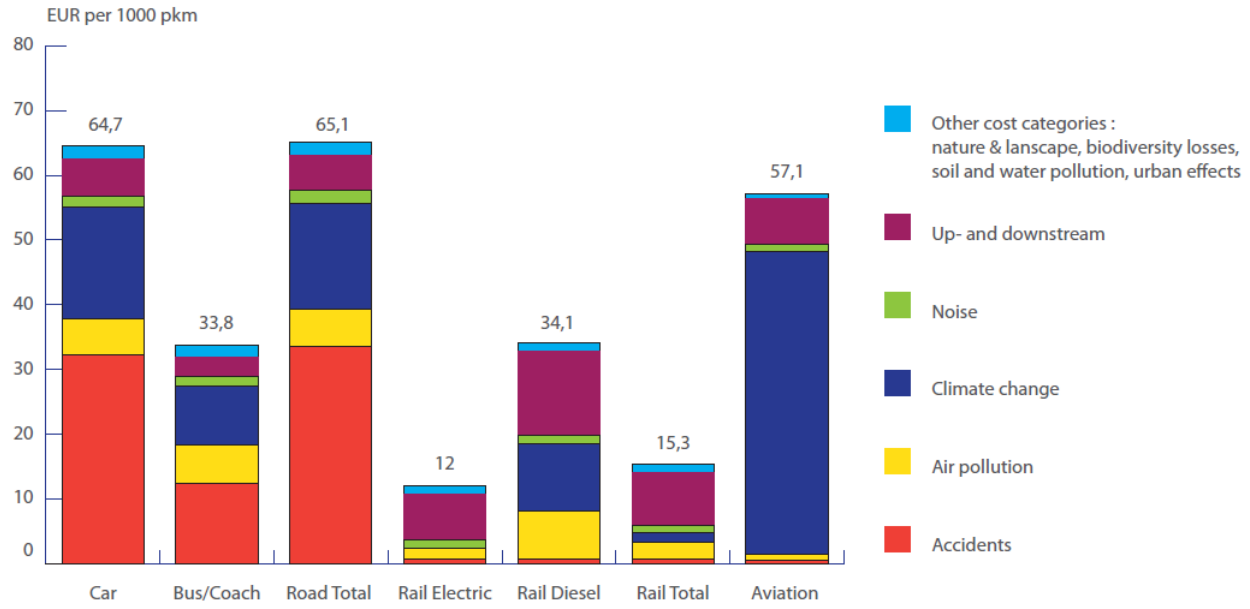
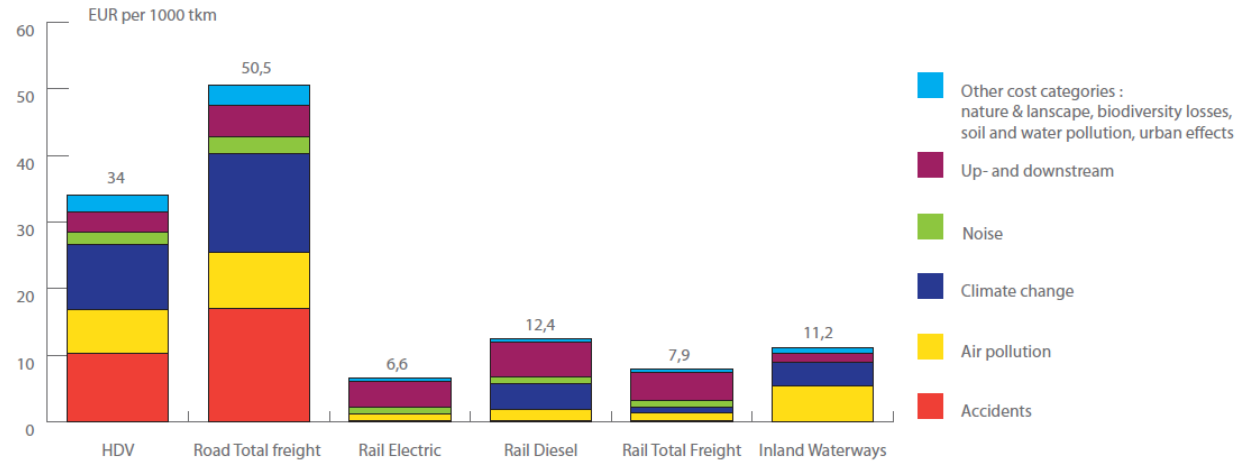


Fig. 8 Average external costs 2008 for EU-27: freight transport (excluding congestion & without LDV)



Source: UIC/CER 2012, CE Delft 2011

Finally, a land planning, especially urban planning, which does not take into account the social, economic and environmental impacts of mobility will influence – often in an irreversible way – the transport demand and a low rail share. The correlation of urban sprawl with the dependency from the use of cars or trucks is well known, for example. In low-density developments with extensive road infrastructure, cars will likely dominate modal choice for most types of trips. On the contrary, rail systems need to be combined with strong land-use and urban planning.

4. Modal shift to rail: multiple benefits

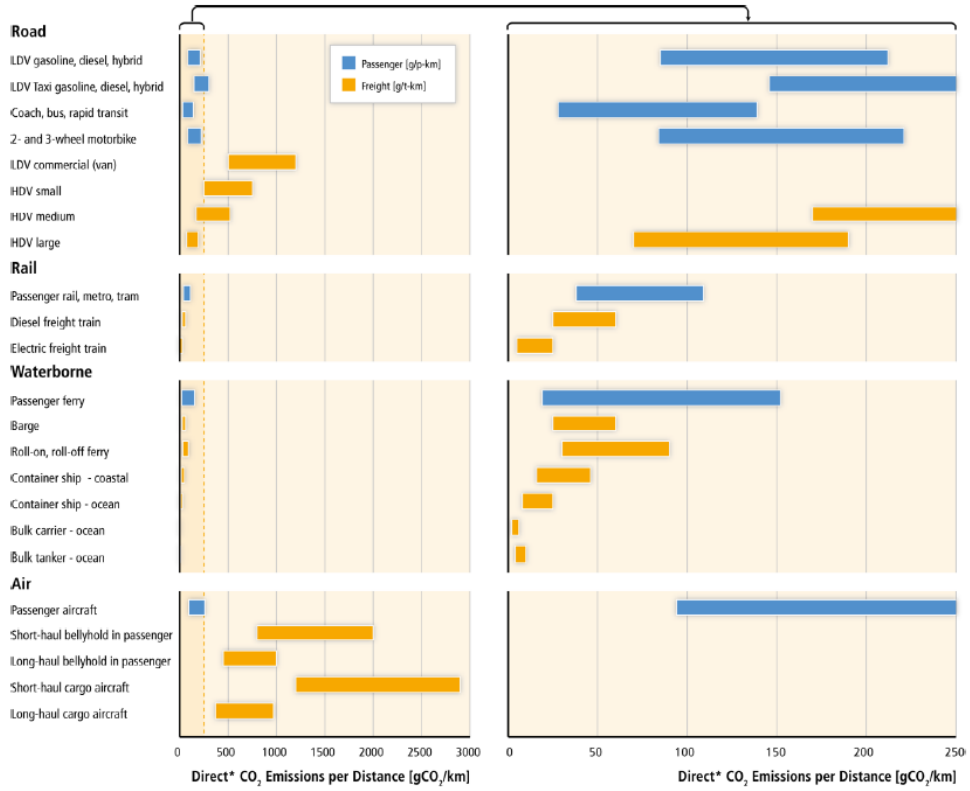
A thorough analysis of the most important reports and studies available on transport and Green Growth leads to the conclusion that a modal shift to rail has multiple positive impacts, from an environmental, economic and social point of view.

The following sections attempt to summarise in a few pages all the interactions and positive synergies that will be achieved by increasing the role of railways in the transport markets.

4.1. Climate change mitigation and lower health impacts

The real challenge of green transport for railways is not just to reduce their specific impact on energy consumption or carbon emissions, but to expand their market share. Currently, the energy consumption and CO_2 emissions of railways are substantially lower than other transport modes: therefore, rail is one of the transport modes towards which mobility has to be *shifted*.

