Rotterdam: Stadt und Verkehr

Course work for;
Seminar zur Verkehrsplanung mit Exkursion,
Institut für Verkehrswissenschaften

Prepared by: Aso Validi
Wien, 30th of September 2018

Summary

Nowadays mobility is of high importance as people want to travel more and at the same time arrive at their destinations very quickly and with a high level of safety. Similar to every part of the world, transportation systems play an important role in the Netherlands mobility. The role of transportation systems in Netherlands is even more important as it is one of the very densely populated countries. In order to facilitate the transport, the traffic network requires a modern infrastructure. Around half of all trips in the Netherlands are made by car, 25% by bicycle, 20% walking, and 5% by public transport. The Dutch transport infrastructure is ranked fourth in the world according to the Global Competitiveness Report for 2014-2015.

This report, "Rotterdam: Stadt und Verkehr", is prepared as a course work for “Seminar zur Verkehrsplanung mit Exkursion”. A thorough investigation into different features and aspects of the city of Rotterdam in terms of its transport system characteristics has been conducted. Published research, national and European statistics reports have been reviewed. As a part of the course, a short visit to the Netherlands and the city of Rotterdam was made during the summer semester 2018. This field trip was organised by the Institute of Transportation Science during 3rd and 9th of June 2018.

Table of Contents

1 Introduction

The word “Netherlands” literally means lower countries as only about 50% of its land exceeding 1 metre above the sea level. The country is located mostly in Western Europe with a population of 17.2 million [1], [2] and consists of twelve provinces (Figure 2). Amsterdam, Rotterdam, the Hague, Utrecht and Eindhoven are the five biggest cities of Netherlands. The Netherlands neighbours are Germany to the east, Belgium to the south and the North Sea to the north west [2]. The country is also sharing maritime borders in the North Sea with Belgium, the United Kingdom and Germany. Rotterdam, the largest port in Europe in 2014, is the eighth largest in the world behind Ningbo-Zhoushan, Shanghai, Singapore and other major Chinese ports. Other major Dutch sea ports are Amsterdam, Vlissingen and Terneuzen [3].

2 The Netherlands and History of Rotterdam

As a well known fact, ancestors of humans have originated on riversides. All the great civilisations once emerged along the banks of major rivers such as Gangs, Niles and many more [1]. This fact is also applied on this part of the world (Netherlands, Rotterdam). Humans settled near the river Rotte (Figure 1). The oldest settlement in the area is called Rotta. As a result of this settlement the population has growth. But due to regular flooding people tried to protect themselves by constructing dams and locks in 13th century, which shaped the city of Rotterdam and resulted in receiving the city right in 1340. During the 17th Century, harbours were expanded and by the end of that century, Rotterdam has become the second merchant city after Amsterdam [1], [2].

Figure 1: Map of Rotterdam (around 1340) [2]

The occupation of the area by France from 1795 to 1815 halted trade temporarily. Transit trade grew in popularity and following the fall of Napoleon, new waterways, bridges, and railroads were developed. During World War II, the Rotterdam’s city centre and many of the Rotterdam’s port facilities were destroyed. After the second world war, the city was rebuilt from the ashes. The newly constructed architectural and structural design of the city with the aims to achieve the most functionality and efficiency, became more appealing to both residents and tourists [3], [4].

An important industry in the area in the 1940s was oil-processing which still continues today. The amount of goods that travel through the port of Rotterdam is considered as the largest in the world. Most of the transported products are crude oil and petroleum. The Rotterdam port is one of the largest harbours when it comes to the transportation of grain and general cargo [4].

3 City of Rotterdam

Rotterdam, the second largest city in Netherlands, is located within Rhine-Meuse-Scheldt river delta at North sea. The current situation of the city within the Netherlands is presented in Figure 2. As have already mentioned, the Netherlands have twelve provinces. Rotterdam is the most populous city located in the "South Holland" province [4].

Figure 2: Netherlands Map [4]

The beautiful river setting, vibrant culture, its rich history and most importantly Rotterdam's position as a major economic centre has contributed to the city's growth over the years. Rotterdam is a popular place to settle and one of the top travel destinations in the area [2]. Considering the mentioned factors, the population of Rotterdam shows a grow at a slow but steady rate over the years. The population of the city has been reported around 634,660 in 2017, which makes it the second largest city by population in the Netherlands [4], [5]. Figure 3 shows the total population of Rotterdam from 2007 to 2017. During this ten years period, the population of the municipality of Rotterdam increased by over 50,000 inhabitants. In 2007, Rotterdam had nearly 584,000 inhabitants [7]. By 2017, the number of inhabitants had increased to roughly 635,000. The Rotterdam's under one million population in 2017 is expected to grow to 1.015 million by the end of 2020. By 2030, the predicted population of Rotterdam is expected to hit 1.077 million [6].

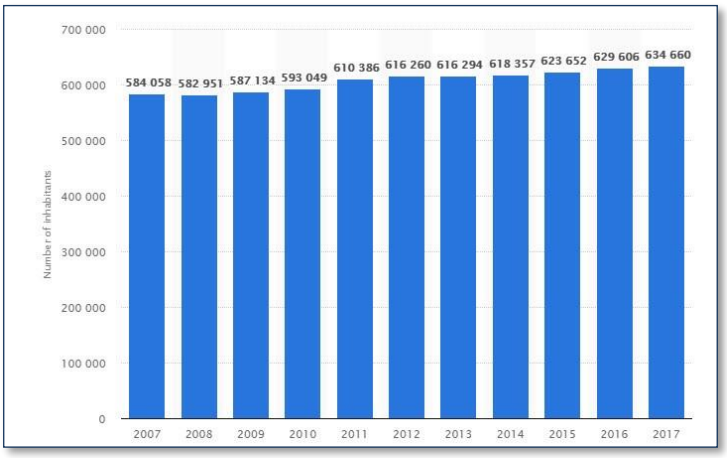

Figure 3: Rotterdam Population [7]

The most important success factors of Rotterdam's logistics industry is known as its location on North Sea, with access to the Rhine-Meuse-Scheldt delta [8]. The city also has a network of railroads, waterways and roads, functioning as a gateway to Europe [8], [9].
In recent years sustainability has become a priority in Rotterdam's development plans. The city invests in sustainability projects in different aspect, especially in transportation [11].

