Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Architecture and Design
Department of Architecture and Planning

Natalia Ardanari Mjøsund

Strategy to provide an optimal bus depot

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Faglærer/veileder: Prof. Nils Olsson.				

Ekstrakt:
As a contribution to urban study, this master thesis discusses the strategies for establishment to an optimal bus depot, a transport infrastructure and facility that requires large area. The research study seeks to a greater understanding about the importance of a bus depot in urban development as well as the characteristics of an optimal bus depot. When there is growing needs in bus, there will be needs in increasing bus depot capacity. Failing to provide bus depot on time will stop bus operation. Bus depot has important roles, but its existence somehow invoke environmentally negative image for the community. People want the continuity of bus operation, but not depot as neighbor.

Following research questions are raised in this master thesis:

- What are the characteristics of an optimal bus depot?
- How would selected regions provide an optimal bus depot to their transport system?

The experiences from selected regions to provide a bus depot to the transport system are investigated. Oslo, Akershus, Hordaland, Stockholm, and Trondheim are chosen as the case study in this master thesis as they rely on bus mode as important public transport and they have continually focused on providing optimal bus depot. The combination of practice in these selected regions shows that all regions expect strong growth and increased demand for bus as public transport, and optimizing in bus depot is an important instrument to support the continuity of bus operation.

Findings show also that there is a gap between what theories has held about an optimal bus depot and the implementation at selected recent practices. The gap has so far been dominated by local situation, and the approach to balance the interests of particular stakeholders and the acceptable overall costs over a long period. Furthermore, an optimal condition to one region is not always optimal to other region.

Following strategies are taken by practices from the case study to provide an optimal bus depot:

- Bus depot as part of long-term urban development plan.
- Choose the solution that has the best time aspect.
- Involve stakeholders as early as possible.
- The importance of a pleasant workplace.
- Choose the solution that has the most acceptable costs with a long-time perspective.
- Think fuel, think environment.
- Creative design.

Stikkord:

1. Strategy.
2. Transport infrastructure and facility.
3. Bus depot.
4. Localization.

Natalia Ardanari Mjøsund

"*Strength does not come from physical capacity.*
It comes from an indomitable will"

Mahatma Gandhi (1869-1848)

PREFACE

This master thesis is submitted as a completion of a master education in Real Estate and Facilities Management at the Norwegian University of Science and Technology (NTNU).

The inspiration about the topic of the research is stemmed from my passion working with infrastructure and facility for public transport. As county moves further into more inhabitants, it requires more area to live and to move. Area is the most demanding factor in urban development. The County Executive Director of Transport at Sør-Trøndelag County, Erlend Solem, 2017, highlighted the challenges on providing sufficient areas and facilities for the operation of public transport to the fast growing population.

Good public transportation is always be coveted. To provide area to ensure the operation of public transportation, public administration must battle extensively against time and resource in a long period. Bus depot is an important transport infrastructure and facility that supports bus operation. Providing an optimal solution is important for effectiveness of bus operation. Unfortunately, the strategic location of a bus depot in the perspective of transport system is sometimes an obstacle in urban development viewpoint.

These thoughts were what motivated me to investigate the experiences from some regions in Norway or Scandinavia countries about their achievement (or failure) on providing bus depot to their transport system. The result from this research study I hope will be contributed as checklists and reminders for public administration that has responsible for planning a bus depot.

I hereby declare that this master thesis is an independent work performed according to the examination regulations at the Norwegian University of Science and Technology.

Trondheim, June 22nd 2017.

Natalia Ardanari Mjøsund.

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Several people have contributed academically, practically and mentally support to this master thesis.

Foremost, I would like to express my gratitude to my advisor Professor Nils Olsson at NTNU for the valuable support of my master thesis, for his patience, enthusiasm, guidance, help to open my mind extensively, constructive response on improving the quality of the thesis, and that no doubt of his enormous knowledge.

I am very grateful for the innumerable goodness and joyful from fellow colleagues of *Class of 2014* and the NTNU's master study program administration team (Elin, Geir, Christian, Nora and Tore).

I would also thank to my previous employer Trondheim Parkering KF and current employer Sør-Trøndelag County for the support to complete this master's degree program.

A great thank to the people I interviewed with, for their warm welcome, sharing on precious experiences and willingly to give information I need to this master thesis.

I would like to thank my family: parents, brother, parents in law, and sons. Special thanks to husband Thomas, a partner of knowledge exchange, and great help with the family routines so I can perform peacefully writing master project assignments, examinations and thesis.

Finally, I could not have achieved this stage without a love support and all the philosophical discussions with my late uncle (whom I was raised by) who passed away last year.

SUMMARY

The purpose of this master thesis is to seek a greater understanding about the importance of a bus depot in urban development. It highlights the characteristics of an optimal bus depot where Oslo, Akershus, Hordaland, Stockholm and Trondheim are selected as the study case. The research study will describe the strategies of these regions to provide bus depot to their transport system. SWOT analysis and urban brief are used as analyzing tools to the research study.

Environmental protection is one of the imperative tasks for the government. Through environmental awareness campaign, the government promotes the importance of emission decline by encouraging community to use actively public transport, cycling, or walking, rather than private cars. One of the success factors to make public transport works is that the infrastructure and facility for the operation is provided.

Bus depot has important roles for a region that chooses bus mode in their transport system. Bus depot development attracts many attentions in the world of real estate development as it is a fixed infrastructure and facility that involves considerable land-use, long-term investment (site selection), resources and buildings. Furthermore, climate changes will pose new challenge when planning bus depot. However, this area is sometimes seen as not the most priority element in urban development plan with a long period perspective.

Bus depot depends on bus volume. When there is growing needs in bus, there will be needs in increasing bus depot capacity. Failing to provide bus depot on time, will stop bus operation. For a region that has bus as the main public transport mode, this matter is crucial.

Bus depot localization, building and design should be able to encounter demand such as the number of bus, type of bus (size, type of fuel, the choice of bus material and concept), bus route network and frequency, method for bus maintenance, limited land and local factors. When the demands are accommodated, the optimal condition is achieved.

The characteristics of an optimal bus depot

What is considered optimal to one stakeholder may not be optimal for other stakeholders. Furthermore, what theory has suggested on a bus depot location that somehow is ideal for accommodating particular routes, may be contrary to the regulation plan, neighbor, politics, local situations or the land-use costs. There are always approaches to balance the interests of

particular stakeholders and the acceptable overall costs in order to implement an optimal situation. Findings from this master thesis have registered following characteristics of an optimal bus depot:

1. The bus depot carries acceptable overall costs for its public administration and public transport operator body, reaches the marked and brings social benefit for the community, with long time perspective.
2. It is optimal for the important stakeholders that are related to the depot. For the owner of public transport (e.g. a county) and its transport operator body, sufficient capacity and optimal location is the desirable situation.
3. It has good building and design with sufficient dimension and right facilities to accommodate people and buses activity continuously in short and long period.

The strategies to provide an optimal bus depot

The combination of practice in the cases in this master thesis shows that all regions expect strong growth and increased demand for bus as public transport, and optimizing in bus depot is an important instrument to support bus service. Strategies are made in order to provide the most acceptable situation. Through political process, Oslo, Akershus, Hordaland, Stockholm and Trondheim finalizes the localization, building and design for their bus depots. Following strategies are registered as efforts to supply optimal bus depot:

1. Bus depot as part of long-term urban development plan.

Planning a bus depot has a time horizon about 10-25 years. A long-term urban development planning should include bus depot as the part of it. Area for the purpose of a bus depot must be regulated as early as possible.

2. Choose the solution that has the best time aspect.

Some regions do not have 10-25 years on planning a bus depot. Therefore, the solution that is chosen must be realistic and has the best time aspect.

3. Involve stakeholders as early as possible.

In order to reach an optimal situation, it is important that the planning have focus on consultation with the representatives of involving stakeholders as early as possible like public administration, employee, operator, neighbor and customer.

4. Choose the solution that has the most acceptable overall costs.

Marked is an important aspect, However, localization, building and design should consider the comprehensive costs such as investment, land-use, operation and journey-to-depot with long time perspective, not only focusing to one element e.g. journey-to-depot costs.

5. The importance of a pleasant workplace.

Bus depot is a work place. Job satisfaction through a good localization, building and design of a workplace is an important aspect. A pleasant workplace that provides convenience facilities for the employees creates proud and productive people. Good production relates to stability in bus operation.

6. Think fuel, think environment.

An important prerequisite for providing an optimal bus depot is the choice of fuel comes as early as possible. Consideration must be given to fuel technology that gives the most promising in terms of climate, environment and cost.

7. Creative design.

Creative design is applied in the planning. Following implementations of creative design are registered from the study case:

- Smooth logistic.
- Sustainable development consideration.
- Multi land-use concept.
- Environmental friendly solutions.
- Creative design to encounter local conflicts.

TABLE OF CONTENTS

FIGURE LIST

Figures in the attachments

TABLE LIST

1. INTRODUCTION

1.1 Background

> "*What is called the governance regime for major public projects embraces the systems and processes that the government or more generally a financial party needs to secure successful investment* " (Christensen, 2009).

Countries around the world are encouraged to be more concerned to the environment impact caused by transportation. Emission is believed to cause negative effect due to pollution and air influential. Achieving emission decline by reducing the number to the use of private car and switching to public transport with environmentally friendly fuel has become an imperative task for the government, especially in Scandinavia countries.

The role of public transport is important for emission reduction from transportation. It is the responsible of the government to encourage people to walk, cycle and make the use of public transport more attractive than private cars. As the population of citizens has tendency to growth, it is expected that the number of public transport modes to serve the citizens be increased. One of the success factors to make public transport works is that the infrastructure and facility are provided adequately so that the continuity of the operation is secured.

Transport infrastructure and facility attract many attentions in the world of real estate development. To a county that chooses bus as their transport mode, it is significant that the bus capacity is adequate to accommodate its passengers. Having bus as the transport mode, there must be area with sufficient capacity to store/park all buses when they are not in operation. Failing to provide bus depot at the right time, will stop the bus operation. Bus depot plays an important role to ensure busses' quality and continuity in operation (Pawlicki et al, 2012).

This master thesis is focusing on bus depot, one of the infrastructures and facilities in transportation that plays a crucial role in the transport system and urban development. According to Edwards (2011), transportation facilities have always to adapt to innovation in the mode of transportation. Climate changes will pose new challenges in planning of the transport infrastructure and facility, so bus depot is critical for innovation and trends development.

In fact, many want the bus but not the depot. The policy on using public transport rather than private cars for transportation obtains supports easily from the community. Nevertheless, having a bus depot as neighbor or right in the center of a municipality is not so desirable situation by the community. The ability to provide an optimal bus depot with an ideal location and optimal facilities is a great challenge. Bus depot requires large area and may affect to noise production, intensive traffics, and reduction to productive agriculture lands.

1.2 Purpose

An optimal bus depot is the most desirable quality to achieve. The purpose of this master thesis is to seek a greater understanding about the importance of a bus depot in urban development and transport system. This master thesis will describe the characteristics of an optimal bus depot, and the way to get there. The integrated concept strategies of bus depot from the theories and the selected regions to ensure usability, effectiveness and efficiency and to reduce costs are investigated.

1.3 Problem statement

The problem to discuss in this master thesis is the ability and capability to provide an optimal bus depot with the right strategies to encounter challenges. An attractive public transport creates more passengers to use it. Better bus service with satisfying route network, good operation frequency, good vehicle with quality and comfort are some of the requirements for the attractiveness of public transport. However, the increasing of bus frequency needs more bus capacity. Better bus capacity can be achieved by increasing vehicle size or adding more vehicles. Furthermore, more bus capacity will require more area capacity to store buses.

The changes of the demand require consequences and changes of supply. Figure 1.1 illustrates the changes on the demand side such as the type of bus, bus route network, method for vehicle maintenance, land availability and local factors will affect the requirement on the supply side such as location, building and design. As for an example, the changes of vehicle type will cause to the changes of supply. It means that special facilities will be required in the depot to accommodate the new type of maintenance.

When there is a good balance between demand and supply side then an optimal bus depot is approached. Optimal situation is the desired quality. The ability to provide a good, significant, subsequent, and sufficient area with required facilities is every region’s dream of a bus depot

to be implemented. Strategies are built to minimize the gap between the demand and the supply.

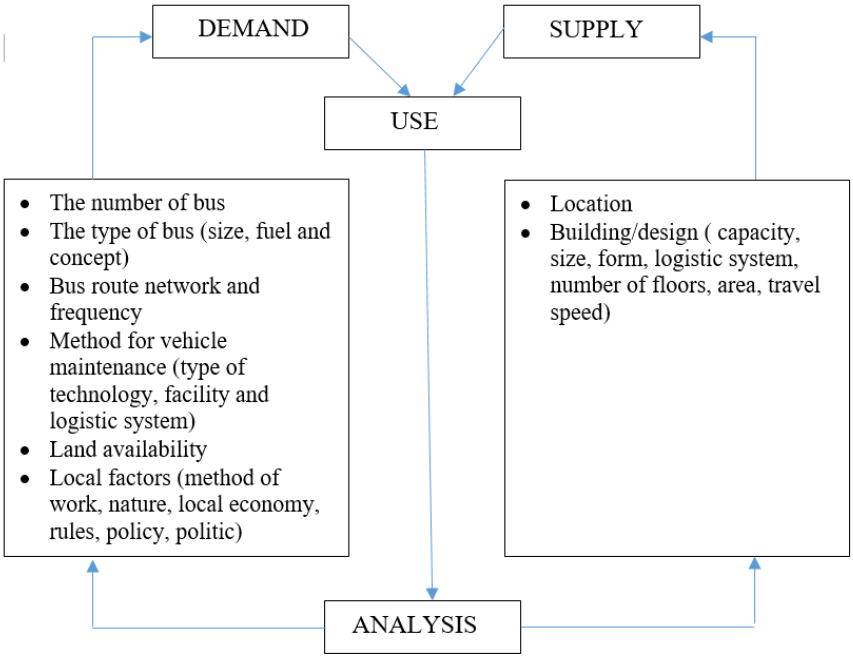


Figure 1.1 Demand and supply diagram using DEGW method.
Source: Blyth et al, 2010.

The research questions in this master thesis are:

Q1: What are the characteristics of an optimal bus depot?

Q2: How would selected regions provide an optimal bus depot to their transport system?

1.4 Limitation

Theories about transportation infrastructure and facility, real estate, and practices related to bus depot development are investigated. Examples from selected recent practices are studied and observed to understand their experiences and their applications on providing an optimal bus depot. The study is focusing on investigating the relationship between the challenge, the strategy and the implementation of selected regions when planning a bus depot. The strategy that will be studied in this master thesis is concentrating on localization, building and design of a bus depot.

Research study has limitation to only a bus-based mode principal. The cases that are investigated have bus as their primarily transport mode. It is assumed that the cases that are studied do not have any plan in the next 25-30 years to substitute their bus-based mode to

other type of public transport modes such as monorail, tram, light rail, etc. It is presumed that bus is still the attractive choice of transport mode in the future.

The infrastructure and facility for bus mode consists of various elements such as bus depot, bus stops, ITS, hubs, roads for public transport, and buses. These elements, as shown in figure 1.2, are in relation to each other where the quality of one element depends on one to another. The investigation of the cases in this master thesis relies to an assumption that other infrastructure and facility elements than bus depot are operated optimally with no deviation and they are provided with good area and capacity. It was not conducted any investigation about the condition and quality of other elements for bus mode rather than bus depot in this master thesis.

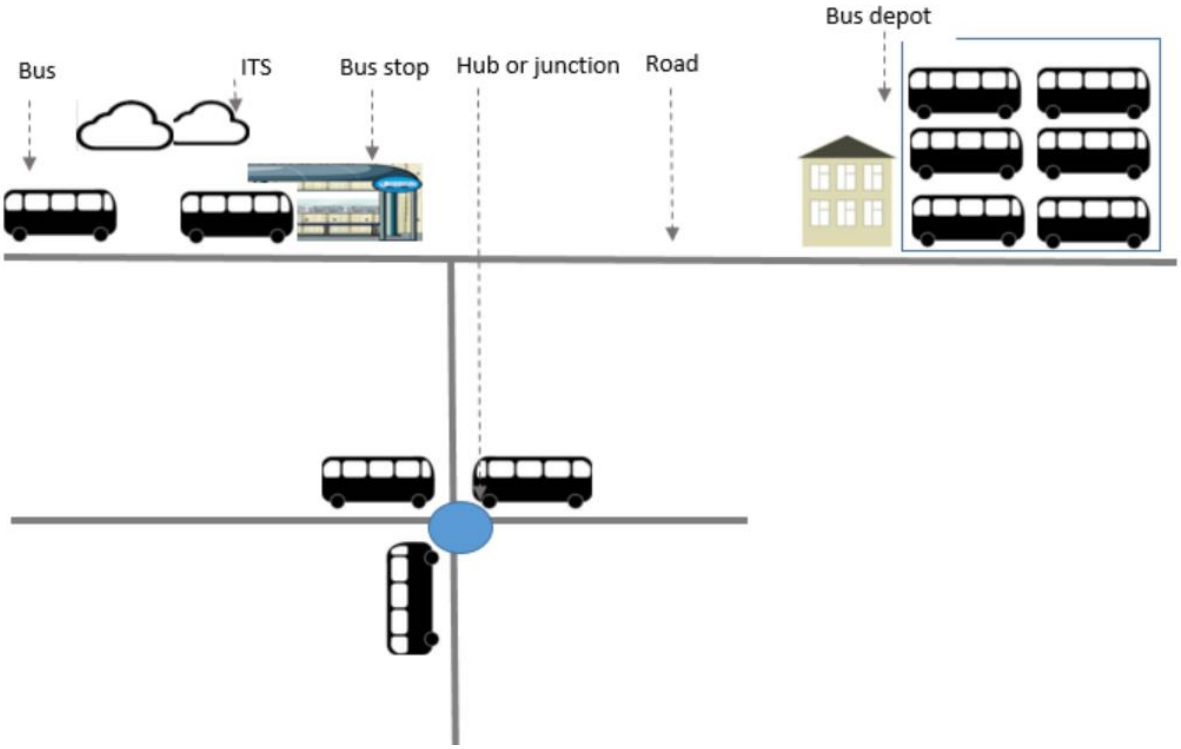


Figure 1.2 Infrastructure and facility for bus as public transport.

1.5 Definitions

County : is the democratically elected body, with responsibilities for public welfare in the county (source: stfk.no, read 2017).

Municipality : is a single urban administrative division with self-government power and granted by national and state laws. (source: https://en.wikipedia.org/wiki/municipality, read 2017).

County council: the principal elected body and directly elected every 4 years. They meet to decide on matters of principle and overriding importance, including budgetary and financial planning (source: stfk.no, read 2017).

County executive board: is the representative from the county council. This body meets twice a month to make decisions and recommendations in all matters unless otherwise provided by statute (source: stfk.no, read 2017).

Bus : is a large over-the-street unit accommodating many riders, individually driven, controlled and steered (source: Vuchic, 2007).

BRT : is a bus with a high standard vehicle types and has the same benefits as light rail. It shall have priority in traffic lights and own trace quality source. (Levinson et al, 2002).

Optimal : is the situation that is the best or most favorable for a given situation (vocabulary.com, read 2017).

Bus depot : is a bus installation facility, bus station fuel systems, washing basin, bus maintenance accommodation, and facilities for employees (Lai et al, 2016)

Bus operator : is the company that operates buses. The operation is based on a contract with a public transport operator. Bus operator is responsible for the implementation of bus traffic.

Public transport operator body: is the company that has the responsibility for operating public transport. Public transport operator awards contracts for operating of bus, light rail, boat and ferries through tender competition.

2. RESEARCH METHODOLOGY

This chapter describes the methods that are used in this master thesis. According to Cargil et al (2015), methods section establishes credibility for the results and should therefore provide enough information about how the work was done. Method is the techniques used to acquire knowledge of reality (Bogdan et al, 1997).

2.1 Data collection

Qualitative research method

The methodology chosen to collect data in this thesis is qualitative research. A qualitative research is the method that enabled researcher to analyze and interpret the facts, symptoms and events that occur in the field. A quality research is focusing on understanding a historical, present or contemporary situation (University of Washington Department of Architecture, 2008).

This master thesis investigates the characteristics of an optimal bus depot and strategies selected regions have chosen to provide an optimal bus depot to their transport system. Qualitative research method is chosen because the empirical data is too complex to be revealed only to numbers. It is needed to collect the information in the form of words.

Descriptive method is also used in this master thesis. The result of this research study will describe theories and the experiences of selected regions to encounter the challenges on providing an optimal bus depot to its public transport. The result from this research study will describe phenomena regarding what theories has held about an optimal bus depot and the implementation on localization and design at recent practices.

2.1.1 Case study

The methodology that is suggested to study transport infrastructure is case investigation, interview with stakeholders and comparison of plans of contemporary examples and related urban layout (Edwards, 2011). Case study is implemented by observing and analyzing a particular site, space or place (Fellows and Liu, 2015). The case investigation in this study concentrates on the general application of bus depot from the recent practices.

Case study is used in this master thesis as data collection to obtain the understanding about the experiences (successful or poor) from Oslo, Akershus, Hordaland, Stockholm and Trondheim want their depot be and the efforts that have been applied to achieve the goal. Method of collecting information in a case study is performed by interview, literature review and observation.

Interview

The role and type of institutions can be influential in decision-making (Pojani and Stead, 2014). Therefore, interviews to different institutions were conducted to contribute information related to vision, the organization, present situation, prognoses of the future, and strategies. Interviews were also conducted to obtain a source of insight of the situation.

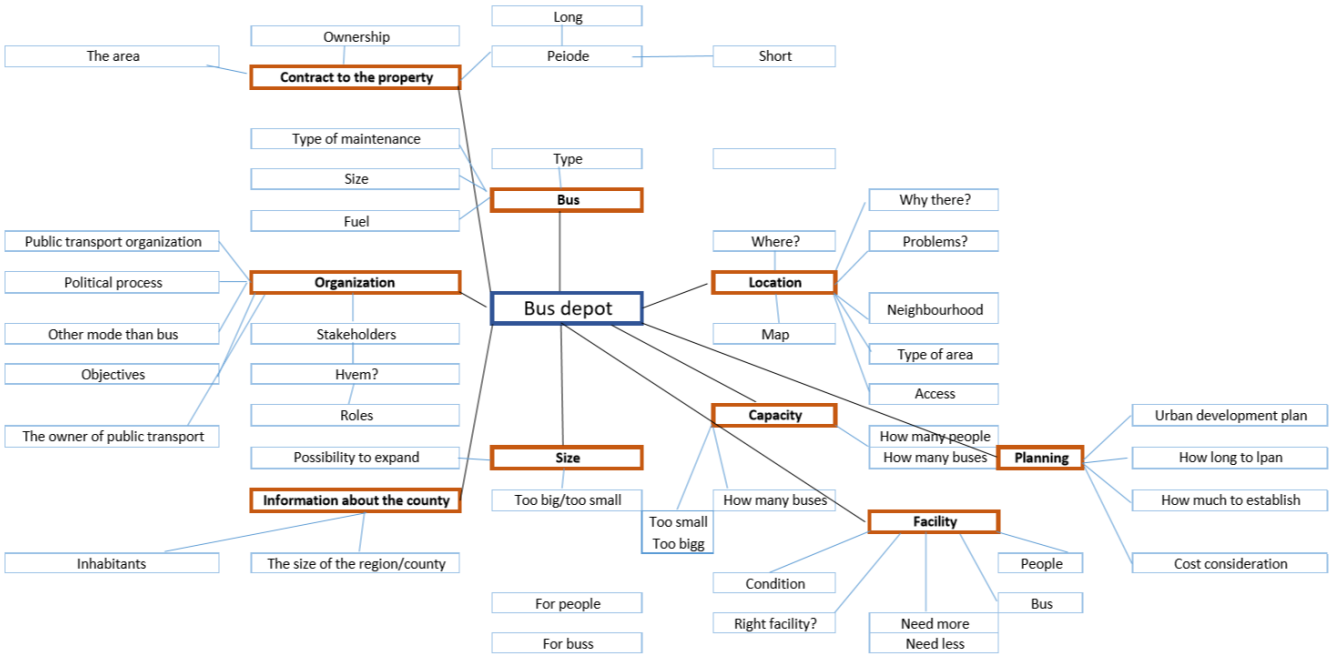


Figure 2.1 The systematic thinking to set up questions for the interview to this master thesis.

Here are the phases throughout the interview realization:

Phase 1: planning

An interview guide was developed with questions about the information wish to obtain from the persons/institutions that were interviewed. The questions were related to the problem statement in this study. Figure 2.1 shows the systematic thinking when setting up questions to the interviews.

Phase 2: conducting the interview

Case	Data source from interview	The number of people were interviewed
Hordaland	The Department of Transport, Hordaland County. The Department of Real Estate, Hordaland County. Public Transport Department, Skyss, Hordaland County.	1 2 1
Oslo and Akershus	Public transport operator company, Ruter	1
Stockholm	The Department of Traffic Management at Stockholm Läns Landsting (SLL) or Stockholm County Council. BBH Arkitekter & Ingenjörer AB.	1 2
Trondheim	Public transport operator company, Atb. Trondheim municipality. The Department of Real Estate, Sør-Trøndelag County. The Department of Transport, Sør-Trøndelag County.	1 1 1 2

Table 2.1 The data source from interview.

Interviews were conducted with persons who involve and responsible for the improvement, development and establishment of a bus depot. The data collection was conducted in Oslo, Bergen, Stockholm and Trondheim. The information about what the interview will seek about was sent in advance by e-mail. The e-mail presented also information about the researcher and the goal of the study.

It was conducted one interview with Oslo and Akershus. The number of interview for the Oslo and Akershus case is the least in this research study. The reason why it was conducted one interview for Oslo and Akershus case because researcher has obtained sufficient information from Ruter as the firm is not only a public transport operator company, but also responsible for the facility of public transport in Oslo and Akershus. The company is more independent than other transport operator like AtB and Skyss. Ruter is responsible for the investment in public transport, so planning a bus depot is one of the company's tasks. Ruter holds responsibilities in transport facility that is normally in Norway held by county. Ruter sets up the objectives of a bus depot and the strategies to achieve the goals.

In Stockholm, researcher conducted an interview with BBH Arkitekter & Ingenjörer AB. The reason why it was conducted an interview with BBH as the company has a department with specialization in bus depot that works with bus depot planning and facility maintenance. BBH is a Stockholm based architect and engineer firm with customers from many countries in Europe and Scandinavia. The interview with BBH was intended to gain data about the transformation of requirements from the owner into solution when designing a bus depot in Stockholm and other places in Sweden.

Phase 3: during and after the interview

During the interview, notes were made to record the conversation. The notes were then read by the researcher at the end of the conversation/interview to obtain confirmation that the data recorded at the conversation/interview is right. Data that contains sensitive information was asked whether it could be presented at the report. It is important to be clear from the persons that were interviewed about which data the researcher is allowed to use in the study. Furthermore, after the conversation/interview, correspondence through e-mail was made to gain more data and to obtain confirmation about the information from the conversation/interview.

Phase 4: data analysis

This is the phase where all data obtained from the interviews are systemized structurally.

- SWOT analysis was used as analyzing tool to investigate strengths, weaknesses, external opportunities, and threats to recent practices have experienced.
- Urban brief was used as an analyzing tool to provide a brief about successful (or poor) experiences and the application of the strategies in providing an optimal bus depot.

By using urban brief method, the data was grouped to following topics: present situation and facts, strategy to provide an optimal situation and example of strategy implementation from selected depot.

Phase 5: writing the data at this master thesis

The systematic data from the interview was then comprised at chapter 4 and at the attachments in this report. The data is used for the basis for discussion at chapter 5. Table 2.2 shows the structure when writing data at chapter 4.

Present situation	Overall strategies	The implementation of the strategies to selected depot
Organization, location of depot today, stakeholders, history of localization, local conflicts, capacity, facility, the contract.	Localization, building and design	Localization, building and design

Table 2.2 The structure of writing data in chapter 4.

Document review

A document review in the case investigation was made to get local information that is relevant to the cases. Data is also supplied in form of reports and documents that were given at the

interview section. Table 2.3 shows the type of documents that were obtained at interview section.