Fig. 9 Typical ranges of direct CO_2 emissions per passenger-kilometre and per freight tonne-kilometre, for the main transport modes when fuelled by fossil fuels including thermal electricity generation for rail

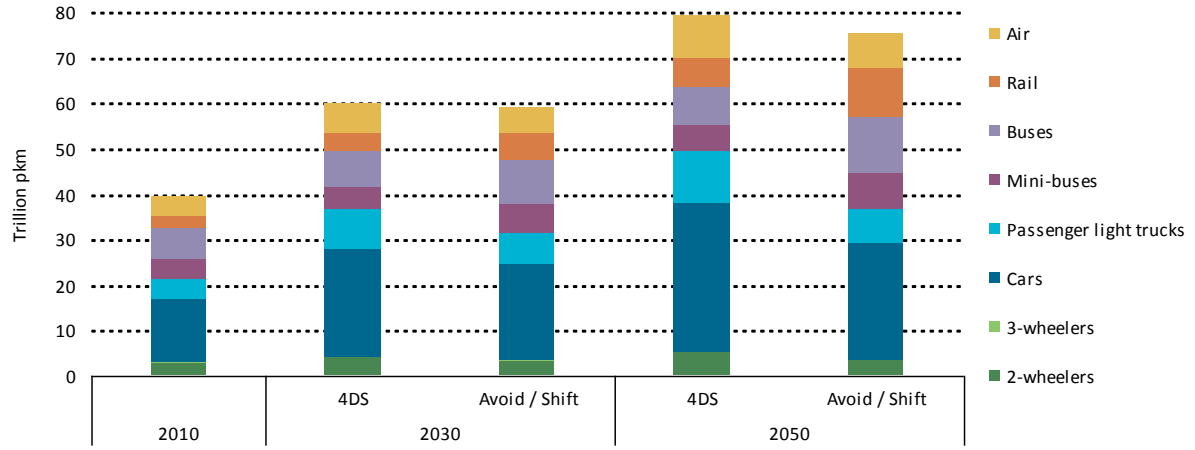


Source: IPCC 2013

IEA has defined three fundamental scenarios at a world level: 6DS, 4DS and 2DS, referred to the potential increase of the world average temperature in 2050. In ETP 2012, the IEA has defined two sub-scenarios: "2DS Improve" and "2DS Avoid/Shift". The IEA Avoid/Shift sub-scenario analyses the potential effects of policies oriented to modal shift and to the reduction of transport demand[5]. In the passenger sector, the Avoid and/or Reduce policies are considered to have more significant effects in the long term, while by 2030 the modal shift is expected to have a greater effect on the reduction of the environmental impact of mobility.

[5] IEA stresses the important contribution that can come from modal shift particularly in an urban environment, where a higher growth and concentration of population is expected in the next decades. An intelligent growth of the cities can reduce the distance and number of movements, and promote the use of more sustainable transport modes such as public transport, cycling and pedestrian mobility.

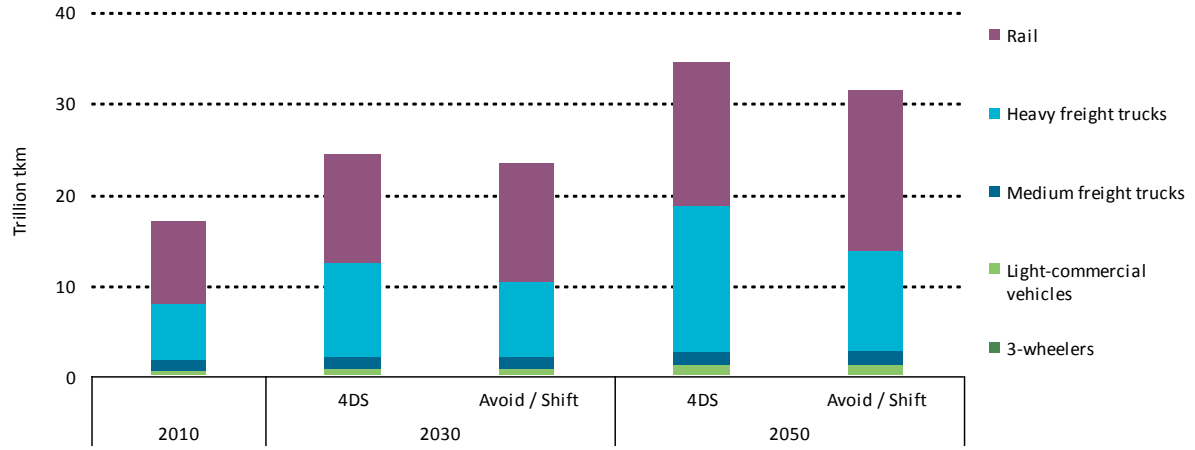
Fig. 10 Volumes of passenger traffic and modal share estimated by IEA



Source: IEA 2012

Railway traffic, both on medium-long range and on urban/suburban distances, can increase considerably and reduce the weight of road transport and aviation. In the land freight transport sector as well, the impact of policies oriented to modal shift on rail is relevant and can be even more relevant in the medium term.

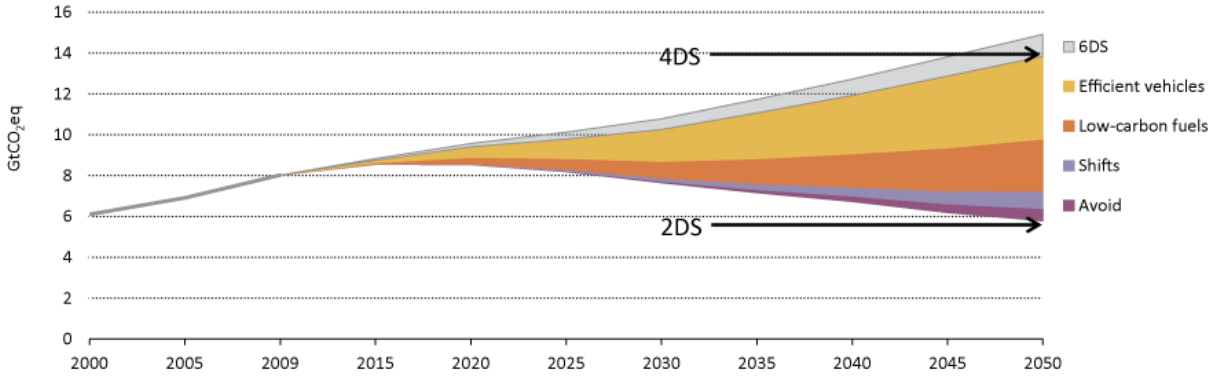
Fig. 11 Volumes of freight traffic and modal share estimated by IEA



Source: IEA 2012

The combination of the effects of the scenarios *Avoid/Shift* and *Improve* can trigger a reduction in emissions of the transport sector by around 8 $GtCO_{2eq}$ by 2050 compared to the 4DS scenario, with a contribution of 1.4 and 6.6 $GtCO_{2eq}$ from the Avoid/Shift and the Improve scenario respectively.

Fig. 12 Greenhouse gas emissions of the transport sector estimated by IEA

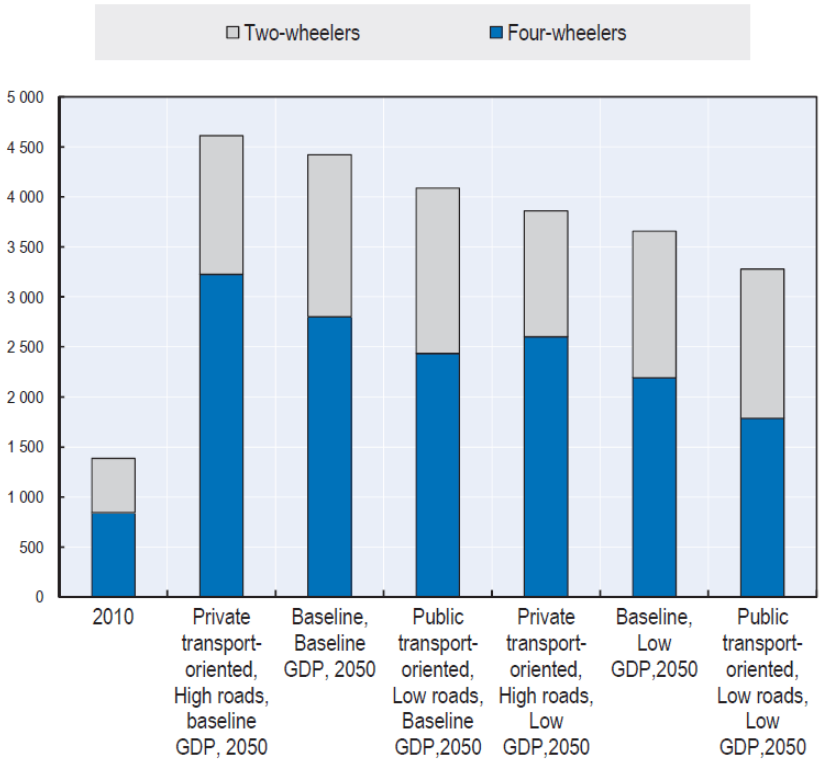


Source: IEA 2012

ITF, in its 2013 Outlook, proposed another interesting estimate about climate change mitigation due to an increase of rail modal share, urban rail in this case study. The International Transport Forum, unlike IEA, focuses its analysis on the contribution that can come from the combination of Avoid/Shift action in an urban context. ITF analyses different scenarios for the reduction of CO_2 emissions generated by vehicle fleet containment policies through Transit Oriented Development in large urban areas in developing economies, via Bus Rapid Transit corridors and Urban Rail corridors.