3.1 Buildings

Architectural works are often perceived as cultural symbols and as works of art. Historical civilizations are often identified with their architectural style, buildings, bridges and other types of structures. Rotterdam is known for top and modern architecture design mixed with old buildings [11]. It is a city of innovation, constantly striving to remain at the cutting edge of modern architecture. The renewal of the city after the World War II was based on considering new technologies, including 3D printing, floating architecture and robotic construction [17]. The city is now the home to ambitious architectural projects, such as The Cube Houses, De Rotterdam and the Markthal. The innovative structure of The Cube Houses with 38 small cubes and two so called "super-cubes" is built during 1982-1988 [17]. The De Rotterdam has been built during 2009-2013 and known as the largest building in the Netherlands with 149 meters height (160,000 m2).

Figure 4: The Rotterdam Markethal [10]

The Markethal Rotterdam (Figure 4) has the biggest ceiling artwork in the world and was named as the best shopping centre in the world. In October 2004 the team of architectures (Provast) won a competition organised by the city of Rotterdam for the design and construction of the Markethall. The municipality wanted to extend the existing open air market with a covered addition with good accessibility. In order to make the construction more efficient, a curve was chosen that fitted a traditional elevator core. By adding some space to the lower floors for extra retail space, the current volume of the arch emerged 120 meters long, 70 meters wide and 40 meters tall [10]. The previous examples of market halls were often dark and introverted buildings with little connection to the surrounding urban area. The Markthal includes a market floor on the ground floor under an arch of apartments. Its shape, its colourful interior and the height turns the Markthal into an unique market place and a modern architectural design. Its uniqueness is not only due to its shape and size, but especially the way that different functions are combined. The combination of an apartment buildings covering a fresh food market which contains food shops, restaurants, supermarkets and an underground parking has made the Markethal more especial [10].

The Rotterdam Centraal Station (Figure 5) architecture also won multiple awards including the International Brunel Awards, the American Architecture Prize and the Living Daylight Award [16].

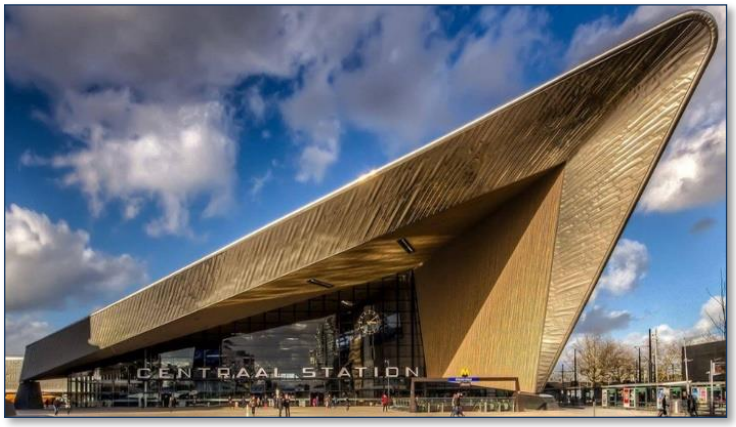

Figure 5: The Rotterdam Centraal Station [16]

Central Station of the city of Rotterdam has been renewed in recent years. The current structure of the Centraal Station is one of the most iconic architectural features in Rotterdam. The roof is partly covered in solar panels. Some of the historic features from the former station building (1957) have remained intact in the new building such as the original clock in the front façade and the letters spelling out Centraal Station. Additionally, two of the granite sculptures on platform 1 has also remained in the new building [16].
Rotterdam Central Station is known as the international gateway to Rotterdam. Nearly 110,000 travellers pass through Central Station every day to catch bus, tram, metro or train [16].

3.2 Bridges

The Rotterdam bridges also play an important role in characterising the city. Most importantly they facilitate the transportation between different part of the city. Some of the most famous bridges are known as Erasmus Bridge, Willems Bridge and Hartelfietsbrug (Hartel cycle bridge) [18].
The Erasmus Bridge with the lengths of 800 meters is made of light-blue steel, with rows of 40 steel cables across the water.

Figure 6: The Rotterdam Erasmus Bridge [21]

The highest point of the bridge is 139 meters. The Erasmus Bridge has been designed by Ben van Berkel and opened in 1996. The Erasmus Bridge has also been labelled by locals as "The Swan" due to its distinctive shape [18]. The Hartel cycle bridge is the longest cycle bridge of South Holand. It connects Spijknisse to the Rotterdam port with the length of 600 meters and has been opened on 2011 [37].

Willems Bridge (Figure 7), the red bridge with a total span of 318 meters connects the north and south of the city of Rotterdam. The 'Willemsbrug' (Willems Bridge) has been opened in 1878 and completely renovated in 1981 [19], [20].

Figure 7: The Rotterdam Willems Bridge [20]

3.3 Public Spaces

Rotterdam has many public parks such as "Het Park", green spaces and gardens which are easily accessible within the city and provide great possibilities for outdoor activities [20].

After fifty years of rebuilding the destroyed city centre of Rotterdam, the city started a programme for redesigning the public spaces and creating new spaces. Old harbour areas like Kop van Zuid which is located on the south bank of the Meuse River in the city of Rotterdam has become the new focal points for urban development. It has been redesigned into a new mixed use town centre. The redesigning has been carried out with the aim of converting the car dominated streets and squares of the centre into an inviting and attractive public domain [21]. Afrikaanderplein is a former football ground that is adjacent to the Kop Van Zuid area. This site was also redesigned into a public park offering a weekly market, play ground [22].

3.4 Universities

Universities are considered as vital entities in each society which can influence almost the whole population. In the Netherlands educational policy is managed by the Dutch Ministry of Education, Culture and Science in coordination with municipal governments [23]. University education in the Netherlands has been claimed to have a high quality and to be internationally recognised [24].

Similar to many countries, there are two main types of universities in the Netherlands; first group of universities are universities of applied sciences and the second type are considered as research universities. The former comprise of general institutions and institutions specializing in a particular fields, such as agriculture, fine and performing arts or educational training, while the latter comprises of twelve general universities as well as three technical universities.[23]

Among the different universities in Rotterdam, Erasmus University is one of the known multicultural universities of the city [23]. Erasmus University Rotterdam is a public university located in Rotterdam, Netherlands. The university is named after Desiderius Erasmus Roterodamus, a 15th-century humanist and theologian [23]. Located in the Netherlands in the city of Rotterdam, Erasmus University, known for its global mindset, offers the chance to join a truly international environment. The university has 5,000 international students, comprising of just under 20% of the whole student body. Furthermore, 40-60% of students are enrolled in English-taught programs coming from outside the Netherlands [25] (part of the university has been visited during the field trip).

4 Transportation in Rotterdam

Dutch people travel on average more than 11 thousand kilometres a year. Most kilometres are made commuting by car but for short distances people often ride their bicycles. Although the most common means of transport is the car, the Netherlands is a real 'bicycle' country; Dutch people own 22 million bicycles and ride nearly 1,000 kilometres a year per person [12]. The modal share for different modes of transport in the Netherlands are presented in Figure 8.

