Cooperation of Transport Modes and Structural Plan

--- A case study in Copenhagen

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Supervisor: Sven-Allan Bjerkemo
Author: Jing Lu
Abstract:
Sustainable transport is a key factor of sustainable development. In Copenhagen, it is very interesting that the urban structure and transportation network correspond to each other to obtain sustainable transport.

This thesis work contains four parts. I start with an illustration of relevant theories about sustainable development and sustainable transportation, which provide guidelines and principles for my further research. Then, I begin to collect official documents, information, and statistics from Internet and Greater Copenhagen Authority. In the third stage, I focus on the case study of Copenhagen's urban structural plan and transport modes. During this period, I have visited Copenhagen and finished a lot of relevant research by myself. At last, based on the theories and analyses above, a summary of combing cycling and public transport in urban structural plan has been carried out. The main questions of my thesis research have been solved.

In general, I find that combining cycling and public transport is related to urban structural plan and sustainable perspective.

Key Words:
Sustainable perspective, Copenhagen Structural Plan, Cooperation, Public Transport, Cycling
Acknowledgement:

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Introduction

Sustainable development has become a wide-ranging topic from local to global scale for such a long period of time. It can be applied to almost every corner of life and mainly focus on the aspects of environment, economy and society. In current plan, there is a significant composing of sustainable development, which is Sustainable transportation.

Greater Copenhagen Region (GCR) is located on an island named Sjaelland, in the eastern part of Denmark, including City of Copenhagen, City of Frederiksberg municipalities, and the counties Copenhagen, Frederiksborg and Roskilde. In this area, the urban area covers approximately 28%. In Nordic area, the status of Greater Copenhagen Region GCR is significant. It plays a leading role among the Nordic countries.

There are two important plans which impact Copenhagen’s structural plan on urban and regional scale. The “Finger Plan” has existed in this region since 1947. Because of the rapid development of urban area, this plan has been evolved for many times. It shaped the main outline of the Greater Copenhagen Region. This plan said that the urban development should be along the suburb railways from city centre to the major five market towns out of Copenhagen city centre. The finger plan also mentioned that the area around the station should be built and developed densely. On the other hand, the regional plan is also a key component in the Copenhagen plan system. There is an important policy named “Proximity- To- Station” Location Policy which impacts Copenhagen’s urban development as well as transportation.

Transportation is a fundamental concept in various urban and regional plans. In recent years, transportation is planned to meet basic principles which drive the transport to benefit our world on several aspects. Sustainable transportation is a key issue of sustainable development, and is used to describe modes of transport, and systems of transport planning.

The authorities and communities encourage citizens to use public transport system to instead car using. As we know, private car using causes a lot of environmental, economic and social problems. Using public transport, in some way, can solve and reduce the problems. The public transport in Copenhagen is composed of metro network, train network and bus network. They cooperated with each other well to provide high quality service for people.

Copenhagen is well-known for its combination of cycling and public transport. There is a large number of Copenhageners to choose bicycles and public transport as the transport tool to go to work and travel. As the number of using
cyclists and public transport is increasing, the number of private automobiles is decreasing. This is a phenomenon to expect the sustainable transportation.

My main research questions in my thesis are:
1) What is the individual definition of sustainable development and sustainable transportation?
2) What urban and regional plan does it exist in Copenhagen and how do they work?
3) Why should transport modes cooperate and how?
4) Why various transport modes integrate with urban and regional plan, how?
Chapter 1: Theoretical Perspective

1.1 Sustainable Development

1.1.1 Sustainable Development Related to Society

Related to the development of our society, sustainability has been regarded as a guideline for a long time. How can we define sustainable development in our society? World Commission on Environment and Development stated that the general definition emphasised the economy in sustainable development. When we are developing the economy, we should consider the needs of our future generations. In other words, we can not compromise their interest to develop our economy. (WCED, 1987)

Robert Goodland argues that sustainable development should be based on three components. They are Environment, Economy and Society. The sustainable development can be achieved when the three components are balanced and weighted equally at the same time. (Image 1-1-1) He also mentioned that sustainable development stressed the economy. In our current society, there is a conflict between the development of ecology and economy, which is not adequate to resolve the conflict by just improving economy. Considering on the three aspects can help us to solve the conflict. (Robert Goodland, 1995)

