Discussion paper issued without formal editing

FOR PARTICIPANTS ONLY
19 November 2014
ENGLISH ONLY

UNITED NATIONS
CENTRE FOR REGIONAL DEVELOPMENT

In collaboration with

Ministry of Environment and Renewable Energy (MERE), Government of Sri Lanka
Ministry of Transport (MOT), Government of Sri Lanka
Ministry of the Environment, Government of Japan, and
Clean Air Asia (CAA)

EIGHTH REGIONAL ENVIRONMENTALLY SUSTAINABLE TRANSPORT (EST) FORUM IN ASIA,
19-21 NOVEMBER, 2014, COLOMBO, SRI LANKA

Expanding Railways – A Vital Means to Meet the Growing Transport Demand in Asia

(Background Paper for Plenary Session 9 of the Provisional Programme)

Final Draft

This background paper has been prepared by Mr. Nicholas Craven, Mr. Raimondo Orsini and Mr. Daniele Arene, for the Eighth Regional EST Forum in Asia. The views expressed herein are those of the author only and do not necessarily reflect the views of the United Nations.

Expanding Railways – A Vital Means to Meet the Growing Transport Demand in Asia

International Union of Railways (UIC)

Authors:

Nicholas Craven,
Raimondo Orsini
Daniele Arene

Date: 14 November 2014

Table of Contents

1 Transport Demand, CO_2 Emissions and Infrastructural Challenges in Asia

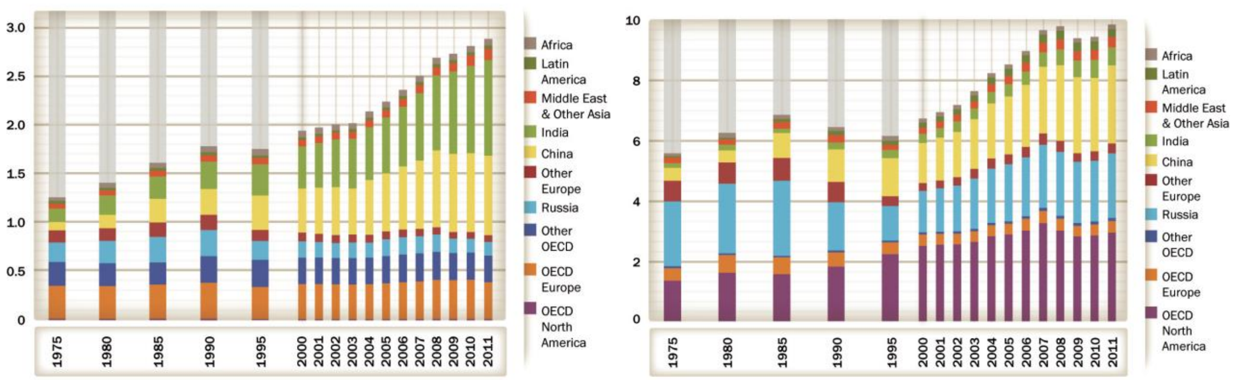
1.1 The growing transport demand in Asia: effects on emissions

There is no question about the growing global relevance of Asia. It is by far the most populated continent, with 60% of the world's population: more than 4 billion people, with an annual growth above 1% (UNDESA, 2013). Asia's gross domestic product (GDP) is reaching the levels of North America and Europe, having grown by more than 5% annually in the last decade (IMF, 2014).

The increase in population and GDP inevitably leads to an expansion in transport demand for passenger and freight services. Whilst transport is a key enabler for development, it has a negative impact on the environment. Rail has the lowest environmental impact of any major transport mode, considering carbon emissions, air quality & land use.

UIC, in collaboration with the International Energy Agency (IEA), publishes every year a *Railway Handbook on Energy Consumption and CO_2 Emissions*, which also contains data on transport demand in several countries and regions of the world. The latest edition (IEA/UIC, 2014) shows (see Fig. 1-1) that rail passenger transport in Asia (in pkm) represented nearly two-thirds of the global rail passenger transport in 2011; rail also transported nearly 36% of global freight (in tkm). Both rail passenger and freight transport doubled between 2000 and 2011.

Fig. 1-1: Railway transport activity by geographic area, 1975-2011. Left: passenger (pkm), right: freight (tkm)



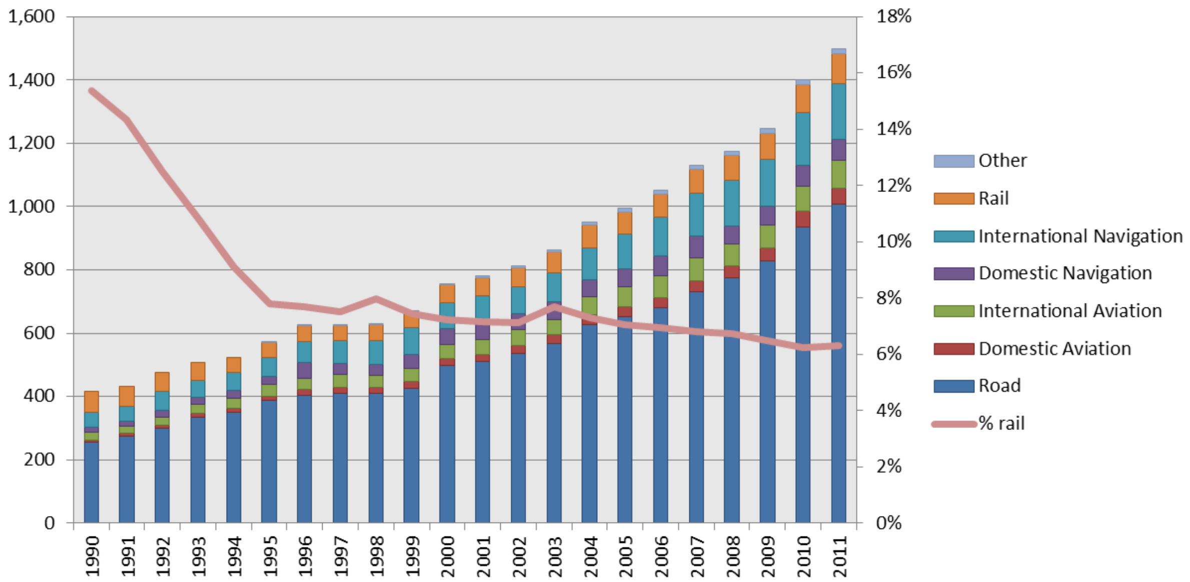
Source: IEA/UIC (2014)

The picture looks even stronger when taking Russian Federation into account: Asia and Russian Federation together made 71% of world rail passenger traffic and 57% of world rail freight traffic in 2011.

Future projections present Asia as one of the regions where growth will be more significant. According to the IPCC WG3 AR5 scenario (IPCC 2014), transport demand – for both passenger and freight – will grow in the next decades until 2050 with most of this growth happening in emerging countries, as a result of higher rates of income and population growth. All scenarios analysed by IPCC show how, due to a strong correlation between passenger mobility and disposable income, **the highest rate of growth will be in non-OECD countries and Asia in particular**. IPCC estimates that freight demand grows with lower rates than passenger demand, with a decoupling between demand growth and GDP forecasted to happen earlier in the passenger sector.

IEA (2012), in the climate change 6 degrees (6DS) and 4 degrees (4DS) scenarios[1], conjectures that the global passenger demand, in a business-as-usual (BAU) perspective, will double between 2010 (baseline) and 2050, with an average rate of 19.3% in 10 years. In the Avoid/Shift (2DS) scenario, where some measures to slow the demand growth are evaluated, the 10-year growth rate is reduced to 17.6%. The IEA assumes that passenger demand will rapidly increase, in particular in non-OECD countries, because of multiple factors: among those, the forecasted growth in population and income. The global growth will be partially mitigated by the stabilization of transport demand in OECD countries. In a BAU scenario, the forecasted growth rates of freight transport demand is not lower than passenger transport demand growth rates, while in the Avoid/Shift scenario the 10-year growth rate goes from 19.5% (BAU) to 16.7%.