Mobility and transport in the city of Rotterdam is characterised by different modes ranging from walking, cycling, public transport (metro, tram and bus) and car driving to water taxis. The transport system is known for its intelligently integrated, functional and efficient capabilities. Despite the various numbers of transport modes, more people appear to prefer bicycles [39].

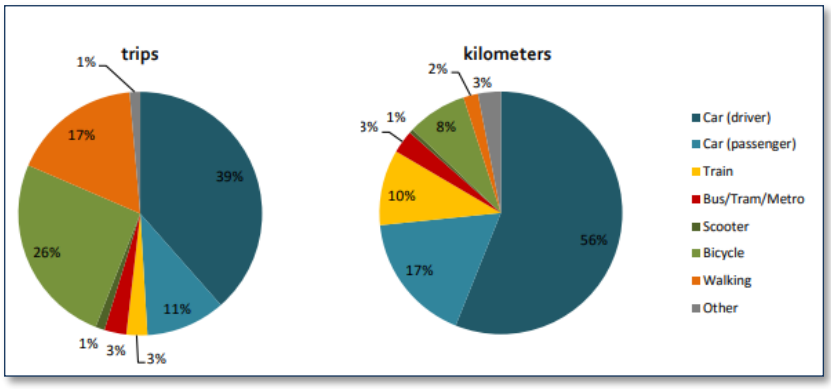

Figure 8 : Modal split in the Netherlands (2016) [36]

According to [31], [36], the modal share of bicycles measured in kilometres is relatively small by most cyclists. Despite this fact, cycling has a very significant modal share in the total number of trips (Figure 8).
The Netherlands' transportation mode preference statistics shows that the modal share in 2017 journeys in some regions reaches beyond 50%. Utrecht, with 51%, is leading for the journeys made by bike. Amsterdam follows with 48% for the trips made using cycling. Rotterdam takes the fourth place in modal share for cycling with 31% share of total trips made in the city right after DenHaag [31].

Based on the reported statistics for the Netherlands , almost all the trips below 7.5 kilometre take place using bicycles. Third of the trips for distances between 7.5 to 15 kilometres are completed by bicycle or e-bike [24].
Modal share is an important component in developing sustainable transport within a city or region [24]. The share of the different modes of transport in the total traffic volume of the city of Rotterdam is presented in Figure 9.

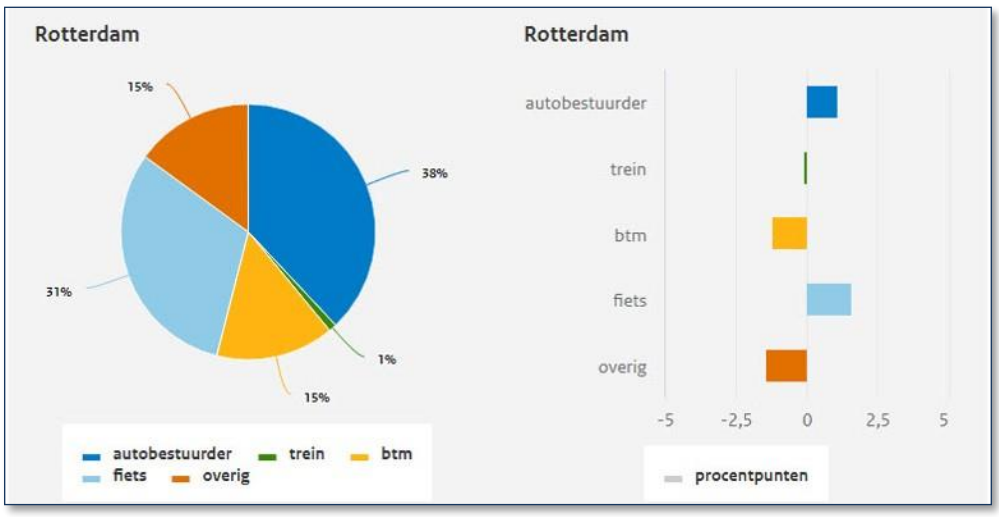

Figure 9: Modal Share in Rotterdam (2016) [26]

In 2016, car driving has been the most used mode of transport in Rotterdam (Figure 9). The cycling mode share for Rotterdam has been reported as 38% [26]. In contrast to Utrecht, Amsterdam and Den Haag car driving is the most preferred mode of choice for Rotterdam citizens.

4.1 Public Transport

The Netherlands has a long tradition of innovations in public transport. The current public transport network has a wide spread regular system consisting of busses, trams, trains and the metros [12], [31].

Initially the railways in the Netherlands, have been operated under different transport companies, they have been merged into one train operator named Dutch Railways (NS) in 1929. In regional public transport merging and integration only began in the 1960s. One of the traditional key features of Dutch public transport is the integration of services. Over the decades, the public transport system increasingly came to operate as one system based on a clear hierarchy of regular interval services: with intercity, semi-fast and stopping rail services complemented by express buses (where there is no rail service) and local bus services. Within the bus network there can also be hierarchies of fast (peak hour), local and community and demand responsive services [41].

The number of passenger kilometres travelled by train increased from 15.2 billion in 2005 to 18.5 billion in 2015, an increase of nearly 22 percent. This amounted to an average annual growth rate of 2 percent over that time period [34], [41].

All Dutch public transport is organised in the form of area or line based concessions, which are governed by governmental authorities. Central government awards the concessions for the mainline rail network and High Speed Line South (HSL South), the local authorities (provinces and urban regions) award concessions for local rail transport, while the regional authorities are also purchasers for urban and regional transport (bus, tram and metro) [43]. The Netherlands has a tradition when it comes to innovations in public transport. Some of them have led to direct innovations for Europe and a global way of thinking applied to public transport.
Examples include [45]:

- the national fixed and symmetrical rail transport timetable (1970)
- the national ticket and fare system for local and regional public transport (1980)
- the broad application of traffic signal pre-emption in favour of public transport,
- the national public transport season ticket for all students aged 18 and over (1991)
- one national telephone number for all public transport travel information (1992)

Rotterdam public transport network has several levels. Multiple trains run through Rotterdam, among which are the high speed connection between Amsterdam and Paris. At a lower level, the city is served by a metro network with five lines and over 50 metro stations. At a few stations a transfer can be made to trains and at most stations a traveller can transfer to a bus and/or a tram [26].

The Rotterdam tramway network, which opened in 1879, is a key element of the overall public transport arrangement in the city. The network currently has nine regular tramlines, and three special or seasonal tramlines. It has been operated since 1927 by Rotterdamse Elektrische Tram (RET). The tram network is the city's more extensive public transport system, while the rapid transit Rotterdam Metro is the more utilized system [30], [35].

