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Faculty of Landscape Architecture, Horticulture
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Introducing charging infrastructure for electric cars
Suitable placement in Landskrona municipality

Införa laddningsinfrastruktur för elbilar
Lämplig placering i Landskrona kommun

Author: Ivana Souckova

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preface - energy landscapes

"1,4 billion tonnes - annual reduction in carbon emissions if the world's largest cities had more efficient transport systems"

Source: Global Commision on the Economy and climate

During my studies in SLU and especially during a course Master planning - Energy landscapes I became interested in energy, flowing in the landscape we are living in.

This thesis is a continuation of a process of learning, intertwining energy, in form of liquid fuels, and landscape.

abstract

Electric mobility is one of the most promising solutions towards decarbonizing the transport sector, especially in cities. It is favourable to use zero – emission vehicles, as conventional cars emit pollution, generate noise, and release particulate matter. Although electric vehicles (EVs) are infrastructure dependent, the distribution grid for electricity is available almost everywhere in Sweden. This basic prerequisite is therefore creating a favourable opportunity.

Dependence upon public charging infrastructure will vary greatly among EV owners. For those that do not have a private parking space, public charging is inevitable, whilst others may charge at home or at work. However, to facilitate the large-scale adoption of EV'-s, the presence of public charging is of great importance.

This thesis combines the theoretical framework and practical implications of EVs and charging infrastructure from both a general perspective and through a case study of Landskrona, Sweden. Geographical Information Systems (GIS) are used to identify suitable placements for standard, accelerated and fast charging stations. Inverse Distance Weighted analysis (IDW), based on the number of potential customers - people living, working or travelling within in the area, is used as a tool to compute the suitability. The number of people and other chosen criteria are layered on top of each other in GIS and the analysis results in suitability maps for different charging stations.

The maps are made on a raster basis using IDW, and cover the whole municipality in the first stage. As a second stage, results from a workshop with the main stakeholders are presented. The third stage presents identified placements of charging infrastructure on a local scale that combines results from the first and second stages of the process. The suitability of charging station placement is analyzed for the present (2016) as well as for the near future (2020), which takes into account proposed development of the municipality.

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Thank you to my supervisor Åsa, your knowledge and experience deserve my admiration and your wise opinions pushed me ever forward and made me reflect upon my work.

Thank you to my supervisor Ingvi, firstly for your cooperation on this project as a whole and, for the opportunity to be part of Green Hub Landskrona. Secondly, thank you for your everlasting guidance, positive energy and quick and thorough feedback.

Thank to all the people that helped me during my work, Michael for constructive feedback when I felt stuck, and Timothy always being there for me when I needed a text check. A big thanks to Neil Sang, who helped me to find out a way to reflect reality in GIS. Withouth you this work would not be as truthful as it is now.

Thanks to my family, expecially my father, for financial and emotional help during my stay in Sweden and beyond. Thank you for your endless care, that can be given only with a pure love.

A great deal of gratitude to all the students and teachers I've met and lived with during my stay at Alnarp. The inspiring environment gave me many opportunities and opened many doors.

And finally thanks to Nico, for pushing me a bit on my way to success. Thank you for understanding me for who I am.

In Alnarp 14/9/2016 Ivana Souckova

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TRANSPORT BASED ON FOSSIL FUELS

It has been scientifically suggested that human activity plays the most significant role in recent climate change. (Schellnhuber, 2014) The main contributor is the burning of fossil fuels to power machines, generate electricity and propel transport vehicles. The Kyoto protoco, agreed to by UNFCCC parties in 1997, proposes that the world must stop, then reverse, the growth in greenhouse gas emissions by 2020. Fossil fuels are the main source of energy in contemporary transport (EC Climate action, 2016). According to Eurostat (2015) shown in Figure 1, 22,2% of CO_2 emissions in 2013 came from the transport sector. This number can decrease because transport has potential for fossil-free future. EU has a plan to cut these emissions by 20% in 2020 and by 80-95% by 2050 (European commission, 2016).

Transport in all its modes (road, air, water, rail) affects the environment in several ways. Vehicles are responsible for emissions of air pollutants and greenhouse gases. The environment is negatively affected by the infrastructure required by vehicles. Valuable natural landscapes are destroyed and cut up by motorways and other infrastructure. Naturally some advances have been made, new vehicles are quieter and cleaner than their predecessors. However, many of these positive effects are diminished by the increase of vehicles on the road.

Environmental problems associated with traffic according to Kvärnbeck (2000) are:

- Air pollution
- Impact on climate
- Noise
- Impact on the landscape

This thesis focuses mainly on pollution and noise. These two negative effects can be diminshed by electrification of the vehicle fleets which will be explained further. Emissions contribute to acidification, which causes damage to soil, forests and water. Nitrogen fallout contributes to eutrophication in seas, lakes and watercourses. Gases in the atmosphere lead to a gradual increase in the average temperature on Earth. Road transport is responsible for a large share of airborne emissions, mainly in the form of carbon dioxide, hydrocarbons, nitrogen oxides and particulate matter. Diesel engines emit more nitrogen oxides than petrol engines, but less carbon dioxide. Emissions can only be cut in fuel consumption or changed to less polluting fuels, preferably based on renewable resources (Kvarnbäck, 2000).

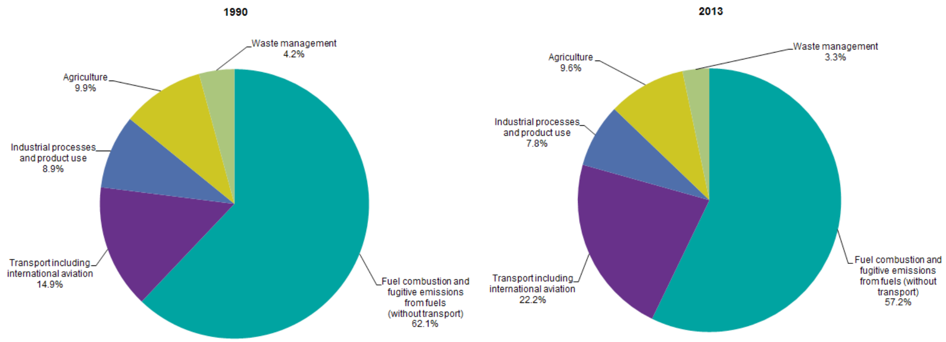


Figure 1: Greenhouse gas emissions, analysis by source sector, EU-28, 1990 and 2013 (percentage of total) (Eurostat, 2015)

For the purpose of this thesis only personal vehicle road traffic is considered. Other associated means of modern transport can be considered for expansion and collaboration: electric freight traffic, electric busses, electric bikes, electric motorbikes, car-pooling and self-driving cars.

Electric vehicles, EVs, provide significant opportunity for fossil-free transport. The vehicles are emission free and the electricity can be produced from renewable sources. With this in mind, electric cars are one way to reach the goal of fossil fuel independent transport. It is unlikely that only one technology will be the solution for this sector, but the combination of electricity, hydrogen and biofuels is promising. However, there are many challenges before it is possible to change the fleets completely from fossil fuels to more renewable technologies. One of the challenges could be to increase renewable electricity production to ensure that electric vehicles are powered from the least environmentally harmful energy sources as possible.

Electricity for vehicle propulsion offers a big opportunity for oil substitution. Renewable and carbon free energy sources in the transport sector could help to meet the EU target of decreased carbon emissions (European commisson, 2012). The first EU fossil-free transport target is to reach 10% of transport fuel derived from renewable sources by 2020. Sweden has it's own goal to reach fossil-free vehicle fleet by 2030 (Sweden, 2016). The governmental analysis group will investigate and describe the political and market changes needed to realize these goals (Government, 2015). According to Swedish Energy Agency the final energy use for biofuels and electricity in the transport sector in 2014 was 19 % as show in Figure 2 (Swedish Energy Agency, 2016).

Swedish parliament adopted a vision for 2050 not to have any net emissions of greenhouse gases (Haghanipour, 2015). In Sweden the fossil fuel dependency for electricity and heat production has decreased after 1970 due to strategies that found new technologies to substitute oil. In 1991 the carbon tax was introduced which accelerated the movement from fossil fuels to biomass that had previously been used mainly for heating. During the past years biomass pellets and heat pumps have accompanied the use of biomass. For energy purposes efficient district heating system have been using biomass and waste products. Biomass and wind power are foreseen as a source of renewable electricity, therefore the use of fossil fuels for heating systems are to vanish in future (Bengt Johansson, 2007).

In 2003 Sweden introduced green electricity certification for energy coming from wind, solar, geothermal, wave power, biofuels and small-scale hydroelectric plants. Power producers receive certification per produced unit of renewable energy and it is compulsory for electricity retailers to buy a certain share of these 'bonds' for all the electricity they sell. (Sweden, 2016)

Sweden has the highest percentage of renewable energy use in the EU, 53 % measured for 2014 (Swedish energy agency, 2016). This value already exceeds the goal for renewable energy determined after the EU directive for 20 % share of electricity production as well as the Swedish target for 49% renewable energy use in 2020 (European comission Energy, 2016;Swedish energy agency, 2016). As for the renewable energy supply, Figure 3 shows the supply from renewables.

Electricity production coming from renewable sources constitutes 63 % of the whole of electricity production in Sweden. Therefore, electric cars can be powered from renewable sources (Swedish energy Agency, 2016). There has been a study done by Linköping university (Infrastrukturnyheter, 2016) showing that 1 million of electric cars could be charged overnight with the electrical systems currently in use. In the mornings and in the evenings electricity consumption reaches its peak,

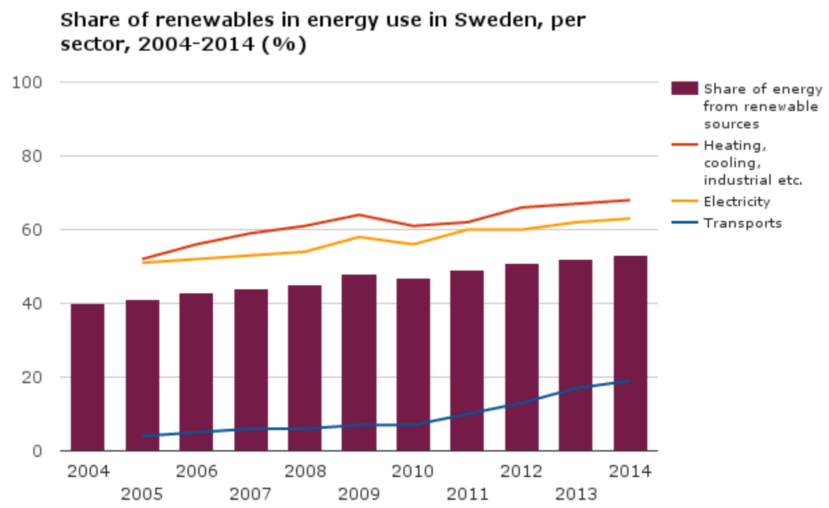


Figure 2: Share of renewables in energy use in Sweden between 2004-2014 (Energy in Sweden, 2016)

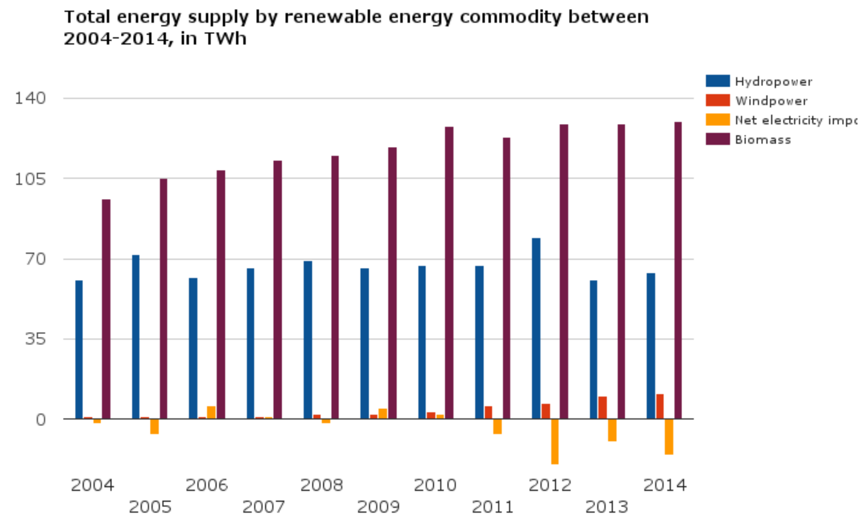


Figure 3: Total renewable energy supply in Sweden between 2004-2014 (Energy in Sweden, 2016)

therefore a system of charging overnight with lower electricity prices is logical. At the end 2015, there were more than 4.5 million personal cars in traffic in Sweden (Myhr, 2016). According to study by Linköping University, 22,2% of these vehicles could be electrified with the existing electrical grid and electricity sources every day.

THE CAR AND THE CITY

Transport is vital to cities and their function. As large cities whose transport systems are based primarily on passenger cars approach gridlock, it has become apparent that a better solution is needed. The assumption that continued automobile use is inevitable must be examined (Crawford, 2009). There are supporters of the personal cars in the last century, like Howard (1902) of Corbusier (1967). The post-industrial revolution and demand on comfortable and healthy living supported the spread of personal vehicles in every day lifes. Later, the critics of the car dependent architecture began to appear, such as Gehl (2011) or Jacobs (2011). In their studies they point out the dissappearance of the human scale and sterility of the public life on the streets, that do not only criticise the personal vehicle transport, but also other aspects of modern architecture.

The car is the most space-intensive form of urban transport system and has forced cities to spread into rural areas (Crawford, 2009). A growing number of studies and publications in planning and social sciences are developing the idea that the car should not be the primary means of transport in future in the global North (Kwan, 2016). However, the automobile infrastructure is deeply ingrained in our urban environments.

In past few years, planners of urban environments have begun to stimulate the use of alternative means of transport whereas in the further past planning it was more about encouraging the use of the car (Graves-Brown, 1997). The car was considered a solution to “modern” society. Cars represent flexibility, freedom, social status and the sensation of speed. Road construction became popular governmental strategy to stimulate local and regional economic development. Auto mobility is perceived as more attuned and receptive to society than, for example, public transport or cycling (Kwan, 2016).

The car is a very effective means of transport, able to rapidly move persons and goods from different parts of an urban area. The car’s performance and capabilities were a major factor behind the economic growth in the West after World War II. The car has enabled longer journeys and greater freedom of movement for many people. During the 1960’s and 1970’s the physical planning of urban areas was largely aligned to meet the needs of car traffic and motorists (RAC foudation, 2014; Sveriges kommuner och landsting, 2011).

Driving has become the dominant factor that suppressed other urban qualities that agglomeration should and can provide. The car, and other fuel propelled vehicles that cause negative consequences, should be reduced in number to ensure good health and unspoiled ecosystems.

The planning policies must support more sustainable modes of travel that provide security, and safe streetscape for pedestrians, cyclists and public transport passengers (Sveriges kommuner och landsting, 2011).

The old paradigm, that when one gets richer they drive more, no longer appears to be valid. Young people are obtaining driving licences later, and according to research, it works the same way as alcohol: if one starts later, they will use it less. In most major cities the road traffic is decreasing or is stationary. This is a result of numerous factors, but is in part due to the increasing redistribution of space from cars to other modes. In larger cities, this is done not only to make the city attractive, but often it is the only way to cope with traffic requirements as more and more people want to stay in the cities. Walking, cycling and public transport are simply much more space-efficient than the car (Ljungberg, 2015). At the same time it must be noted that car traffic is still needed for community businesses and citizens to carry out their business. Car traffic will continue to be a significant part of travel in urban areas. This requires that a functioning structure serves all modes of transport, even cars (Sveriges kommuner och landsting, 2011).

Fossil-fuel cars could be gradually replaced by electric cars. Such a trend would not solve the problems associated with a car dependent society, but could serve as a first step towards a better mix of transport modes.

Ramboll’s The Primer (2016) presents a little different thought for climate friendly urban mobility. They highlight that cities should consider growth to organise smaller communities around the main urban area in a way that everyday activities are mostly reachable by walking or biking. That requires a top-down planning of land use and urban structures to minimise the spatial distances and travel times.

Cities should also provide a mix of modal choices, prioritising the most community-friendly options such as walking and cycling. Residents should be offered reasonable prices to allow the choice of the most convenient travel option.

Such a mobility as a service (MAAS) schemes are being implemented in some

Nordic cities and offer bike and car share programs. Multi-modal transport systems overlaying densely organised cities more fairly empower all residents, resulting in more attractive conditions, stronger social cohesiveness, and increased economic competitiveness.

The five-minute principle for sustainable community in dense cities has been implemented in Nordhavn, a part of Copenhagen, Denmark (Ramboll, 2016). This principle prioritizes climate and space friendly modes of transport in a sustainable city. It can serve as an inspiration for urban planning, but every city is different and should adapt a scheme that suits according to its own needs.

- Ensure that public transportation is provided
- Allow for direct and high quality bike routes
- Plan for indirect car routes
- Locate all services within a five minutes walking distance

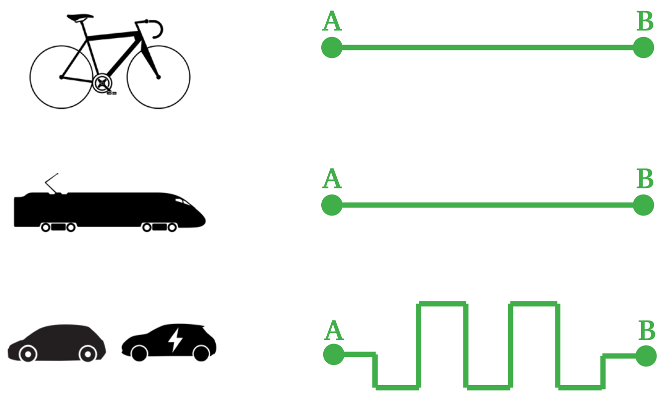


Figure 4: The five-minute city principle designed for sustainable mobility (inspired by Ramboll, 2016)

To conclude, it is essential to make the transport systems in urban environments more efficient and reduce the dependency on cars. The shift towards electric vehicles is one element - along with carpooling, adequate public transport, and walkability - towards livable communities.

PEOPLE'S BEHAVIOUR AND TRANSPORT

MOVEMENT PATTERNS IN LANDSKRONA

The travel survey for Skåne in 2013 (see Figure 5) shows that the car is the most common transport mode for Landskrona's residents. The people participating in the sourvey, took a car for 57% of the trips, which is a slight increase compared with 2007's 55%. The proportion of train and bus travel has decreased whereas the bike journeys stayed constant. The car is also used the most when travelling to and from Landskrona, with 71% of trips taken by car.

Figure 6 shows, that 57% of car journeys are between 1-5 km, and 25% of all trips to 1 km are done by car in Landskrona. According to Sveriges kommuner och landsting (2011), part of this number of journeys could be substituted by cycling or walking if the infrastructure was better planned.

COMMUTING PATTERNS

According to a survey done in Landskrona municipality for the bus company Nobina people travel within the municipality to certain work places identified during the survey. Many more people commute to and from Landskrona for work. The number is higher for commuting out, 7 977 persons, than for commuting in - 5 990 persons (Landskrona stad, 2016). For the commuters living outside of Landskrona, it is sometimes easier to use a car for going to work. It simply takes more time to travel by train or bus. Residents of Landskrona commuting outside of the municipality could be motivated to take their electric car to work if it would be the most convenient option for them. However, it is difficult to identify these potential commuting customers and placement of charging stations in their home.

THE LENGHT OF JOURNEY

According to the study by Svensson (2014), people travel on average 72,5 km per day in Landskrona. That exceeds the average in Skåne, which counts 61,8 km per person/day. The average length of journey is 25,6 km in Landskrona, again higher than the Skåne average - of 19,5 km/per journey. The most common electric car in Sweden - the Nissan Leaf - can today reach up to 250 km on a fully charged battery (Nissan, 2016), which would be enough for 3 days of average Landskronan travel.