Fig. 1-2: Total emissions from different modes of transport in Asia (million tonnes CO_2 – left) and share of rail over total (% - right), 1990-2011



Source: Elaboration from IEA (2013a), IEA (2013b), IEA (2008), IPCC (2006)

Transport in Asia makes for 10% of total CO_2 emissions (IEA, 2013a). As seen in Fig. 1-2, **total emissions from transport in Asia have increased almost fourfold from 1990 to 2011**.

In the same timeframe**,** emissions from railways (for all tractions: steam, diesel and electric) have been halved, dropping from nearly 16% of total transport emissions to about 6%. This makes railways one of the most sustainable modes of transport in Asia, managing to satisfy an increasing demand and at the same time lowering its emissions.

This success is due at least in part to the transition from steam traction to more efficient types of traction, such as diesel and electric traction. In 1990 the energy consumption from steam traction was more than three-quarters the total energy consumption of railways in Asia; now, this share is down to 19% (and an even lower percentage of rail activity due to its relative inefficiency). There is still quite a long way to go to reach coal-free railways (especially for People's Republic of China, for which more than a quarter of the energy is consumed by coal-powered trains), but the direction is clearly set.

[1] The IEA has defined three scenarios at a world level, which have been declined sector by sector. Those scenarios (called 6DS, 4DS and 2DS) are referred to the potential increase of average world temperature in 2050: 6, 4 and 2 degrees Celsius.

IEA projections show that **CO_2 emissions from the whole transport sector in India and People's Republic of China will grow** significantly in the next decades (see Fig. 1-3 and Fig. 1-4).

Fig. 1-3: Total passenger transport CO_{2eq} emissions evolution in India for 2DS and 4DS scenario

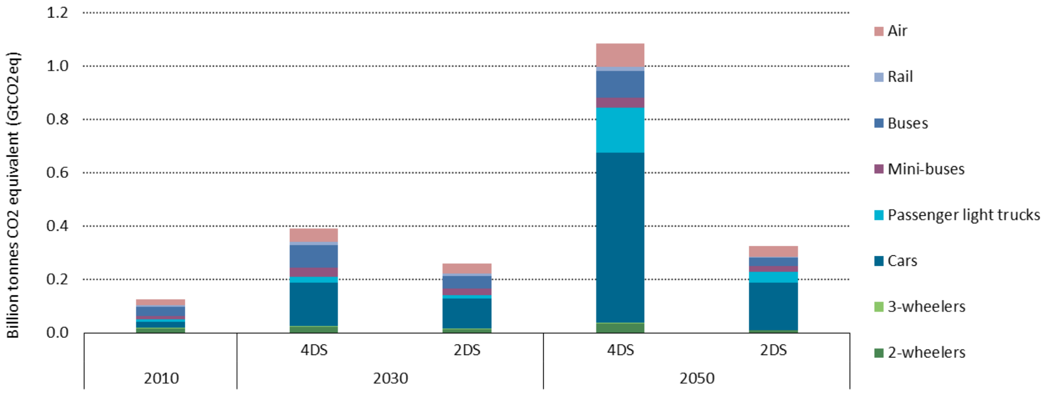
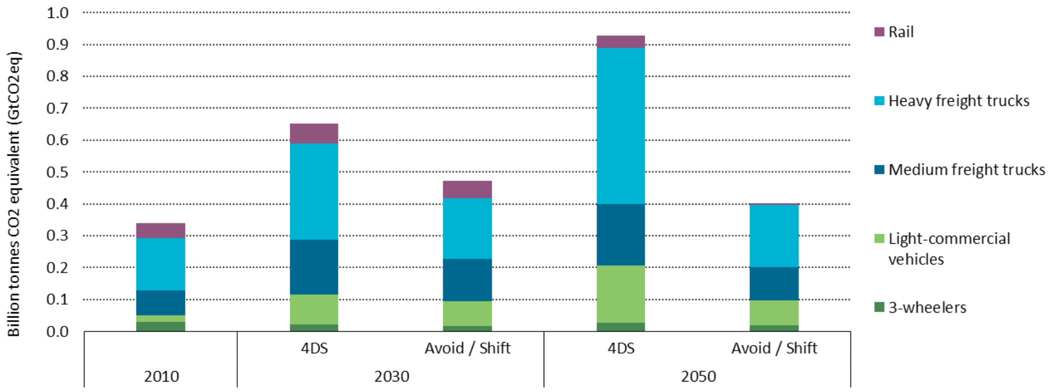


Fig. 1-4: Total freight transport CO_{2eq} emissions evolution in People's Republic of China for 2DS and 4DS scenario

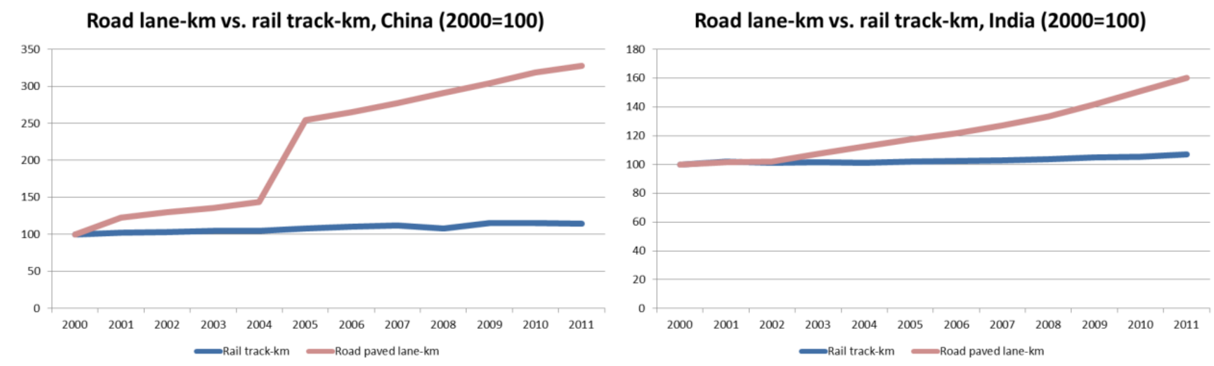


Source: IEA (2014)

1.1.1 Road and rail in Asia

Investment in new rail infrastructure over the past years does not match the forecast increase in demand for transport across the Asian region. Whilst there has been a modest increase in the length of the rail network, this is overshadowed by a much larger increase in the size of the road network. As can be seen in Fig. 1-5, People's Republic of China has more than tripled the amount of paved roads (in lane-km) from 2000 to 2011; India has also increased its road network by 60% in the same timeframe. Meanwhile, the rail network has only grown very little (14% in the case of People's Republic of China, 7% in the case of India).

Fig. 1-5: Road paved lane-km and rail track-km in People's Republic of China and India, 2000-2011 (2000=100)



Source: Elaboration based on IEA/UIC (2014)

It is clear that **infrastructural choices have been heavily imbalanced in favour of road construction**, as UNESCAP (2013a) data shows: the total investments in road in Asia (new infrastructure and maintenance) is estimated at 332 billion USD, while the total investments in rail are estimated at 17 billion USD (about one-twentieth the amount for road). In all likelihood, this behaviour is maybe due to the fact that road constructions *may appear* cheaper (per kilometre of infrastructure built): IEA (2013c) estimates that the construction cost of a lane-km of road in Asia (excluding operation, maintenance and reconstruction/upgrade) is between 1 and 1.2 million USD. The construction cost for a track-km of rail is about four times higher.