The metro system provides the passengers with an easy, quick and efficient commuting in Rotterdam and the surrounding areas. There are five lines (routes) specified with a letter A to E [13]. Beurs station is the biggest metro hub [30]. The Rotterdam metro network belongs to RET, and it transports passengers within and around the city. It is the oldest metro network in the Netherlands, being first opened in 1982 [28].

Bus Rotterdam offers 55 city bus lines with a total length of 432.7 km. RET runs buses in the city of Rotterdam and surrounding places like Spijkenisse, Barendrecht, Ridderkerk, Rhoon, Poortugaal, Schiedam, Vlaardingen, Delft and Capelleaan den IJssel. Arriva Netherlands, Connexxion and Veolia run buses from other cities to Rotterdam [44].

4.2 Cycling

Based on the reported statistics [47], [48], in a national level the Dutch people have travelled 16.3 billion kilometres by bicycle in 2014; nearly 1,000 kilometres per person. The Dutch transportation is characterised by bicycle which is the primary mode for short distances up to 5 kilometres [41]. All together the Dutch own 22.5 million bicycles. This accounts for the highest number of bicycles per capita in the world meaning on average the Dutch own 1.3 bicycles per capita. In terms of distance travelled , bicycle is the third means of transport [46]. The international distribution of bicycles per inhabitant is presented in Figure 10.

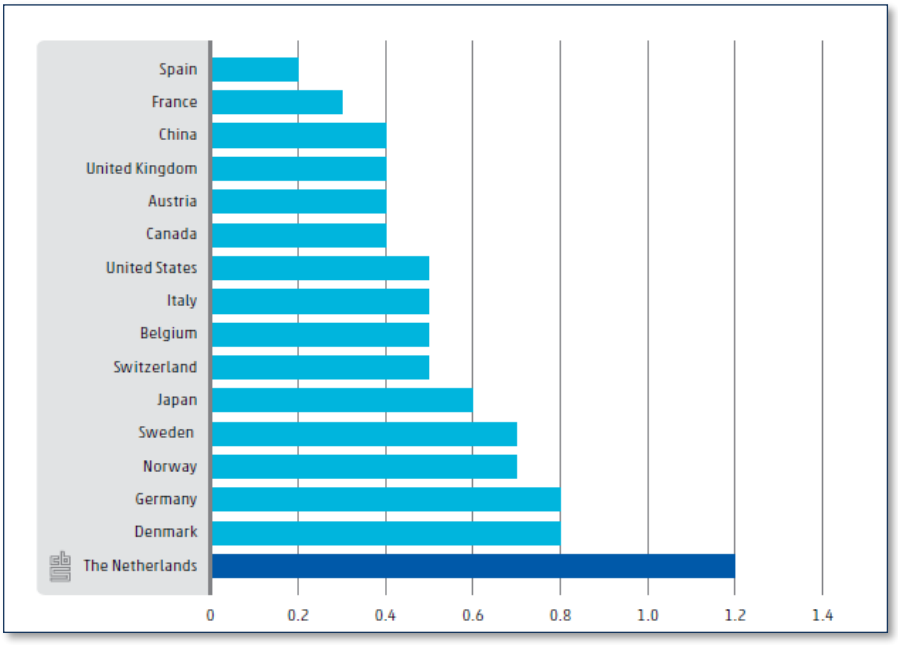

Figure 10: Bicycles per Inhabitant Internationally, 2014 [47]

The bicycle ownership in Netherlands is followed by Denmark with 0.8 bicycles per capita. Surprisingly, Chinese only own 0.4 bicycles per person, just slightly more than the US with 0.3 bicycles per person (Figure 10). The Netherlands modal share of cycling has been more or less stable for a long time now (Figure 8). The bicycle share is around 27% of all trips. Within the cities cycling has increased significantly since 2005. The cycle paths have became noticeably busier in urban areas since 2005 due to the 12% increasing in cycling [36]. The bicycle network growth in the city of Rotterdam is presented in Figure 11.

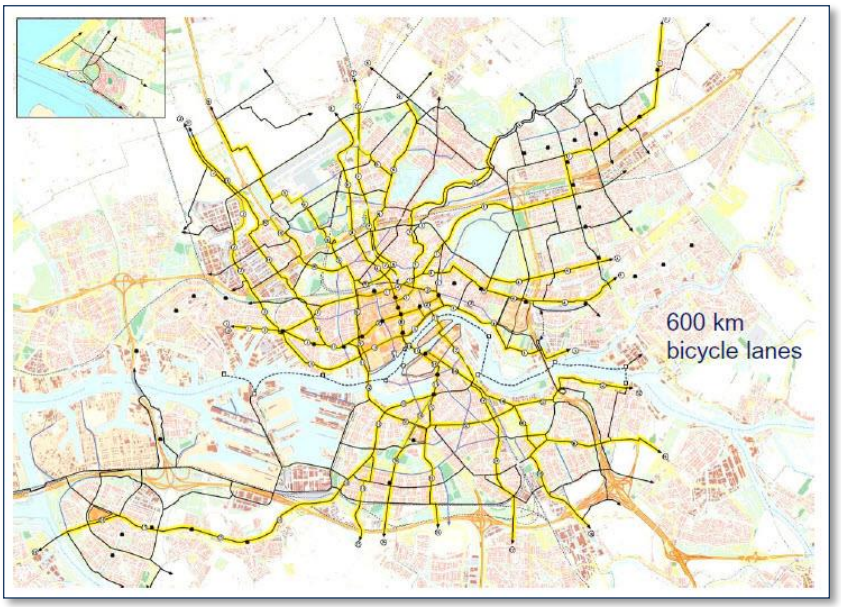

Figure 11: Bicycle Network in Rotterdam 1975-2015 [40]

Cycling has decreased in the country side in Rotterdam. The growing population and the increased use of motor vehicles are some other factors which make the final modal share figure deceptively stable [48].
Figure 11 presents all the different cycling path categories; bicycle-only route, fast bike route and cycle highway in the city of Rotterdam. A bicycle-only route intended for cycling longer distances for practical reasons such as commuting, sport and exercise it can either be called a snelfietsroutes (fast bike route) or a fietssnelweg (cycle highway). Some characteristics of these cycling routes have been defined by governments (both national and local) and traffic experts as;

- bi-directional paths with recommended unidirectional lane widths of 2 metres and minimum widths of 1.5 metres
- very level and straight stretches (i.e. few ups and downs, curves or turns)
- and the absence of traffic lights and level crossings with motorised traffic; and superior pavement quality [40].