Image 1-1-1: Three components of sustainable development
(Source: by The Centre for Sustainable Transportation. Edit: by author)
World Commission on Environment and Development argued that there were a lot of ways to protect our world to be sustainable, and the participants got totally diverse consequences at the same time. In human society, there are environmental, social, economic, ecological, cultural, ecological, political and legal dimensions and indicators for sustainable development which enquire some attention. Our society can be built to be more harmonious through these indicators. (WCED, 1987)

Meanwhile, the indicators of sustainable development should be valued and estimated on developing views to encourage these indicators to develop constantly. Why? The problems of our world are changing continuously, but the information transmitted by the certain indicators is limited. They are not adequate to help us to solve the current problems. So developing these indicators constantly and steadily is necessary. This also indicates that when we face the problems in society, we should stand on the view of constantly changed views. (WCED, 1987)

1.1.2 Sustainable Development in EU

Sustainable development has been regarded as a key issue for a long time. According to the Review of the EU Sustainable Development Strategy—Renewed Strategy, 2006, sustainable Development stands for meeting the needs of present generations without jeopardizing the ability of future generations to meet their own needs. In other words, sustainable development is to improve the quality of life for everyone, not only the present generation, but also the future generations.

In European Union, firstly, sustainable development is a guideline and principle for setting out all the policies, and every activity should also follow it. Secondly, this directs guide us to develop our world on the both views of short-term and long-term, and also regard on social, economic and environment aspects. Thirdly, the target of sustainable development is to improve the quality of life for both of current and future generations by creating a high level of security, equality, freedom, democracy, education, health protection and employment and so on. At last, we should respect cultural diversity. (Council of the European Union, 2006)

In European Union, sustainable development is not just adopted in policies. It is also taking up as guidelines and principles in the people’s daily life. In the process of making economic and social decisions, they are also crucial principles.

The climate change and new energy, sustainable consumption and production,
natural sources conservation and use, social inclusion and people's migration, global poverty, health protection and sustainable transportation are the major challenges that EU are facing with. Until 2010, the actions of EU is regarding on dealing with these challenges. (Council of the European Union, 2006)

1.2 Sustainable Transportation

1.2.1 Sustainable Transportation in Sustainable Development

According to the report of Definition and Vision of Sustainable Transportation by The Centre for Sustainable Transportation, there are three components of sustainability. They are environment, economy and society, and the sustainable transportation also involves three factors. Sustainable Development and sustainable transportation are both involved to satisfy the requirements of present generation without reducing the profits of future generations. (The centre for Sustainable Transportation, 2002)

1.2.2 What is Sustainable Transportation?

What can be regarded as sustainable transportation system? It should meet some requirements. Firstly, the emission of pollution should be reduced, the consumption of natural sources should be limited, the use of land and non-renewable sources should be minimized and the noise should be reduced. Meanwhile, maximizing the use of clean and cycled resources is also quite important. Secondly, the system can afford various choices of transport modes. Thirdly, the transport system should be safe, healthy, secure, comfortable, efficient and convenient.

1.2.3 How can transportation become more sustainable?

From the perspective of sustainable development, transportation systems can be developed more sustainable on three factors of environment, economy and society.

1) Guidelines on Environmental Aspects:
   ● To Reduce the Use of Natural Resources and Land
     Most of natural resources and land are non-renewable. Ensuring the use of these non-renewable sources efficient is necessary for preserving the diversity of ecology and environment.
   ● To Prevent from Pollution
The pollution made by transportation is bad for people’s health, the world climate and ecological diversity. The sustainable transportation needs should be satisfied without pollution emission.

2) Guidelines on Economic Aspect:
Transportation systems must transport people and goods as rapidly as possible. The rapid transportation can save economic costs as well as environmental and social costs. Meanwhile, people can pay less for the transportation.

3) Guidelines on Social Aspect:
- To Improve capacity of integrating with Diverse Planning
The transport should integrate with diverse planning. The related departments and authorities have responsibility to combine transport planning with municipal, regional and national plans.

- To Ensure Safety and Health
When the related departments and authorities design and operate the transportation systems, they should make sure the systems to protect public health and safety. Meanwhile, ensuring the transport systems can improve the quality of life.

- To Improve capacity of Access
The transportation system is aim to meet the needs of transport people and goods from one place to another. It should be accessible to public.

- To Improve Capacity of Equity
All people, including women, the disabled, and the poor, enjoys the equal right to use the transportation systems. It should be designed and operated without discrimination. Meanwhile, the systems can meet all the basic needs of transportation in the regional and interregional areas.