Case	Type of document
Hordaland	Competitive basis of bus depot. Public transport strategy. The status of public transport infrastructure. The facts of selected bus depots.
Oslo and Akershus	Needs analysis for bus depot. Development plan for bus depot. Strategy plan for bus depot. Input to functions for bus depot. Dialogue conference bus system strategy. The facts of selected bus depots.
Stockholm	Risk analysis of bus depot. Guidelines to establishment of bus depot. The facts of selected bus depots
Trondheim	The future of bus route. The facts of Sorgenfri and Sandmoen bus depot. The documents from County Council political meeting.

Table 2.3 Type of document as data source from case study.

Website review

Table 2.4 shows recommended important website that contains local data that is suggested from the interviews.

Case	Website as the source of local data	
Hordaland	Hordaland County website. Skyss website.	http://www.hordaland.no/ https://www.skyss.no/
Oslo and Akershus	Ruter website.	https://ruter.no/
Stockholm	Stockholm County Council website. Storstockholms Lokaltrafik (SL) website. BBH Arkitekter & Ingenjörer AB website.	http://www.sll.se/ http://sl.se/ http://www.BBH.se/
Trondheim	Sør-Trøndelag County website. AtB website.	https://www.stfk.no/ https://www.atb.no/

Table 2.4 The internet side as source of local data.

Observation

A visual field observation was implemented by visiting to several bus depots. Observation was conducted as is to be able to view participants and activities as well as space and time usage that occurs in the depot and surround.

2.1.2 Literature review

The interpretation and clarification of term bus depot must be clear. Theories related to real criteria and indicator that characterizes transport infrastructure, and facility especially bus

depot, was investigated. A literature review is made to get a relevant theory from socially and physically point of view.

Database such as **Oria** at NTNU and **Google scholars** were intensively and extensively used to find literatures that related to this study. The library of Department of Architecture at NTNU was also actively visited to obtain textbooks related to the topic of this research study.

When conducting a literature review, Creswell's (2014) 7 steps were used as guidance:

1. To identify key words. These key words were most used in this research study: bus depot, bus garage, bus park, bussdepå (Swedish literature), bussdepot (Norwegian literature), bussanlegg (Norwegian literature), transport system, urban transit, BRT, localization, and optimal.
2. With these key words, to focus initially on journals and books related to the topic. The literatures to this master thesis were obtained from national and international sources. Theory and study methods from scientific journal, article, former thesis and dissertation were also used in this research study. Following fields were investigated: organization and project management, real estate development, land-use planning and urban transport planning.
3. To locate reports related to research of the topic and set a priority on the search.
4. To skim the reports and duplicate those are central to my topic.
5. To design a literature map.

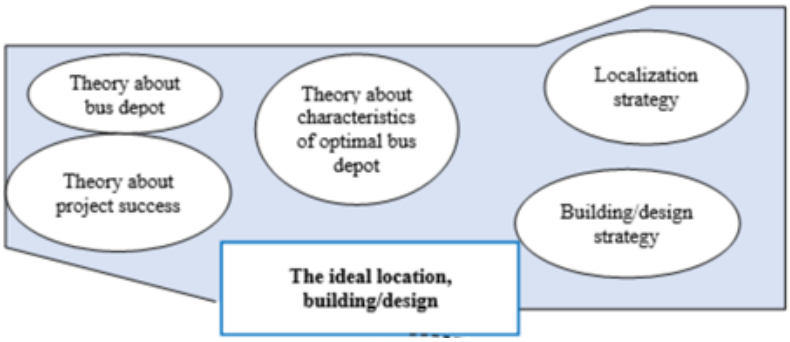


Figure 2.2 The grouping of the literature based on the topic in this master thesis.

6. To draft summaries of the most relevant articles.
7. To assemble the literature review and to structure thematically. The literatures were then grouped based on the topic in this research search study. Figure 2.2 shows how the literatures were grouped.

2.2 Reliability

Reliability means how reliable and trustworthy a data is (Everett et al, 2012). It is important that the data that is collected in master thesis is as reliable as possible. Both consistency and inconsistency are factors that can contribute to reliability.

Demographic trends

This master thesis investigates the strategies of selected regions have chosen on their depot to adapt today and future challenges. It is a great challenge to predict the future condition. The strategies that are chosen from the study cases are all based on the positive assumption that the demographic trends will have an increasing in human population and greater needs of buses in the future. Prerequisites can occur to the decline in population. The decline of population caused by disease, nature catastrophes, war, etc. are seldom taken into consideration when planning transport infrastructure and facility. Numbers and conditions in this research study rely on the future condition will have higher population than today.

Bus attractiveness as transport mode

Technology may lead to traditional bus is no longer a choice as a public transport mode in the future. Better infrastructure for other transport mode (tram, better bicycle road, carpool system) than bus and better local facilities can reduce the number of bus using in a county. An advanced internet connection may lead to people reducing their movement to other places than home for working. When buses are no longer attractive as a public transport mode, bus depot may not be needed anymore. Data source in this thesis are all on the positive assumption that buses are still popular as transport mode and the use of bus will be increased in the future.

Time limitation when collecting data and politic change

The method that is used in this master thesis is qualitative, where interview, literature review and observation were conducted to collect the data. A very limited time for data collection may not accommodate full information. Every interview was held within 2 hours and the additional information was obtained via e-mail after the interview. Furthermore, observation was conducted to some depots in the counties that is studied. Every observation visit was held within 1 hour. The data from the case study used in this research study is based on the information that is obtained from the period of December 2016 until May 2017. Changes of

information that comes after this data collection-period following new policies after politic election can affect the prioritizing in strategies.

2.3 Validity and generalizability

According to Samset (2008), information is valid if these two criteria are met:

- It is corresponded between the interpretation and the phenomenon one wishes to describe (the definition is valid).
- The expression is reliable.

Transport trends

The result of this study may have some challenges to validity as the time of the study research is held. Predicting transport demand for the year 2030 in a study that is conducted in 2017 may have more challenges in data reliability and validity than if the study is conducted later in 2025. Bus depot is a source of land that requires large area and strategically location and the planning require a long-range forecast. Due to technology development and innovation, the capability to set up strategies as the response for the future demand in longer perspective is more challenges than in shorter period. It requires good prediction to meet transport demand in the future.

The stakeholders that are not represented in this case study

Interview were not conducted to all stakeholders that are related to the planning of bus depot. Every stakeholder can have different perspective about an optimal situation. What is said to be optimal to one stakeholder may not be optimal to other.

Medium size vs large size region

What is said to be optimal to one region may not be optimal to other region. A situation of a place can affect the validity and generalizability. The data obtained to this master thesis was always analyzed if it is relevant to what it investigated. The information that was collected was continuously checked if it is related to problem statement and research questions in this research study.

The experiences on providing an optimal bus depot in Oslo, Akershus, Hordaland, Stockholm and Trondheim are investigated in this study. The cases that are chosen in this research study

have similarity in policy in environmental, democracy, politics, economic and urban development plan.

However, it is quite a dilemma if the experiences from Oslo, Akershus and Stockholm are valid for and can be generalized to Trondheim and Hordaland. Oslo, Akershus and Stockholm have long time and many experiences accommodating the demand for an optimal bus depot that can represent as examples from large regions. Trondheim and Hordaland may not have as complicate challenges as in Oslo, Akershus and Stockholm. Moreover, politics play an important role in finalizing localization. What is considered optimal to large region may not be optimal situation for medium size region, and vice versa.

2.4 The summary of chapter 2 – Research Methodology

The method

- The methodology to collect data in this master thesis is qualitative research.
- Descriptive method is used as is to describe the experiences from recent practices.

Data collection

- Case study and literature review are the method of collecting information.
- Through case study, following methods were conducted: interview, document review, website review and observation.
- Case study were conducted as is to be able to do the comparison of plans and strategies of contemporary examples.

The quality of the data

- Consistency and inconsistency are the factors that can contribute to reliability.
- Cases that have been chosen to this study rely on the optimist condition that the future will have higher population than today.
- The result may have some challenges to validity as the time of the study research is held and the politics that has been run in the regions that have been investigated.
- A situation of a place can affect validity and generalizability.
- Validity and generalizability of the result may be difficult to accept for counties with different size and number of inhabitants.
- Different stakeholders can affect validity and generalizability of “optimal”.

3. THEORY

Chapter 3 deals with different approaches in relation to bus depot optimization needs and the strategy to achieve it in theory.

3.1 Bus depot

"*The provision of new and improved public transport service cannot be delivered without adequate supporting facilities such as bus garages and bus stands*" (Lai et al, 2013).

A bus depot is the starting and ending place for busses that serves first and last bus stops, and it is more than a bus parking place (Lai et al, 2013). According to Lai et al (2016) who has cited from Wright (2003) and Lai et al (2013), bus depot is a site where facilities are installed to repair, rehaul, service, clean, store and assemble buses. Bus depot is a land supply, which is the source of planned land to provide accommodation for busses, cars and people who work in the depot (Lai, 2016).

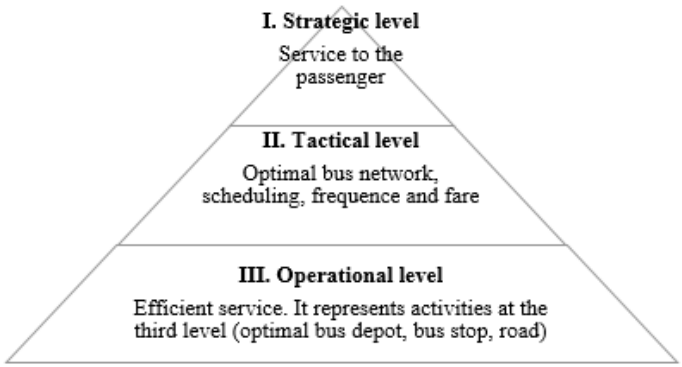


Figure 3.1 The conceptual model of transit service provision.
Source: Vuchic, 2005.

The main goal of a public transport system is the transport service to passenger. As illustrated in figure 3.1, an operational function relates to the efficient services represents activities at the third level (operation level). Bus depot has an operational function in public transport system. Transport infrastructure and facility is built to support the operation of the public transport. Bus depot is an important infrastructure and facility in public transportation to a region that stresses bus service to its community. Failing to provide a sufficient bus depot to the transport system, it will stop the bus operation and service to the community.

3.2 An optimal bus depot

"An optimal situation means something that is the best or most favorable for a given situation" (vocabulary.com, read 2017).

The standard of an optimal bus depot can be varied from one county to another and from one stakeholder to another. Næss (2004) describes needs as a fundamental characteristic of human beings, both as a biological and social being. Moreover, Næss (2004) cited from Maslow's hierarchical system of needs, explains that the most basic need is important to be satisfied first. Needs is a psychological feature that arouses actions against a measure which gives purpose and direction to behavior (Wikipedia.org, read 2017). Identifying needs is a process of describing problems with goals and possible solutions to problems.

The needs form the basis for a strategy that will lead to the goal to achieve (Samset, 2008). Needs, goals and effects are very close related and they are defined in different levels. Needs should be focused on today and tomorrow, and what should be done, rather than what was done.

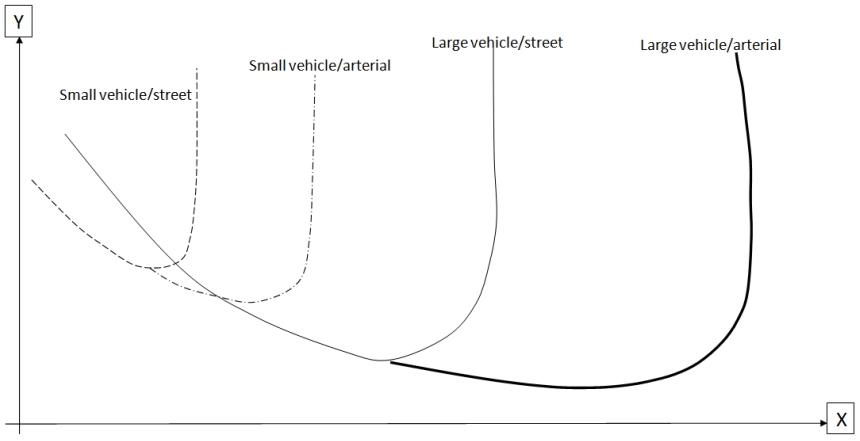
How optimal a depot can be seen from its system performance, level of service, impacts and costs (Vuchic, 1981). Optimal condition is the desired situation for every county. According to Vuchic (2007), an optimal bus depot is achieved where the result of the activities has achieved operating efficiency and the bus production brings passenger convenience.

However, providing an optimal solution is a challenge. Through the passage of time, there will always be new demand and changes in public transport that requires new supply to support the operation of a public transport. Vuchic (1998) has registered that changes and new demand in transport system leads to innovation and new facilities. He has observed following situations:

- Modernization in urban transportation requires the newest technology with high complexity.
- Changes in the dimension of a vehicle is the corresponding to the need where the priority is on the number of passengers a vehicle must carry.
- The need to favor public over private transport leads to the increase of the number of buses and bus depot and larger space for bus depot.

- The need on improving transit management requires a strategic location of a bus depot.
- The need to use environmentally solution, using of electricity bus is preferred. An el-bus requires pantograph and el-bus maintenance at the depot.

Moreover, Vuchic (2007) describes that when the public transport capacity increased, it brings effect to the size to its infrastructure and facility. As the response to greater capacity, widening of the paths, introduction of larger cabin and more depots are the strategy that are mostly implemented. Figure 3.2 shows the change of capacity of transport and its infrastructure will have an effect on the unit cost of transportation such as investment, operating and user costs.



Y = Total unit transportation costs (cost/pers-km), X= Passenger volume (cost/h).

Figure 3.2 Impact of street capacity and vehicle size on unit cost.
Source: Vuchic, 2007.

In the planning of a bus depot, the owner of public transport must define the objectives where the depot is steered towards. The effect shall correspond to the objectives. The objective must be cleared, normative and be known to everyone that is related and involved to the project. Samset (2008) indicates the SMART ideal principle for formulating objectives:

Specified - well defined, clear and unambiguous.

Measurable - quantitatively if possible, possibly verifiable in other ways.

Accepted - common understanding of all the stakeholders.

Realistic - they should be reachable by the resources that are used.

Time limit - implemented within the current time.

Figure 3.3 shows the relationship between the different perspectives of objectives in a project. Samset (2008) defines conception's output as the results, goal as the strategic objectives and purpose as the benefits to be achieved. In this study research, an optimal bus depot is an output. Output (scope, cost and time) is related to the solution that the project will generate within the project period (Samset, 2008). The goals and purposes are rather hypothetical. An objective hierarchy says about how general or specific the objective is.

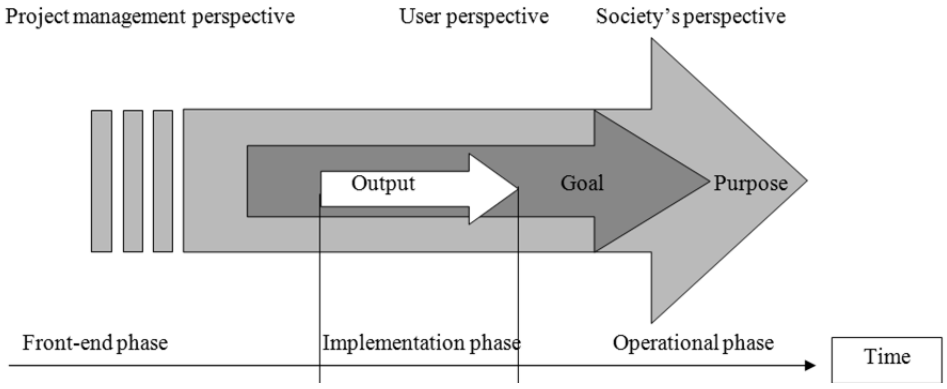


Figure 3.3 The relationship between the different perspectives in an investment project. Source: Samset, 2008.

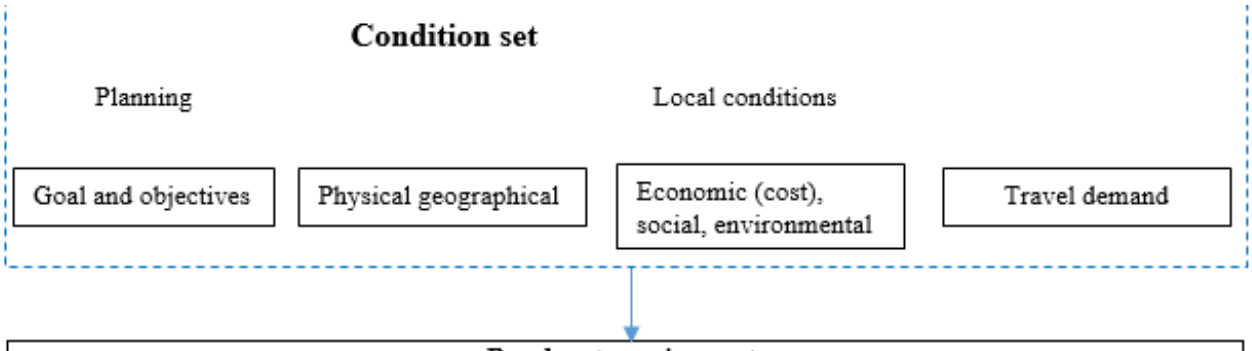
3.3 The importance of an optimal bus depot

The primary objectives of a good public transport system are to encourage short and long-term operation continuities. The location, building and design of transportation facilities should serve these objectives. Urban planner and architects have an important role in the overall process in providing good facility to the public transport (Griffin, 2004).

Vuchic (2007) classified bus depot as a fixed facility and infrastructure in transit system. It has functions to facilitate traffic flows (Hejden et al, 2006). Bus depot is a vital transit system that supports public transport system. Every bus must be assigned to a depot. It means that buses must start from a bus depot at the beginning of the day, and they must return to a bus depot at the end of the day (Maze et al, 1983). If there are no sufficient areas to store and maintain buses, then bus operation stops.

According to Vuchic (1981), bus depot has functions to support the traffic flow of buses, to store, clean and maintain buses, to control vehicle operation and to supply fuel. Transportation infrastructure performance can be defined as the ability to provide service, including reliability, comfort, condition, and safety (McNeil et al, 1992). Buses that are operated on the street must be in a ready condition to receive passengers on board. The

performance of public transport services depends on the condition of the vehicle. Lack of bus performance may lead to unsatisfied passengers. The condition of the vehicle depends on good bus maintenance at the depot.



Bus depot requirements		
The user of the bus Passengers	The user of the bus depot: Bus operator	The owner (county, municipality) The community, The authority that responsible for public transport
Passengers require following services from a public transport: - Availability - Frequency/headway - Punctuality - Speed/travel time - Comfort - Convenience - Security and safety - User cost	Bus operator require following conditions in a bus depot in their operation: - Area coverage - Reliability - Cycle speed - Capacity - Flexibility - Safety and security - Costs	- System cost - Reliability in emergencies - Social objectives - Environmental impact - Energy consumption - Long-range impact

Figure 3.4 Conversion of goals and local conditions set into bus depot requirements using Vuchic model. Source: Vuchic, 2005.

Figure 3.4 illustrates the conversion of goals and local conditions set into bus depot requirements. It shows also that different stakeholders have different requirements to a bus depot. Service to passengers is the goal in a transport system. Public transport facilities are built in order to make the transport system work well and continuously. Passengers are the user of the bus and they are not related directly as the user of bus depot. However, passengers must be considered as the important stakeholders when planning a bus depot since they are the customers to buses that bus depots accommodate to.

3.4 Bus depot planning is a long-range forecast

Bus depot is a source of land that requires large area and strategically location. Vuchic (2005) categorizes bus depot planning as a long-range forecast. It requires a good bus depot supply (land and buildings) prediction to meet the transport demand in the future. To provide the

right supply, the owner of public transport should be able to forecast the number of passengers in the future.

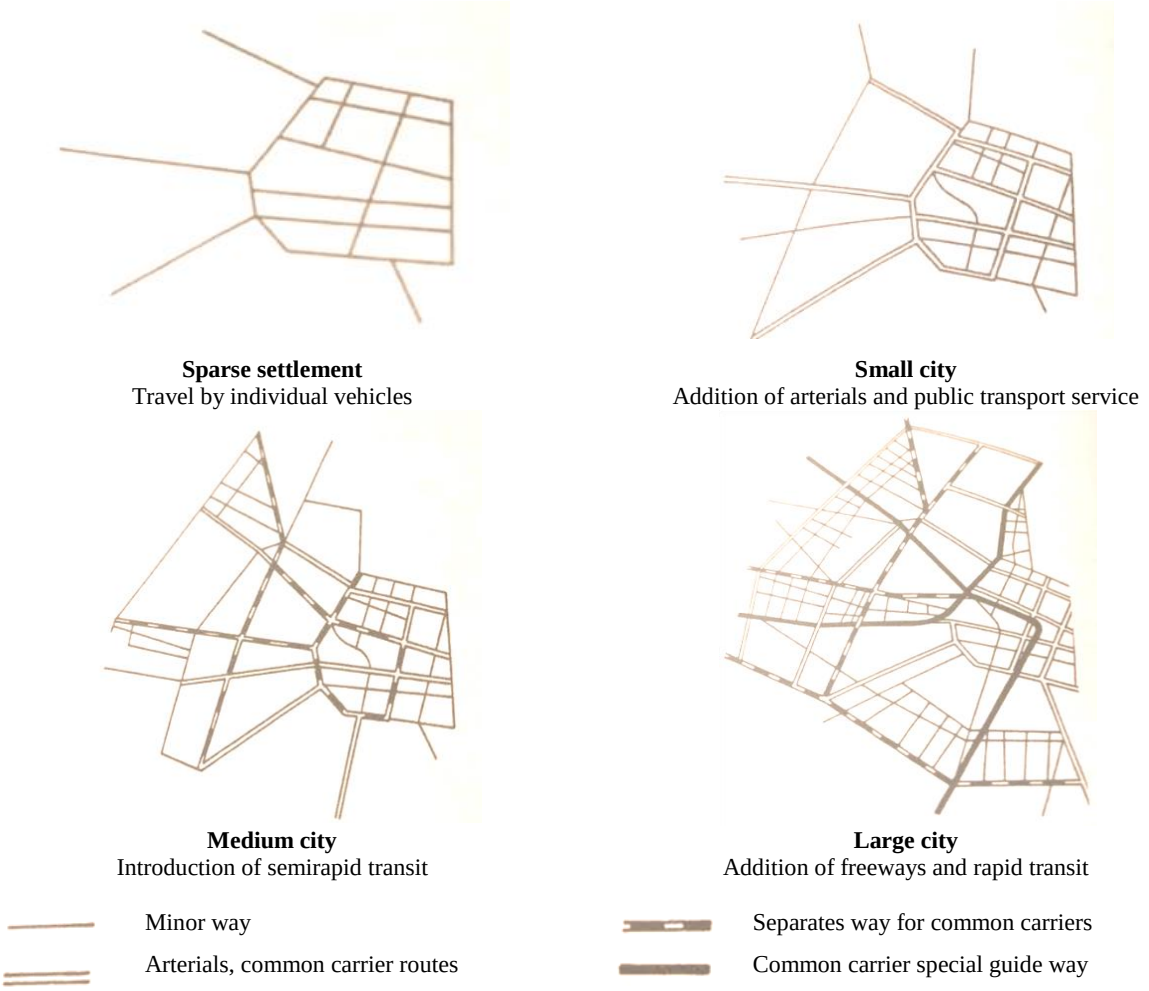


Figure 3.5 Transportation system evolution with urban area growth
Source: Vuchic, 2007.

Figure 3.5 illustrates the transportation evolution with urban area growth where area is the most demanding factor for urban development. When a small settlement grows into a town, it will give impact to the capacity of transport system as the travel of cabin intensifies (Vuchic, 2007). According to Hejden et al (2006), the development of an urban transit system is the reaction to a volume passenger to be transported.

Table 3.1 shows real estate development for a bus depot is a long-range planning with horizon about 10-25 years as it involves area, large capital investment and physical and organizational modification. A long-range planning is implemented for major infrastructure project, facilities, construction and permanent development, and bus depot is one of them. When a region plans to improve or develop a new bus depot, there must be carried out assessments to the effect, impact and interaction in urban perspective. The effect of a depot improvement or development must be carefully evaluated. The plan should be reviewed every 5 years and it should be revised or modified if some changes have occurred (Vuchic, 2005). Financing a project that requires a long-range planning must be evaluated with economic, social and environmental benefits and cost to community as a whole.

	Characteristics	**The example of element**
A short-range planning	Time perspective **3-8 years.**	Service schedule, purchase of new vehicles, route lines and network, fare types, easy bus stop.
	Not a major investment.	
	Not an infrastructure construction project.	
	Depending on present conditions and near future trends.	
	The change is easily modified.	
A medium-range planning	Moderate investment.	
	Implementation period **5-8 years.**	
A long-range planning	Time perspective **10-25 years.**	Bus depot, development of new vehicle types, new rail line, ways, travel ways, highways, network, transit terminal, control system, complicated bus stop, and power supply.
	Large capital investment.	
	Needs physical and organizational modification.	
	Major infrastructure project, lines and similar facilities, construction and permanent development.	
	It has many impacts and interactions with other activities.	

Table 3.1 Time perspective in planning transport infrastructure and facility.
Source: Vuchic, 2005.

3.5 Strategy to provide an optimal bus depot

"A successful project is one that significantly contributes to the fulfillment of its agreed objectives" (Samset, 2008).

An optimal bus depot is the desirable output. Haavaldsen et al (2012) emphasizes that a successful project can be achieved by doing the right project. Moreover, he states that it is not by making a good design, but agreeing about what the purpose of the project in the first place and choosing a conceptual solution to achieve the goal is by definition doing the right project (Haavaldsen et al, 2012). Samset (2008) referrers a concept of project success to Pinto and Slevin (1988) is when the result has near budget and schedule, and the project achieves an

acceptable performance as well as it satisfies client. Therefore, a project should be developed with sets of criteria's so it will result to the most favorable outcomes.

Efforts should be carried out in order to pursue the ideal conditions. Strategic planning should be implemented to approach an ideal bus depot for the county that suits its transport system. A strategic planning consists of formulating benefits or purposes and determining course of actions using the associated means available to achieve benefits (Berens et al, 2007).

> *Matching the demand and the supply so that the user needs are continually reconciled with the building capacity is the basis of the successful real estate management*" (Blyth et al, 2010)

Figure 3.6 shows a graphic about management decision-making process on the performance of transportation infrastructure. Data collection and monitoring, impacts modeling and application of impact models, strategy selection, strategy implementation and objective specification and re-evaluation are the process that is commonly used in transportation infrastructure (Humplick et al, 1988)

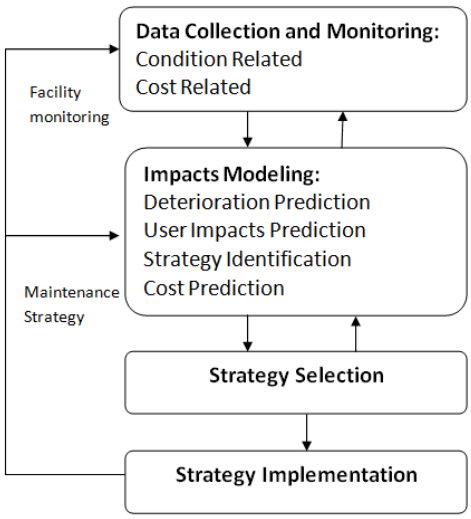


Figure 3.6 Strategy selection and implementation in transportation infrastructure.
Source: Humplick et al, 1988.

Bus depot is critical for innovation. The desirability of sufficient locations, size and design of a bus depot will depend on future urban land-use pattern. If the capacity of present bus depot does not meet the future needs, a new land must be acquired. Bus depot development involves considerable land-use, long-term investment (site selection) and resources and these may cause impacts to environment and social dislocation (Amiril et al, 2014).

Successful development of a transport infrastructure will depend upon achieving a quality of environment based (Amiril et al, 2014). Sustainable bus depot will be implemented on the development strategy with more focus on environmental standards for building and location. In the future, green design strategies will be more favorable and implemented to protect the environment as well as to conserve energy. High sustainability performance will be strongly applied in planning a transportation infrastructure (Amiril et al, 2014).

Strategies are designed in response to needs (Samset, 2008). In response to today and future urban demand, municipalities or county must ensure adequate supply that reflects to the growth and change.

