A comparison study on the carbon footprint between the proposed
Kuala Lumpur - Singapore High Speed Rail and other transportation modes

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ABSTRACT

As of now, the Kuala Lumpur city and Singapore is connected and linked by three main transportation modes, which include aviation, tar road and conventional rail. But with Malaysia continuing to make progress, the traffic on the North South Expressway rapidly increase to a point that the expressway can no longer meet its traffic demand satisfactorily. So, the building of high speed rail is proposed to decrease traffic demand of the expressway by lessening the travel time needed to travel from Kuala Lumpur to Singapore to 90 minutes. This research aims to study the effects of the proposed Kuala Lumpur to Singapore high speed rail upon the environment in terms of carbon emission. Ridership prediction data was obtained from the Malaysian Commission of Public Land Transportation and carbon emissions data of private cars, busses, airplanes and high speed rail are obtained via researches done in other nations. These secondary data was applied to the context of Kuala Lumpur to Singapore route, for analysis and prediction of the carbon emissions by different transportation modes from 2010 to 2030. Three aspects of carbon emission contributions are considered for each different transportation modes, which includes the carbon emissions contribution of the production and maintenance of the transportation vehicle, the construction of the infrastructures and equipment that support the transportation modes’ operation and the transportation modes’ operations. By using comparison analysis method upon yearly total carbon emission produced by different transportation modes catering for the Kuala Lumpur to Singapore route with and without the introduction of the proposed Kuala Lumpur to Singapore high speed rail, carbon emissions are expected to be reduced up to 3384.383 million kg by 2030, the ninth year of its operation if the proposed KL-SG HSR shall begin operation in 2022.
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<td>CO₂</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td>FSCs</td>
<td>Full service carriers</td>
</tr>
<tr>
<td>g</td>
<td>Gram</td>
</tr>
<tr>
<td>HSR</td>
<td>High Speed Rail</td>
</tr>
<tr>
<td>kg</td>
<td>Kilogram</td>
</tr>
<tr>
<td>KL</td>
<td>Kuala Lumpur</td>
</tr>
<tr>
<td>KLIA</td>
<td>Kuala Lumpur International Airport</td>
</tr>
<tr>
<td>KLIA 2</td>
<td>Kuala Lumpur International Airport 2</td>
</tr>
<tr>
<td>km</td>
<td>Kilometre</td>
</tr>
<tr>
<td>km²</td>
<td>Kilometre square</td>
</tr>
<tr>
<td>kWh</td>
<td>Kilowatt hour</td>
</tr>
<tr>
<td>LCCs</td>
<td>Low cost carriers</td>
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<tr>
<td>SG</td>
<td>Singapore</td>
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<td>SPAD</td>
<td>Suruhanjaya Pengangkutan Awam Darat Malaysia</td>
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CHAPTER 1

INTRODUCTION

1.1 Introduction

Since Malaysia achieved independence in the year 1963, the Malaysian government have chosen to connect the places of large population in Peninsula Malaysia with tar roads. So, tar roads were heavily maintained and upgraded. The main road in Peninsula Malaysia that connects the most important cities is the North South Expressway.

The Kuala Lumpur (KL) – Singapore (SG) route experienced a sharp rise in traffic. Thus, the building of a high speed rail system to cater for the KL-SG route is proposed. The main goal for the building of the High speed rail (HSR) is to decrease the travel time needed to travel from Kuala Lumpur to Singapore and from Singapore to Kuala Lumpur to 90 minutes.

This study aims to provide sound, reliable prediction of the impact that the proposed HSR will bring upon Malaysia in terms of environment. The predictions made are based upon researches of HSR impact in other countries, contextualized to suit the KL-SG route. These predictions are important as they provide critical information for the Malaysian government for the justification of the building of the HSR.

Environment impact study is important as it is for the interest of the people of Malaysia that the HSR is to be built. People are dependent on the environment for survival and quality of life. The building of the HSR should not impact environment to an extent that jeopardize the well-being of the people of Malaysia. The HSR
should also be built sustainably so that in the long run, it can function well and reliably without harming the environment significantly.

1.2 Problem Statement

The proposed KL-SG HSR will be built very soon. Naturally, public concern on the impact it will have on the environment in terms of carbon footprint exists. However, no comparison study on the carbon footprint between the proposed KL-SG HSR and other transportation modes has been revealed to the public in detail. Such study is needed to identify the impact of the proposed KL-SG HSR upon the environment, and thus, mitigate the public concern. The Malaysian Land Public Transport Commission (SPAD) has done certain predictions and evaluations of their own and this research can also be a reference for them for validation purposes.

1.3 Aim and objectives of the research

The aim of the research is to evaluate the environmental impact in terms of carbon emission that the HSR shall generate.