The different urban transport policy packages result in significant variations in the growth of the world's private vehicle fleet. The highest case results from a context where urban transport in the existing and new urban centres develops according to the Private transport-oriented, High roads policy package. The lowest case corresponds to a scenario where this development occurs under the conditions of the Public transport-oriented, Low roads scenario. Overall, urbanisation under these two pathways accounts for a difference of 500 million private vehicles by 2050 in the Baseline GDP case, and 600 million in the case of Low economic growth case.

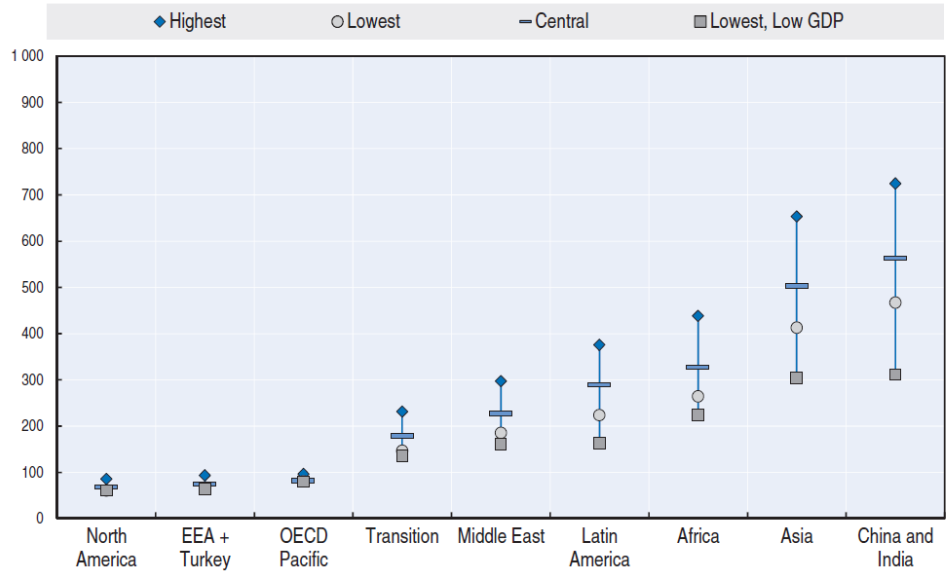
Fig. 13 World private vehicle fleet, 2050 Different urban policy pathways and alternative economic growth scenarios (million units)



Source: ITF 2013

Fleet differences between scenarios are translated into average vehicle travel depending on different fuel prices under the scenarios split by world region, modelled under baseline growth assumptions. According to ITF: "[…] Overall, significantly higher rates of vehicle travel will happen outside the OECD, since it is in these regions where income elasticity of ownership will continue to be high, and where higher economic growth prospects are expected. It is therefore within these regions that diverging urban policies will have a largest effect on the private vehicle ownership pathways and on future growth of CO_2 emissions".

Fig. 14 Growth of CO_2 emissions for passenger transport by region, 2050



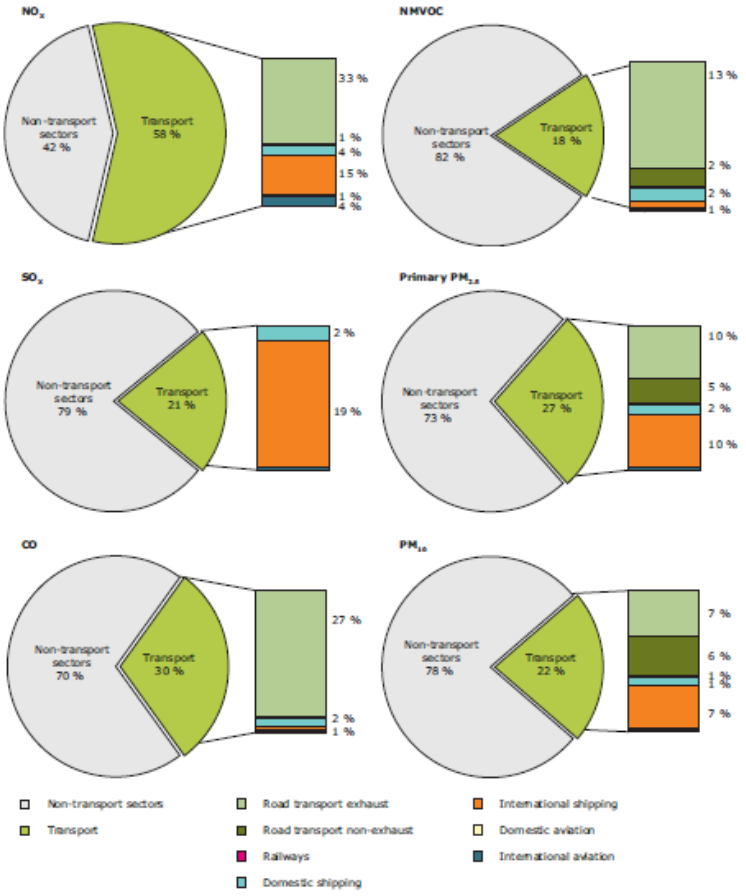
Source: ITF 2013

Emissions of all primary air pollutants decrease because of climate policies. Co-benefits of climate policies on air pollution exist and no net trade-off (e.g. an increase of pollutant emission as a result of a decrease of GHG) was found until now. Many studies have highlighted the positive effects of climate policies on air pollution and concluded that climate mitigation policies also reduce the costs of air pollution control, and these cost savings can be substantial compared to those of climate mitigation measures.[6] The effect of climate policies on air pollution depends (ceteris paribus) on the mix of climate measures taken. Reducing energy demand and increasing the share of carbon-free electricity, e.g. by shifting to rail from road transport, leads to a decrease of air pollutant emissions too. This is not necessarily the case for substitution of fossil fuels by biomass, neither on train nor on car and truck.

The advantages of a modal shift to rail on greenhouse gas emissions linearly correspond to lower emissions of polluting agents. It is important to stress how the reduction of the concentration of pollution in an urban environment is the goal: it is in fact inside large and congested urban areas that pollutant agents, including those coming from transport, cause the greatest damage (on human health, on nature and on buildings). At the same time, the urban environment is where railways have a great competitive advantage compared to road.

[6] However, emissions of air pollutants from the transport sector have a much higher reduction potential than GHG due to the combined effect of lower fossil fuel consumption and technological improvements imposed by tighter emission standards on vehicle. Therefore, analysing efforts to comply with GHG reduction target confirmed that climate policies alone are not sufficient to solve air pollution problems, especially in Asia.

Fig. 15 The contribution of the transport sector to total emissions of the main air pollutants in 2010 (EEA-32)



Source: EEA 2012

4.2. Increasing transport efficiency

The constant drop in transport costs has a key role in the current economic system and, in general, in modern society. The costs have decreased in time thanks to the increase in productivity caused by the formidable technological and organizational progress of the transport sector in the last 200 years.

While the transport sector is important by itself and contributes to the global output of an economy, it is also instrumental in increasing the productivity of the whole economic system. **The real output of transports is accessibility**: in increasing accessibility, the transport system has a crucial impact to the competitiveness of an economy.

Since the productivity is an average measure of the efficiency of production, expressed as the ratio of output to inputs used in the production process, the productivity of transports increases when its output (accessibility) increases and its fundamental input (mobility) decreases. To maximise the productivity of transportation and therefore economic development, each mode should be used for what it does best.