Cycling interest groups along with national and local governments, advocate such routes as being a solution for the further reduction of vehicular traffic congestion in the area. Through providing and use of cycling paths, cyclists can achieve higher average speeds than on the usual types of cycling infrastructure, so cyclists are better able to compete with the car drivers for longer commutes [33]. As

of 2012, cycle highways have been constructed; one between Rotterdam and Delft and one between Nijmegen and Arnhem (the RijnWaalpad). Most fast-cycling routes/cycle highway projects are not entirely purpose-built, but they do upgrade existing infrastructure and add missing links between them [33], [40].

In 2016, bicycle was the most important mode of transport for commuting to work within the centres of the urban areas of Amsterdam and Utrecht when car is used more often in Rotterdam and Hague. The bicycle-use trend in Rotterdam between the years 2001 till 2014 has been shown in Figure 12. According to the presented results in Figure 12, the tendency for using bicycle has increased by 60% . It has been used more for work trips during the last few years [45], [52].

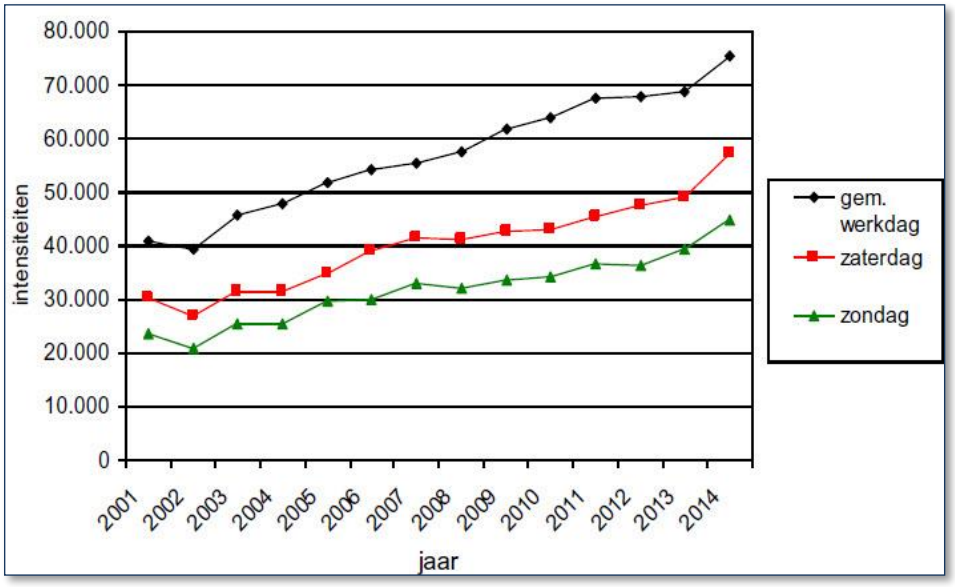

Figure 12: Bicycle Use Trend in Rotterdam [52]

Bicycle use has grown by nearly 12% since 2005. Dutch people cycle more frequently and further distances to pursue educational and leisure time activities. Moreover, the distances that people commute by cycling are now longer than they were 11 years ago [51]. E-bikes partially contributed to this increased bicycle use rate. E-bikes have become more popular among all members of the society, younger generation in addition to senior members of society. In total, e-bicycles account for 16 percent of all bicycle kilometres travelled by people aged 12 and older. The number of kilometres travelled by foot has also increased by 11 percent since 2005, with people particularly walking more frequently and for longer distances in order to engage in leisure activities [41], [52].
E-bikes have been using increasing and rapidly in all European countries. The number of sold bikes in Netherlands is illustrated in Figure 13. In 2015 nearly 1 million bicycles were sold and in 2017, 31% of all bikes sold were e-bikes with the value of around 294,000 Euro. According to the presented figures (Figure 13), one out of four sold bicycles was an e-bike [48].

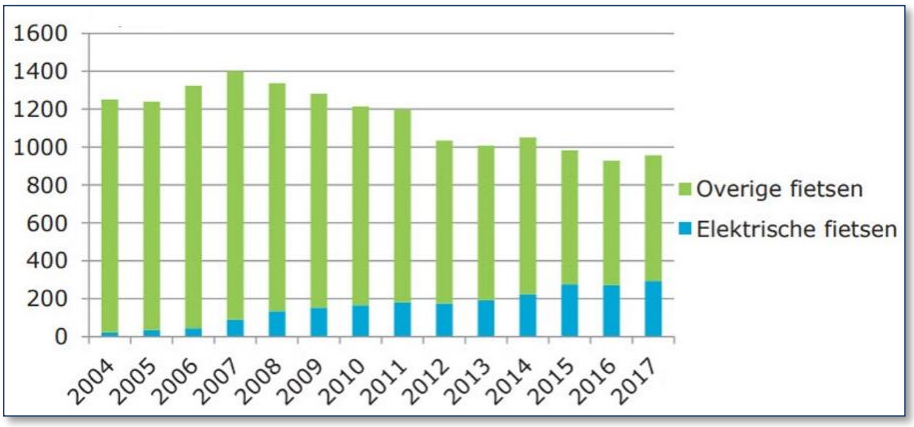

Figure 13: Electric Bike Trends in the Netherlands [48]

More than a tenth of all cycling kilometres are covered by e-bikes. People cover 1.5 times more distance with an e-bike than with a standard bike. However, the e-bike is also increasingly used for shorter distances [48].

4.3 Car Driving

The number of passenger cars also shows an increasing trend in the Netherlands (Figure 14). According to national statistics office CBS, there are almost eight million cars in the Netherlands. It can be estimated as less than a car for each two inhabitant [47], [49].
Number of cars have been increased by nearly 28% since the record began, increasing by 1.5% in 2015 as well. At the beginning of 2016, the Dutch population owned 7.9 million cars, compared with five million 25 years ago, crossing the 8 million mark for the first time. At the beginning of 2017, number of car passengers are estimated at 8.2 million. The 7 million mark was already crossed a decade ago. 1963 confronted over one million cars for the first time in Dutch history [43], [52].
The number of motorcycles and mopeds has risen continually as well. The number of commercial vehicles has remained unchanged. The lowest number of car ownership is in Amsterdam where one in four people own a car [52].