DESTINATION

According to the survey (Svensson, 2014) the most common destination for people

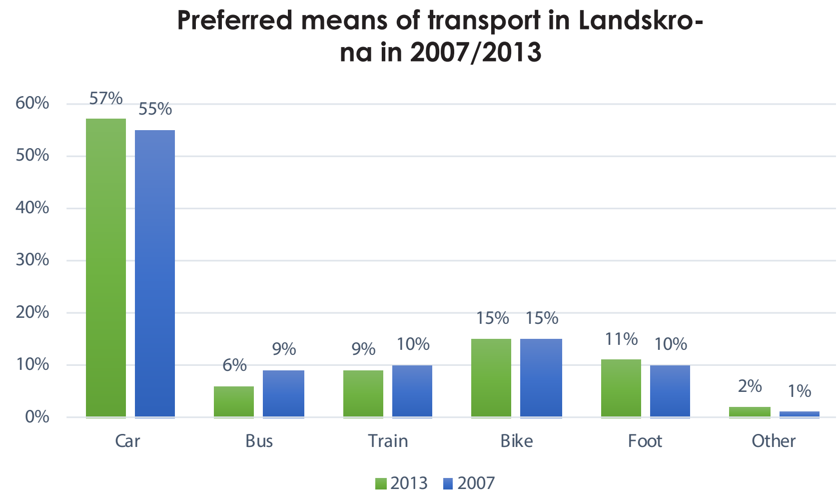


Figure 5: Mean use in transport in Landskrona in 2007 and 2013 (Svensson, 2014)

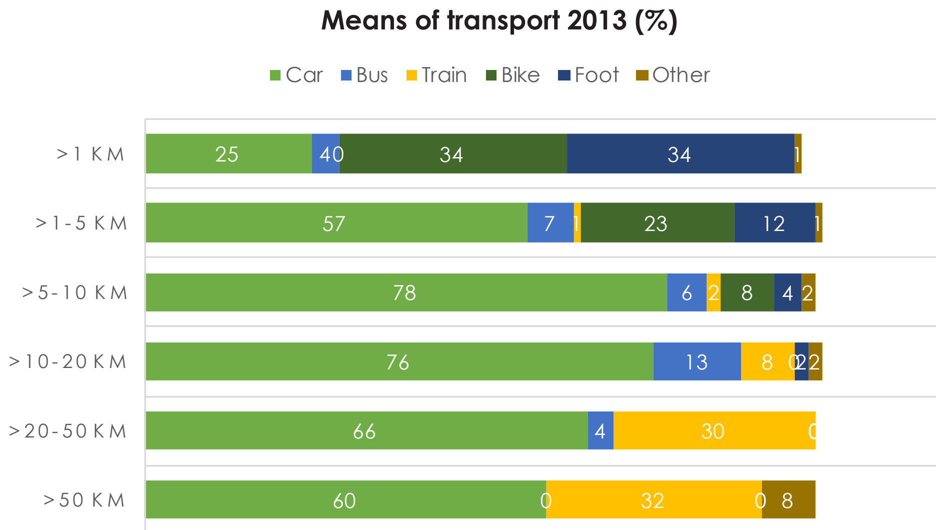


Figure 6: Mean of transport depending on the length of journey in Landskrona (Svensson, 2014)

is home (Figure 7). 41% of journeys in 2013, were homebound. The second most common journey (20%) was to work. Third place with 14% are destinations connected with movement or recreation. Journeys for shopping represent 12% of total journeys. These destinations, representing 87% of all trips, play an important role in electric vehicle planning; these places provide potential locations suiteble for charging infrastructure development.

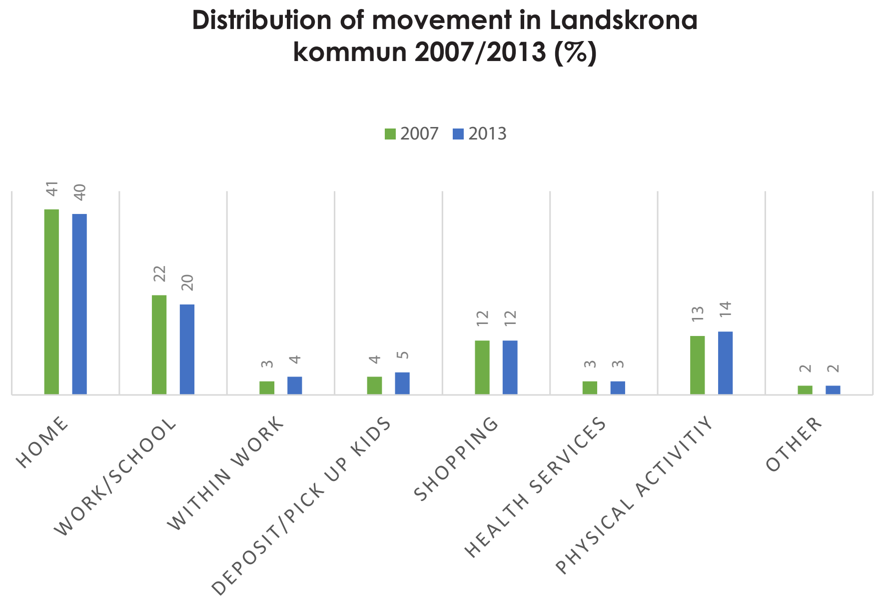


Figure 7: Destinations of travels in Landskrona in 2007 and 2013 (Svensson, 2014)

PERSONAL TRAFFIC

The reduction of fossil transport is of great interest. When the distances are too long to use public transport or bike it is important to make use of alternative fuels instead of fossil fuels to reduce the environmental impact. Electric vehicle or other environmentally friendly vehicles provide a sustainable option (Energiinventering, 2014).

So what can electric car offer? That is dealt with in the next chapter.

CHAPTER 1 - INTRODUCTION

This theses is a part of Green Hub Landskrona project (GHL). It is a collaboration between Landskrona Energi AB, Landskronahem AB and LSR AB with the task of stimulating the transition to a sustainable society. Currently, the main focus of GHL is on cooperation with universities on academic theses. Specifically for this thesis Landskrona Energi AB would like to investigate its role and other stakeholders' role when it comes to developing charging infrastructure for electric cars in the municipality of Landskrona. Determining suitable places for charging stations may support the stakeholders in determining appropriate investments.

AIM

The aim of this study is to find the most suitable locations for electric vehicle charging stations, in order to maximize their use and value. These locations may include 3 types of charging station - standard, accelerated or fast. The goal is to determine locations for each type of station through a literature review and collaboration with the stakeholders.

The result is spatial analysis as a suitability map for implementation of charging infrastructure on a municipal scale for year 2016 as well as at a local scale or the years 2016 and 2020. Suitability map showing the range of not suitable - suitable places for charging infrastrurcture introduction. The focus is made on close future development areas to encourage the initial adoption of electric cars, because the evolution from fossil fuels in the transport sector is needed as soon as possible. With this feasibility study interested stakeholders have the opportunity to consider their role in future transport strategies in Landskrona.

A suitability map is created for each type of charging station at the municipal scale. The results also include local scale placement depending on a set of criteria resulting from the workshop and literature review.

After an implementation of the charging infrastructure, fossil fueled vehicle owners will have further incentives to switch to electric vehicles. With a complete transition to electric vehicles in future the municipality will become cleaner, less noisy and transportation will adhere to the sustainable strategies and image of the municipality.

RESEARCH QUESTION

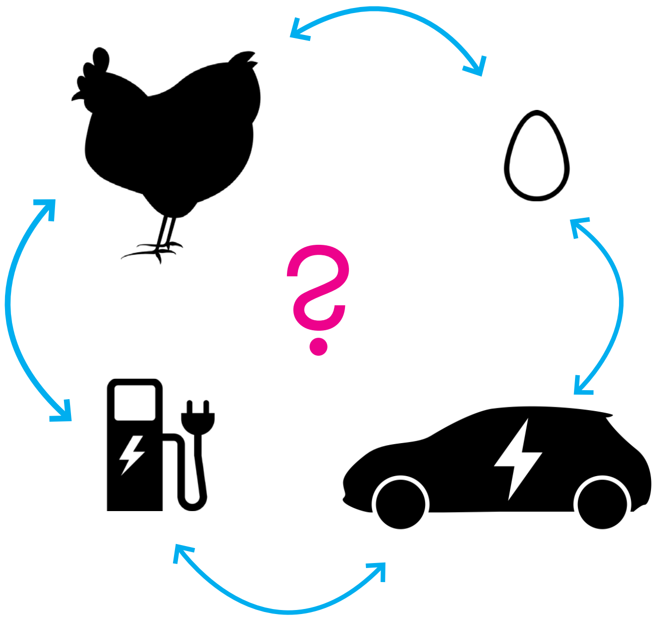


Figure 8: What came first, the chicken or the egg?

- *Where would it be the most suitable to place charging infrastructure for electric personal vehicles in Landskrona municipality?*

To find the best places for charging stations it is important to set criteria for each type of station. These criteria are found with the help of literature and through cooperation with stakeholders. From a city planning perspective it is important to be strategic when locating the stations. The station locations should direct the drivers to park their electric vehicles in areas that are convenient for the driver. Areas that are designated to have limited vehicle parking can more easily develop other spatial qualities of the space. The chicken and egg paradigm is present here, the paradigm is visualised in Figure 8. Do charging stations have to be first or are the electric cars first?

METHODOLOGY

To answer the research question and fulfill the objectives and aimes, the thesis used literature review, spatial analysis and participation with stakeholders as research methods. The method is described in Chapter 3.

The literature review (see Background and Chapter 2) combines findings from international and Swedish sources. The plannning of charging infrastructure is in it's infancy, but a few good examples were found (Portugal, USA, Norway). The aim of the review was to find argumentation and support for the thesis, as well as significant criteria influencing the position of charging infrastructure for electric vehicles.

The criteria were further developed during the spatial analysis, using Geographic Information Systems (GIS), shown in Chapter 4. The GIS were used to answer the question of how to spatially determine areas in Landskrona municipality that are most suitable for different kinds of charging stations. During spatial analysis, a raster analysis was introduced, showing a range of suitability based on potential number of people living, working or travelling in the area.

Finally, a workshop (see Chapter 3 and 4) is held with the main stakeholders to determine goals, visions and focus areas for Landskrona. Some of the areas decided on the workshop are then further developed in GIS spatial analysis with a proposal for the approximate placements of stations in the municipality and focus areas.

CHAPTER 2 - TO MOVE WITH ELECTRICITY

ELECTRIC VEHICLES

Incorporating EVs into the existing transportation system is challenging. Expansion of the vehicle fleet without proper infrastructure, parking and road connections can suppress the practicability of EVs. On the other hand EV facilities with low usage can be considered as a waste of valuable resources. Therefore it is necessary to carefully plan introduction of EVs into the city and its surroundings (Lam, 2013).

In Sweden, Power Circle is an electricity industry association focusing on future issues within the sector. They also promote the importance of e-mobility in future transportation.

THE HISTORY OF ELECTRIC VEHICLES

In 1886 the fist gasoline-powered automobile was invented by Karl Benz. This was the beginning of the 'mass' production of vehicles (Eckermann, 2001).

In 1898 Porsche first manufactured an electric car and dominated the US market until the 1900'-s. Due to the short distances possible with electric vehicles, internal combustion engine (ICE) powered cars soon took control of the market. But electricity was still used by smaller vehicles such as golf carts or lifts (Haghanipour, 2015).

The Toyota Prius was the first car of the modern era with hybrid technology that was widely implemented. It contained both an electric and a combustion engine. Up to 30 km/h the electric engine was used. When the ICE was used, it would divert part of its energy to recharge the battery. It was therefore not defined as an electric car because it was not externally rechargeable (Energy.gov, 2015).

Today the definition of rechargeable vehicle is a vehicle with one or more electric motors. Electric motors include batteries that can be recharged from an external power grid.

There are two types of plug-in electric vehicles (PEVs) one combining combustion and electric engine and the other using only electricity. There are 2 main designs for plug-in electric hybrids (PHEVs). For ***series hybrid*** only the electric engine propels the vehicle. The internal combustion engine only provides necessary power to charge the electric engine. ***Parallel hybrid*** has electric and combustion engines working together. When the battery is empty, the combustion engine takes over and drives the vehicle.

Pure electric vehicles, also called battery electric vehicles (BEVs), include only electric motors. The battery is charged via a cable from power grid. This energy is used to propel the vehicle (Haghanipour, 2015). Both kinds, plug-in vehicles and electric vehicles need charging infrastructure to be more widely adopted. Figure 9 shows the number of PEVs until April 2016 in Sweden, according to national statistics database (Elbilsstatistik, 2016).

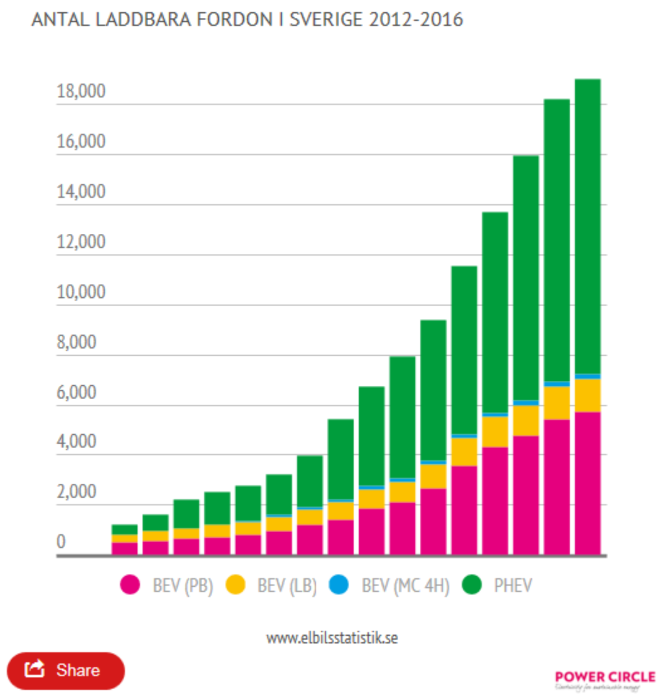


Figure 9: The number of BEVs and PHEVs in Sweden in 2012 - 4/2016 (Elbilsstatistik, 2016)

ADVANTAGES OF ELECTRIC VEHICLES

Electric cars have several advantages compared to classical combustion engine. Some of these advantages contribute to the fight against climate change. Nevertheless there exist many prejudices and myths. There are no cars that are “good” for the environment, but EVs have very low impact on the climate compared to the traditional ICE vehicles.

Another important aspect is that, EVs reduce traffic noise (note that it is possible to activate a noise to draw the attention of pedestrians when required). The car has also 30% fewer moving parts, which reduces maintenance compared to combustion engine cars. Another interesting aspect is the reduced fuel cost. EVs costs about 0,2 SEK/km to run, whereas with diesel or petrol engines cost 1 SEK/km. The user saves 0,8 SEK/km. Electric engines are also much more efficient: in a combustion engine, 62% of energy goes into heat, 15% is lost in the process and 5% is driverless loss. Only 18% of the energy used actually propels the vehicle (Haghanipour, 2015).

In an electric car, the whole power capacity is available from the start whilst in a ICE vehicle, the engine needs to gain revolutions before all the power is available. EVs therfore accelerate faster and more efficiently than many traditional vehicles. Electricity doesn’t need to be transported the same way as gasoline, hydrogen or other fuels. It is transported by cables, which is faster and more efficient, but requires an adequate infrastructural network.

THE CHALLENGES OF ELECTRIC VEHICLES

The biggest issue with contemporary battery technology is the availability of lithium and a question of whether supply would meet the large scale in the the demand. However, batteries can be reused and other kind of batteries may be developed (Haghanipour, 2015). Davidsson et al. (2013) conclude that the availability of lithium could be a limiting factor, depending on the scale and pace of EV production. To enable the transition towards a fossil-free car fleet, other types of batteries should be considered and lithium batteries should be recycled as much as possible. An EU funded project SyrNemo developed a machine free from rare earth materials. This technology is new and will be further presented at SAE 2016 - World congress and exhibition in Detroit (European comission Research and innovation, 2016).

EV range is limited and relates to cost. Battery prices have fallen in the past years, and, as technology continues to advance, will lead to cars having greater range (Haghanipour, 2015). In March 2016 Tesla introduced the Model 3 with pricing geared towards average consumers. It will be available in 2017, and in April of 2016 Tesla already received more than 325 000 orders globally. Electric cars haven’t been on the market for long so it is unsure how the resale will function, but there will be likely no difference in comparison with conventional cars (Tesla motors, 2016).

For mass distribution of electric vehicles in Europe it is necessary to raise awareness about electric mobility. Awareness needs to reach local policy makers, as a prerequisite for consumer acceptance and widespread charging infrastructure (Green emotion, 2016). Sweden currently has a limited number of fast chargers with several companies, for example CLEVER, developing fast chargers along the main roads between Malmö, Stockholm and Gothenburg. However, the availability is insufficient for car owners to take longer of more remote journeys (Haghanipour, 2015).

CHARACTERISTICS OF ELECRIC VEHICLES

The comparison between EV and ICE vehicles is inexact, but there are similarities. The first one is battery vs. fuel tank. A traditional car has a tank where fuel is stored in the form of gasoline, diesel or other fuels, measured in liters, whilst an EV’s battery engine is measured in kWh. Secondly, fuel consumption in liters/km corresponds to kWh/km. Thirdly, engine size in conventional cars is about cylinder capacity such as 1.8 or 2.0 litres. The combustion engine is measured in horsepower whilst the electric engine is measured in kW. One horsepower is comparable to 0,75 kW. The range of EVs on a full charge depends on external conditions such as outdoor temperature, road conditions, acceleration etc. The range of a traditional car depends on many factors as well, but generally can travel further on a full tank than an than EV with a full charge

(Haghanipour, 2015).

ELECTRIC VEHICLES IN SWEDEN

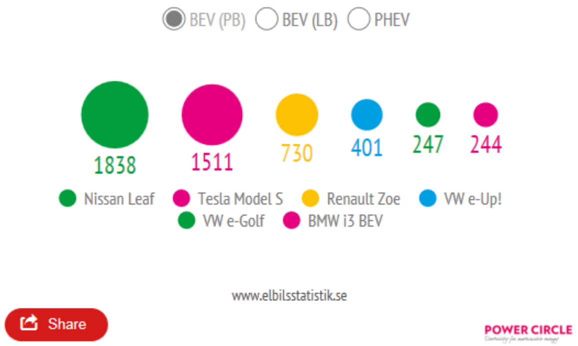


Figure 10: The number of personal PEVs in Sweden, April 2016 (Elbilsstatistik, 2016)

Figure 10 to Figure 12 show the current (April, 2016) number of EVs in Sweden. In total, there are 19 323 EVs (Elbilsstatistik, 2016). Regeringskansliet (2015) supports the purchase of EVs with a 40 000 SEK credit, but in future the government plans to adopt a bonus-malus (bonus-penalty) system. The system would provide PEVs with a bonus of 60 000 SEK and PHEVs with 35-45 000 SEK, upon purchase. On the other hand ICEs vehicles would receive a penalty in the form of a higher tax (Elbilsstatistik, 2016). The commission has been instructed to submit a proposal of this bonus-malus system to increase the proportion of environmentally friendly vehicles and therefore this system reduce the transport sector's dependence on fossil fuels. The report *Ett bonus-malus-system för nya lätta fordon* (2016) includes cars, light/electric trucks and light/electric busses manufacture in 2018 or later, registered in the system in 1.1. 2018 or later.

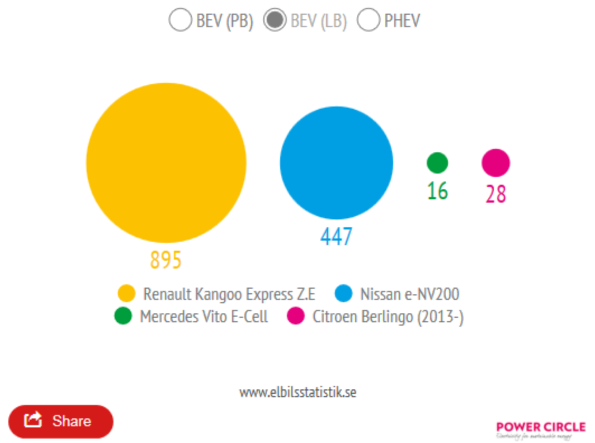


Figure 11: The number of truck PEVs in Sweden, April 2016 (Elbilsstatistik, 2016)

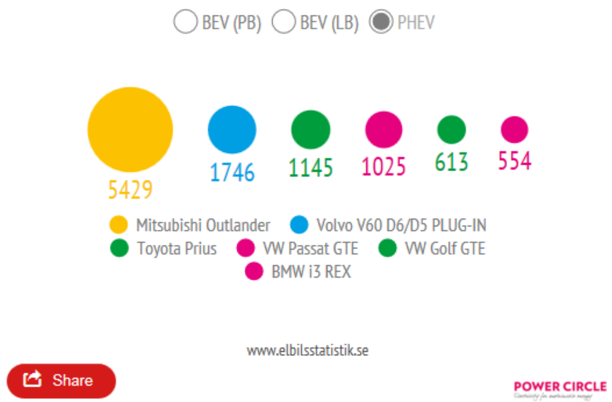


Figure 12: The number of PHEVs in Sweden, April 2016 (Elbilsstatistik, 2016)

CHARGING INFRASTRUCTURE

Charging infrastructure consists of charging stations. Charging stations can have different number of charging points, but the most common is 2 points per station. EVs can be charged in different ways. In general the higher the power the shorter the charging time. However, higher power means higher cost for purchase and establishment of the charging station. There are 3 main categories of charging stations: standard, accelerated and rapid (Svensk energi, 2014), however there exist other kinds of charging stations with mixed currents and plugs. For the purpose of this theses it is enough to work with the three primary types of stations with charging time as a main feature.

Charge map (2016) creates statistics about electric cars and charging in some countries in the world. According to their website, there are currently 742 charging points with 1 956 charging plugs in Sweden. According to the Nobil website (2016) there are 588 charging points with 2054 charging plugs in Sweden. Additionally there are 106 Tesla charging stations. Association Power Circle (2016) specifies that according to the national database there are currently 1 600 charging points. In Skåne, according to Eniro (2016) and Laddinfra (2016), there are 37 charging points with 121 charging plugs. In Landskrona municipality, according to Eniro (2016) there are 2 charging stations, but on the Uppladdning (2016) website it shows 4. One fast charging station and three standard stations. Uniform data is not available , but Uppladdning (2016) provides the broadest coverage of charging stations in Sweden.It is also possible to download a mobile application to see the availability of the station (Svensk energi, 2014).

TYPES OF STATIONS

The most common type of station with low power is ***standard charging***. To charge from completely empty to completely full takes approximately 8 hours. This type of charging takes place typically at home overnight or at work during the day (Haghanipour, 2015; Brown, 2013). According to Charge map (2016) 57,7 % of charging stations installed in Sweden are this type.