System costs

According Musso et al (1997), failing to place the optimal location and sufficient dimension of a bus depot can cause ineffective urban planning. He mentioned that in addition to investment costs, the overall costs of a bus depot includes:

Land-use (space) costs (and construction) + operational costs + journey-to-depot costs

Land-use (space) costs are related to the land value where the depot is located. Having a bus depot at a strategic location must include to land-use efficiency as the property in big cities has overall high costs (Pawlicki et al, 2012). Land-use costs consist of following costs:

- Potential value: it is the land value that is determined by the demand for alternative use of the space.
- Actual value: it is the land value that is affected by urban planning regulations concerning area.

Lai et al (2013) proposes elements that determine land-use value. Land-use values are determined by its physical attributes and institutional parameter such as:

- Physical attributes such as topography and the condition of the landscape, farm and site quality, ground condition, flood risk, vulnerable habitat and accessibility.
- Institutional parameters such as tenure, ownership, stakeholders, market values (the availability and cost of property), regulation to the area, zoning and development use permit.

Operational costs are related to servicing and maintaining busses, depot management, and all functions and activities taking place in the depot. The operational costs consist of following elements:

- Labor.
- Consumption: electric power, fuel, water, communication.
- Disposable and spare parts.
- Management: general and sundry expenses, contract works.
- Bus preparation, servicing expenses, cleaning, plant servicing.

Finally yet importantly are **journey-to-depot costs**. These costs are related to journey of a bus from a depot to the first terminal/stop, and from the last terminal/stop back to depot. The costs consist of following elements:

- Labor.
- Power.
- Consumption.

3.5.1 Localization strategy

According to Lai et al (2016), the economic geography of a bus depot is a quite neglected area in public transport system planning. It seldom becomes a priority with the decision of expanding or establishing new location for bus depot when planning a transport system. The location of bus depot is not usually efficient as the consequent growth of the city/municipality/county as well as the changes in location pattern (Musso et al, 1997).

Musso et al (1997) concludes that an optimal location of a bus depot will depend on: the supply model, the shortest paths between lines and sites, the optimal sites to minimize total empty journeys, minimize operational costs related to depot sizes and possible benefits/costs of relocation (present site value minus new site's value minus cost of relocation). Nevertheless, as the alternative of sites suitable for a bus depot are usually not many, Musso et al (1997) proposes that a county should start with the selection of the suitable sites first, and then minimize the objective functions for possible combination of these elements:

- The supply model (route network and sites).
- Shortest path between lines and sites.
- Optimal sites for any possible number of sites.

- Operational costs related to depot sizes.
- Possible benefits/costs of relocation.
- Comparison among the best solution.

3.5.2 Building and design strategy

The building and design strategy is used to develop a bus depot that able to support daily maintenance activities. The strategy is used for the continuity of bus operation that require a particular technical and physical standard. Attentions have been given to problems where depot condition does not supporting the primary activities. When the function of a depot fail, or the condition does not meet the requirement, it will increase operation and capital costs. Lack of bus service and quality can be the result of a not optimal bus depot.

One of the efforts to achieve the attractiveness of using buses than private cars can be applied by increasing the quality of bus service and its facility. Low quality buses will not encourage passengers to use buses as transport mode (Pawlicki et al, 2012). On the other hand, good quality buses bring passenger convenience. The quality of a bus can be measured by its technical and physical condition. To produce buses leaving the depot everyday with good technical and physical condition, it requires attention to the maintenance of buses (Pawlicki et al, 2012).

Depot dimension

Better infrastructure and facility is built to support the continuity of public transport operation. Without good infrastructure, public transport will miss the opportunity to improve the travel experience of crowded roads (Blow, 2005). The evolution of transport infrastructure and transport facilities provides the opportunity to test and develop new forms of construction (Edwards, 2011).

The demand of an optimal building and design of a bus depot would grow with an evolution in bus type (concept, size, and fuel) and method for vehicle maintenance Vuchic, (2007) states following causal about new demand in a bus depot as the responds to the evolution of buses:

- The size and capacity of a bus depends on the required line capacity, passenger comfort, type of machine and type of fuel.
- The size and a capacity of a bus depot depends on the number of buses and their types (bus size, bus concept, bus fuel).

- The size and capacity of a bus depot also depends on bus route network and the frequency, method for vehicle maintenance, land availability and various local factors like method of work, nature adaptation, local economy, and rules.

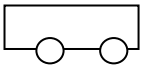
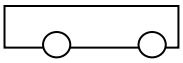
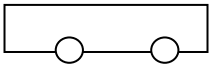
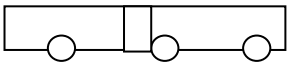
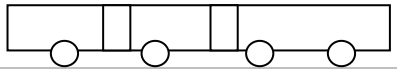
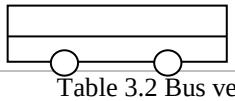
Type		Length (m)
Minibus		6-7
Midibus		8-10
Standard bus		10-12
Articulated bus		16-18
Double articulated bus		22-24
Double-decker bus		10-12

Table 3.2 Bus vehicle types.
Source: Vuchic, 2007.

Buses use the most area in a bus depot. Capacity of a bus depot must be at least equal to the number of buses assigned (Maze et al, 1983). A bus is a large over-the-street unit accommodating many riders, individually driven, controlled and steered, and it possesses a number of significant advantages as a transit mode (Grava, 2003). Busses are produced in greater numbers and have wide use with short life (5 to 12 years) and long life (15 to 20 years) (Vuchic, 2007). Bus has variation in sizes. Table 3.2 shows bus type that operates today. With the introduction of larger capacity buses, public transport changes its operation as well as larger or many small bus depots are required in order to facilitate large vehicles.

Figure 3.7 Bus Rapid Transit (BRT).
(Source from https://samferdsel.toi.no which was taken from http:/www.nanataes.fr.)

Bus concept can be distinguished by a conventional concept and a Bus Rapid Transit concept (BRT) as shown in figure 3.7. A conventional bus according to Vuchic (2007) is a regular bus that operating on the streets with mixed traffic and its performance depends on traffic conditions. Levinson et al (2002) cites the definition of BRT from Thomas (2001) as a rapid mode of transportation that can combine the quality of rail and the flexibility of buses. BRT is designed as an integrated system of distinct buses with the creation of improved and high performance bus system (Vuchic, 2007).

There are no immense differences in concept generally when planning a bus depot for a conventional bus or for BRT. BRT is still bus-based solution, with higher standard transit system component. BRT is a bus concept that stresses on better ways to provide bus service than the originally bus. It is popular for its attractiveness and high performance and quality (Levinson et al, 2002).

There are no generally accepted about common standards for bus depot criteria because it is developed by individual transportation authorities and then tailored for its use (Grava, 2003). To determine the dimension of a transport infrastructure, following factors is important to be considered (Vuchic, 2007):

- Circulation and parking planning for various types of buses with requirements: convenient, safe and accessible.
- The height of the building.
- Vehicular circulation to this site.
- Open space characteristics with the neighborhood.

Depot Facility

Bus depot facilities have been arranged consequently in there major categories (Mouzet, 1975):

- The whole buses are located in the open air. Open air storage depot must be equipped with external or internal equipment for pre-heating engines and interior in cold weather (Vuchic, 2007).
- All the buses under cover/roof. According to Vuchic (2007), bus storage in depot requires approximately 30-50% higher investment cost and usually ventilation and heating.
- The mixed system, i.e. some buses are parked in the open air, and some under the roof.

In order to facilitate activities to both people and buses at a bus depot, following functions must be considered in the design strategies (Vuchic, 1981):

- Bus storage area.
- Building with maintenance service to maintain: vehicle, traction power facilities, communication, paying system unit, mechanical.
- Washing facilities.
- Accommodation of ancillary function including ventilation and smoke exhaust.
- Rooms for administrative functions, personal and dispatcher.
- The traffic at the depot and surroundings: buses (running in and out several times per day.
- Parking for the staffs, customers and guests.

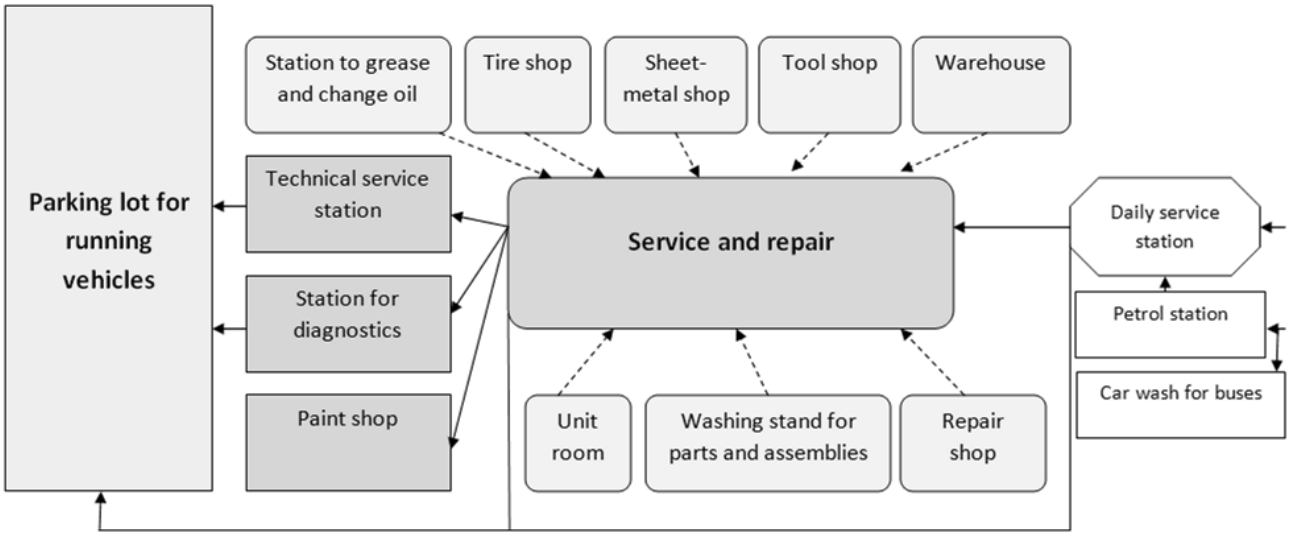


Figure 3.8 Functional diagram of buss technical resources.
Source: Pawlicki et al, 2012.

Operating efficiency and passenger convenience covers on system performance, level of service, short-run impacts and long-run impacts and cost (Vuchic, 2007). There is a strong correlation between FM and transportation infrastructure. According to McNeil et al (1992) timely maintenance and a good facility management at bus depot are essential for safe operations and the overall economics of transportation.

The definition of FM in EN 15221-1 term and definitions is "*integration of processes within an organization to maintain and developed the agreed services which support and improve the effectiveness of its primary activities*".

Facility management in transportation facility has been focusing to the ability for mobility and accessibility. Grava (2003) states that mobility and accessibility are the two most important elements when designing transportation facility. Mobility is the ability of any person to move between points, while accessibility is the possibility of reaching any activity, establishment, or land-use in a community (Grava, 2003). Facility management in a bus depot is used to ensure that mobility and accessibility are functioned well.

> "*The actual condition of a facility is influenced by the original quality of design and construction, operation and use, maintenance and rehabilitation actions, and the environment*" (McNeil et al, 1992).

The goal of facility management in a bus depot is to provide cost reduction (efficiency) as well as added value for the organization (owner or bus operator) and passenger (bus user), in a convincing way (effectiveness). Efficiency is closely connected with cost reduction and minimization of resource consumption. While effectiveness on the other side is closely linked to how an organization is able to achieve its goals. The lecture of Foss (AAR 6031 autumn 2014) specifies on instruments that can be used to achieve the organization's objectives to reduce costs and create value, and they are strategy, organization, corporate governance and sustainability.

3.6 Analyzing tool

3.6.1 SWOT Analysis

Figure 3.9 SWOT Analyze.
Source: https://estudie.no/soft-analyse-swap-analyse-swop-analyse/

SWOT is an abbreviation of strength, weakness, opportunities and threats. SWOT analysis is a method that is used to identify and understand what might be the strong and weak sides of bus depots in a region and what could be market opportunities and threats. The method consists of an external analysis (the opportunities and the threats) and an internal analysis (the strong and the weak).

SWOT analysis is carried out from the correspondence between needs, objectives and effects. The data that is obtained should include internal strengths and weaknesses and external opportunities and threats. The analysis is assessed by identifying internal environments by mapping the strengths and weaknesses of object study and the external environments by mapping the opportunities and threats from object study.

3.6.2 Urban brief

Planning a bus depot requires challenges in urban environment. A traditional bus depot typically invoke environmentally negative image for the area around the depot. Efforts are always made to find to improve or to develop new depot at the best location that will be accepted by the related stakeholders.

This master thesis conducts several studies from theories and recent practices from selected regions to have an understanding about the organizational expectation and how to achieve the desired quality. Case study is conducted in this research study to investigate strategies to provide an optimal bus depot in counties as to encounter challenges like new bus route network, bus evolution, land price, or other local factors.

Briefing is a process for managing responsibility, expectation, and it starts when the client identifies business objectives are not being fully met (Blyth et al, 2010). Urban brief is equivalent to strategic brief but the process is established for buildings are equally as relevant for urban areas (Blyth et al, 2010). Following information is presented in urban brief:

- Mission: the successful development of a building/area will depend upon achieving a distinctive quality.
- The objectives: the description what the development has to achieve.
- Challenges/precedent/desired quality: it can demonstrate the challenges and desired qualities of the building and urban fabric.
- The process: it is to set out general management framework to reach better situation.
- Response: it is to set out issue and possible effort to change.

3.7 The summary of chapter 3 – Theory

Bus depot

- is a land supply to accommodate buses, people (and cars).
- is the starting and ending place for busses that serves first and last bus stops.
- is a vital public transport infrastructure and facility to support the traffic flow of buses, to store, clean and maintain buses, to control vehicle operation and to supply fuel.
- is a workplace for administrative, drivers, mechanics, engineers, electricians, etc.

Optimal

- The main goal of public transport system is the service to passenger.
- A bus depot should bring a good effect to the public transport service.
- A bus depot should have efficient operational.

Strategies to provide an optimal bus depot

Planning a bus depot has horizon about 10-25 years as it involves area. Strategies are made to response the changes in bus route network, the number of buses, evolution of bus, vehicle maintenance, land availability, or local factors. Particular strategy in localization, building and design are made to encounter the changes and new demand for new depots.

Failing to place the optimal location and sufficient dimension of a bus depot may cause ineffective urban planning as the overall costs of a bus depot includes the investment and the total costs of land-use (space and construction), operational, and journey-to-depot.

The tool to analyze

SWOT analysis is analyzing tool to investigate strengths, weaknesses, external opportunities, and threats. Urban brief is an analyzing tool to provide a brief about successful (or poor) experiences and the application of strategies in providing an optimal bus depot. The analyzing will cover present situation and facts, the objectives, the challenges now and the future, the process to reach better situation, the response (effort/strategy).

4. CASE STUDY

Case study is used to build an understanding as well as to describe the experiences of selected recent practices want their depot to be and the strategies to get there.

The case that are presented

Oslo, Akershus, Hordaland, Stockholm and Trondheim are presented as the case in this chapter. They are selected as the case because they rely on bus mode as important public transport and have continually focus on providing optimal bus depot.

What to present in the case study

Urban brief is used as the tool to collect and present data in this report. Following data that is presented in this chapter:

- **Present situation and facts**. At this part, following information is presented: bus depot organization, bus depot location, stakeholders, the history of current location, challenges (high-pressure area, response from the neighborhood), capacity, condition of the building and facility, and type of contract.
- **Overall strategy to provide an optimal situation**. At this part, following information is presented: the objectives, strategies for localization, building and design.
- **Example of strategy implementation from selected depot**. 1-2 depots from every region are presented with facts and the concept of localization, building and design.

The source

The main source of information comes from the interview with persons at the authorities and companies that works with the planning of a bus depot. Some information is also supplied from reports and documents that were given at the interview section. The persons that were interviewed also recommended several websites as the source for local data. In addition, observations to several bus depots were conducted to obtain visual experiences.

4.1 Oslo and Akershus

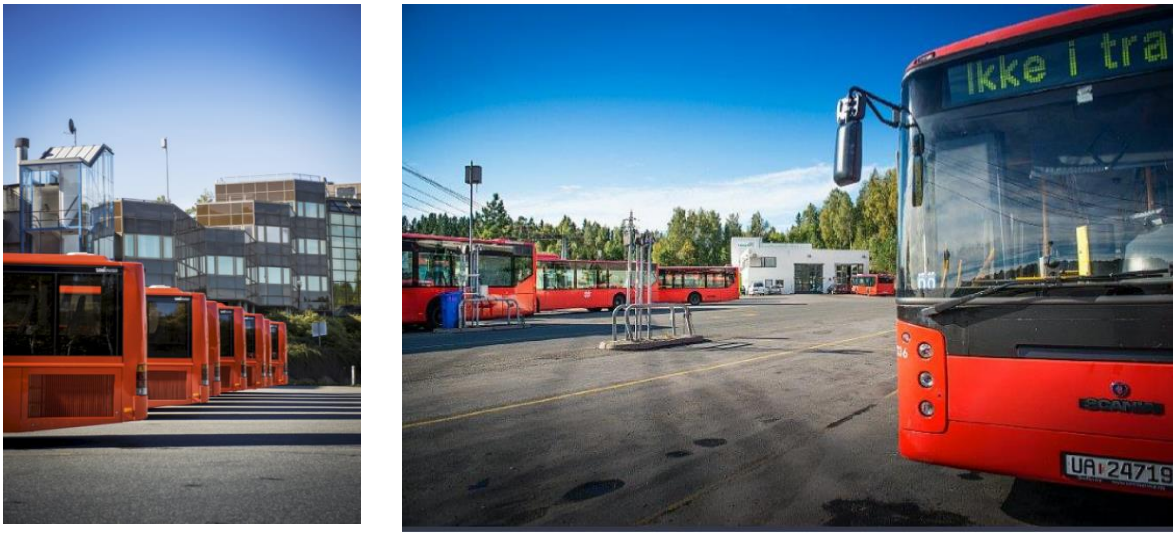


Figure 4.1 Bus depot Rosenholm and Klestrud.
Source: Strategi for bussanlegg, og skisser til organisering av øvrig buss- og båtinfrastruktur, Ruter, 2012.

Oslo Municipality and Akershus County are selected as the case mainly because they are considered to have a well-established and extensive public transport system. Bus is the operating mode of transport beside train and has an important role in transport system. Oslo and Akershus are the fastest growing regions in Norway with the greatest growth transport system. The regions have a broad experience in developing an optimal bus depot.

4.1.1 Present situation and facts

Oslo is the capital city of Norway that constitutes both a municipality and a county with total area about 480,76km^2 and a population as per January 1st 2016 were 658.390 (Wikipedia.org, read 2017). Akershus County is located just next to Oslo Municipality. The county has a total area about 4.918 km^2 and a population as per 2014 were 573.326 (Wikipedia.org, read 2017).

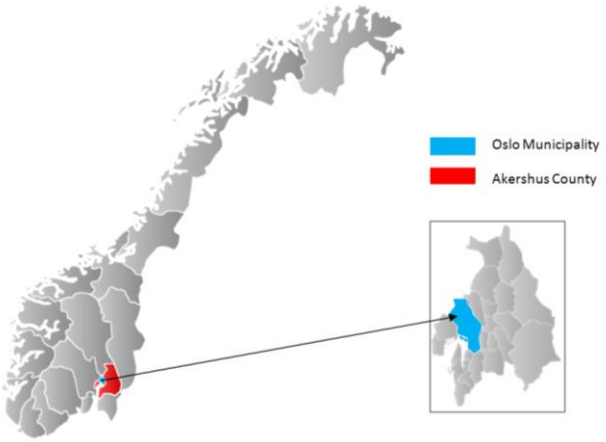


Figure 4.2 Akershus County and Oslo Municipality.

Bus depot organization

Ruter is a public transport operator body owned by Oslo Municipality (60%) and Akershus County (40%). The company has the responsibility to manage public transport in Oslo and Akershus and establish principles for the design and location of the bus facilities as well as to plan, coordinate, book and promote public transport in Oslo and Akershus. Bus operators perform public transport in the region by contract with Ruter.

Ruter's tasks that are related to bus depot are setting specific requirement specification for a bus depot, giving suggestion on localilzation, performing administration task, conducting procurement in terms of rental and purchase of bus plant, developing existing depot, building new depot, assessing the need of a new depot, ending the contract, and transaction tasks when changing bus operator.

Bus depot in Oslo and Akershus

Totally about 1.200 buses today are using bus depot spread in Oslo and Akershus. The number of depot operates in these regions are about 21 bus depots and 4 bus parking areas. A depot accommodates around 2 - 138 buses (excl. spare wagons). 6 depots handle 50% of the traffic. Bussanlegg AS is owned by Oslo Municipality that owns 6 depots in Oslo, while Nettbuss owns 4 bus depots. Private and municipality own the rest bus depots.

Figures 4.3 show the locations of bus depot in Oslo and Akershus today. The type of contract between Ruter to these bus depots is either ownership or an agreement on a sublease to bus operators who win the tender on bus operation.

Figure 4.3 The location of bus depots in Oslo and Akershus.
Source: Behovsanalyse og utviklingsplan for bussanlegg, Ruter, 2016.

Bus depot stakeholders

Public administration	The State of Norway Oslo Municipality Akershus County All municipalities in Akershus
The employees	The union and the employee of the bus operator and bus depot
Neighbors	The neighbors of bus depot
Bus customer	The passengers who travel with bus in Oslo and Akershus
The operator/drifter/ tenant/owner	Public transport operator (Ruter) Bussanlegg AS Bus operator, The owner of bus depot The drifters of bus depot Buss supplier

Table 4.1 Bus depot stakeholders in Oslo and Akershus.

The history of current bus depot location and dimension

The current location of bus depot in Oslo and Akershus is partly due to historical condition that bus depot has always been there, partly adjustments related to supply development, and

partly the size and composition of the tender packages. The decentralized structure is due to a relatively large proportion school bus driving in rural areas.

The majority of buses operate in the morning rush and afternoon rush, and stop at bus depot for midday break. There are some short trips where bus runs only one or few departures in the morning rush or at school starts. Therefore, morning rush is the determinant factor for bus depot dimension.

Some of the existing bus depot locations are not optimal considering the long-term needs, as they are located outside the route network to the buses they are serving. As the results, buses produces many empty runs, or even worse, the service zone of a bus depot has a geographical overlap with other bus depot.

Ruter defines empty runs as when the bus is driving at the *break time* with schedule longer than 90 minutes and it runs empty to and from bus depot. Figure 4.4 and 4.5 shows the number of kilometers empty runs per bus per bus depot. Empty runs cause high operative cost.

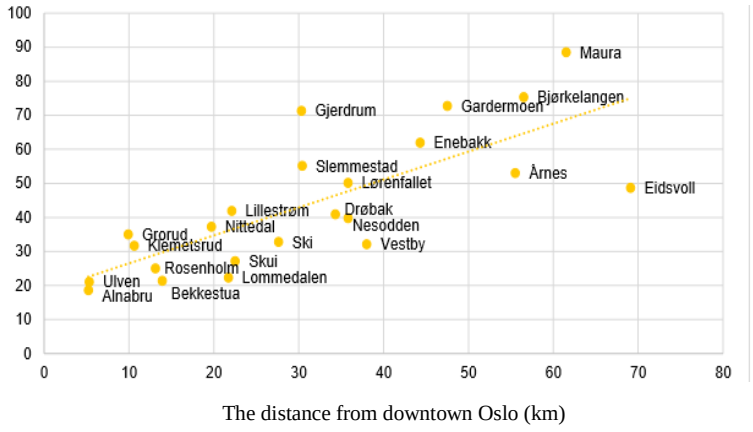


Figure 4.4 The number of kilometers empty runs pr. bus pr. depot from city center Oslo. Linear trend curve. Source: Behøvsanalyse og utviklingsplan for bussanlegg. Ruter, 2016.

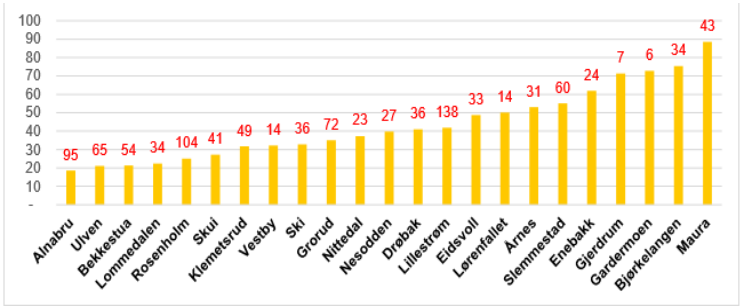


Figure 4.5 The number of kilometers empty runs pr. bus pr. depot. The number is sorted from lowest to highest. Red numbers indicate the number of buses per bus depot excl. reserve units. Source: Behøvsanalyse og utviklingsplan for bussanlegg.Ruter, 2016.

High pressure on area

Population, building growth and area densification in Oslo and Akershus increase the battle for areas. There is almost not enough area available for bus depot expansion. Ruter is currently experiencing challenges of securing area for public transport infrastructure and facilities for the long term. Ruter does not always experience succeed in providing available bus depot to the winning bus operator, especially in the central area.

The response from the neighborhood

Some depots are experiencing comprehensive neighborhood conflicts. Bus depot at Rosenholm, Furubakken, Skui, Bjørkelangen, Nittedal and Årnes have received complaints because of the noise that comes from the depot such as noise from the starting bus every morning.

The depot capacity

The capacity of existing bus depots in Oslo and Akershus is low. Public transport in Oslo and Akershus is currently experiencing strong growth, far beyond the increase in population. The regions have always focused on strengthening public transport offer and taking over the growth in private car use. Bus and train are the operating mode that underwent the greatest growth in recent years. More capacity in bus will increase the need for bus parking capacity. Therefore, it is necessary for Oslo and Akershus that the capacity offered in bus depot is increased parallel to the market growth.

According to Ruter, it is expected a population growth against 250.000 people over next 15 years in Oslo and Akershus. In 2011, buses made about 128 million trips. Ruter has assumed that in 2030 they will have bus around 250 million trips. Ensuring capacity to 2.000 buses in 2030 to accommodate bus passenger is crucial. Oslo and Akershus are facing the switch to higher capacity bus. To increase bus capacity, it can be solved by providing bigger vehicle (double decker or double articulated bus) or increasing the number of bus with present size. However, higher capacity bus requires bigger bus depot capacity than today.

As it illustrates in figure 4.6, a critical depot occurs in Alnabru, Klemetsrud, Ulven, Ski and Lillestrøm as the number of buses that park at the depot exceeded available depot capacity significantly. Bus depot in Grorud, Rosenholm, Lørenfallet, Nittedal, Bekkestua, Skui and Slemmested are categorized limited according to Ruter. Limited situation means that although

current capacity covers the current needs, there is not much room for extensions even in the existing contracts. Only bus depot in Drøbak, Nesodden, Vestby, Bjørkelangen, Eidsvoll, Enebakk, Maura, Årnes and Lommedalen are categorized sufficient because the capacity outweighs demand within the existing contract.

