Implementation of sustainable mobility on emerging housing growth needs in suburban areas

The case of Ravnsborg Enge in the Municipality of Køge

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Preface

Although the traditional approach in issues emerging from the transport sector would recommend adjustments on the infrastructures and the surrounding urban environment, the municipality of Køge desired a collaboration with Sustainable Cities' students in order to tackle these issues by relying on alternative methods that focus on the better use of the existing infrastructure and discourage unsustainable behavior. My collaboration with the municipality of Køge in order for me to create this thesis came through the connection of my supervisor Dr. Andres Felipe Valderrama Pineda and municipality officials that had stated these transportation issues and their desire to collaborate.

Through my initial meeting with Mr. Jacob Skjødt Nielsen (Green ambassador for the municipality of Køge) and Mr. Ulrik Djupdræt (Traffik planner for the municipality of Køge), I was presented with some transportation system issues projected that concern the municipality and could be addressed in this thesis. At first, I was presented with a traffic projection forecast which stated that there will be a rapid growth in traffic in some streets of the municipality. The street that was presented as an example and potential under-study area was Søndre Viaduktvej which was expected to have a traffic increase of 96% in the following years.

There was no pressure on choosing the aforesaid street as a study area but more as an example on which issues the municipality wants to act on. After examining the area and discussing with the two officials, there were some issues getting in the way of interfering with the form and use of this street. First of all from my point of view, the street is functioning as a main road quite broad and therefore is not easily eligible for reforming (limiting car access, introducing cycling and walking to replace car use in the road). In addition, the two officials mentioned that its use is mainly for cars passing by and not entering Køge, so its traffic flows are coming from other areas (Hårlev and Strøby, south of Køge) and connect to Sydmotorvejen. So there was not any potential plan of using sustainable mobility practices in order to counter the traffic issues forecasted for the area. Instead there is a plan under consideration which suggests a connection of these two areas to the Sydmotorvejen

through a new road passing across from the bay all the way to Sonnerup, connecting with the ring road.

After establishing that the initial proposition was not eligible for a thesis project and that the two officials had this proposition for them to show me their disposition on the issues they want to act on, two further under-study cases were presented to me. The first one concerns the area around North Køge and more specifically the area around the Sjællands Universitet Hospital including the institutional area in Køge Campus and the logistics area hosted in Nordhøj street. The idea is to introduce sustainable mobility practices in order to counter the issue of potential traffic inflow of health workers that will eventually be employed by the hospital and will mainly be residents outside of Køge, in addition to visitors' inflow. Also there is the addition of logistics' workers and students using the transport network in the area either by car or by train or by bus.

The unofficial initial suggestions from the two officials were either constructing a new train station in the junction established in the area, providing a meeting point closer to all these three establishments. There were also suggestions about improving the bike lanes and their accessibility to reduce road demand and use, carpooling through workers' communication and improvement of the bus function to be more efficient for all of these three establishments. Through personal choice I decided not to proceed with this case as the complexity and the importance of the area in combination with the time I had available did not seem to be realistic to complete my thesis on time having this project as a content.

The other project suggested concerns the Ravnsborg-enge upcoming residential area, which is placed in the southern part of Køge and is delimited by Egøjevej street from the East, the railroad from the north, Husmandsvejen from the south and Hastrupvej from the west. This area is owned by Mr. Jesper Bælum and Mr. Claus Bælum who will also develop the area. The emerging issue in this area's creation is its connection to the road network around it. The solutions should be aligned with sustainable mobility principles, take into account the surrounding residents' opinion and effects on them and maintain the attractive design that the

area wants to introduce (leisure, mobility, biodiversity and community)(Ravnsborg Enge, 2023).

The vision and the design direction followed by the developers are aiming towards the creation of an area that *“Must be a vibrant community that combines high quality of life with a sustainable lifestyle. The district must make an active contribution to the green transition and contribute to meeting the Køge Municipality's climate plan.”*. The choice of Ravnsborg-Enge as the under-study area is based on the desire of the municipality officials to provide sustainable mobility solutions to a new residential area and use them as a directive or as an example for potential housing growth needs and the approach of the owners on the creation of the area.

After establishing the under-study area and starting the data gathering process, I was presented with an area that is named Køge Fælles Jord which can be found in the northern part of Ravnsborg enge and serves as the northern border of the area. This piece of land is owned by the municipality and initially was in service of a program that helped people that faced mental and other relevant challenges. It was used as a land that activities relevant to natural environment preservation and cultivation could be in place. Eventually some of the members of the program along with some volunteers shared their interest of inhabiting the area and creating a project of sustainable living in terms of using the resources given by their surroundings and inhabiting the area with the least environmental impact possible.

Through my introduction to this project, I got in touch with mr Lars König, active member of this society, so I can have some insights about the area, its connection to the Ravsnbrog enge plan, the dynamics between actors and potential ideas that could be relevant to my suggestions. Through this meeting I got a solid overview of the negotiation process between actors about the new plan, opinions about what is possible to be done or ideas that could be implemented. Through this interview I designed the extra initiative found in the final analysis that concerns the “brand areas”.

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Introduction

Climate change has become an important global concern and the transport sector is a significant contributor to greenhouse gas emissions. As the world's population continues to grow, the demand for transportation rises and creates the need to understand the intricate relationship between population growth, housing development, and transportation systems (Litman, T. 2019a).

The European Union has decided to address the transport sector's environmental impacts through a Common strategy for "sustainable mobility" which: "should enable transport to fulfill its economic and social role while containing its harmful effects on the environment". To be more clear, sustainable mobility has the aim of taking into account all the related aspects of a society in its planning and success, aside from solely countering transportation efficiency and its environmental hazards. Studies around sustainable mobility have developed for the past 30 years and this development includes changes on the approach on research and policies, which are the impacts of transportation, categories of travel, which scientific sectors must be included, methodological approaches and the research questions set into these studies (Holden et. al, 2019).

This research has brought new views on the sustainability levels of the current mobility system. At first the approach included technological innovation (e-cars, more efficient fuels, etc.) while the current situation has brought new arguments to the discussion. Nowadays sustainable mobility does not focus only on environmental issues but also on civilians' health and quality of the surrounding environment, through the promotion of solutions such as walking and cycling, the effects of motorized vehicles on the air quality and other health related impacts (Ryley et. al, 2019).

Moreover, it is worth mentioning that the demand for transportation is anticipated to rise further due to the substantial global issue of population growth, which carries multifaceted implications for numerous domains, encompassing housing, transportation, and natural resources.. As an example, in Denmark, it is

projected that the population will escalate from 5.8 million individuals in 2020 to 6.2 million by the year 2050 (Statistics Denmark, 2021a). As previously highlighted, such growth exerts its influence across diverse sectors, spanning housing, transportation, and infrastructure. It can be then safely assumed that there is a need for the design for transportation to consider all these aspects, Current discussions on sustainable mobility consider both environmental impacts and the social and economical impacts of an unsustainable mobility system (Holden et. al, 2019).

The municipality of Køge has taken into account all of these aspects that can bring pressure to the urban environment and its functions (transportation demand, population and housing growth) and focuses on planning and developing, for the under construction and to be constructed suburban and other kinds of residential areas, to support a sustainable mobility system. Through this project I will examine the link between transportation and population growth along with housing growth. In addition, I will look into the implemented, proposed and possible-realistic solutions that can support a sustainable mobility network.

Problem analysis

Climate crisis and connection to the transport sector

Climate change is one of the biggest threats facing our planet, and the transport sector is a significant contributor to greenhouse gas emissions. Transportation is responsible for nearly a quarter of global energy-related carbon dioxide emissions, with the majority coming from road transport (IEA, 2021). The impact of transport emissions on climate change is exacerbated by the continued growth of global transport demand, which is projected to increase by more than 50% by 2050 (ITF, 2019).

The transportation sector plays a significant role in the emission production as it is the only sector that has increased in GHG (Greenhouse Gas) emissions (Figure X) and there has been an immediate need for interventions and changes in the planning approach followed until recently, to make the environmental targets (carbon emission reduction, climate change mitigation, etc.) set by the UN and the EU possible to reach (UN, 2021). One source of identifying the type of harm that is coming out of certain fuel use or a specific sector, is their contribution to greenhouse gas emissions. Another important aspect is the level of fuel use, as an increase in use can only bring more pressure from greenhouse emissions and resourcefulness (European Commission, 2021a).

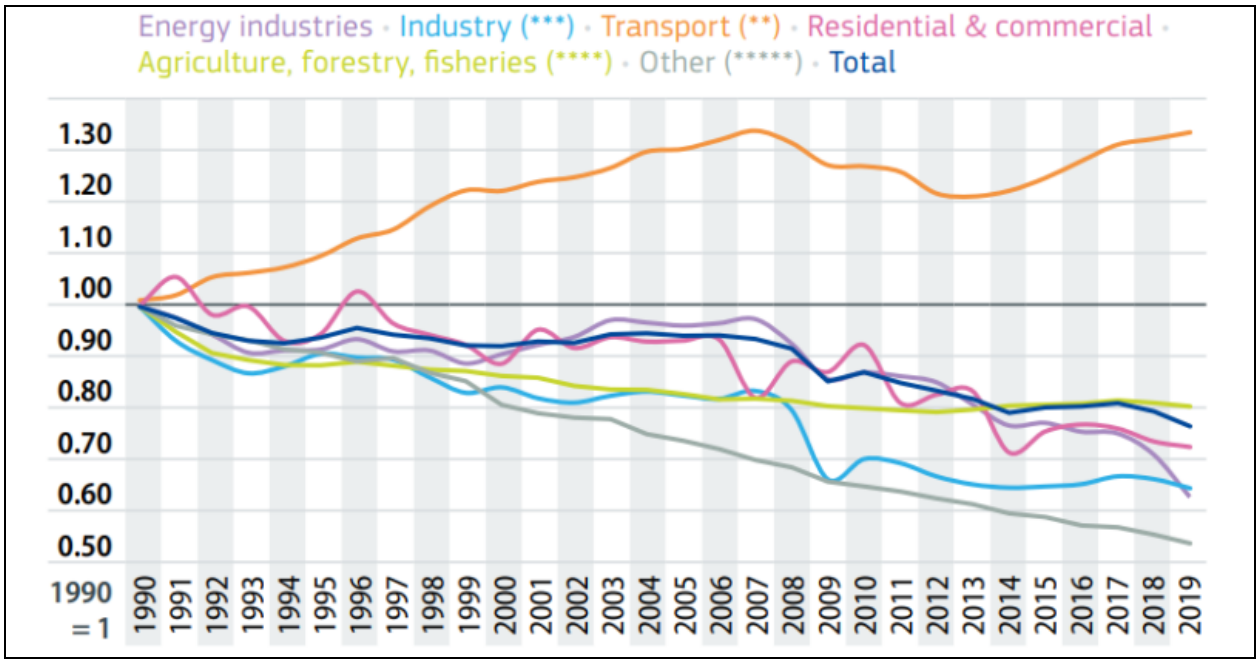


Figure 1: Greenhouse Gas Emissions (GHG) by sector: EU 27 (European Commission, 2021a).

As seen in Figure X Transportation is the only sector showing an almost standard increase in Greenhouse Emissions and already raises concerns about how to counter the issue. The EU's role on achieving international agreements and implementation of initiatives and regulations relevant to the mitigation and protection from climate change is crucial. The EU has started planning around the issue with different initiatives mainly to bring a shift to low-emission mobility and further research on the effects and the reasons behind this standard increase (European Commission, 2021b). The EU commission is optimistic on being able to decrease net greenhouse emissions by 55% by 2030 and this has been planned to happen, among others, by countering problems and exploiting opportunities in different transport modes.

Current approaches to counter the issue are focusing on the efficiency of the sector in terms of time consumption, cost, connection efficiency and technological achievements to boost the development of these aspects. Although as seen above, these approaches have been proven unsustainable and their focus does not include currently discussed issues that are connected to climate change mitigation and

environmental targets that are included in the modern sustainable planning approaches. The development of the approaches will be explained in another section (Bannister, 2008).