- To Improve Responsibility of Individual
Everyone has responsibility to our environment, economy and society. In transport, each citizen has responsibility to choose a more sustainable transport mode to reduce the consumption of sources and the polluted emission.²
Chapter 2: Urban and Regional Structure of Copenhagen

In Greater Copenhagen Region, related planning and policies of urban and regional structure, it created a comprehensive and advanced system of co-operating transport modes, urban and regional development. The urban and regional structure is aimed at meeting people’s need on a sustainable way.

2.1 Great Copenhagen Region

2.1.1 Geographic location of Great Copenhagen Region

Greater Copenhagen Region (GCR) is located on an island named Sjaelland, in the eastern part of Denmark. Joanna Chew mentioned that Greater Copenhagen Region consists of: City of Copenhagen, City of Frederiksberg municipalities, and the counties Copenhagen, Frederiksborg and Roskilde. (Image 2-1-1 Joanne Chew stated that, in this area, the urban area covers approximately 28%. In Nordic area, the status of Greater Copenhagen Region GCR is significant. It plays a leading role among the Nordic countries. It is regarded as a natural gateway to the Baltic countries (Norway, Sweden, and Finland) from the mainland of Europe. (Joanna Chew, 2005)

Image 2-1-1: Greater Copenhagen Region
(Source: Joanna Chew, 2005)
2.1.2 Green Planning in Greater Copenhagen Region

The green space is regarded as a crucial factor in the Greater Copenhagen Region. The Greater Copenhagen Region is shaped like a hand with five fingers, and there is a significant planning in this region to create a better environment. The Greater Copenhagen Region is also Green Structure Plan

1) Outline
The area of Greater Copenhagen Region is about 2870 km². It has 50 municipalities. There are approximately 18 million people living in and almost 1 million workplaces in this region. Elsinore, Hillerød, Frederikssund, Roskilde and Køge are the five provincial towns in the Greater Copenhagen Region. (Image 2-1-2)

Image 2-1-2: Greater Copenhagen (Source: Niels Ostergard, 2007)

Greater Copenhagen comprises one cohesive housing and labour market. The areas between individual municipalities are covered by green space. (The Ministry of the Environment, 2007)

2) Copenhagen's Green Structure Plan
Green Structure Plan emphasises the statues of green space in the Greater Copenhagen Region. It aims to improve environment and the quality of life for
the inhabitants. This plan is to make sure that people can access to green spaces conveniently and possibly when the city area is developing dramatically, including parks, natural and undeveloped areas and open spaces. Meanwhile, this plan intends to bring some new green elements into the current green space system. In other words, it means that there will be more green space between the neighbours in this region.

The key guideline of Green Structure is integrating entertainment and better environment in the city development. The Green Structure Plan mentioned that the factors of cultural, historical and ecological should also be considered in planning.

There are some key principles of this plan, they are: urbanization should be develop in the slender fingers; the spaces of undeveloped land should be preserved between fingers; the towns out of the city should be developed like peals on the strings; the habitants should live in the area where is close to green spaces; and the slender fingers should be developed with public transportation.

**2.2 Urban Structure Plan in Copenhagen**

**2.2.1 Finger plan**

“The main principle of the Finger plan implying that the layer-upon-layer growth should stop and that most of the future city should develop in narrow town fingers along exiting and future railways”. (John Jørgensen, 2008)

Greater Copenhagen Region is operated as a one city. The current finger structure of Greater Copenhagen Region originated from the first Finger Plan in 1947. (Image 2-2-1) Until now, all the municipal planning in this region is still effected by the plan. Major towns outside of the Copenhagen city are settled along the slender fingers which are connected by public transportation. (Image 2-2-1)

In August 2007, the first Finger Plan 2007 is carried out in the Greater Copenhagen Region. It is a national Plan which directs the development of the region, and it set up the framework for urban development and transportation development. It stated that, when area if this region is developing,
transportation should be developed at the same time.

2.2.2 Evolution of the Finger Plan 2007

In 1947, the first finger plan was carried out to direct the urban development. The main contents in the first finger plan are:

- Establish the network of radial roads.
- The urban development should be in the fingers, and should be followed by the network of suburban railways.
- The green space should be preserved between the radial fingers.

Since 2007, the finger plan has carved up the urban area and suburb area clearly. The plan creates a good condition for developing public transportation. Meanwhile, it is also helpful to the future urban plan in the individual municipality in the region. (Danish Ministry of Environment, 2007)

The finger plan has a long history in Copenhagen, and has continuously developed for around 70 years, from 1939 to present. Till today it has been improved so much.