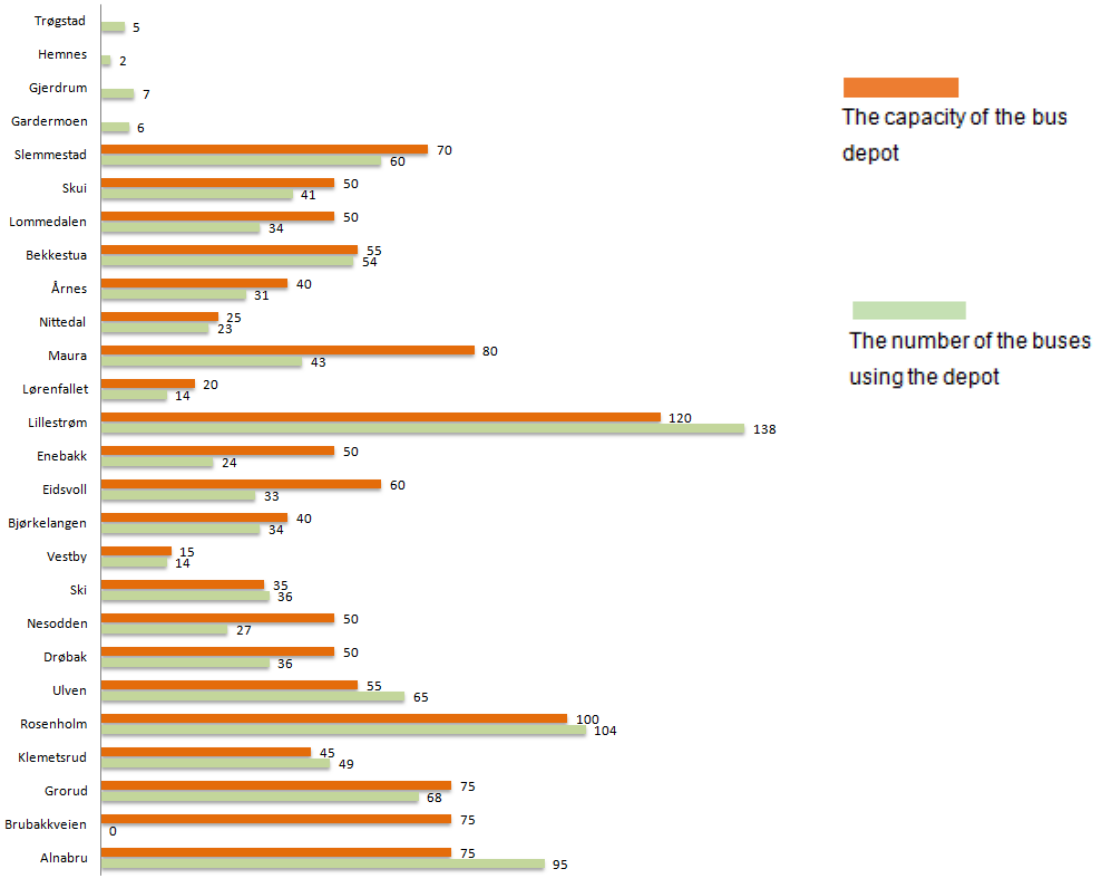


Figure 4.6 The location, the number of buses per depot and capacity utilization.
Source: Behøvsanalyse og utviklingsplan for bussanlegg, Ruter, 2016.

The contract with the property

The length of contact between Ruter and the bus depot property owner is varied. Some bus depots are driven by temporary operating permit and some are with long period. Bus depot that is located in a central area must compete with other real estate purposes like residence, offices and community facilities. Table 4.2 shows period and type of contract Ruter has with landowner of all bus depot in Oslo and Akershus.

Building and facility condition: from best suited to poorly suited

Ruter has implemented a registration of current condition of all bus depots in Oslo and Akershus. The quality of the elements in the building such as the logistic, lighting, washing hall, workshop for service and repair, and offices were measured. Figure 4.7 shows that some depots are at poor condition. According to Ruter, 50% of bus damage and crash occurs at bus depot. Therefore, the number of bus damage and crash at the depot must be minimized. Ruter has attempted many efforts to reach to the best suit situation.

Sentrum	**Grorud**	*"Jernkroken"*	0,82
	Alnabru		0,89
	Rosenholm		0,94
	Ulven	*"Persveien"*	1,42
	Klemetsrud		1,46
Follo	**Nesodden**	*"Fagerstrand"*	1,11
	Drøbak		1,17
	Vestby		1,17
	Ski		1,40
Romerike	**Eidsvoll**		0,66
	Enebakk		0,77
	Maura	*"Kopperudgarasjen"*	0,77
	Lillestrøm	*"Leiraveien"*	1,06
	Bjørkelangen		1,30
	Årnes		1,40
	Nittedal	*"Kjulgarasjen"*	1,71
	Lørenfallet		1,92
Vest	**Bekkestua**	*"Furubakken"*	0,54
	Lommedalen		0,94
	Slemmestad		1,20
	Skui		1,37

Figure 4.7 Facility score.
0 expresses best suited and 3 expresses poorly suited. The depots are divided into route areas, with formatting from green (best score) to red (worst score).
Source: Behøvsanalyse og utviklingsplan for bussanlegg, Ruter, 2016.

The zone	The location	Contract period between Ruter and the land owner or direct contract between bus operator and land owner	Owner
Sentrum	Grorud	Nobina	Rom Eiendom
	Alnabru	2018+10+10 years	Bussanlegg AS
	Rosenholm	2023+5+5 years	Bussanlegg AS
	Ulven	Norgesbuss	Persveien 23 AS (Ruter AS)
	Klemestrud	2025+10 years	Bussanlegg AS
	Brubakkveien (new)	2031+10 years	Brubakkveien 16AS
Follo	Nesoden	2020+6 years	Torneveien 10 AS, Aker Eiendom
	Drøbak	Norgesbuss	Frogn kommune/Venøy Industrumontering AS
	Vestby	Nobina	Schous buss
	Ski	Nobina	Transportformidlingen
Romerike	Eidsvoll	2023+6 years	Rom Eiendom AS
	Enebakk	2023+5+5 years	Bussanlegg AS
	Maura	2020+6 years	Kjulsveien 15 AS
	Lillestrøm	Unibuss	Autotrans Utleiebygg AS
	Bjørkelangen	2023+6 years	Rom Eiendom AS
	Årnes	2023+6 years	Rom Eiendom AS
	Nittedal	2020+6 years	Kjulsveien 15 AS
	Lørenfallet	Unibuss	Bjørkes bilruter AS
Vest	Bekkestua	2023+5+5 years	Bussanlegg AS
	Lommedalen	2026+6 years	Lommedalsveien 301 AS
	Slemmestad	2024+6 years	Kappa Eiendom
	Skui	2023+5+5 years	Bussanlegg AS

Table 4.2 Bus depot contract in Oslo and Akershus.
Source: Strategi for bussanlegg, og skisser til organisering av øvrig buss- og båtinfrastruktur, Ruter, 2012.

4.1.2 Strategy to provide an optimal situation

Through a political process, the prioritization in localization and design alternatives of a bus depot in Oslo and Akershus are finalized. An internal working group in Ruter has been working with requirement analysis to give guidelines to a development or an improvement of bus depot. Requirement analysis was performed to identify what will be the *must* and the *should* requirements when planning a bus depot. A *must* requirement means the criteria that must be fulfilled, while a *should* is the criteria that should be met and must not be fulfilled. The requirements are based on the experiences in terms of depot capacity, current tender package and economy of the operation. Furthermore, strategies are made to achieve the goal based on the requirements that has been set.

For Ruter, there are three important elements that must be considered when improving a bus depot: function, capacity and localization.

The objectives

The objectives of public transport for Ruter is that public transport, along with bicycle and walk, will take the growth in the region's passenger traffic. Ruter's strategy document M2016 aims that public transport must produce 160 million new public transport trips in 2030 so that zero growth traffic in private car use to be achieved. Infrastructure and facilities must be ready and functioned well to support the service of public transport.

Ruter defines a bus depot as a parking area for buses when they are not in operation and it accommodates buses with facilities such as outdoor facilities with electricity connection for buses, filling station for fuel, wash and service hall, workshop, office space for traffic management, and wardrobe for the employee.

Furthermore, Ruter describes an optimal bus depot is where it has the correct localization, sufficient capacity and the necessary facilities to serve the winning bus operator.

Following lists are bus depot requirements for Ruter:

- Bus depot must cover long-term capacity needs in a predictable manner, and ensure long-term control and / or ownership to the strategic areas.
- Bus depot must be environmentally friendly and appropriate in terms of design and location.
- Bus depot must be facilitated as a good workplace for employees of the bus operator.
- Bus depot must contribute to produce the most operation to public transport.
- Ensure an equal competitive condition for all bus operators wishing to submit tenders.
- Bus depot must be suitable for the introduction of new environmental technology.

Strategy to reach an optimal situation

According to Ruter, bus as public transport in Oslo and Akershus will take a minimum of the average of the necessary market growth to meet the target in 2030, and towards 2050/60. As the bus needs increased, the capacity of buses will grow. From this derived, bus depot must be sized up and preferably possessing into future growth opportunity.

Following documents and basis are used as guides for Ruter when working with planning and strategy to provide an optimal bus depot to Oslo and Akershus:

- National goals and guidelines
- Regional goals
- Plan Cooperation: Regional plan for land-use and transport in Oslo and Akershus
- Ruter strategic M2016
- Concept study Oslo hub
- New, rail infrastructure
- Fossil free 2020
- Development plan for bus depot 2017-2030
- Ruter bus depot strategy
- Principles for route network (Ruter report 2011:17)
- Regional traffic plans

Strategy for building and design

Ruter's strategy document M2016 states that in 2030 there must be around 160 million people using public transport so that the *0-growth in cars traffic* goals is achieved. Ruter needs flexibility solution to adapt changes in production and conditions as the result of market needs. Bus depot that is located in the densely populated areas was put on focus on possibility with future expansion.

Flexibility is also applied in designing bus depot as to adapt changes to bus size (longer and more bus) and the type of vehicle. The type of the vehicle determines the capacity, dimension and layout of a bus depot. Moreover, it is the goal for Ruter to have bus depot with environmentally friendly operation. A depot with fossil free will be implemented in Oslo and Akershus from 2020. All activities at the depot must not give impact to the environment. In the future, electricity buses will be preferred in Oslo and Akershus. Therefore, it is expected that a bus depot must accommodate facility and particular method for the new type of vehicle maintenance and charging facilitates.

Strategy for localization

For Ruter, localization of a bus depot deals with many considerations. Bus depot that causes many empty runs to and from the start and end point of the routes is not desirable. As empty runs causes journey-to-depot costs, the increasing of empty runs must be weight against the economic advantage for an example to a large bus depot. However, Ruter has the strategy that the localization should not focus only to a purely economic motivation, but also a good positioning in relation to market to serve is a great importance. Besides reducing empty runs

motivation, localization should also involve attention to neighborhoods, access to the road network, and land value.

Ruter has engaged a localization analysis by examining present bus depot location against an optimal bus depot as the desired qualities. The results give clear information for Ruter which bus depots in Oslo and Akershus have more driving distance and which ones are not. Localization analysis is implemented so that Ruter can identify the condition of location today and the possibility of relocating to reach the optimal situation. Table 4.3 shows information about suggested optimal area and their km saving using current type of contract.

The route	Current bus depot	Optimal location	Savings by relocation (km/ bus)
Follo	Vestby	Vestby	0
	Ski	Nordby	1
	Drøbak	Måna	2
	Fagerstrand	Hellvik	16
Romerike	Bjørkelangen	Bjørkelangen	0
	Årnes	Årnes	0
	Eidsvoll	Eidsvoll	0
	Enebakk	Enebakk	0
	Nittedal	Slattum	1
	Leiraveien	Lillestrøm	5
	Lørenfallet	Sørumsand	6
	Maura	Eltonåsen	24
Vest	Bekkestua	Vækero	2
	Skui	Dønski	5
	Lommedalen	Toppenhaug	7
	Slemmestad	Holmen	8
Sentrum	Ulven	Ulven	0
	Rosenholm	Klemestrud	0
	Alnabru	Grefsen	6
	Klemestud	Vækerø	9
	Gronud	Vækerø	16

Table 4.3 The summary of localization analysis.
Source: Behøvsanalyse og utviklingsplan for bussanlegg, Ruter, 2016.

4.1.3 Example of strategy implementation from selected bus depot

Bus depot Brubakkveien

Figure 4.8 Property at Brubakkveien 16.
Source: http://linstow.no/eiendommer/eiendom/projectaction/show/project/brubakkveien-16/

Long-term lease Ruter signed in spring 2016 a long-term lease contract to a property at Brubakkveien 16. The agreement was made between Brubakkveien 16 AS that is owned by Linstow AS and Bussanlegg AS. Bussanlegg AS then sublets to Ruter on a contract basis until 2031 plus 10 years option. Bussanlegg AS is owned by Oslo Municipality.

Strategic localization Brubakkveien is an industrial estate with area about 24.000m^2 at Grorud Oslo. The property is rented by Ruter to secure area for bus depot for the district lines in Groruddalen and for the route lines to the city border. The property has only a short distance to Grorud station that is designated as an area for future urban and hub development in long-term municipal plans. The property is centrally located at the upper side of Groruddalen with a well connected to the road network and near to Østre Aker vei.

Necessary facility The area was built with necessary bus depot facilities such as wash and parking areas for buses, and offices. There is a considerable capacity for two parallel wash line and four workshops for buses in all length. The outdoor area features with spacious capacity to 75 normal buses.

Good neighbor condition The neighborhood is considered favorable, as industry and railroad are the nearest neighbors.

4.2 Hordaland

Figure 4.9 Haukås bus depot.
Source: Hordaland County.

Hordaland is selected as the case mainly because the county has far stepped forward and experienced in providing an optimal solution to its transport system. Bus is one of Hordaland's public transport mode that plays an important role for the county and it has a welfare aspect. The county has gained many efforts for a new travel distribution to reach zero growth in private cars.

4.2.1 Present situation and facts

Hordaland County has a total area about 15.436,68 km^2 and a population as per January 1st 2016 about 516.497 (Source: https://ssb.no) The County of Hordaland consists of 33 political municipalities (Wikipedia.org).

Figure 4.10 Hordaland County.

Bus depot organization

Hordaland County is responsible for public transport in the county. As the assignment from The Department of Transport of Hordaland County, The Department of Real Estate is responsible for the development and establishment of bus depot.

Hordaland County established Skyss in November 2007. Skyss takes care the development and operation of public transport in Hordaland. In addition, Skyss manages public transport as well as responsible for implementing works strategies to achieve goals for public transport in Hordaland. Hordaland County through Skyss is responsible for strategy development, scheduling, contract awarding, monitoring, sales, ticketing, marketing and information of the public transport. Skyss awards contracts for operating of bus, light rail, boat and ferries in Hordaland through tender competition. Bus operator is responsible for the implementation of bus traffic.

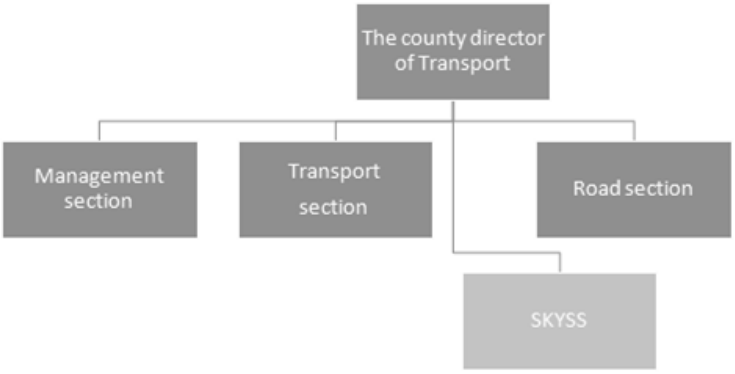


Figure 4.11 The organization chart in Transport Department at Hordaland County.
Source http://www.hordaland.no

The Department of Real Estate of Hordaland County established HFK Bussanleg AS as the strategic corporation partner of Skyss. The purpose of the establishment of the company is to ensure bus depot capacity in the long term and ensure equal conditions for bus operators in the contract competitions.

The history of current bus depot location and dimension

As in Oslo, old depot location in Hordaland is due to historical condition that bus depot always been there and were owned earlier by transport operator company. New empty lands outside the densely area are acquired and built by the county for establishing new bus depot.

Bus depot in Hordaland

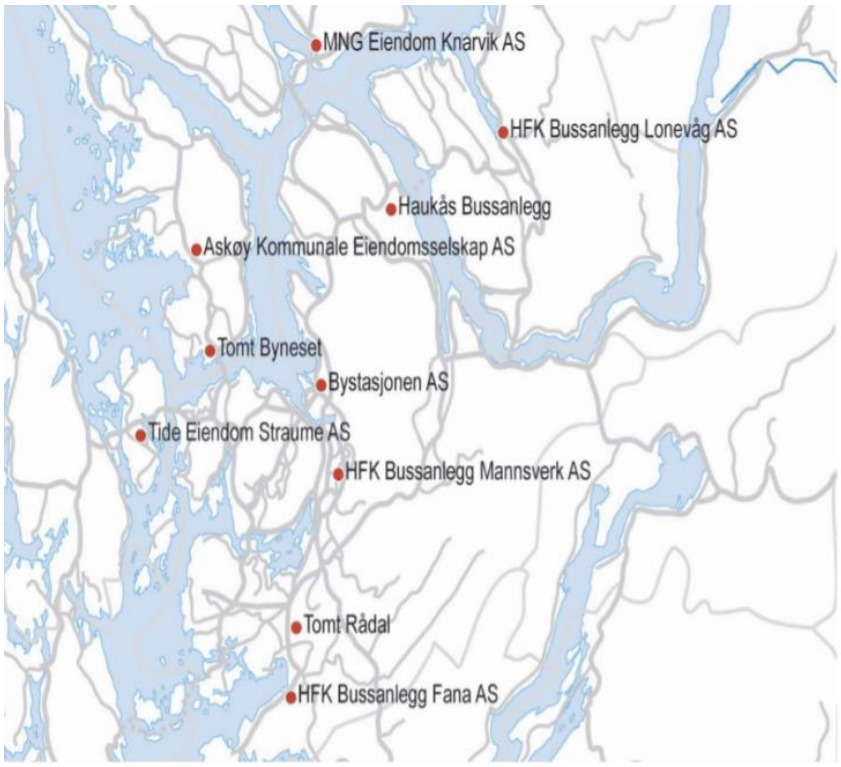


Figure 4.12 Bus depot in Hordaland.
Source: Department of Real Estate, Hordaland County.

Figure 4.12 shows the location of depots spread in the region of Hordaland to accommodate sufficiently all bus networks in the county. Bus depot in Hordaland plays an important role in public transport sector. Among all transport modes in Hordaland (bus, rail and boat), bus has the largest number of user.

Figure 4.13 HFK Bussanlegg Fana AS.

Bought in 2009 with the sum 62 million NOK. Brutto area 7.061 m^2, site 36.062 m^2, the year of construction 1930/80 , 120 parking spaces for bus.

Figure 4.14 HFK Bussanlegg Lonevåg AS.

Bought in 2009 with the sum about 15 million NOK, brutto area 1.876 m^2, site 11.636 m^2, year of construction 1975/78 and 35 parking space for bus.

Figure 4.15 Haukås bus depot.

Finished in July 2012. It has the gross building area is about 3.000 m^2 and has spacious capacity to 150 normal buses, or to 105 articulated bus and 58 normal buses.

Figure 4.16 HFK Bussanlegg Mannsverk AS.

Bought in 2009 with the sum about 105 million NOK. Brutto area 6.029 m^2, the site 23.513 m^2, year of construction 1959/69/81, 105 parking spaces for bus where 50 is for gas bus.

Figure 4.17 MNG Eiendom Knarvik AS.

Leased from 2009 7+2 years, renting price about. 3,7 millon NOK. pr. year, brutto area 3.620 m^2 site 3.566 m^2, year of construction 1964/84/92/94, 50 parking space for bus.

Figure 4.18 Askøy Kommune.

Bought in 2009 with the sum of 25 million NOK. Sold in 2010 for the same price. Renting price from 2012 7+2 year, brutto area 3.268 m^2, site 35.379 m^2, year of construction 1938/46/64/70, 50 parking space for bus.

Figure 4.19 HFK Eiendom Straume AS.

Bought in 2010 with the sum about 65 milion NOK, brutto area 3.365 m^2, site 37.435 m^2, year of construction 1986 and 146 parking spaces for bus.

Source: Department of Real Estate, Hordaland County.

Bus depot stakeholders

Public administration	The State of Norway Hordaland County All municipalities in Hordaland
The employees	The union and the employee of the bus operator and bus depot
Neighbors	The neighbors of bus depot
Bus customer	The passengers who travel with bus in Hordaland
The operator/drifter/ tenant/owner	Public transport operator (Skyss) HFK Bussanlegg AS and bus operator The owner of bus depot The drifters of bus depot Buss supplier

Table 4.4 Bus depot stakeholders in Hordaland County.

High pressure area

In order to be able to implement a contract for bus route production, the bus operator will depend on a sufficient bus depot with good capacity to park, operate and maintain the buses. Some bus depots are no longer disposable and there is no land close by is available either to be leased or purchased. To achieve an equitable route production competition, Hordaland County needs new depots that are placed strategically to be rented to the bus operators.

The response from the neighborhood

Some bus depots are located strategically regarding bus route they are serving, but unfortunately, the location is on an attractive area for residence development. These depots can have the risk be relocated to outside of the densely area.

The depot capacity

According to Skyss, the population in Hordaland will be increased by more than 20% in 2030 and in 2014; the population of The County was passing about 600.000 people. There is enough bus depot capacity in Hordaland to accommodate buses today. Nevertheless, this number of bus depot will not be sufficient to the future transport demand. The arising of population in Bergen area will lead to increasing of public transport.

The contract with the property

For the contract with the bus operator outside the densely areas, it is the bus operator's responsibility to set up depot for their buses. For contracts that serve the urban area around Bergen, the county has the responsibility to provide bus depot to the winning bus operator.

Current bus depots are organized as share company under HFK Bussanlegg AS. The leases have been established between the relevant subsidiary company under HFK Bussanlegg AS and the bus operator with the contract duration corresponds to the tender period.

4.2.2 Strategy to provide an optimal situation

The objectives

The objective of public transport for Hordaland is 0-growth in private car traffic by implementing environmentally friendly modes of transport with good mobility to contribute better climate and environment. Developing sufficient infrastructure and facility to support public transport has been a high focus in the county.

The requirements of a bus depot from the perspective of the county:

- Environmental friendly bus depot with a sufficient condition.
- Sufficient capacity and facility that is able to take care of the buses properly.
- The county has the ownership.

Strategy to reach an optimal situation

For establishing bus depot in Bergen area, a project group was set up with participants from the finance department, property department and transport department of Hordaland County and Skyss. The project group's mandate is to implement the county's bus route production and the access to bus depot as well as the power of attorney to negotiate purchase or rent of bus depot. It has also responsibility for land acquisition and bus depot establishment on the land that is purchased.

It requires politics engagement to support the supply of infrastructure and facility for buses. Hordaland County has run many politic meetings with County Council, County Executive Board and County Principal Standing Committees in order to raise support and approval on implementation and strategies for infrastructure for buses.

Strategy for building and design

Below are the strategies for building and design bus depot in Hordaland:

- A depot with environmental friendly solutions.

  Hordaland puts highly focus on biogas with CO2 neutral fuel especially for Bergen area. With a good cooperation with Bergen municipality, it was established a biogas bus depot to facility gas buses. Not only CO2 neutral buses that will be driven in Hordaland, but the bus depot must be environmental friendly.

- Focus on creative design that will not bring neighbor conflict.
  Bus depot that is located close to the city center should have a good façade rather than a usual industrial building design in order minimize neighbor conflicts.
- A depot with possibility for future expansion.
- Some old bus depots are upgraded with better logistic system and facilities in order to achieve the required standards.

Strategy for localization

There are little potential to build bus depot near a hub or city center in Hordaland. Due to the concerns to land availability and the nearby neighborhood conflicts, the new land that will be used for bus depot must be located outside the city center. Approved by The County Council, Hordaland purchased several lands and some private bus depots in various municipalities to ensure capacity, ownership and a good infrastructure for buses to run in Hordaland.

Below are the strategies for localization bus depot in Hordaland:

- Reserving capacity for the future.
- Avoid potential local conflicts.
- Relocating bus depot to area where there is no neighbor conflicts.
- New land acquisition outside the densely area.

In order to have the permit to build a bus depot in Hordaland, Environmental Impact Assessment (EIS) was conducted to the new location of a bus depot that is proposed. Support for strategic land acquisition is illuminated in the needs analysis and investigation stage in the County Council's investment process.

4.2.3 Example of strategy implementation from selected bus depot

Acquiring land for a new bus depot at Leirvik

With the intention of providing a good infrastructure and facility for the bus route production for Sunnhordland, The County Council of Hordaland approved in 2014 to purchase a land for bus depot at Leirvik in Stord Municipality. Ther land has a gross area about 2.193 m^2 that can accommodate 34 buses and in Svortland in Bomlø with gross area about 445m^2 to accommodate 19 buses.

Acquiring land for a new bus depot at Rådal

Figure 4.20 Rådal.
Source: Department of Real Estate, Hordaland County.

The site is regulated for the infrastructure of public transport. It has land area about 17.000 m^2. Halv site was bought in 2009, sum 6 million NOK, area 14 000 m^2. The other halv was bought in 2011. Sum 5 million NOK, area 12.000m^2

Acquiring land for a new bus depot at Byneset

Figure 4.21 Byneset.

The site was bought in 2008 with the sum about 16 milion NOK, land area 37.000 m^2 where 27.000m^2 is for bus depot in the municipality plans.

Bus depot Haukås in Åsane

Figure 4.22 Bus depot Haukås.
Source: Department of Real Estate, Hordaland County.

The depot

Owner : Hordaland County

Architect: Forum arkitekter AS

General contractor: Sognnes Bygg

Technical contractor: YIT

Localization and neighborhood

As there are little potential to build bus depot near a hub or city center in Hordaland, and due to the concerns to land availability and the nearby neighborhood conflicts, the county acquired a new land and build a depot on the area at Haukås in Åsane. The location is outside the city center, at the industrial and business estate on the mountain grounds. New and permanent access roads were established to serve this depot (EV39).

Design concept

Bus depot Haukås is designed so it will serve buses in the most efficient way. The building is designed with easy expansion concept and the facade is design with maintenance-free concept. The gross of the building area is about 3.000 m^2. The property consists of a huge paved area so it will be a lot water to be led away.

Necessary facility

The building is physically divided into 3 parts: wash and service (1.300 m^2), workshop (2.000 m^2), offices and drivers' facility (650 m^2). The outdoor area features with spacious capacity to 150 normal buses or 105 articulated bus and 58 normal buses. It is also provided with 98 parking spaces for cars. In the basement, there are two diesel tankers of 75.000 liter each and oil tank of 50.000 and several smaller tankers for fuel oil and waste oil. For environmental reasons, the basement is molded waterproof.

Bus depot at Knarvik

Figure 4.23 Bus depot at Knarvik.
http://www.strilen.no/nyheter/Kjoper-Nobina-bygget-8083b.html

Localization

The bus depot is located with access to E39, on the outskirt of Knarvik. Knarvik is an administration center in Lindås Municipality.

From leasing to acquisition and the ownership concept

In 2008 Hordaland County had undersigned a lease contract to bus depot Knarvik with Tide Eiendom AS. Tide Eiendom Knarvik AS sold the company shares to MNG Holding Bergen AS (MNG Eiendom Knarvik AS). Hordaland County then rented the property from MNG Eiendom Knarvik AS. The contract is valid for 7 years from 2009 with the right to extend by 1+1 year. Hordaland Fylkeskommune then rented the bus depot to the bus operator Nobina Norge AS in bus route package for Nordhordland.

This is the capacity acquirement strategy for Skyss that will soon launch operator contract competition for Nordhordland route service from 2018. There will be a need for a bus depot in Nordhordland from 2018. In order to able to complete route production contract for the region, the operator will depend on sufficient space, capacity and facility to serve the buses. By providing the county an optimal bus depot for the operator, it will ensure the equal competition between the bidders. The County Council of Hordaland approved the purchase of existing bus depot at Knarvik. The purchase of the depot has more economically advantageous than signing a new lease contract from 2018. The acquisition is to buy 100% of the shares in MNG Eiendom Knarvik AS. The company then became a subsidiary company of HFK Bussanlegg AS and subsequently changed the name into HFK Bussanlegg Knarvik AS.

4.3 Stockholm

Figure 4.24 Fredriksdal bus depot.
Source:
http://www.skanska.se/vart-erbjudande/vara-projekt/57873/Fredriksdals-bussdepa%2c-Stockholm

Stockholm is selected as the case as the county is considered to have a well-established and extensive public transport system. Bus as public transport has an important role for the county. The county has experienced the great growth passengers in recent years.