The following are the objectives of the research:

a) To evaluate the carbon emission contribution of different transportation modes that caters for the KL-SG route without the introduction of the proposed KL-SG HSR.

b) To evaluate the carbon emission contribution of different transportation modes that caters for the KL-SG route with the introduction of the proposed KL-SG HSR.

c) To do a comparison study on the carbon footprint between different transportation modes that caters for the KL-SG route with and without the introduction of the proposed KL-SG HSR.

d) To determine the impact of the proposed KL-SG HSR upon the environment in terms of carbon footprint.
1.4 Scope of study

This study involved only the carbon emissions contributions by transportation serving KL-SG route. It also considered only the carbon emission contributions of certain types of transportation modes that cater the KL-SG route, namely the private car, bus, HSR and airplane. Only three aspects of carbon emissions contributions of transportation modes were considered, which include the contribution of the production and maintenance of the transportation vehicle, the construction of the infrastructures and equipment that support the transportation modes’ operations and the transportation modes’ operations.
CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, the key concepts and terms shall be presented in detail. The key concepts include the different transportation modes catering for the KL-SG route and the environmental aspects that are involved. The terms that are used in these key concepts shall also be introduced. These key concepts and terms needs to be presented to facilitate the understanding of this research.

2.2 Transportation Modes
2.2.1 High Speed Rail (HSR)

Nowadays, HSR is regarded as one of the most significant technological breakthroughs in passenger transportation systems. The HSR are rail systems that have operating speed up to 300 kilometres per hour. In the early years of 2008, there was around 10000 km of new high speed lines in operation around the world and, in total (including upgraded conventional tracks), more than 20000 kilometres of the worldwide rail network served in providing high speed services to passengers who are willing to pay for shorter travel time and rail transportation quality. (Ignacio, 2009)
High-speed rail is the alternative that relives those exhausted modes of transportation because it costs a lot less than the never-ending efforts to widen highways and expand airports. (Hosansky, 1999)

High speed rail is basically a complicated system that includes a variety of technical elements, which comprises of infrastructures such as train stations, tunnels and bridges, even train tracks. Also included are the high speed train’s hardware and software operations which involve design and planning, technology, control and rules for comfort and reliability. There are other elements that are also included in the high speed rail system, such as the signalling systems, maintenance policy, legal issues, human elements, financial elements, commercial elements and the managerial elements. (UIC, 2010)

All these elements are joined and linked together simultaneously in a high speed rail system through the highest standard of technology available to ensure a smooth and safe operation of high speed rail system. High speed systems rely on the way all these elements are taken into account and adapted. The final high speed rail system produced in terms of cost and performances could differ very much from one country to another, depending on, among many other aspects, commercial handling, operation approach, and revenue for high speed railways. (UIC, 2010)

High speed as a new land transportation mode is expanding rapidly. Frequently, it is known as the ‘transport mode of the future’. The reason is that it provides three essential reasons for ridership for its customers, namely safety, high speed and sustainability. (UIC, 2010)

Such successful operations of high speed rail require high speed train sets that are specially made for high speed operations. This is so because the power-to-weight ratio and many other technical aspects which include aerodynamic considerations need to meet certain required standards that guarantee the reliability and safety of high speed railway operations. (UIC, 2010)

Special dedicated rails are also required for successful operations of high speed rail system. Normal conventional rails are generally not capable to support trains operating at more than 200-220km/h, even if major improvements are made upon those rails. The high speed rail layout parameters, transverse sections, railway track quality, catenary and its power supply, as well as any special environmental conditions must be suitable to support high speed rail system operations. (UIC, 2010)
Special signalling system is another aspect required for successful operations of high speed rail systems. Rail side signals are not suitable anymore for trains operating at more than 200km/h because the rail side signals may not always be seen in time. Thus, in-cab signalling system is more appropriate and definitely required for high speed rail system operation. (UIC, 2010)

2.2.1.1 The proposed KL-SG HSR

As of now, the Kuala Lumpur (KL) – Singapore (SG) route is connected and linked by three main transportation modes, which include air, road and conventional rail. However, during the early years of Malaysia’s independence, the North South Expressway was sufficient to cater to the needs of the people travelling between KL and SG. But with Malaysia continuing to make progress towards becoming a high-income country, the rise in Malaysian population and the strengthening of economic and business ties between Malaysia and Singapore, the traffic on the North South Expressway rapidly increase to a point that the expressway can no longer meet its traffic demand satisfactorily. The Kuala Lumpur (KL) – Singapore (SG) route experienced a sharp rise in traffic in terms of passenger-km of travel. (MyHSR, 2016)

An increasing need to improve the transportation that links KL and SG definitely exists; since the traffic congestion experienced by the KL – SG route is critical at times and the highway that connects KL and SG has exhausted its capacity to carry serve more vehicles during peak hours. Currently, the traffic capacity of the highway has been exceeded by 33%. Its traffic will continuously increase as the GDP of Malaysia-Singapore grows, which is at a rate of 3-5%. It is expected that in the long term future, the increase rate would taper off as the market matures, averaging just 3.2% of increase rate per year in 2011 to 2060. (MyHSR, 2016)

The Malaysian government had launched the Economic Transformation Program (ETP) in the year 2010. The ETP aims at changing Malaysia into a high income nation by the year 2020. The Southern Corridor High Speed Rail connecting Malaysia’s capital city, KL and SG was one of the Entry Point Projects (EPPs) under the Greater Kuala Lumpur/Klang Valley (GKL/KV) National Key Economic Area (NKEA) that aims at enhancing the economic dynamism of KL and its live-ability rankings. (MyHSR, 2016)
The main goal for the building of the High speed rail (HSR) is to decrease the travel time needed to travel from Kuala Lumpur to Singapore and from Singapore to Kuala Lumpur to 90 minutes. This can be achieved by introducing a better transportation system that caters for the travels between these two of Southeast Asia’s most vibrant and fast-growing economic powerhouses. Furthermore, the HSR creates opportunities for smaller cities along the west coast of Peninsular Malaysia to be rejuvenated economically by effectively linking them to the two major metropolises. The HSR is a fast and safe transportation system which significantly reduces travel time. (MyHSR, 2016)