Housing growth and transportation demands that occur

Denmark, like many other countries in the world, is experiencing population growth, but it is not projected to reach overpopulation levels. According to Statistics Denmark, the country's population was estimated at 5.8 million in 2020, and it is projected to reach 6.4 million by 2050. This growth is mainly due to immigration, as the country has a relatively low birth rate. However, Denmark's population growth rate has been slowing down in recent years, and it is not projected to reach unsustainable levels (Statistics Denmark, 2021a).

In fact, the Danish government has implemented policies to manage population growth and promote sustainable development. For example, the government has set a goal to reduce greenhouse gas emissions by 70% by 2030, which is expected to help mitigate the environmental impact of population growth. Additionally, the government has implemented policies to encourage sustainable urban development, such as promoting public transportation and affordable housing. It is worth noting that while Denmark is not projected to experience overpopulation, it does face housing challenges due to the population growth and demand for affordable housing (Government of Denmark, 2021).

According to Statistics Denmark, the population in Denmark is projected to grow by around 200,000 people by 2030, with the majority of this growth expected to occur in the largest cities and suburban areas (Statistics Denmark, 2021b). To meet the demand for housing, the Danish government has implemented various measures and policies to encourage new housing construction, including providing financial support for affordable housing, streamlining the planning process, and allowing for denser development in urban areas (World Economic Forum, 2019).

Housing growth’s connection with transportational needs can be explored in various ways. To Begin with, it is obvious that housing growth and increase in

residents in the area also increase the demand for transportation which leads to further congestion on the roads and more pressure on the existing transportation system. These can lead to longer travel times, reduction in accessibility on land uses that concern employment, education and other services, as well as increase in air pollution and carbon emissions (Ewing, R., & Hamidi, S., 2014).

In addition, the structure and the design of the newly built environment affects the ways of travel used by the people. If the newly constructed areas are far away from existing transportation options, the residents may rely on options that are not related to public transportation systems (Sheller et. al, 2006). On the other hand if the new areas are developed to encourage solutions such as active transportation (cycling, walking) or are close to the existing public transportation system, it can reduce the need for cars and promote more sustainable solutions (Litman, 2015).

Finally, it is important to consider the impact of housing growth on land use patterns. Sprawling development patterns, where new housing is built on the outskirts of cities or in rural areas, can lead to greater reliance on personal cars and more fragmented communities. In contrast, compact, mixed-use development patterns that prioritize public transportation and active transportation options can promote more sustainable and connected communities (Litman, 2019c).

Municipality of Køge and their connection to these issues (case)

As stated above, the involvement of the municipality of Køge with the current environmental challenges relies on the design of the DK2020 Climate action plan and Køge's inclusion in the planning towards CO2 neutrality by 2050 (planned reduction of 47% of the 2017 emissions until 2030). Transportation's contribution to the emissions and therefore its environmental impact is an important part of the plan (Local Government Denmark KL, 2020). In the Municipality of Køge transportation makes up a large part of CO2 emissions, and it is essential that these emissions are reduced in order to reach the goals of the Paris Agreement. Mobility accounts for approximately 28% of the municipality's total greenhouse gas account

in 2017, of which road transport accounts for 76% of the total emissions (Transportvaneundersøgelsen, 2019).

The mayor at the time of the Klimate Plan design Ms Marie Stærke has stated among others that *"the municipality is growing, bringing more jobs and citizens as inhabitants in the area"*. The solutions and directions that have been included in the plan were designed in order to form a sustainable future for the area as a whole. Population growth can lead to creation or construction of new areas such as Ravnsborg Enge which is the understudy area of this project (Ravnsborg Enge, 2023).

Problem formulation

How to design a suburban area that supports sustainable mobility?

Research questions

1. How can Ravnsborg Enge be connected to the current transport network by using business as usual solutions?
2. Which are the sustainable mobility solutions that can be used in suburban areas?
3. Which practices can support a sustainable mobility network development in the area?

Research design

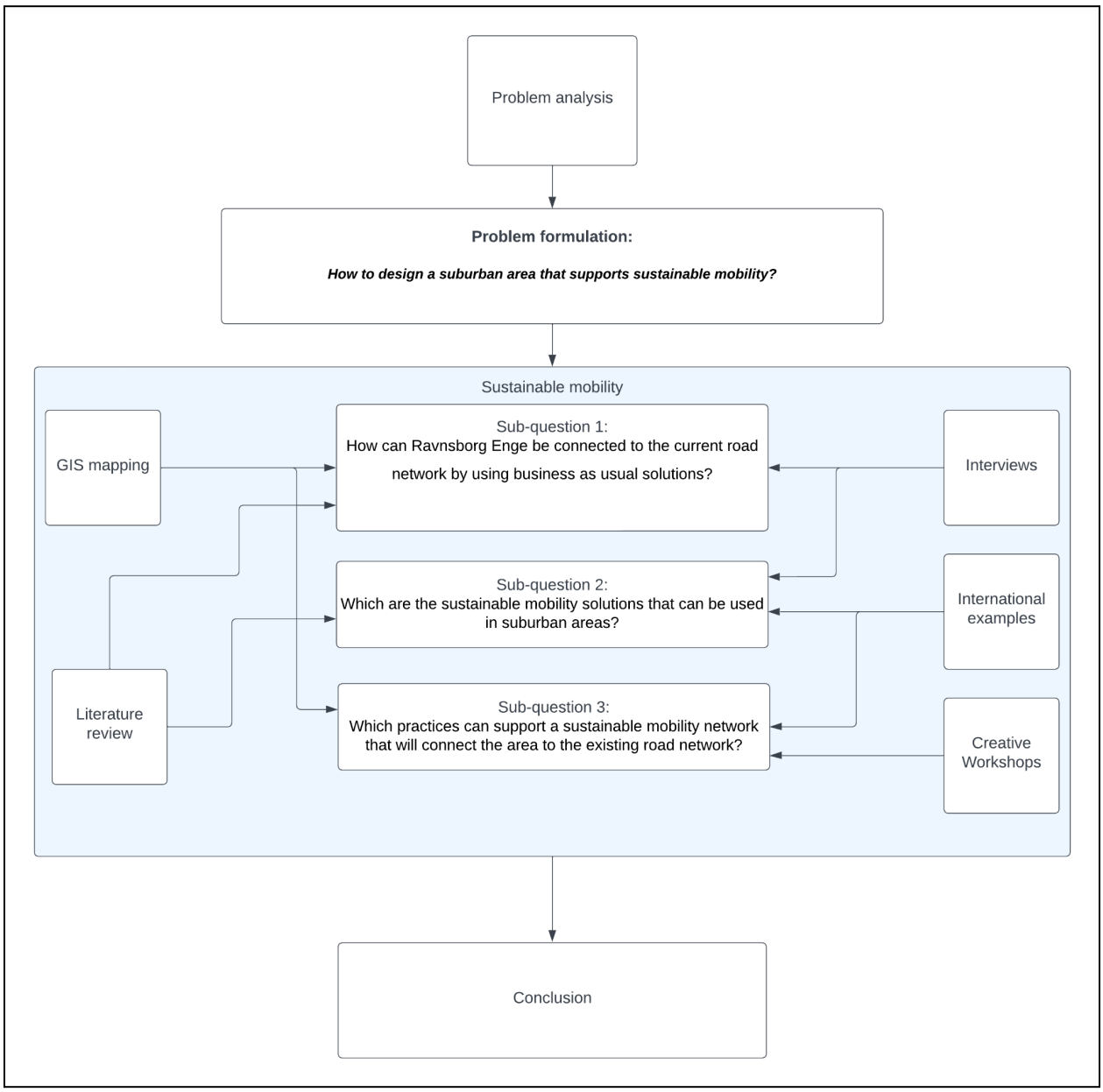


Figure 2: Research Design

This section's use is to visualize and explain the structure of the report, the theories and methods used to form the problem formulation and answer the research questions. As seen in Figure x, this report consists of 3 analyses which are connected to 3 different sub-questions. These analyses aim to explain the existing

situation in Ravnsborg enge and the existing practices, which actors can contribute on the realization of this project, and finally which proposals and actions can help address the initial issue of connecting the area to the road network.

As seen in Figure X the report is based on the concept of sustainable mobility, its modern understanding and the practices that are designed in order to achieve a sustainable mobility system. The connection of the concept of sustainable mobility with the under-study area is explained through the literature review and the examples found in the literature that concern sustainable mobility practices. The literature review will be of additional help in this report on examining past and current practices that concern countering transport system issues (traffic, hazards, etc.) and for examining examples of sustainable mobility practices for situations similar to the under-study area.

In addition, collaboration with the available municipality officials, affected locals and other contributing actors is needed for the construction of a complete image of the current situation, clarifying the potential of the area and designing efficient solutions. In order to achieve this collaboration, interviews with the involved actors as well as workshops that involve the municipality's officials that can contribute to the project were conducted. Finally there is use of photographs of the under-study area and Geographical Information Systems (QGIS) for the visualization of the current state of the area, potential connections and ways to the road network as well as the presentation of the final suggestions with visual aid in order for the readers to have a complete image of the area, its current state and the final view on potential changes.

Theories

The theories section of a thesis is a critical component that establishes the theoretical framework that supports the research. This section identifies and explains the theories, concepts, and principles that underpin the research topic and helps readers understand the significance and relevance of the study. In this section the main and only theory used in this project is presented. As stated in the preface and

the introduction the project focuses on sustainable mobility solutions for a specific area. The only theory that can present the issues and supports the arguments and the development of the solutions is sustainable mobility.

Sustainable mobility is closely connected to sustainability in general as transportation is contributing significantly in the climate challenges that we face at the moment. Sustainability's main goal is to achieve a balance between society, the environment and the economy as to "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (The United Nations, n.d.(a)). Sustainability recognizes the interconnectedness of these three elements and emphasizes the importance of finding long term solutions that address the issues of resource overuse, environmental degradation, climate change, social inequality and economic instability (The UN Environment Programme, n.d.).

Environmental sustainability is the initial term of sustainability and refers to reducing the damage the environment endures and is stated by the UN as "acting in a way that ensures future generations have the natural resources available to live an equal, if not better, way of life as current generations" (The UN Environment Programme, n.d.). This includes resource management and conservation, such as air, water, land, biodiversity and ecosystems. The actions connected to that area pollution minimization, waste reduction, protection of endangered species and preservation of ecological balance (The UN Environment Programme, n.d.).

Social sustainability considers human existence as an integral part of rea;ozomg a sustainable society. It secures the maintenance of the quality of life and well-being within a country, an organization or a community in the long term. This includes equal access to resources, opportunities and benefits for all individuals. The main aim is to give everyone a fair and meaningful participation in decision making processes that affect their lives (UN-Habitat, 2016).

Economic sustainability requires economic systems that use the available resources both efficiently and responsibly to ensure economic growth that is compatible with environmental limits and can also produce an operating profit. Without responsible consumption a company will not be able to maintain its

activities in the long term and if there is no operational profit the economic system cannot sustain its activities (UN, 2015).

Sustainable mobility is directly connected to these aspects as it focuses on the environmental impact of the transport sector and seeks to minimize it through low carbon and alternative modes of transport such as cycling, public transport, walking and Electric Vehicles (EVs). Its contribution to climate change mitigation relies on reducing green gas emissions, air pollution and better resource consumption. In addition, sustainable mobility aims to provide equal access to transport modes for all citizens as it focuses on accessibility infrastructure, affordable transportation, increase in safety and ensuring that transport services can be available to anyone whatever their income, age and physical ability. Finally economic viability is ensured by sustainable mobility through reducing the cost of transportation infrastructure, energy efficient modes and vehicles, welcoming innovation and potential job creation through promoting new technologies. Additionally by promoting active modes of transportation (cycling, walking, etc.) sustainable mobility can support local businesses.