4.3.1 Present situation and facts

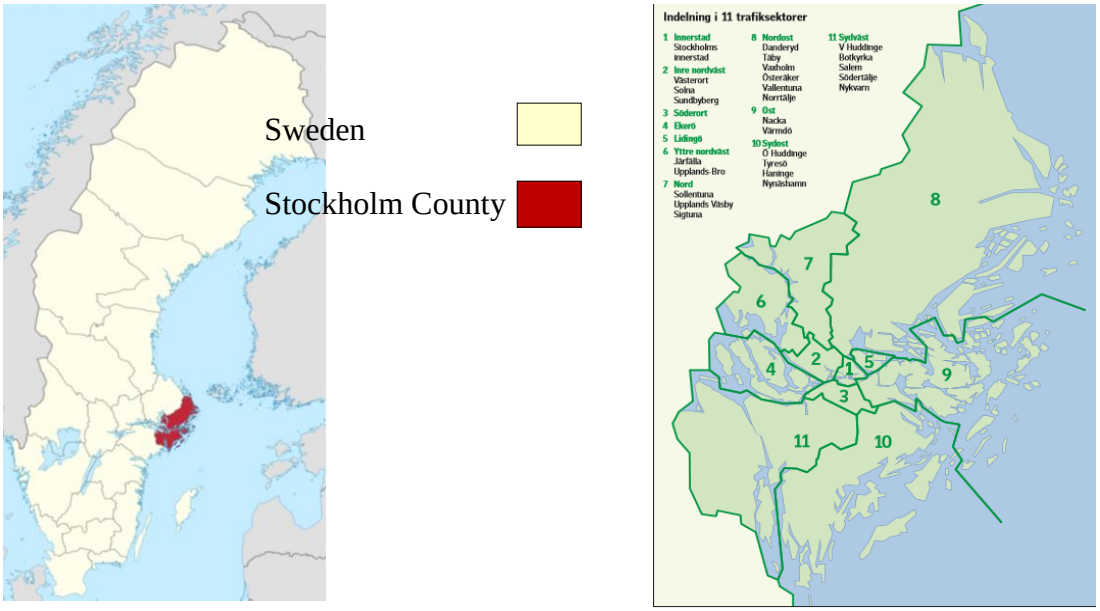


Figure 4.25 Map Stockholm County.
Source: Wikipedia.org, read 2017 and Stockholm Traffic plan 2020.

The capital city Stockholm lies in Stockholm County. Stockholm is a county in Sweden with a total area about 6.519 km^2 and a population per September 30th 2014 about 2.192.433 (Wikipedia.org, read 2017). The county of Stockholm consists of 26 political municipalities (Wikipedia.org, read 2017). Figure 4.25 shows how the traffic sector is divided by 11 sectors in Stockholm.

Bus depot organization

Figure 4.26 The public transport organization chart.
Source: Stockholm Läns Landsting (SLL).

Stockholm Läns Landsting (SLL) or Stockholm County Council is responsible for all public transport in Stockholm County. AB Storstockholm Lokaltrafik (SL), Waxholmsbolaget and Färdtjänsten are the companies that have the responsibility for operating the transport service in Stockholm.

Bus depot in Stockholm

Bus depot in Stockholm are located in Lidingö, Hornsberg, Jordbro, Täby, Åkersberga, Norrtälje, Kallhäll, Råsta, Tyresö Nacka/Värmdö, Björknäs, Mölnvik, Grisslinge, Älvsby, Björknäs, Mölnvik, Huddinge-Botkyrka. New bus depots are built at Fredriksdalsteatern in Hammarbyhamnen, Åkersberga, Enlunda in Ekerö, Handen and Charlottendal in Värmdö.

Bus depot stakeholders

Public administration	The State of Sweden Stockholm County All municipalities in Stockholm County
The employees	The union and the employee of the bus operator and bus depot
Neighbors	The neighbors of bus depot
Bus customer	The passengers who travel with bus in Stockholm
The operator/drifter/ tenant/owner	Public transport operator (SL) Bus operator The owner of bus depot The drifter of bus depot Buss supplier

Table 4.5 Bus depot stakeholders in Stockholm.

The response from the neighborhood

Bus depot brings concerns to nearby neighbor. Noises that come from the ventilation of the bus as well as increased traffic to/from the depot are the examples of the disturbance that a bus depot generates in Stockholm.

The depot capacity

The need to secure long-term bus depot solution in Stockholm has become priority for SLL. It is prognosed that by 2020 the travel by public transport in Stockholm is increased gradually about one percent a year (Trafikplan Stockholm, 2020). As a matter of fact, some existing bus depots in Stockholm are now already at full capacity and these depots cannot be expanded. Old depots have enough capacity to provide present demand, but not for the future. It is a problematic to find new depot location to accommodate the extension inner city routes as Stockholm has a quite limited area to build new bus depot.

Building and facility condition

It sometimes occurs that a traffic cancellation or delay happens because the buses do not have properly condition. The vehicles that do not meet the standard to operate on the street need more time at the depot to be worked on it. When a depot has ineffective operation, e.g. it cannot accommodate on bus maintenance, the situation is not optimal.

The contract with the property

The winners of the bus operator must rent and use the main depot to SL. It is optional for the winner bus operator to rent smaller bus depot.

The type of bus operates in Stockholm

Type of propulsion system buses are using in Stockholm are: biogas, nature gas, ethanol, biodiesel (RME, HVO), diesel, electric.

Body type: articulated bus (19 m), bogie (13,5 -15 m), standard (12 m), double-decker (15 m, height 4,25 m). Soon: double articulated (25 m).

4.3.2 Strategy to provide an optimal situation

The objectives

Stockholm has following objective in public transport: "*The contribution of public transport in Stockholm will make Stockholm as Europe's most attractive metropolitan region*". A bus depot as one of the facility that support public transport must have a long-term good management, energy efficient facilities and good work environments because an optimal bus depot will conduct to efficient operation.

These are the requirements for a bus depot in Stockholm County:

- A pleasant workplace with facilities that provide staff with a good working environment.
- To facilitate and stimulate bus operator competition.
- It has a good logistic.
- A depot with facilities that support daily operation.
- Flexibility with possibility for expansion.
- Optimal for traffic operation.
- Bus depot without disruption.
- To create long-term view of the city's physical environment.
- Economical consciousness.

Strategy to reach an optimal situation

SLL established "*RiBussdepå*" that contains requirements to condition and location of a bus depot that must be followed. RiBussdepå is also a guidance to control how a bus depot should be designed and located. The Department of Traffic Management is a public actor that strives for beautiful and aesthetically pleasing transport buildings. In a feasibility study, it includes a design program and suggested new location as parallel assignments for the architects.

SLL must have a full control (ownership) to the depot. The application for registration of ownership must be sought within three months after the purchase took place.

Through a political process, the prioritization in location and design alternatives of a bus depot is finalized. In order to facilitate the planning of a bus depot in Stockholm, SLL established a strategic document "*Guidelines for bus depot"*. The document should increase

the understanding of how a bus depot achieves the best planning (location and good architectural design) in the transport system. Moreover, the document illustrates guidance and principal in planning a bus depot to ensure the most cost-effective way. Idea and creation to the depot planning and solution should be accorded with cost-consciousness.

These are the guidelines for Stockholm when planning a bus depot:

Strategy for building and design

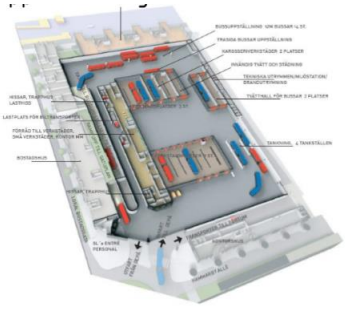
- The design must have economical consciousness.
- Producing the right guidelines for bus depot development.
- Creating a pleasant workplace for the employee.
- Facilities for employee and buses.
- Smooth logistic.
- Grouping the operator contract with based on geographical localization.
- Take benefit from all public commutations such as roads, bicycle paths and public transport.
- Flexible and possibility for future expansion.
- Not all bus depot should have full facility, only the large ones.
- To apply depot size at maximum (building in several level).

Strategy for localization

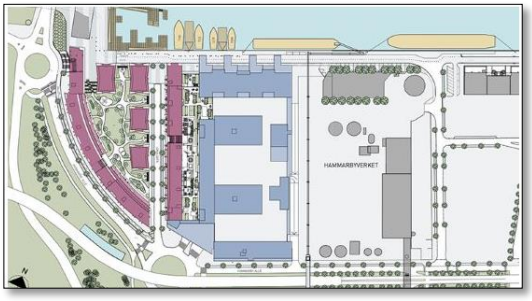
- Land acquisition as early as possible.
- Get the ownership
- Locating at the center of the municipality.
- Locate depot more at the city that accommodate city buses.

4.3.3 Example of strategy implementation from selected bus depot

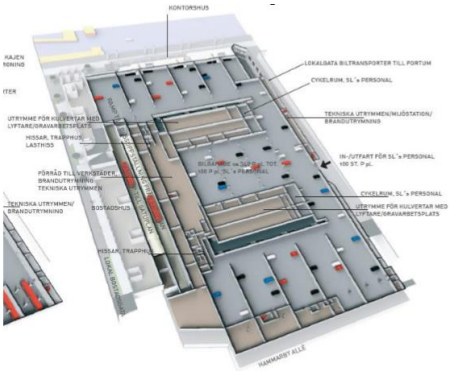
Building Fredriksdal in Stockholm City Centre



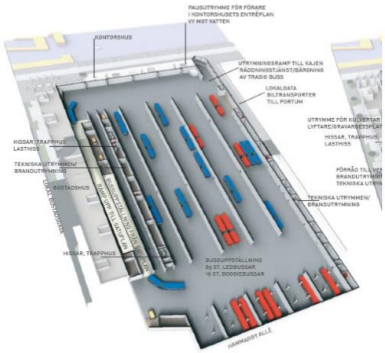
Plan 3



Ground plan



Plan 2



Plan 1

Figure 4.27 Bus depot Fredriksdal divided by 3-floor levels.
Source: http://www.skanska.se/vart-erbjudande/vara-projekt/57873/Fredriksdals-bussdepa%2c-Stockholm.

The depot Owner : Storstockholms Lokaltrafik (SL) General contractor: Skanska

Localization and neighborhood Bus depot Fredriksdal is built to replace Bus depot Søderhallen. The depot is located at Stockholm City at the Fredriksdal district, which is located in the western part of Hammarby Sjöstad. The neighbor is large warehouse, industrial buildings and offices.

Design concept and necessary facility The property has a land-use mix concept. The buildings where the bus depot is located consists of 7 floors. The bus depot comprises approximately 50.000m^2 in 3 floors which consists of a large multi-level building complex with a hall for about 140 inner city biogas-driven buses (25 buses@14m and 95 buses @18m), car parking, refueling, washing and workshop. The level for bus parking is located on the ground plan seen from Hammarby Kaj with a total area about 17.200m^2 and free height of 4,5meter. The depot is also provided with offices for administration and staff rooms. The topography of the area gives a slight incline at north at the edge of Stockholmsåsen. Therefore, two floors are located underground plan.

Bus depot Tomteboda in Solna

Figure 4.28 Tomteboda bus depot.
Illustration: Karavan landskapsarkitekter + BBH arkitekter & Ingenjörer
Source: http://www.iterio.se/projekt/tomteboda/

Figure 4.29 Inside bus depot Tomteboda.
http://www.bbh.se/projekt/tomteboda-verkstad/

The depot

Owner : Storstockholms Lokaltrafik (SL)
Architect: BBH Arkitekter & Ingenjörer AB
Environmental planning support: Iterio

Localization and neighborhood

SL has an interest in moving the current bus depot in Hornsberg to the property that once used by Post Sweden in Tomteboda in Solna Municipality. Terminal Real Estate Sweden AS owns the property where Tomteboda depot is located.

The location is believed to be a suitable place for bus depot. The property is located strategically as it near to E4 and pampas link at the south and Huvudstavängen in the west, and good access to the east. A new depot in Tomteboda with larger capacity than Hornsberg is important to be provided to ensure bus depot capacity to serve about 240 SL's inner city buses. Moreover, the large area at Tomteboda is also able to handle double-headed inner city busses. Refueling of biogas is also possible to implement at Tomteboda.

Design concept and facility

Bus depot Tomteboda will contain workshop, laundry, refueling, office and green area. The workshop part will be furnished at the ground floor of the existing giant ex-post office building. The façade is preserved and maintain as the original.

4.4 Trondheim

Figure 4.30 Sandmoen bus depot.
Source: http://www.arkitektur.no/sandmoen-bussdepot.

Greater Trondheim is selected as one of the case as bus as public transport mode has an important role in Trondheim. The interesting about Trondheim case is that the region will soon provide BRT. The name of MetroBuss for Trondheim's BRT concept has had a politically approved at June 9th 2017, which was called superbuss previously. In order to ensure the available depot capacity from 2019, it was considered whether the current bus depot at Sandmoen should be expanded and/or rebuilt to accommodate new and longer buses.

4.4.1 Present situation and facts

Figure 4.31 Map of Trondheim.
Source: https://www.oslosportslager.no/

Sør-Trøndelag county consists of 25 municipalities. Trondheim is a municipality under the administration of Sør-Trøndelag County. The municipality has a total area about 341,19 km^2 and a population as per 1st January 2016 about 187.353 (source: https://ssb.no/sok?sok=folkemengde+trondheim). Trondheim is the administration centre and the largest city in the county. Greater Trondheim area (Norwegian: Stor-Trondheim) includes the municipality of Trondheim, Klæbu, Melhus and Malvik.

Bus depot organization

Sør-Trøndelag County through The Department of Transport is responsible for the infrastructure for public transport in its region. AtB was established in 2009, is the administrative company for public transport in Sør-Trøndelag County. The company is responsible for planning, promoting and managing tenders for public transport. The company is owned 100% by The County of Sør-Trøndelag.

Among all transport modes in Greater Trondheim, buses have the largest number of user. The bus route lines are operated by several operators that have contract with AtB. The contracts are awarded through competitive biddings by law on public procurement. The Department of Real Estate is appointed by The Department of Transport in Sør-Trøndelag County for localization task and planning of a bus depot.

The Municipality of Trondheim has a role as the planning authority for a bus depot that is located in Trondheim. Sør-Trøndelag County is the proposer and is responsible for contacting the municipality regarding the regulation of areas.

Bus depot in Trondheim

Figure 4.32 Sorgenfri bus depot and Sandmoen bus depot.

Bus depot plays an important role in public transport sector in Greater Trondheim. Today, two major bus depots serve public busses. Figure 4.32 shows two locations of the depot spread in Trondheim municipality, as one near city center (Sorgenfri bus depot) and one at the south of the city (Sandmoen bus depot). Today, there are currently more available bus parking spaces

than needed; however, the operating situation is disadvantage with too many busses at Sorgenfri bus depot than Sandmoen bus depot.

Figure 4.33 Sorgenfri bus depot.

Source: STFK.no

Figure 4.34 Sandmoen bus depot.

Source: STFK.no

Sorgenfri bus depot, shown in figure 4.33, has capacity about 164 buses divided into two areas on a total 43.000 m^2. Bus depot Sorgenfri is equipped with offices, car wash and hall for service and maintenance. The depot is modernized with new fuel tanks bio and diesel and has upgraded with 46 filling spaces for gas. For the facilities for the employee, there are about 152 parking spaces, canteen and changing facilities

Figure 4.34 illustrates bus depot Sandmoen. The depot is located at the south of Trondheim with a capacity about 152 buses on a total area about 35.000 m^2. Bus depot Sandmoen was built with passive house standard (NS3700/3701) and low energy building (NS3701). It is equipped with workshop, car wash and a round sink hall and dry hall service maintenance. It has about 87 places for gas filling and electricity and compressed air at all bus parking places. For the employee, there are about 118 parking spaces, canteen and shower facilities.

At Melhus and Stjørdal current bus operator rents bus depot with parking spaces for approximately 20 buses each, facilitated with carwash, a dry hall, an 100m^2 office with canteen room and shower.

Bus depot stakeholders

Public administration	The State of Norway Sør-Trøndelag County Trondheim Municipality, Stjørdal Municipality and Melhus Municipality
The employees	The union and the employee of the bus operator and bus depot
Neighbors	The neighbors of bus depot
Bus customer	The passengers who travel with bus
The operator/drifter/ tenant/owner	Atb Bus operator The owner of bus depot The drifter of bus depot Buss supplier

Table 4.6 Bus depot stakeholders in Trondheim.

High pressure area and the response from the neighborhood

Bus depot Sorgenfri was established in 1961. Sorgenfri area in the early of 1960 was considered the outskirt of Trondheim city. It was back then an acceptable idea to place a bus depot at Sorgenfri as it was not in a central area. However, today Sorgenfri area is developed, with many offices and residents in the area. Sorgenfri has greater economic potential for commercial business district and residences now than a decade of years ago when The Sør-Trøndelag County started to rent the property from Trondheim Municipality. Bus depot Sorgenfri is to be regarded as a temporary and it will be form for commercial uses from 2020.

Bus depot Sandmoen is located at an established industry area. The area will be in the future developed for industrial purposes. There is no negative response coming from the area surround.

The depot capacity

These are the type of fuel for buses that operate in Trondheim today:

- Gas: buss class 1, length: 12m, 15m and 18,75m (articulated).
- Bio diesel (inclusive hybrid): buss class 1, length: 12m.
- Bio diesel: bus class 1, length: 15 m.

Today, it runs about 319 buses in Great-Trondheim. The sum of passengers 2016 was about 26.894.291. With a new route system from 2019, Trondheim has the ambition that more people in the future will take public transport. New routes with more bus frequency require more bus capacity and bus depot capacity.

The depot capacity is sufficient for today's requirement. Nevertheless, for the bus operation from 2019, when bus depot Sorgenfri and other depots are no longer available, Trondheim

will have no place to park their buses if bus depot Sorgenfri is not allocated to other area. Sør-Trøndelag County is at the process for finding the possibility to build one or more bus depots as replacement of bus depot Sorgenfri.

It is the responsibility for bus operator to use the given bus depot in Trondheim, and/or obtain or establish bus depot outside bus depot in Trondheim. The operator must choose bus depot that has suitable premises for buses, meet the requirements for cleaning and technical task with a good establishment/rent price.

Furthermore, the growth of population affects the increase use of public transport. Table 4.7 provides forecast of future population growth in Trondheim. In order to accommodate the increased number of passengers, the bus capacity must be increased. AtB has assumed a growth of the number of buses about 6% every 5 years. It means that Trondheim needs bus depot to facilitate around 299 buses in year 2029.

	Year 2016	**Year 2050**	**The growth**	**% growth**	**% growth compare to Trondheim**
City Centre	49 887	5 8561	8 674	14,8%	12,4%
East side	51 412	84 053	32 641	38,8%	46,7%
Lerkendal	51 438	68 953	17 515	25,4%	25,0%
Heimdal	33 999	45 108	11 109	24,6%	15,9%
∑**Trondheim**	**187 353**	**257 320**	**69 967**	**27,2%**	

Table 4.7 The future population growth in Trondheim.
Source: https://ssb.no/sok?sok=folkemengde+trondheim.

The contract with the property

To ensure fair competition between bus operators, the county must offer sufficient bus depot to accommodate buses. Sør-Trøndelag County owns bus depot in Sandmoen. Bus depot Sorgenfri is owned by Trondheim Municipality. The leasing contract will be ended at 31st December 2019. When the contract is over the area will be used for other operations than a bus depot.

In Greater Trondheim, Sør-Trøndelag County has responsibility to set the land area and facilities for a bus depot. For the area outside Greater Trondheim where the scope of operation is significantly less, it is the responsible for the operator to acquire bus depot. The depot in Sorgenfri and Sandmoen were rented to AtB where then AtB provides further rental of facilities to operators who win the tenders. The bus operator through Atb must sign a rent contract in the period for bus tender. It is the responsibility of the winning contract operator to drift the depot.

4.4.2 Strategy to provide an optimal situation

In February 2016, Trondheim Municipality, South-Trøndelag County, The Norwegian Public Roads Administration and The Norwegian National Rail Administration signed an agreement on urban environmental (bymiljøavtale). The agreement has the ambitious goal the reduction in emissions from transportation in Trondheim by reducing the number of private car use and increasing the use of public transport.

Urban environment agreement covers the entire portfolio of *Greener Trondheim* or *Miljøpakken* in Norwegian (http://miljopakken.no, read 2017). From 2010 to 2025 Miljøpakken will invest around 15 billion kroner in roads, facilities and traffic safety for pedestrians, cyclists, and public transport. The aim of the program is to reduce greenhouse gas emissions, congestion, traffic noise, and the number of traffic accidents through better traffic management and a greater share of transport on foot, by bicycle, bus or tram.

One of the implementation of Greener Trondheim is all buses in Greater Trondheim shall be fossil free from 2019. To realize this goal, it requires 63% of city buses runs on biogas. Urban environment agreement contains the funding about 1,4 billion kroner to BRT concept buss (Bus Rapid Transit). The State will cover half of infrastructure investments in line with the framework for the urban environment agreement.

The objectives

A new bus depot must be established for both regular bus and MetroBuss by summer in 2019. It is a prerequisite for introducing MetroBuss that there is access to a depot that is adapted to buses of length up to 25 meters.

Strategy to reach an optimal situation

For the capacity availability for both regular bus and MetroBuss, it is considered if the bus depot at Sandmoen should be expanded and/or rebuilt to accommodate new and longer buses. Other alternative is to build several depots or establish one more new depot at the east side of Trondheim to replace Sorgenfri bus depot. Sandmoen will be a depot with all necessary facilities.

Strategy for building and design

To provide sufficient space for all type of buses is a great challenge. The new depot in Trondheim should have the possibility to accommodate the growth number of buses with different sizes and employees. According to Ruter, bus depot capacity in Trondheim in 2019 must be equal to the need in 2023.

The depot should be flexible to adapt the changes. MetroBuss has larger size than conventional one that requires a depot that can adapt buses with a length up to 25 meters. Present depot was designed for buses with regular size. The area to be built will need to be adapted for longer buses where the articulated buses will not drive on reverse. Bus depot must be planned with specific requirements for driving pattern in the depot without possibility restrain, and that the entry to and exit from the depot are best solved separately. Technical facilities must be adapted to all types of buses.

It is important that a bus depot is seen as part of the urban development. AtB has the requirement that a bus depot must provide enough capacity and environmentally friendly focus. Furthermore, bus depot in Trondheim must be climate neutral and from 2019 is able to facilitate biogas and electricity buss as all buses that operate in Trondheim will have fuels like biogas, electricity and hydrogen. The change of fuels of the buses will lead to a different type maintenance and facility that is applied in the depot.

Strategy for localization

Sør-Trondelag County, AtB and Trondheim Municipality has worked together on providing a new bus depot on the city's east side with the consideration of capacity, areal availability, safety, and cost. Architect and consultant firms were appointed to work with the analyzing study on localization and design of a bus depot in Trondheim. The Department of Real Estate of The County of Sør-Trøndelag presented the strategy for establishing bus depot in Trondheim to the politicians in a County Council meeting in December 2016. The County Council agrees that due the extensive needs of capacity expansion, Sandmoen depot must be expanded. In addition, the temporary depot at Sorgenfri must be substituted with better condition and sufficient capacity at the east side of Trondheim. The County Council supports idea of multi land-uses concept where the site can be combined with other functions like residential on the level above and parking space under ground.

4.4.3 Example of strategy implementation from selected depot

Bus depot Sandmoen

Figure 4.35 Sandmoen bus depot (2).
Source: https://beportal.stfk.no/Hovedside/Dokumenter/Byggpresentasjon_Sandmoen.pdf

The depot	Owner : Sør-Trøndelag County Architect: Lusparken arkitekter AS General contractor: HENT AS
Localization and neighborhood	There are little potential to build bus depot near a hub or city center in Trondheim. Due to the concerns of land availability and the nearby neighborhood conflicts, Sandmoen that is located at the south of Trondheim and outside the city center and at the industrial and business estate is seen as the perfect location for a bus depot. Bus depot Sandmoen also covers the routes scheduled from Trondheim South.
Design concept	The depot is designed with environmentally friendly concept, built on a compact area. The material that is chosen for the building is easy to maintain. The northern part of area is prepared for two levels parking spaces for minibus or cars. The depot has met the demand for energy-efficient buildings and obtained support from Enova. The administration building was built with a passive house concept. There is a of flexibility in the design as there is possible expansion on the washing hall into the car park.
Necessary facility	For safety reason, the depot plan has a clear distinction between areas for bus traffic, administration building, laundry hall and employee parking. The whole depot is designed with a good pedestrian traffic solution The administration building has opened, continuous areas around a closed center core. The depot provides good and transparent rooms with day-to-day qualities.

The future bus depot at the east side of Trondheim

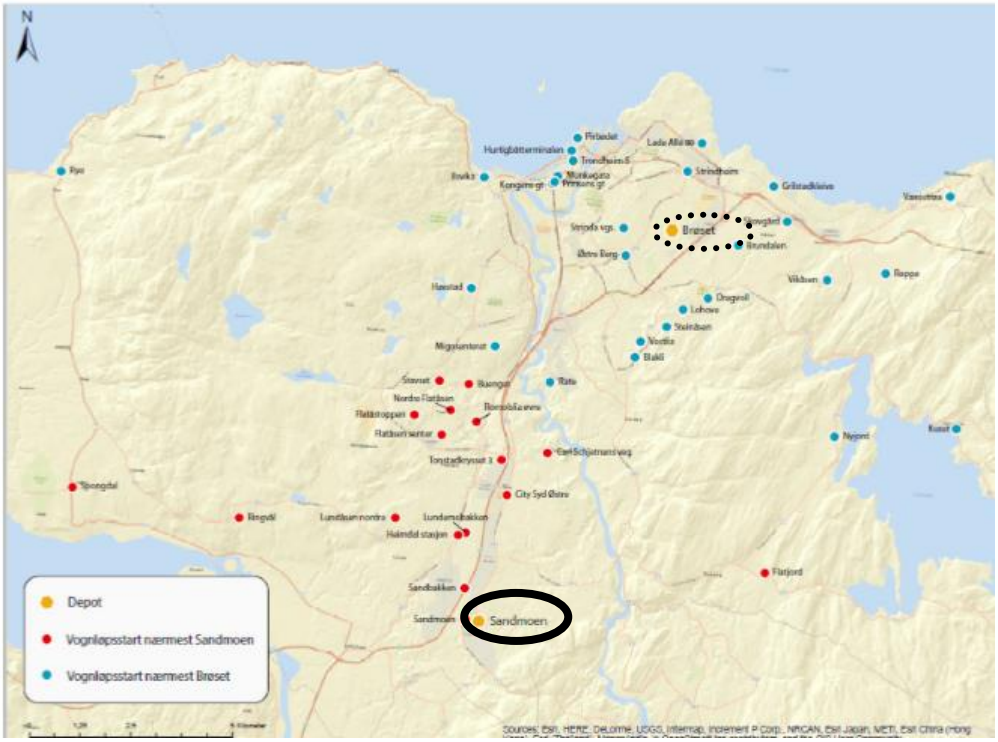


Figure 4.36 Map of depot and first bus stop in Trondheim.
Source: Framtidig rutestruktur med superbuss i Stor-Trondheim 2019-2029, Ruter, 2016.

Localization AtB considers it would be the most appropriate situation in the future with modern bus depot built at each end of the city: one in the south (now Sandmoen) and one in north / east to minimize empty runs. A new bus depot located on Trondheim east is recommended by Atb be placed at Brøset/Dragvoll/Rotvoll/Leangen. AtB has calculated annual kilometers related to empty runs for some alternative depot locations compared to current route production. Depot position at Brøset produces 8.807 km/week for empty runs, while Sorgenfri is 13.594 km/week and Ranheim is about 19.341km/week. Localization of a new depot in Brøset in addition to Sandmoen bus depot will be almost optimal. As a matter of fact, the status plan today at Brøset is an area for residential purposes. The area has never been considered to place a bus depot. It then requires a site regulation for bus depot localization at Brøset.

Necessary facility By utilizing today's infrastructure for gas operation and arranging a depot in Trondheim East for other fuel types, it then will be able to harvest different operating experiences and reduce investment costs at Sandmoen. It is still at early stage whether the depot at Trondheim East will be built on the ground, below ground or several levels.

4.5 The summary of chapter 4 – Study Case

The overall strategy of the region

	Oslo and Akershus	Hordaland	Stockholm	Trondheim
The organization				
The operator of public transport	Ruter.	Skyss.	AB Storstockholm Lokaltrafik. (SL)	AtB.
Localization and design of a bus depot is finalized	Political process.	Political process.	Political process.	Political process.
The ownership				
Responsible for providing bus depot at the city	Ruter through Bussanlegg AS. (public transport operator body) via	Hordaland County. (a county).	Stockholm Läns Landsting (SLL) or Stockholm County Council. (a county).	Sør-Trøndelag County (STFK). (a county).
Who owns the depot	Majority depots are owned by Ruter via Bussanlegg AS. The rests are owned by private or the state with a long-term contract. Bussanlegg AS is owned by Oslo Municipality.	Majority depots are owned by Hordaland County through organizing as share company under HFK Bussanlegg. Hordaland has the ambition to own all the bus depots. Otherwise, a long-term contract is necessary. HFK Bussanlegg is the strategic partner of Skyss that is responsible for ensuring bus depot capacity in the long term.	SLL through SL	Sandmoen depot we owned by STFK. Sorgenfri depot are owned by Trondheim municipality, a long-term of contract that expires in 2019.
The establishment				
The objectives	A depot that has the correct localization, sufficient capacity and the necessary facilities to serve the winning bus operator.	Developing sufficient infrastructure and facility to support public transport.	A long-term good management, energy efficient facilities and good work environments as an optimal bus depot will conduct to efficient operation.	Developing sufficient infrastructure and facility to support public transport.
Bus depot is part of urban development plan	Yes.	Yes.	Yes.	Yes.
It is included in plan regulation with 10-25 years perspective	Yes, but not all.	Yes.	Yes.	No.