The technical and economic constraints that determine the market segments in which railways can be more competitive with other modes such as cars, light and heavy-duty vehicles and aviation are always in evolution. Anyway, with reference to the actual experiences collected in different geographic areas and

transport systems, currently railways can well compete with other modes of transport mainly in the following market segments[7] under specific conditions:

- intracity passenger market in congested urban areas
- business and leisure intercity passenger market between medium/large urban areas
- bulk long distance freight market
- intemodal containerized long distance freight market

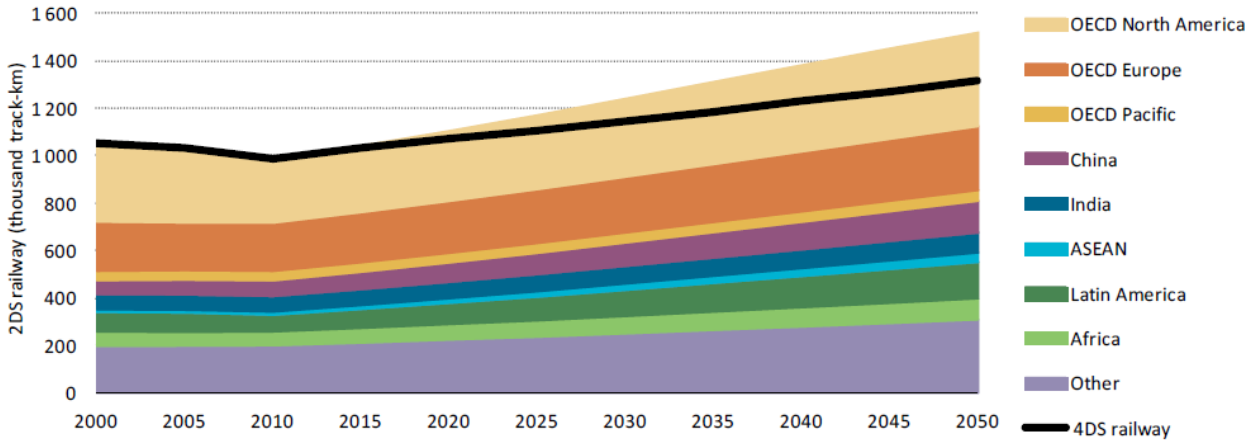
When the modal share of railways in these markets is below its potential, there is either a misallocation or a scarcity of capital (financial, technological, human, etc.). In Both cases, an investment on modal shift to rail induces an improvement of the overall transport system, which in turn generates a higher competitiveness of the economic system and a growth factor[8].

A useful and interesting demonstration of what it means to increase the productivity of a transport system through an efficient use of transport can be extracted by a recent IEA study. The International Energy Agency analysed the infrastructure requirements to support projected road and rail travel through 2050: the investigation shows **that infrastructure in the transport sector (road and rail) must increase by 60% from 2010 to 2050, as a direct consequence of a surge in global mobility.**

In a BAU scenario, cumulative expenditures for the infrastructure additions (road, rail, BRT corridors and parking), reconstruction and upgrade costs, annual operation and maintenance spending are expected to reach $120 trillion (2% of projected global GDP to 2050). Most of these costs and the increased infrastructure capacity would take place in emerging economies.

On an "avoid and shift" scenario, where road passenger and freight travel are either shifted (e.g. to rail) or eliminated (e.g. due to land use changes), global transport infrastructure requirements could be reduced considerably. Roadway additions should decrease by more than 10 million lane-km whilst global rail infrastructure needs to increase by nearly 200 000 track-km to accommodate greater rail travel, and BRT networks would grow by more than 25 000 trunk-km (above BAU projections).

Fig. 16 Railway projections in a "shift to rail" scenario



Source: Dulac 2013

Despite increases in expenditures on rail, HSR and BRT infrastructure aimed at shifting demand to rail and other public transport modes, cumulative global land transport infrastructure spending necessity decreases

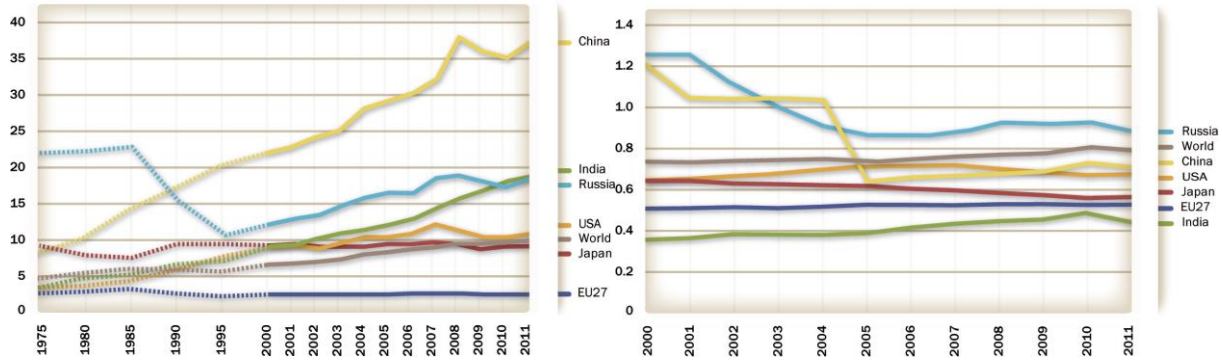
[7] One of the more significant segmentations is based on the optimal range of the different transport modes. The optimal range is intended as the range that can be served best by a specific mode of transport in terms of efficiency and effectiveness. The efficiency integrates in the range the optimal use of the "value of time".

[8] Note that in this formalisation of the problem, the issue of external costs is not taken into consideration.

by nearly $20 trillion over a BAU scenario estimates. Including global vehicles, fuels and infrastructure costs, expenditures in a BAU scenario reach nearly $515 trillion and $465 trillion in the avoid/shift scenario, representing net savings of $50 trillion ($30 trillion in savings in vehicle and fuel expenditures and $20 trillion in infrastructure savings).

This result is also due to the high occupancy of railways. **Worldwide, for each kilometre of track, railways transport 10 times more transport units (pkm + tkm) than what is transported in one kilometre of paved road** (see Fig. 17). The higher occupancy level allows railways to support a higher amount of passengers and goods with a smaller infrastructure: when the goal is to satisfy a growing demand of transport (which will be the case in the coming years, particularly in Asia), railways can do it much more efficiently than roads, even if rail transport infrastructure is still on average more expensive by track-km compared to a lane-km of road.

Fig. 17 Evolution of railway tracks (left) and paved roads (right) occupancy level, 2000-2011 (million transport units per paved lane-km or rail track-km)



Source: UIC/IEA 2014

This study shows that a modal shift to rail, together with avoid/reduce policies, needs less investments than in a BAU scenario, in which road and air transport continue to gain market share compared to rail and public transport. Instead, a multimodal transport system is more efficient, because it guarantees the same accessibility with lower investments.

4.3. Stimulating economic growth with long-term benefits

Infrastructure investments are prescribed to stimulate the economy in the short term by creating construction employment, and to foster longer-term economic growth by making the transportation system more efficient and reliable. Several governments have acknowledged the potential fiscal multiplier of infrastructure investments responding to the global economic crisis.

After the U.S. economy entered a severe recession in 2007, the US federal government intervened with the American Recovery and Reinvestment Act of 2009 (ARRA) providing $831 billion in new spending and tax relief, to reduce the costs of the recession and enhance economic recovery (TRB 2014, Meyer 2013).

Table 4 ARRA Government Expenditures for Highways and Transit, 2007 and 2010

	expenditures (USD billions)			
	2007	%	**2010**	%
Highways	**468,9**		**549,6**	
Federal	2,3	0,5%	3,6	0,8%
State	95,4	20,3%	112	23,9%
Local	58,6	12,5%	67,6	14,4%
Total, all units of government	156,3	33,3%	183,2	39,1%
Capital	81,1	17,3%	100,2	21,4%
Maintenance and operations	75,2	16,0%	83	17,7%
Intergovernmental transfers for highways	**45,8**		**63,8**	
Federal payments to states	33,3	72,7%	42,1	91,9%
Federal payments to local governments	0,9	2,0%	1,4	3,1%
Net state payments to local governments	11,6	25,3%	20,3	44,3%
Transit, all units of governmental *	**48,4**		**55,6**	
Capital	14,5	30,0%	17,8	36,8%
Maintenance and operations	33,9	70,0%	37,8	78,1%
Federal payments to state and local governments for transit	8,5		11	
Total Highways	**514,7**	**90,0%**	**613,4**	**90,2%**
Total transit	**56,9**	**10,0%**	**66,6**	**9,8%**
Total ARRA	**571,6**		**680**	

* Excluding intergovernmental transfers, interest on debt, and bond retirements.