This "advantage" of road over rail is superficial, as is shown later in section 2.1: for instance, the higher capacity of rail is not taken into account, nor is the fact that the vehicles circulating on a stretch of road have a higher environmental impact than trains. However, policymakers often have short timespans and prefer to spend less and obtain larger numbers of kms of infrastructure built which are easier to communicate.

In the long run, nonetheless, **a policy that favours road at the detriment of rail is destined to be not sustainable.** Given the long term nature of transport infrastructure there is a risk that these investments will lock in unsustainable patterns of transport activity for years to come.

IEA (2013c) projected the roadway occupancy levels[2] of several regions to 2030 and 2050. As the IEA says, "roadway travel is expected to outpace infrastructure additions". In fact, to maintain the current road occupancy, "[for] the next 30 years, People's Republic of China would need to continue to build at maximum capacities (roughly 350 000 lane-km per year) and India would need to ramp up construction rates (roughly 200 000 paved lane-km per year)".

A cost which is seldom considered when making estimates for new infrastructure is parking space. Since most passenger vehicles sit idly in parking most of the time, an increase in road demand inevitably requires additional parking space. In the 4DS scenario, global parking needs increase from 30 000 km^2 in 2010 to 80 000 km^2 in 2050. Under the 2DS scenario, the space needed for parking is reduced by about 27 000 km^2 worldwide, with global savings reaching 250 billion USD a year in parking construction, operation and

[2] Occupancy levels are defined as "travel per infrastructural kilometre". In the case of road, it is the number of vehicle-kilometres passing through one lane-kilometre of paved road.

maintenance (and further savings in environmental impact due to reduced land take). About half of the space needed will be in Asia, and therefore about half of the savings could be made in the continent.

The 2DS scenario, which generates so many savings in road infrastructure expenditures (and incidentally allows for a world temperature increase of only 2 degrees) calls in fact for *Avoid* and *Shift* strategies in the transport sector. On one hand, travel should be avoided where possible (e.g. by using videoconferencing for meetings); on the other hand, where necessary travel (both passenger and freight) should be shifted to more sustainable modes of transport, such as rail or non-motorised transport (bicycle or foot). Thus, a substantial portion of passengers and freight will use rail instead of road.

An increased effort in the construction of new rail infrastructure is therefore needed: the 2DS scenario calls for 200 000 more track-km than in the 4DS (or business-as-usual) scenario. However, the additional expenditures to reach this effort would be 35 billion USD globally, just 10% of what is saved in the avoided construction of roads (and disregarding the 250 billion saved in parking expenditures).

As seen before, the construction of railway infrastructures calls for a more systemic and coordinated endeavour, which is nevertheless necessary to face the inevitable issues that will arise in the coming years if the transport demand is allowed to grow unchecked.

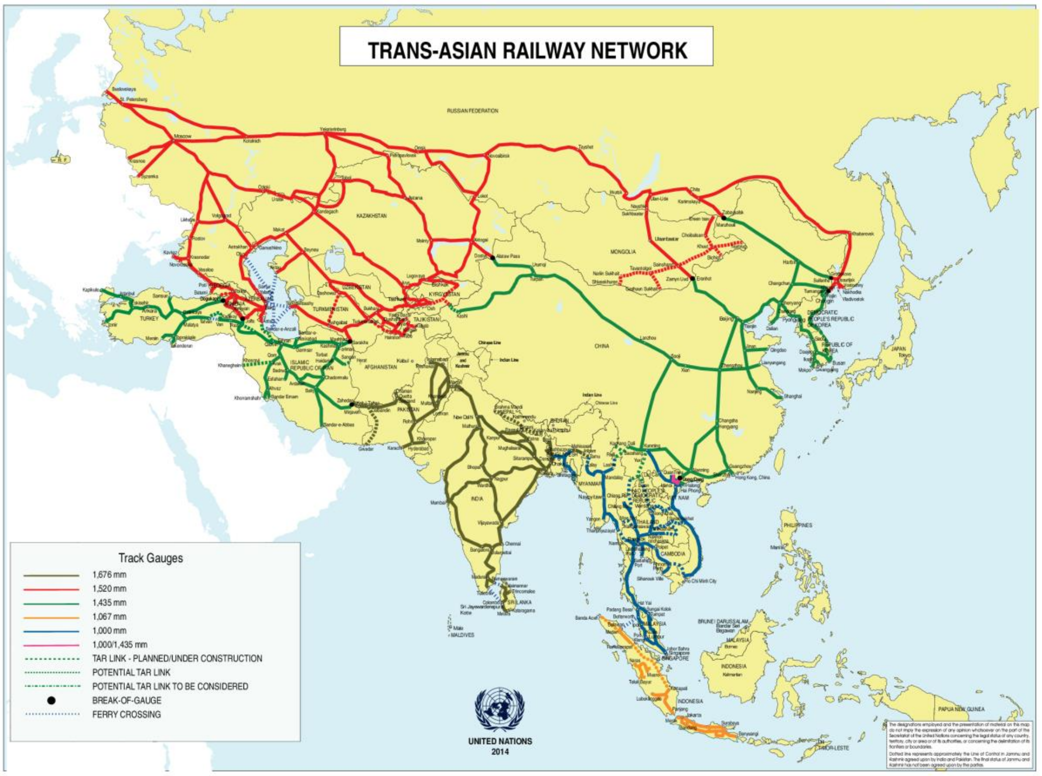
1.1.2 The state of rail infrastructure in Asia

Despite being the largest and the most populated continent on Earth, Asia only contains 22% of the world's railway lines (30% when including the whole of Russian Federation). About 35% of the region's overall route length is electrified. Asian railway tracks have grown by 8% from 2000 to 2011, in opposite trend with the rest of the world (globally, the kilometres of railway tracks have decreased by 1% in that period). Nonetheless, there is still a huge potential for development of the railway infrastructure throughout the continent. For instance, the average track density per 1 million inhabitants in Asia (not including Russian Federation) is 72 kilometres; in Europe (including Russian Federation), track density is 662 kilometres per 1 million inhabitants.

The main initiative being developed to facilitate rail communication in Asia is the Trans-Asian Railway (TAR), an integrated railway network comprising 117 500 km of line and serving 28 Asian countries[3]. The project is promoted by UNESCAP, The United Nations Economic and Social Commission for Asia and the Pacific: the map of the TAR network is shown in Fig. 1-6.

[3] http://www.unescap.org/our-work/transport/trans-asian-railway/about (accessed October 20, 2014)

Fig. 1-6: Map of the Trans-Asian Railway Network



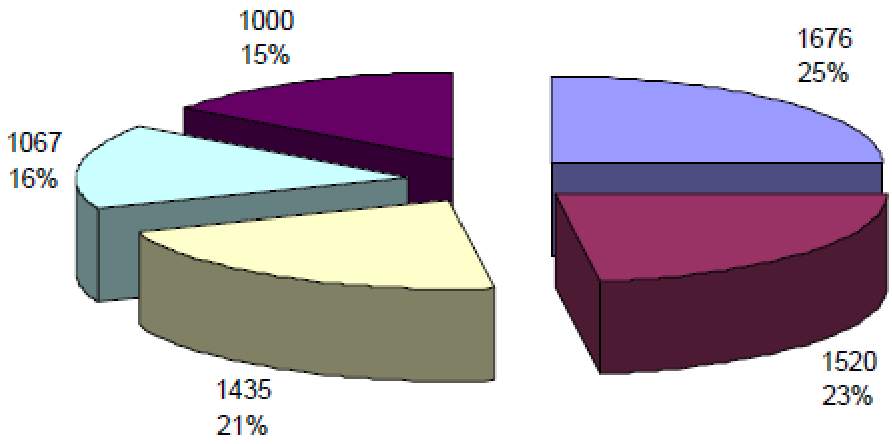
Source: UNESCAP

The TAR network has several missing links that still need to be built and lines that need to be upgraded in order to connect different networks and make rail a more viable option for passenger and freight transport. There are multiple initiatives throughout the continent aiming to strengthen the international Asian railway infrastructure: for example the Economic Cooperation Organisation (ECO) rail corridors that connect Turkey to Iran and Central Asia, or the OSJD corridors that go from Eastern Europe to People's Republic of China, Mongolia and Vietnam. Some countries have very little useable infrastructure, such as the Lao PDR which has almost no railway infrastructure to speak of.