As mentioned above the municipality belongs to a Climate Plan which includes a sustainable design approach to all sectors including transportation and therefore sustainable mobility as a concept, is directly connected to the municipality's future plans. The transport sector challenges that the Municipality of Køge officials want to address are more or less under planning and designing already. This is done through following the "business as usual" approach that will be explained further down. The officials I met, however, have the desire to either complement these solutions with a design and plan more related to the sustainable mobility concept or design and plan solutions that are for the most part aligned with the concept of sustainable mobility and solutions that relate to it.

Sustainable Mobility

Sustainable mobility refers to transportation systems and modes of transportation that are designed to be environmentally and socially sustainable. The goal of sustainable mobility is to provide access to transportation while minimizing

negative impacts on the environment, public health, and social equity (Litman, 2019c). There are several key components of sustainable mobility. These include:

- Active transportation: Modes of transportation that involve physical activity, such as walking and cycling. Active transportation is sustainable because it does not produce greenhouse gas emissions or other pollutants, and it promotes public health and social equity (Pucher et. al, 2012a).

- Public transportation: Transit systems that provide access to transportation for large numbers of people. Public transportation can be sustainable if it is designed to be energy-efficient and low-emission, and if it promotes social equity by providing affordable access to transportation (Transportation Research Board, 2010).

- Sustainable vehicle technology: The development and use of vehicles that produce lower emissions and require less energy to operate. This includes electric and hybrid vehicles, as well as alternative fuel vehicles such as hydrogen fuel cell vehicles.

- Land use planning: The design of cities and communities in a way that promotes sustainable mobility, such as designing walkable neighborhoods, promoting mixed-use development, and reducing dependence on automobile transportation.

- Transportation policy: The development of policies and regulations that promote sustainable mobility, such as fuel efficiency standards, emissions regulations, and funding for sustainable transportation infrastructure.

The European Commision introduced the concept of sustainable mobility over 30 years ago. This concept has been developed over these years and its meaning has gone through certain stages until its modern form.. Initially, sustainable mobility studies focused on the transport sector's impacts on the environment mainly through the development of technological progress of the time. The next generations of studies developed the inclusion of concepts and sectors available for change or creating new perspectives in some aspects (Holden et.al, 2019).

The first generation was primarily on production travel, the second generation was broadened to include reproduction travel and finally the third generation was broadened further to include leisure-time travel. Additionally, between 2000 and 2010 there has been a combined focus on local pollution and congestion reduction, increasing in competitiveness and quality of life which have taken more and more focus over the years. Moreover, the complexity of the transport sector and its planning and the interaction of those aspects with land use was being understood which provided researchers with the view that a sustainable transportation system cannot be provided with a sole concentration on transport efficiency (Holden et.al, 2019).

There are both positives and negatives in designing and implementing solutions that support a sustainable mobility system. One of the positives is the environmental benefits that contribute to greenhouse gas emission, air pollution and noise pollution reduction. Transportation modes such as walking, cycling, public transport and electric vehicles can help mitigate the environmental impact of the transport sector and complement the efforts to counter climate change. Reducing public health effects and promoting physical activity is another positive that sustainable mobility solutions can provide. Regular physical activity associated with sustainable mobility can reduce the risk of chronic diseases, such as obesity, cardiovascular diseases, and diabetes (Woodcock et. al, 2009).

Reduced congestion is also another aspect that can be realized through the use of public transit and carpooling-shared mobility which decreases the need for private vehicles. This results in fewer motor vehicles on the road which by effect provides smoother traffic flow and shorter time on the road. In addition, cost savings can be an important element of sustainable mobility, for example through reduction in private car use and the cost reduction with divided costs in gas, service and other motor vehicle use fixed costs (Litman, 2020). The creation of walkable and bike-friendly areas also promotes social interaction and improvement of the accessibility of amenities and services and can provide a better quality of life for residents. These positive aspects of sustainable mobility may vary according to the

context of each case, the location of the area under intervention and ways of implementing sustainable mobility initiatives (Titze et. al, 2010).

The negatives of sustainable mobility systems may not be related to issues such as environmental impact or health problems but are quite important and have to be taken into account for various reasons. Construction and maintenance of the infrastructure needed for sustainable mobility systems such as bike lanes, pedestrian walkways and public transportation systems can be costly. These costs can be a challenge to local, regional and national governance as well as transportation authorities (Santos et. al, 2010). Travel time and convenience of combining sustainable mobility options to reach the final destination is another aspect that has to be taken into account. Private vehicle use provides more flexibility in time scheduling and effectiveness as an individual can plan his own route, in comparison for example to following the route provided by public transportation (Shiftan et. al, 2012).

Solutions such as walking, cycling and public transportation can sometimes be difficult to make accessible and convenient for all individuals. Civilians that have limited mobility, maybe live in distant areas and those without access to reliable public transportation can face difficulties in using and adapting to the sustainable modes of transportation. In addition, the weather and climate characteristics of an area can make these options difficult to use and having in mind the under-study area of this project, Denmark can be really uncomfortable to use active mobility options due to extreme weather conditions. That can discourage citizens from using these transportation options. Safety can be another issue when it comes to these solutions as inefficient infrastructure, conflicts with motor vehicles or an individuals' perception of safety may also discourage people from using these options (Lohrey et. al, 2019).

Finally a shift towards a sustainable mobility transport system may require changes and alterations in individual behaviors and habits. Citizens may be resistant to change or maybe are not comfortable enough with the new options for transportation, in addition to everyday struggles and need for transportation (work, access to services, etc.). Psychological barriers and their overtaking can be

challenging (Lohrey et. al, 2019). Although all of these challenges and negative aspects are not absolutely certain and can vary according to the context, location and individuals' perception for each area. Comprehensive and analytical planning, infrastructure investment, educating both operators and users, awareness and policy intervention can help promote a sustainable mobility system that is accessible, convenient and safe for all citizens (Zhang et. al, 2017).

Methods

This section has the purpose of providing a comprehensive understanding of how the research was conducted and how the information and data was collected, analyzed, and interpreted. The way of data collection in this project is mainly through interaction with people directly affected by the situation and its form is mainly qualitative and theoretical, empirical and cannot be effectively measurable. Along with this kind of information, there is a need for visualization of the area as an urban environment, its land uses, landscape and the possibilities and obstacles that it may contain. It is data that is qualitative but mostly quantitative. This is done through the Geographical Information System (GIS) application that will be analyzed further in the next section.

Geographical Information Systems (GIS)

A Geographical Information System is a system that can be applied to create, manage, analyze and map all kinds of data. A GIS includes Digital Data, Computer hardware to store data, visualize and display maps and graphs and process data and Computer software (programs and applications) to use through the hardware to work on the available data. The Digital Data contain geographical and spatial information that are viewed and analyzed through the computational means (hardware, software) or other data that can be used to create new spatial information or visualize them into a map (QGIS, 2022).

A GIS application has different uses such as opening digital maps, creating new spatial data, performing spatial analysis and printing maps for visual assistance.

The GIS can help us present location data and give us the privilege to implement any descriptive information we need. The map analysis process is used from many industries (science, spatial planning, social sciences, etc.) to assist in understanding different patterns, relationships and geographic context. This improvement in understanding can help structures that relate to decision making, communicate better with data providers and have a more efficient approach to problems that can lead to a more informed decision making (ESRI, 2022). Two types of GIS data are used in this report, Vector data and Raster data.

Vector data contain the visualization of real world features in a spatial map, such as residential areas, forestry (trees, forests, grasslands), urban green areas (parks, leisure, etc.), water masses (rivers, ponds, lakes, sea etc.), industry, etc. In the use of a GIS Application these objects are seen as features of a map and the information that helps us visualize them can be either text or numerical that describe their nature. Vector data's shape is formed through geometry which is made up of one consisting of one or more interconnected vertices.

Raster data's main difference with vector data is that geometry (point, polylines and polygons) is used to represent the data from real world features. Raster data is characterized by pixels inside a pixel matrix, in which each pixel has different values that show the characteristics of the area covered by that cell. In addition, raster data is a representation of continuous data (elevation, depth, temperatures, etc.) and can represent different feature types (points, polygons, lines, etc.) as single feature types (cells). The use of Raster over Vector data gives an advantage in showing landscape features that may need a more complex and analytical view (elevation, flora differences, sea depth) and vector data are not easily used to represent data that are not the same in type. In this project GIS are used through the program QGIS to visualize the current landscape and infrastructure of the understudy area, indicate the possible solutions that concern the research question and provide solutions designed through the procedure (QGIS, 2022).

Interview

In the context of a thesis, interviews serve as a valuable tool for collecting primary data that can be analyzed to address research questions or test hypotheses. This process typically entails selecting participants who possess relevant knowledge or experience pertaining to the research topic and conducting structured or semi-structured interviews to gather information. Interviews can be carried out in person, over the phone, or through video conferencing software (Bernard, 2011).

The data obtained from interviews can be analyzed using various methods, depending on the research question and chosen methodology. Content analysis, thematic analysis, and discourse analysis are commonly employed approaches. These analyses involve examining the collected data to identify patterns, themes, and underlying meanings. By applying these analytical techniques, researchers can gain insights that help support or challenge their research hypotheses and draw informed conclusions about the research topic (Bernard, 2011).

Interviews provide a direct means of accessing participants' perspectives, allowing researchers to delve into specific topics and gain in-depth understanding. The richness and depth of information obtained from interviews can greatly contribute to the overall quality and validity of a thesis study. It is important to carefully plan and conduct interviews, ensuring proper ethical considerations, consent, and appropriate recording or note-taking methods. Thorough analysis of interview data plays a vital role in drawing meaningful conclusions and advancing the knowledge within a given field of study (Creswell, 2014). This also includes the participants’ perspective that allows them to share perspectives, beliefs, and attitudes, allowing researchers to capture the subjective nature of human experiences and provide authentic data (Kvale, 2007). Additionally flexibility allows researchers to explore emerging themes or delve deeper into specific areas of interest during the interview process (Brinkmann, 2014).

All the aforesaid positives can hide aspects that affect the outcome and the data gained in a negative way. The personalized approach can introduce bias and influence participants' responses. Participants may convert into more socially

accepted ones that can lead to distorted responses (Fontana & Frey, 2005). In addition this limited generalizability can hide the complexity of answers from a larger population. It is then difficult to capture the diversity of views within the target population. Also, conducting a personal or a limited participant interview is time and resource-consuming and it cannot be feasible for studies that need a bigger mass of data (Rubin & Rubin, 2012). Finally the interview itself cannot validate the skill and the correct judgment of the interviewer and it relies solely on these aspects, so avoidance of misinterpreting the participants' responses requires attention and avoidance of researcher's bias (Brinkmann, 2014).

Creative workshops and international examples

Through the creative workshops, mainly with Mr. Jacob Skjødt Nielsen and Mr. Ulrik Djupdræt, I have been presented with an overview of the problematic situations concerning the transportation system in Køge and which issues have to be countered first. In addition, current planning, future plans and possibilities along with public perception and social state of the area were shared. After the overview of the current situation and the possibilities some possible solutions were discussed, including "business as usual" solutions and solutions that can support a sustainable mobility system. These workshops had the form of establishing what is happening, what people that have an active role want to achieve and what can actually be done.

After taking into consideration all of the above, a search for international examples that have similar characteristics, possibilities and vision was conducted. These examples have provided possible approaches to the environmental, economical and social aspects of developing solutions that can support sustainable mobility either in built, under-construction or in the design process environments.

The business as usual approach for the area's connection to the transport system

The "business as usual" approach to connecting suburban areas to the current transport network typically involves expanding roads and highways to accommodate more cars, building new parking facilities, and increasing the number of bus and train routes to connect suburban areas to urban centers. Traditional transportation planning approaches have focused too much on engineering solutions such as building more roads and adding more cars, rather than considering the role of spatial planning in shaping transportation systems (Litman, 2019d)

However, this approach has several drawbacks. Expanding roads and highways can lead to increased traffic congestion, air pollution, and greenhouse gas emissions. Building new parking facilities can be expensive and take up valuable land, and may encourage more people to drive instead of using alternative modes of transportation. Additionally, increasing bus and train routes can be costly and may not be financially sustainable in the long term (Litman, 2019d).