Source: TRB 2014

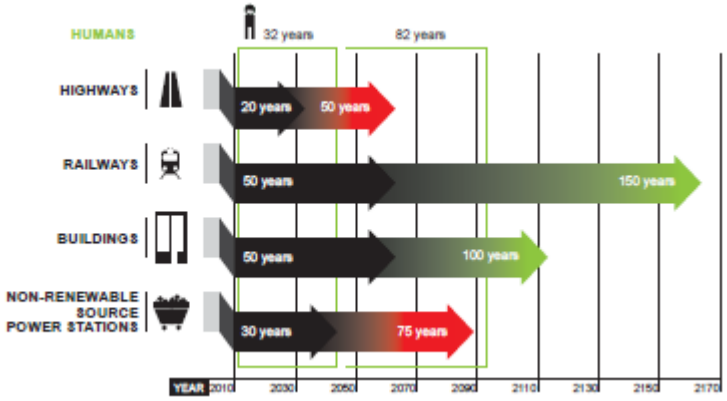
ARRA appropriated $48.1 billion for capital expenditures for roads, transit, airports, and passenger rail. The Transportation Research Board of the National Academies (TRB 2014) has evaluated the effectiveness of stimulus spending and the role of transportation in the stimulus program. Several different studies were analysed, concluding that there is evidence that the short-term government spending multiplier is positive (with a range from 0.4 to 4). The estimation is that the multiplier is greater than 1 when the economy is in a serious recession.

Deeper insight in the distribution of growth impacts of transport infrastructure is provided by ITF, with an average estimated output elasticity of transport infrastructure investment of 0.06, meaning that a 10% increase in infrastructure investment raises output by 0.6%.

Economic growth has the indirect potential to alleviate poverty as a result of a simultaneous increase in employment opportunities, increase on average wage rates and employee or household incomes.

The potential of green transport to drive growth and create new employment was well acknowledged across the world in the aftermath of the 2008 financial crisis and many economic stimulus packages included sustainable transport. Thus, investing on railway infrastructure is a form of stimulus spending that directly supports productive investment providing long-term benefits. Well planned railway investments increase connectivity, reduce congestion and sustain a long term goal of green transport.

Fig. 18 Infrastructure life span



Source: UNESCAP 2012

Choices made today on infrastructure investments will determine the prospects of competitiveness, quality of life and environmental sustainability of countries for years to come. The socio-economic needs and trends, such as population growth, urbanization and development goals, as well as environmental factors, such as projected climate change impacts, are consistent with the rail infrastructure lifespan and its development. Actual railways investments, integrating eco-efficiency concepts into infrastructure development, will not result in growing externalities on the future.

Given the high capital costs and long lifespan, investment in transport infrastructure should strategically consider the socio-economic changes envisioned in a few decades. **Currently, however, the opposite is happening, with priority given to lower short-term investment costs and immediate gains, such as transit time savings**. As a result, the investment in road infrastructure, which takes less construction time and has lower capital costs, is often favoured over rail infrastructure. Developing an eco-efficient transport system for low carbon green growth requires reversing this trend.

4.4. Creating green jobs

A green job[9] is defined as a "*position in agriculture, manufacturing, R&D, administrative and service activities aimed at alleviating the myriad environmental threats faced by humanity. Specifically, but not exclusively, this includes jobs that help to protect and restore ecosystems and biodiversity, reduce energy consumption, decarbonizes the economy, and minimize or altogether avoid the generation of all forms of waste and pollution.*"(UNEP 2008)

A job created in a green transport perspective by shifting to rail is definitely a green job.

A green job in railway transport may be direct, indirect or induced. A direct job is one in the construction and maintenance of rail infrastructure, the manufacture of rail rolling stock or the operation of rail services. An indirect job is one in the supply chain of the relevant construction, manufacturing or maintenance industry or one in professional and administrative services for managing the operation of railway transport systems. Induced jobs are those created when the overall level of spending in the economy rises as a result of increased direct and indirect employment.

Green jobs lead to a net gain in the number of employment opportunities, especially in developing countries. According to UNESCAP, facing a constant decline in rail transport over the past few decades, a strategic policy that channels investment towards building and rebuilding railway networks and integrating high-speed inter-city lines with regional and local lines would lead to a substantial expansion of green jobs.

[9] The concept of "green job" derives from Green Jobs Initiative which was started jointly by United Nations Environment Programme, International Labour Organization and International Trade Union Confederation in 2007.

As with any policy, however, the jobs that might be created by measures to support railway and public transport mode could have a negative impact on jobs in other sectors. WHO suggest that several studies have shown that investment in transport policies that benefit the environment, particularly in relation to climate change, will deliver net employment benefits. This is because public transport and railways are more labour-intensive, so the increase in jobs in green transport will more than make up for any job losses in other sector.

The literature review shows that the public transport companies as railways, are a **significant net employer**. Labour costs commonly represent 60 to 80% of the total costs of a public transport company. A study conducted in Germany to estimate the potential increases in employment under various policy packages for transport, concluded that **increasing the modal share of public transport by 10% by 2030 would increase employment in the transport sector by 5.3% as a whole** (Doll 2013). A study in Spain concluded that 290 000 to 565 000 additional jobs could be created in sustainable transport, depending on the definition used (ILO, 2012). In a case study of the potential number of green jobs that might be created by investments in rail and mass transit in the European Union budget, the GHK Holdings consultancy estimated that an additional 21 500 jobs might be created in railways and public transport by an investment of €1 billion per annum, comprising 78% in direct and indirect jobs and 22% in induced jobs (GHK 2011).

Table 5 Summary of case study results – Annual EU employment (FTE) impacts per €1 billion of investment in "Green" activities

Case	Ful Time Equivalents (FTE) jobs per €1 billion investment
Renewable energy	52,700
Investment in the Natura 2000 Network	29,900
Energy efficiency (housing)	25,900
Sustainable transport	21,500
Waste recycling	9,200
Habitat restoration (including peatlands)	8,700
Organic farming	7,800
Agri-environment (including rural development)	6,600

Source: GHK 2011

Moreover, **even the construction of railways is more labour intensive than the construction of roads**, which creates the fewest jobs of any public infrastructure investment. The Surface Transportation Policy Project (2004) compared employment effects of alternative categories of transportation spending. The analysis indicated that $1 million of spending on federal-aid supported projects for constructing new highway capacity would generate 35 jobs; for highway maintenance, 38 jobs; and for public transit construction and operations, 41 jobs. The study concluded that "investing in a balanced transportation system rather than a new roads-only system will help get more Americans get back to work."

In addition, the design and manufacturing of public transport vehicles is a highly job-intensive activity. There is much less automation than in the private car industry, vehicles are produced in smaller series and follow specific criteria defined by operators and authorities, even though the rate of standardisation and automation is likely to increase in the coming years. Infrastructure and vehicles also generate jobs throughout their life cycle, notably for maintenance and renewal.

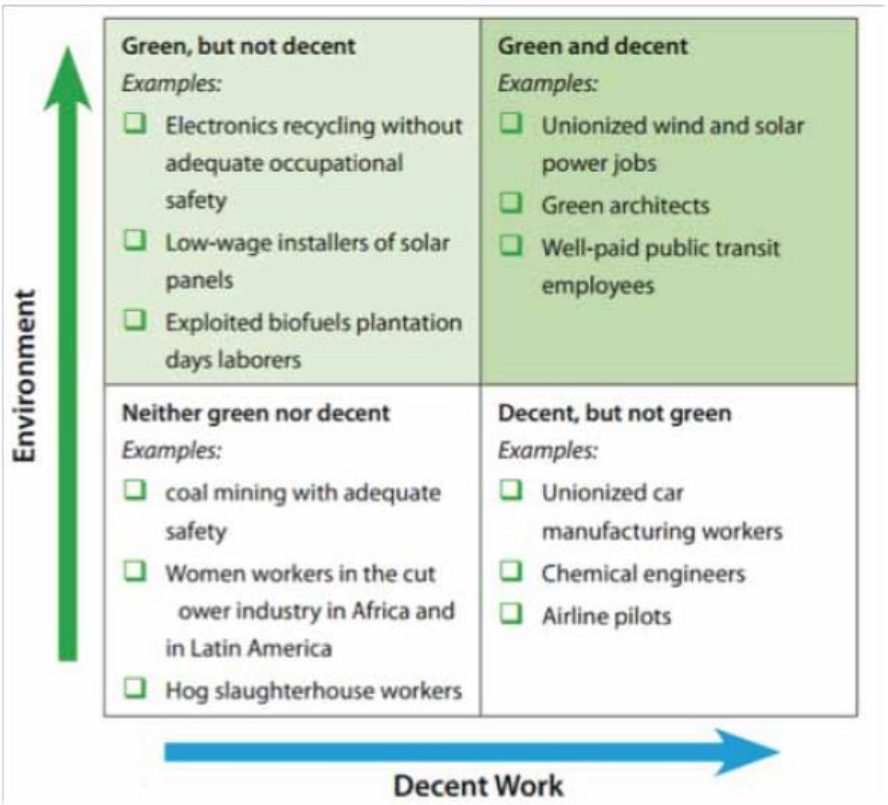
Table 6 Green Jobs progress to date and future potential