![Estimated point to point travel time](image)

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<th>Destination</th>
<th>Estimated Time (hours)</th>
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Figure 2.1: High Speed Rail estimated travel time compared to other alternatives (Source: SPAD)

HSR can act as a medium for political cooperation by improving the connection between different cities and enhancing the improvement of other transport modes. HSR system improves the mobility of people from city to city. Just as a metro network organises the city, HSR organises the cities. HSR persuades people to travel by a greener mode of transport and generally enhances the quality of life. (MyHSR, 2016)

The HSR shall be an attractive alternative mode of public transportation that caters for travels between Kuala Lumpur and Singapore. The HSR contributes to the transformation of the Malaysia as it effectively connects two urban agglomerations to
meet growing travel demand, enhancing economic growth and economic competitiveness in the long run while improving the quality of life of its people. The HSR will effectively link 5 cities in Malaysia to Singapore, through a coastal route. At the present time, the locations of the stations that are identified are the HSR station in Kuala Lumpur (at Bandar Malaysia), Seremban, Melaka, Muar, Batu Pahat, Nusajaya and the final stop shall be in Singapore’s Central Business District. (MyHSR, 2016)

**Seven stops in Malaysia**

A total of eight stations will be on the new high-speed rail line between Kuala Lumpur and Singapore.

![Map of Seven stops in Malaysia](image)

Figure 2.2: Proposed High Speed rail stations’ locations (Source: SPAD)
2.2.1.2 Taiwan HSR (THSR)

Taiwan is located in the western Pacific between Japan and the Philippines off the south east coast of China, from which it is separated by the Taiwan Strait. With a total area of about 36,200 square kilometres, Taiwan is 394 km long and 144 km wide at its widest point. Taiwan’s population is approximately 23 million in 2008. Kaohsiung in the south is the most densely populated place, followed by Taipei in the north, and Taichung in central Taiwan. Almost 70% of Taiwan’s population is concentrated in the western corridor’s metropolitan areas. The THSR connects Taipei to Kaohsiung with a dedicated high speed line of 345 km. (Kao, 2011)

![THSR line and stations](image)

Figure 2.3: THSR line and stations (Yung, 2009)

A one-stop train takes just 90 minutes to travel from Taipei to Kaohsiung, while a train that stops at all stations takes 120 minutes to reach Kaohsiung. HSR can be a catalyst to stimulate the integration with air transportation and HSR’s integration with the local transportation system, yet the THSR’s current accessibility is not satisfactory. HSR’s integration with other modes is important; if it’s full potential benefits are to be realized. (Yung, 2009)
2.2.1.3 HSR's socio-economic impact

HSR operations in Japan, France, Germany and the UK have proved that HSR systems, if leveraged suitably, have the potential to catalyse development of cities and enable clusters which benefit from the economics of agglomeration. HSR as a whole has tended to offer all-inclusive benefits for the nations and cities in between. The improvement of transportation means is not the only push factor; rather, the potential for contribution to economic development is an equally tantalising prospect. Cities along the corridor stand to benefit immensely in terms of rise in quality of life, employment opportunities and talent recruitment opportunities. HSR Socio-Economic initiative will be part of the larger programme operating in parallel to HSR project to further develop Peninsula Malaysia east coast cities. (Kamal, 2013)

In China, the World Bank Beijing Office had informed that broader economic benefits that span way beyond what is shown by the conventional cost-benefit analysis exist. Methodical approach that was piloted by the World Bank has revealed quantitative measurement, which was not done before, of these wider benefits as a result of HSR providing larger and better connected markets. The quantification makes use of ‘Economic Mass’ or agglomeration, where HSR can increase the economic value by increasing people mobility and accessibility of an area with different cities. Broader economic development benefits of HSR projects are significant and are worthy of consideration, in addition to the traditionally measured direct transport benefits. Research have been done and have revealed broader benefits of several HSR projects, and has found them to be significant, additional to the direct transport benefits that are traditionally measured. Also, it is evident that in the development of HSR in China, where national and provincial governments stress the importance of regional economic development in almost all feasibility studies, the benefits provided by HSR are significant. (Kamal, 2013)

In Japan, HSR Shinkansen line that caters for Chiba, Tokyo, and Yokohama (Chiba-Tokyo-Yokohama HSR) have made Yokohama to become the most gigantic Bio-technology cluster in Japan. To achieve this success, certain preconditions need to be met in conjunction with on-going HSR operation. In the case of Chiba-Tokyo-Yokohama HSR, Information Technology and Bio-technology were set as top priority industries. Even Yokohama Science Frontier was set up there with incentive
programs to relocate its head office and R&D. HSR Shinkansen line also attracted
and produced talent pool with Yokohama Jóin Research Centre. (Kamal, 2013)