This approach is still prevalent in many regions around the world, particularly in areas where public transportation infrastructure is lacking or underdeveloped. However, with growing awareness of the negative impacts of this approach, there is increasing interest in promoting sustainable mobility solutions that prioritize public transportation, active transportation options, and compact, mixed-use development patterns. These solutions can help address the challenges posed by suburbanization and population growth while promoting more sustainable and connected communities (European Environmental Agency, 2016).

Municipality's Plan

As mentioned above I conducted a meeting with two municipality officials that provided me with information about the plans around Ravnsborg Enge and its development. In that meeting it was made clear that the solution of how to connect

the area to the existing transportation network was through an underground tunnel-road connecting the north-western part with Orkestervej. There was no clear indication on if the created road would serve cars, bikes, pedestrians, a combination, etc. Therefore the plan can be translated as a "business as usual" option if we consider the characteristics of such an option, in the previous section.

This plan serves as a passage for vehicles that the residents can use to get in and out of the residential area, moving and delivery services and could also serve as a bike lane and as a walk path for pedestrians. It was also mentioned that its use is very important for municipality service vehicles such as garbage trucks, service vehicles for disabled people, public transport buses (that are maybe planned to serve the area). It is essential for these services to be fulfilled for obvious reasons.

Ravnsborg Enge plan

The new district of Ravnsborg Enge includes a new residential area that is divided into 4 smaller areas, which are surrounded by green spaces and recreational areas. The plan was based on the UN's Global goals for sustainable development and Køge Municipality's inclusion on the DK2020 Climate plan. Both of these elements are connected to the municipality's green transition, in accordance with the national Climate Act, and compliance with the Paris Agreement.

The green spaces in the area serve as a tool to promote sports, movement, biodiversity and communities. The house construction in the area was planned with consideration of the natural environment through building house limits (max 3 floors and lower heights closer to the natural areas), materials used and longevity of those and spatial distribution (save as much space possible). It is mentioned in the website that "It is a neighborhood for those who love to get soil under their nails" and it can be clear from the above that the plan about the area aims to be connected to design and solutions about construction and planning, that area considerate of the environmental impact of such a venture. It is also clear that the reconnection of the human element with nature is one of the main targets of this plan and it can be understood through the phrase " Ravnsborg Enge must be a vibrant community that

combines high quality of life with a sustainable lifestyle", which was stated by the owners.

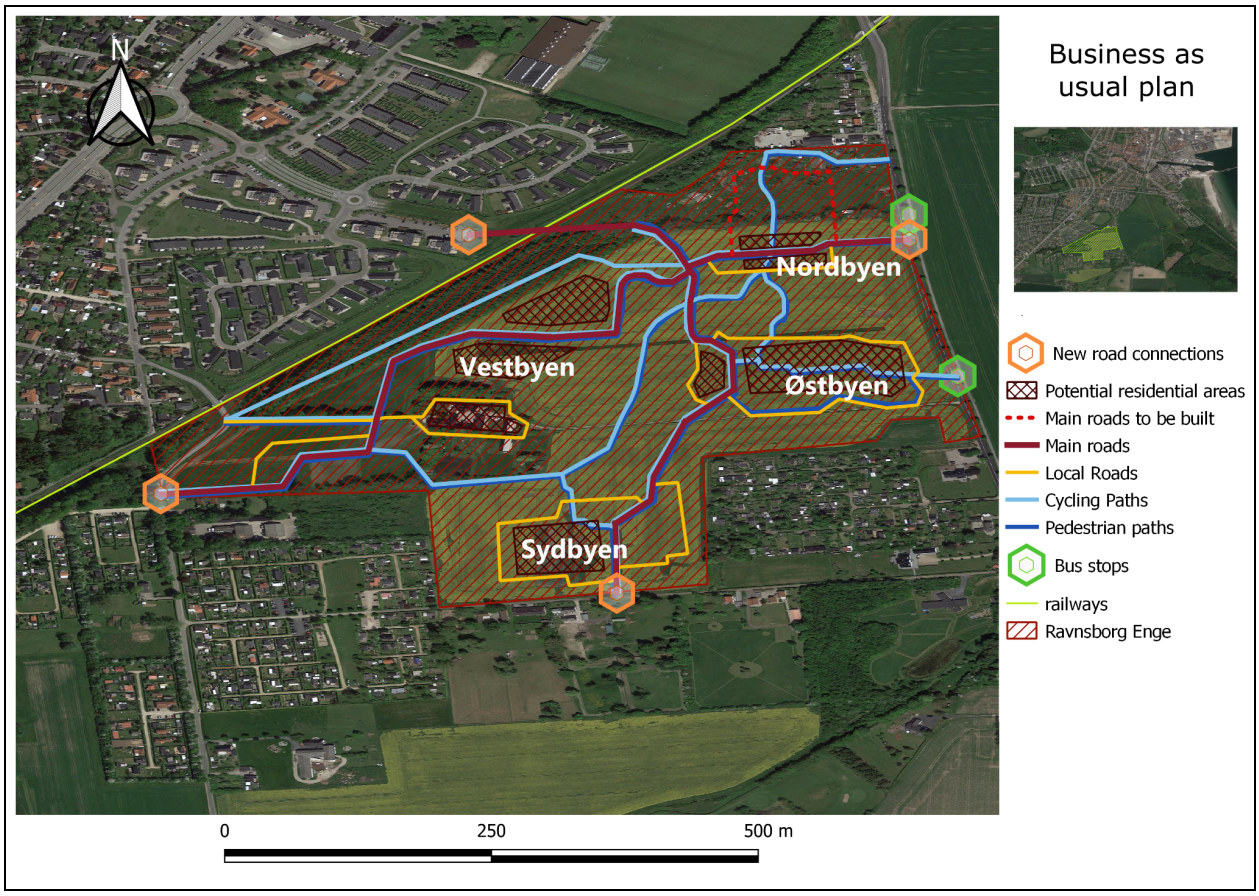
In the practical part, the area is divided into 4 smaller areas which contain a mix of residential, natural environment and transportation land uses. The map included in the official planning of the area indicates that the dense residential areas rely mainly on Nordbyen (Northern area), Østbyen (Eastern area) and Sydbyen (Southern area) while Vestbyen (Western area) has a settlement but there are more open spaces available. There are many green spaces in the area with the most significant one to be an artificial lake designed to be placed between Nordbyen and Østbyen. In the green areas it is essential to mention the small forest that serves as a border between the area and the railway and a complex of smaller water masses in the center of the area (Figure 3).

Figure 3: Current plan Landscape

Source:https://ravnsborg-enge.dk/wp-content/uploads/2022/10/Ravnsborg-Enge_Helhedsplan_Oktober2022_komprimeret.pdf

Transportation needs in and out of the area is the main concern of this project, as well as one of the issues that has not been addressed completely. The purpose of the plan is to promote green mobility in Ravnsborg Enge, by switching the heavy traffic away from diesel and petrol for electricity and other green alternatives such as active mobility. Infrastructure such as bike lanes and pedestrian ways, as well as connection to public transportation are main elements of the transportation planning. Although the most important point in the transportation plan for the area concerns electric vehicles. The use of electric vehicles in the area will be promoted through offering a safe and welcoming infrastructure that will promote soft road user traffic in and out of the area, electric car availability provided by the ownership and charging stations in the parking spaces.

Some ideas that area also suggested are the reduction of parking spaces outside the needs of the area, smart charging stands, facilities that can support working from home, shared mobility signs and carpooling promotion, parking spaces that are helpful for electric car users and a partnership of the ownership with electrical operators for an advantageous setup of charging stations at private car parking. Although there is no specific plan about the placement of the chargers, the parking requirements of the area and if there is any prohibition for gas and diesel engine vehicles.



Map 1: Business as usual plan

As mentioned above the only established construction plan that concerns the transportation needs in the area is the underground tunnel from Orkestervej (under the railway) that will connect the area with the current transport network. The orange hive shapes indicate the connection to the road system, the dark red line indicates roads that will serve motor vehicles, the light blue line indicates bike paths and the orange line pedestrian paths. The two green hive shapes indicate bus stops that can serve the area, with an addition of a connection to another bus stop north-west of the area (cannot be seen in the map). In Map 1 it is clear that there are many roads (for cars, bikes, pedestrians) that the owners want to get constructed as well as connections to the current road system. Additionally there is a potential road that will pass by the area of Køge Fælles Jord which will serve engine powered vehicles.

The data and information I needed in order to create the map and provide all the essential aspects of the current plan about the development of Ravnsborg Enge, were obtained through the interviews with the Municipality officials and Mr. Konig and the available information on the website that concerns the under-study area.

Summary

The drawbacks of “business as usual” solutions, increased traffic congestion, air pollution, and greenhouse gas emissions as well as construction works (noise, dirt, cost, etc.) in the current situation (road construction in residential areas) are clear. Although there was a desire towards investigating, searching, designing or suggesting solutions that are not entirely related to “business as usual”, the current solution does not seem to be far from the established solutions.

All the above mentioned can identify the transport plan of the area as a “business as usual” complex of solutions. Taking aside the promotion of active mobility and use of electric cars, there is a potential construction and connection with the current road system through any possible angle, in addition to another connection with an area that has no particular need of motor vehicle use (Køge Fælles Jord). Also even if there is only one main road that is then following 3 main connections to the residential areas, there are local roads in all the residential areas. Road expansions and new parking facilities even if there is promotion of electric vehicles, indicate a direction towards “business as usual” and there is no prohibition for the use of other kinds of motor vehicles so there is no insurance that only electric vehicles will be used to at least minimize the environmental and noise impact.

Additionally the construction and connection to the road network can bring noise and environmental pollution which can affect local areas. Having in mind the vision of the owners and the Climate Plan that the municipality of Køge wants to promote, the ideas that have been designed so far might need some alterations or promotion of different solutions that can better support a sustainable mobility system. In the following section I will make an effort to present and explain some sustainable mobility solutions that either have been or can be applicable to suburban areas with similar characteristics to Ravnsborg Enge.

Sustainable mobility solutions applicable in suburban areas

As mentioned above, the business as usual approach to connecting suburban areas to the current transport network before the rise of sustainable mobility resulted in sprawling development patterns, where new housing developments were built on the outskirts of cities or in rural areas with limited access to public transportation options. The focus on road infrastructure also led to increased congestion and air pollution, contributing to negative impacts on both the environment and public health (Litman, 2019d).

In his dissertation, Martin (2020) suggests that spatial planning can be used to promote sustainable urban mobility by encouraging compact, mixed-use development patterns that prioritize active and public transportation options over personal cars. A more sustainable approach to connecting suburban areas to the transport network may involve promoting alternative modes of transportation, such as walking, cycling, and public transportation, and designing communities to be more walkable and bike-friendly. This could involve creating more bike lanes and pedestrian paths, developing public transportation systems that are convenient and affordable, and encouraging mixed-use development that enables people to live closer to their workplaces and amenities (Handy, 2015).