2.2.3 Structure of Copenhagen Planning Act

Niels Østergård mentioned that the Planning Act divides Greater Copenhagen into four geographical zones with different planning opportunities. (Image 2-2-2)

<table>
<thead>
<tr>
<th>Four Zones:</th>
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<tbody>
<tr>
<td>a—Centre urban region</td>
</tr>
<tr>
<td>b—Outer urban region</td>
</tr>
<tr>
<td>c—Green space between the fingers</td>
</tr>
<tr>
<td>d—Rest of Greater Copenhagen</td>
</tr>
</tbody>
</table>

Image 2-2-2: Four Zones of Finger Plan (Source: Niels Østergård, 2007)
• a--- In the centre urban region, the development of urban area should be limited in this zone. Meanwhile, the urban development should stress that developing of urban area must be followed by public transportation service.
• b--- In the outer urban region, the development of urban area should be limited in the existed zone. Meanwhile, the urban development should stress that developing of urban area must be followed by public transportation service.
• c--- The green space between the slender fingers should be preserved, and can be protected as farmland and recreational area for the habitant.
• d--- In the rest of Greater Copenhagen, this area in this zone can be connected with other zones by convenient transport. The municipalities in this zone can cooperated with each other to complete the urban development, and the communities in these municipalities can also developed with the municipal centre. (Niels Østergård, 2007)

2.3 Regional Structure Plan in Copenhagen

2.3.1 Evolution of Regional Structure Plan

In 1947, the famous finger plan established in Copenhagen. This plan regulated the urban development should be along the suburb railways from city centre to the major five market towns out of Copenhagen city centre. The finger plan also mentioned that the area around the station should be built and developed densely.

With the rapid development of the city centre, the demand of secondary centres and single family housing was increasing in the early of 1970s. The city centre suffered hard pressures. In 1989, a new regional plan was carried out in the Greater Copenhagen Region. This plan mentioned that the secondary centres should be built and developed in the fingers out of Copenhagen city centre. Meanwhile, there is a policy in the plan mentioned every secondary centre should build a transport junction, and the workplaces, factories and enterprises should locate at these transport junctions. This policy is called "Proximity- To- Station". It became an important item in the later regional plan.

Meanwhile, some related policies in the plan mentioned the excessive buildings and road networks should be built in the centres. In the city centres, the car use is limited by increasing parking fee and decreasing the number of parking spaces. Walking, cycling and public transport are encouraged with creating more pedestrians, cycling paths and public transport modes. (Peter
After around seven decades, the finger plan has been extended. The fingers are ended at five provincial towns, which are away from the Copenhagen city centre for 30-40 km. There are a lot of secondary centres along the radial railway lines from the Copenhagen city centre to the five provincial towns.

Image 2-3-1: The Evolution of Regional Structure
(Source: Peter Hartoft- Nielsen, 2002. Edit: by Author)

2.3.2 “Proximity- To- Station” Location Policy

There is an authority responsible for the planning in the Greater Copenhagen Region, which is named Greater Copenhagen Authority. Since 2001, this authority is responsible for regional planning in the whole Greater Copenhagen Region. As a policy in regional plan, it should be implemented in the whole region by Greater Copenhagen Authority. Meanwhile, every municipal authority in this area should also adopt the policy in the municipal planning.

Peter Hartof- Nielsen stated that the main contents of the Proximity- To- Station Policy are followed: (Image 2-3-2)
Firstly, work places should be located within 600 meters from suburb railway stations. It is to ensure that the workers can get the workshops within 10 min by foot.

Secondly, residence areas should be set within 2000 meters from the stations. It aim to make sure that the inhabitant can achieve the destinations of station, home or food shop by foot or by bike.

Thirdly, public service and commercial service should be settled close to station.

Fourthly, the green space between the fingers can be achieved easily.