Stakeholders involvement				
Involving stakeholders in early process	Yes.	Yes.	Yes.	Yes.
Localization				
The challenges	Possible area at center located, but not that many.	Not available area in center located.	Possible area at center located, but not that many.	Possible area at center located.
The concept of localization	Center located area.	Available area.	Center located area.	Depending on the route concept. Network concept requires bus depot at the border of a municipality. Center concept requires bus depot at the center of municipality.
The consequences of the selected localization concept	High land-use costs.	- High journey-to-depot costs. - High investment costs (new roads as the access).	High land-use costs.	High land-use costs.
The benefit of the selected localization concept	- Low empty runs. - Low journey-to-depot costs.	Low land-use costs.	- Low empty runs. - Low journey-to-depot costs.	- Low empty runs. - Low journey-to-depot costs.
Pressure from neighborhood or local conflicts	Yes to center located bus depot. No to depot outside municipality center.	Yes to center located bus depot. No to depot outside municipality center.	Yes to center located bus depot. No to depot outside municipality center.	Yes to center located bus depot. No to depot outside municipality center.
Building and design				
Environmental friendly bus depot	Yes.	Yes.	Yes.	Yes.
Material friendly bus depot	Yes.	Yes.	Yes.	Yes.
Energy effective house	New depots yes, not to old ones.	New depots yes, not to old ones.	New depots yes, not to old ones.	New depots yes, not to old ones.
To secure future capacity	- Land acquisition both center and outside city center. - Long time period contract.	- Land acquisition outside city center. - Old depot acquisition. - County ownership for controlling purposes.	- Land acquisition both center and outside city center. - County ownership for controlling purposes.	Long-term period contract or land acquisition at east Trondheim.
Workplace concept	Provide sufficient and good facility for employees.	Provide sufficient and good facility for employees.	Good interior for the convenience of workplace with excellent facilities for employees.	Provide sufficient and good facility for employees.
Bus service	- Sufficient space for bus maintenance. - Smooth logistic.	- Sufficient space for bus maintenance. - Smooth logistic.	- Spacious bus maintenance - Smooth logistic. - Excellent facilities for buses.	-Sufficient space for bus maintenance. -Smooth logistic.

Strategy implementation to selected bus depot

	Oslo and Akershus	Hordaland		Stockholm		Trondheim	
	Bus depot Brubakkveien	**Bus depot Haukås**	**Bus depot Knarvik**	**Bus depot Fredriksdal**	**Bus depot Tomteboda**	**Bus depot Sandmoen**	**Future's bus depot in east Trondheim**
The objective	To secure capacity for Groruddalen route.	To secure capacity in Bergen area for the future.	To secure capacity for Nordhordland area.	To secure capacity for city bus route in Stockholm city.	To secure capacity for inner city buses.	To secure capacity for buses in Greater Trondheim.	To secure capacity for buses in Greater Trondheim.
Ownership	Long-term leased by Ruter.	Owned by Hordaland County through HFK Bussanlegg	Owned by Hordaland County through HFK Bussanlegg	Owned by Storstockholms Lokaltrafik (SL).	Owned by Storstockholms Lokaltrafik (SL).	Owned by Sør-Trøndelag County (STFK).	*The county will own the depot.*
Strategy in localization	- at Groruddalen, short distance to a station (urban and hub). - Well connected to the road network. - Near Østre Akerv. - The neighbor is industry and railroad.	- No land to build in city center. - It is located in Åsane, ouside city centre, industrial and business estate - New access roads was established. - Good neighbor condition.	- Located at E39, on the outskirt of Knarvik in Lindås Municipality. - Strategic location to provide bus service for Nordhordland area.	- To replace depot Søderhallen. - At Stockholm City. - Near Hammarby Sjöstad, - Easy for fuel filling. - The neighbor: large warehouse, industrial buildings and offices.	- Strategically as it near to E4 and pampas link at the south and Huvudstavängen in the west, and good access to the east. - Large area at refueling of biogas consideration.	There are little potential to build near city center, so the depot is located at the south of Trondheim and outside the city center, at the industrial and business estate.	Minimizing journey-to-depot cost at minimum level by land acquisition/ leasing and relocating Sorgenfri depot to east of Trondheim.
Facility	Built with necessary facilities, sufficient capacity for depot activities.	Built with necessary facilities, sufficient capacity for depot activities.	Facilities was already there before it was bought.	Built with necessary facilities, sufficient capacity for depot activities.	In the process.	Built with necessary facilities, sufficient capacity for depot activities.	*It is not built yet.*
Capacity	Spacious capacity outdoor for bus parking.	Spacious capacity outdoor for bus parking.	Spacious capacity outdoor for bus parking.	- Spacious capacity for bus parking maintenance. - Sufficient capacity for the future.	A new relocated depot for Hornsberg with now larger capacity .	- Spacious capacity for bus parking maintenance. - Sufficient capacity for the future.	*It is not built yet.*
Expansion	No.	Possible for expansion.	No.	No.	Possible for expansion.	Possible for expansion.	*It is not built yet.*
Land-use	One level on the ground.	One level on the ground .	One level on the ground.	Land-use mix in 3 floor levels.	One level on the ground.	One level on the ground.	It is not built yet but it is thought to be several floor levels.
Passive house	No.	Yes.	No.	Yes.	Yes.	Yes.	*It is not built yet.*

5. DISCUSSION

Transport infrastructure and facility attract many attentions in the world of real estate development. To a county that chooses bus as their transport mode, it is significant that the bus capacity is adequate to accommodate its passengers and sufficient bus depot capacity to accommodate buses. The problem to discuss in this master thesis is the ability and capability to provide an optimal bus depot with the right strategies to encounter the challenges. The strategy from recent practices are compared against what it is identified in the theory.

Findings from interview, observation, document review and website review from selected recent practices are applied as the basis for the discussion to findings from the theory. Figure 5.1 illustrates the systematic thinking that is applied in this master thesis when investigating the problems and situations.

Theories have mentioned that the main goal of a public transport at the strategic level is to provide service to the passenger. The ability of a county and its public transport operator company to provide an ideal infrastructure and facilities is one of the success factors for the continuity of public transport operation, both for short and term.

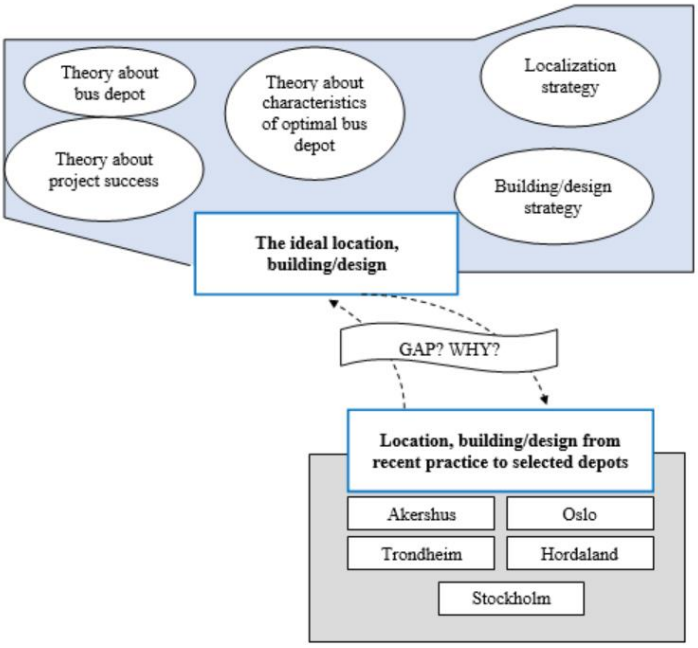


Figure 5.1 The systematic thinking of the investigation in this master thesis.

5.1 Service to passenger

Passenger is the user (customer) of the bus mode. Passenger convenience is achieved when they feel safe in the bus, bus is on the route, and bus facility works well (Vuchic, 2007). There is a strong correlation between facility management and customer satisfaction in public transport. Timely maintenance and a good facility are essential for safe operations and the overall economics of transportation (McNeil et al, 1992).

Failing to provide bus that starts to drive from a depot with good condition, will bring inconvenience to the passengers. On the other hand, good performance bus will convey passenger satisfaction. The combination of practice in Oslo, Akershus, Hordaland, Stockholm and Trondheim shows following factors that influence bus performance:

- Buses are maintained properly.
- Buses are on the route.
- Buses come on time at the bus stop and terminal (punctual).
- Facility in the bus works well (air conditioner works, the seats are not broken, the floor and steps are in a good condition, the door opens/closes well no breaking glass window, etc).

Bus with good performance relies on bus maintenance and the people who work with bus performance. An optimal situation is achieved when a depot manages to produce a good performance bus. To reach this condition, recent practices stress that mobility and accessibility is an important element that must be provided in the depot. Mobility is the ability of any person to move between points, while accessibility is the possibility of reaching any activity (Grava, 2003). The activities happen because of the people. The people at bus depot are the employees who work with the administration, bus maintenance and bus driving, etc. Therefore, providing good facilities to the employee is essential for the passage of the activity at the depot and for bus operation.

5.2 The characteristics of an optimal bus depot

How optimal a depot can be seen from its system performance, level of service, impacts and costs. Before the decision to keep, improve, or develop a bus depot, the county together with its public transport operator body defines the objective where the depot is steered toward. The effect shall correspond to the objective. The objective must be cleared, normative and be

known to stakeholders that are related and involved to the depot. These are the characteristics of an optimal bus depot:

1. **The depot carries acceptable overall costs, reaches the marked and brings social benefit to the community with a long time perspective.**

Figure 5.1 illustrates the systematic thinking that the researcher is using in this master thesis. Findings from the analysis show that there is a gap between what theories has held about the ideal bus depot and the implementation in selected recent practices. The gap has so far been dominated by the approach of a county (the owner of public transport) to balance the interests of the stakeholders and the overall costs.

There are general element determinations of demand that can affect supply (location, building and design) as it is illustrated in figure 5.2. The element determination are: the number of buses, the type of the bus (bus size, bus fuel and bus concept), bus route network and frequency, method for vehicle maintenance (type technology, facility, and logistic system that are chosen), land availability and local factors like: method of work, nature adaptation, local economy, rules, etc.

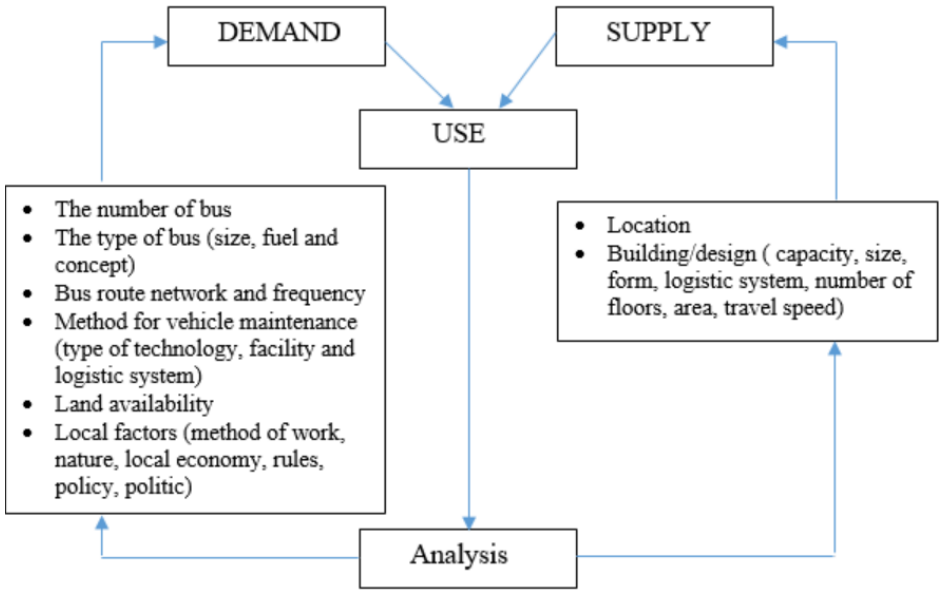


Figure 5.2 Demand and supply diagram using DEGW method.
Source of idea: Blyth et al, 2010.

In demand and supply weighs, when one of the sides is heavier than the other side, a gap occurs. It happens when the supply cannot accommodate all or some of the demands. Gap can be costly, but it is also costly to minimize the gap. The question is how long a county can withstand before the cost becomes greater. The change of demand and supply in terms of a

bus depot will not change significantly in a short time. It changes due to the growth of population and increase number of buses as planning a bus depot is a long-range planning horizon.

The planning takes about 10-25 years as it involves area, large capital investment, and physical and organizational modification. Depot is a source of land that requires large area and strategically location. Therefore, bus depot should be the part of a long-term planning of an urban development. The planning should be reviewed and revised every 5 years (Vuchic, 2005).

Location

Location is important as element determination of an ideal supply. A depot needs a site to place buildings, parking and maintenance facilities. The supply (the location, building and design) has a major influence in operating efficiency. Failing to find the right location will lead to high costs. Bus depot carries following costs in addition to investment costs (Musso et al, 1997):

- Land-use (space) costs.
- Journey-to-depot costs.
- Operational costs.

Land-use costs and journey-to-depot costs play an important role when planning to localize a bus depot. Land-use (space) costs cover a potential value and an actual value of the land. A potential value is determined by the demand for alternative use of space, while actual value is affected by urban planning regulation. Journey-to-depot covers costs for labor, power and consumption. There is consequences in price if focus only be concentrated in operational (journey-to-depot and operational). Land-use price get higher simultaneously to the strategic area whit low empty runs. In addition to costs, stakeholders and local factors play a huge role in determining localization of a bus depot.

Oslo and Akershus

Strength	Weakness
- Some depots are located optimal. - Some depots are located in a city center or municipality. - Land value at city center location is increased.	- Present depots have no area for expansion. - Expensive land-use price at city/municipality center. - Some depot locations contribute to produce many empty runs to buses. - Two depots serve the same bus route network zone and the depots are located separately far from each other.
Opportunity	**Threats**
- Land availability, but not at the center of the municipality. - Lower price for land outside city center than city center.	- Today's depots that are center located must compete with other real estate purposes than transport facility. - Neighbor conflicts. - Bus route network and frequency changes.

Table 5.1 SWOT analysis - bus depot location in Oslo and Akershus.

Some bus depots in Oslo and Akershus have ideal locations for present demand. However, due to the growth needs of accommodating more numbers of buses in the future, bus depot capacity today is needed to be expanded. In fact, Oslo and Akershus are experiencing that the number of busses that park at the depot today is more than the capacity a depot is advisable. Therefore, an area expansion must be established in addition to present site. With the land condition in Oslo and Akershus today, Ruter is struggle to expand the capacity of bus depot today.

In addition to having challenges with site expansion, bus depots that are located ideally in terms of transport system must compete with other real estate purposes. Bus depot that is at center located stands at a site that is attractive for residences and offices purposed. On the contrary, bus depot with a good local support, the location is ineffective in terms of transport system because it results heavily empty runs for buses. Empty runs happen when the bus is driving between the depot and the starting point of first departure on operating days.

Oslo and Akershus are also experiencing the situation where two depots serve the same bus route network zone, and these depots are located separately far from each other. This situation brings high journey-to-depot costs and high operational costs for the county. The ideal situation for Oslo and Akershus is to combine bus depots that serve the same bus route network zone to be at one new site and bigger size with sufficient facility.

Hordaland

Strength	Weakness
- Some depots are located optimal. - Some depots are located in a city center or municipality. They serve city buses. - The county has secured lands outside densely area for depot capacity expansion.	- No more area in city center for expansion. - Expensive land-use price at center area. - Producing empty runs for buses. - Some depots are outside the center area.
Opportunity	**Threats**
- Land availability, but not really at the center of municipality.	- Neighbor conflicts to central located depot. - Competition with other real estate purposes. - Bus route network and frequency changes. - Some depots result environmental impact.

Table 5.2 SWOT analysis - bus depot location in Hordaland.

As in Oslo and Akershus, Hordaland experiences land limitation at the ideal location to provide more bus depot capacity. The depots that are center located in a municipality are experiencing neighbor conflicts. As the subsequent of urban growth, the center located bus depot has become an attractive site for commercial and community facility use.

Present bus depot location in Hordaland is difficult to change. The alternative sites suitable for bus depot at center located or near a hub are not many. Journey-to-depot costs are undoubtedly wished to be minimized. However, the local situation and condition force the county to choose a site outside municipality center where journey-to-depot costs are quite high. The advantage of establishing a new depot outside the densely area leads to less land-use costs.

Other challenges that Hordaland experiences are poor condition to some depots. If the depot quality is low, it will affect the operation efficiency of the depot. Moreover, the low quality of a bus depot will lead to cost ineffective and poor performance bus that brings to unsatisfied passengers. Therefore, relocating an old depot to a new site with better facility is somehow important to maintain the cost for operational.

Stockholm

Strength	Weakness
- Some depots have ideal location: near center and hub.	- No area for expansion. - Expensive land-use price. - Producing empty runs for buses to depots outside municipality center. - Some depot locations are also outside the center area.
Opportunity	**Threats**
- Politic support to establish depot in the center of municipality. - Multiplan depots available in municipality center area.	- Competition with other real estate purposes. - No land availability to one plan only depot. - Neighbor conflicts. - Bus route network and frequency changes. - Environmental impact.

Table 5.3 SWOT analysis - bus depot location in Stockholm.

Reducing journey-to-depot costs and operation costs are the focus for localization of bus depot in Stockholm. It is the desirable situation for Stockholm that depot is best located at city/municipality center or near hub. With the support of the politics, empty runs and operational costs are must be the acceptable level.

The understanding to costs minimizing on journey-to-depot and operational is supported by Stockholm's local politicians. Through a political process, the prioritization in location and design alternatives of a bus depot are finalized.

Long-term perspective is used to consider the level of costs that are acceptable. Placing a depot in the center of a municipality brings benefit as it gives low empty runs and brings challenges as it gives high land costs now. However, in the long term, the sum of the overall cost is considered acceptable.

Trondheim

Strength	Weakness
- Present depots are located strategically. - There are areas for expansion at Sandmoen depot. - Center located at Sorgenfri today.	- Contract with Sorgenfri depot expires in 2019. - Expensive land-use price. - Location is outside the center area. - Many empty runs with only one depot. - Areas in the east Trondheim are not regulated for bus depot.
Opportunity	**Threats**
- New technology development. - Better method of working.	- Land availability. - Competition with other real estate purposes. - Neighbor conflicts. - Bus route network and frequency changes.

Table 5.4 SWOT analysis - bus depot location in Trondheim.

Minimizing costs in investment, land-use, operational and journey-to-depot is somehow the desire situation for Trondheim. The county needs to provide a new location to replace Sorgenfri bus depot, which the contract expires in 2019.

The decision for the new location for Sorgenfri has not been made, but the choice of the bus depot location in Trondheim will have priority on minimizing operational costs and journey-to-depot costs.

Bus depot capacity should accommodate the purchasing of new buses. Any extension of bus depot capacity in 2019 must correspond to the estimated capacity requirement in 2024.

2. Involve stakeholders as early as possible.

Optimal means something that is the best, ideal, or most favorable for a given situation (vocabulary.com, read 2017). In fact, determining whether a situation is optimal is somewhat subjective. Ideal for whom? Is it for public administration? For the employees? Or to the neighbor? Optimal for bus customer (passenger), how about the operator? To bus depot drifter? Tenant? Owner? An optimal situation may convey a good solution for one particular group, but may not serve the needs for other group with equal ability.

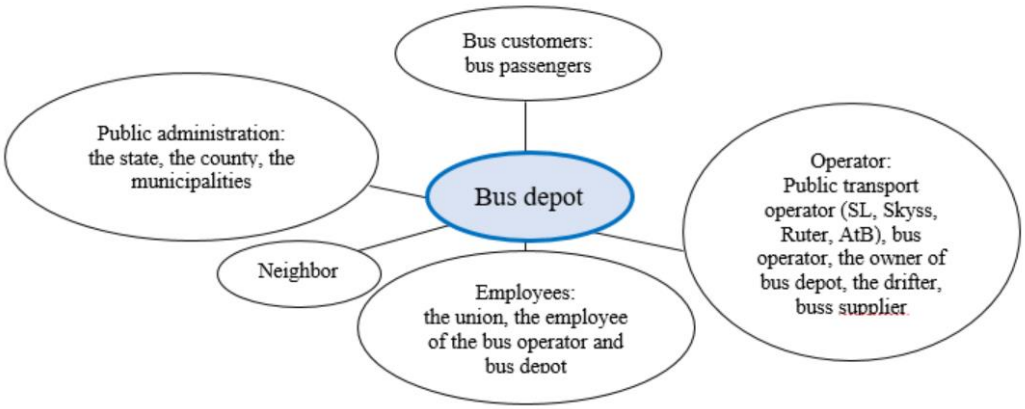


Figure 5.3 The stakeholders of a bus depot.

What is considered optimal for the county and its public transport operator body may not always be optimal for other stakeholders, for example neighbor and municipalities. A location of a bus depot that somehow is ideal considering the bus route can be contrary to municipality's plan. A location that solves the problem of empty runs, as it is located strategically in the middle of a city or municipality, often is intended for housing and offices as the location is attractive for business purpose.

Theory has mentioned that. Having an optimal depot helps public transport operator body (AtB, Skyss and Ruter) and the county to achieve their goals (economic, social, and environment). An optimal situation brings comfort as it carries a level of risk that fits well with the overall strategy as the county and public transport company employs.

Stability in infrastructure and facility is particularly important for public transportation. All counties will always need a stable condition. Bus depot's role is not only to provide accommodation to buses, but it also can steer urban development. To determine whether a bus depot is optimal, it is important to look carefully at the goal of its development. Strategies are made to encounter the challenges that may arise now and the future so the goal is achieved.

3. **A good building and design with sufficient dimension and right facilities to accommodate people and buses.**

Building and design can determine the operational costs in a depot. The operational costs consist of following elements: labor, consumption (electric power, fuel, water, and communication), disposable and spare parts, management (general and sundry expenses, contract works) and bus preparation, servicing expenses, cleaning, and depot servicing. Building and design are closed related to space and dimension.

Function and capacity determine the space and dimension. A bus depot is a facility to accommodate people and buses. The building and design of a bus depot depends on who is the user and what activities take place at the depot. Buses use the most area at the depot. Therefore, the building and design of a depot must consider the number of buses and their types (size, concept, fuel), bus route network and the frequency, method for vehicle maintenance, land availability and various local factors (Vuchic, 2007). In addition, since bus depot is a workplace, the design should also consider the people as the user of the building. The people who work at bus depot are related to administration, maintenance and bus operation.

There are no generally accepted about common standards for bus depot building and design because it is developed by individual transportation authorities and then tailored for its use (Grava, 2003). However, there are the same elements that are focused in the planning such as bus circulation, parking planning should be convenient, safe and accessible, the height of the building matches the type of the buses and open space characteristic match with the neighborhood (Vuchic, 2007). An optimal bus depot has **sufficient dimension** to accommodate a particular capacity as well as providing the **right facilities** to accommodate people who work there and the buses (Vuchic, 2007)

Recent practices that are studied in this master thesis are facing following common challenges in urban situation: population growth and increasing demand for public transport use, therefore, more capacity in public transport to accommodate more passengers are required to be provided. To provide more capacity for public transport leads to more number or bigger vehicles (bus). Bigger bus can be longer or higher. When a county chooses more number or bigger buses operates on the street, the transport infrastructure and facility should be adapted to this. Bus depot then needs more space to accommodate more buses. If there is no capacity expansion in a depot, it will impede the course of the logistics.

A satisfactory bus depot provides sufficient capacity, smooth logistic and good facility. BRT concept that will come in Trondheim in 2019 requires bus depot to accommodate up to 25-meter buses. The number and capacity of bus depot today will be not enough to accommodate the future demand. Oslo experiences that today 50% of bus damage and crash occurs at bus depot. This happens due to the number of buses that park at the depot is greater than the capacity the bus depot is able to accommodate. Hordaland and Stockholm experiences already more buses and bigger busses have come.

Furthermore, a satisfactory bus depot contributes to sustainable development and it has environmentally friendly solutions on all its activities. The type of fuel used for bus and bus depot comes early when planning bus depot. The fuel that is used by bus and bus depot must contribute to better society and cleaner environment. The method for vehicle maintenance at the depot is therefore adjusted to this requirement. Moreover, building material that is chosen to develop and improve a bus depot do not harm the environment. Recent practices in this study show that they have put social responsibility on the environment as a high focus (CSR = Corporate Social Responsibility). The county must always report financial result and environmental social performance to its citizen. All activities that happens in public transport system must take social responsibility to environmentally friendly solution and sustainable development.

A satisfactory bus depot should apply creative design as to encounter limited land availability. Adaptability is the key success on providing an optimal bus depot. Recent practices have a great focus on center located or near a hub. As a matter of fact, due to land availability, an ideal situation is difficult to implement. Recent practices are facing common challenges: limited available site. There is almost no land available at center located or near a hub for capacity expansion of a bus depot in Oslo, Akershus, Hordaland, Stockholm and Trondheim. They look therefore to the opportunity for finding area outside the center located with bigger site.

Due to the land scarcity and great land price at center located or near a hub, recent practices look also for opportunities to keep present location and build with multi floors or underground. The benefit of building a depot underground or as multi floors, it can give space for other functions like residents and offices above. The solution will help to finance land cost and provide benefit to the area.

In addition, an optimal bus depot should apply creative design as to minimize local conflicts such as neighbor conflict and minimizing devastating impact on the landscape. Bus depot is an important facility to the urban transport system. Without bus depot, bus operation stops. Unfortunately, the existence of a bus depot location is always challenging. Local factors are unique in every site. Nature and neighborhood factors can be challenges. Present bus depots that are center located or near a hub are being pressured by the surrounding circumstances. The location can have many restrictions on bus activity at the depot.

It is quite unpopular to have a bus depot as a neighbor in a residential area. The view and the noise that is produced from a bus depot may undermine the comfort of the residents that live around the depot. In addition, a new bus depot building is sometimes unwanted because the size of the area is thought able to harm the nature surround and may bring devastating impact to the landscape. Local conflicts can be costly. Creative design is used to encounter these challenges. The design must consider local factors surround the depot.

5.3 The efforts to provide an optimal bus depot

Strategies are designed in response to needs (Samset, 2008). The efforts to achieve ideal location, creative building and design are made to provide an ideal situation. To investigate the selection and implementation of strategy in this study, management decision-making process on the performance of transport infrastructure from Humplick et al (1988) is used. He states that before a strategy can be selected and implemented, it is important to perform data collection and monitoring, impacts modeling and application of impact models. Information that is obtained in this master thesis has a little data on how the monitoring process is and the impact models.

5.3.1 Strategy in localization

Reducing empty runs costs or paying high land-use costs?

Empty runs are a common problem that recent practices in this study have experienced. Empty runs generate journey-to-depot costs, which is the cost for the journey of a bus from depot to first terminal/stop and from the last terminal/stop back to depot. An empty run brings more cost for labor, power and consumption. Ideally, a bus depot must be placed where empty runs is avoided. Empty runs happen when a depot is located at a long distance to the first stop of the bus. Moreover, empty runs happens when a depot serves buses that are not belong to

the same route zone as the depot they are leaving from. Bus depot should be ideally located in the area that it serve and facilitate buses from the same zone.

Oslo and Akershus

Oslo, Akershus and Stockholm are focusing on minimizing empty runs and lack of capacity by relocating *the not optimal bus depot* to *more optimal location*. Bus depot relocating will save driving and journey-to-depot cost.

Recent practices in this study have engaged localization analysis to investigate which depot location gives more distance in driving and is economically important to be moved. Many bus depots in Oslo and Akershus are not located optimal because the location gives more distance in driving. For an example, by relocating Fagerstrand bus depot in Follo to Hellvik, it gives saving about 16 km/bus. The location of Gronud bus depot at City Centre is also considered not optimal. Moving Gronud to Vækerø gives savings around 16 km/bus. In addition, Maura in Romerike is far from optimal. Maura depot stands negatively regarding the bus route network this bus depot is serving today. Relocation of Maura bus depot to Eltonåsen will reach an optimal location where the operative costs may reduce by potential saving 24 km/bus.