Active mobility

Active mobility refers to a sustainable form of transportation that relies on human power, such as walking, cycling, or using a wheelchair. It is termed "active" because it involves physical activity, which brings about numerous health and environmental advantages. The concept of active mobility is gaining traction worldwide as people become increasingly conscious of the detrimental effects of motorized transportation on both the environment and personal well-being (Pucher et. al, 2012b). Notably, active mobility offers not only sustainability but also cost-effectiveness in terms of transportation. It brings a range of benefits, including

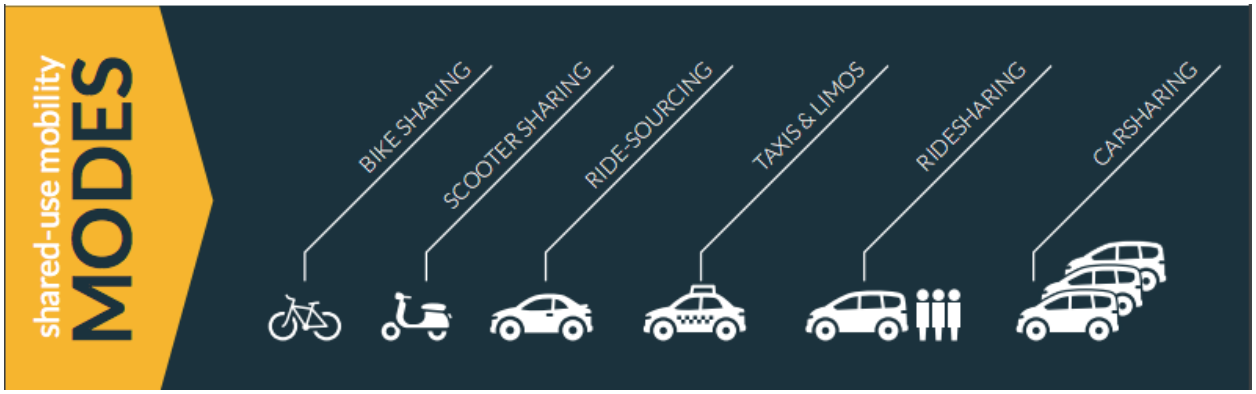
enhanced physical fitness, reduced air and noise pollution, and alleviated traffic congestion. Moreover, active mobility fosters social interaction and cultivates a stronger sense of community among individuals (Danish Cyclists' Federation, n.d.).

To encourage active mobility, cities and communities can invest in infrastructure such as bike lanes, pedestrian walkways, and accessible sidewalks. Education and awareness campaigns can also promote the benefits of active mobility and encourage people to adopt more sustainable transportation habits (Martin, 2020). In Denmark, active mobility is a well known concept as for its strong cycling culture and infrastructure, making active mobility a popular and convenient mode of transportation in the country. Cycling and walking are common modes of active transportation in Denmark (Christiansen et. al, 2020).

The country's cities and towns have well-designed pedestrian infrastructure, including sidewalks, crossings, and pedestrian-only zones. To support active mobility, Denmark has invested in infrastructure such as bike lanes, bike parking facilities, and pedestrian walkways. The country has also implemented policies to promote sustainable transportation, such as a congestion charge for driving in Copenhagen and other urban areas. In recent years, there has been a growing interest in electric bikes (e-bikes) in Denmark as a way to encourage more people to adopt active transportation. Overall, Denmark's strong focus on active mobility along with the issues that this paper addresses provides a good layout for planning suggestions and solutions that promote sustainable mobility (Christiansen et. al, 2020).

Shared Mobility

Shared mobility refers to the sharing of vehicles or transportation services among multiple users, rather than each person owning their own vehicle. This can include car-sharing services, bike-sharing programs, and ride-sharing platforms. Shared mobility has gained popularity in recent years due to its potential to reduce traffic congestion, improve air quality, and promote more sustainable transportation habits (Shaheen et. al, 2016).



https://www.shareable.net/think-tank-sumc-releases-shared-mobility-guide-for-cities/

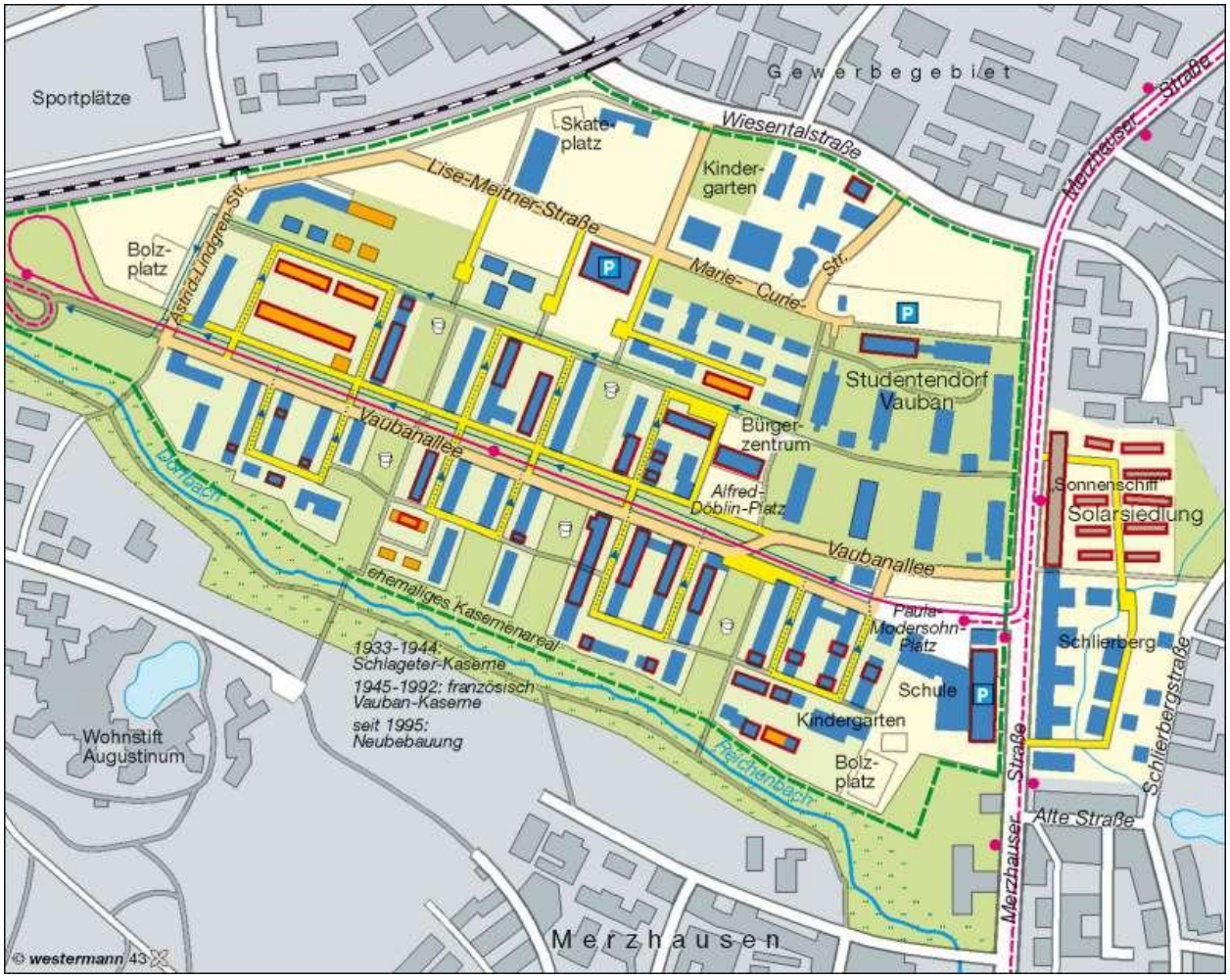
One form of shared mobility can include the use of rental cars. This allows individuals who may not own a car or need a second car for occasional use to have access to a vehicle when needed, without the financial burden of owning and maintaining their own car. Another form is bike-sharing programs and mobile applications, where bicycles are available for short-term rental at designated stations throughout a city. This promotes active mobility by encouraging individuals to use bicycles for short trips instead of relying on motorized transportation. Additionally, some ride-sharing platforms have introduced carpooling options, where multiple passengers can share a ride and split the cost, further promoting the concept of shared mobility.

While shared mobility has many potential benefits, there are also challenges to implementation, including the need for infrastructure and regulations to support these services, as well as concerns around equity and accessibility. It is important for policymakers and transportation planners to consider these factors when implementing shared mobility solutions. Shared mobility has the potential to play an important role in promoting sustainable and efficient transportation systems. By reducing the number of cars on the road and promoting active mobility options, shared mobility can help to address environmental concerns while improving accessibility and convenience for users.

International examples

Quartier Vauban, Freiburg

Quartier Vauban is a sustainable neighborhood located in the city of Freiburg, Germany. The area was designed with a focus on sustainability, and it is a prime example of sustainable urban planning. The neighborhood is characterized by its compact, mixed-use design, pedestrian and bicycle-friendly streets, and extensive public transportation options (Müller, 2016).



https://diercke.westermann.de/content/quartier-vauban-freiburg-nachhaltige-stadtentwicklung-978-3-14-100700-8-71-5-0

A very important characteristic of this neighborhood is the implementation of active mobility initiatives, with a particular focus on cycling. The neighborhood has a comprehensive network of bike lanes and paths, making it easy and safe for residents to bike to work, school, or other destinations. This has led to a high level of cycling among residents, with the biggest margin of all trips within the neighborhood being made by bike (almost 70%) (Müller, 2016).. In addition to active mobility, the area is well-connected to Freiburg's public transit system, with multiple tram and bus lines running through the area (Kohler et. al, 2009).

The planning process for Quartier Vauban revolved around the principles of sustainable mobility, with a primary emphasis on promoting walking, cycling, and public transit usage while reducing reliance on cars. Collaborating with residents and community groups, the transportation plan incorporated key elements such as pedestrian and cycling infrastructure, public transit connections, car-free zones, and parking management. Car-free zones were implemented to foster a safe and pedestrian-friendly environment, encouraging residents to opt for walking, cycling, or public transit. Parking management strategies were employed to discourage car usage, limiting parking availability within the neighborhood. Residents were required to purchase parking permits at a higher cost than public transit fares, creating an incentive for them to utilize public transportation instead of driving (Kohler et. al, 2009). .

In addition to sustainable mobility, Quartier Vauban places significant emphasis on energy efficiency and renewable energy. Many buildings in the neighborhood are designed with passive solar features, such as large windows and insulated walls, to minimize heating and cooling requirements. Furthermore, the district heating system in Quartier Vauban utilizes renewable energy sources like wood chips and solar power to provide heating and hot water to residents, contributing to the overall sustainability of the communities(Kohler et. al, 2009).

According to the study from Kroesen et. al. (2011) the project was generally well-received by the locals. The residents actively participate and are involved in initiatives to contribute to these sustainable practices and they have a high level of satisfaction with their living environment. The spatial design is appreciated as well as

the transportation options provided by it. Car-free zones have created a peaceful and safe atmosphere making it more appealing to families with children. The sense of community has also had a big impact on the quality of life as green spaces, community gardens and communal facilities promote social interaction.

They appreciate the ecological design and the emphasis on sustainable transportation options, such as walking, cycling, and public transit. The car-free nature of the neighborhood has created a peaceful and safe atmosphere, making it particularly appealing to families with children. In addition the integrated sustainable living has created a shared value system which strengthens the community bonds in the area. Although there are some concerns relevant to the limited parking availability and the constraints of car-free zones (Kroesen et. al, 2011).

Schoemaker Plantage

A case of shared mobility initiative has been implemented in The Hague, Netherlands under the name Shared Mobility Schoemaker Plantage (SMSP) project. The SMSP project is a public-private partnership that involves the municipality of The Hague, the local housing association Staedion, and shared mobility provider Greenwheels. The main aim of this project was to reduce car usage and promote active and sustainable mobility options by providing residents of the Schoemaker Plantage neighborhood with a range of shared mobility options, including electric cars, e-bikes, cargo bikes, and shared parking spaces (The Hague Municipality, 2021).

https://schoemakerplantage.nl/nl/aanbod/deelgebieden/

A feature that has helped the process of the project's implementation is the area's integration with the existing public transportation system. The neighborhood is located near a tram station, and residents are encouraged to use public transportation for longer trips, while shared mobility options are available for short trips and daily errands. The SMSP project has been successful in promoting sustainable mobility in the neighborhood.