Furthermore, due to historical reasons, there are five different track gauges used in the railway lines which are part of the TAR network: and none of them are so dominant that it would make sense to convert the rest of the infrastructure (see Fig. 1-7). This produces the *break of gauge* issue: crossings – typically at international borders – where the track gauge changes, so the trains cannot go on without additional operations such as the transfer of goods and passengers to a different train or a bogie change of the train itself[4]. All these operations need time, and thus reduce the efficiency of international rail transport.

[4] A *bogie change* means that the train is equipped with a new set of wheels for the different track gauge. Some trains are fitted with *variable gauge axles* and can cross breaks of gauge almost without interruptions; however, these types of rolling stock are seldom used on Asian railways.

Fig. 1-7: Distribution of rail track gauge over the Trans-Asian Railway Network



Source: UNESCAP (2013b)

Some other issues are more operational and commercial, and need to be dealt with by railway undertakings, which can offer trainings and access to best practices that can help railways to practice commercial policies that gain the acceptance of shippers, and to have qualified personnel that can operate the infrastructure at the highest level. Other issues yet are more technical/economical: up-to-date railway technology such as train control systems by radio communication, asset management, and energy management for smart grid can be effective and helpful in terms of life cycle cost, comfort, reliability and safety.

The electrification of the network is another great option for development. Only about one-third of the lines are currently electrified, and Asia's demand for oil is much higher than the region's production. A possible consequence is therefore that the future energy bill may have a huge impact on the cost of transportation in general, as well as a direct impact on railway transportation operated on non-electrified lines. An increase in electrification, together with new initiatives to obtain electricity from renewable and other sources[5], would increase the energy security of the region and at the same time improve the environmental impact of railways (and transport in general). The electrified rail system is the only major transport system that is immediately compatible with renewable energy and can in fact use any source of energy.

2 Sustainable Transport Policy Options

2.1 The Higher Sustainability of Rail as a Land Transport

Rail is often quoted as one of the most sustainable means of transportation. From a CO_2 emissions point of view, it can be seen that railways worldwide emit only 3.3% of the total transport sector CO_2 emissions, while having a modal share of 9.3%. In contrast, road is responsible for 72.6% of worldwide emissions and

[5] Currently, the electricity mix of many Asian countries is very much dependent on non-renewable sources. Over the continent, most of electricity is generated with coal (nearly 70%). Only 17% of electricity is generated from renewable sources (mainly hydroelectric).

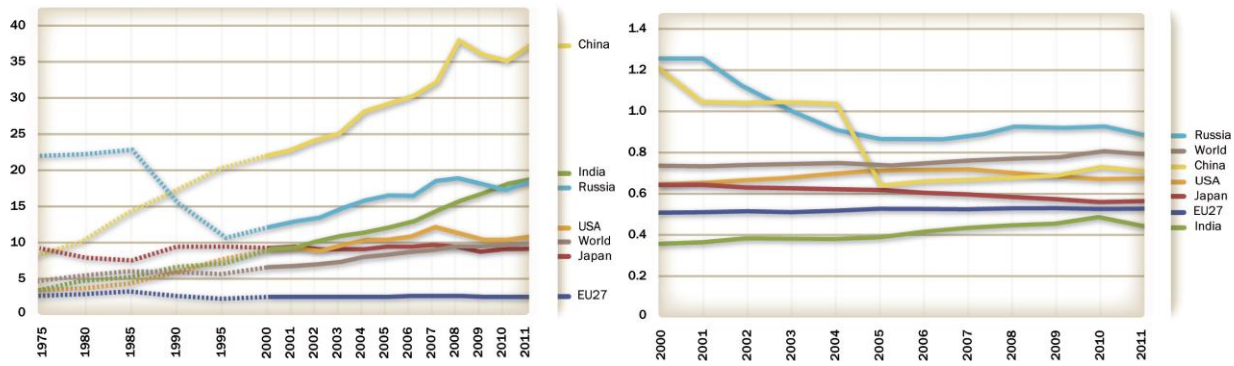
has a modal share of 34.8% (IEA/UIC, 2014)[6]. Due to the high capacity, energy efficiency and electrification, rail can also reduce air pollution in urban areas. In rural areas the reduced land take compared to roads results in improved biodiversity with reduced fragmentation of natural habitats.

Investing in rail infrastructure means to support an all-round more sustainable and more efficient mode of transport than road.

2.1.1 Higher occupancy

Railways have a much higher occupancy level than road; that is to say, 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. 2-1). In India and People's Republic of China railways transport at least 40 times more transport units than road per km of infrastructure. Furthermore, while road occupancy has been stable since 2000, it has grown by 50% for rail worldwide (70% in People's Republic of China and nearly doubled in India).

Fig. 2-1: 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: IEA/UIC (2014)

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.

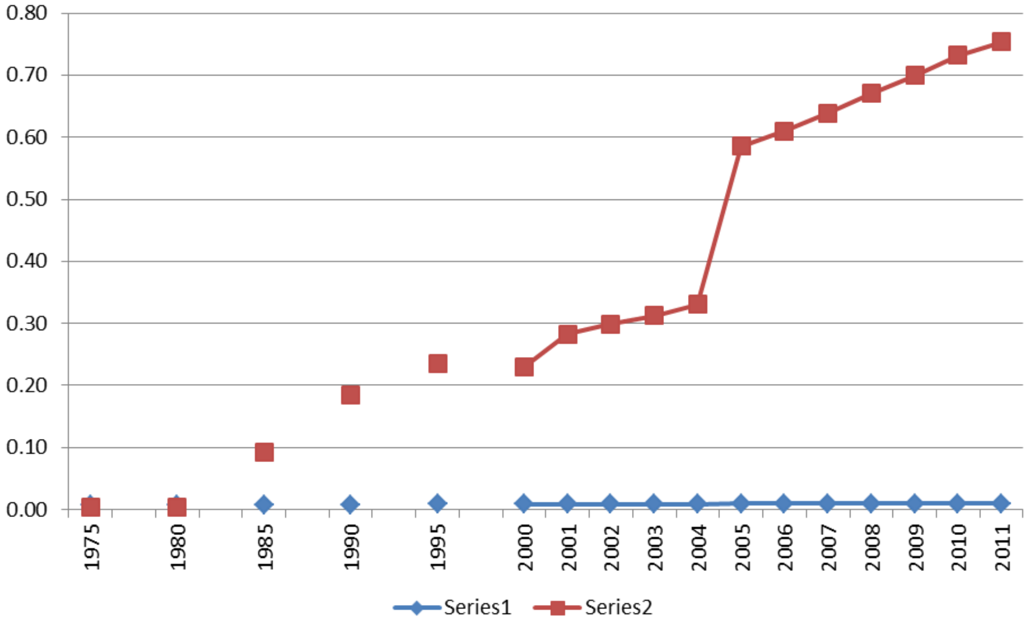
2.1.2 Lower land use

Land use is a critical concern, especially in densely populated areas. The land used to build transport infrastructures 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. Fig. 2-2 shows that the amount of land used by road infrastructures in People's Republic of China is 79 times higher than the amount of land used by railway infrastructures.