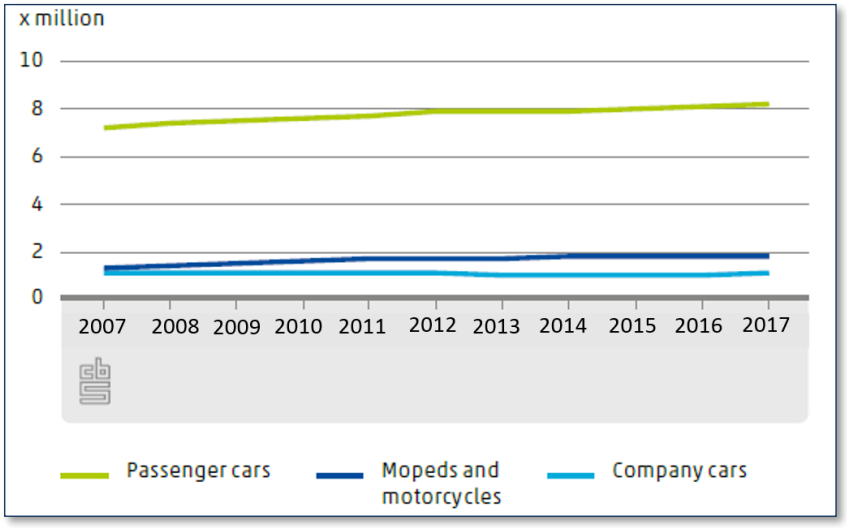

Figure 14: Number of Passenger Cars in the Netherlands [52]

At early 2016, nearly 211 thousand electric and hybrid passenger cars were registered in the Netherlands. The majority of this group, 124 thousand, consisted of regular hybrid cars. There were also 76 thousand plug-in hybrids. Beside hybrids, there are also nearly 10 thousand fully electric cars, with just one electric engine [51]. Sales of these vehicles accelerated over the last year (2017). On 1st of January 2018, there were nearly 22 thousand Fully Electric Vehicles (FEVs) in the Netherlands, 60% increase comparing with the previous year . The total fleet of FEVs and Plug-in Hybrid Electric Vehicles (PHEVs) increased by nearly 9% in 2017, according to the figures released by Statistics Netherlands (CBS). Out of all new car sales in the Netherlands in 2017, 2.7% consisted of plug-in electric vehicles. The Netherlands maintains its top position in the EU in this respect; only Sweden has a higher share with 5.2% (Figure 15). In 2014 and 2015, the absolute number of FEVs and PHEVs sold in the Netherlands was the highest in the EU [51].

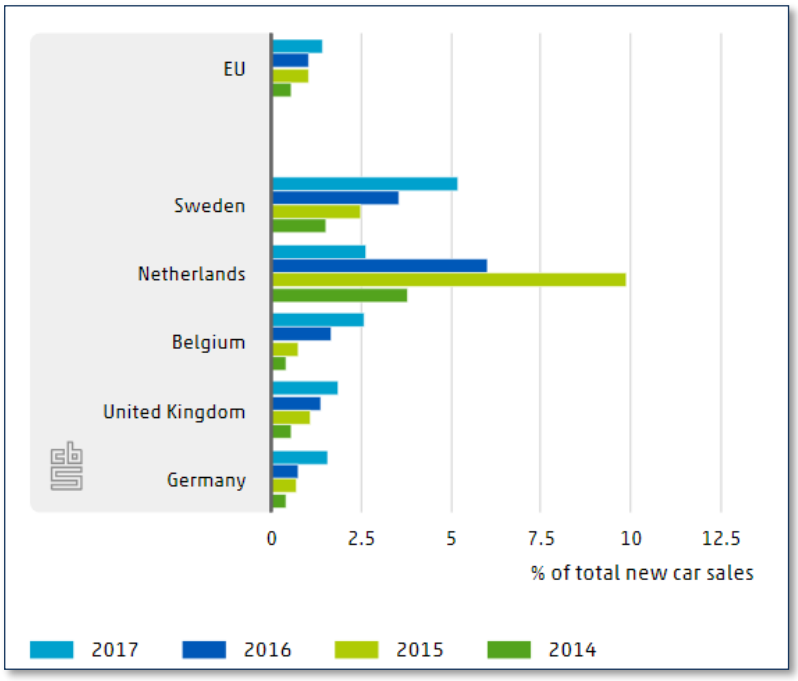

Figure 15: Sales of Plug-in Electric Cars [47]

The trend in car use in different areas of Rotterdam are presented in Figure 16. According to the presented results, there is no growth in car use in the urban areas in Rotterdam (the blue area and line on the map and graph in Figure 16).
There is a considerable level of growth in car use in the rural area of the Rotterdam (yellow doted line) [40].

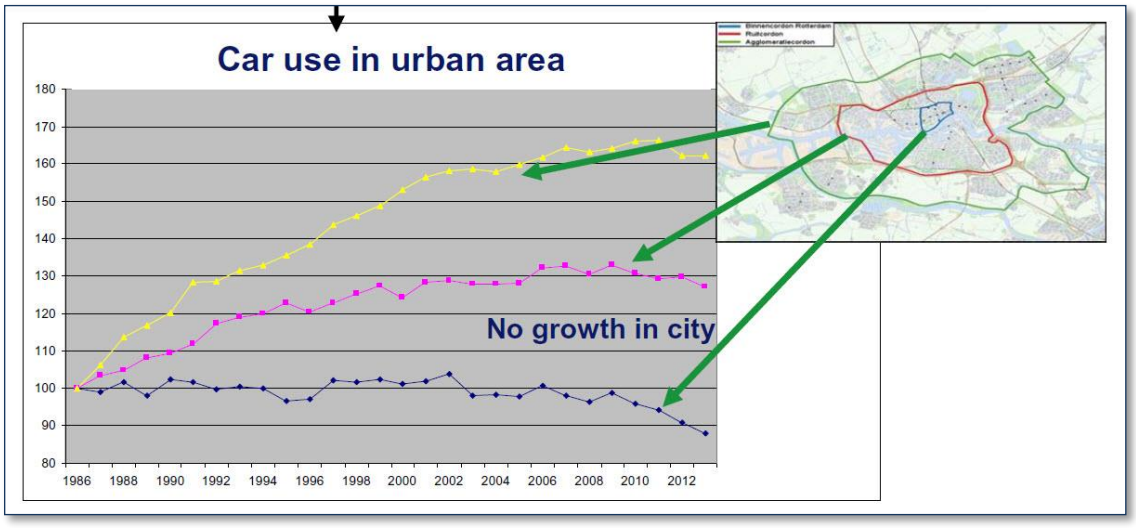

Figure 16: Car use in Urban Areas in Rotterdam [40]

4.4 Sustainability and Future Transport Plans

In the last few decades, sustainability has become a growing focus and a goal to achieve in many countries. By switching to alternative fuels, the use of sustainable infrastructure and sustainable materials, fully sustainable systems can be achieved. In mobility, by the use of technological and social developments, greater sustainable opportunities can be obtained to address the existing issues [48].