Also, the HSR Shinkansen line that caters for Tokyo and Osaka (Tokyo-
Osaka HSR) brought forth strong employment growth and inhabitants in Shin-
Yokohama. The preconditions for such success includes clear prioritization of key
industries such as Information Technology and Bio-technology, existence of
integrated set of policies to attract businesses and talent by providing incentives for
R&D centres, the strengthening of Shin-Yokohama’s position as Japan’s port city.
(Kamal, 2013)

In Europe, the HSR that caters for London and Paris (London-Paris HSR)
was the catalyst for strong employment growth and inhabitants in Lille.
Preconditions for such success is the creation of 74 ha Euralille district, also known
as the ‘temple to the tertiary’, which combines commercial, office, green spaces,
housing, hotels & public facilities in 1990. (Kamal, 2013)

An important outcome of the HSR socio-economic development plan will be
a set of sector priorities across the HSR hubs and targeted incentives and policies. In
KL, Greater KL shall place priority on business and financial services. It shall be the
home to regional headquarters of Multinational Companies (MNC) from the
financial and business service sectors under the 100 MNC programme by InvestKL.
Supported by The Tun Razak Exchange (TRX), it is poised to be a catalyst for Kuala
Lumpur to be a leading global centre. (Kamal, 2013)

In Seremban, Small-Medium Enterprises (SME) TechValley shall be placed
as top priority. Ambitious plans to develop a 1000-acre TechValley in Sendayan to
attract SME manufacturing and research investments in the areas of sustainability,
green manufacturing, biotechnology shall exist. In Melaka, Tourism and health
tourism shall be emphasized. Melaka shall represent a hub of tourism and health
tourism. Its reputable medical centres, experienced specialists, proximity to
Singapore and Indonesia combined with a charming historical atmosphere shall draw
thousands of health tourists annually. (Kamal, 2013)

In Muar, consumer goods industrial design shall be the top priority. By
leveraging its current position as the furniture manufacturing hub of Malaysia, it has
the potential to move upstream towards industrial design to serve local and regional
furniture manufacturers. In Batu Pahat, textile design and manufacturing shall be
emphasized. It is home to over 300 garment and textile factories and produces 50%
of exported textile from Malaysia. Batu Pahat has the potential to move upstream and become the center of design and manufacturing of textile for Malaysia. (Kamal, 2013)

In Johor Baru, education shall be the top priority. EduCity at Nusajaya is positioned to be a regional education hub and a destination for quality, world-class education. It will be a fully integrated knowledge-based hub comprising world-class universities, knowledge-based industry leaders, international schools and colleges, and exhibition amenities of world standing. (Kamal, 2013)

HSR is literally the “Game Changer”. Ninety minutes of travelling time between KL to Singapore means you can cover more ground in a day and still find time for love ones. The possibilities are endless. There is also the power of Agglomeration. By connecting the two largest cities in South East Asia, it not only signify a closer than ever bilateral ties, it is also an opportunity to be stronger and a more attractive gateway to ASEAN. The collective strength with seamless travel provides larger opportunity to access a larger demand market and talent pool. (Kamal, 2013)

2.2.2 Bus

With the pace of urbanization accelerated, the urban traffic jam spread from big cities to middle and small sized cities in China. The urban traffic jam has decreased city’s attraction, integrated competition ability and efficiency. The problems of traffic congestion become more and more prominent. The increased trips by private cars would need lots of road resources and produce serious air pollution, while the bus travel has the advantage of intensive, effectiveness, energy-conservation and environment-protection. Therefore, bus is an effective mean for alleviating traffic jams. It would be meaningful to increase bus’s competition ability and attract more car travellers to switch to public transport. (Qin, 2013)

Accessibility and effectiveness of buses service can be measured by both tangible outcomes of services performances as well as intangible indicators including passengers’ comfort and convenience. From these categorisations, various measurements of level of services can be derived. These includes the fleet and vehicle types, the services types, the stations and waiting facilities, the route and schedule systems, fare and zoning systems, travel, waiting and delay time, information systems, and passengers’ comfort and convenience. (Syahriah, 2015)
Bus conditions differ from one trip to another. Bus chassis, engines, comfort and convenience levels also differ from one passenger to another. The initiatives undertaken by the public-private partnership types of development and construction collaboration, project management and regulatory functions can indeed revitalise some parts of the city, including areas along the routes traversed by the buses services. (Syahриah, 2015)

Physical improvements such as development, construction and upgrading of buses waiting facilities should be aimed at revitalising the derelict city centres, creating vibrant and robust economic activities and more frequent and higher quality social interactions between various walks of life. Higher accessibility can be achieved by carefully selecting programmes, schemes or initiatives that increase the buses catchment areas, introduce or sustain the routes plying through strategic land uses with the highest numbers of traffic generation and also encourage mode switching from private vehicles to buses for trips made especially during congested periods and through overcapacity road sections. On the other hand, regeneration to preserve the biological eco-system of run-down city centres should not neglecting the restoration of good public bus system to accommodate the accessibility for the city users. Bus services levels such as waiting amenities being improved and upgraded in derelict urban centres have indeed assisted in the regeneration of declining city centres. Urban regeneration through improvement of transportation terminal, integrated public transport interchange facilities and mixed use building components including commercial and waiting facilities should indeed occur. (Syahriah, 2015)