Industry sector	Industry subsector	Green job progress to date	Long-term green job potential
Energy	Renewables	Good	Excellent
	Carbon capture and storage	None	Unknown
Industry	Steel	Fair	Fair
	Aluminium	Fair	Fair
	Cement	Fair	Fair
	Pulp and paper	Fair	Good
	Recycling	Good	Excellent
Transportation	Fuel-efficient cars	Limited	Good
	Mass transit	Limited	Excellent
	Rail	Negative	Excellent
	Aviation	Limited	Limited
Buildings	Green buildings	Limited	Excellent
	Retrofitting	Limited	Excellent
	Lighting	Good	Excellent
	Efficient equipment and appliances	Fair	Excellent
Agriculture	Small-scale sustainable farming	Negative	Excellent
	Organic farming	Limited	Good to excellent
	Environmental services	Limited	Unknown
Forestry	Reforestation/afforestation	Limited	Good
	Agroforestry	Limited	Good to excellent
	Sustainable forest management	Good	Excellent

Source: UNESCAP 2012

Another important element in determining whether a job can be considered to be green is whether it provides "*decent work*" that is defined as work for both men and women that is productive and is undertaken "*in conditions of freedom, equity, security and human dignity*" (UNEP 2008). As shown in the following figure, working in railway operations is included in the array environment/decent work in the best possible option.

Fig. 19 "Green" and "Decent" jobs



Source: UNEP 2008

4.5. Boosting urban sustainable development, lowering land use, increasing city liveability

The 21st century is the century of cities. More than half the world's population (54%) reside in urban areas[10], and 7 of every 10 people will live in cities by 2050, with about 90% of the growth happening in developing countries[11]. Cities globally generate about 75% of gross domestic product but at same time consume about 67% of energy and produce about 70% of greenhouse gas emissions. Congestion, air pollution, greenhouse gas emissions, lengthy commutes, and social inequality in accessibility have been increasing rapidly, especially in developing countries, as a result of car-dependent urban development.

Cities are the powerhouses of the economy. Efficient mobility in cities creates economic opportunities, encourages social integration, enables trade, facilitates access to markets and services, and makes effective use of resources. For an urban transport system to be efficient and effective, the public transport network needs to serve the main corridors of urban traffic. An adequate provision of public transport helps make cities more dynamic and competitive. In the case of mid-sized to large cities, in order to be effective, the public transport network has to be built with a railway backbone (commuter rail, heavy rail e light rail).

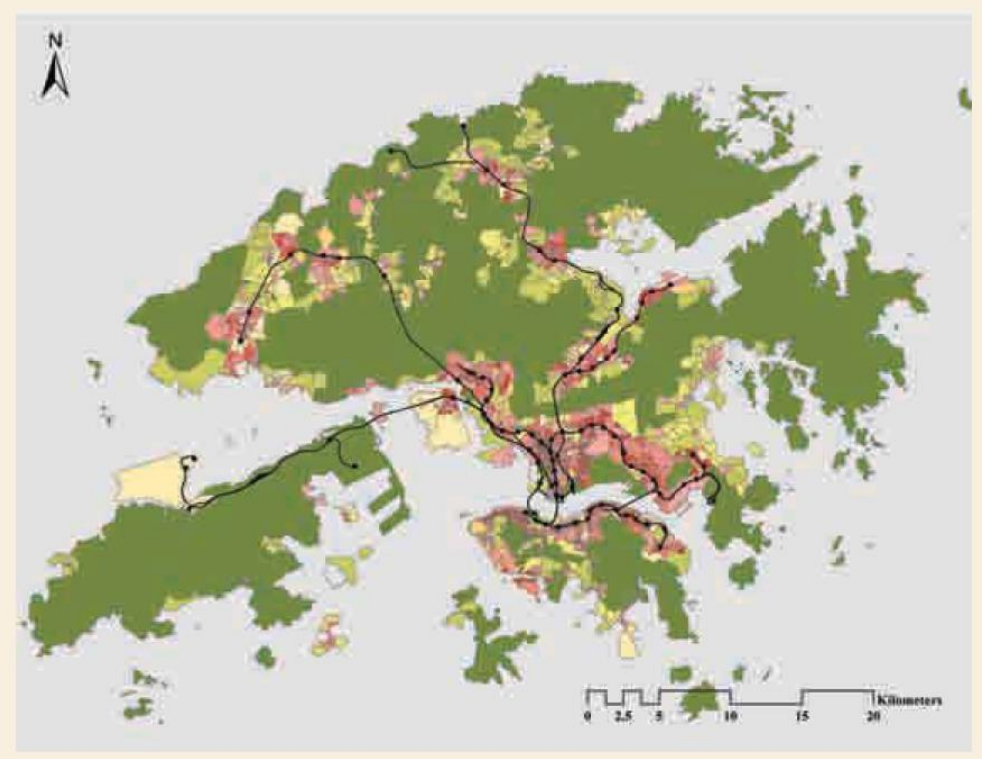
Well-integrated urban railway network and land use fosters economic competitiveness, environmental sustainability and social equity of cities. More specifically, transit-oriented development – which creates articulated densities around transit hubs by locating amenities, employment, retail, and housing in close proximity – is one of the most effective ways to achieve sustainable urban transport.

World Bank (2013) concluded that compact, mixed-use, pedestrian-friendly development organized around a mass transit station is one of the most effective strategic initiatives to address the negative effects of motorization and identifies **rail transit systems as the backbone of urban development.** In congested urban areas, high-quality public transport systems are the most efficient way for people to access employment and education, which are crucial for a prosperous society .

[10] Data from UN Department of Economic and Social Affairs, 2014

[11] Data from UNHabitat 2013

Fig. 20 Urban population density along mass railway transit lines, Hong Kong SAR, China, 2011



Source: Murakami 2010, World Bank 2013

To reverse unsustainable development trajectories caused by rapid motorisation, cities can unlock unexplored land values to finance transit investments, such as for urban railways, and promote transit-oriented development for the well-being of people today and for their sustainable future. However, rail transit infrastructure is extremely costly. Many cities in the world (e.g. Hong Kong, Tokyo, New York, Washington and London) facing the severe fiscal constraint in financing capital-intensive mass transit systems are using development-based land value capture (LVC)[12] not only to generate funds for transit investments and operation and maintenance but also to promote sustainable urban development. The world's largest metropolis has adapted LVC to match the variety of stakeholders, locations, time periods, and scales over the world's most expansive railway network.

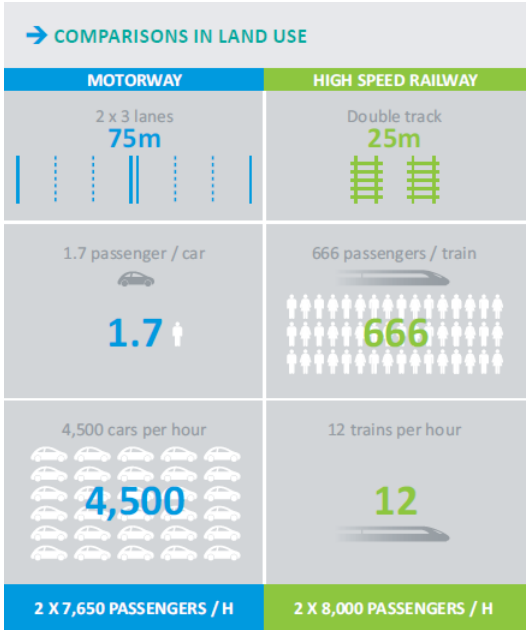
Land use is a critical concern, especially in densely populated areas. The land used to build transport infrastructure cannot be used for other vital needs, such as agriculture, industry or lodging. Policies should aim to an efficient use of land, and the data makes it clear that the amount of land used for building roads is much higher that the land used to build railway tracks. The amount of land used by road infrastructure in China is 79 times higher than the amount of land used by railway infrastructure. The appetites for land of the road sector are in fact growing: worldwide, between 1990 and 2011, the land use of roads has grown by 62%. This increase has been of 143% in India and more than 300% in China.

All the while, the land use of railway has been more or less constant globally, with small increases of 8% and 13% in India and China respectively. This happens in the context of a modal split indicating that globally

[12] Land value capture (LVC). LVC is defined as a public financing method by which governments (a) trigger an increase in land values via regulatory decisions (e.g., change in land use or FAR) and/or infrastructure investments (e.g., transit); (b) institute a process to share this land value increment by capturing part or all of the change; and (c) use LVC proceeds to finance infrastructure investments (e.g., investments in transit and TOD), any other improvements required to offset impacts related to the changes (e.g., densification), and/or implement public policies to promote equity (e.g., provision of affordable housing to alleviate shortages and offset potential gentrification).

road activity (in transport units) is barely 3.5 times higher than rail demand. In China, road activity is in fact less than double rail activity, with a land use 79 times higher.