Accelerated charging can be done with single, three phase alternating current and direct current. From empty an to a fully charged battery takes between 30 min to 2 hours. These stations are suitable for public charging points. It uses mainly direct current charging power with 22kW. Because it can take an hour to charge the battery up, charging locations are well suited to exist near services such as

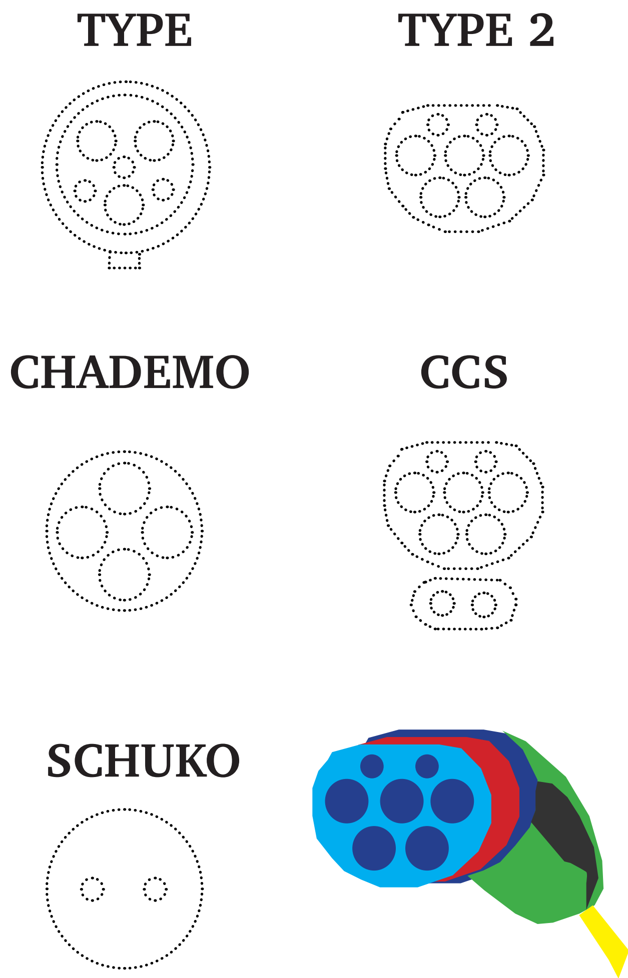


Figure 13: Different kinds of charging contacts (Haghanipour, 2015)

restaurants or shopping malls (Haghanipour, 2015; Svensk energi, 2014). The percentage of accelerated charging points in Sweden according to Charge map, is 21,8 %. There is only one of these in Landskrona municipality.

With ***fast/rapid charging*** the battery is fully charged in about 20 or 30 minutes. When establishing this kind of station, it is convenient to have quick services available, such as toilets, fast food restaurants or free Wi-fi. These stations are comparable to gas stations where the driver can rest, easily buy food, newspapers, etc. It is also important that charging stations are not occupied for more than 30 minutes to keep customers moving efficiently. There is a risk of the station being occupied by other drivers, therefore checking the availability of charging station online would be helpful (Haghanipour,2015; Svensk energi, 2014).

Figure 14 shows the types of charging stations in Sweden and Figure 15 identifies the municipalities with most numbers of charging points. Tesla supercharger represents a different type of charging station. The Tesla EV owners charge their car for free and Tesla motors determines the placement of each charging station. The power is higher than for the standard and accelerated charger (Haghanipour,2015). Landskrona's closest Tesla supercharger to stands outside of Löddeköpinge near ICA Maxi and other shopping areas (Tesla motors, 2016).

OTHER KINDS OF CHARGING

There are other methods for charging electric vehicles. For example ***electrical paths*** are already used in toothbrushes and tramways. In the future electric pathways could be used to recharge also the EVs.

Another way is ***conductive charging***, where electric energy is transferred from the roadway through rails or other electric lines. Vehicles recharge while driving or standing still. This technique is being tested on a small scale in Sweden.

Inductive charging takes place wirelessly, the location is equipped with loading place and the vehicle has an induction receiver. It is new in vehicle industry but has been used for toothbrushes and mobile phones. Being tested in Japan, the advantage of this method is that it charges where vehicles have to stop such as red lights, for private vehicles or bus terminals. There are no exposed cables, and

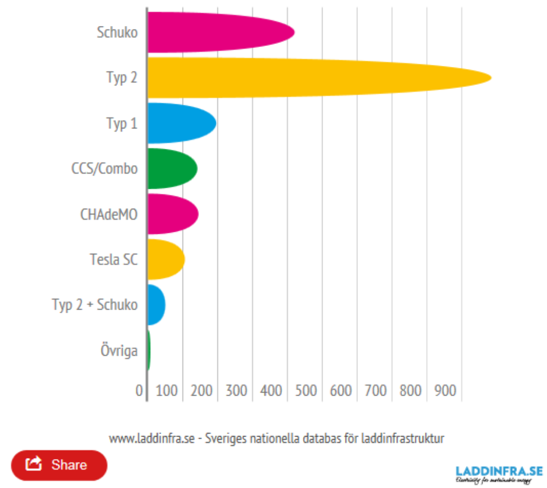


Figure 14: The variety of charging types in Sweden in April 2016 (Laddinfra, 2016)

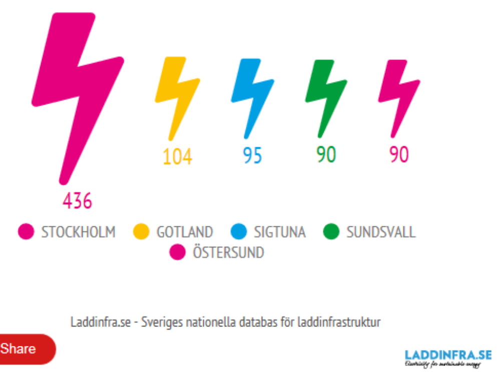


Figure 15: The municipalities with highest numbers of charging stations in April 2016 (Laddinfra, 2016)

therefore reduced possibility for shock or electrocution.

An interesting and fast option are ***battery replacement stations***. Battery replacement should take 5-8 minutes, and would be the quickest option to fully charge a battery. The switch is fast and the driver in theory doesn't even have to leave the car. The disadvantage is that this technology and process would be expensive (Haghanipour, 2015).

THE PROCESS OF CHARGING

Vehicles cannot be charged with higher power than its installed capacity. When the car has an installed capacity of 16A and the station is 32A, it will still be charged only with 16A. There is no risk in installing station with higher power, because the car determines the current. Although few cars only can handle higher power. It is more convenient to put higher power now rather than later, due to costs.

There are also technical specifications about the cables and contacts. For charging stations, the most common are shown in Figure 13. A contact type 2 is currently used as a standard in Europe, but there are some cars with other types of contacts. CHAdeMO will be the standard for fast charging stations in Europe (Haghanipour, 2015).

The length of battery charging depends on which station is used, the capacity of the battery, and current battery charge. Voltages are 230V and 400V. When talking about the speed of charging, it is the time from 0 to 80% of battery's charge, the last 20% charge slower, due to battery properties (Haghanipour, 2015).

LOCATION

There have been many studies done about the suitable charging station placement, based mainly on mathematical modelling (Brown, 2013; Frade, 2011; Namdeo, 2014; Sadeghi-Barzani, 2014;etc.)These models were based on for example, optimization of electrical output (Brown, 2013), and the number of vehicles owned, income and household type (Namdeo, 2013). Other aspects were development, electrification and grid losses (Sadeghi-Barzani, 2014). Optimal placement can therefore depend on multiple factors, including location.

Namdeo (2014) concludes that well distributed public charging infrastructure is essential, both from the perspective of EV drivers and the promotion of the EV market. Strategic locations could reduce range anxiety while facilitating public charging.

The appearance of charging stations is important from several perspectives. Firstly, high visibility is convenient for drivers and secondly, public relations/marketing for the owner of the charging station. There is a risk that the base of the station can become damaged, but many of the actors today have chosen not to install protection. Stations can handle winter and summer conditions. Next to fast charging stations there could be a form of shelter for safety against weather. Traditional vehicles can be fined if parked on the site designated for electric vehicles, so obvious signage reserving the spot for charging is needed. The charging station should be illuminated, which will facilitate use and reduce the risk of sabotage or vandalism (Haghanipour, 2015).

To reach as many users as possible, stations must be placed strategically. They should be easily accessible, located in an attractive location , and be close to other facilities to allow the user of the charger to pass the time while the vehicle is charging. Figure 19 shows Sweden's charging locations according to Charge Map (2016) and Figure 16 the rest of the world. For normal charging it is convenient to place the station near residential areas, neighborhoods. Other attractive public spaces can be airports, train or bus stations, where the driver can park his vehicle and continue to his or her destination. For accelerated stations suitable sites can be supermarkets, restaurants, cafés and places of interests (parks, cinemas, beaches, etc). Finally, the location of fast charging must be well planned mainly due to high cost. The parking time of the vehicle should not be more than the charging time to allow other EV drivers access in an efficient manner. It can be placed at fast-food restaurants, cafés, rest stops along highways and country roads, and at service stations for traditional combustion engine vehicles.

An interesting aspect is presented in a paper from Brown (2013), considering the placement of charging stations according to where people spend the most time, (see Table 1 on page 43). According to the table, EV owners charge primarily at home and at work. Lower amount of charging takes place while shopping or visiting services and meal related activities.

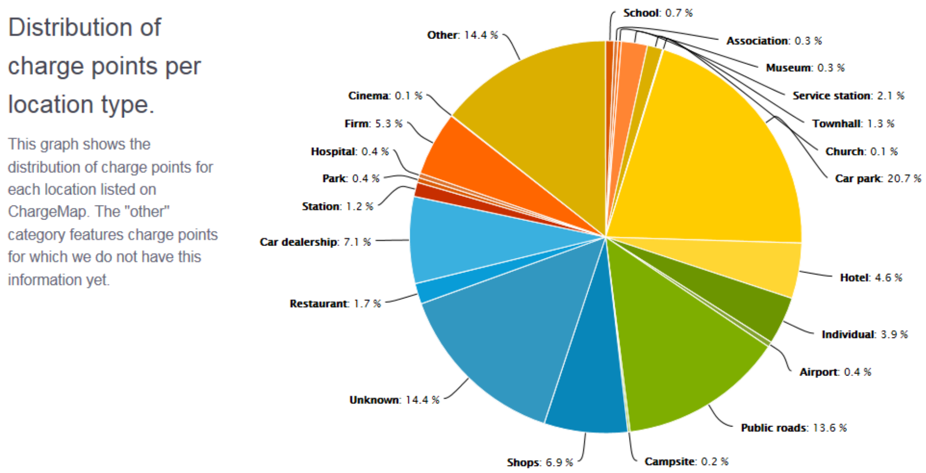


Figure 16: Placement of charging stations in the world (ChargeMap, 2016)

CHARGING STRUCTURE

There are three principles developed to determine where charging infrastructure should be placed (Haghanipour, 2015). The charging stations can be used mainly for fast charging development, especially for long-distance travel or commuters.

First is a ***corridor structure*** - the station is placed between two points, for example two urban areas. To provide flexibility and margin for error in the system, charging stations should be placed 60-80 km apart from each other.

Second is a ***cluster structure*** - creating a cluster in urban areas. Normal, accelerated and fast charging stations are placed at strategical locations so that electric vehicles can travel in and around the city on pure electricity. This structure has been beneficial to businesses travelling long distances within cities, such as delivery vehicles, car sharing, taxi companies, couriers or domestic care, where daily mileage reaches the limits of today's electric vehicles. Strategic placement for clusters of stations can also be airports, railway stations, ferry terminals, and city or shopping centers. For the purpose of faster charging that services require, fast or accelerated stations are suitable. Railway stations, bus terminals or sometimes airports could accommodate standard charging types as well.

The last principle is ***combined structure*** - in which a corridor is created between clustered urban areas and ess populated areas (Haghanipour, 2015).

PAYMENT OF THE CHARGING AND PARKING

Decisions about the payment method should be made before installing the infrastructure. If parking and charging are offered for free, it clearly promotes EVs and the electrification of the vehicle fleet in Sweden. The revenue from payed parking and charging is not in close future associated with high benefit. The benefit is however enough to cover the establishment and maintenance. When choosing a payment method, user ease is paramount. Some positive methods include charging cards, payment via SMS or app, or charging directly to the user's electricity bill. Parking and charging should be distinguished. When paying for both charging and parking, the benefit from it should be taken as reduced cost of charging infrastructure establishment, not a business opportunity. Subscriptions could allow usersto pay monthly fee for charging the EV wit certain types of charging, but may require increased fees for fast charging (Molmen, 2013).

Table 1: People spending time on certain activities and charging their car meanwhile, California (Brown, 2013)

Locations	Charge count (%)	Dwelling count (%)
Residential	67	36
Work	12	13
School/religious	2	2
Medical	2	2
Shopping/service	7	21
Gym/exercise/sports	2	3
Visit friends	2	3
Meal related	3	6
Relax/entertainment	2	3
Other	2	12

FIRST STEPS

What should come first? The chicken or the egg? Charging infrastructure or broad adoption of EVs? There are already thousands of EVs in Sweden (April 2016) and the number is increasing rapidly, even doubling every year. Increasing the number of charging stations is a prerequisite for sustainable growth in the number of EVs on Swedish roads. If local authorities lead the way, local businesses will follow (Haghanipour, 2015;Namdeo,2014).

There are currently 4 charging stations in Landskrona municipality, shown in Figure 18. In Glumslöv gas station OKQ8 are one fast charging station with 2 plugs and 1 accelerated point. All of the stations are public. (Uppladning, 2016) The first steps have therefore already been taken.

EXAMPLES OF CHARGING STATIONS PLACEMENTS

Inspiration could be drawn from many parts of the world, but chosen examples are Oslo, Sigtuna and Sundsvall. Figure 17 and Figure 19 show the placement of charging stations in Norway and Sweden.

Oslo is a capital city, bigger than Landskrona, but lessons about placements of charging stations can be transferred. Sigtuna municipality has similar number of people as Landskrona municipality and has the third most charging stations in Sweden. Sundsvall is a municipality in northern part of Sweden and is bigger than Landskrona municipality,and has fourth most charging stations.

OSLO - NORWAY

Norway is a country worth emulating. It has the highest market share of EVs (Hybrid cars, 2016) and electricity production comes from renewable source, hydropower (Statkraft, 2016). Norway took away the fee for toll roads for EVs

Figure 18: Placement of charging stations in Landskrona municipality (Uppladdning, 2016)

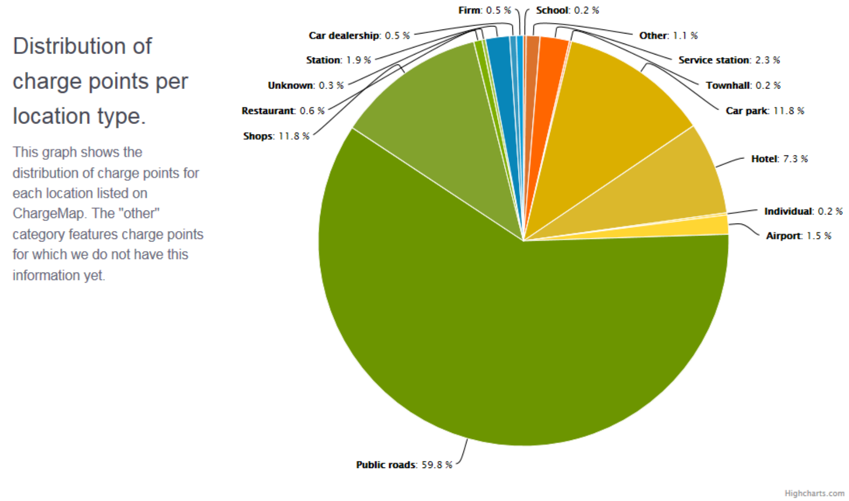


Figure 17: Placement of charging stations in Norway (ChargeMap, 2016)

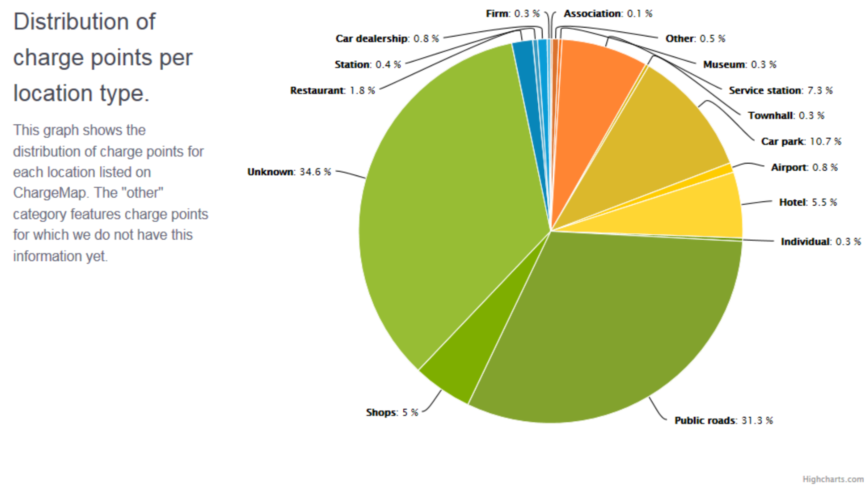


Figure 19: Placement of charging stations in Sweden (ChargeMap, 2016)

as well as tolls on ferries. EVs also have free parking and access to bus and taxi lanes. (Portvik, 2015)

With help of the project UrbAct from the Agency of Urban Environment, a set of charging stations were planned in Oslo to meet the municipal goal for installing 400 charging stations between 2008-2011 (Molmen, 2013). Recognizing the lack of charging infrastructure, Oslo installed an additional 300 public charging stations in 2014 (Eltis, 2014; Portvik, 2015). In 2015 the municipality installed another 400 charging stations, becoming the country's largest owner of charging infrastructure. Oslo had a large EV community and a strong users' association, who were asked where would they like to have charging stations placed. Residents were asked aswell via local newspapers.

Early on a lot of EV drivers suggested public spaces, such as sport arenas, concert halls, theaters and shopping areas. Placement into residential areas, where residents are dependent on on-street parking, was highlighted aswell. The Agency of Urban environment also drove around in the city, trying to find where the most EV's were parked, without an opportunity for charging. They mapped the electricity coverage in the city, for electric transformer placements. (Molmen, 2013)

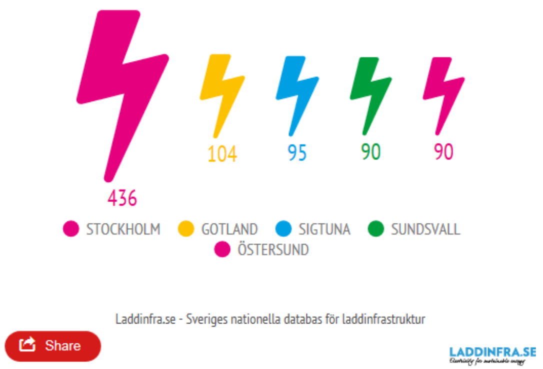


Figure 20: The municipalities with highest numbers of charging points. The leader is Stockholm, analyzed Sigtuna third with 95 and Sundsvall forth with 90. (Laddinfra, 2016)

Figure 17 shows that over half of charging stations in Norway are placed on public roads. In second place are parking garages and third are shopping areas. Distribution of other locations are quite equal. It can be assumed, that public charging combined with on street parking is important and convenient for EV users.

SIGTUNA - SWEDEN

Sigtuna municipality had 44 786 inhabitants in 2015

(Sigtuna kommun, 2016). As of 2016 it has the second most EV charging points in Sweden with 95 charging points as shown in Figure 20. The municipality has collaborated since 2009 with all major hotels and Arlanda airport on the issues of sustainable development. There is strong hotel and conference service in Sigtuna and they decided to set up initial charging stations by the hotels and conference centers around the municipality (Sigtuna, 2013). According to Google maps (2014) most of the charging stations in this municipality are placed beside hotels or conference houses. Fast chargers are by gas station and outside fast-food areas. There are currently 14 charging stations with 95 charging points according to Sigtuna municipality website and Google maps (2016).As Sigtuna municipality is so characterized by the airport and hotels/conference centers, collaboration with these entities allowed for effective network development.

SUNDSVALL - SWEDEN

Sundsvall together with Östersund and Trondheim created a partnership called Green Highway. It stretches over 450 kilometers from Sundsvall in Sweden to Trondheim in Norway. The goal is to create a fossil-fuel free transport corridor, as well as contribute to sustainable growth, and to create the right conditions for fossil-fuel free and energy efficient transport corridor in Scandinavia (Green highway, 2016). According to a report (Gustafsson, 2009), the residents of the municipality choose to take a car 72-80% of their trip depending on the season. The use is higher than in Landskrona, where the percentage is 57% in 2013. The use of the car is therefore higher in Sundsvall than in Landskrona, if elilminating the error from using a different research method, but is considered as a main mean of transport for the residents in both municipalities.

Sundsvall doesn't have any general information about the placement of charging stations available, but Eniro (2016) makes it possible to see where, and which type, they are. Sundsvall's inner city has 14 public charging stations. Locations are shown in Figure 21. The placement confirms to previous research about combining charging stations with urban destinations.

Table 2 shows the location of charging stations in central part of Sundsvall. Most of them are in parking lots, where the function is mixed. Most of the stations are close to each other. There are also some stations near recreational and cultural areas. The only 2 fast stations are near the highway, connecting with the Green Highway network.

Charging stations outside the city center are connected to the Green Highway network, leading towards Östersund. There are other charging stations within the municipality, usually a single charging station with 2 points (standard, accelerated). The placement under these areas differ, but is often close to shopping facilities or municipality services. There are fast charging points by the airport and by a highway shopping area in Harnösand.