2.2.3 Private car

In many cities today, the private car has become an important and dominant mode of transport. The increasing dominance of the private car as a mode of transport is due to inherent advantages associated with its use. The unrestricted freedom that car users enjoy is one important reason why many people wish to own a car. Whilst public transport modes necessitate the sharing of services with strangers, the private car affords privacy and comfort for its user. Additionally, the private car has become more popular and dominant than public transport because it is usually available when required, takes the user from door to door and can reach dispersed destinations. It is also worth noting that the private car has become a symbol of power, status and prestige. Furthermore, private cars enable drivers to offer free lifts to travellers, and
expensive car models are often associated with wealth in society. It is therefore not surprising that car ownership and use are widely perceived as both a sign of affluence and increasing personal wealth. (Amin, 2007)

Malaysia’s recent rapid growth in car ownership particularly in conurbations such as Kuala Lumpur offers evidence that rising incomes are the major driving force for car ownership. An important challenge posed by the recent rapid motorization phenomenon is the increasing traffic congestion. Traffic congestion is a major problem both in the developed and developing world. Traffic congestion is a direct result of increased traffic flow. The volume of traffic on a link consists of a series of vehicles, the drivers of which each want to minimize their own journey time on the road. The speed and flow of the traffic is entirely dependent on the behaviour of each vehicle’s driver. Each vehicle’s progress therefore is necessarily dependent, except on an empty road, on how its driver adapts his or her behaviour to that of other drivers. Thus, congestion is primarily a function of personal behaviour and dynamics. In addition, traffic congestion further induces accidents and air pollution. (Amin, 2007)

Malaysia is a prosperous rapidly growing country with high private vehicle ownership automobile and only approximately of urban travel is by public transport. In order to make restraint on private transport politically feasible, public transports have to be greatly improved. The increasing number of car users involved in crashes and the associated injury has prompted the government of Malaysia to undertake various studies to address the problem. (Abdalla, 2007)

One of the studies done was regarding the shift of transportation mode from private car to public transportation such as buses and trains in Malaysia. Evaluation of policies and strategies can help to formulate the model shift of transportation mode from private car to public transportation in Malaysia, to formulate the modelling of possible model shift from private car to public transportation and to predict the future model shift. There are researches that have been done that focused on model shift initiatives. These initiatives focused on shifting car users to safer modes of transport in order to increase road safety and enhance road environment. To date, many cities have attempted to restrict the use of private cars in favour of public transport. Such policies exist in France, Germany, Britain, Netherlands, Romania, Australia, Asian countries, and Canada. The attempts have been by changing the public perception to it. (Abdalla, 2007)
2.2.4 Airplane
The popularity of travelling by airplanes is constantly growing. Airline ticket price depends on many different dynamic factors, such as airline pricing policies, flight distance, class of service, airline, global population mobility, all of which define the travel demand. Ticket costs can vary significantly for the same flight, even for nearby seats. The model of airline tickets market varies from country to country and depends on the volume and structure of supply (number of airlines and air flights) and demand (number of passengers, seasonal peculiarities). Air travel demand is affected by the global population mobility, which itself is influenced by various factors. Most people tend to work on the schedule. So, tickets with dates of departure/arrival on the weekend are usually more expensive. Also, the increase in prices can be seen during public holidays. (Anastasia, 2015)

Traditionally, there is a common belief that the plane tickets are cheaper if they are bought in advance. Today, this is true only in part. For example, due to the pricing policy airlines offer cheap flights shortly before departure to maximize the load of their flights. It happens due to the sharpening of competition between airlines. The cost also can depend on the seasonal factor. Tickets for the low season are always cheaper because people fly on rare occasions, and usually that is the time when airlines organize promotions and sell tickets at discounted prices. The service type is another main factor affecting ticket price. There are three basic classes of different price categories: economy, business, and first class. Flights can also be divided into regular, charter and low-cost. The latter two types are nearly always the cheapest, but they have their distinctiveness. Information on airline pricing policies can be publicly available such as in the form of promotions, or hidden from customers. (Anastasia, 2015)

Promotions often are not made public in advance, so it is hard to plan the purchase of a ticket for the promotion. Usually, there are two windows of time associated with a promotion. Each special offer includes flights, which have very limited number of tickets. Some airlines organize their promotions six months prior to the date of departure while other sells tickets with great success during the season of departure. Airlines want to maximize their profits balancing between filling their flights and increasing prices. The dates of seasons may vary slightly for different airlines. With the expansion of the Internet around the globe, the ticket selling industry underwent a series of changes. Tickets are available for purchase 24 hours a
day, 7 days a week from anywhere in the world, and the potential buyer can compare prices from the great variety of airlines before making his final decision. Due to this fact, prediction of the ticket price is becoming a more difficult problem as it depends on many factors. (Anastasia, 2015)

After the declaration of the 1978 Airline Deregulation Act in the United States, the market situation of the air transport industry changed significantly. With the adoption of free competition, airlines tried to improve their customer services. They began flight services in new routes and developed various airfare policies to ensure their survival. Various new airlines, including low cost carriers (LCCs), entered the air transport market to satisfy diverse air transport demands. The concept of LCCs is to offer the flight services with the attractive prices that are much lower than the conventional full service carriers' (FSCs) and even comparable to those of a car or train. By increasing the number of passengers, LCCs can get sufficient profits even though the unit profit per passenger tends to be less than that of FSCs. In addition, LCCs have tried to reduce all kinds of cost-related elements to secure their operating profits. Therefore, even though they cannot provide sophisticated services as compared with FSCs, the demand for LCCs has increased steadily by passengers who want only a basic transportation function. (Young, 2016)