---

[6] These calculations include indirect emissions caused by the production of electricity used in rail traction.

Fig. 2-2: Evolution of paved roads and railway tracks land use in People's Republic of China 1975-2011 (paved lane-km or rail track-km per km² of land)



Source: IEA/UIC (2014)

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 People's Republic of 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 People's Republic of China respectively.

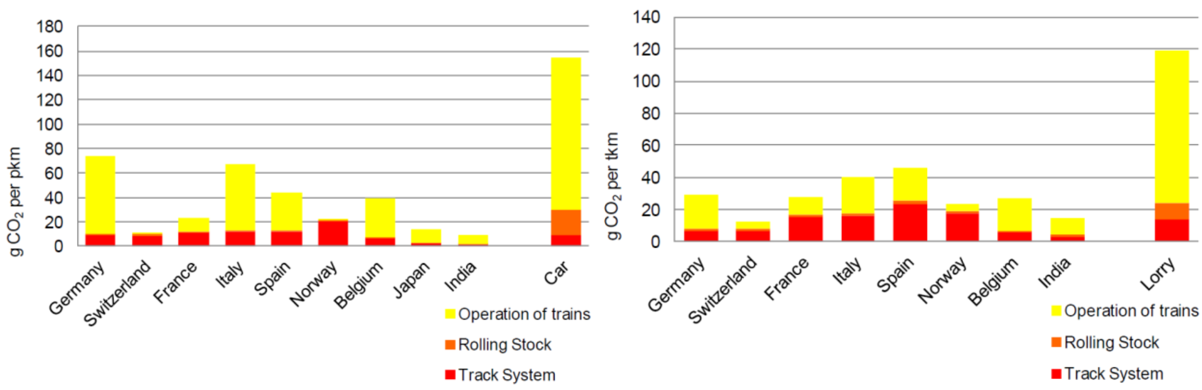
This happens in the context of a modal split indicating that globally road activity (in transport units) is barely 3.5 times higher than rail demand. In People's Republic of China, road activity is in fact less than double rail activity, with a land use 79 times higher.

2.1.3 Lower carbon footprint of infrastructure

It has been shown in section 1.1 that railways have low CO_2 emissions. Those emissions are only related to train operations and do not include the construction of rail infrastructure (e.g. stations, tracks, railroad yards) or of rolling stock (locomotives, railcars etc). A natural question would be whether the total carbon footprint of railway infrastructure is in fact lower than the carbon footprint of road infrastructure, which would include the operation of the vehicles but also the construction of roads and the vehicles themselves.

A research commissioned in 2011 by UIC (Tuchschmid 2011) has studied exactly this issue, defining a methodology and calculating the carbon footprint for several countries (among which India and Japan). The result is that even though the construction of rail infrastructure has a considerable impact on the footprint, the environmental advantage of railways compared to road is kept both in passenger and freight transport (see Fig. 2-3).

Fig. 2-3: Carbon Footprint of passenger and freight rail transport in selected countries

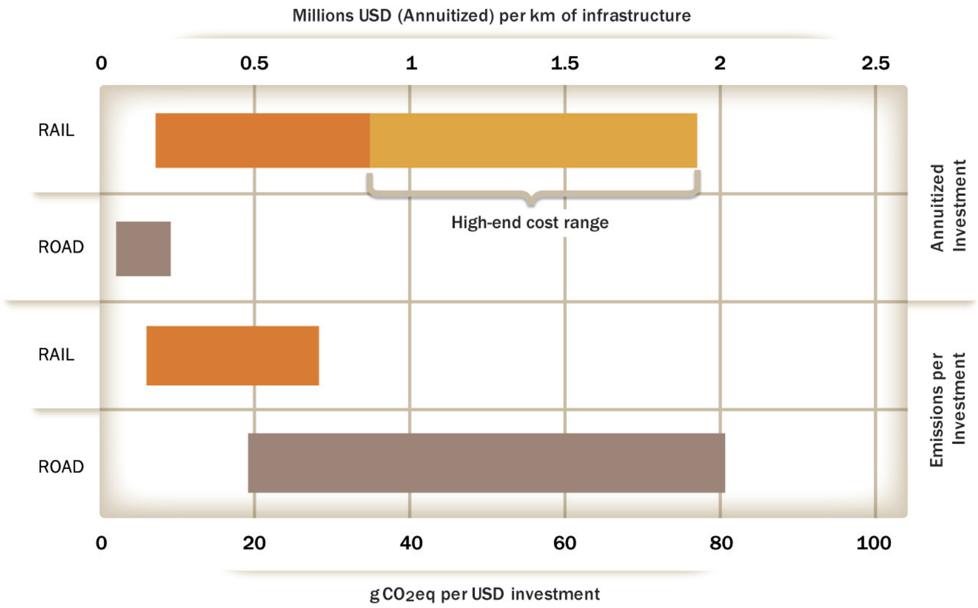


Source: Tuchschmid (2011)

2.1.4 Lower emissions per investment

It could be said that even if the carbon footprint of passenger and freight rail transport (infrastructure included) is lower than the carbon footprint of road transport, it is still more expensive. While this is true, IEA estimates show (see Fig. 2-4) that each dollar spent in road infrastructure gives rise to road activities which generate from 3 to 14 times more CO_2 than what would be generated by rail activities if that dollar was spent in rail infrastructure.

Fig. 2-4: Estimate of annuitized investments (top) and emissions per investment (bottom) for road and rail

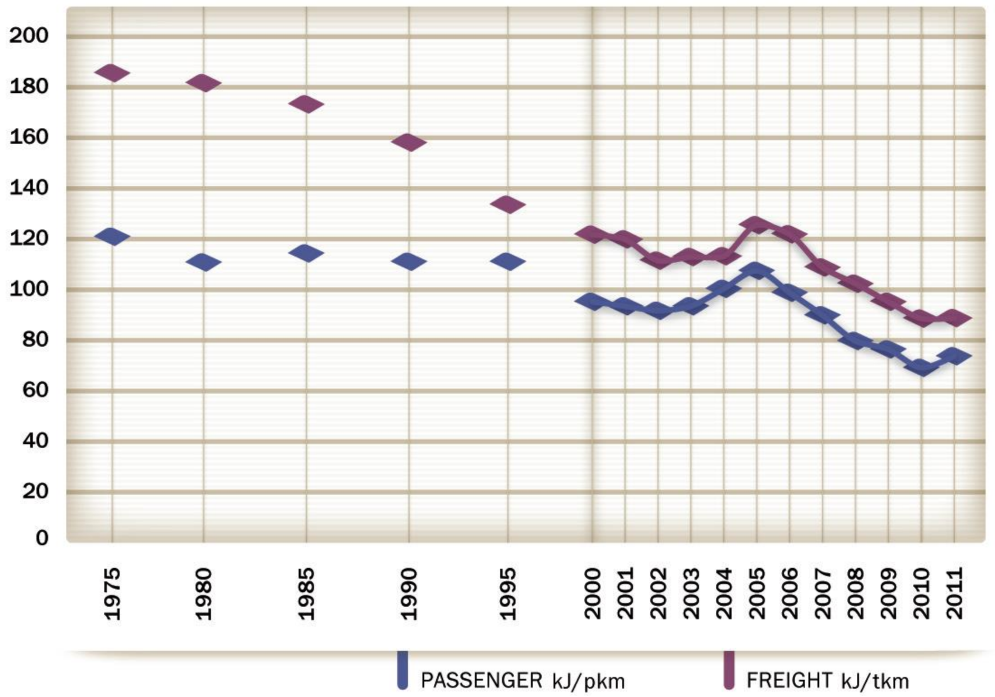


Source: IEA/UIC (2014)

2.1.5 Higher energy efficiency

Railways are arguably much more energy efficient than other modes of transport, and they are improving: as can be seen from Fig. 2-5, the specific energy consumption in India has decreased by 40% for passenger and by 53% for freight transport.