SUMMARY

What can be learned from these 3 cities? Every city or town has unique local condition that have different levels of importance for placement. In Oslo, the success was based on cooperation with the electric motorists, determining the placement of charging stations according to users needs. Norway heavily supported the mass adoption of EVs with lower taxes and driving priorites.

Sigtuna municipality has approximately the same number of inhabitants as Landskrona, but the image and function of the town is different. Sigtuna is in close proximity to the capital city's airport, Arlanda. Sigtuna is therefore a place for international conferences and overnight stays, charging stations are therefore often adjacent to hotels.

Sundsvall is a bigger municipality, but with a character similar to Landskrona, with high car use and town services. The stations are located next to transport hubs, shopping centers, cultural attractions, sport halls and parking houses. The principles of Sundsvall are adopted for use in this thesis.

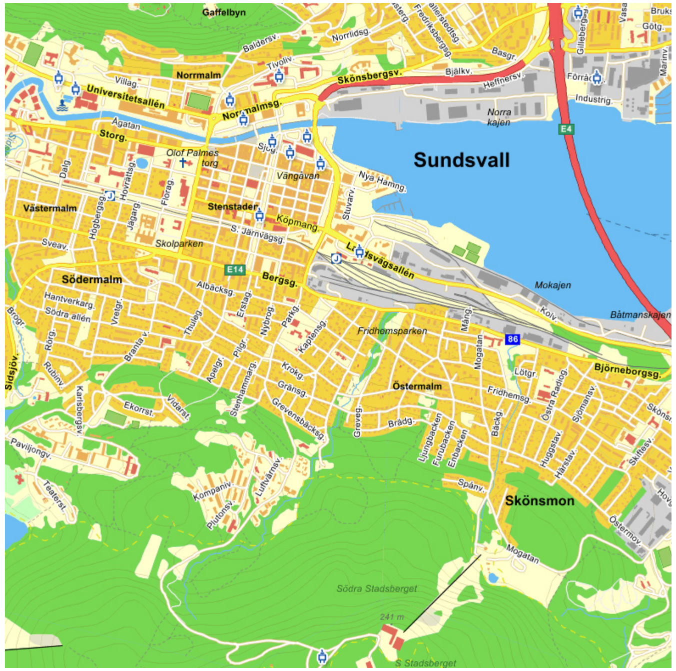


Figure 21: A map over placements of charging stations in Sundsvall central area (Green highway, 2016; Eniro, 2016)

Table 2: A table of placements of charging stations and points in Sundsvall central area (own work according to Eniro, 2016)

Number	Placement	Function	Standard	Accelerated	Fast	Tesla
1	Central station	Travelling hub	1	1	-	-
2	Esplanaden parking	Shopping/work/ residential	1	1	-	-
3	Harbor area/ higway	Shopping/work/ residential/relax/ visitor	2	2	2	-
4	Museum	Shopping/work/ residential/relax/ visitor	1	1	-	-
5	Fish square	Shopping/work/ residential/relax/ visitor	1	1	-	-
6	Kulturmagazinet	Shopping/work/ residential/relax/ visitor	4	2	-	-
7	Parking house	Shopping/work/ visitor	3	3	-	-
8	Parking house/ gas station	Shopping/work/ residential/visitor	2	2	-	-
9	Town hall	Work/visitor	1	1	-	-
10	Museum	Relax/work/	1	1	-	-
11	Industrial area	Work/visitors	2	-	-	-
12	Gas station/ Tesla	Service/residential	-	-	-	6
13	Sport hall	Sport	1	1	-	-
14	School	School/Relax/ Sport	1	1	-	-
15	Hospital	Health/services	2	2	-	-
16	Outdoor center	Relax/sport	1	1	-	-
Total: points 52, stations: 23			23	19	2	6

CHAPTER 3 - THE PROCESS

METHOD

Suitable placement of charging stations in Landskrona municipality is done quantitatively in the first and third stage through the use of GIS, and qualitatively in the second stage through a workshop.

STAKEHOLDERS

Project Green Hub Landskrona is a collaboration of 3 companies and is organized by the municipality of Landskrona. This project was undertaken mainly with the cooperation of Landskrona Energi AB, Landskronahem, LSR and Landskrona municipality. The main actors are introduced in Figure 22.

Ingvi Thorkelsson
Development ingeneer
Landskrona energi AB

Johan Holmstedt
CEO
Landskrona energi AB

Mattias Schriever-Abeln
Landscape architect
Landskrona municipality

Birthe Bunke
Traffic ingeneer
Landskrona mu-nicipality

Jonny Ask
Property Manager
Landskronahem

Figure 22: Introduction to the main stakeholders (foto: Linkedin, 2016; Landskrona stad, 2016)

THE PROCESS

The work flow is concisely shown in Figure 23. It consist of 3 stages, each of which results in different maps. According to the literature review, possible charging station locations had been suggested depending on site characteristics. The thesis used Geographic information system (GIS) to identify these locations spatially. GIS is a technology to support decision concerning location. The program creates a better understanding about what is happening and what can happen in geographical space. GIS-based maps and visualisations promote understanding of the situation and support storytelling (ESRI, 2016).

"A geographic information system (GIS) lets us visualize, question, analyze, and interpret data to understand relationships, patterns, and trends.It is also designed to capture, manage, analyze and display all forms of geographically referenced information. "

- ESRI (2016)

FIRST STAGE

Using aspects from different articles that identify optimal location s for charging stations (Brown, 2013; Fraude, 2013; Namdeo, 2013) a GIS raster analysis has been chosen as an effective method of analysis in the first stage of the process. Specifically IDW (inverse distance weighted) analysis, that interpolates a raster surface based on points having a certain value (in this case population) (ArcGIS, 2016).

The first part of the study consists of a GIS raster analysis based on the number of people living, or approximately moving, in the area. The number of people represent number of potential EV drivers. With a set of criteria derived from the literature review, possible locations for each type of charging station are determined. The placement in an appropriate

coverage for each type of charging station. The analysis is based on current municipal conditions and creates a gradient of suitability for each type of charging station.

Further visual representation was undertaken through a GIS network analysis to identify a service area the fast station placement. A network service area is a region that encompasses all accessible streets within specified distance or time. (ArcMap, 2016)

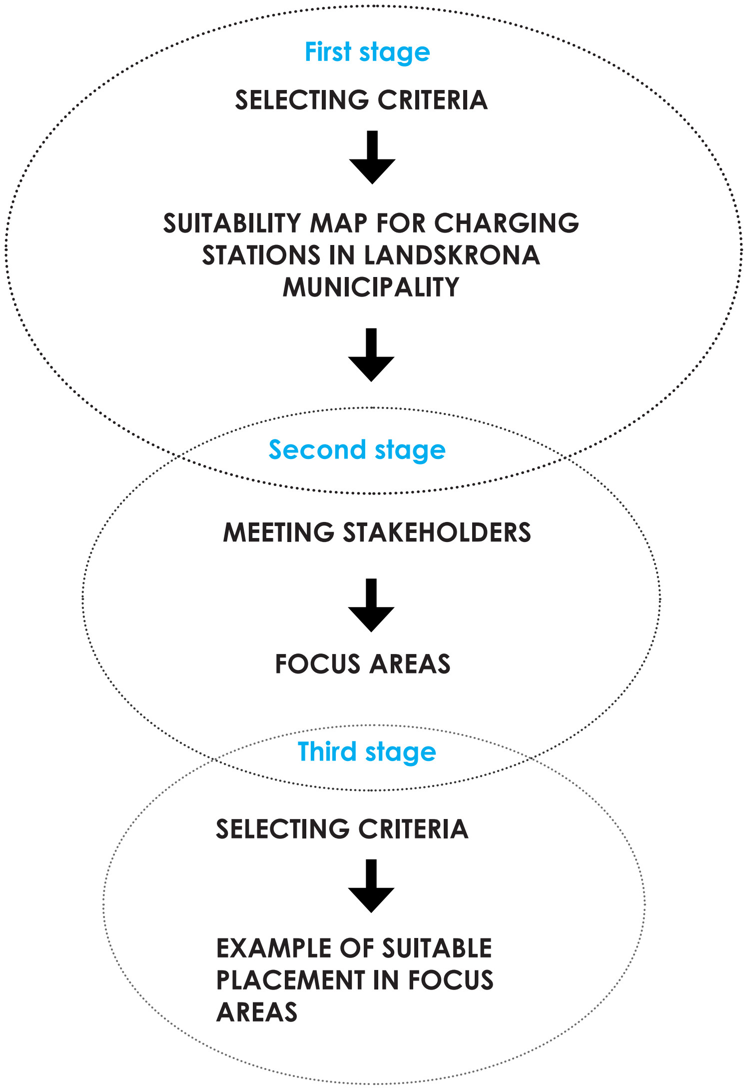


Figure 23: Simple flow diagram of the process

1 First stage

Standard charging stations

Table 3: Standard charging station criteria

Criteria	Explanation	Point value	Source
Block of houses	People living in blocks of houses are dependent on public charging infrastructure	population	Namdeo, 2013
Work places (services, industry)	Long distance commuters require workplace parking. At the same time the municipal strategy is to eliminate workplace parking	services: 2 industries: 13	Landskrona, 2016
Train station	Commuters that take the car to the station leave the car there during the day	Glumslöv: 1500 Häljarp: 1500 Landskrona: 5000	Landskrona, 2016
6-8 hours time aspect	This is the time spent at these destinations for appropriate standard charging use.	-	Brown, 2013

Table 3 shows the chosen criteria for standard charging station placement. Map layers were taken from Lantmäteriet, they were chosen and converted into points. IDW tool was used to produce a map showing the range of suitability in Landskrona municipality.

1 *First stage*

Accelerated charging stations

Table 4: Accelerated charging station criteria

Criteria	Explanation	Point value	Source
Services (visitors)	Dynamic parking for shopping purposes	150	Brown, 2013
Nature interests	Visitors parking encouraging the visit	50	Brown, 2013
Cultural monuments	Visitors parking encouriging the visit of a monument	20	Brown, 2013
Nature reserve	Visitors parking encouriging the visit	20	Brown, 2013
Planned recreation outside of the city	Visitors parking encouriging the visit	20	Brown, 2013
Natural parks outside of the city area	Visitors parking encouriging the visit	20	Brown, 2013
1-2 hours time aspect	This is the time spent at these destinations for appropriate standard charging use.	-	Brown, 2013

Table 4 represents different criterias for accelerated charging station locations. Previous research varies for placement of this type of charging station, therefore probable locations were selected by to approximate amount of time spent doing each activity.

1 *First stage*

Fast charging station

Table 5: Fast charging station criteria

Criteria	Explanation	Point value	Source
Gas station	A gas station is a typical placement for this type of station	-	Brown, 2013 Power circle, 2015
E6 proximity	Typical placement along highway	max. 5 minutes	Brown, 2013 Power circle, 2015
Traffic count	High number of vehicles can lead to increase use of charging station, but at the same time increased safety in placement	layer based value	GIS department Landskrona
Services (visitors)	Dynamic parking for shopping purposes	150	Brown, 2013
20-30 minutes time aspect	This is the time spent at these destinations for appropriate standard charging use.	-	Brown, 2013

Table 5 represents criteria for fast charging station locations. Placement is suitable at destinations where visitors/customers spend 20-30 min. Fast charging is often associated with fast services, such as gas stations or fast food restaurant areas by highways. Traffic count was added, as density of traffic can represent potential EV drivers moving in the area.

SECOND STAGE

The second phase consisted of a half-way presentation and workshop with the primary GHL stakeholders

to determine their visions for future development and focus on selected areas within the municipality of Landskrona. EVs in Landskrona are seen to promote an attractive and environmentally conscious life style. The presentation held on April 7th, 2016 was a combination of students involved in GHL project for their master theses'. The questions asked are presented in Table 6 and identify 4 different subthemes that arose from the work. The questions were discussed and it was decided to continue to a more detailed discussion during the workshop.

2 *Second stage*

Half-time presentation

Table 6: Questions discussed during the presentation with the stakeholders

Method	Placement	Ideologies	Sustainability
Add income layer?	What influences where to put the stations?	Are commuters more likely to take the car or public transport?	If people have 2 cars and one electric, is this sustainable?
What is acceptable distance?	1 station for 10 EVs?	How to predict who will buy EV?	How the use of public transport and cycling can be improved at the same time?
	Can we make people go where we want them to go in relation to health?	Where the municipality is going to develop?	Do we want busy streets or do we want to free them from parking?
		Which kind of people to attract?	
		How acceptable is to prefer electric cars?	

Organizations involved in the workshop were: Landskrona Kommun, Landskrona Energi and Landskronahem. It was held on April 12th, 2016 in Landskrona's town hall. It was 2 hours of discussion that continued the questions raised on April 7th, 2016. The goal of the workshop was to understand detailed information about the future plans of the organizations. The main questions discussed were the vision, strategies, future development and focus areas within the municipality of Landskrona (see Table 7). The results were used to develop detailed focus areas in the third stage of the analysis.

Three time frames were identified during the 2016, 2020 and 2050. 2016 was identified as the most important time frame in order to encourage the implementation of charging stations as soon as possible. Areas currently undergoing detail planning, and that were located near to Landskrona's urban centre were chosen in order to support a jump start to EV charging in the municipality.

THIRD STAGE

In the third stage a multi-criteria GIS analysis has been performed within the identified places of interest to approximate potential placement of the charging stations. Possible locations were chosen using all parking spots as initial possible. These spots were overlaid with the results from the first stage and stations were placed according to the results. Placement criteria are shown in Table 9.

Placement is only a demonstration of possible implementation, real placement will have to be demand-oriented and researched more deeply, mainly to accommodate the electricity network's capacity, impact on the urban design and property borders. The stakeholders can determine their role and requirements for charging station placement at this scale.

Finally, the results were discussed and analyzed. Suitable placements ares were chosen according to the results from first stage of analysis combined with acceptable walking distances according to the Landskrona parking plan (see Table 8).

2 *Second stage*

Workshop with stakeholders

Table 7: Workshop questions to stakeholders

Vision	Strategies	Future development	Focus areas
How do Landskrona want to be? - sustainability - social - environmental - economical - transport - energy	What are the strategies of the municipalities? - how to fulfill those goals	Where it is important to develop and can the development be described? - transport - social - environmental - other?	Point out together where should the thesis focus on to solve problems and help the future development
	Can more strategies be added in relation to electric cars?	Is it wished for people to take cars?	What details can be added?
	Differenciate different strategies for different places at the municipality?	How can the accelerated charging stations be used to promote EVs?	What is the acceptable distance?
		Detail planning of stations - density/ frequency?	
		Social mixture - car possesions?	

Table 8: Buffer distances the analysis: the longest acceptable walking distances to parking lots for Landskrona (Bunke, 2016)

	Acceptable walking distance to/from parking
Housing	300 m
Workplace	500 m
Services - visitor	300 m

3 *Third stage*

Placement of the stations into focus areas in 2016

Table 9: Combined criteria for 3 types of charging station

Criteria	Explanation	Source
Parking place	Strategic placement of parking place	Frade, 2011
Destination points	Future number of people living, working or moving in the area	Brown, 2013
Previous results from stage 1	More people provide better opportunity for owning the EV	Consultation with Neil Sang
1-3 min from E6 highway	Possibility for fast charging station to be placed	----

DATA ANALYSIS

Data that has been used are described in Figure 24. The flowchart presents all layers needed to perform the analysis. The layers needed determined by the set of criteria used in GIS modelling. These criteria strongly influence the final result.

The data was analysed throughout the process. Due to lack of information regarding real demand, the suitability maps are based on approximate distribution of charging stations placement. The 2016 vision is highlighted to determe the main areas for immediate implementation. Visions 2020 and 2050 are developed for descriptive purposes only. The assumption is that a similar model to identify focus areas in 2016 could be used in future visions of 2020 and 2050.

In addition to the 3 visions and focus areas from the perspective of stakeholders, the first stage of analysis provides interesting results. The first stage considers broad landscape architecture considerations, using charging stations as attraction for people to be attracted to.

Data collection

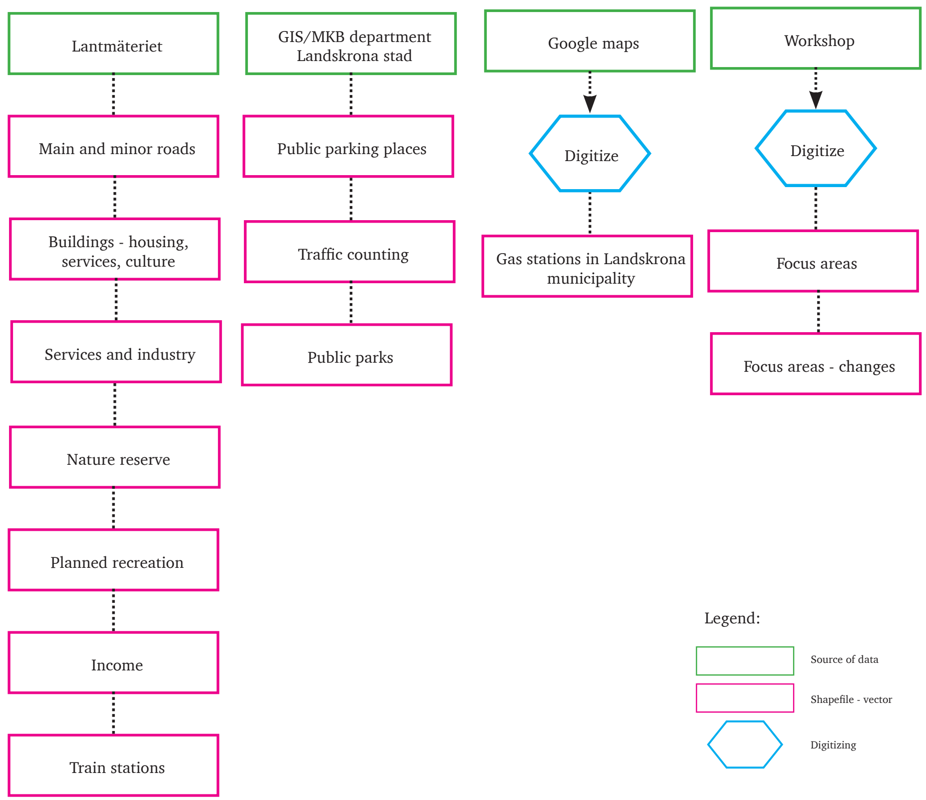


Figure 24: Flowchart of data needed for performing analysis

CHAPTER 4 - CASE STUDY

LANDSKRONA MUNICIPALITY

INTRODUCTION

Landskrona municipality is located in Skåne (Scania) on Sweden's southwestern coast and is part of the Öresund region, which includes the main cities Copenhagen and Malmö.

The municipality contains approximately 43,000 inhabitants (Landskrona, 2016). Landskrona is a growing municipality thanks to its geographical position in a growing region and its access to commuting opportunities. The latest commuting statistics show that more people commute from Landskrona than to, every week day (Svensson, 2014). Landskrona's unemployment rate is higher than the Scanian average, about 15-16%, compared to 10,1% (Labour Force Surveys, 2014) of the region.

Landskrona has history as a fortress city that continues to define its urban character. The center is a grid structure and the building stock consists mainly of city-owned apartment buildings and a main service center clustered around the main square and nearby streets. Nearby towns and villages accommodate another 11 774 inhabitants. The towns, sorted by population include: Häljarp, Glumslöv, Asmundstorp, Saxtorp, Annelöv, Härslöv, Kvärlöv, Ven and Vadensjö. An overview of the town is shown in Figure 25 and plan of the municipality in Figure 26 (Översiktsplan för Landskrona stad, 2015).

CHALLENGES

Landskrona is facing challenges that must be addressed to continue the municipality's progress towards a sustainable future. According to the Översiktsplan för Lanskrona stad, 2015, the most important challenges include following:

- Residents in surrounding towns do not identify with Landskrona's town center, and are therefore likely to look outside of Landskrona for shopping, education, entertainment, and recreation.
- Small towns have the highest rate of commuting outside of the municipality. Landskrona is working to strengthen the connection between center and the surrounding towns to improve regional competitiveness.

Figure 25: Bird-eye view over Landskrona (Landskrona, 2016)

Figure 26: Map over Landskrona municipality/stad and location in Sweden

- Landskrona needs a stronger link to the larger population center and labor market of Copenhagen.
- Public transport in rural areas is inconvenient, so most people depend on their cars.
- Opportunities for rural and natural recreation is limited, there is only a small forest in Saxtorp.
- Highway E6 creates significant noise pollution.
- Landskrona's social and health challenges lead to feelings of insecurity and discomfort.
- There exist barriers to integration of residents due to ethnicity, socioeconomics and physical barriers.
- Landskrona struggles to adopt a post-industrial economy that focuses on service and modern industry.
- The agricultural land is of national interest for preservation, but also presents valuable development opportunities.
- As a coastal municipality Landskrona will have to manage rising sea levels and extreme rainfall in the future (Stadsbyggnadsförvaltningen, 2015).

OVERALL GOALS AND FUTURE PERSPECTIVES

The municipality has a convenient location in the region, between Malmö and Helsingborg, and relative proximity to Copenhagen. The West coast railway and the E6 highway provide excellent access. The sea is attractive for housing development, leisure and business activities. There are also economic activities that could be further developed further in the future such as shipyard heritage, logistics industry, or creative and cultural industries.

Landskrona 2030, the municipal comprehensive plan comprises of five overrearching topic areas: sustainable development, attractive housing, modern industrial city, urban mix, and managed heritage. Industrial heritage should be seen as an opportunity and vision for the municipality to develop green industry and become a green municipality (Översiktsplan för Landskrona stad, 2015).