The fare class structure of LCCs is relatively simple because they only operate one class: Economy and LCCs generally offer two kinds of airfares: Discount fare and regular fare. In addition, they usually provide flight services in point-to-point routes for simple and easy management. LCCs tend to choose lower-tariff airports. To get rid of commission payments, LCCs do not use travel agents and adopt the electronic ticketless systems or e-ticket utilizing websites. In addition, they keep a high flight frequency to maximize their utilization and adopt team competitive wages and profit sharing to maintain high productivity and efficiency. Generally, LCCs’ airfares are 30-40% lower than FSCs’, and LCCs’ operating costs are 40-50% compared to FSCs’. Through the emergence of LCCs, various alternatives are given to customers when they are choosing their airline, in terms of preference, airfare, flight frequency, etc. Thus, with the remarkable growth of the customer demand for LCCs, it is difficult for FSCs to ignore the LCC market and focus on the premium market. (Young, 2016)
2.2.5 Conventional Rail

The railway as a piece of technology and as a policy was an important tool of empire which projected and consolidated imperial rule in British Malaya. Not only did the railway bolster commercial activities in the Malay Peninsula and make the colonial economy valuable to the British, it established a network of transport linkages and economic interactions that connected the separate Malay polities with British possessions to form an integral unit of the Empire. Following its inception in the Malay states, the railway first prospered and then floundered together with British rule in Malaya. Railway development in the Peninsula thus mirrored the evolution of British rule and became an allegory of British imperialism in the region as well as a testament to Britain’s colonial legacy. (Lim, 2009)

A product of its times, the railway was inextricably linked to imperialism and empire, as it tied overseas colonies to Europe and promoted their economic exploitation in the phase of imperial consolidation. When Thomas Newcomen invented the first steam engine in 1712, the English East India Company (EIC) had already established a large overseas colonial enterprise in America and Asia for a century. As the Industrial Revolution harnessed steam energy into railway technology, the engines of empire had propelled British imperialism over Portugal, Spain, France and the Netherlands into the position of global ascendancy by the end of the nineteenth century. During this period, nationalism fuelled the onset of a new phase of imperial expansion which portrayed the railway as an icon of conquest and empire. Grand imperial railway schemes around the world were driven by the success of transcontinental lines in forging ‘one nation of continental dimensions’. (Lim, 2009)

Similarly, the introduction of railway technology into the Malay Peninsula occurred in conjunction with by the imposition of imperialism in the Malay states, whereby railway tracks and British rule were consolidated and extended concurrently in the Peninsula. The railway connected the centres of mining and commercial activities in the hinterland to the ports on the West Coast of the Peninsula, as characterized by the first lines built between Taiping and Port Weld in Perak, Kuala Lumpur and Klang River in Selangor, and Seremban and Port Dickson in Negeri Sembilan between 1885 and 1891. Although the decision to build these lines had stemmed from the economic interests of the Straits merchant community, railway
construction was nonetheless predicated upon a measure of British rule in these states which functioned as an adjunct to the colonial economy in the Straits Settlements. This had been achieved by the presence of British Residents instituted by the Pangkor Engagement in 1874 and the establishment of State Councils initiated by the administrative reforms of Hugh Low in 1877. (Lim, 2009)

By the time the FMS was established and placed under a British Resident-General in July 1896, twenty railway lines had already been constructed in these states. Following a greater centralization of British authority with the creation of Federal Departments in 1902, which established the Federated Malay States Railway (FMSR), an additional thirty-seven lines were constructed across the FMS. (Ibid.) These states were also drawn closer to imperial rule in the Straits Settlements with the completion of the railway line between Tamping and Malacca Town on 1 December 1905, which reinforced existing transportation, communication and economic links between the crown colonies and the rest of the Peninsula. The FMSR network reached its furthest extent at the height of British imperialism in Malaya. At the same time, the imposition of imperial authority in Malaya was sealed with the extension of railway lines into Penang and Singapore, the seat of British power in the region. By 1935, the FMSR had woven a net of British imperialism around Malaya with 1,321 miles of railway tracks, 213 permanent stations and 76 halts across the Peninsula. Now, the conventional rail links the north of Peninsula to the south. (Lim, 2009)

2.3 Green House Gasses (GHG)

A few decades ago, only among academics were the change of climate and global warming known and discussed, with various environmental specialists forecasting the environment of the future. However, climate changes and the effects of global warming is currently a major global environmental issue that transportation businesses of all sizes need to face, including airline businesses, train businesses, buses businesses and others. This is because the slow but steady climatic changes and effects of global warming have supported some of the original forecasts regarding what is going to happen to the planet Earth if we do not change the way we live and go about our lives. Since the effects of global warming are becoming obviously irrefutable, responsible actions by the transportation businesses to reduce
and compensate for their respective impacts on the environment are expected and required with increasing intensity. (Dimitris, 2012)