Fig. 2-5 Railway specific energy consumption in India,1975-2011

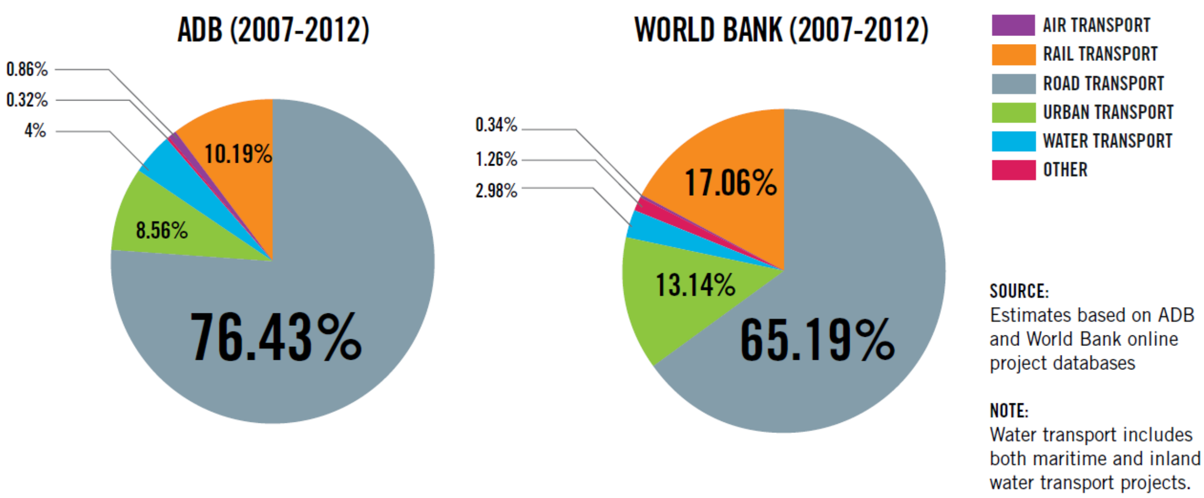


Source: IEA/UIC (2014)

2.2 Policy opportunities

As previously said the investment on rail projects in Asia is still very much unbalanced towards rail transport. As UNESCAP (2013a) shows (see Fig. 2-6), more than 76% of the Asian Development Bank's investment in transport is spent on road projects, and only 10% on rail. The World Bank is only slightly more focused on rail, with 17% of its spending compared to 65% spent on road.

Fig. 2-6: Modal split of Asian Development Bank (ADB) and World Bank (WB) investment in transport, 2007-2012



Source: UNESCAP (2013a)

As shown in the previous sections, investments in rail are more sustainable – from many points of view – than investments in road. Therefore, a modal shift from road to rail presupposes an investment shift from road to rail projects. This can be done for instance through investments in new rail projects (in particular urban rail services and freight corridors), investments in existing rail infrastructure (e.g. electrification of the infrastructure and removal of bottlenecks), internalisation of external costs (e.g. via road pricing), providing the right environment for private finance, smart land use, planning to support stations as intermodal hubs.

There is some scope to increase the research capacity at Universities and other institutions to a level similar to that which currently exists in Europe and other regions. This would improve qualitative documentation on the basic activities carried out by railways within the region and support a better informed and more strategic approach to developing the rail sector.

2.2.1 Competitiveness of rail versus other modes

There are technical and economic factors – always in evolution – that determine the market segments in which railways can out-compete 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 mobility segment.

Currently, with reference to the experiences collected in different geographic areas and railway systems, the greater potential of rail can be observed where it has the technical means to compete for significant market shares with other modes of transport:

- In passenger service:
    - Commuter rail vs. private car;
    - High-speed train vs. plane;
    - Medium-long range rail (high-speed included) vs. private car;
- In freight service:
    - Freight rail vs. trucks;
    - Freight rail vs. cargo ships.

A reduction in the environmental impact of transport can be realised where rail wins this competition.

Local/urban mobility: commuter rail vs. private car

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 train can be chosen 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.

Medium-long range mobility: high-speed train vs. plane

In countries that have invested in High-Speed Rail (HSR), e.g. Japan, People's Republic of China & Republic of Korea, several studies have shown how its introduction has taken a large number of passengers away from airlines. HSR is definitely faster and cheaper than a plane when travel time is lower than 2 hours, and normally has a dominant market share (>90%). When the train travel time is more than 4 hours, the plane is faster than the train and has the majority of the market share. When train travel time is between 2 and 4 hours, the competition between rail and aviation is very strong.

Medium-long range mobility: intercity train (including HSR) vs. private car

Both High-Speed Rail and Intercity[7] can compete with the car in the movements above a certain distance. 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 Japan where well-performing Intercity services on some routes engender modal shares for rail well above the modal shares for road, even though the network of roads and highways is extremely developed and the rate of penetration for private cars is much higher than the world average.

There is a very strong correlation between the modal split between rail and road and the travel time needed for each mode: thus, fast railway networks with frequent connections out-compete road transport. The conditions most favourable to this are high population density with an equally high density of railway capacity and demand.

Medium-long range mobility: freight train vs. truck

Railway freight traffic is a strategic transport system and plans to keep such a position. In Russian Federation, railway transports nearly 90% of freight, thanks to the rail infrastructure which is well developed and in better state than the road system. In People's Republic of China and India, rail freight has doubled from 2000 to 2011.

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 distance: 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, 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.

Medium-long range mobility: freight rail vs. cargo ships

For very long distances, freight transport through ships can be more efficient than rail. However, rail freight can be competitive with navigation when it can significantly reduce the distance travelled by the goods. This is the case of the Trans-Asian rail network that connects the markets of People's Republic of China, India and Europe, or the Dedicated Freight Corridor that connects the west coast and the east coast of India.

2.2.2 The opportunity of inter-modality

Inter-modal integration for freight is one of the opportunities that would increase the importance of the role that railways have in Asia. As mentioned above, railway can be competitive with road transport over

[7] Generally speaking, Intercity trains connect stations of different cities with a high demand. They differ from local/regional trains on price, commercial speed and fleet used. Depending on railway systems, the distance between terminal stations can vary, as well as the distance between stops (which is usually larger than for local/regional trains).

mid-range distances to transport freight that has arrived by ship. Normally, for distributing the goods over shorter distances (e.g. first & last mile) road freight is more viable.

For the ship-rail inter-modality, it makes sense to spend some efforts on specific infrastructures and layouts for ports that facilitate the loading and unloading of container trains from ships: currently, most Asian ports do not have ideal infrastructure. For rail-road inter-modality, "dry ports" are an on-going trend, offering all the services of a port and facilitating the transfer of goods between rail and road. Companies can open logistic centres in dry ports, thereby taking advantage of the availability of cheap and fast long-range railway transport and limiting road transport to local distribution. Several dry ports are being developed in the Asian region, from Republic of Korea to Uzbekistan.

2.2.3 Two good examples of modal shift investments

The Indian Dedicated Freight Corridor (DFC)

The Indian Dedicated Freight Corridor (DFC) is a set of planned rail infrastructure projects which will cross the Indian subcontinent from East to West and from North to South, in the so-called "Golden Quadrilateral" (Mumbai-Delhi-Kolkata-Chennai) and provide dedicated freight links to connect the largest cities in India. The goal is to strengthen the current lines, which are saturated (the capacity utilisation is higher than 115%). To build the DFC, India has established a special company, the Dedicated Freight Corridor Corporation of India (DFCCIL), under the control of the Ministry of Railways.