Transportation, energy and buildings are to a high degree green in the Netherlands. Public transport plays an important role in this achievement. The most remarkable aspect of Dutch sustainable culture is its population's effort to travel fuel-free. According to the "Administrative Agreement on Zero-Emission Public Transport", the entire bus fleet will be emission-free in 2030 in the Netherlands [49]. Based on their future vision "Together We Can Achieve a Carbon Neutral Rail Service" the entire rail sector is stated to have a carbon neutral footprint by 2050. In addition removing all the gas and diesel vehicles from the roads by 2030, will make the country a leader in sustainable regional and urban transport [50]. Through combined efforts in transportation, energy and industry, the Netherlands' sustainable infrastructure serves to reduce the country's carbon footprint. The Netherlands has committed to providing 50% of the county's electricity through sources such as wind and solar by 2025 [51].

5 Excursion and Personal Observations

The 2018 summer semester field trip "Zwischen Hafen und Radhighway (Rotterdam, Houten, Nijmegen, Münster)", took place on 3rd to 9th of June 2018. The great starting point was the Netherlands; the bustling, beautiful and historic city of Rotterdam followed by Houten, Nijmegen and Münster. Due to the efficient scheduling, organising and arrangement of the field trip, the most important, useful and interesting features of each visited city was explored by the group. The appropriate timing of the excursion made some spare time available during the stay in each city for some additional personal observation and exploring.

The city's important characteristics in terms of transport, cycling and the university were investigated during the stay in Rotterdam. Visiting Rotterdam started with an interesting presentation (related to the history of the university, the city and the port of Rotterdam) in the Erasmus University. It was then followed by visiting the Centraal Station Rotterdam and receiving the useful information about the newly designed Station, as well as the huge underground and roadside bicycle parking area nearby the Centraal Station. The last day of staying in Rotterdam (05.06.2018) was dedicated to visiting the amazing port of Rotterdam and most importantly visiting the modern intelligent facilities of the port.

The small green city of Houten was visited with the group on 06.06.2018. Visiting the Radbound University, cycling through the city and attending three interesting lectors have enriched the stay in Houten.

Nijmegen, known as the oldest city in the Netherlands, was visited before ending the field trip in Münster. Nijmegen, with its beautiful sunset over the Waal river and arch bridge as well as the interesting cycling experience, pleasantly ended the Netherlands trip.

The last day of the field trip was spent in the rainy Deutsch city of Münster. Visiting the Netzplan der Stadtwerke Münster, bus tour through the city and experiencing cycling under the rain through the city of Münster finalized the field trip in summer semester 2018.

Traveling has the capacity of enriching personal skills in a very broad aspect. This enriched experience can be more valuable and more feasible in group travels; more specifically in a diverse group. Participating in field trips during studying is a great opportunity to learn even more and enrich university life and further build upon that experience. This summer semester field trip provided just that.

Bibliography

[1] Couvreur.home. (2018) . "Rotterdam's history in a nutshell". (accessed on: 24.05.2018). [Online]. Available at: https://couvreur.home.xs4all.nl/engl/rdam/history.htm.

[2] eupedia. (2018). Interesting facts about the Netherlands. (accessed on: 28.09.2018). [Online]. Available: https://www.eupedia.com/netherlands/trivia.shtml

[3] R. de Ruite. (2013). ROTTERDAM (800-1570). (accessed on: 28.09.2018). [Online]. Available: https://web.archive.org/web/20160305123510/https:/www.rotterdam.nl/tekst:bescheiden_begin

[4] Encyclopaedia Britannica. (2016). "Rotterdam NETHERLANDS". (accessed on: 24.05.2018). [Online]. Available: https://www.britannica.com/place/Rotterdam-Netherlands.

[5] Wikipedia. (2018). Provinces of the Netherlands. (accessed on: 24.05.2018). [Online]. Available: https://en.wikipedia.org/wiki/Provinces_of_the_Netherlands.

[6] Rotterdam vanaf de Euromast. (2018). Rotterdam Population 2018. (accessed on: 28.09.2018). [Online]. Available: http://worldpopulationreview.com/world-cities/rotterdam-population/

[7] Centraal Bureau voor de Statistiek. "Total population of Rotterdam from 2007 to 2017". (accessed on: 06.09.2018). (2018). [Online]. Available: https://www.statista.com/statistics/753250/total-population-of-rotterdam/

[8] Wikipedia. (24 August 2018) . Transport in the Netherlands. (accessed on: 28.09.2018). [Online]. Available: https://en.wikipedia.org/wiki/Transport_in_the_Netherlands#cite_note-1

[9] Erasmus University Rotterdam.(11 Apr 2018)." Six reasons why Rotterdam is the best city for urban planners". (accessed on: 06.09.2018). [Online]. Available: https://www.ihs.nl/en/news/six-reasons-why-rotterdam-best-city-urban-planners

[10] Markthal Rotterdam (MVRDV). (08 Oct 2014). (accessed on: 28.09.2018).[Online]. Available: https://www.archdaily.com/553933/markthal-rotterdam-mvrdv

[11] Groenendijk, L., Rezaei, J., & Correia, G. (2018). Incorporating the travellers' experience value in assessing the quality of transit nodes: A Rotterdam case study. Case Studies on Transport Policy.

[12] Transportation Research Board. (2001)."Public Transport in the Netherlands".(accessed on: 28.09.2018).[(Feb 6 2006). [Online].Available: https://trid.trb.org/view/775263

[13] "Metro in the Netherlands". (accessed on: 28.09.2018). [Online]. Available: https://www.iamexpat.nl/expat-info/transportation/dutch-public-transportation/metro

[14] Rotterdam Tourist Information. (2016). "Public transport in Rotterdam". (accessed on: 28.09.2018). [Online]. Available: https://en.rotterdam.info/visitors-info/in-rotterdam/

[15] Ministry of Transport "Public Transport in the Netherlands" in Public Works and Water Management, 2010

[16] Rotterdam Tourist Information. (2015)."Centraal Station Rotterdam". (accessed on: 28.09.2018). [Online]. Available: https://en.rotterdam.info/locations/centraal-station-rotterdam/

[17] Winston, Anna, 2016. “17 of the architecture projects helping to transform Rotterdam”. (accessed on: 24.05.2018). [Online]. Available: https://www.dezeen.com/2016/01/20/17-architecture-projects-helping-transform-rotterdam-netherlands/.