This policy impacts the development of towns, secondary centres and municipal towns in the radial fingers. (Peter Hartoft- Nielsen, 2002)

2.3.3 Sustainable Impact of “Proximity- To- Station Policy”

The “Proximity- To- Station” Policy benefits the region from the sustainable perspective. Why? Because of the objectives of the policy involves the basic three factors (Environment, Economy and Society) of sustainable development. This policy is aimed to encourage people to walk, cycle and use public transport to instead of using private cars. This can help to relieve the city’s pressure and pollution from transport. On the other hand, this policy limits the land use of undeveloped area between the fingers, as well as preserves the green space between the fingers. Further more, this policy benefits everyone in this region, and it makes the functions of city to be accessible for every inhabitant. (Peter Hartoft- Nielsen, 2002)

Peter Hartoft- Nielsen argues that a lot sustainable benefits are achieved because of this policy. For example, the average car use by every employee reduced for approximately 10 km per day. (Figure 2-3-3) The daily car use by every resident reduced for around 5 km.
This statistics show that as the work places closer to stations, the car use will be less. It indicators that the employees prefer to walk, cycle and use public transport. It is helpful to relieve the traffic pressure to the city centre. Especially on the traffic peak time, the pollution from traffic reduced for 6%. According to statistics, the total car use in the region reduced for 2%-3%. (Peter Hartoft-Nielsen, 2002)

2.4 Conclusion

In Greater Copenhagen Region, related planning and policies of urban and regional structure, it created a comprehensive and advanced system of co-operating transport modes, urban and regional development. The urban and regional structure is aimed at meeting people’s need on a sustainable way.

On urban scale, the Finger Plan since 1947 has impact the urban development for around 70 years. This is a basic and overall plan for Greater Copenhagen Region. Every sub-plan should follow this plan. On regional scale, there existed a large number of regional plans in Greater Copenhagen Region. These plans guide and limit the development of Copenhagen city centre, every secondary centres, municipalities and provincial towns. Especially, there is a policy in regional plan which is named “Proximity-To-Station” policy. This policy concerns about the stations location and the management of the areas surrounding the stations. All these plans of urban and regional structure benefit
the development of Copenhagen. These plans related to sustainable
development. Since now, this region has gotten a lot of sustainable benefits
because of them. These plans are the vital foundation for the development of
sustainable transportation. The Finger Plan and regional plans have stressed
the transportation development.

Furthermore, these plans should be implemented in the whole Greater
Copenhagen Region by various authorities and departments, such as: Greater
Copenhagen Authority, municipal authorities and so on. Meanwhile, these
authorities should cooperate with each other well.
Chapter 3: Related Transport System to Planning in Copenhagen

John Jorgensen argues that, in Copenhagen, transport system should meet the basic need to transport, and the need of accessing to every mode of transportation easily. Every inhabitant can go to the green space by these modes conveniently.

3.1 Copenhagen’s Transport Network

Niels Tørslev mentioned in the city of Copenhagen, the transport system is composed by a variety of modes, such as bicycle, bus, metro and train and so on. The public transport plays a vital role in the traffic system. There are around 1,200 bus stops and 40 stations for metro and trains.

For the reason that the ability of accessibility is improving, the number of using public transport network to travel is increasing in recent years. For example, according to a report by Greater Copenhagen Authority, at the central location of Copenhagen, there is a 34% increase in passengers on the public transport network. (Joanna Chew, 2005)

In Copenhagen there existed a very important mode in the traffic system, which is cycling. Cycling acts as a feeder to public transport, and plays a key role of the overall transport.

3.1.1 Bicycle network

In Copenhagen, mode of cycling is regarded as complementary modes to public transport, and playing a crucial role in Copenhagener’s daily life. To transport system in Copenhagen, this mode is regarded as a key component. Today the bicycle road in Copenhagen is almost 390 km. This bike network is compromised by 320 km of cycle tracks, 40 km of green routes and 15 km of cycle lanes.

3.1.2 Bus network

According to a report by Urban Sustainability Study Group in 2004, there is around 25% of Copenhageners using the bus system everyday. Public
transport mode of bus enjoys a long history and the bus routes connect almost all communities in Copenhagen. (Image 3-1-2) There are different kinds of bus operation in Copenhagen. They are the normal bus, A-bus, S-bus and Harbour bus. These kinds of buses are cooperation with each other well to meet the need of people.