According to a study by the municipality of The Hague, car usage among residents of the Schoemaker Plantage neighborhood has decreased by 10%, while the use of shared mobility options has increased by 45% since the project's launch in 2018. The project has also led to a reduction in traffic congestion and air pollution in the neighborhood (The Hague Municipality, 2021). The success of the SMSP project can be attributed to several factors, including its integration with the existing transportation system, the availability of a range of shared mobility options, and the

active involvement of residents in the project's design and implementation (Greenwheels, 2021).

Summary

As mentioned above, the positives of sustainable mobility solutions are relevant to environmental impacts of the transport sector, health issues, costs and quality of life. The negatives are relevant to the costs of the creation of such solutions, the flexibility and accessibility as well as the convenience that they can provide to citizens and finally the public's perception and use of these solutions. The solutions selected for the transport plan I suggest in this project were selected through taking into account all of these aspects, as well as the examples where the solutions were implemented in similar context.

To begin with, active mobility includes options that are already established in Denmark and are perceived as a norm (cycling, walking, public transport), the infrastructure either exists or there is experience in their establishment and governance has already established similar solutions. All of these elements neglect most of the negative aspects mentioned in the theories section and that can be encouraging in promoting and implementing them in the suggested plan. Additionally, active mobility is a very important aspect of the current plan for Ravnsborg Enge and is a significant part of the branding for the area. The only two negative aspects rely on the weather conditions established in Denmark and the accessibility to citizens with disabilities, issues that cannot be calculated or easily mitigated especially when active mobility is an option that exposes the individual to these conditions.

Shared mobility can provide a solution to the blank part of active mobility through the vehicle protection and services, exposure to weather conditions as well as accessibility and efficiency for citizens with disabilities. It is also an already suggested aspect of the current plan, is included in the branding of the area and is already used through some platforms (e.g. carpooling) in the Køge Municipality. Both of these solutions are supported by the public's perception of their implementation found in the examples given in this section.

In Quartier Vauban the design of the area affected by the sustainable mobility solutions is highly appreciated by citizens and the Shared Mobility Schoemaker Plantage Project has made a significant impact on affecting the two main issues it needs to (car use decrease, significant increase in shared mobility options). The positives of these two sustainable mobility travel options are mentioned above but it is interesting to highlight how important the current situation of the public perception on these solutions is, if there are similar options currently used and if there is the available infrastructure and support provided from the government.

Suggestions that can support a sustainable mobility network development

Although there has been development of ideas and solutions regarding the designing of transportation systems that promote sustainable mobility and there are examples of successful implementation, there are some aspects that have to be taken into account for any area that has the need for intervention. These aspects can vary from public opinion, affected residents, conflict of interest, technological change, economic trends etc.

The traditional approach of relying on long-term forecasts and modeling may not be sufficient to capture the complexity and uncertainty of the transport system. According to Lyons and Davidson (2016), transport planning and policymaking must take into account various uncertainties such as technological change, demographic shifts, climate change, and economic trends. They have proposed a framework for decision-making that includes four stages: identifying and characterizing uncertainties, exploring alternative scenarios, evaluating and selecting strategies, and implementing and monitoring strategies. The purpose of this is to help transport planners navigate through an uncertain future, take into account the stakeholders' role and help build transport policies and strategies that avoid public conflict and are legitimate (Glenn Lyons et. al, 2016).

According to Gallo and Marinelli (2020), the importance of stakeholder involvement in the planning and implementation of sustainable mobility policies and actions. They argue that sustainable mobility planning should take into account the diverse interests and needs of stakeholders, including citizens, businesses, transport operators, and government agencies.

Stakeholders should be involved in all stages of the planning process, from the identification of problems and opportunities to the evaluation of policies and actions. Through their involvement they can help ensure that sustainable mobility policies and actions are well-suited to local needs and preferences and are more likely to be effective and accepted by the public. In addition, the authors stress that stakeholder involvement can help build support for sustainable mobility policies and actions, as it allows stakeholders to contribute their knowledge and expertise, as well as to have a say in decision-making processes (Gallo and Marinelli, 2020).

Køge Fælles Jord

Koge Fælles Jord, also known as Køge Common Land, is an area located in the municipality of Køge, Denmark. It is the northern spatial border of Ravnsborg Enge and there is no technical boundary that splits the two areas. The area is owned by the municipality and it accommodates an urban development project that has as a main focus to create a sustainable and inclusive neighborhood that promotes natural environment preservation, the use of the resources given by it, community spaces and finally, cover transportational needs through sustainable mobility solutions.

The initial use of the area was for a rehabilitation program that concerned people that faced psychological or mental challenges. Through activities that are relevant to agriculture (ornamental plants, edible products, etc.) in connection with exposure to nature and avoidance of urban stress, the focus was to help these people with their rehabilitation. All that information was given to me through an interview with Mr. Lars König who is an active member of the community of Køge Fælles Jord. Mr. König informed me that after some time the people who were in this rehabilitation program expressed their desire to inhabit this area due to its exposure to the natural environment and their connection to the place as they worked in and

for it. After the expression of that idea, volunteers, members of the program and citizens interested in inhabiting the area developed the project of Køge Fælles Jord.

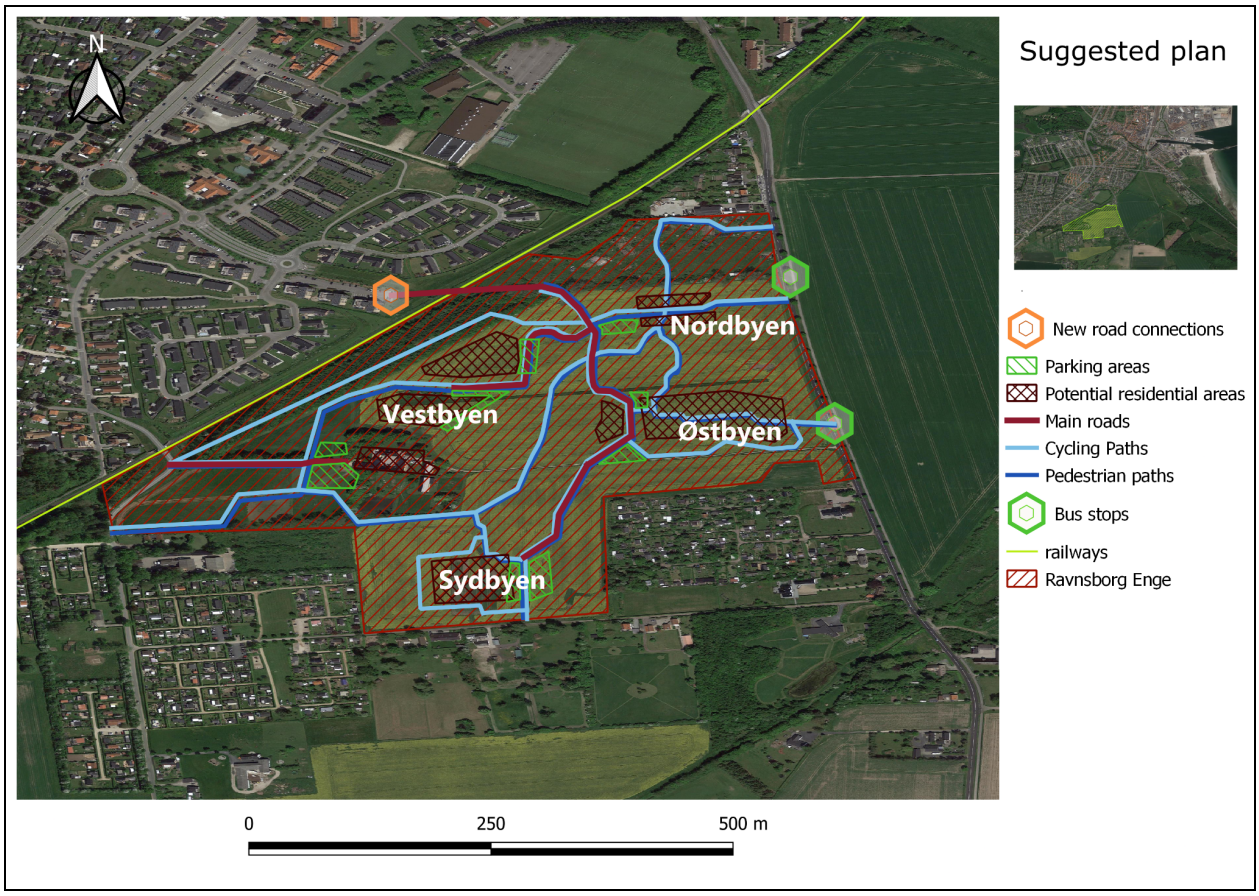
This project of balancing the urban environment and its development with nature conservation, includes a mix of residential areas, green spaces and recreational facilities. Housing is limited to the ones created by the own members of the community, with materials that are considered to be the least harmful possible to the environment. This, in addition to the green spaces and recreational areas, seeks to promote a harmonious relationship between human activity and the natural environment which aims to provide a high quality of life. All this information was obtained by the community's website and through the interview with Mr. Lars König.

In relevance to sustainable mobility, Køge Fælles Jord encourages active mobility through walking and cycling as well as the use of public transportation to reduce car independence and promote an environmentally friendly lifestyle. Walking is very important for the area as by the words of Mr. König in many questions regarding the transport network connection to the area "we can be able to walk that far". The conversation included the questions about the accessibility of the two public transport stations that are both less than 8 minutes walking distance (Egøjevej and Vordingborgvej) of which Vordingborgvej connects the area with the train station of Køge.

Suggestions

Taking into account all of the above sections, the interviews with people of interest, my autopsy on the under-study area and suggestions or implemented examples of sustainable mobility solutions, I have created some suggestions that can be implemented to service the transportation needs of Ravnsborg Enge. The main suggestion is limited car access and use in the area to a bare minimum through the use of active mobility and shared mobility to cover the traveling needs as well as discouragement and restraint through limited hour access to motor vehicles for specific uses which will be explained further below.

Active mobility includes cycling, walking and use of a wheelchair and it is already an important part of the initial plan for the area. It is a solution that is significantly less harmful than motor vehicles, danish citizens have already adapted to that kind of travel option and that the pathways constructed within the area will be directly connected to an already existing cycling paths and pedestrian walkway system. The only difference from the initial plan is that all of the small roads designed for Vestbyen, Østbyen and Sydbyen will be replaced by Cycling paths MAP 2, but will have the needed width for emergency vehicles to have access (ambulances, fire brigade trucks, etc.). Active mobility is not only encouraged because it is a sustainable mobility solution. The environment that will be created in the area promotes active mobility as a recreational activity which can provide with even more use of cycling and walking which can lead to even higher possibility of health benefits from these activities. Finally, by limiting the traffic to non-motor vehicles (bikes, scooters, etc.) and pedestrians, it improves the accessibility and safety of these pathways for people with disabilities and difficulties in relevance to mobility.



MAP 2: SUGGESTED PLAN

Shared mobility is another important suggestion which has similarities with active mobility regarding its implementation in the area. The infrastructure that is in order to be constructed (main roads, EV chargers, parking spots) can be the basis on which this suggestion can be built, with some minor differences to the original plan. For example, as seen in MAP 2 the new parking spots are placed either outside or around the residential areas, to eliminate the possibility of private parking spots that require bigger space consumption, costs and makes the sharing mobility process more difficult as there will be limitations on the number of shared vehicles. Additionally, the parking spots on the Nordbyen and Sydbyen can only be accessible to shared mobility vehicles for reasons that will be explained in another section. Also the EV chargers will be placed in these parking spots close to each other so it can be more convenient and available according to residents' needs as a community and not as individuals.

The owners could start a process of negotiating with established operators of shared mobility (Share now, Green Mobility, GoMore, etc.) in order to provide EVs and have a strong argument or selling point in the process of convincing potential residents about the security of that travel mode. This agreement will provide the owners with a solid selling point as they can actively provide vehicles for shared mobility and not just suggest the action but also give motivation to the companies which can be given fixed income each month. Finally, as there is already a system of carpooling (shared mobility) and some shared mobility apps are already well established (Share now, Green mobility, GoMore etc.), it will not be an extra obstacle to find the means and services to implement such a solution and establish that kind of travel mode (Statista, 2023).