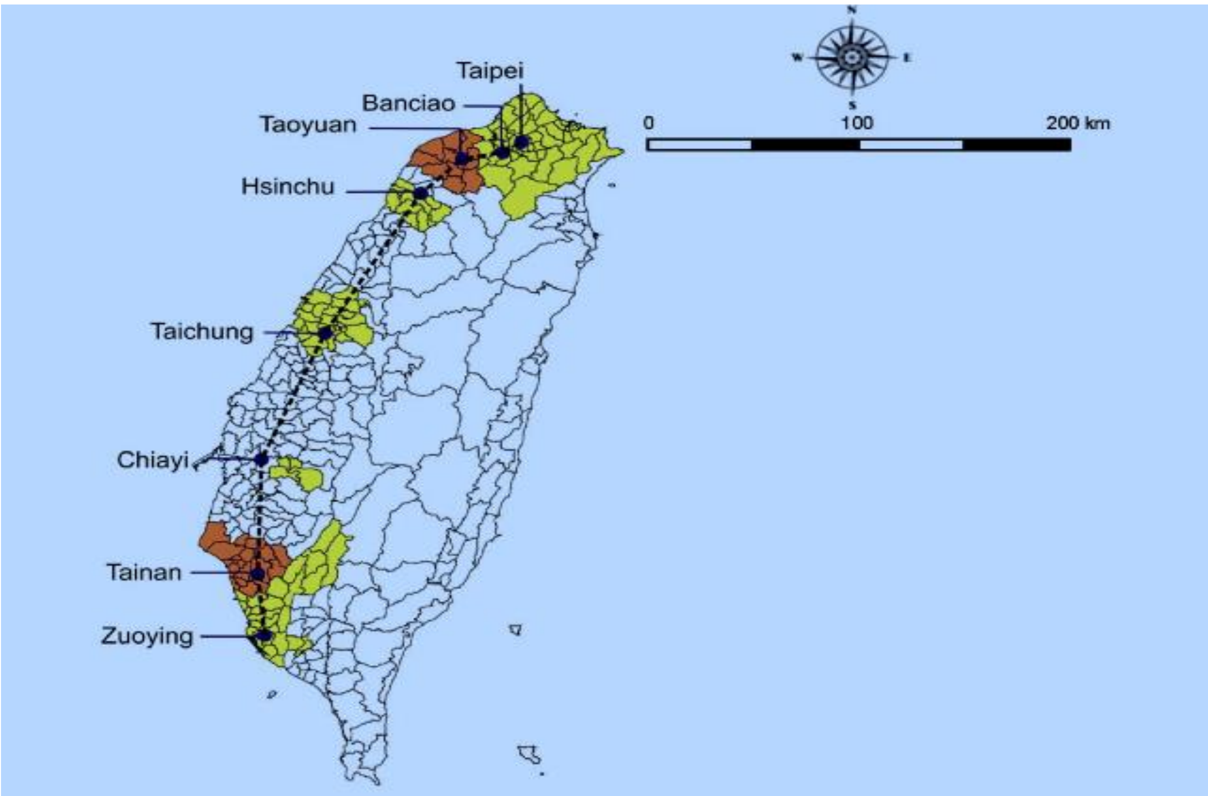
The first part of the project is the construction of two dedicated freight corridors, the Western DFC and the Eastern DFC. The first (1 839 km) will connect Mumbai and Delhi, while the second (1 499 km) will connect Delhi and Kolkata. Most of the line will run parallel with the existing infrastructure and be double-track.

The two corridors are currently under construction. The cost for the completion of the project (forecasted by 2017-2018) is estimated at Rs. 80,000 crore (i.e. around 10.5 billion Euros or 13 billion U.S. Dollars). The funding for the Western corridor comes entirely from a loan provided by the Government of Japan, while the Eastern corridor is funded in part directly by the Indian Ministry of Railways, in part with an IBRD loan and in part through public-private partnerships.

The DFCCIL has commissioned to Ernst&Young a study (E&Y 2011) to assess the greenhouse gas reduction potential of the construction of the Western and Eastern freight corridors. The study estimates a cumulative emission reduction (in the 25-year period between 2016-17 and 2041-42) of 60% for the Eastern corridor, and about 83% less emissions in the Western corridor (for a total reduction of 457 million tonnes of CO_2, or 79%). The DFC will allow to shift 474 billion tonnes annually of freight from rail to road initially, gradually increasing to 1 367 billion tonnes annually by 2041.

A study by UNEP (2012) also estimates the projected CO_2 emission reductions for the construction of the six DFCs. In a "business-as-usual" scenario, the construction of the DFCs would remove 77% of the CO_2 emissions from the atmosphere; in a "low-carbon" scenario (which assumes that some strong policies to reach only a 2°C increase of global temperature in 2100), the reduction would be up to 93%.

<u>**HSR from Taipei-to Kaohsiung, People's Republic of China**</u>



The recently built HSR line between Taipei and -to Kaohsiung in People's Republic of China, represents a notable example of successful modal shift from air and road to rail.

The project consisted in a 345 km of high-speed rail, connecting eight major cities along the densely populated west corridor between Taipei and Kaohsiung: ten new stations, with a large number of new bridges, tunnels and viaducts, so as to avoid conflicts with other forms of transport wherever possible.

Efforts were put in trying to minimize impacts on the environment by including a series of dedicated crossing for use by animals and safety at high speeds was ensured by avoiding earthquake faults and soft ground as much as possible along the HSR route.

The project investment cost was large: around 15 Billion dollars. The first plans for a high-speed rail line able to provide a quick connection between the island's two major cities were already drawn up in the early 1990s, once financing had been agreed construction commenced in the year 2000. The financing solution was found in 1998 with a 35-year concession agreement signed with the Taiwan High Speed Rail Corporation (THSRC), who completely funded the project. This project represents one of the largest privately-funded rail construction projects in the world.

Before the construction of the new line, the rail transport on the island consisted of an extensive network of 2 615 km with 216 stations connecting small and remote towns and cities, but no fast direct rail connections between the eight major cities of the west corridor were available.

With the journey time between Taipei and Kaohsiung being of about 4 hours and half via conventional rail, the business and private transport demand in the west corridor was satisfied mainly via domestic flights, express and intercity buses and private cars, causing a constant increase of traffic congestion.

The development of the HSR has deeply revolutionized the way people live and work, greatly expanding overall accessibility along the western urban corridor.

One-way travel times between the Taipei and Kaohsiung metropolitan areas have been cut to 90 minutes. From Tainan HSR Station, it is possible to reach Kaohsiung–Zuoying in 17 min, Chiayi in 19 min and Taichung in 43 min. All these time distances are below the critical 50-min one-way threshold, after which commuting frequencies tend normally to drop.

During the period going from January 2007 to December 2012 the amount of domestic flights serving the west coast declined dramatically by 44%. Express buses rides and private car rides also decreased significantly.

According to several analysis on the line, it can be said that HSR has practically supplanted air travel as a means of traversing the island, leading to a redistribution of the share in the long-distance travel market.

Faster times associated to cheaper fares of the HSR compared to domestic flight markets have been identified as determining factor of the success of the HS line vs. domestic air travel.

2.3 The UIC Green Growth Agenda and Low Carbon Rail Transport Challenge

The previous section showed how adopting the IEA 2DS scenario in the transport sector would be a solution both from an environmental point of view and for the sustainability of infrastructure.

UIC, the International Railway Association (240 members worldwide), wants to put forward rail as part of the global solution to climate change. 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.