Through different studies done throughout the world, facts have shown that the temperature of planet Earth has been rising steadily over the past 100 years and the temperature will continue to rise by another 4°C by the end of the century if we continue to do things the same way. The biodiversity of our dear planet Earth is in danger, with different living creatures and plants under the terrible danger of becoming extinct. (Dimitris, 2012)

The gasses that are mainly responsible for the warming of the planet Earth are also known as the Green House Gasses (GHG). GHG includes carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF₆). Carbon dioxide (CO₂) is one of the most significant GHG as it is estimated to be responsible for two thirds of the overall global warming. It exists in the Earth’s atmosphere in high quantities, representing 99.4% of the six GHG. By tonnage, CO₂ emissions are the most significant of the GHG. (Kirti, 2013)

Among the negative effects of GHG emissions, we can mention global warming, deduction of water availability for humanity, reduction of air, water and soil cleanliness, melting of ice caps and increasing oceans level, reduction of the ozone layer, extreme weather events, abnormal changing of the seasons, reduction of biodiversity, and desertification.

2.4 Carbon Emissions

A growing number of studies, research and collected data reveal the existence of a direct relationship between climate change and carbon dioxide emissions (CO₂). According to the Fourth Assessment Report prepared by Intergovernmental Panel on Climate Change (IPCC), activities all around the world generate increasingly more GHG emissions, having significant adverse effects on climate change due to the compositional changes taking place in the atmosphere, and also on the increase of the average earth’s temperature since the mid of the 20th Century.

The main source that produce huge quantities of carbon dioxide are fossil fuels (especially oil and coal), through burning them to generate energy. Emissions
of other greenhouse gases are converted in units of CO\textsubscript{2} equivalent (CO\textsubscript{2}e), using the warming potential related to each different gas.

During the Kyoto Conference in 1997, the agreement to reduce the GHG emissions was established to stabilize the gases concentration in the atmosphere. 192 countries have agreed to reduce carbon emissions by 2012, with an average of 5% compared to the carbon emission level of 1990. If a country fails to meet its carbon emission reduction target, surpassing the agreed rate, it is forced to buy carbon emission allowances from countries that have not consumed theirs. Thus, the mandatory market for carbon certificates was created. (Andreea, 2013)

2.4.1 Carbon Dioxide Emissions’ Sources

The 10% of sectors that would have most of their carbon footprint (80+%) represented by Tiers 1 and 2 are well-known sources such as power generation, cement manufacturing, and the transportation sectors (air, truck, rail, and water). (H. Scottmatthews, 2008)

Transportation is a major element of air pollution worldwide, yet the negative impact of transportation infrastructure upon air cleanliness is not well known. Nowadays, road transportations systems are heavily reliant on internal combustion engines powered by petroleum. Emissions of carbon dioxide (CO\textsubscript{2}), have steadily risen along with travel rates, energy use, and oil imports. If constraints or effective countermeasures are not present, transportation energy use and GHG emissions will continue to increase. (Xing-ju, 2012)

There are many aspects of the transportation’s carbon emission to be considered, which include the contribution of the production and maintenance of the transportation vehicle, the construction of the infrastructures and equipment that support the transportation modes’ operation, transportation’s energy source carbon footprint, and the transportation modes’ operations and utilities resources’ carbon footprint. These aspects are affected greatly by the transportation ridership demand, which is affected significantly by the nation’s population growth and economy growth in terms of its gross domestic product (GDP). (Network Rail, 2009)

In terms of pollution, the amount of carbon emission that results from the empowering of a high speed train for a given trip depends on both the amount of energy consumed and carbon emission of the electricity plant that generate such
energy. Since the primary energy sources used in each country may be different, it seems that to make comparisons about HSR' carbon emissions would be complicated. However, it is an accepted fact that HSR contributes less carbon emission compared to other transportation modes, such as the private cars and airplane. The primary energy required by high speed rails in litres of gasoline per 100 passengers-km was 2.5, whereas by car and airplanes were 6 and 7 respectively. Likewise, the amount of carbon emissions per 100 passengers-km by airplanes and car was 17 tonnes and 14 tonnes respectively, because of the use of derivatives of crude oil. For HSR the carbon emission was just 4 tonnes. (Ignacio, 2009)

There are certain main elements that affect the overall carbon emissions comparison of different transport modes that serves the KL-SG route. For the purposes of this study, the comparison is restricted to the greenhouse gas emissions, carbon emissions, only and not energy usage or any other carbon footprint that may be involved during the construction of transportation vehicles or infrastructures. However, to completely and precisely consider the relative impacts of each transport modes to the amount of carbon emission produced, certain factors need to be evaluated. These factors can be loosely grouped into these major categories. (Network Rail, 2009)

First, the direct operations of the different types of transportation modes. In making comparisons it is important to understand both the current situation and the anticipated operations of the different types of transportation modes that would be catering for the KL - SG route with and without the introduction of HSR. Comparisons between different transportation modes along the similar route from KL to SG are most usefully made in terms of the operations. For example, the total carbon emission produced per kilometer per passenger trip for different transportation modes. (Network Rail, 2009)