Landskrona works well with sustainability. Sustainability is defined by its 3 pillars: social, economic and environmental. These 3 aspects are indivisible. For social sustainability Landskrona would like to enhance the image of the city and its community. To strengthen its image, urban planning and the city's physical structure can be used to improve living environments to improve well-being and health. A feeling of inclusion in the environmental decision making process is also crucial for a society to thrive. It is also important that presidents have good jobs. Landskrona's position offer multiple good options.

One of Landskrona's environmental sustainability goals is increased energy efficiency and reduced climate impact. In order to move towards a more energy efficient society, changes in production and use of energy are required (Stadsbyggnadsförvaltningen, 2015).

Economic sustainability is seen as a tool to stregthen social and environmental dimensions of sustainability. The contemporary industrial city should embrace new industries, cultural/creative activities and tourism. It should take advantage of existing structure and, dense urban areas with homes, businesses, trades and services. Dense structures allow cost efficiency and a dynamic economy. An attractive urban environment brings people to socialize, shop, take advantage of cultural amenities etc. More people will create better conditions for trade, services and cultural venues (Översiktsplan för Landskrona stad, 2015).

VISION 2050

The long term vision is that in 2050 all energy operations must be ecologically, economically and environmentally sustainable. The energy system is secure, cost-effective and has minimal negative impact on health, environment and climate. New energy and renewable fuels are the primary sources of energy. All the transport in the city uses environmentally friendly fuels. The city is free from fossil fuels (Översiktsplan för Landskrona stad, 2015).

TRAFFIC IN LANDSKRONA

It is important to feel safe and in a clean and attractive environment. Communications in the city should be planned to be accessible, available and safe. At the same time, the environment should not affected negatively. Giving priority to biking and walking before cars can lead to higher proportion of sustainable transport. Vehicle traffic should be directed to the main network. On minor roads, private vehicles have reduced priority compared to public transport, cycling and pedestrians. The municipality's own vehicle fleet has been managed holistically since 2012. Investigation from 2014 (see Table 11) show the number and kind of vehicles in the municipality's fleet. The goal was to determine the proportion of environmentally friendly vehicles (miljöbilar) among total number of cars (see Figure 27). Environmentally friendly vehicles do not mean fossil-fuel free or renewable energy vehicles, but a certain level of energy savings. These numbers are similar to the rate of environmentally friendly cars from a survey in 2013. 64% of

Table 11: The municipality's car fleet in 2014 (Energiinventering, 2014)

Type of vehicle	Bensin	Diesel	Electricity	Metan gas	Bensin/ etanol	Bensin/ metan gas	Bensin/elec-tricity	Total
Personal car	21	19	1	7	42	5	5	**100**
Light truck	14	48	3	22	0	8	0	**95**
Heavy truck	0	7	0	0	0	0	0	**7**
Moped	19	0	1	0	0	0	0	**20**
Tractor	0	14	1	0	0	0	0	**15**
Other	6	2	4	0	0	0	0	**12**
Special fleet	3	10	0	0	0	0	0	**13**
Total	**63**	**100**	**10**	**29**	**42**	**13**	**5**	**262**

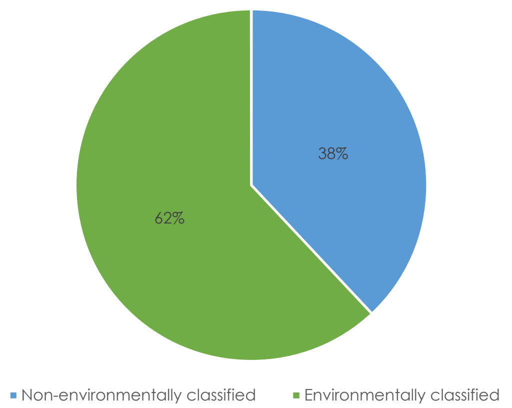


Figure 27: Rate of environmentally friendly vehicles (Energiinventering, 2014)

Landskrona's registered vehicles were environmentally friendly (Energiinventering för Landskrona stad, 2014). Having a large number of environmentally friendly vehicles in the municipality's fleet is a step in the right direction and it is necessary to examine which kind of energy source are most used and how it can be converted to renewables (Energiinventering för Landskrona stad, 2014).

PARKING PLAN

Because parking places have great potential for charging EV, it is interesting to look closer at parking in Landskrona. Parking has a central role in traffic and has a major impact on how the city functions and is experienced. Access to parking is fundamental prerequisite for vehicles, whether cars or bicycles, but requires significant space and affects the urban environment. Therefore it is important to balance availability in proportion to need. Numerous parking places increase vehicle accessibility, but often correlates with increased car use. Insufficient parking, however can lower accessibility by car and increase risk of unauthorized parking which affects safety and flow of transportation.

Landskrona will be densifying in coming years and several main parking areas will be used for other purposes. A compact city provides greater proximity and thus a reduction in vehicle transport. Parking in urban environments takes valuable space - a car park takes up to 12.5 m^2, which could fit 12 bicycles. If including the maneuvering areas, each park places requires up to 25 m^2.

There are currently 980 parking spaces on municipal land in central Landskrona. The general plan for parking in Landskrona is to reduce car commuters and promote other means of transport which contribute to sustainable development of the city. The parking plan also promotes new technologies and implementation of charging stations in future, but provides no details.

Landskrona city should prioritize parking for visitor and business, carpooling. Studies show that one carpool vehicle can substitute 5 personal cars. The parking plan also targeted 3 spots for parking house placement and other open parking areas, while building on other parking places around the city center.

The types of parking places described in Table 10 show different functions of parking spaces, and the activities for which people park their car. Buffers (see Table 8 on page 53) are interesting to determine which parking spots are connected to which destination. (Bunke, 2015)

PUBLIC TRANSPORT

Landskrona city has good public transport links for both train and bus. The surrounding towns and villages, however, do not have the same connectivity. Häljarp and Glumslöv lie along the train tracks between Malmö-Lund-Helsingborg, but other towns and villages depend on buses. The main train station is located outside of the city center with a commuter parking lot. The bicycle plan for Landskrona was developed in 2015 and aims to provide support in planning to prioritize measures for increased cycling. At short distances biking and walking dominate (Bunke, 2015; Svensson, 2014). Landskrona was recognized as the city in Sweden where biking covers 34% of travels within 1 km and walking another 34% (Svensson, 2014).

Landskrona's public transport includes trains and 5 lines for busses. Landskrona is the only city in Sweden with an electric trolley bus line. The line opened in 2003 and is run by the bus company Nobina. The line was developoed after construction of West Coast train track, connecting Malmö and Helsingborg. A new train station was built on the outskirts of the city center. A new bus connection to the center was needed. Landskrona also investigated other kinds of connection, such as trams, battery bus, hybrids or magnetic track. Today, trolley and combustion engine buses connect the town with the train station (Regionstyrelsen, 2009). In addition, the SlideIn project started in 2013, and enables the bus to drive without wires, because the vehicle is equipped with a battery. A fifth bus with a battery that can be charged quickly was ordered; it can drive for 10 km after a full charge (SlideIn, 2012).

Table 10: Different kinds of parking in the municipality of Landskrona defined by the parking plan(Bunke, 2015)

Types of parking	
Residential	Require within walking distance to dwelling. Greatest need during night and evenings.
Workplace	Greatest need during daytime on weekdays.
Services - visitor	For commerce and leisure have greatest need during afternoons, evenings and weekends.
Parking for disabled	Should represent 2-3% of all parking spaces, at least one have to be 25 m from entrance of the target buliding
Co-usage of parking	

CHAPTER 5 - LOOKING FOR SUITABLE PLACEMENT

ANALYSIS

INTRODUCTION

The analysis is based on the current situation and data from sources described in Figure 24 on page 54. There are 3 sets of maps to illustrate the placement of standard, accelerated and fast charging station. Visions 2016 and 2020 focus on certain areas indentified by stakeholders as pertinent. Vision 2050 is presented but detailed information is not developed.

FIRST STAGE - IDW ANALYSIS

According to the methodology described in chapter 2, suitability maps are produced for 3 types of charging stations. Suitability map in brief shows a gradient of suitable to unsuitable areas in the municipality for charging station placement. The analysis works for a range of potential customers; if all of them owned a car and if all of them traveled to their destinations by car, this is how many users the stations would have. The darker the color the greater the density of people working, living or moving in the area. It is only a model, trying to reflect a dynamic situation. It is an approximation of density of people and their activities which is vital to identify potential use of each type of charging stations.

TIME ASPECT

The 2016 vision developed suitability maps for 3 kinds of charging stations according to available data from Lantmäteriet and current potential for charging stations.

READING THE MAPS

Suitable locations are shown as a gradient from lighter to darker color because the planning for charging stations in detail is not possible for the purpose of this thesis. Further investigations would have to be done. If stations are placed, recommended distance from parking place to destination was considered, as shown in Table 8.

Criteria for geographic information system (GIS)

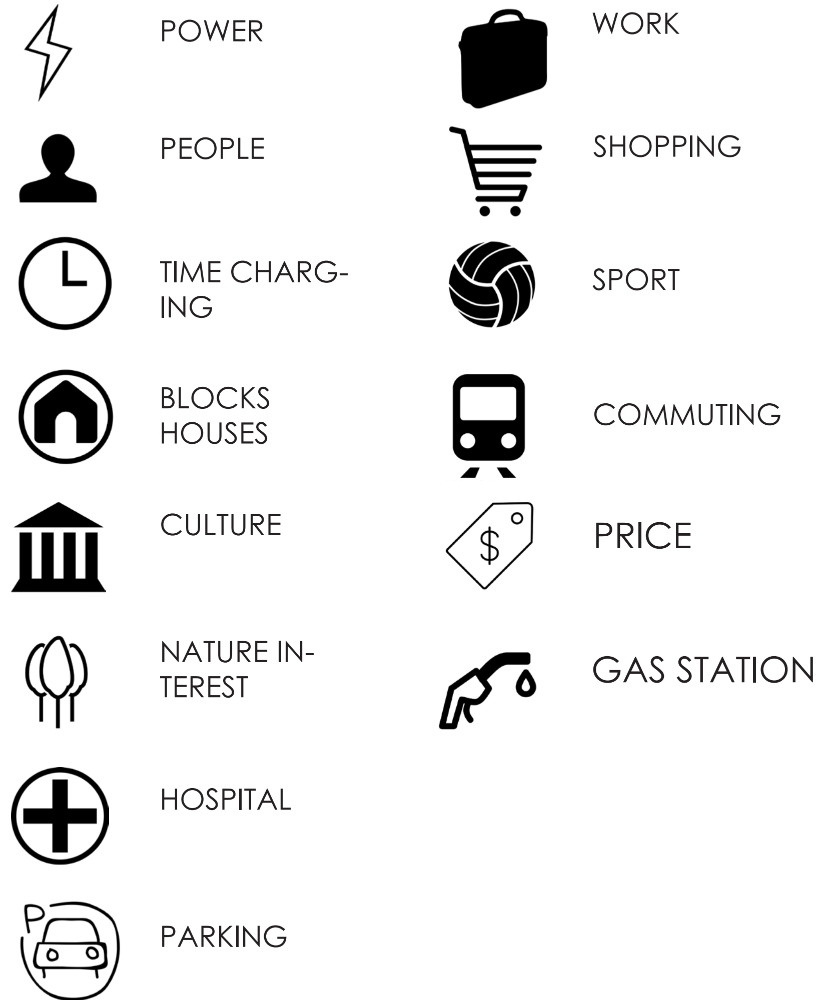


Figure 28: Visualisation of criteria used in GIS

STANDARD CHARGING PLACEMENT

Standard charging stations, as the literature review reveals, are usually located in residential areas, in which inhabitants do not own a parking place (blocks of houses). It is also interesting to consider working areas, that are outside of central (industrial area of Landskrona). Lack of public transit and the provision of parking spaces means that workers can commute to work more easily by car. Since the municipality has high commuting values, train stations become interesting for standard charger placement since people living in the outskirts of the town, dependent on the cars to reach the station, could park and charge at the train stationwhile commuting via train (Översiktsplan för Landskrona stad, 2015).

These locations are chosen due to approximate amount of vehicle time spent at the locations: standard charging requires to 8-10 hours for a full charge. As Figure 29 shows, there are 7 areas where the number of potential customers is the highest. Other less densely covered areas could also be interesting at later stages of development depending on demand. This map provides an overview and is limited in criteria and methodology. However, it leads to a basic understanding of suitable locations for standard charging stations.

RESULT

The most suitable areas according to this map are the train station due to the high number of commuters (Landskrona, 2016). Karlslund also shows a high density of possible customers due its density of residents. Sport activities are close by and provide possibilities for both standard and accelerated charging. Future development of Karlslund (Jaenecke arkitekter AB, 2016) brings opportunity to develop the new community center and sport facilities in a fossil-fuel free way by installing different kinds of charging stations, in this case standard chargers by blocks of houses.

Another suitable area is located east of Borstahusen. Many people live there densely and, public parking is available. In the center of Landskrona city, blocks of houses and working places create opportunity for standard charging. The tricky part is to manage densification and public parking when, the municipality is planning parking houses in the center. The terminal to Ven creates a good opportunity for tourists leaving their car while travelling to the island Ven in the season. The industrial area represents a perfect place for electric parking at work, and can provide a modern attraction to investors interested in the area.

POTENTIAL STANDARD CHARGING STATION PLACEMENT IN 2016

Glumslöv train station

- the train station represents the highes value due to the number of commuters from Glumslöv / day (cca 1000)
- Up to 100 potential customers are located in the residential area.

South of Borstahusen

- high value is due to many people living in the area, presence of some services.

Karlslund

- high value is due to many people living in the area, presence of some services.

Landskrona station area

- high value is due to many people commuting from Landskrona (cca 5000 / day), presence of working places in proximity.

Landskrona center

- higher value is due to many people living, but also many people working in the area.
- interesting for long-term hotels customers

Häljarp train station

-- the highest value lies next to train station due to the number of commuters
- some service and housing areas have up to 100 potential customers.

Industrial area

- area with mainly worklplaces outside of the city center is also interesting for placement for workers coming by car

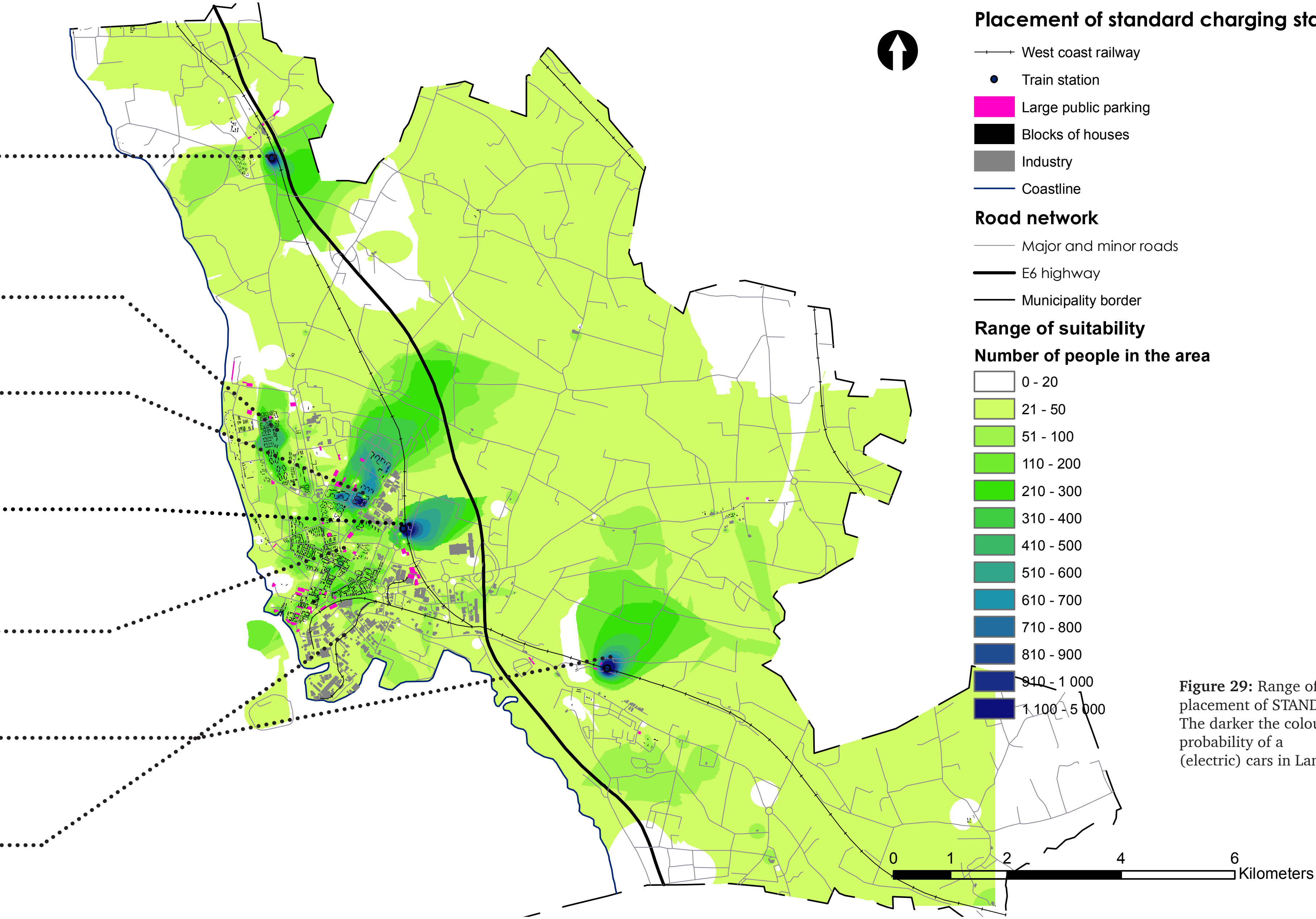


Figure 29: Range of suitability for placement of STANDARD charging stations. The darker the colour, the greater the probability of a high density of parked (electric) cars in Landskrona municipality

ACCELERATED CHARGING PLACEMENT

The highest values appeared in the center of the city due to many businesses and their potential visitors. The center should try not to be too accessible for car travels, but some visitors/customers parking are required. This system is preferred in the parking plan of Landskrona. Charging for 1-2 hours can provide a dynamic environment needed for businesses and inner city streets. Outside of the city the charging stations can serve as an attraction to visit cultural or recreational areas. The coastal area provides attractions, for bathing and camping. Smaller towns in the municipality can strengthen their position and attract visitors to recreation and local markets.

RESULT

Figure 30 shows that the highest number of potential customers appear in the center of the city, where visitors spend around 1 hour for shopping, eating, exercising etc. The shopping area in Weibullsholm, close to the E6 highway and train station, is planned for services and housing development (Tengbom arkitekter, 2016). These features could strengthen the suitability for accelerated and standard charging stations in the near future. The coastal areas provide recreational opportunity, especially during the summer. During that time the harbours are visited, recreational and fishing boats are docked. Station towns Häljarp and Glumslöv provide good recreational opportunities such as golf or nature walks. Smaller towns such as Asmunstorp or Saxtorpsskogen provide recreational opportunities as well, such as horse riding, community gardens or walks in the forest. In general 1-2 hour visits provide enough time to patronize all kinds of services, even those that are not included in the GIS layer maps from Lantmäteriet such as gyms or restaurants.

The rest of the municipality not covered with any value is either lacking data or is not suitable for this type of charging station. The latter could be lack of road infrastructure or preferred activity criteria in the area. Other functions, such as agriculture or forestry preclude the use of charging infrastructure.

POTENTIAL ACCELERATED CHARGING STATION PLACEMENT IN 2016

Glumslöv

- higher value for recreation and small businesses.

Camping places

- camping provides natural place for charging of caravans for instance. This activity can provide standard charging as well.

Coastal areas

- high value is due to cultural and recreational activities.

The city center shopping areas

- high value is due to number of businesses and the people visiting them during the day. Dynamic environment.

Asmunstorp

- higher value due to sport activities and small businesses.

Häljarp

- higher value for recreation and small businesses.

Saxtorpsskogen

- higher value for coastal and forest area.