The final suggestion which is not visualized in MAP 2, concerns the time limitation for motor-vehicles to operate in the area. This is with the exception of EVs that belong either to the area as a whole (either from the companies checked with plates, or with stickers on the EVs of residents that indicate they live there). The restraints will exclude the operation of private oil and gas engine vehicles that do not have service use. The only oil and gas engine vehicles allowed will for example be moving trucks, vans for the service of disabled citizens, vehicles that operate for kindergarten, schools, etc. These kinds of vehicles will be restricted as much as possible, for example moving trucks and trucks that may contain consumable goods (furniture, house supplies, etc.) can be restricted to very specific operating hours (9-11 am for example), but vans that are for the service of disabled people can have a more flexible access time. Preferably the restrictions will let these vehicles operate during working hours so that the after-work hours can be free of noise and pollution. These restrictions will not be applied for operations that are relevant to municipality's essential services, such as waste collection vehicles, ambulances, fire brigade trucks etc.

There is an extra initiative that can be included in the suggestions and it is connected to the existence of Køge Fælles Jord. As mentioned above this area has the aim of promoting the connection of humans with the natural environment, avoiding urban stress and giving the people the opportunity to operate and act

around the creation and maintenance of the natural environment around them. Through the discussion with Mr Konig I brought up the idea of branding Ravnsborg Enge to be as close to the concept of connecting with nature and having the least impact on the environment. Then he suggested that the area could be closer to the principles of Køge Fælles Jord in terms of maintaining and creating inside the natural environment that surrounded the residential areas. These actions will be carried out by the residents themselves. As seen in the Ravnsborg Enge website, the owners want to invite residents that "want to get their hands dirty" meaning that they want to get their residents closer to nature.

The final idea is to isolate Sydbyen and Nordbyen from the original plan in terms of leaving some aspects either creatively flexible or not completely constructed. The branding of these areas will focus on the residents' will of operating and creating their own living environment, being active around nature and understanding the world around them a bit more. The two areas are highlighted differently in MAP 2 and while Nordbyen is close to Køge Fælles Jord and there is direct connection and affection from the people that have some experience in these concepts, Sydbyen can also be easily transitioned into this kind of area as there is no construction at the moment whatsoever and there is plenty of space and isolation from urban elements.

Summary

While the initial plan for the area has many ideas that can set a good basis for the establishment of solutions that can support a sustainable mobility system, there are still many areas and blank points in which "business as usual" solutions can be brought up as arguments either for profit or for easing the attraction of residents and investors or maybe due to lack of infrastructure. There are though many infrastructural and design oriented ideas in the initial plan that can be brought closer to already established solutions and support a sustainable mobility system. I believe that the suggestions in that section use most of the already designed plan so there will not be significant conflict with the owners' ideas and plans. The owners seem to have a direction towards sustainable solutions in all sectors affected by this

construction and in combination with the municipality's environmental targets there can be a basis for discussion.

Active mobility, shared mobility and time limitations can provide common positives relevant to the environmental impacts of the transport section (greenhouse emissions, pollution etc.), health issues (air quality, noise, etc.) and quality of life (traffic congestion, equity and social impact, etc.). Although it is important to consider the challenges that sustainable mobility solutions can bring to the surface. The stakeholders' role, the context of the situation, location, land uses involved and the public's perspective are very important elements. For a sustainable mobility system to be effective, its planning and design has to consider the conduction of feasibility studies, engagement with the stakeholders and monitor the outcomes to ensure that the desired environmental and social benefits are achieved.

As mentioned above the importance of stakeholder involvement is crucial and the interests, conflicts and effects of such an operation are complex and multiple. The involvement of municipality officials and active citizens and considering the complexity and uncertainty of the transport system is very crucial in this plan. The interviews that I conducted and the information I obtained for the owners' plans and ideas gave me a solid overview of the situation although there is room for improvement. Extensive interviews with locals and survey conduction could be helpful to grasp their perception on the ideas presented.

Discussion

In this section I will go through the process of answering the three sub-questions and finally the main research question as well as compare the two main projects in hand, the initial idea from the owners and the suggested plan that I have created. The first research sub-question of this project concerns the issue of "How can Ravnsborg Enge be connected to the current transport network by using business as usual solutions?". Through the first analysis I presented what is considered a business as usual approach to connecting a new suburban area to the existing transport network, the municipality's plan that is connected to that sector and the owners' plan on how to address that issue.

My findings indicated that the usual approach would rely on road construction, creating new parking spaces and connecting the public transport system with the area. Although, the municipality's plan along with the owners' vision about the area includes solutions that differ and are not considered completely as business as usual approaches. The infrastructures that are connected to business as usual solutions (road construction) are a part of the plan but active mobility, use of shared mobility to a certain extent and keeping the road construction to a minimum indicate that there is a different approach. Currently the only established road construction concerns the connection of the area to Orkestervej while there are indications for 3 additional connections to the road network. To summarize, while the current plan has elements from the business as usual approach, it has considered sustainable mobility solutions but also has not fully committed to creating solutions that strongly support a sustainable mobility system.

Through the second research sub-question "Which are the sustainable mobility solutions that can be used in suburban areas?" I aimed to identify sustainable mobility solutions that concern suburban areas along with examples that such solutions have been used in areas and cases with similar context. Active mobility and shared mobility were the two solutions that I believe can be realistically implemented due to the size of the area, the land uses, its purpose and the possible connections with Køge and other transport options. Creating dedicated pedestrian

and cycling paths that connect Ravnsborg Enge to nearby transportation hubs and amenities encourages active modes of transportation. Implementing well-designed infrastructure, such as bike lanes and pedestrian-friendly pathways, can contribute to safer and more accessible travel options. In addition, promoting a mix of transportation modes, including car-sharing services and ride-sharing platforms, can enhance connectivity between Ravnsborg Enge and the wider transport network. Encouraging the use of shared mobility options reduces the reliance on private cars and promotes more sustainable travel behavior.

Finally, I explored practices that can support the development of a sustainable mobility network in the suburban area through the third research sub-question "Which practices can support a sustainable mobility network development in the area?". The following practices were identified:

- Active mobility: Infrastructure that promotes active mobility and can connect the area to the current infrastructure that either concerns that issue or serves other transport modes (train, buses, etc.)
- Shared mobility: Use of EVs for shared mobility to support the adoption of electric vehicles, reducing carbon emissions and dependence on fossil fuels and also decreasing the dependence on private ownership and car use.
- Limited access to motor-vehicles: reduce emissions and improve air quality, noise and stress elimination.
- Use of some areas for branding purposes: Enhance current vision of connecting people to nature in a more direct way, attract target buyers and emotional connection of the buyers to the area.

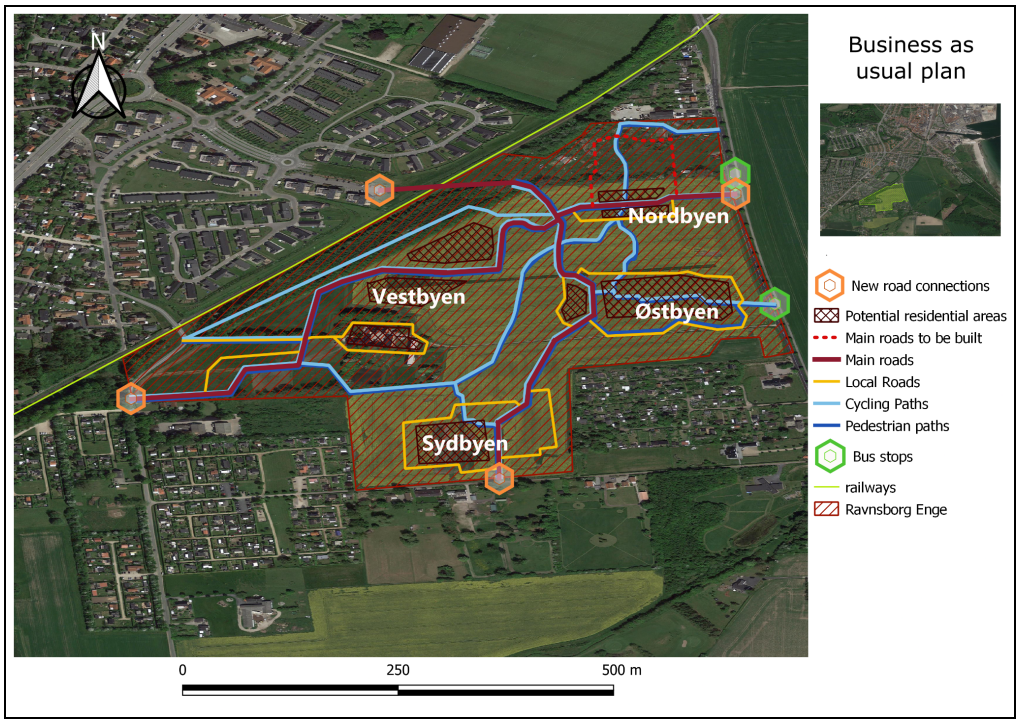
Although the positives and negatives of these solutions have been presented there are some points that have to be considered in order for these suggestions to be efficient and successfully implemented. Inclusion and collaboration of the stakeholders involved such as local government, transportation authorities, urban planners, and residents, is crucial for creating and maintaining a sustainable mobility system. Engaging stakeholders in decision-making processes and incorporating

their perspectives ensures that the infrastructure and services align with the community's needs and preferences.

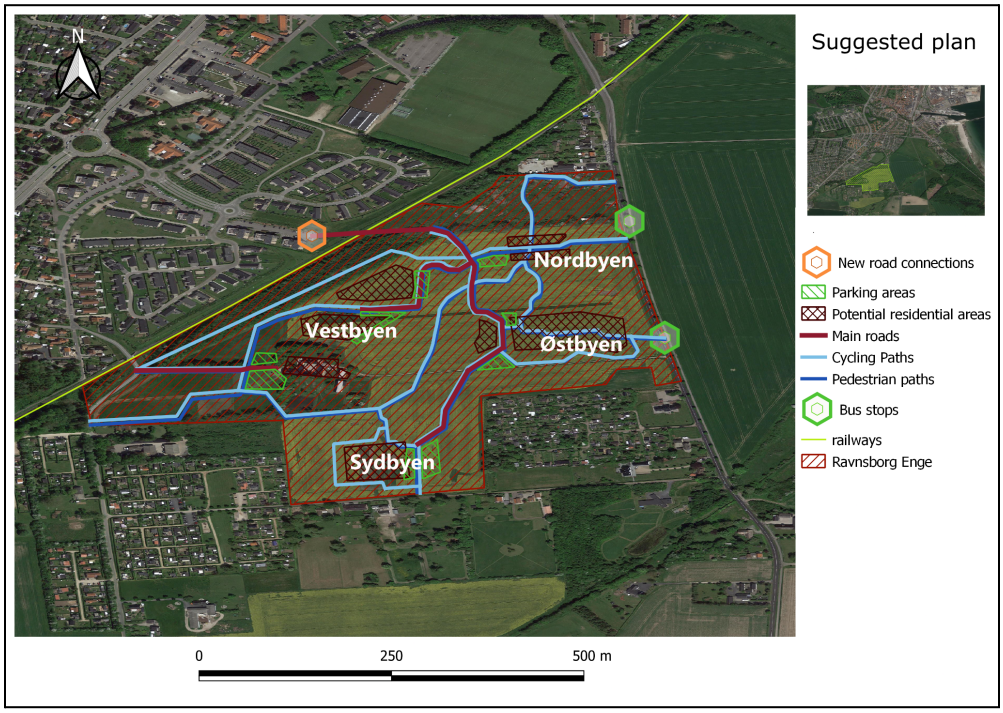
In addition, establishing policies and incentives that can help with the transition towards a sustainable mobility system such as parking regulations, promote public transport use, cycling, walking and use of electric vehicles can make residents opt for sustainable transportation alternatives. FInally, monitoring and evaluation of the established system is essential to assess its effectiveness and make any adjustments needed. Collection of data concerning travel patterns and travel modes' use and infrastructure usage, as well as efficiency of connection with the current transport system can help identify aspects that need improvement and decision making processes.