There are also bus depots in Oslo and Akerhus that are located optimal. Bus depot Vestby in Follo, Bjørkelangen in Romerike, Eidsvoll in Romerike, and Enebakk in Romerike are categorized optimal. However, their existences are not 100% secure. Bus depot that has an optimal location, which is center located or near a hub, must compete with other real estate purposes, as the location is attractive for residences, offices and community facilities. Unfortunately, the strategic location in the perspective of transport system is sometimes an obstacle in urban development viewpoint.

Hordaland

Hordaland also experiences the same empty runs situation. Due to the local situation, it is difficult for Hordaland for new land acquisition at the area that empty runs can be minimized. There is a limited land availability at the ideal location. Hordaland have to find alternative site outside municipality center. For some depots in Hordaland that are already center and strategic located in terms of the bus route, they bring a dilemma to urban development perspective.

It is crucial for Hordaland to have a sufficient bus depot capacity in the future to accommodate more and bigger buses. Therefore, Hordaland selects the strategy on reserving capacity and ownership by purchasing new lands at Haukås, Rådal, and Byneset. These area are located outside the densely populated area. The land acquisition is financed by loans that the county takes and lends furthermore to the holding company that owns the land or bus depot. The price of land outside center located is lower than the site close to the center located. The advantage of purchasing a new land is that the county has the possibility to find the suitable property and form it to an optimal bus depot. At Haukås, Hordaland County built a new bus depot and finished in July 2012. At the beginning, Haukås did not have access to the main road, as it is located outside the densely populated area. Hordaland County did not see this as a threat. The county built then access to the depot from the main road.

To ensure capacity and ownership, Hordaland County purchased old depots like HFK Bussanlegg Fana AS, HFK Bussanlegg Lonevåg AS, HFK Bussanlegg Mannsverk AS, Askøy kommune / Haugland, HFK Eiendom Straume AS. Purchasing of a bus depot requires an agreement with the municipality on compensation to option that the municipality has for the facility. The option here means repossess the purchase against the payment first buyer has committed.

HFK Bussanlegg AS is a holding company that is established and owned by Hordaland County. HFK Bussanlegg is the strategic partner of Skyss that is responsible for ensuring bus depot capacity in the long term. For the contracts of the region outside the densely populated area (outside Bergen), bus operator sets bus depot it selves. For the winning contract in the urban area around Bergen, bus depot is available through The County with renting contract.

Every bus depot in Hordaland belongs to a holding company that owned by the county. A holding company has a share capital. For an example, the acquisition of a bus depot in Straume is proposed through the holding company HFK Bussanlegg AS that acts as the owner.

Stockholm

Investments are made in preparing bus depot availability to accommodate population growth and traffic efforts. In Stockholm, following parameters are taken into consideration for the localization of a bus depot:

- The area that the depot must serve/facilitate.
- The buildings surround consideration.
- Areal condition consideration.
- Empty runs consideration.
- Zoning, plan and property-related consideration.
- Take benefit from all public commutations such as roads, bicycle paths and public transport.
- Take benefit from all public commutations such as roads, bicycle paths and public transport.
- Bus depot is located at the center of a municipality.

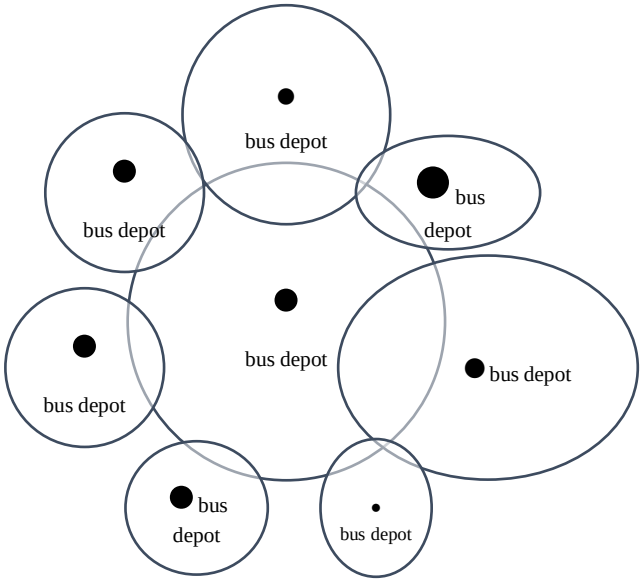


Figure 5.4 The best location of a bus depot is the middle of a municipality or near a hub.

In Stockholm, SLL acts as early as possible to purchase land for capacity expansions to secure public transport supplies for the future. In the making of master plans, SLL comes early in the process together with the municipality to ensure future site for bus depot. For SLL, a bus depot is ideally placed right the middle of all municipalities and close to a hub. The concept is built as to minimize journey-to-depot costs and operational costs as the goal. The benefit with the ability to localize bus depot centrally is to reduce empty runs. Figure 5.4 illustrates the desired localization for bus depot in Stockholm, placing in the middle of every municipality.

Due to the extensive track expansions for city buses, new depots are built to secure future capacity such as Fredriksdalsteatern in Hammarbyhamnen, Åkersberga, Enlunda in Ekerö, Handen and Charlottendal in Värmdö. Finding a new place for a bus depot in a strategic

location is important. Localization of a depot in the middle of municipalities requires smart utilization of the property. For Stockholm, multiple land-use and creative design concept is used to encounter challenges that come from neighborhood and limited land.

Bus depot is a workplace. Fredriksdal bus depot is built in a city center and near a hub. The location gives easiness for the employee to come to work. For a bus depot that is located near hub, car park facilities for employee should not be large. Fredriksdal depot can be reached by several modes of transport. The depot is facilitating inner city buses so the transport distance to get to and from center Stockholm is not too far. A convenient distance will minimize emissions used. However, placing a depot near city center, or a hub has a great land-use (space) costs that must be paid.

The location of Fredriksdal bus depot is also considered to support depot operation. The depot is facilitating about 140 biogas buses. As the location is on the quayside, the bus can reach the fuel directly at the depot as biogas is transported by underground pipe from *Henriksdal reningsverk.* The location does not require a heavy transport to ship the gas to the bus depot.

Trondheim

Strategies for capacity expansion than today's bus depot in Trondheim are selected but not implemented. Trondheim is at the search for finding the best bus depot solution to secure the future bus depot capacity. The region soon will have BRT concept buses from 2019. The building and design concept for bus depot for this BRT buses is still bus based solution, but with bigger area and different type in maintenance.

Longer buses like requires larger area to park and maintain as well as for swinging/turning at the bus depot. Therefore, in order to provide smooth logistic, Trondheim needs better bus depot capacity. The strategy of bus depot establishment that has been approved by the county council mentions what Trondheim has to set as consideration for the selection of land for bus depot. The considerations are: area, investment cost, traffic, security, environment, operation, social and flexibility.

For Trondheim, the highest usage basis is used as consideration for the new area of bus depot. The east side of Trondheim is believed in 2050 has the greatest growth in the municipality. The area for the new place of a bus depot is suggested at the east side of the city with connection to future population growth. The placement of bus depot in the east side of

Trondheim will be near optimal condition in terms of the production (the km bus must drive to/from depot). The strategy is selected as it is believed to minimize journey-to-depot costs.

Upgrading road network will give more value for the depot and urban development. The new location of a bus depot in Trondheim is thought should be the location that able to minimize empty runs. It is not determined whether the new depot should be built with several depots or one large depot. Table 5.5 shows the consideration of having several new depots compare to one large depot.

Building several small bus depots or one large bus depot?

By building several depots:

	Advantages	Disadvantages
The county	- Easy to find available area	- Building several small bus depots in a municipality will not be optimal as it leads to: - Increase investment and operating costs. - More infrastructure measures such as the access (roads construction), washing halls, and offices for operation. - The management functions are established at several places.
The operator	- Provide a good distribution of buses around the region and each location will require less space. - If all depots have the necessary facilities it will have good proportion of empty runs (ability to reduce journey-to-depot costs). - Better flow if there are many tender packages. - It probably gives fewer traffic challenges.	
Employee	- Easy routine.	- Social conditions as fewer colleagues will be deployed.
The municipality	- Easy to find available area. - Smaller area to regulate.	- Many areas in a municipality to regulate. - More pressure from neighbor.
Bus customer (passengers)	No effect	No effect

Table 5.5 Several small depots rather than one large depot: advantages and disadvantages.

5.3.2 Strategy in building and design

The efforts to provide sufficient capacity, smooth logistic and good parking facility

Good capacity leads to smooth logistic. In order to achieve smooth logistic, there must be enough space for the realization of people and bus activities. Ideally, the number of buses located in a depot must not exceed the optimal number of bus parking space. Practices show that designing a bus depot must consider not only that the bus depot has sufficient capacity, but it has 20% expansion opportunity. When the capacity of a bus depot is enough only for present demand and it does not have the ability to be expanded, the bus depot is said as not optimal.

Selected recent practices show that the driving pathway for bus is designed with the consideration of effective circulation. Reversing is avoided at all, as it may cause collisions.

Bus activities at the depot must not be disturbed. Separate lanes for buses between entry to and exit from the bus depot are implemented to new bus depots. Separate access is applied so that the depot has a reserve lane if something happens on the main access. Depends on the fuel that is used for the buses, some bus depots are designed so that a tanker truck can deliver fuel without reversing inside the depot.

Not all bus depots have full facilities. Recent practices show that a large bus depot has a full facility and all amenities, while smaller bus depot has not. Large bus depot has capacity about 120 buses and can accommodate about 60-80 buses per day for cleaning. Ideally, large bus depot is placed in the central location and smaller ones located decentralized.

Bus depot facilities depend on the depot function and location. A full bus facility is built with outdoor parking spaces with electricity connection for buses, filling station for fuel, wash and service hall, workshop facilities, office space for traffic management; relax room and wardrobes for the employee.

Think fuel, think environment

Different fuel affects the type of maintenance and repairs. Recent practices have put many efforts on planning so that disruption to the environment from the transportation is minimized. The desired quality is that bus depot buildings must contribute to sustainable development. Choosing the right of material to develop bus depot is important aspects for sustainable development. Upgrading old bus depot to be the one that will not harm the environment for a long-range period is very important. Practices also show that bus depot is built with recycled station and separate handling of hazardous waste and filling oils and fuels are located in separate areas with the collection of waste oil in a special place. The goal of these implementations is to create long-term good management objects, energy efficient facilities and good work environments.

Think creative design

Bus depot has an important role in public transport system. Everyone wants the bus but no one wants bus depot as the neighbor. Stockholm takes these challenges by solving with creative design. Due to the land availability and neighbor concern, the new bus depot Fredriksdal in Stockholm was built with the breakdown of 3 floors so the land usage is optimized.

To encounter challenges with neighbor conflicts, Fredriksdal bus depot is designed with no visible as bus depot from the facade. At the same site above the depot, it is built offices and residential buildings that cover the depot from Hammarby Allé. Bus depot Fredriksdal has the main purpose to integrate with the urban environment. The buildings have a multiple land-use concept where other function like offices and residential are located at the level above.

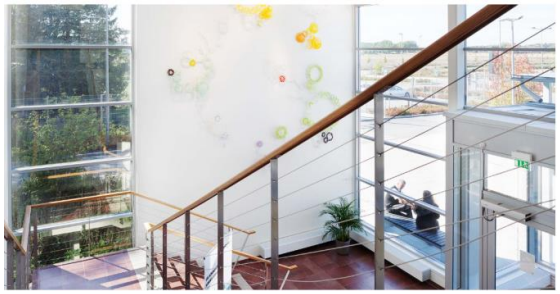
Trondheim also considers the relocation of Sorgenfri will be localized underground at the east side of Trondheim and the building will be designed as in Fredriksdal Stockholm with several floor levels to utilize land limitation. Placing a bus depot underground is thought be the solution for limited land availability and neighbor conflicts. Having a bus depot as a neighbor is somehow an unwanted condition.

Think workplace

The Building entrance to Fyrislund bus depot.

A little statue Torso II. Material: bronze. Artist: Jerzy Nowakowski.

The eating/relaxing area.



The decoration on the stair wall.
Artist: Elisabeth Henriksson and Fredrika Linder.

Figure 5.5 Fyrislund bus depot.
Source: www.BBH.se with the right to use from BBH.

Bus depot is a work place. BBH architects and engineers have worked with many bus depots in Stockholm and Sweden general. The design of a bus depot as workplace has a concept that working with public transport is an important task for the community. The fulfillment of the facilities that the employees experience in their daily working days will bring work joy. The work satisfaction of the employees leads to the quality of public transport service.

Fyrislund bus depot has high environmental ambitions with a new propellant biogas is established at the depot. BBH was the driving force in the project from the localization to the complete depot. The company is appreciated with a winning price at their achievement and design. The depot provides convenience workplace with good art design, and beautiful interior. The depot stands as the working place with the best working environment. The concept of good working environment is implemented not only at Fyrislund bus depot, but also at bus depots in Sweden general. The architect stresses the concept of convenient and pleasant workplace. The interior for the meeting points like canteen, stairs, living room, and relaxing area are designed with beautiful arts decorating the rooms. The common area for the employees is also very spacious

5.4 The summary of chapter 5 – Discussion

The strategy from recent practices are compared against what it is identified in the theory. Findings from interview, observation, document review, website review from selected recent practices are applied as the basis for the discussion to the findings from the theory.

The characteristics of an optimal bus depot:

- The bus depot carries acceptable costs for the county and its public transport operator and it brings social benefit for the community. The costs related to a bus depot are: investment costs, land-use (space) costs, operational costs and journey-to-depot costs.
- Optimal for the important stakeholders of the depot.
- Sufficient dimension and right facilities to accommodate a particular capacity.

The combination of practice in the cases in this master thesis has following strategies to provide the most acceptable situation:

- Bus depot as part of a long term urban development planning.
- Choose the solution that has the best time aspect.
- Involve stakeholder as early as possible.
- Chose the most acceptable overall costs.
- The importance of a pleasant workplace.
- Think fuel, think environment.
- Creative design.

6. CONCLUSION

This master thesis discusses the strategies for the establishment of an optimal bus depot to the transport system. As a contribution to urban study, the research seeks a greater understanding about the importance of a bus depot in urban development. The purpose of this master thesis is to describe the characteristics of an optimal bus depot, and the way of selected regions provide the optimal situation. Oslo, Akershus, Hordaland, Stockholm and Trondheim are the study case as they put highly focus on bus mode in public transport system. SWOT analysis and urban brief are used as analyzing tools to this research study.

Environmental protection is one of the imperative tasks for the government. Through environmental awareness campaign, government promotes the more use of public transport, cycling or walking than private cars. One of the success factors to make public transport works is that the infrastructure and facility for the operation are provided.

Bus depot has important roles for a region that chooses bus mode in their transport system. Bus depot involves considerable land-use, long-term investment (site selection), resources and buildings. Although bus depot is the most challenge facility in bus mode, unfortunately, the strategic location in the perspective of transport system is sometimes an obstacle in urban development viewpoint. The economic geography of a bus depot is quite neglected area in public transport system planning. Moreover, a traditional bus depot typically invoke environmentally negative image for the area around the depot.

A long time planning in transport system should be implemented for major infrastructure project, facilities, construction and permanent development. Bus depot must adapt to innovation of buses. Due to the climate change and population growth, bus depot poses new challenges in its development. Climate change leads to the demand for environmentally focus in the transport system. An optimal bus depot should be able to encounter following demands:

- The number of buses.
- The type of buses (size, type of fuel, the choice of bus material and concept).
- Bus route network and frequency.
- Method for bus maintenance.
- Land availability.
- Local factors.

6.1 What are the characteristics of an optimal bus depot?

1. The bus depot carries acceptable overall costs for the county and its public transport operator, reaches the marked, and it brings social benefit for the community with a long time perspective.

The change of capacity in transport and its infrastructure will have an effect on the unit cost of transportation such as investment costs, land-use costs, operational cost and journey-to-depot costs. An optimal bus depot would have these costs at an acceptable level. A bus depot is success when it has brought a good effect to the public transport service. A long-term efficiency of a bus depot should be the base when choosing the location and design of a bus depot.

2. Optimal for the important stakeholders of the depot.

Due to a local situation, it is challenging to meet all cost-elements at acceptable level as well as to take into consideration all the important stakeholders. Public administration, employee, operator, neighbor and customers have different perspectives to what an optimal bus depot is.

Journey-to-depot costs are seen as the most common focus for a county that stresses bus mode. Empty runs are not ideal situation for the environment and economy. In fact, competition with other real estate purposes, land availability, local restrictions, environmental impact, and neighborhood situation are registered in this master thesis as the obstacles to localize a bus depot at an area with the lowest price in journey-to-depot costs. Plan regulation and local circumstances play the most important role in localization of a bus depot.

3. Good building and design with sufficient dimension and right facilities to accommodate the desirable capacity and activities.

There are no generally common standards for the building and design of a bus depot. It is tailored with particular circumstances and needs. An optimal bus depot has a sufficient dimension to accommodate a particular capacity and it has the right facilities to support the activities at the depot. An optimal condition provides good capacity, smooth logistic and good parking facility. It contributes to sustainable development and it has environmentally friendly solutions on all its activities. Selected recent practices apply creative design to encounter land-limited condition. Creative design is also applied as to minimize local conflicts such as neighbor conflict and devastating impact on the landscape.

6.2 How would selected regions provide an optimal bus depot to their transport system?

Empty runs, not enough depot capacity, bigger or more buses, logistic problems, environmental impact, land availability, far from hub neighborhood situation are the examples of the problems recent practices in the case study have experienced. Following strategies are made to provide an optimal bus depot:

1. Bus depot as part of long-term urban development plan.

As planning a bus depot has a time horizon about 10-25 years, a long-term urban development plan should include bus depot as the part of it. To ensure bus depot capacity and good transport system in the future, area regulation for the purpose of a bus depot should begin as early as possible.

2. Choose the solution that has the best time aspect.

It takes time to process and approve a regulation plan. Areas that have not previously been considered for a bus depot and not in accordance with the overall plan trigger the requirement for impact assessment that prolongs the time perspective. Through political decision, localization and design of a bus depot from the study cases is finalized. In addition, it may contribute to the longer-term planning process if a bus depot should be combined with other purposes such as housing or offices.

Furthermore, a new bus depot will affect the traffic situation that it may contribute to the longer-term planning process. Extensive investigations are required before a plan can be adapted to such a complicated situation. An assessment related to risks is implemented that may lead to objections or delays. If a region does not have 10-25 years on planning a bus depot, the solution should be realistic and has the best time aspect.

3. Involve stakeholder as early as possible.

The planning of a bus depot should involve the representatives of the stakeholders (public administration, employee, operator, neighbor and customers). Operators concerns with the future capacity and the facilities that are offered from a bus depot. As an operator, a bus depot is expected to meet the needs of corporate management and operational and traffic management. Furthermore, depending on the location, neighbor protest could occur which cause delays.

The goal at strategic level of a public transport is the service to the passenger. An optimal depot helps the county and its public transport operator body to achieve their goals on economic, social, and environment and the passengers (customer convenience). An optimal situation brings comfort as it carries a level of risk that fits well with the overall strategy as the county and public transport company employs.

4. Choose the solution that has the most acceptable costs.

Localization, building and design involve costs. Ideally, the ability to place a bus depot in the middle of a municipality with easy road access is the desirable situation. However, the ideal situation can require high costs. Location, building and design selection of a bus depot should consider the overall costs (investment, land-use, operation and journey-to-depot), and not only to one cost element.

The depot should be flexible to adapt the changes. A flexible bus depot may require high cost in the short term but brings cost efficiency in the long term. Possibility of future expansion should be considered. The area will need to be adapted for bigger (longer or higher) buses that can accommodate particular maintenance or difficulties on drive reversely.

5. The importance of a pleasant workplace.

Bus depot is a work place. A pleasant workplace that provides convenience facility for the employee creates productive people. Employee satisfaction at their workplace creates work motivation. Good facilities and environment for the employees is important to be focused on a designing bus depot. A pleasant workplace is one of the solutions to solve employees' turnover.

6. Think fuel, think environment.

An important prerequisite for providing an optimal bus depot is also the choice of fuel comes as early as possible. Consideration must be given to fuel technology that gives the most promising in terms of climate, environment and cost.

7. Creative design:

- Smooth logistic.
- Sustainable development consideration.
- Multi land-use concept.
- Environmental friendly solutions.
- Creative design to encounter local conflicts.

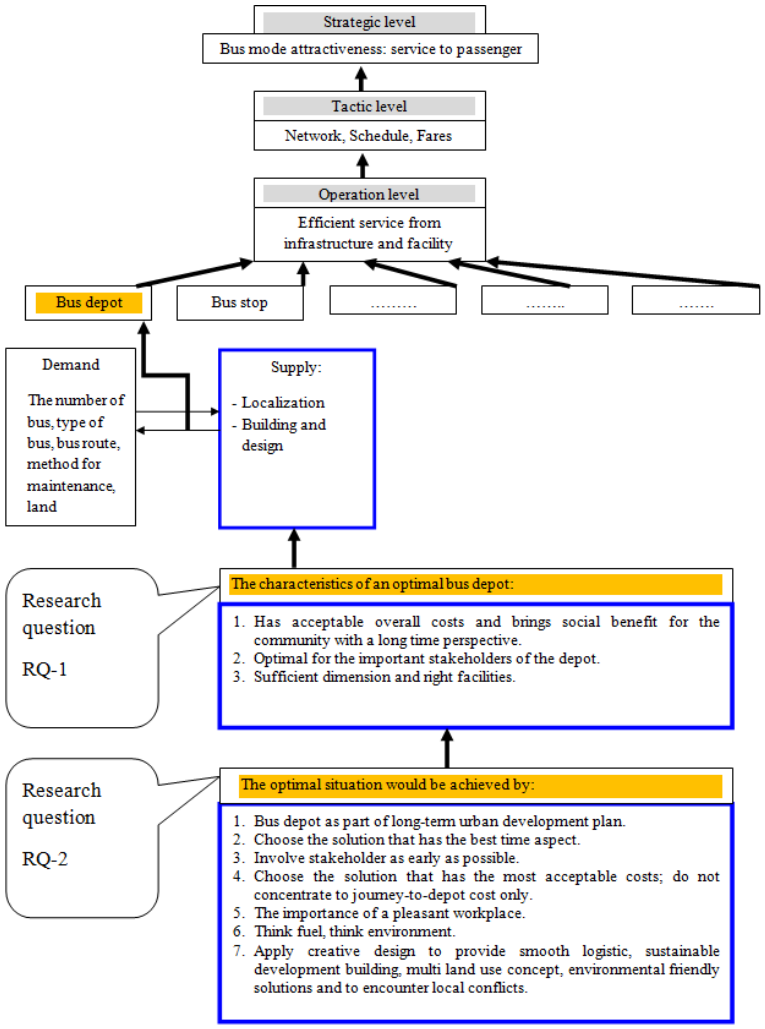


Figure 6.1 The conclusion diagram.

6.3 Future research suggestions

This master thesis is focusing on greater understanding about the strategy to establish an optimal bus depot in transport system. Experiences from Oslo, Akershus, Hordaland, Stockholm and Trondheim are investigated. Oslo, Akershus and Stockholm are categorized as large regions with well-established transport system. For future research, it is suggested to obtain more information about the experiences from other regions with well-established transport system in Scandinavia countries for the comparison.

The role and type of institutions can be influential in decision-making (Pojani and Stead, 2014). Political process has influenced the suggestions on focus when establishing a bus depot. Moreover, the role of stakeholders that are involved in a bus depot establishment plays an important role. It is interesting to go deeper research about the experiences from other stakeholders than county and its public transport operator body that stresses bus-based mode principal about their experiences and involvement in establishment of a bus depot.

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ATTACHMENT 1 – Interview guide

Introduction

- Presentation of the researcher.
- The explanation of why the theme of the master thesis is chosen.
- The goal of the interview.
- The general information that is wished to obtain from the interview.

About the person that to be interviewed

- What is your name?
- What is your current position?
- What institution are you working?
- What is the role of the institution you are working now to the establishment of a bus depot?
- Do you have a role or responsibilities with the establishment of a bus depot?
- If yes, what is your role to the establishment of a bus depot?
- Which bus depot do you have worked with?

Organization

- Could you describe bus depot organization in this county?
- Could you describe the stakeholders involved in a bus depot?
- What are those stakeholders' roles?
- How difficult is it to cooperate between the stakeholders?
- Are buses the only public transport mode in this county?
- Will buses compete with other public transport mode in the future?
- Is the decision of localization, building and design of a bus depot finalized in a political process?

Location

- Where is all the bus depot location in this county?
- Do you have a map you can show me about the location?
- What is the reason the depots are localized as where they are now?
- Is there any problems (challenges) with their location now?
- Do the bus depots in this county have good response from the neighborhood?

Capacity

- How many busses can be accommodated by the bus depots in this county?
- Could you tell me about the condition of the bus depot?
- Do the bus depots in this county need more capacity for today? Why?
- Do the bus depots in this county need more capacity for the future?

Facility

- Could you describe about facilities in all bus depots in this county?
- Could you tell me about the condition of the bus depot?
- Do all depots in the county have complete facility? Why?
- Do all depots in the county have sufficient capacity? Why?

Buses

- What type of buses that operates in this county? (size, type of fuel, concept, and type of maintenance)
- Do you think the size of the buses will be bigger in the future? Why?
- Do you think the number of buses will be higher in the future? Why?

The contract

- Can you explain about the contract to the property that is used for a bus depot?
- Does the county own the depot?

Optimization

- Do you think the location is optimal? Optimal for whom? Not optimal for whom?
- Do you think the building and design of the depot is optimal? Optimal for whom? Not optimal for whom?
- How long does it take for planning a bus depot? Has planning a bus depot been a prioritized task in this county? Why?

The overall strategy of the county

- What is the objective of a bus depot?
- What is the strategy of the county to provide an optimal bus depot to its transport system?
- What are the challenges?
- What are the most success factors when planning a bus depot?
- What can go wrong when planning a bus depot?
- Does the county has the localization strategy to reach an optimal situation? What is it?
- Does the county has the strategy in building and design when planning a bus depot? What is it?
- Could you describe about the efforts of the county to provide an optimal situation?

Selected bus depot

- Could you mention two bus depots in the county you think is interesting to share about (success/failure in implementing the county's strategy)?

Supplement

- Is there any information you would like to add further?
- Is there any information you think is important to supplement that we have not touched?

ATTACHMENT 2 – The source of information

These are the sources of data that are obtained through conversation, e-mail and interview:

Oslo and Akershus County

- Kristin Cecilie Mathisen, route planner at Ruter.

Hordaland County

- John Martin Jacobsen, leader for Road Sector, The Department of Transport, Hordaland County.
- Helge Haavardtun, former leader for The Department of Real Estate, Hordaland County.
- Rune K. Aadland, Engineer for operating agency and area manager, The Department of Real Estate, Hordaland County.
- Målfrid Vik Sønstabø, leader for The Public Transport Department, Skyss, Hordaland County.

Stockholm County

- Kenneth Domeij, a specialist in specification requirements and planning for depot and terminal, The Traffic Management Department at Stockholm Läns Landsting (SLL) or Stockholm County.
- Jan Linder, structural engineer, BBH Arkitekter & Ingenjörer AB.
- John Gustav Almquis, business development specialist at depot, BBH Arkitekter & Ingenjörer AB.

Greater Trondheim

- Erlend Solem, County Executive Director for Transport, Sør-Trøndelag County.
- Thor Eggen, Section leader, AtB.
- Helge Halse, The Department of Real Estate, Sør-Trøndelag County.
- Bjørn-Arve Raanes, The Department of Transport, Sør-Trøndelag County.
- Frank Grønås, The Department of Unit Ownership, Trondheim Municipality.

ATTACHMENT 3 – More facts from Oslo and Akershus

Figure 1. Bus depot in 2016 in Oslo and Akershus.
Source: Ruterraport Behovsanalyse og utviklingsplan for bussanlegg, Ruter, 2016.