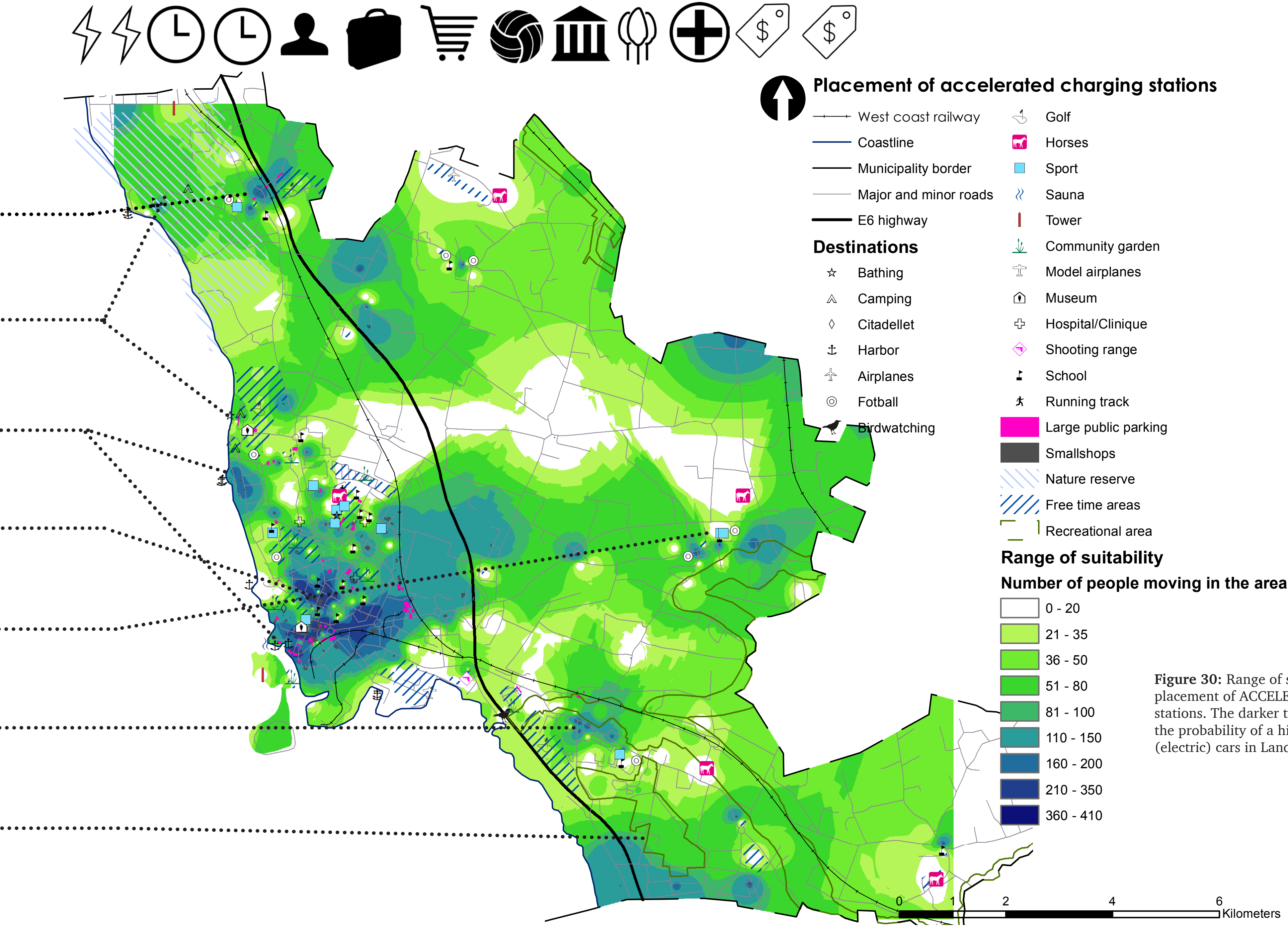


Figure 30: Range of suitability for placement of ACCELERATED charging stations. The darker the colour, the greater the probability of a high density of parked (electric) cars in Landskrona municipality

FAST CHARGING PLACEMENT

The values for the raster layer are obtained through a combination of the approximate number of short term customers (visitors rate) and the average number of vehicles per day. The number of vehicles are dependent on the method for gathering the data, but the distribution of the vehicles is clear: most of the vehicles are by the train station, in the center and by Hälsingborgvägen in Landskrona. Vehicle count near Häljarp also shows a high number of cars in traffic. Visitor rate is approximated and is used as a ratio of approximate number of people moving in the area. Gas stations, as noted in the literature study, are very suitable to be used for fast charging. Other areas that have high traffic and service values, such as the center of Landskrona and east of Borstahusen, can be also used as an attraction for electric vehicles.

RESULT

Figure 31 shows the suitability for fast chargers. The potential is the highest by the gas stations, because they represent in mindset of the drivers, a place where a driver spends max. 30 min for refreshments and filling the tank. They are often associated with different kinds of services, in this case Weibullsholm developed in the future as a shopping area, represents the best solution for on-site fast charging. The Preem gas station was identified as the closest accessible gas station from E6, only 3 minutes off the highway. The dark blue areas, where gas station is not located, could potentially serve to attract more customers coming by electric car in Häljarp and center Landskrona for short shopping visits.

The rest of the municipality with lighter colors or blank places is not suitable because of absence of data for number of vehicles per day or an absence of gas stations.

POTENTIAL FAST CHARGING STATION PLACEMENT IN 2016

Glumslöv gas station

- this gas station is very close to E6, within one minute drive. A fast charging station already exists there.

Hälsingborgvägen

- there is quite a lot of traffic along this road, the gas station has quite a wide reach

The center

- the central area could be used as a location, can serve as a magnet to shops

Weibullsholm gas stations

- Preem is the closest gas station in Landskrona city reachable within 3 minutes to E6 highway.

Häljarp

- many vehicles has been counted also in Häljarp, however the reach from E6 is not that interesting

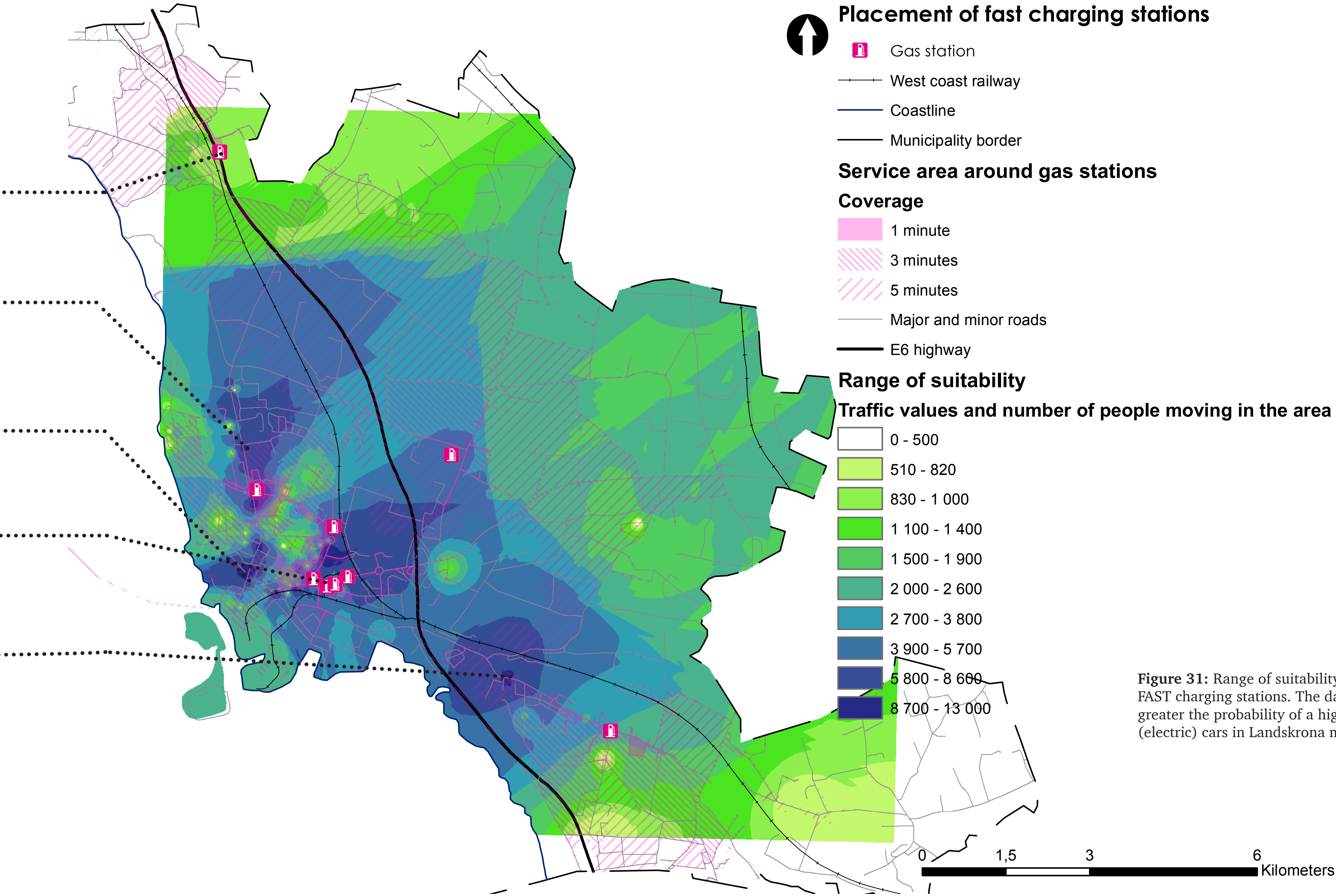


Figure 31: Range of suitability for placement of FAST charging stations. The darker the color, the greater the probability of a high density of parked (electric) cars in Landskrona municipality

SECOND STAGE - WORKSHOP

Focus areas had been digitized after the workshop. The time scales are approximate and sometimes overlap. Figure 32 shows the overall results and focus areas. The areas that will be further investigated during third stage are highlighted in pink in Table 12 and are described briefly in Figure 33. For these areas a detail plan as a planning document had been received to support further investigations in the third stage.

Table 12: Focus areas that came as a result from the workshop

Focus areas	Vision
Jönsaplan	2016
Weibullsholm	2016
Karlslund	2016
Borstahusen	2016/2020
Kronan	2016/2020
Walk along Saxå	2020
Öresund connection	2050
East station area	2050

RESULTS FROM WORKSHOP

All the actors want to make Landskrona a more attractive place for living, in all aspects. Buildings should be energy efficient in the future, possibly connected to a larger project funded by the state or European authorities.

Landskrona Energi wants to focus on smart investments - in future densifying plans the buildings will use the same amount of energy and infrastructure for more housing units.

The municipality would like to densify the city center and develop Weibullsholm outside of the city center. In Weibullsholm shopping mall, Biltema and other businesses will be located. Further away, next to the E6 highway, the Kronan logistic

AREAS FOR FUTURE PLANNING FOR VISION 2020/2050

Glumslöv

- new mixed housing development. The central area should be strengthened to create quality public space. Strengthen recreational activities.

Härslöv

- new buildings should respect the character of the area, mixed housing is planned.

Asmunstorp

- a public meeting place has to be created, also investigate the opportunities for mixed housing development. Some natural areas will be developed for urban recreation.

Häljarp/Sax ån/Saxtorpsskogen

- station area will be connected with the town through new mixed housing development. Here a center is needed. Recreation is strengthened through Saxån walk. Saxtorp needs to develop it's accessibility.

Annelöv

- the town is close to the train station in Dösjebrö, but the link can be strengthened. New apartment housing development is planned. Recreational equestrian qualities will continue to be strengthened. Saxån walk will connect Annelöv with Häljarp.

Öresund connection

- a strip between the old town and industrial area will create an office area. New stations will be developed, likely in Weibullsholm. Development of a new railway line gives opportunity for expansion of the town.

East station area

- in the future the east side of the area will be developed for mixed housing and parking areas for commuters.

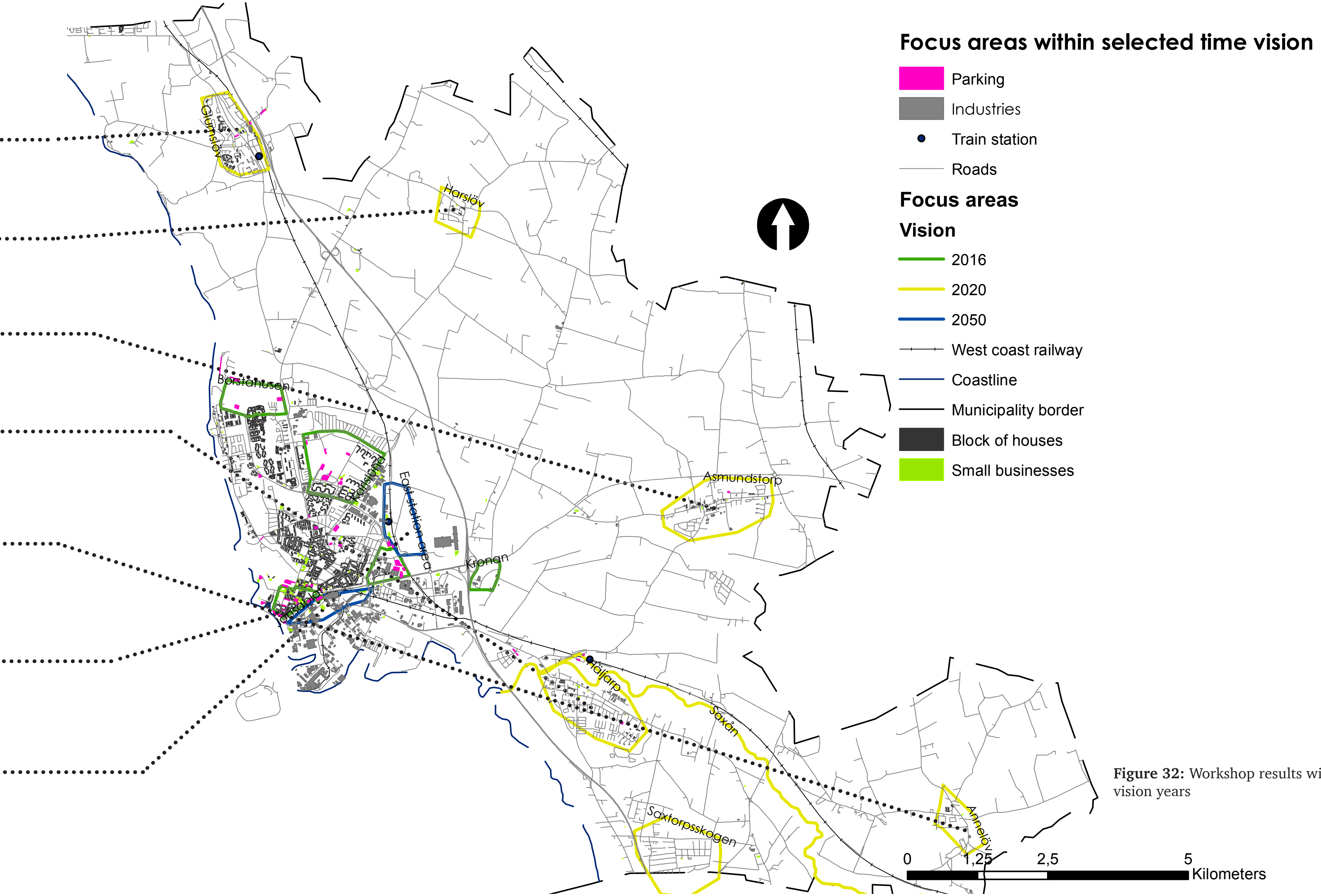


Figure 32: Workshop results with focus areas for different vision years

center and fast food restaurants will be developed. As for car traffic, the priority is focused on visitors and convenience for businesses. The residents should not often use their vehicles in the center, pedestrians and cyclists are preferred. There are opportunities for new business models for EV's parking and new agreements between businesses.

The accelerated charging stations can be used for strategic planning outside of the city in Landskrona municipality. Green areas are not easily accessible by bike or walk, therefore could be more visited if charging stations were placed there. Similarly, it could be an opportunity for small villages to attract people. Infrastructure availability is the key issue here, as roads may not be accessible by car, and electric cables are unavailable.

It was determined to focus on three time periods: 2016, 2020 and 2050. It is important to write about how to start development, attempt different placements and business models. After they are approved and working well, models can be copied in future development. Only 5 focus areas will be developed in the third stage of this thesis due to the higher number of people visiting or living in these areas, therfore the greater practically of developing charging stations.

FOCUSED AREAS DEVELOPED FURTHER IN THIRD STAGE FOR VISION 2016/2020

Borstahusen 1

- area adjacent to the existing road structure north of Borstahusen area. Approximately 1500 homes ofl mixed types, services and business premises will be built. There will be green string across the area creating a migration corridor in the landscape.

Karlslund 2

- urban renewal of Karlslund area - paths for high-quality public transport and mixed traffic are under investigation. Urban renewal of the district's well-defined districts will be integrated with each other by a process of densification.

Jönsaplan 3

- building a new hotel opposite the town hall and densification of the central area. Development of new parking places but also removal of existing spaces.

Weibullsholm 4

- future mixed-use area combining living and services (shopping, working, parking houses). This area can serve as a possible attraction to travellers on the E6 highway to come to Landskrona for shopping.

Kronan 5

- scheduled plans include offices, non-intrusive businesses, trades and a service center. That includes a new motel and restaurants, also the expansion of existing industry.

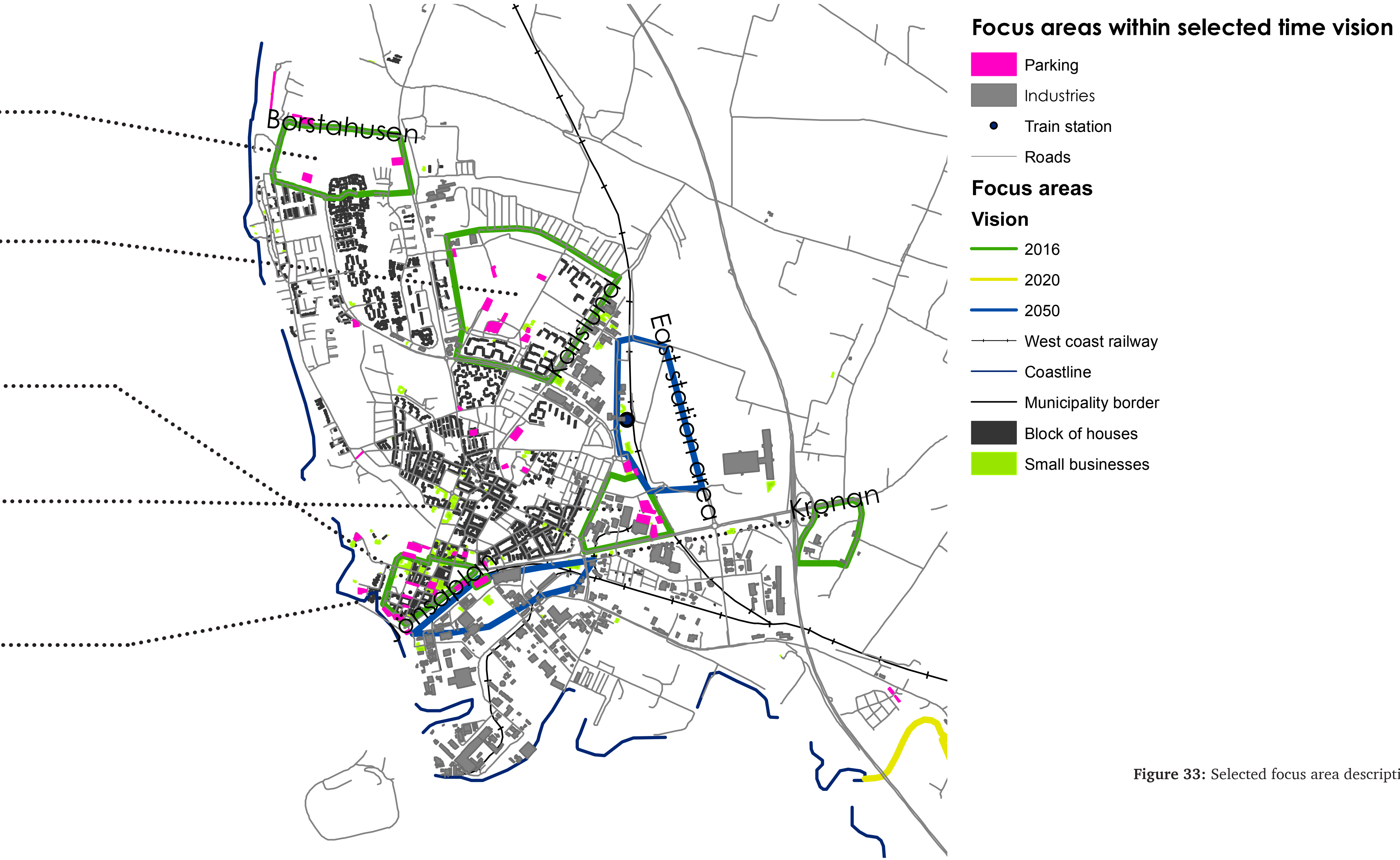


Figure 33: Selected focus area description

THIRD STAGE - PLACEMENT OF CHARGING STATIONS

1 BORSTAHUSEN

Development of mixed-use housing is planned in this attractive seaside area. 1500 new apartments, detached and semi-detached houses will be developed. New buildings are placed behind the shore line and the protection area and beach campsites will be available to the public. Mixed recreation services such as golf, swimming, sauna, beach, events, museums, art galleries, restaurants, camping sites, fishing and sailing are good prospects for tourism all year round. A new school, sport hall and a smaller number of homes will be located in the southern part. A new bus line will connect the area with the rest of the town. The plan for the area is shown in Figure 34. For the third stage of analysis the plan has been digitized in GIS according to chosen criteria. For apartment buildings and attraction areas the number of visitors or residents has been approximated.

Borstahusen is an interesting area for standard and accelerated station placement, as shown in Figure 35. As a start, an accelerated station could be placed at the parking for bathing, at the beach. Standard charging stations could be placed at camping sites for electric caravans or visitors with electric cars. Standard and accelerated charging stations in the residential area close to the beach could serve as parking for both visitors and residents. Analysis presented in the first stage of analysis shows more people in the north-east of Borstahusen, so that is where we are likely to find the most vehicles. In the southern part of the new development of Borstahusen, an older urban structure appears. The density of people is very high, therefore it is appropriate to place standard charging stations there for the residents. As a start, a few standard stations could be placed, but in time more standard and accelerated stations could be added, in the same place or elsewhere, according to need. This option would cost approximately 190 000 SEK with all costs at the establishment phase (Haghanipour, 2015).