Fig. 21 Comparisons in land use



Source: UIC

The direct use of land by lines and railway facilities and is also lower than in indirect terms. The feedback that exists between the transport system and the shape and size of the city is well known. The railway, like other public means of transport, tends to "thrive" within a dense urbanisation, localised along public transport infrastructure corridors. Conversely the flexibility of road transport tends to mate with the territorial dispersion (urban sprawl).

The railways as a mode of transport are also extremely efficient in terms of space: land transport capacity per unit of space and time is always favourable to the railroad. This means that the rail infrastructure, for the same unit of traffic carried in a unit of time, consume less land than road infrastructure (even taking into account the slight gradeability of railway lines).

In total, road, rail and parking infrastructure by 2050 is expected to account for between 250 000 km^2 and 350 000 km^2 of built surface area – or roughly the size of the United Kingdom and Germany, respectively.

5. UIC Low-Carbon Rail Transport Challenge: energy, CO_2 and modal shift targets

UIC, the International Railway Association (240 members worldwide), wants to put forward rail as part of the global solution to climate change and economic growth. UIC has proposed a "Low Carbon Rail Transport Challenge" in the framework of the green growth agenda and climate change perspective for 2030 and 2050. The Challenge is designed to clearly illustrate how increased investment and modal shift to rail can help to secure the 2DS climate change scenario and rich at the same time strong economic benefits.

The Challenge has quantitatively measurable mitigation targets that have been voted unanimously by UIC worldwide members in the UIC General Assembly, held in Paris on June 27th 2014, and presented at the UN Climate Summit on 23 September 2014.

This challenge sets out ambitious but achievable targets for the improvement of rail sector energy efficiency, reductions in greenhouse gas (GHG) emissions and a more sustainable balance between transport modes.

These worldwide voluntary reduction objectives follow what has already been put into practice at the European level by UIC and CER with the "European Rail Sector Sustainable Mobility Strategy" that envisages specific targets for energy efficiency, CO_2 emissions reduction, PM/NOx emissions reduction and noise reduction to be met by the EU railway sector in 2030 and 2050[13].

5.1. Targets for energy consumption and CO_2 emissions

The world railway sector has set for itself ambitious 2030 and 2050 targets for energy consumption and CO_2 emissions:

- Reduction in specific average final energy consumption from train operations:
  - 50% reduction by 2030 (relative to a 1990 baseline)
  - 60% reduction by 2050 (relative to a 1990 baseline)
- Reduction in specific average CO_2 emissions from train operations:
  - 50% reduction by 2030 (relative to a 1990 baseline)
  - 75% reduction by 2050 (relative to a 1990 baseline)

These targets will be achieved by railway companies across the world, in aggregate terms.

5.1.1. Energy intensity target

According to UIC and IEA data elaborations, from 1990 to 2010 there has already been a 33% reduction of energy intensity in railways worldwide.

The progressive alignment of world railways to the standards of more advanced companies would hold considerable improvements of technical and organisational efficiency in the energy field. Even though railways are already enjoying the lowest specific consumption compared to other transport modes, the increasing weight of the energy bill in the budgets of railway companies is creating the conditions for investments in energy efficiency as one of the keys for increasing profitability.

Some railway companies in Europe and in the world have officially published energy efficiency strategies, with targets for 2020 and 2030; and all relevant train operators and infrastructure managers have on-going

[13] European railways committed to a 30% specific CO_2 reduction in 2020 and 50% in 2030, baseline year 1990. The 2020 target has been reached in 2011 already.

projects related to energy recovery from braking, renewal of rolling stock, energy efficient time-tabling, load factor management.

It is realistic to assume that in the near future, the tendency towards reduction of energy intensity noticed for the world railway sector in the 1990-2010 timeframe will continue: this makes the energy intensity targets of the Challenge ambitious, but feasible.

The experience of the UIC *Environment Strategy Reporting System* (ESRS) allows the transfer to a world level of the methodological and organizational structure set up to monitor the European targets, guaranteeing an official, reliable and homogeneous data collection for the global railway sector.

5.1.2. Carbon intensity target

The UIC-IEA elaborations demonstrate that there has been a 29% worldwide reduction of specific emissions for the railway sector between 1990 and 2010. With the expected increase in electrification and improvement of the electric emission factor, the potential improvements are considerable, even more than for energy intensity; this could confirm the assumptions of the IEA 2DS scenario, on which the targets definition is based.

Railways are already featuring the lowest values of emissions per pkm and tkm among all transport modes, thanks to the high rate of electrification. The railway sector can enjoy without any additional investment the improvements generated by the progressive decarbonisation of electricity.

The reduction of carbon intensity will allow the world railway sector to avoid 98 Million tonnes (MT) of CO_2 in the freight sector and 23 MT of CO_2 in the passenger sector, i.e. 121 MT CO_2 in total compared to the 6DS scenario.

5.2. Modal shift challenge

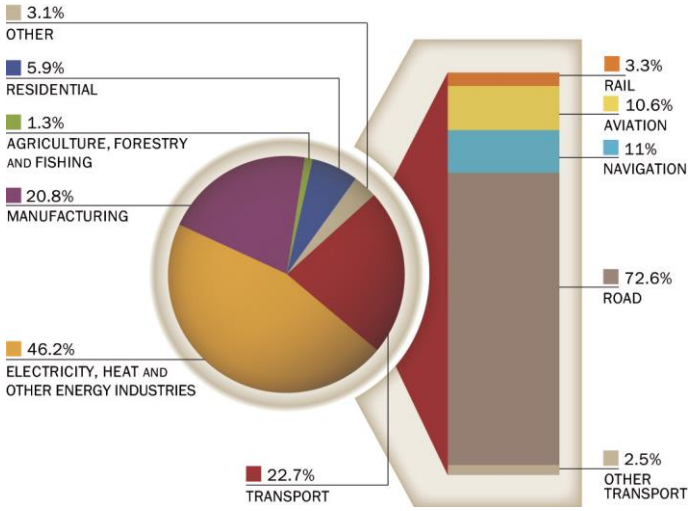
5.2.1. Why a modal shift challenge

On an environmental level, the real challenge of railways is not just to reduce their specific impact on energy consumption or carbon emissions, but to expand their market share. Currently, the energy consumption and CO_2 emissions of railways are substantially lower than other transport modes.

Railways contribute with a very low share (2.2%) to the energy consumption of the transport sector. This share is much lower than the weight of railways in the modal split, thanks to a lower specific consumption compared to other modes.

Similar considerations can be made about greenhouse gas emissions. GHG emissions of the transport sector have doubled from 1970, growing at a stronger pace than other sectors. Around 80% of this growth can be attributed to road transport. Railways only contribute for 3.3% of the transport sector CO_2 emissions.

Fig. 22 Share of CO_2 emissions from fuel combustion by sector, 2011

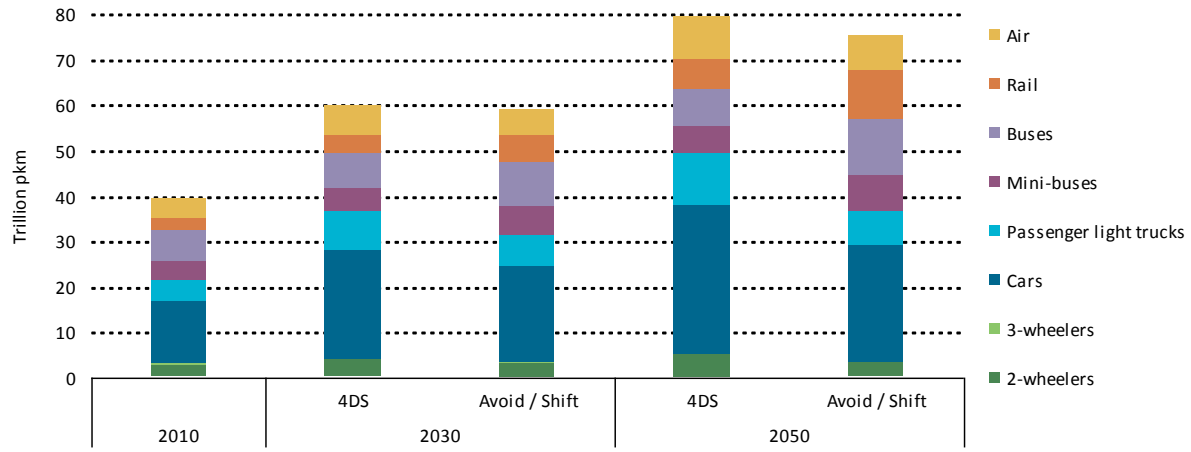


Source: UIC/IEA Railway Handbook on Energy Consumption and CO_2 Emissions (2014 edition)

Analysis by the International Energy Agency (IEA) confirms that only with the combination of the effects of the scenarios *Avoid/Shift* and *Improve* can trigger a reduction in emissions of the transport sector by around 8 $GtCO_{2eq}$ by 2050 compared to the BAU scenario, with a contribution of 1.4 and 6.6 $GtCO_{2eq}$ from the Avoid/Shift and the Improve scenario respectively.