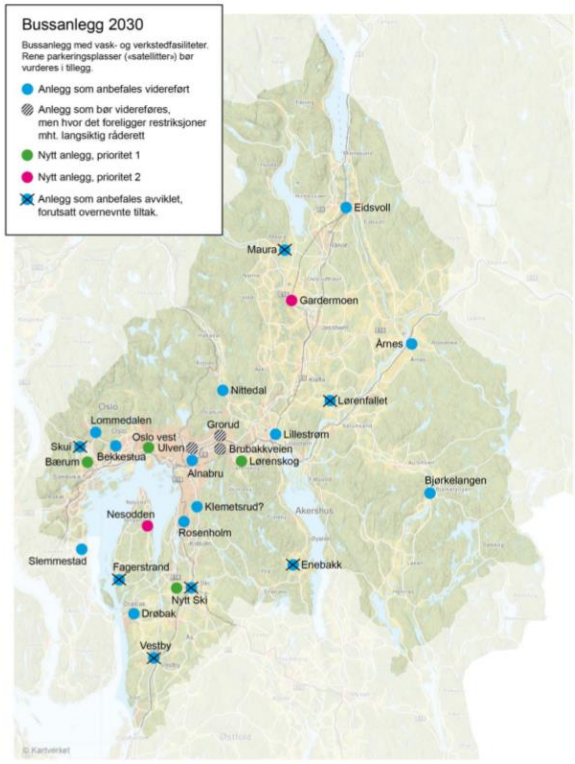

Figure 2. Suggested bus depot from 2030 in Oslo and Akershus.
Source: Ruterraport Behovsanalyse og utviklingsplan for bussanlegg, Ruter, 2016.

Figure 3. The goal for Oslo and Akershus is success in the marked.
Illustration from M2016. Source: Ruterraport Behovsanalyse og utviklingsplan for bussanlegg, 2016.

Figure 4. The needs for bus system in 2030 for Oslo and Akershus.
Source: Ruterraport Behovsanalyse og utviklingsplan for bussanlegg, 2016.

Figure 5. The objective hierarchy of localization and development of bus systems in Oslo and Akershus. Source: Ruterraport Behovsanalyse og utviklingsplan for bussanlegg, 2016.

ATTACHMENT 4 – More facts from Hordaland

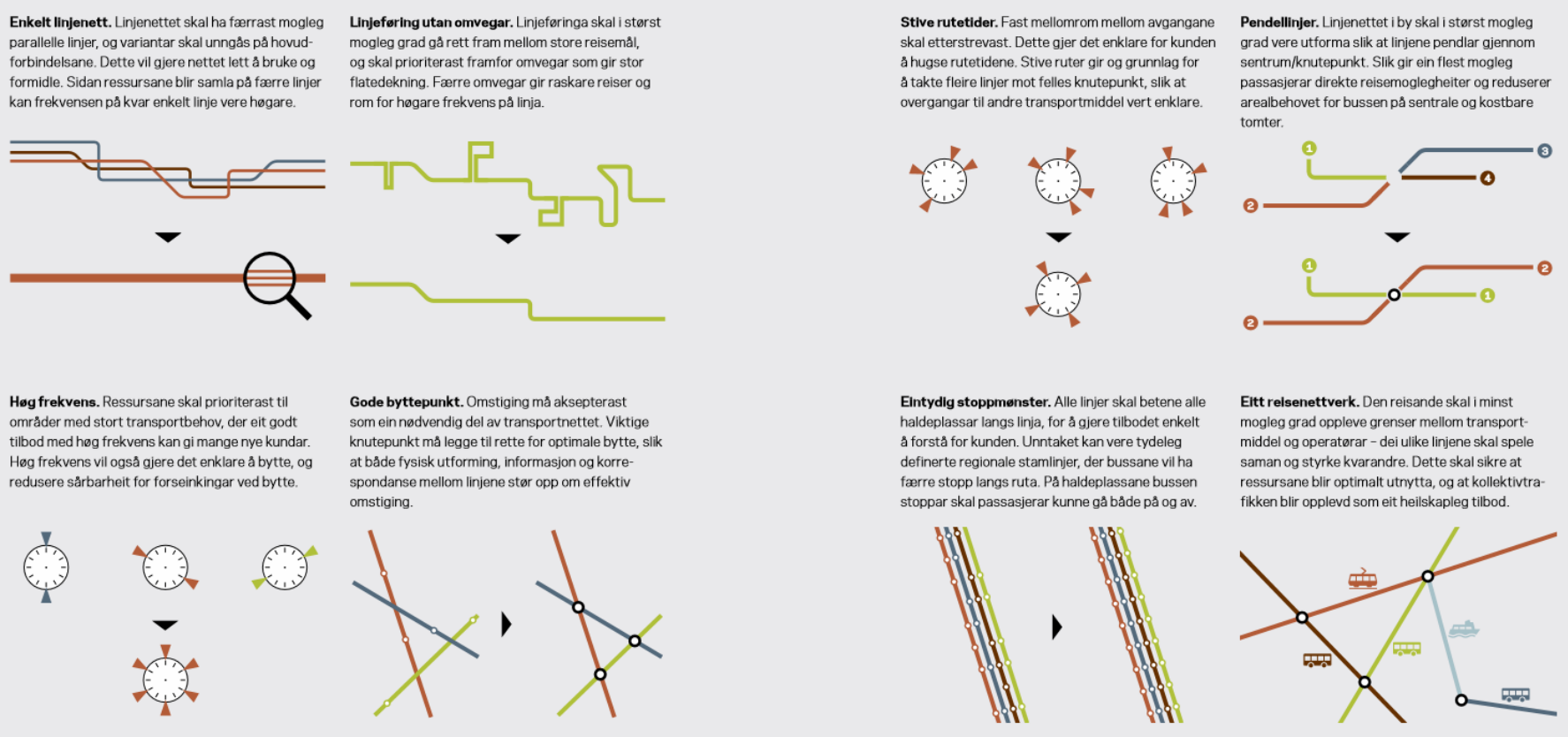

Figure 6. The principles of development of public transport network in Hordaland.
Source: Kollektivstrategi for Hordaland utvikling fram mot 2030, 2014.

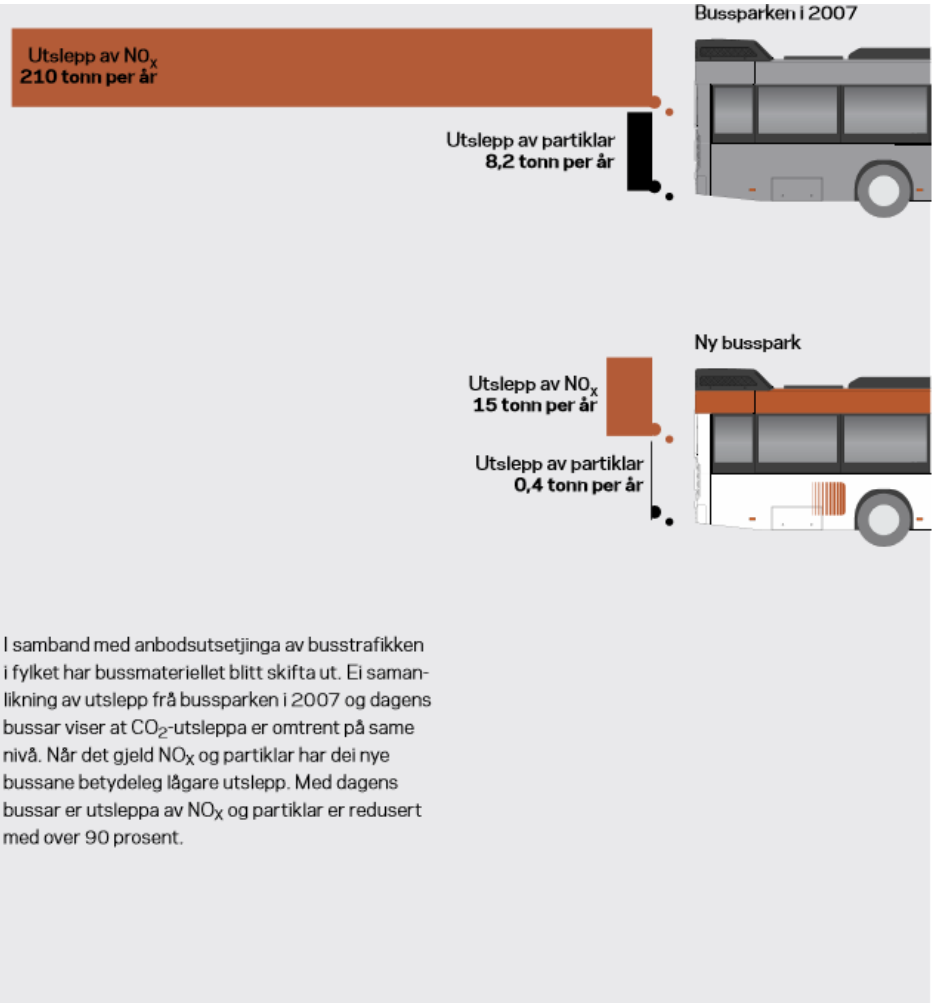

Figure 7. Lower emission at new bus depot in Hordaland.
Source: Miljøstrategi for Skyss, 2014.

ATTACHMENT 5 – More facts from Stockholm

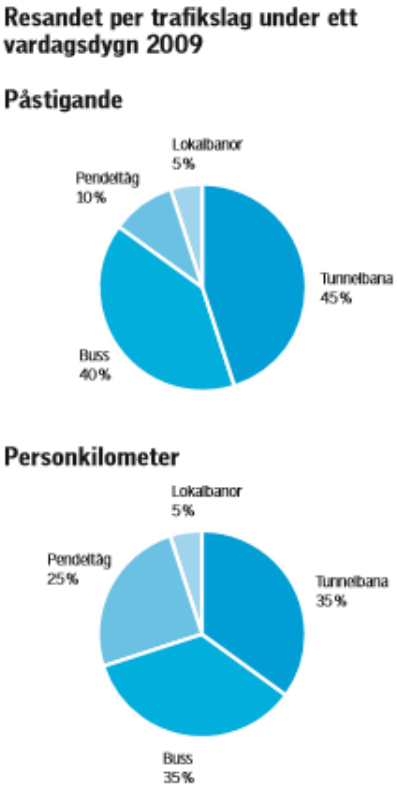

Figure 8. The composition of passenger travelling with public transport during daily day in 2009.
Source: SL Trafikplan 2020.

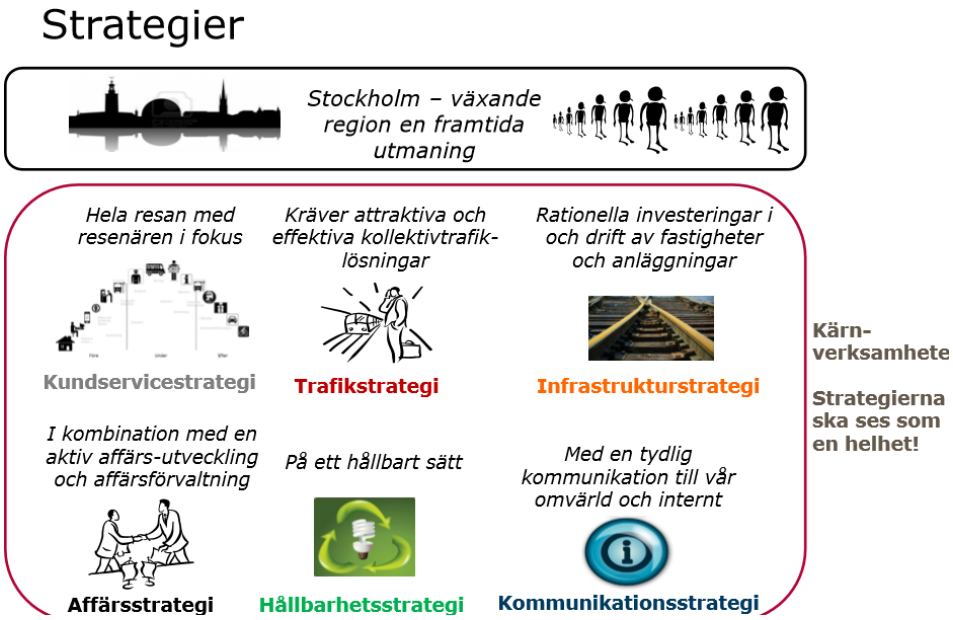

Figure 9. Strategy for public transport in Stockholm.
Source: Kollektivtrafiksatsningar i Stockholm av Stockholm Läns Landsting, 2015.

Trafikförvaltningen
STOCKHOLMS LÄNS LANDSTING

18(39)

RIKTLINJE

Fastställt datum
2016-01-07

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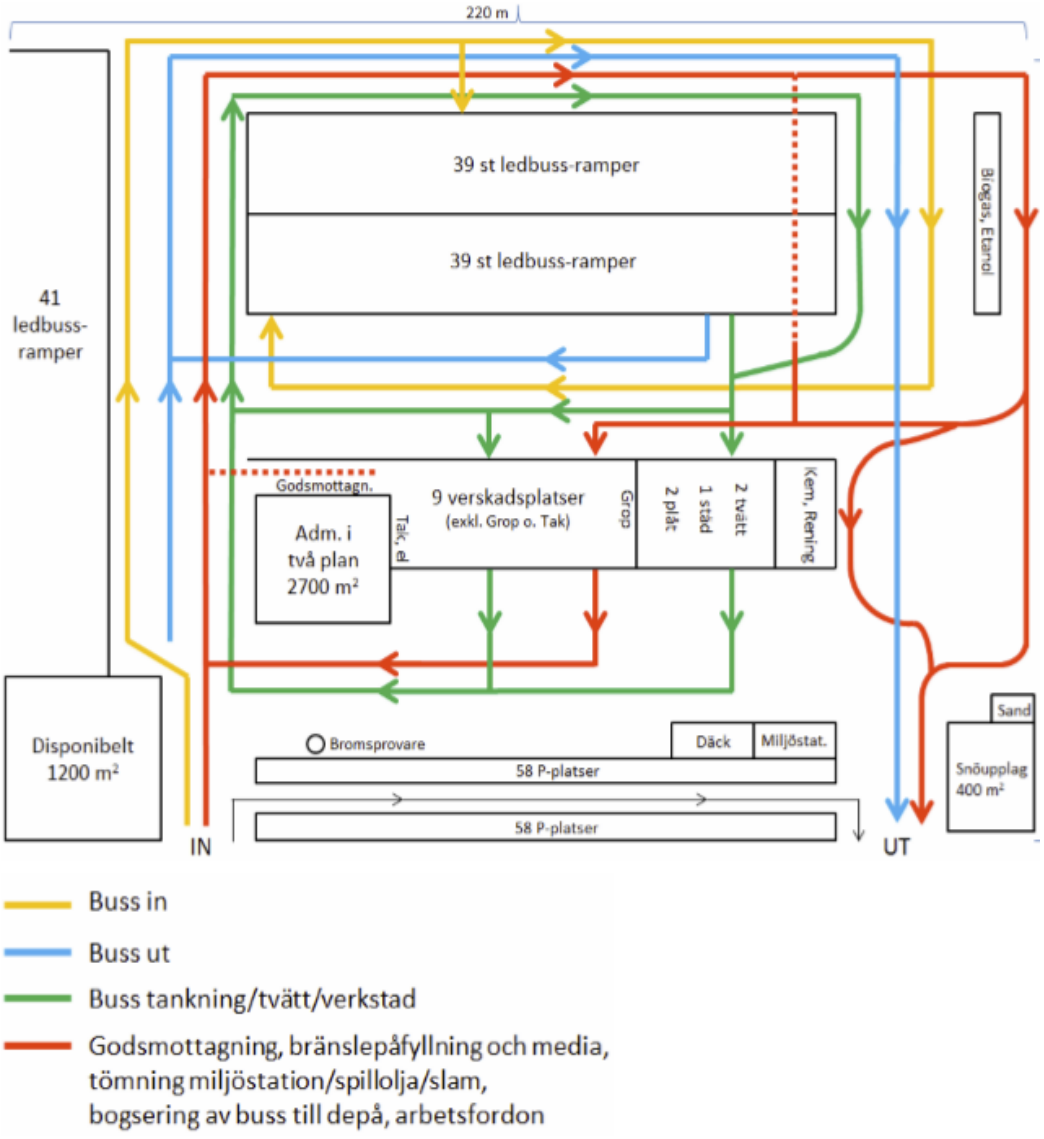


Figure 10. Suggested design and traffic flow in a general bus depot for outdoor placement. Source: Riktlinjer Bussdepå, Stockholm Läns Landsting, 2016.

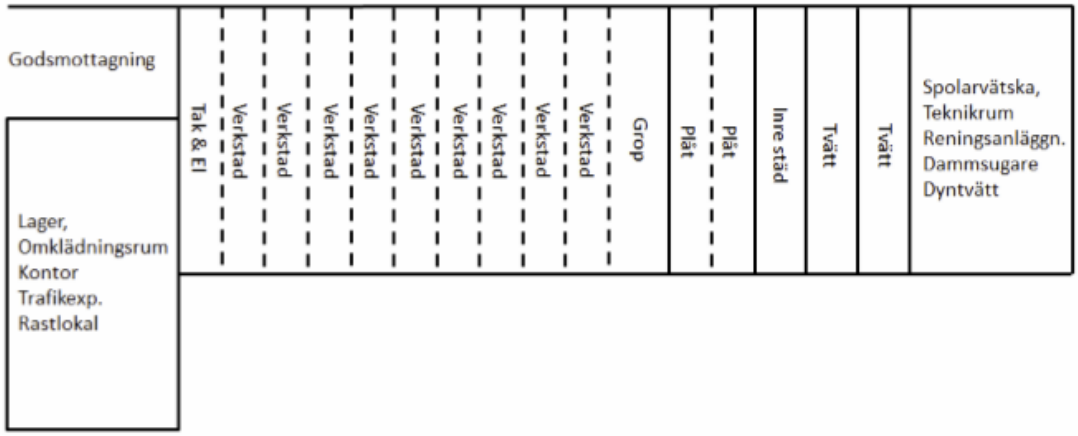


Figure 11. Suggested design and traffic flow of parking for bus maintenance in a depot.
Source: Riktlinjer Bussdepå, Stockholm Läns Ländsting, 2016.

ATTACHMENT 6 – More facts from Trondheim

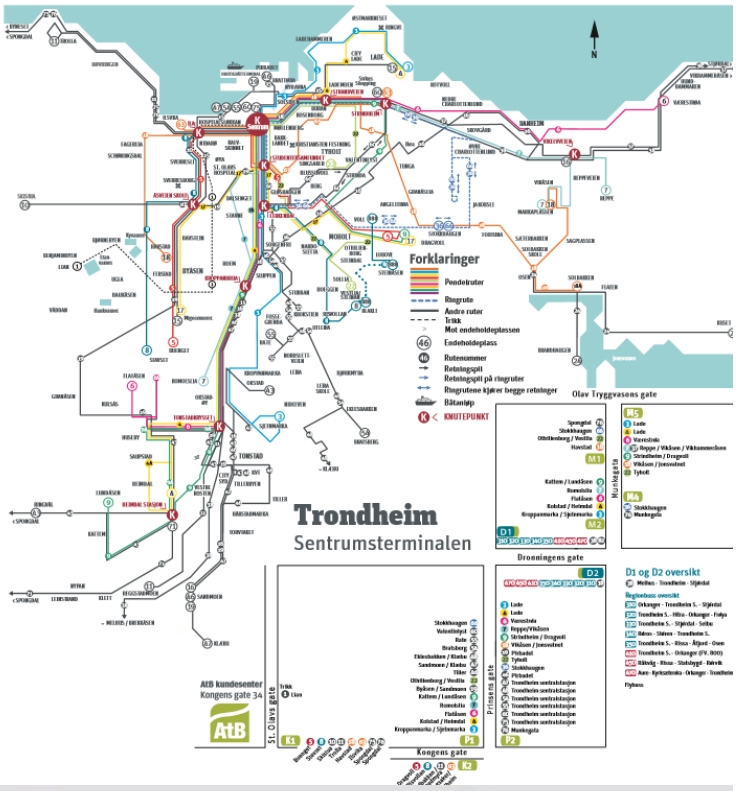


Figure 12. Route structure in Trondheim today.
Source: Atb.

Figure 13. Suggested route structure in Trondheim from 2019.
Source: Stasjonstilgjengelighet Trondheim, Trondheim Municipality, 24.02.2017.

Figure 14. The organization of public transport today in Sør-Trøndelag County.
Source: AtB

Figure 15. The future of public transport in Sør-Trøndelag. What to consider?
Source: Framtidig rutestruktur med superbuss i Stor-Trondheim 2019-2029, 2015.

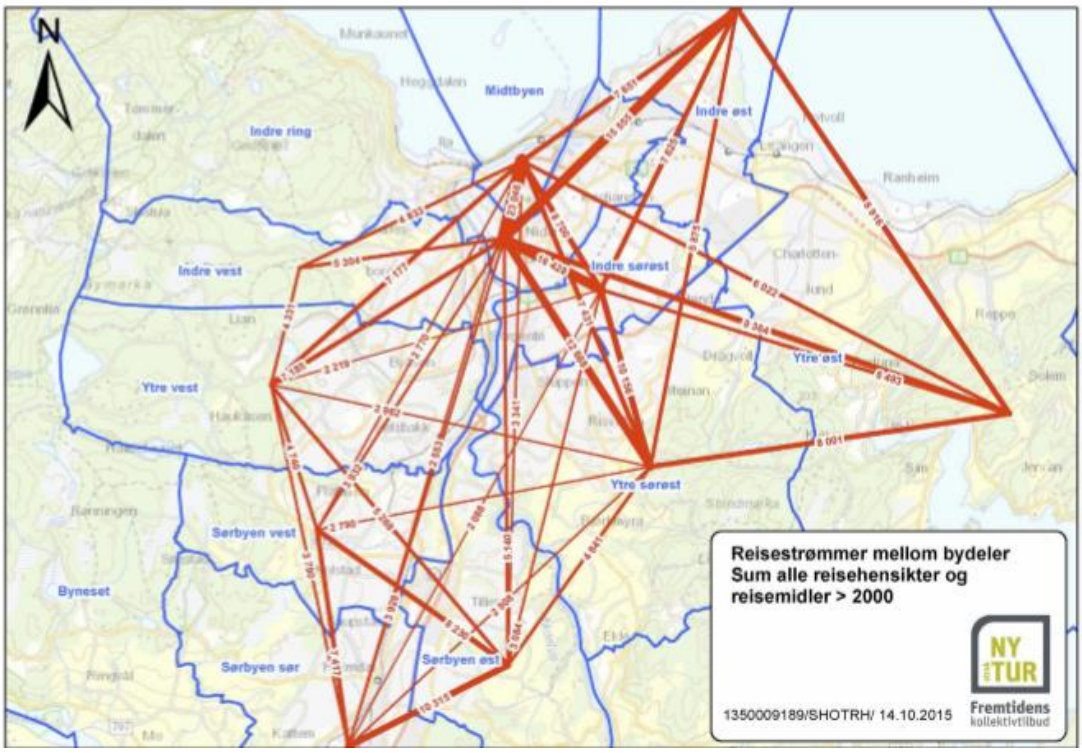


Figure 16. Travel streams between areas in Trondheim.
Source: Framtidig rutestruktur med superbuss i Stor-Trondheim 2019-2029, 2015.

Uttak av masteroppgaven

Studieprogram: Eiendomsutvikling og –forvaltning, erfaringbasert masterprogram

Personopplysninger

Etternavn. Fornavn:

Mjøsund, Natalia Ardanari

Masteroppgavens varighet Netto 40 uker

Uttaksdato: Innleveringsdato: 15.06.2017

Endelig tittel på masteroppgaven

Norsk:
Strategi for etablering av et optimalt bussdepot.

Engelsk:
Strategy to provide an optimal bus depot.

Formål

This master thesis seeks to a greater understanding about the importance of an optimal bus depot in a transport system as well as its requirements to be optimal. The research questions that are raised in this research study are:

- What are the characteristics of an optimal bus depot?
- How do selected regions apply their efforts to provide an optimal bus depot? Oslo, Akershus, Hordaland, Stockholm and Greater Trondheim are chosen as the case study.

Følgende hovedpunkter skal behandles:

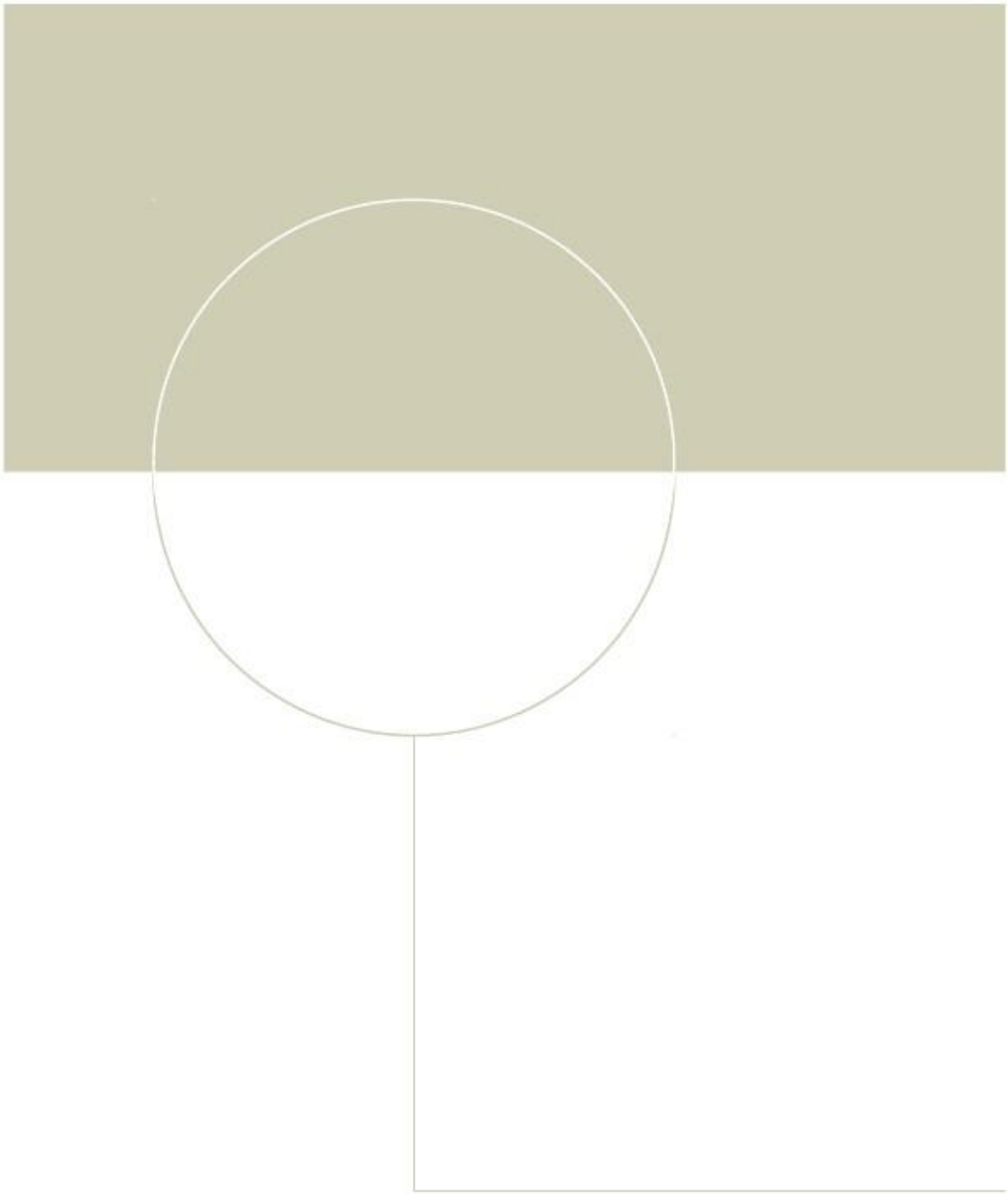
1. Initial tasks in an early phase of a project.
2. Public transport in the future.
3. The new concept of a bus depot and transport politics in the future.
4. Stakeholders.
5. Characteristics of an optimal bus depot.
6. Efforts to apply an optimal bus depot.

Underskrifter	Dato
Student: Natalia Ardanari Mjøsund. Nataliamjøsund	23.08.2016
Veileder/faglærer: Nils Olsson. Nils	
Leder for studieprogrammet:	

Postadresse
7491 Trondheim

Besøksadresse
A. Getz vei 3

Telefon +47 73 59 50 98
Telefaks +47 73 59 50 94
Org. nr. 974 767 880



NTNU

Det skapende universitet