BORSTAHUSEN PROPOSAL

Figure 34: Overview of Borstahusen in progress (Proposal for Borstahusen, 2016)

1. Camping
2. Single houses
3. Mixed housing
4. Golf course
5. Urban recreation
6. Sport and school
7. Retirement home

CAMPING AND BATHING AREA

- accelerated charging station creates opportunity for attraction

RESIDENTIAL AREA

- standard charging stations for residents and people working in the area

Figure 35: The suitability of charging stations placement according to selected criteria. The darker the color the more suitable the placement.

2 KARLSLUND

There is a variety of locations in Karlslund, such as housing, education facilities, sport facilities, park and infrastructure. At the same time the area is segregated and it is difficult to access the rest of the town. The Karlslund development seeks to answer how the area can be tightened together and opened to the rest of the town and region. It will become an attractive place with sport fields that will be visited by people from the city and hopefully from the whole municipality.

The new housing areas, both apartment buildings and single houses, will be developed together with mixed-use planning. A new road will lead through the area and bring flow and accessibility from the rest of town. Figure 36 shows the conceptual plan that is still a work in progress.

Figure 36: Overview of Karlslund in progress (Jaenecke arkitekter, 2016)

KARLSLUND CHARGING STATION PROPOSAL

SPORT FACILITIES

- accelerated charging station could attract people to the sport park

HIGH DENSITY OF PEOPLE

- standard charging stations in places where many potential customers live
- the private parking places with high density of people for standard charging

Figure 37 shows the possible placement of standard and accelerated charging stations in Karlslund area for future and current situation. Public parking is one criterion for station placement, because of the method used and due to the preference for parking separated from residences. Other stations can be placed where the density of residents is high, because of the potential number of customers and the convenience of customers.

Accelerated stations by the sport facilities can create dynamic and modern image for the future and existing sport park. Standard stations can be added closer to the residential area for use by residents with electric cars.

The development of electric charging in Karlslund area could attract more people to live or found a business, and highlight the sustainability and attractiveness of Karlslund.

This alternative, with 3 accelerated and 7 standard charging stations would cost approx. 380 000 SEK (Haghanipour, 2015). The distribution serves as an example, because it is not possible to say precisely how many stations are needed.

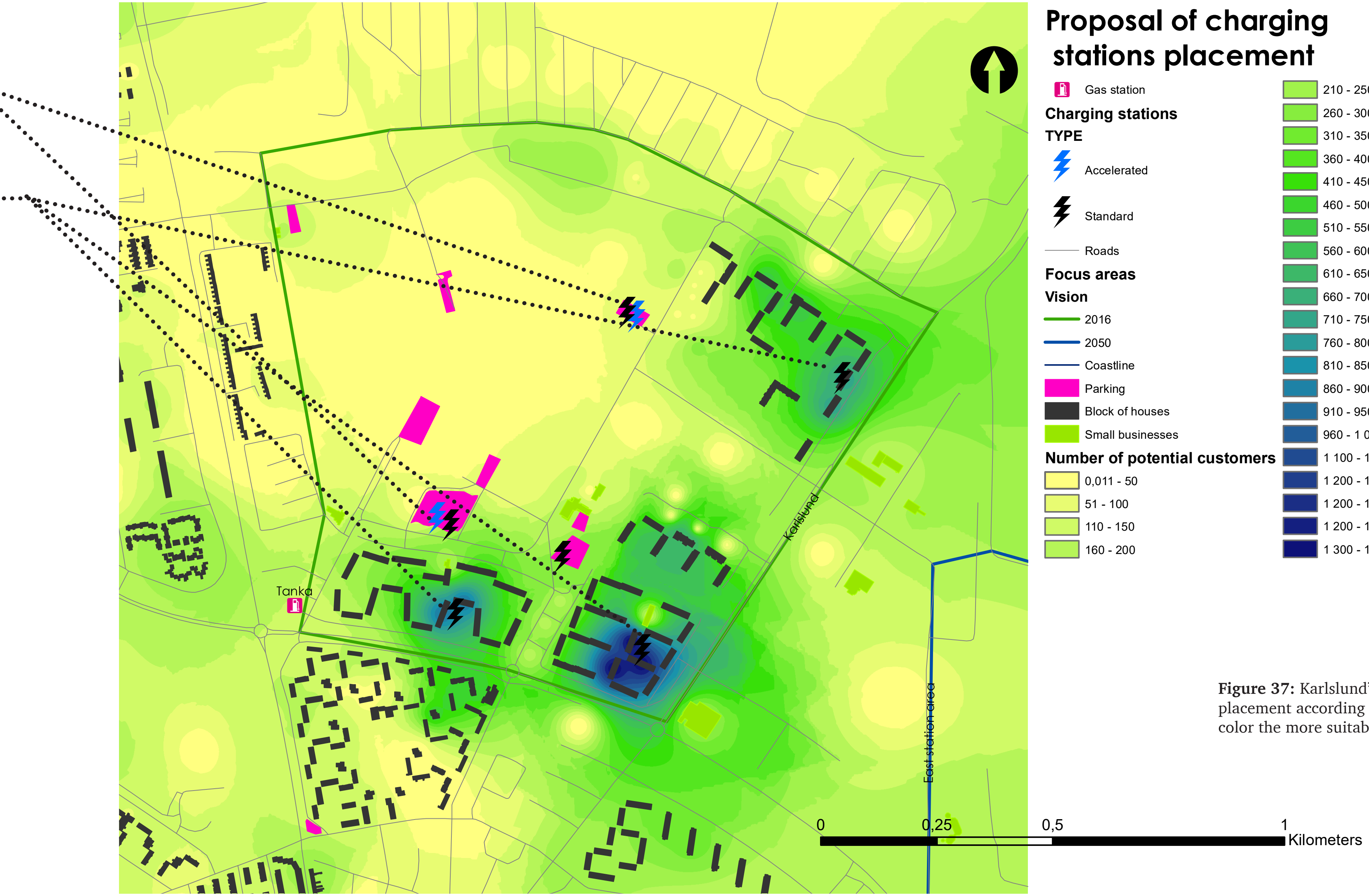


Figure 37: Karlslund's suitability of charging stations placement according to selected criteria. The darker the color the more suitable the placement.

3 THE CENTER

The municipality has plans for the densification of their town center, such as to build a new hotel opposite the town hall, and other apartment houses nearby. Development of new parking places is necessary, but some old ones will disappear. In general, as the parking plan states, the municipality is focusing on cars visiting of the businesses and not on residential or work place parking. Figure 38 shows current and planned parking places. Figure 39 shows suitable placement of parking houses. Both these maps point out the importance of parking planning in Landskrona. Integration of electric infrastructure and its suitability after densification is shown in Figure 40.

JÖNSAPLAN CHARGING STATION PROPOSAL

RESIDENTIAL/SERVICES

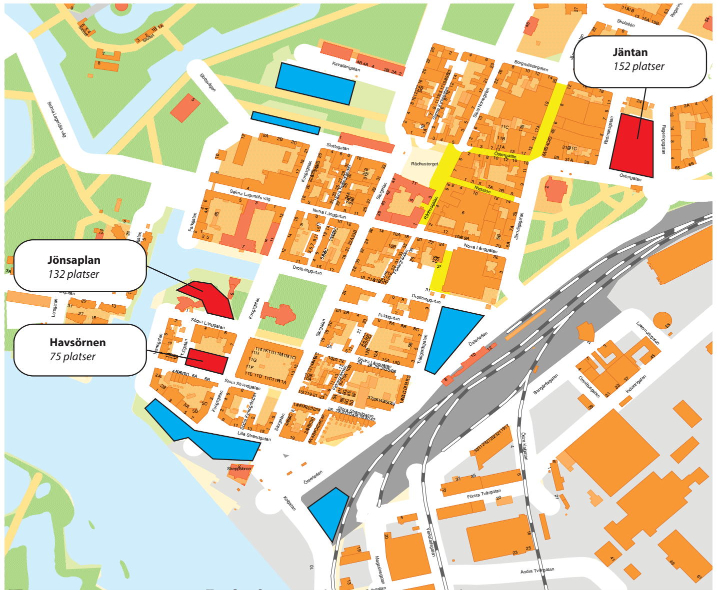
- standard and accelerated charging stations can be developed together

HIGH DENSITY AREAS

- standard and accelerated charging stations can be developed together

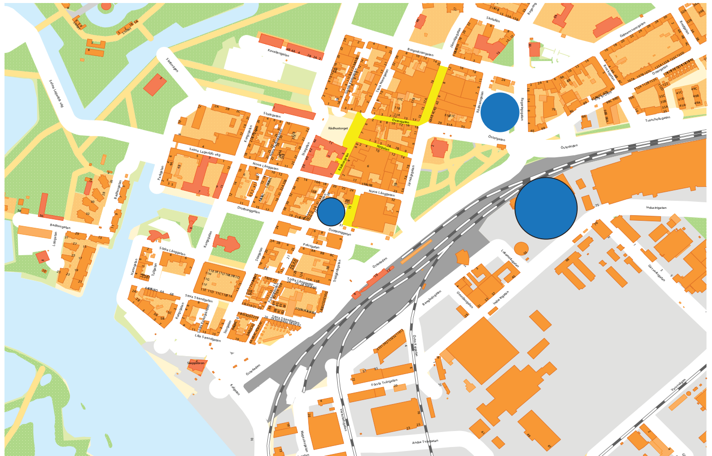
PARKING HOUSE

- standard and accelerated charging stations can be developped together



Förtätning av centrum. Befintliga parkeringsytor som försvinner.

Figure 38: Densifying in the center. Parking places will disappear (Bunke, 2016)



Lämplig lokalisering av framtida parkeringshus i Landskrona centrum

Figure 39: Suitable placement of future parking houses in Landskrona center (Bunke, 2016)

For Landskrona city it is important to decide which strategy to follow in relation to car accessibility in the center. Pedestrians and cyclists can be prioritized, as well as public transportation. In Figure 40, the combination of standard and accelerated charging stations seems useful, according to the results from IDW analysis. There is an opportunity for fast charging stations due to the high number of visitors and people travelling close to the city. Standard chargers can serve people working and living in the center, accelerated can boost the businesses with visitor parking.

Planned parking houses shown in Figure 40 create an opportunity for standard charging station placement. The position is out of city core but accessibility to the center or industrial area is high.

This alternative would cost 1 020 000 SEK (Haghanipour, 2015).

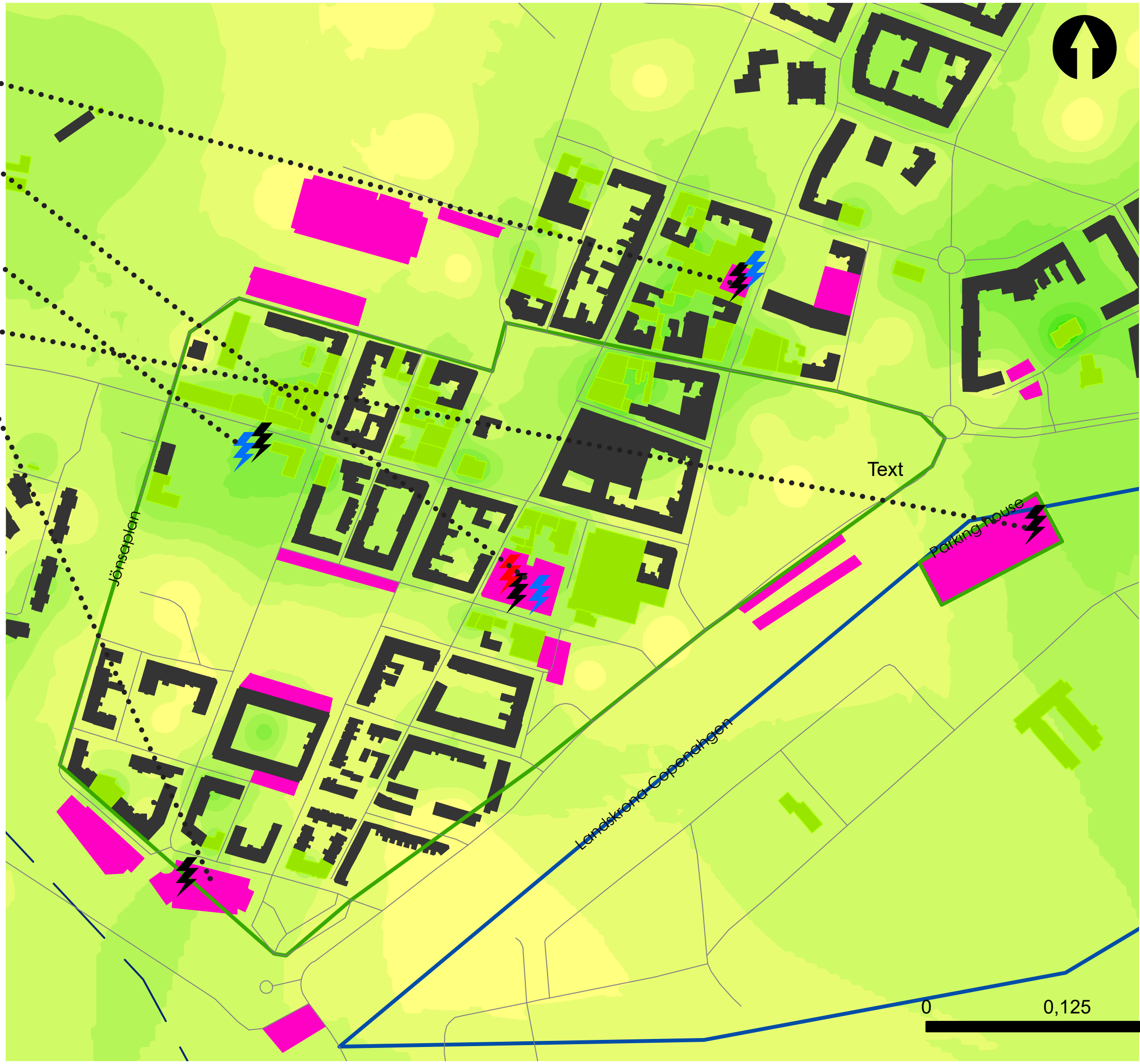


Figure 40: The center's suitability of charging stations placement according to selected criteria. The darker the colour the more suitable the placement.

4 WEIBULLSHOLM

Currently, there is existing activity and retail. Future land use, considering the region's strategic location and simultaneous consideration of ongoing activities, needs to be investigated. Weibullsholm, a former office building and catalog park, is included in the area. The park's historical value should be taken into account. Restoration or new forms of urban farming would be interesting urban experiments. The park can be an important asset to the rail station, and eastern part of Landskrona city.

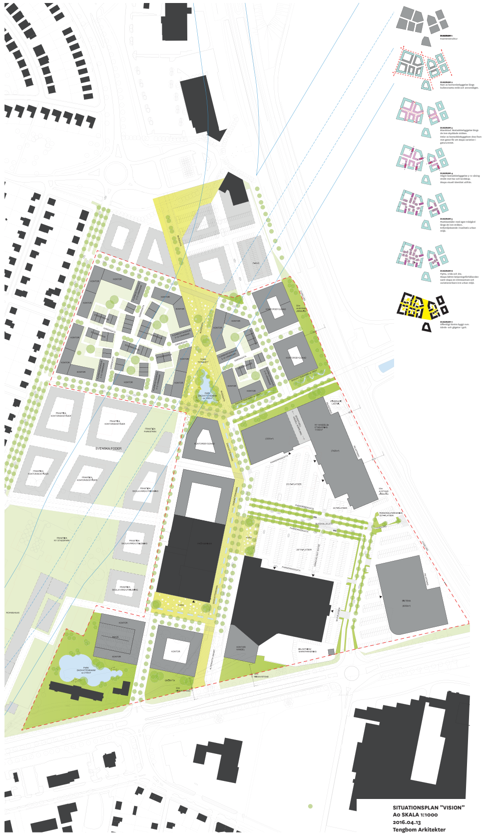


Figure 41: Overview of Weibullsholm in progress (Tengbom arkitekter, 2016)

WEIBULLSHOLM CHARGING STATION PROPOSAL

RESIDENTIAL/OFFICES/SHOPPING

- standard and accelerated charging stations can be developed together

FAST FOOD/GAS STATION

- fast charging station covers accessibility within 300m of the whole Weibullsholm area

As Figure 42 shows, 7 charging stations are proposed. Future plans for this area focus on the business potential, because the location is close to the station area as well as E6 highway. The mixture of residences and shops create a suitable option, environment for all kinds of stations. Standard stations can be used during the night for the residents and during the day for workers. Locating the stations within 300 m walking distance to destinations assure maximum use of the stations. This use dependent on actual demand for charging stations, according to how many EVs frequent in the area.

A fast charging station is located by the nearest gas station, because of its proximity to the E6 highway. Services are within walking distance and create opportunities to spend the half hour charging, however one needs. Cars can reach this gas station in 3 minutes from the highway. There is another charging station proposed near another gas station provide 300 m accessibility coverage for the whole Weilbullsholm area. The number of fast chargers depend on demand and can be increased in future. It is also important to mention that there is already existing fast charging station by gas station in Glumslöv, creating possible competition between those 2 chargers. With the projected increase in use of electric cars, this should not be a problem.

This option combining 7 charging stations would cost cca 1 290 000 SEK (Haghanipour, 2015).

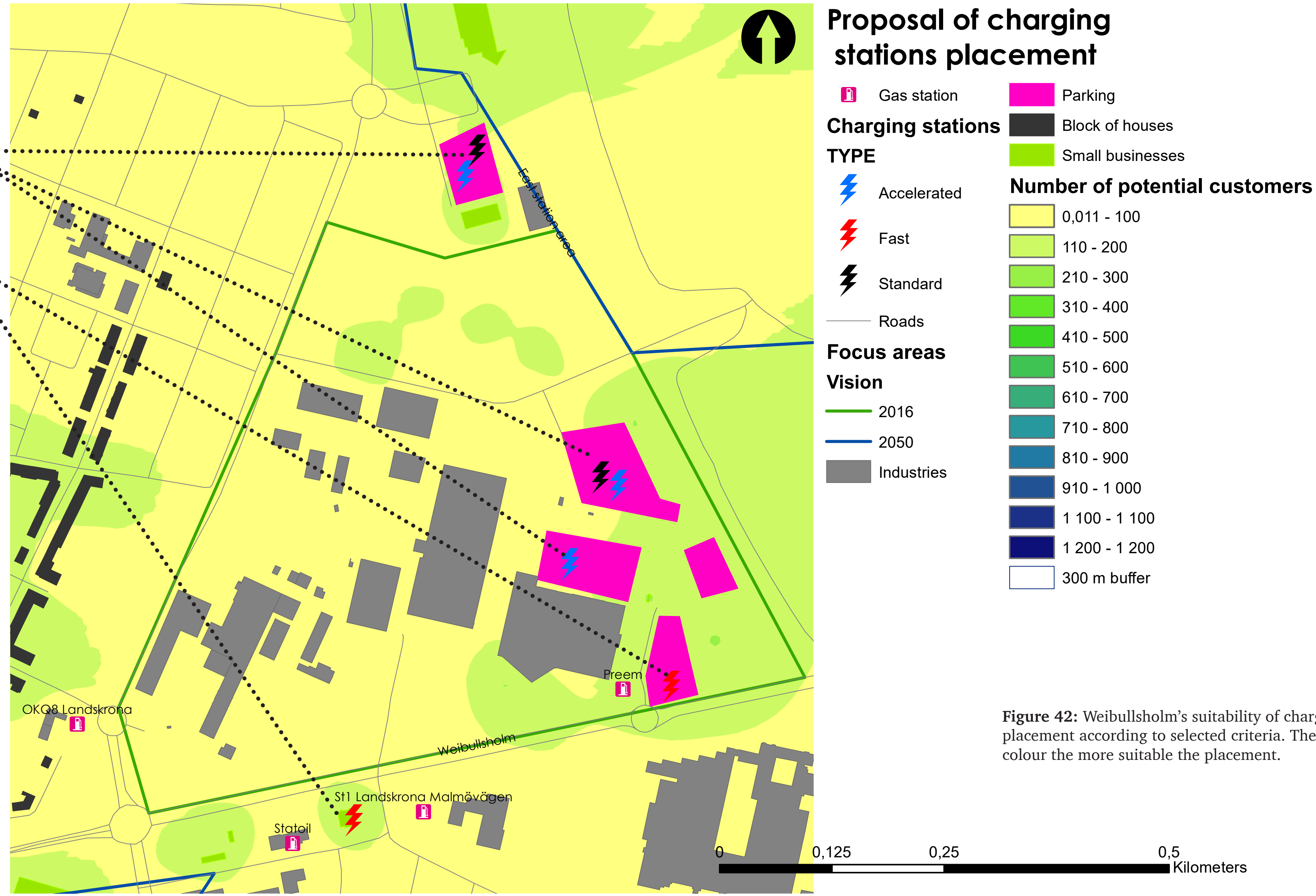


Figure 42: Weibullsholm's suitability of charging stations placement according to selected criteria. The darker the colour the more suitable the placement.

5 KRONAN

Currently, the companies: Oatly facilities, Cestron and Stefan Pålsson AB are located in the area of Kronan. The detail plan, shown in Figure 43, shows the scheduled expansion of these facilities. Other businesses are also planned to be built, especially fast-food services, motels or gas stations.