[18] Holland.com. “Erasmus Bridge”.(2014). (accessed on: 28.09.2018). [Online]. Available: https://www.holland.com/global/tourism/destinations/rotterdam/erasmus-bridge-rotterdam.htm

[19] Holland.com. “Willemsbrug”. (2015). (accessed on: 28.09.2018). [Online]. Available: https://www.holland.com/global/tourism/destinations/rotterdam/willemsbrug.htm

[20] B.V.Putten,.(2016). (accessed on: 28.09.2018). [Online]. Available: https://rotterdamstyle.com/informative/the-bridges-of-rotterdam

[21] M.CAMPBELL, (2014).(accessed on: 28.09.2018). [Online]. Available: https://mabrycampbell.wordpress.com/2015/04/24/erasmus-bridge-rotterdam/

[22] DE URBANISTEN. “Rotterdam public space” .(2015). (accessed on: 28.09.2018). [Online]. Available: http://www.urbanisten.nl/wp/?portfolio=rotterdam-public-space

[23] Education in the Netherlands (2018). (accessed on: 28.09.2018). [Online]. Available: https://en.wikipedia.org/wiki/Education_in_the_Netherlands

[24] “Dutch Higher Educatin”.(2018). (accessed on: 28.09.2018). [Online]. Available: https://www.ru.nl/english/education/bachelors-programmes/parent-website/practical-information-ba-international-parents/more-information/dutch-higher-education-why-study-netherlands/

[25] “Erasmus University Rotterdam”.(2015). (accessed on: 28.09.2018). [Online]. Available: https://www.topuniversities.com/universities/erasmus-university-rotterdam

[26] M.Murel.“Green spaces in urban areas and human health: Exploring the connections ”. Master Thesis. Utrecht University .2013.

[27] City Rotterdam. “Parks in Rotterdam”.(2017). accessed on: 28.09.2018). [Online]. Available: https://www.cityrotterdam.com/en/visit/parks-rotterdam/

[28] Sutton, Mark. “Netherlands further builds on cycling’s modal share, hitting 51% in Utrecht”. (September 6, 2018). (accessed on: 06.09.2018). [Online]. Available: https://cyclingindustry.news/netherlands-further-builds-on-cyclings-modal-share-hitting-51-in-utrecht/

[29] Van de Velde, D. M., & Eerdmans, D. (2016). Devolution, integration and franchising-Local public transport in the Netherlands.

[30] Cycling Expertise .“The Cycling Mode Share in Cities” .in German Institute of Urban Affairs (Difu). 2012.

[31] P.Bakker, H.Derriks and J.Francke, Netherlands Institute for Transport Policy Analysis. “Mobility report 2016 (English)”. Ministry of Infrastructure and the Environment. 2017.

[32] P.Bakker, H.Derriks and J.Francke, Netherlands Institute for Transport Policy Analysis. “Mobility report 2017”. Ministry of Infrastructure and the Environment. 2018.

[33] J.Walljasper. “How to Make Biking Mainstream: Lessons from the Dutch”(Sep 29, 2010). (accessed on: 28.09.2018). [Online]. Available: https://www.yesmagazine.org/planet/how-to-make-biking-mainstream-lessons-from-the-dutch

[34] Schmidt, M., & Voß, S. (2017). “Advanced systems in public transport.”

[35] Wikipedia .“Trams in Rotterdam”.(16 July 2018). (accessed on: 06.09.2018). [Online]. Available: https://en.wikipedia.org/wiki/Trams_in_Rotterdam

[36] Bicycle Dutch. “Dutch cycling figures”.(2 January 2018). (accessed on: 06.09.2018). [Online]. Available: https://bicycledutch.wordpress.com/2018/01/02/dutch-cycling-figures/

[37]] Wagenbuur, Mark, 2011. Hartelfietsbrug near Rotterdam. BICYCLE DUTCH, (accessed on: 24.05.2018). [Online]. Available: https://bicycledutch.wordpress.com/2011/12/15/hartelfietsbrug-near-rotterdam/.

[38] Kroesen, Harms, Maarten, Lucas, 2018. User characteristics and trip patterns of e-bike use in the Netherlands. TU Delft KiM Netherlands Institute for Transport Policy Analysis, 2, 34.

[39] Directorate-General for Communication (DG COMM), “QUALITY OF TRANSPORT” in Special Eurobarometer 422a, 2014

[40] J.Akkerhuis, “Bicycle policy Rotterdam ”, in Gemeente Rotterdam, 2016.

[41] M.J. Van Strien, “National Data Warehouse for Traffic Information The Dutch approach”, in National Data Warehouse for Traffic Information, 2010.

[42] P.Langenberg,“Making sustainability a way of life for Rotterdam (Rotterdam Programme on Sustainability and Climate Change 2015-2018)”, in Gemeente Rotterdam, 2016.

[43] “Almost one in two people own a car in the Netherlands”.(August 22, 2014). (accessed on: 28.09.2018). [Online]. Available: https://www.dutchnews.nl/news/2014/08/almost_one_in_two_people_own_a/

[44] Statistics Netherlands (CBS). (August 22, 2014). (accessed on: 28.09.2018). [Online]. Available: https://www.iamexpat.nl/expat-info/organisations/statistics-netherlands-cbs.

[45] A.Tjin, V.Tsoi, “Transport and Mobility 2016”, in Statistics Netherlands, 2016.

[46] CBS, “Trend in the Netherlands 2017”, in Statistics Netherlands, 2017

[47] CBS. “Number of all electric cars increasing rapidly”. (24.05.2018) . (accessed on: 28.09.2018). [Online]. Available: https://www.cbs.nl/en-gb/news/2018/21/number-of-all-electric-cars-increasing-rapidly

[48] Government of Netherlands. “The future of public transport”. (24.05.2018) . (accessed on: 28.09.2018). [Online]. Available: https://www.government.nl/topics/mobility-public-transport-and-road-safety/public-transport/the-future-of-public-transport

[49] Ministry of Infrastructure and Water Management .“Transfer to 2040, Flexible and smart public transport”. January 2018.

[50] Kuijpers, H. “Transportation, energy and buildings are all greener in the Netherlands”.(20 April 2018). (accessed on: 28.09.2018). [Online]. Available: https://investinholland.com/dutch-lead-sustainability/

[51] Vermie, A., & Blokpoel, M. (2009). “Rotterdam, city of electric transport”. World Electric Vehicle Journal, 3(3), 581-588.

[52] CBS. “Number of Passenger Cars in the Netherlands”.(2017) . (accessed on: 28.09.2018). [Online]. Available: https://www.iamexpat.nl/expat-info/organisations/statistics-netherlands-cbs

List of Figures

List of Abbreviations

RTE	Rotterdamse Elektrische Tram
HSL	High Speed Line
CBS	Central Agency for Statistics
FEV	Fully Electric Vehicle
NS	Dutch Railways
PHEV	Plug-in Hybrid Electric Vehicle