The IEA Avoid/Shift sub-scenario analyses the potential effects of policies oriented to modal shift and to the reduction of transport demand[14]. In the passenger sector, the Avoid and/or Reduce policies are considered to have more significant effects in the long term, while by 2030 the modal shift is expected to have a greater effect on the reduction of the environmental impact of mobility.

Fig. 23 Volumes of passenger traffic and modal share estimated by IEA



Source: IEA 2012

5.3. Target and benefit assessement

The "Modal shift challenge" outlined by UIC does not entail making forecasts or outline a plan.

It means to:

[14] IEA ETP 2012. IEA stresses the important contribution that can come from modal shift particularly in an urban environment, where a higher growth and concentration of population is expected in the next decades.

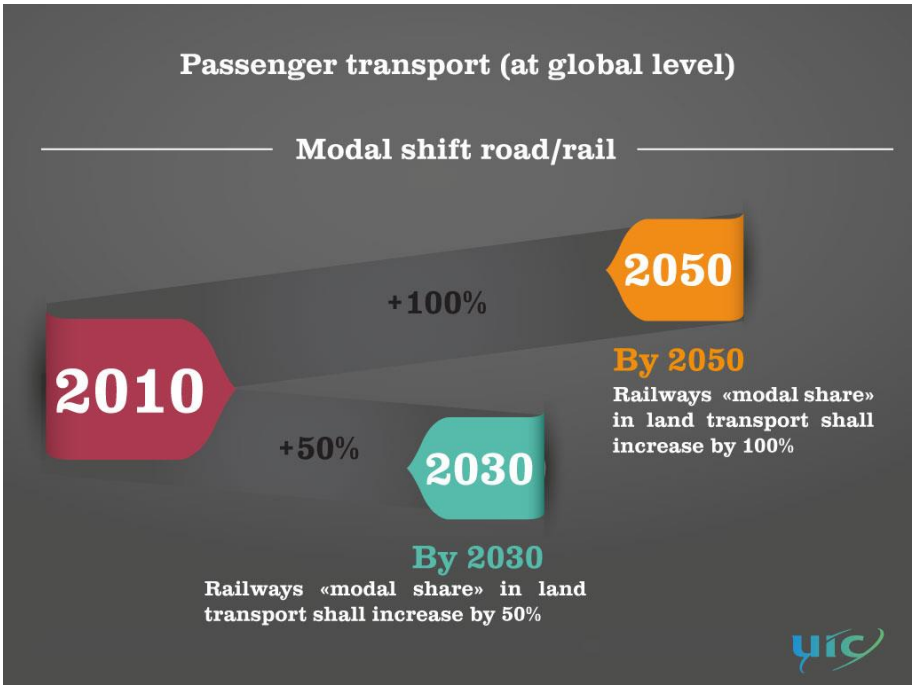
- Define a *challenging* objective
- Commit to reach the objective with the instruments at hand
- Outline the enabling conditions allowing to reach the objective
- Involve key partners and stakeholders

The modal shift challenge is based on the definition of two targets for the railway sector at a worldwide level, both for passenger and for freight transport. The targets are referred to a global scale, i.e. to the whole world railway sector, and are measured respectively in passenger-kilometres (pkm) for passenger transport and tonne-kilometres (tkm) for freight transport.

The targets are based on the estimates produced by the International Energy Agency (IEA) for the transport sector in the definition of the 2DS scenario, used also in the analysis of the Intergovernmental Panel on Climate Change (IPCC) and mentioned in the previous sections.

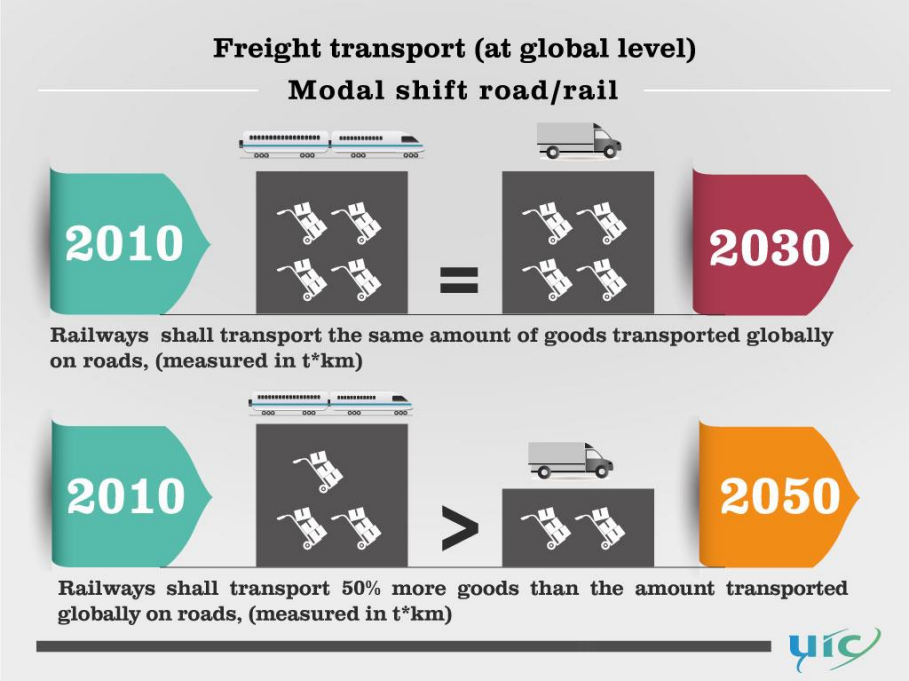
In passenger transport the challenge is to increase the passenger modal share of rail by 50% in 2030 and by 100% in 2050 compared to 2010. The modal share of rail is calculated with respect to all other passenger transport modes, i.e. road, aviation and navigation.

Fig. 24 The modal shift challenge for passenger transport



In freight transport, the challenge is to reach the freight modal share of road in land transport in 2030, and exceed it by 50% in 2050. In this case, the modal share of rail is calculated with the exclusion of navigation and aviation.

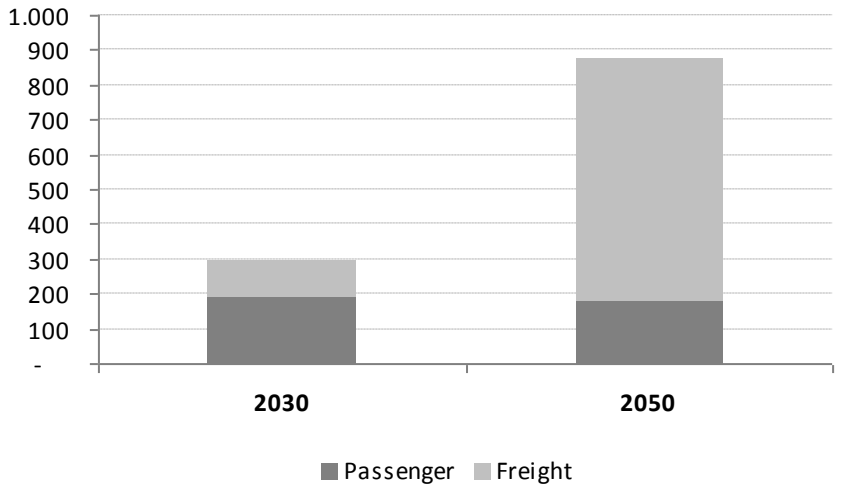
Fig. 25 The modal shift challenge for freight transport (billion tkm)



These targets are ambitious and reachable in view of a development of a Green Economy; they set themselves to be an essential requirement to reach the objective to keep the increase in the average temperature of the planet within the limit of 2°C, in line with the IEA 2DS scenario.

Fig. 26 shows the estimate of CO_2 emissions that can be avoided by reaching the objectives of the "Modal Shift Challenge". To calculate those estimates, the reduced specific consumption and emission targets for 2030 and 2050 has been used for all passengers and freight shifted to rail.

Fig. 26 Modal shift challenge GHG reduction ($MtCO_{2eq}$)



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