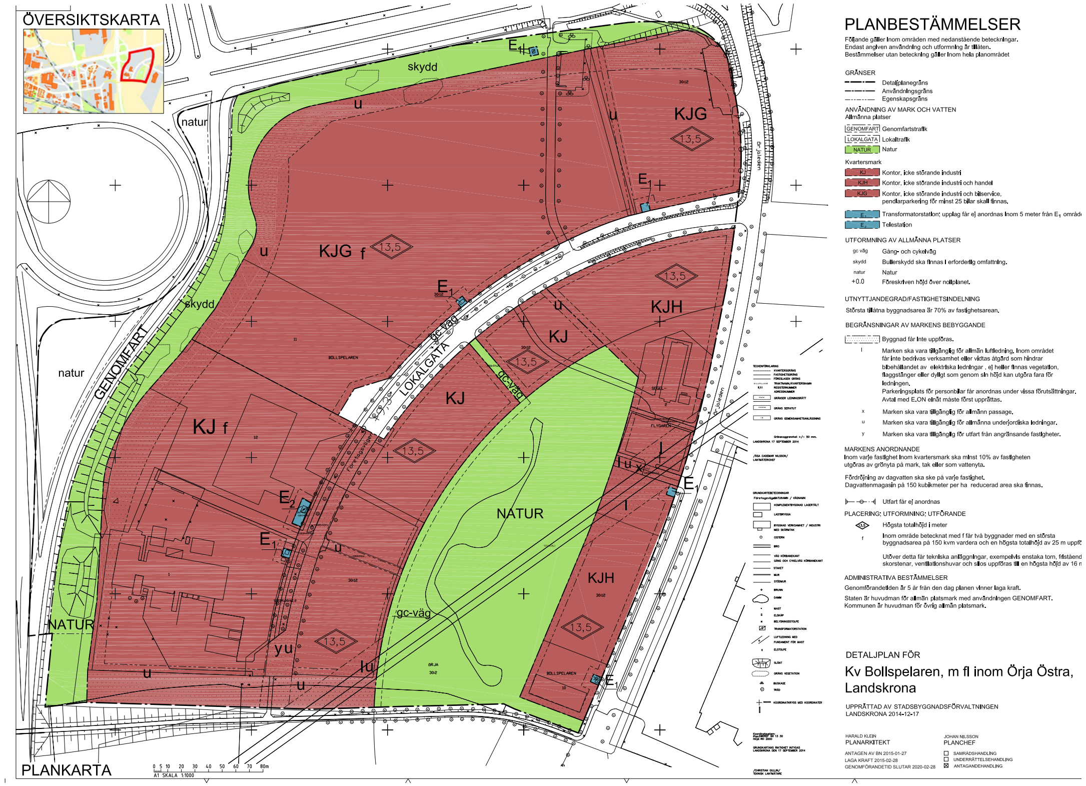


Figure 43: Overview of Kronan in progress (Stadsbyggnadsförvaltningen, 2014)

KRONAN CHARGING STATION PROPOSAL

FAST FOOD/GAS STATION

- fast charging station covers 300 m accessibility of the whole Kronan area

WORKING PLACE/MOTEL

- standard chargers could be installed for people working or sleeping in the area

The approximate placement of charginig stations are presented in Figure 44. Standard charging stations are placed close to existing, and planned buildings. Dots represent future buildings and are shown as points due to the IDW analysis. Standard charging is provided for workers commuting by car to Kronan. This area is quite small and is outside of the town. Therefore workers or visitors are likely to take their cars. A motel is planned for visitors to Landskrona, so overnight charging for EVs is possible.

Fast charging stations can be placed by the proposed gas station. This gas station is located in proximity to the E6 highway, and can serve as an optimal point for motorists to charge their EV and use the services.

This option with 2 stations would cost approximately 540 000 SEK (Haghanipour, 2015).

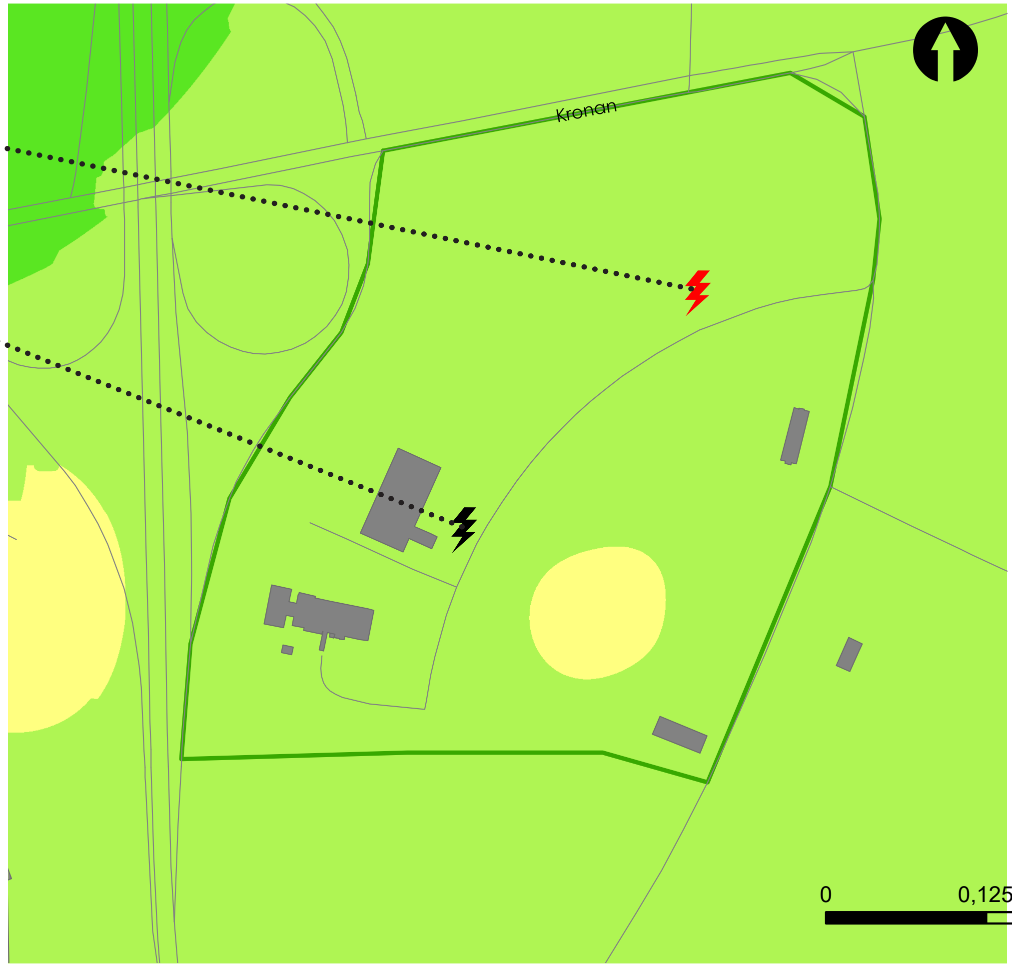


Figure 44: Kronan's suitability of charging stations placement according to selected criteria. The darker the color the more suitable the placement. (own work)

CONCLUSIONS OF THE ANALYSIS

INTRODUCTION

The suitability maps in this case study, for the purpose of this thesis, create an understanding on how to plan charging stations on a large scale. The results are dependent on the criteria, selected from previous studies in literature review and workshop discussions with stakeholders. Three types of charging stations can be placed in most suitable places within the municipality, according to the suitability maps.

Placement of charging stations can help to fulfill goals set in the municipality's comprehensive plan. First, for the social part of the sustainability triangle, there is an advantage for urban construction process that can increase participation among residents. Charging infrastructure development provides opportunities for good communication, a mixed urban structure and an attractive public room. The mental and physical barriers of traffic can be eliminated to facilitate urban life.

Secondly, sustainability's environmental corner, apart form social and economic, says that the traffic system should be developed in a way that minimizes use and waste of resources. Strategic planning and the implementation of technologies that save energy and resources are favourable. That municipally produced electricity and heat should be fossil-fuel free, is not directly dealt with in this thesis, but adds to the overall vision of a sustainable municipality. A building's construction and energy performance can be tight together with the charging stations in front of it.

Finally, a sound business strategy for charging stations needs to be developped. Such a strategy could broadly stimulate business development in Landskrona by offering different types of attractive places for business. The goals encourage a diversified housing supply, for both housing types and tenure. EV charging infrastructure supports this, and can provide an extra service; ti also supports the municipality's desire to promote rural development for recreation and tourism.

SUITABILITY MAPPING

The first stage developed a suitability map for the placement of different types of charging stations in 2016. This method was used to better reflect the real context, but actual placement will be dependent on the stakeholders and customer demand. The map was developed according to approximate number of customers living, working, visiting or passing the area, because that represents possible EV users. The 2016 vision was the most appropriate to develop, since the current situation is known and short term plans are ready to implement. The placement of charging stations for other parts of the municipality can help to enhance sustainable transportation and attract more businesses, residents and visitors.

For standard charging stations the main areas are train stations due to high number of people commuting by train as shown in Figure 29 on page 65. The placement of charging stations can be interesting for commuters from outside of the main town (farther 8 km) who could take their EV to the train station. For distances lower than 8 km, it is possible to use bicycles or electric bicycles. Other possible areas for standard charging implementation are in Karslund and the south of Borstahusen. The center also contains quite a few areas with a high number of residents.

Accelerated charging stations, shown in Figure 30 on page 67, are the most variable and hard to predict. It is difficult to say how many people will visit shops or attractions for (2 hour charging) duration. The map shows that it is interesting to place accelerated charging stations in the city center to enhance the dynamics of the visitors' parking. Attractive places along the coast also provide good spots for EV drivers that are going to a restaurant or for a swim in the sea. Smaller towns such as Glumslöv or Häljarp are likely locations or accelerated station placement to enhance the dynamics of parking near shops, or for people visiting recreational or free time areas. In Asmundstorp, there is a small recreation area that could be interesting for EV drivers to visit.

Fast charging stations, see Figure 31 on page 69, are bound to fast services, such as fast food restaurants or gas stations. With the help of network analysis and service area, a Preem gas staion closest to the E6 highway is identified as the most suitable place for a fast charging station. The layer also includes information about the traffic density. Due to high number of cars it could be interesting in the future to have fast charging stations in the city center or along Hälsningborgvägen. Also Häljarp shows suitability due high levels of traffic.

PLACEMENT

A second stage, a workshop described in Table 12 on page 70, identified areas, that are currently focused on by the municipality and other stakeholders, mainly Landskronahem. 5 areas were chosen for deeper analysis, those who have detail plans available and are more prepared for car planning.

Detailed plans were digitized according to set criteria. Different areas of the city were more or less appropriate for different types of charging stations. Borstahusen can accommodate a few standard charging stations for residents or campers, but also accelerated stations for visitors to the beach as shown in Figure 35 on page 75.

Karlslund is densely populated area that is ready for development of standard charging stations, but accelerated ones may be added for visitors to the sport park as shown in Figure 37 on page 77.

Central Landskrona see Figure 40 on page 79, provides space for accelerated charging stations that can dynamically respond to the business character of the area. New parking places and new buldings are planned. Residents can have spots for standard charging that can be used during the day by area employees, while they use them at night time for themselves. Strategic distribution of cars can be enhanced here, more charging spots could be in parking houses.

Weibullsholm is a future mixed use area, focused on retail. Therefore it is suitable for accelerated and fast charging stations because they relate to amount of time the customers spend shopping. The plan includes some office areas and apartment buildings. These conditions are appropriate for standard charging stations to be used during the day for workers, during the night by residents. The plan is to have parking houses, so that spatial distribution would is more efficient. This area also covers the most interesting spot for a fast charger, the Preem gas station Preem, which lies within 3 minutes of the E6 and can attract travellers to Landskrona. The Weibullsholm proposal is shown in Figure 42 on page 81.

Kronan, in Figure 44 on page 83, is focused mainly on truck drivers, but its fast-food character can invite EV motorists from the E6 for fast charging. Working spaces, outside of the city, create an opportunity for standard charging stations.

HEADING FOR THE FUTURE

This study can be used for future visions and development of the municipality. Electric trolley busses and charging stations around the city can support the electric sustainable city of Landskrona in the future. The use of biogas, waste heat plant and sustainable electricity production (wind, solar) can can add to this image. Landskrona could be the fist fossil-free municipality in Sweden, even before the 2030 national goal. The Swedish government launched the project “Fossil Free Sweden”, to encourage all kinds of actors towards a fossil-free future. (Government offices of Sweden, 2016)

The method of the thesis can be replicable to other municipalities and large scale planning for charging infrastructure placement. Every case study is specific, but adapting the method to site-specific planning can add the value and needs for each location.

CHAPTER 6 - REFLECTIONS AND THOUGHTS

DISCUSSION

INTRODUCTION

Electric transport provides a significant reduction in carbon emissions, decreased noise in the city, and, if electricity comes from renewable sources, harms the environment as little as possible. There are other means of fossil-free motorized transport, such as biogas-fueled vehicles or hydrogen cells, but electricity is leading the industry and has many advantages. In the future there will be more innovations providing options of even more diversity, to meet the needs of all customers. All these innovations have disadvantages, for electric cars the main challenge is the battery storage and the scope of the vehicle per full battery charge. Therefore electric urban transport can be foreseeable better in personal transport and electric freight trains, until the technology advances.

Since the beginning of 20th century, society has been creating a car-dependent society. Personal vehicles have become a part of life for many people living in urban sprawls. Today, the trend of car use and car ownership in developed countries is decreasing, but the car is still the primary means of transport in most places. The use of public transport, cycling and walking is rising in developed countries. In developing countries car ownership and use is predicted to rise even as public transport or cycling remain the primary means of transport here. EVs can be seen as a shift towards a sustainable future, and planning should be done in a way to not diminish other forms of transport. In developed countries EVs can be seen as a way to shift car planning to a more healthy and sustainable level, strategically providing space for cars, but prioritizing public transport, cycling and pedestrian traffic.

Travel patterns, according to the survey in Landskrona, show a slight increase in car use in 2013 compared to 2007. Landskrona, located strategically in the Skåne region, has more people commuting out of the municipality than to it. To some extent people are dependent on their cars due to inconvenient public transport connections. It is important to plan for cars in Landskrona in different kinds of areas, while at the same time improving the public transport connections.

There is a discussion as to whether it is even appropriate to plan a future of the city for cars (Ljungberg, 2015). Firstly, the municipality should plan for pedestrians, cyclists, public transport and then for cars.

Limiting the number of cars in the center of the city will increase safety and improve public life. Landskrona is the city where people bike the most in Sweden, 34% of total trips, but what determines why people go by bike or car? If the city decreases the number of parking spots, would people cycle more or would it increase anxiety and unwillingness to move to Landskrona?

Electric cars are an alternative for fossil-fuel free transport in the future, but the paradigm of a car-dependent society remains. This is not as much seen in Sweden, but in other big cities such as Sao Paulo, Los Angeles, and Kuala Lumpur, where the traffic jams determine a city's movement (Gertten, 2015). The goal is to switch the paradigm and engage people in local activities, where it would be convenient to use public transport and bikes. EVs can serve as a mediator for a start of a different kind of thinking. Charging stations can be located outside of the city core to leave the center almost free of traffic. Some people cannot take bikes, public transport or walk and need to take the car. It should be permitted to park next to important destinations, but pedestrian zones should be left almost vehicle free for the safe movement of high number of people.

Installing charging station can lead to discrimination against those who cannot, in short term, afford to buy an electric car. If parking places are reserved for electric vehicles, fossil-fuel vehicle owner would have nowhere to park. In the future electric vehicles will become cheaper and generally more affordable, but until then regular vehicles need to continue to be considered in parking plans.

The question of safety was discussed in Brown (2013) working with parts of the city where the crime rate is the lowest. This aspect could be also considered for Landskrona: strengthen security in problematic areas or place charging stations inside a surveilled buildings or parking houses. Gentrification is a problem, when high-income families are separated from low-income families. Not everyone can afford an EV, so mixed housing areas around the municipality should be planned in a way to not divide the society. Common spaces for all kinds of transport and types of vehicles should be planned.

S

STANDARD CHARGING STATIONS

Standard charging stations provide charging/parking space for vehicles for 6-8 hours. According to the literature review, the location of the station is mainly in residential areas, but also in work places. The car is parked 95% of it's life, therefore the parking place is important. In Landskrona people with no parking place are dependent on public or semi-public car parks. It is interesting to locate the apartment buildings, to determine where a public charging station could be placed. Charging is needed during the night, which can help to balance electricity use thoroughout the day.

It is hard to say who will actually buy an EV. It can be assumed that families with higher income will be the first ones to adapt and probably those owning 2 cars will change one to electric. The exact placement of charging stations is therefore not possible to determine: that will depend on real demand. Educational platform for the demand could be launched, as the education of the public is important for right acceptance of this relatively new technology.

In work places the situation is similar. Going to work by car is according to the new parking plan not preferred, but some work places such as industrial area provide space for parking and also have unfriendly environment for biking, walking and public transport. The question is if it will be like this in future or these areas will be converted to more pedestrian and bike friendly environments.

ACCELERATED CHARGING STATIONS

Placement of semi-fast charging stations can be seen as the most strategic. 1-2 hour charging can be located in areas, where people spend a similar amount of time, such as shopping areas, free-time places, sport halls, etc. Stations can be also placed outside of the city in rural area to attract visitors for recreation. These stations would be used mainly during the day, creating dynamic environments for visitors. During the night it could be used by the residents, or the station could go un.

The most suitable locations, according to the map in Figure 30 on page 67, are Weibullsholm and the center. Placing the stations there can attract more visitors for the retail. In future, visitors from neighbouring municipalities that are more car dependent can be drawn towards shopping in Landskrona. Recreational places such as the harbor in the coastal area, the castle, or the natural reserve near Glumslöv can provide facilities for semi-fast charging for visitors who run or walk the dog in the area and then return home by car. Such a system could again attract visitors from neighbouring municipalities.

FAST CHARGING STATIONS

This type of station is traditionally used in fast-food areas or gas stations. The Preem gas station in Landskrona is closest to the E6 highway, so travellers on the route could come to Landkrona for fast charging and refreshments. Currently, there is one fast charging station in Glumslöv. Another one in Landskrona can relieve the anxiety of EV drivers to have more diversity in charging. Kronan creates an ideal place in the future for fast chargers as explained in Figure 44 on page 83. Restaurants and gas station can attract travellers from the E6 route. The availability of all charging stations should be shown online. Particularly for fast chargers, as the queue is undesirable, since it will increase the waiting time. The cost of a fast charging station is high, so the location has to be carefully planned. In the future there can be more of them in other gas stations close to the E6 highway to ensure that travellers have safe continuity on the road.

THE METHOD AND LIMITATIONS

GIS is alluring interface for merging all the values and criteria together resulting in maps of suitability. At first a buffer analysis was performed, using the parking-walking distances in Table 8 on page 53, but that did not provide significant results. The modelling of the existing context was imprecise. Raster IDW analysis was introduced after consultation with Neil Sang. This method better reflected the reality with broader scale of suitability for charging station placement. Nevertheless, even this method is imperfect and the results are highly dependent on selected criteria. The values for criterion were challenging to determine due to the lack of spatial information and the large scale. The main criterion was number of potential customers - people living, working or moving in the area. The data for people living or in the area was clear, but people working, commuting, visiting and moving had to be estimated. These numbers therfore serve as a ratio of approximate number of people, determining mainly the density of people in the area. The numbers were selected according to the population living in the area.

Location-allocation network GIS analysis was also preferred at the beginning of the process since Sadeghi-Barzani (2014) used this method with acceptable results. At the end it was not relevant for this scale and was hindered by the absence of future road network data. In the third stage, the charging stations are placed according to the results from IDW and located on existing or future planned public parking spots. The results only propose one of the options of how to place stations of each kind. Real demployment will depend on the willingness of the stakeholders to support EVs, or the demand from people living in the area.

During the workshop the focus areas were determined, as shown in Table 12 on page 70. The chosen areas have a potentially high number of customers. Placement in other parts of the municipality could have been proposed, but these areas consist mainly of single-family houses, therefore the need for public infrastructure is not great. Areas outside of Landskrona city have high recreational potential, so accelerated charging stations could be placed on public parking lots, depending on the accessibility of electric grid. During the workshop, Landskrona's goals were set, with one above all: to become an attractive place to live. It is recognized that the prioritization of clean transport in the area this can serve as attraction for people to move or visit. Landskrona could be seen as a modern municipality, adopting innovations, but still planning for other means of transportation such as public transport, cycling or pedestrians. It was discussed that there are already customers willing to have charging station in their home, so this pre-study of placement is highly appreciated. It was also determined that the actual placement of stations is determined by the demand.

This workshop was narrowed down the parameters for charging infrastructure according to the wishes of key stakeholders. It was valuable input to the work because helped the project to meet the needs of the stakeholders.

LANDSKRONA'S DEVELOPMENT

Introduction of charging infrastructure into Landskrona can support the goal for fossil-free transport in Sweden and the EU. It is difficult to say which comes first, the EVs or charging infrastructure, but introducing charging infrastructure based on a mixture of research and demand could be efficient. It is almost assured that EVs will soon be on our roads in huge numbers, if only because there are so few other options to meet the goals for fossil-free transportation.

Landskrona can be seen as an electric city, with trolley busses and charging infrastructure. The city will follow the lead of other countries such as Norway, Denmark and the Netherlands. Electric infrastructure can be connected with electric car pools, similar to what was done in Helsingborg. Car pool planning requires a different study to be done, but its potential is significant and it has been implemented used in many other cities. A car pool can substitute up to 5 cars, and even more cars can be taken off the road in the future with the development of other means of transport.

Electric vehicles are improving in technology becoming more recognized and accepted by the public. The strategic placement of charging infrastructure is necessary, not only for the efficient use of electricity and space, but develop more sustainable and healthy cities.

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