Second, the seating occupancy levels and service frequency for the different types of transportation modes that would be catering for the KL - SG route with and without the introduction of HSR. Seating occupancy levels, also known as the load factor directly influence the carbon emissions per passenger. There are significant differences of average load factor between different types of transportation modes that would be catering for the KL - SG route, with high-speed services typically having higher occupancy levels. Together, average seating occupancy and service frequency provide a measure of the intensity of the use of the different types of
transportation modes that caters for the KL-SG route. This is important to enable the embedded emissions from infrastructure to be allocated on a per passenger-km basis. (Network Rail, 2009)

Third, direct and indirect greenhouse gas emissions from energy source such as fuel or electricity production (current and likely future electricity mix). Assumptions on the projected carbon intensity of electricity or fuel in the future will significantly impact the relative importance of the components of direct energy consumption for operations by different types of transportation modes that caters for the KL-SG route versus other elements such as the indirect/embedded energy consumption/ emissions from vehicles of different transportation modes and its infrastructure production and disposal; (Network Rail, 2009)

Fourth, indirect emissions resulting from the construction, maintenance and decommissioning of vehicles of different transportation modes. A complete assessment of the impact of vehicles of different transportation modes that caters for the KL – SG route needs to factor in the energy consumption and emissions resulting from the production, disposal and maintenance phases, as well as the direct energy consumption for vehicle operations considered in earlier sections. There may be differences between the types or volumes of different materials used for vehicles of different transportation modes that cater for the KL – SG route that will affect their relative impacts; (Network Rail, 2009)

Fifth, energy consumption and carbon emissions resulting from construction and use of the infrastructures that support the usage of vehicles of different transportation modes that caters for the KL – SG route. These can be very significant in size and could potentially significantly alter the picture if there are significant differences between different transportation modes that caters for the KL – SG route in the total passengers carried on its infrastructure. Elements include the materials used in the construction of infrastructure and the energy consumption /carbon emissions per ton of these materials, energy use or emissions resulting from infrastructure construction activities, and annual variable energy use/carbon emissions from infrastructure use and maintenance. (Network Rail, 2009)

Sixth, carbon emissions savings resulting from modal shift and factoring in demand generation. Modal shift, such as shift from car and air transport to HSR, and journey creation have effectively opposing impacts on the overall evaluation. Whilst modal shift from other modes of transport will provide additional benefits, demand
creation effectively reduces the benefits of the higher occupancy rates (and total passenger numbers) typically achieved by high-speed rail. It is therefore important to provide a quantitative estimate of their respective impacts in the overall evaluation. Abstraction from existing rail services is much more complex to quantify due to changes in the type and frequency of service provision affecting the total energy consumption and passenger-km. (Network Rail, 2009)

2.4.2 Carbon Dioxide Emissions’ Measurement

Carbon footprint assessment is important to the understanding of the negative effects of the proposed HSR on the environment. Although the transport sector is still not part of the carbon market, issues related to the environment should be handled responsibly and proactively. The main benefit of carbon footprint assessment is that it enables the environmental actions to be seen from a more suitable perspective and shows which actions have the most impact on reduction of GHG, which may not necessarily be the most costly or most complicated actions. Estimation of carbon emissions is essential to the reduction of carbon emissions, because no actions can be taken to reduce something that is not measured before. We may be aware of certain actions that reduce carbon emissions, but only through carbon assessment can the exact impact of an action be determined. (Dimitris, 2012)

Carbon footprint tools such as the EcoTransIT and EcoPassenger help people to choose the most environmental friendly way of transport, which in mostly involve rail travel. These calculation tools consider only the operation phase and energy provision, but not the infrastructure (track system, motorways, and airports) nor the construction of rolling stock, cars and aeroplanes. So, if we also consider the carbon emission from the construction of vehicles, and from construction, there may be a difference in total carbon emission. (T. Baron, 2011)

The greenhouse gas emissions have been determined using an orienting material flow analysis. Detailed life cycle assessment is not part of the scope of this study. The methods used in the material flow analysis comply with product category rules for rail infrastructure and rolling stocks. These Product Category Rules (PCR) are closely related to the ISO standard 14025 (environmental declarations) and the ISO standard 14040 (Life Cycle Assessment). (T. Baron, 2011)
The effects of HSR upon the carbon footprint has been analysed from its construction, to its operation, to its maintenance and even to the end of its life cycle. Furthermore, the conception and planning stages of the HSR have been taken into account to give a holistic overview of the project’s life cycle. The manufacturing of pre-produced parts such as telecommunication equipment has not been taken into account. Also, some simplifications are done, for example, the exclusive assessment of UIC60-rail, other possible rail types as S54 or S49 has been neglected. (T. Baron, 2011)

This study also do not consider the maintenance of the track systems, the heating and electric consumptions of the buildings and switches and further emissions without direct relation to specific material flows such as emissions from leaking air-conditioning devices in rolling stock. Please note that the conception phase is normally not within the analysis focus of other Life cycle studies and is also excluded in PCR for Railways in 2008. (T. Baron, 2011)

Enhanced project data was collected throughout the SYSTRA-archives, different research literatures, various reports from UIC and national railways in order to conduct this carbon footprint analysis of High Speed Rail. The project data has to be combined with emission factors to calculate the total amount of carbon emissions. Due to its high reliability, transparent documentation and the international usage of its data (inside the rail sector and more broadly), the ecoinvent database v2.0 has been chosen for the emission factors. (T. Baron, 2011)

Figure 2.4: Considered Life Cycle phases
REFERENCES