The Challenge has been presented at the UN Climate Summit on 23 September 2014.

2.3.1 Voluntary objectives of the world railway sector

On one hand, the world railway sector has set for itself ambitious 2030 and 2050 targets for energy consumption and CO_2 emissions:

- **Reduction in specific final energy consumption[8] 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[9] 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 in the world through the means at their disposal: electrification of existing lines, decarbonisation of electricity supply, improving load factors, procurement of more efficient rolling stock, energy management systems and efficient driving. The targets were discussed and unanimously approved at the UIC General Assembly on 27 June 2014 (including the major railways of Europe, People's Republic of China, Russian Federation, India & the USA). UIC will monitor and report the progress by the rail sector towards achieving these using a dedicated Reporting System.

2.3.2 The Modal Shift Challenge

CO_2 emissions from railways in the world are less than 1% of total emissions. Railways will do their part to reduce them, but the real challenge to reduce GHG from transport is to realize a serious modal shift from road to rail, both in passenger and freight business.

The second pillar of the Low Carbon Rail Transport Challenge concerns shifting transport activity towards low carbon rail transport (modal shift):

- 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.
- 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.

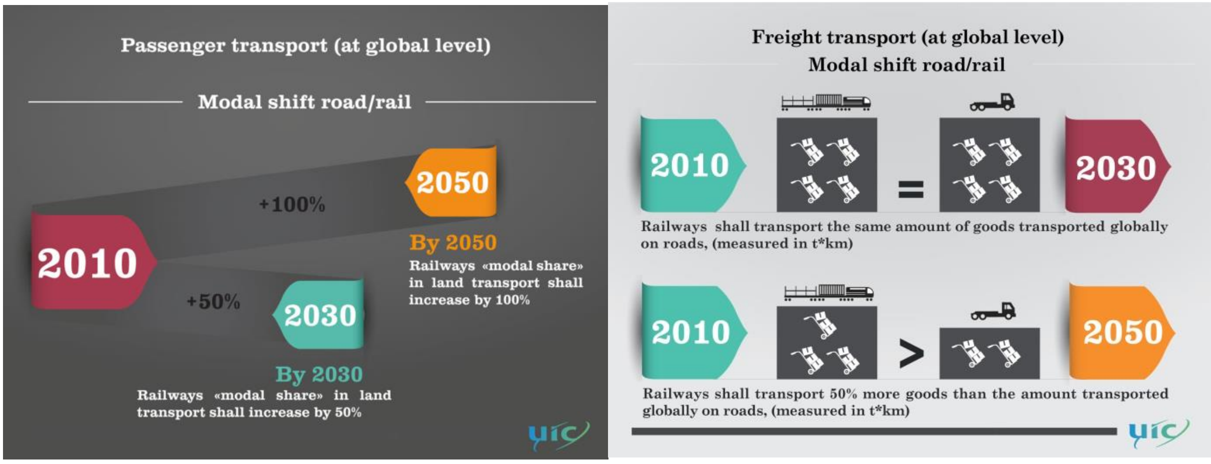
The targets are referred to a global scale, i.e. to the whole world railway sector, and are measured respectively in passenger-kilometres (pkm) for passenger transport and tonnes-kilometres (tkm) for freight transport. These targets are ambitious and reachable in view of a development of a Green Economy; they

[8] "Specific final energy consumption" is defined as the ratio of energy consumption per transport unit.

[9] "Specific average CO_2 emissions" is defined as the ratio of CO_2 emissions per transport unit.

set themselves to be an essential requirement to reach the objectives of the IEA 2DS scenario. The modal shift targets are summarised in Fig. 2-7.

Fig. 2-7: UIC modal shift targets for passenger and freight transport



The Modal Shift Challenge is designed to be ambitious but achievable in a *green economy* perspective. The targets represent consistent savings in total transport expenditure (including infrastructure, maintenance and fuel costs) over the business-as-usual 4 degrees scenario, and constitute a minimum level to reach the 2DS scenario.

Technology may deliver an improvement in road sector performance; however a shift to rail is essential given the expected explosion of demand, in particular in emerging economies such as Asia.

It is necessary for the railway sector (UIC, railway undertakings, infrastructure managers) to build partnerships to achieve these targets and help to secure the 2DS. These include:

- Partnerships with the private sector to support innovation and greater energy efficiency;
- Partnerships with national governments & International Institutions to support modal shift.

The private sector needs to respond to the challenge, to provide innovation and drive down costs, with the goal of financing the sustainable transport systems of the future.

International institutions need to support the development of international transport (freight & passenger), financing for sustainable transport, technology transfer and capacity building.

National governments are one of the major players in this challenge, which they can support through a credible long-term policy which would include investments in new rail projects (in particular urban rail services and freight corridors) and in the requalification of existing rail infrastructure (e.g. electrification and track addition to remove bottlenecks). Governments can also support the challenge through significant enabling actions such as:

- Internalization of external costs (e.g. via road pricing, carbon tax, eco-taxation, subsidies for greener transport);
- 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;

- Smart land use and planning, to allow easy access to infrastructure and intermodal exchange;
- Supporting railway stations as intermodal hubs;
- Providing financial support for procurement of new rolling stock.

References

E&Y 2011, *Green House Gas Emission Reduction for Dedicated Freight Corridor*. Ernst & Young, 2011.

IEA 2008, *Energy Efficiency Indicators for Public Electricity Production from Fossil Fuels*. International Energy Agency (IEA). Paris, 2008.

IEA 2013a, *CO_2 Emissions from Fuel Combustion*. On-line data service. Internet: http://data.iea.org/. Accessed March 3, 2014.

IEA 2013b, *World Energy Balances*. On-line data service. Internet: http://data.iea.org/. Accessed March 3, 2014.

IEA 2013c, *Global Land Transport Infrastructure Requirements. Estimating road and railway infrastructure capacity and costs to 2050*. IEA/OECD, Paris.

IEA 2014, *Energy Technology Perspectives 2012*. OECD/IEA, Paris 2012.

IEA/UIC 2014, *Railway Handbook 2014. Energy Consumption and CO_2 Emissions*. International Energy Agency and International Union of Railways. Paris, 2014.

IMF 2014, *World Economic Outlook (October 2014)*. International Monetary Fund, Washington DC. Internet: IMF Data Mapper. http://www.imf.org/external/datamapper/. Accessed 13 October 2014.

IPCC 2006, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds), *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Prepared by the National Greenhouse Gas Inventories Programme. IGES, Japan, 2006.

IPCC 2014, *Climate Change 2014: Mitigation of Climate Change. Working Group III Contribution to the Fifth Assessment Report*. Intergovernmental Panel on Climate Change. Geneva, 2014.

Tuchschmid 2011, *Carbon Footprint and environmental impact of Railway Infrastructure*. Matthias Tuchschmid, IFEU and Öko-Institut. Commissioned by UIC. Heidelberg – Zurich – Berlin 2011.

UNDESA 2012, *World Population Prospects: The 2012 Revision*. United Nations Department of Social Affairs, New York. Internet: http://esa.un.org/wpp/. Accessed 13 October 2014.

UNESCAP 2013a, *Review of Developments in Transport in Asia and the Pacific – 2013*. United Nations Economic and Social Commission for Asia and the Pacific. Bangkok 2013.

UNESCAP 2013b, *Monograph Series on Transport Facilitation of International Railway Transport in Asia and the Pacific (First Edition)*. United Nations Economic and Social Commission for Asia and the Pacific. Bangkok 2013.

UNEP 2012, *Promoting low-carbon transport in India. Infrastructure for Low-Carbon Transport in India: A Case Study of the Delhi-Mumbai Dedicated Freight Corridor*. United Nations Environment Programme. Nairobi, 2012.