

Rail Transport

HIGHLIGHTS

■ **TECHNOLOGY STATUS** – This brief focuses on heavy rail transport; for information specific to light rail and trams, see ETSAP T09 Public Transport. Rail transport plays a significant role in fulfilling global demand for passenger and freight overland transport, particularly in industrialised nations. In 2005, rail transport accounted for around 6% of passenger transport, and just under 60% of overland freight transport worldwide. Present day rail transport is powered mainly by diesel fuel (particularly freight rail) and electricity (particularly for passenger routes with high traffic volumes); overall in 2006 around 31% of global rail transport was electrified, with almost all of the remainder powered by diesel fuel. Around 85% of rail energy consumption is used for traction energy. Technologies to reduce diesel-powered traction energy include diesel-electric motors, which can include regenerative braking, and using a series of smaller engines ('genset') that can be stopped and started to react to engine power demand. Electric rail is 15 - 40% more energy efficient than diesel rail, and has no direct emissions, but requires extensive infrastructure that can only be justified on a cost-basis for busy routes. High-speed electric trains are becoming widespread and offer an alternative to short-haul aviation. There is scope in all types of rail transport to reduce energy and emissions through improving aerodynamics and reducing train weight, and by reducing the non-traction loads, particularly passenger comfort functions. Alternative fuels, such as hydrogen and biodiesel, offer further potential in reducing emissions from rail transport (as alternatives to conventional diesel), but a fuel supply chain is less well developed.

■ **PERFORMANCE AND COSTS** – Rail transport is inherently energy efficient when transporting large volumes of passengers or freight on a fixed route even at relatively low load factors. IEA estimates global averages for carbon intensity of passenger rail to be 30 - 60 gCO₂eq/pkm (compared with 200 - 270 gCO₂eq/pkm for air transport), and carbon intensity of freight rail to be 15 - 40 gCO₂eq/tkm (compared with 190 - 300 gCO₂eq/tkm for long distance trucking). For this reason, shifting passenger and freight demand onto rail from other modes (in particular short-haul aviation and long-haul trucking) is often considered an effective way to make transport more carbon efficient. There is scope for further improving the energy and emissions performance of rail transport, but most technical measures are only presently cost-effective in new rolling stock (i.e. retrofitting outside of refresh cycles is usually uneconomic). Electric rail is typically 15 - 40% more efficient than diesel rail, but only lines that run at least 5 - 10 trains per day are economically suited to electrification. Reducing auxiliary loads on passenger rail, and using a separate auxiliary power unit on freight trains to reduce engine idling, result in energy savings of 4 - 8%. A 10% weight reduction can result in energy savings of up to 8%; savings are significantly higher for trains that accelerate and brake often (i.e. frequent stopping services).

■ **POTENTIAL AND BARRIERS** – Many national governments are prioritising rail investment as a route to decarbonisation of their transport system. For this reason, it is expected that globally rail transport volumes will increase into the future. IEA scenarios project a 20% increase in freight rail volumes to 2050, and an almost doubling of passenger rail volumes in the same period. Investment in high-speed rail is particularly prominent at present, with nations such as China rapidly expanding their high-speed passenger network. The International Union of Railways has set a target of a 50% reduction in specific energy consumption from rail in the period 1990 - 2050. However, the long service lifetime of rail rolling stock, together with the economic barriers to retrofitting new technologies, mean that there are limited opportunities to improve the train fleet in that time period. In addition, current trends for safety and comfort standards may mean that some of the energy efficiency improvements expected are offset against features that increase train weight and energy consumption. Infrastructure is also a major barrier, and cost, when considering rail efficiency improvements; for more information, see ETSAP T14 (Rail Infrastructure).

TECHNOLOGY STATUS – In most countries, heavy rail transport (i.e. excluding tram and urban light rail public transport, which is covered in ETSAP T09 Public Transport) accounts for a modest proportion of both passenger and freight transport volume. In 2005, rail accounted for around 6% of global passenger transport, and just under 60% of global overland freight transport (this excludes shipping) [1]. However, there is considerable variation between countries. Passenger rail is particularly well suited to transporting high volumes of passengers between large population centres (e.g. major cities), whilst freight rail is a very efficient way of transporting bulk goods over large distances [2]. Approximately 85% of energy consumed by the rail sector is providing traction energy to trains [3]. The vast majority of rail transport is powered by

diesel fuel or electricity [2]. Electricity has a lower, but increasing share globally, rising from 17% of rail sector energy use in 1990 to 31% in 2006 [1]. Some regions already have well developed electric rail networks; in Europe, for example, 80% of passenger and freight rail movement is electric-powered [3].

Trains (diesel or electric) can be powered either by a **locomotive** at one or both ends of the train with unpowered carriages in between, or by **multiple power units** distributed along the length of the train (also known as railcars, diesel multiple units/DMUs or electric multiple units/EMUs). Locomotives are more commonly used for freight trains due to their flexibility in operation, whilst the lighter, more efficient multiple units are favoured in modern passenger rail.