I created this project having in mind that I will suggest a plan that can answer the research question "*How to design a suburban area that supports sustainable mobility?"*. During this process I have identified and looked into current solutions (business as usual) and solutions that are closely connected to sustainable mobility systems. Two main points had to be considered during the research and during the design of the suggestions.

The first one is to approach the matter in accordance with my studies and my purpose as a student, to find a solution that can support a sustainable mobility system. Additionally the municipality was in need of a plan that can be implemented in different areas with similar context, mainly relevant to the landscape and the use of the system. The second point was to have in mind that the area is privately owned and economical aspects have to be considered. I considered this in order for the plan to be as realistically applied as possible. In the following paragraphs I will compare the two plans and try to explain my reasoning behind it in accordance with all of the aforesaid points.



Map 1: Business as usual plan



MAP 2: SUGGESTED PLAN

The main differences that can be seen in the two maps rely on the potential road construction, car dependency and accessibility, as well as connection to the main road network. As described in the first analysis, although the initial plan has many inputs that are included in sustainable mobility systems such as active mobility, EVs, public transport, etc. there is no limitation whatsoever of business as usual solutions. Road construction is clearly the main plan as in MAP 1 we can identify 4 new road connections which will be completed with construction, as well as main and local road connections to and out of all the residential areas that will be built. In addition there are no areas clear of motor-vehicles aside from the center of the area where the green areas and water masses will be placed. The only areas that pedestrians and non-motor vehicle users can be safe from motor-vehicles are in the center and in the parallel area near the railways where only cyclists can have access.

The main concept behind my suggestion is creating a car-free area. Although I considered the difficulty in that radical transition from a citizen perspective, the difficulty in the selling process for the owners and the accessibility in the area for service vehicles (vans for individuals with mobility challenges, fire brigade, garbage trucks, etc.). I created an area that eliminates car existence as much as possible and additionally the limited accessibility in oil and gas engined vehicles limits the use of the roads almost completely to EVs. This way any kind of pollution, resource consumption and safety issues that are relevant to these kinds of vehicles is reduced in a significant level. Furthermore, the local roads are completely erased from the map and are replaced by pedestrian and bike lanes to give accessibility in the areas as well as create infrastructure for service vehicles to have maximum access in times of emergency.

Considering all of these aspects, this project suggests that designing and planning for an area that needs to support a sustainable mobility system has to start with the idea of eliminating the possibility for business as usual to be applied. If there is a plan on eliminating car dependency, reduce costs and emissions but can risk public perception and the difficulties of a transition to transport modes less comfortable than private cars, it can be possible that a new suburban area or an area

that needs a new transport plan can be designed and reformed in a way that it can support a sustainable mobility system.

Sustainable mobility challenges

There are a few challenges that the implementation of a sustainable mobility system can bring to the surface and they will be explored in this section so there will be a solid overview of implementing a sustainable mobility system. While infrastructure and costs may be an important concern, public perception, political will and stakeholder collaboration as well as the behavioral change needed for that kind of transition to a sustainable mobility system are the main obstacles that planners have to have in mind (Gakenheimer et. al, 2017).

Developing infrastructure for that system such as bike lanes, pedestrian walkways and charging stations for electric vehicles can become an issue due to limited space, existing urban design and landscape as well as costs. Investing in that infrastructure can require considerable amounts of financial resources. Funding mechanisms, securing financial support and allocating resources effectively are some key challenges that have to be considered (Shaheen, 2013).

The public's resistance to change and adopt more sustainable choices in travel modes is a significant challenge of this transition. It requires a significant shift in their travel behavior and habits to promote a culture of sustainable mobility. Also, ensuring that sustainable mobility options are accessible to all citizens and include low-income communities, elderly individuals and people with disabilities is necessary to ensure equity and accessibility in transportation (Zhang et. al, 2017).

Additionally, implementing sustainable mobility systems in general and especially in the case of Ravnsborg Enge, requires support from the local government and forming a collaboration between multiple stakeholders such as government agencies, transportation planners, urban planners and others. Coordination between these sectors and overcoming institutional and political barriers is necessary for a new system to be effectively implemented and monitored (Shiftan et. al, 2017).

Finally, integrating emerging technological advances and innovations such as smart mobility, autonomous cars, etc. in sustainable transportation systems can bring up technical challenges in the infrastructure, data management and cybersecurity. Infrastructure upgrades, investments and updates in regulations and policies are essential for countering this issue (Ryley et. al, 2016).

There have been some cases that the implementation of sustainable mobility solutions has faced some challenges. For example in New York city, the implementation of bike lanes has gotten criticism from community members and local businesses. The parking space reduction has brought potential impacts on local businesses and conflicts between cyclists and pedestrians which have led to public debates and legal disputes in some instances. So the investigation of the context of each area in the implementation of sustainable mobility solutions is essential (Davidson et al., 2019).

Introducing congestion charges in Stockholm has faced resistance from some citizens. These charges have been perceived as an additional financial burden and opposition political parties have been put up against it. Although public opinion has shifted its attitude towards it as the benefits of reduced traffic congestion and improved air quality became very clear (Eliasson, 2018). In Barcelona, there has been an effort to pedestrianize some areas such as the city center and the waterfront. Some business owners and residents have been opposed to this solution and the negative impacts on delivery accessibility, reduced parking availability and repositioning of commercial activities have been expressed (Balaguer et al., 2020).

Although these cases indicate potential challenges for sustainable mobility solutions they do not negate the benefits of successful sustainable mobility initiatives as the international examples mentioned above. Sustainable mobility is a complex trade-off between different stakeholders and people of interest and requires careful planning, stakeholder involvement and strategies that can help mitigate the concerns, objections and potential negatives of the implementation of a sustainable mobility system.

Strengths and Limitations

The strengths of this report are not many in number but can create a solid basis for future projects to build on. These strengths are; *Practical Relevance: Contribution to Interventions*.

The practical relevance of the project relies on that it addresses a real-world challenge and identifies the challenges that the municipality, the owners and the planners might face. It helps in the process of demonstrating the applicability of the initial project and its potential positive or negative impact in the issue that it wishes to address.

The contribution to intervention is supported by the creation of an original plan that differs in many points to the initial one and offers practical suggestions for implementing a sustainable mobility system in areas with similar context. It might be based on existing models and have existing examples as arguments but there is a more complex and combined approach to the plan that can make this project a good tool for further research

In this section the limitations of the report are presented, which were followed throughout the project. The limitations that have been established are; *Inability to conclude surveys with citizens, Inability to forge a meeting with the owners, Distance from the understudy area*.

I have been presented with the difficulty of approaching citizens, locals and individuals that are affected by the current plan as people from the surrounding environment. A connection with them could give me a better overview, more conclusive data and maybe a feedback on the current situation, the proposed plan and my suggestions. That could provide me with the opportunity to design a more realistic plan, create more solid arguments and maybe re-evaluate my own design if there was agreement by the citizens on the initial plan. In addition, a contact with the potential buyers or tenants of Ravnsborg enge could give me the same data in a different context and from people of a different perspective and interests.

A meeting with the owners would definitely answer many questions about their motivation behind the project, a more accurate and detailed image of their plan so I could either compare costs or construction time or anything relevant to the realization process. Also I could get in contact with potential residents of the area, the planners hired by the owners and maybe learn more about the regulation they had and still have to face to realize the project.

Finally, as I am a resident of Copenhagen it has been difficult for me to conduct more meetings with stakeholders, try to approach the area, the citizens and the locals more times than i already did. I traveled to Køge a total of 5 times but the cost, the time and the inconvenience of working on the road could not help me with the process of building this project.

Conclusion

The main Research question of this thesis is: How to design a suburban area that supports sustainable mobility?. Through the research sub-questions I have established which are the current business as usual solutions and processes do address the issue of connecting a new suburban area to the current transport system, then I made an effort to identify solutions that can be included in the design of a suburban area to support a sustainable mobility system and finally identify which of these solutions can be implemented in the under-study area, Ravnsborg Enge.

Current processes and solutions cannot support a sustainable mobility system and cannot help on the transition towards sustainable mobility planning as they do not consider the aspects that sustainable mobility aims to address. That being said, the plan suggested by the owners about the area, although it has many points that can be connected to a sustainable mobility system, still gives space and opportunity for business as usual solutions to be designed and implemented. Road construction, accessibility to motor-vehicles and the non elimination of oil and gas engined vehicles can be considered as business as usual solutions.

My suggestion has considered sustainable mobility solutions, which can be easily implemented in the area without the need for further infrastructure than the already planned, no significant costs in the alteration of the initial solutions (can be even considered as less costly) and solutions that can be directly identified as parts of a sustainable mobility system. Furthermore, the interests of the owners, the municipality's plan as well as the landscape of the area has been considered as well. The formation of two brand areas that implement a more radical change in design with implementation of an even more committed sustainable design can also bring a significant advantage to the owners' selling process as it highlights their vision of connection with nature and will target specific buyers without being concerned about comparison to other projects.

Initially the idea of the municipality officials was to create a transport plan for the area that has been affected from sustainable mobility systems but also, they had in mind that the example of this area could be potentially be implemented in areas that will be constructed or areas that will need this kind of planning, due to population increase and even internal migration. It is safe to assume that the plan suggested can be implemented in areas where the investment levels might not be as high as in Ravnsborg Enge, as the plan relies on active mobility and mobility solutions, in which case the vehicles can be provided by the companies that will provide the service. Although the initial plan with bringing EVs to the equation, shared mobility and the creation of a well preserved natural environment, the investments on private EVs, charging stations, road construction etc. can be very costly and can bring many conflicts with the surrounding areas (noise, dirt, construction conflicts, urban environment, etc.).

As mentioned in the limitation section, surveys and connection with locals, citizens of the area, potential buyers and the stakeholders (owners) is essential to create a feasible plan that can be effective and successful and well perceived by all the parties involved. Also further research on the perception of sustainable mobility solutions in other areas is a very important part. Sustainable mobility is a concept of extensive research but there are still many areas to be researched and in need for development.

Through this project I identified some key areas that require further academic development and literature work. First of all, in relevance to emerging technologies and innovation, there is a need for further and more thorough research on understanding the impacts, challenges and potential use for sustainable transportation of shared mobility, EVs, autonomous vehicles and active mobility. Moreover, the transition towards designing a sustainable mobility system and avoiding business as usual solutions requires behavioral change and decision-making for all the individuals that use a transport system.

The underlying factors that influence public's opinion, choices, travel behavior patterns and effectiveness of the interventions from governmental structures have to be further researched. The impacts of policy instruments such as congestion fees, parking management, etc., have to be examined and evaluated. Equity and accessibility is an integral part of sustainable transportation and the research on this matter should focus on understanding the social, economic and spatial factors that are connected to transportation and the solutions that will address this issue. Developing evaluation and assessment systems is essential to look into the effectiveness and sustainability of a new system. Research on implemented systems and development of literature that will set a framework on which new evaluation systems can be designed would be very helpful.

Finally, having in mind my suggestions and all the aforesaid challenges for sustainable mobility, getting direct feedback from the users is essential as the transport planning is to serve citizens, commercial areas and services. This project has reduction of car dependence as a final suggestion and while this is very difficult in terms of behavioral change, public perception and conflict of interests between stakeholders, it is essential to consider this solution as EVs are yet to be economically accessible to everyone and electricity still has an impact on pollution and oil and gas engined vehicles still occupy the biggest part of the transport sector.

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