3.1.3 Metro network

Copenhageners are served by two Metro lines which are named by M1 and M2. The Metro network is composed of around 28 km metro ways and 22 stations. The metro system started in 2002. It is cross through the Copenhagen city centre. It connects the city centre with Frederiksberg and Amager. (Image 3-1-3-a & 3-1-3-b) According to statistics, it carried 50,000,000 passengers in 2009.³
3.1.4 Trains network

There are two types of trains to be used in Copenhagen, which are the red S-trains and regional trains. (Image 3-1-4) The red S-trains take passengers in Copenhagen and North Sealand. The frequent regional trains connect
Copenhagen and other parts in Denmark. \(^4\)

Image 3-1-4: Routes of Trains
(Source: http://www.wandawanders.com/content/view/106/76/)

The S-trains is regarded as suburban train which connects the city centre with other secondary centres, towns and municipalities in Greater Copenhagen Region. Since the first line of S-train was built in 1934, the S-train has served Copenhageners for almost 80 years as the heart of public transport in Copenhagen. The S-train carries more than 350,000 people everyday.\(^5\)
3.2 Improving Cooperation with Different Transport Modes

On the sustainable views, public transport system focuses on co-operation instead of competition. One of the long-term aims is to reduce journey time from door to door by 10-15%. It requires a good cooperation between different kinds of transport mode.

3.2.1 Cooperation in Public Transport System

In Copenhagen, public transport system contains various modes of metro, train and bus. Although they are owned by different companies, they cooperate with each other well.

As we know, there are two new metro lines in Copenhagen which plays a crucial role in public transport system now. The driverless light metro was incorporated into the total range of public transport service. It integrated with local trains and buses, and the S-train system, for example:
- There is a system which is composed of Copenhagen Metro and bus network. The system uses interchangeable tickets on the metro and bus in Copenhagen.
- In Copenhagen, the rail system is very important to Copenhageners’ daily life. It serves more than 500,000 people per day. The bus terminals are usually located near the railway stations, and also the Metro stations.
- There are 85 S-train stations and 22 Metro stations in Copenhagen city. Most of the Metro stations are integrated with the S-train station. Passengers can take the modes of Metro and Train at some common stations without long distance.

All the methods above can improve the public transport to be more efficient and help people saving time. (Image 3-4-1)
3.2.2 Cooperation of Cycling and Public Transport

Bicycles and public transport provide an alternative choice for passengers, who plan to have long-distance trip by motor cars. Allowing bicycles on the suburban trains and metro is very important. There are 5,000 cyclists bringing a bicycle on board train every day. (Jensen, 2006) Meanwhile, it is important to secure bicycle parking at train stations. (Image 3-4-2-a & 3-4-2-b) For example, the central station of Copenhagen offers this service of locked and covered parking for 10 DKK for the first day and 5 thereafter. So people feel safe riding to the train station and leaving their bikes there. Additionally, there are some
repair and rental shops located next to the stations and parking. These methods can improve the rate of cooperation between cycling and public transport.

Image 3-4-2-a & 3-4-2-b: Bicycle Parking at Copenhagen Central Station
(Source: Image3-4-2-a: http://sf.streetsblog.org/2009/12/17/hopenhagen-or-carbonhagen-well-still-be-cycling-regardless/
Image 3-4-2-b: http://www.travelstring.com/denmark-copenhagen/, Edit: by author)

3.3 Cooperation of Transport modes and Plan

Today the public transport system in Copenhagen consists mainly of suburban commuter trains and buses, serving a region of 1.8 million people. Highlighting the development of transport system, especially the development of public transport system is more important in the plan. It makes this region to be more attractive. (UITP, 1998)

Public transport should be considered as a key issue in every urban and regional plan and transport plan. Meanwhile, the bicycle is also an unforgotten mode in every planning in Copenhagen. There exist a lot of related policies to encourage the citizens to use public transport and bicycles to alternate private motor cars.

3.3.1 Cycling

1) Soft Plan
Bicycle is a type of sustainable transportation mode. It can be operated without any pollution and non-renewal resources. In Copenhagen, cycling is a vital component of transport system. This city is regarded as a cycle city. What approaches does Copenhagen use to improve the bicycle use?
A sense of security and safety, effective travelling speed as well as the experience of cycling is proved to be principles of cycling quality. The quality of bicycle is significant to Copenhagen's transport.

a) Quality of Security
According to the Cycle Policy 2002-2012, there are about half of people who reject bicycle as a transport mode feeling the cycling environment in Copenhagen is not secure. As a result of this, they choose public transport or other transport modes primarily, and do not cycle at all.

b) Quality of Safety
In 2000, the Copenhagen related department registered 168 serious casualties of cycling. The number of cyclists that were killed over the past 10 years varies from 3 to 9.4 cyclist died in 2000. When the cyclists increase, the risk of the cyclists is dramatically reduced. The number of cyclists is increasing in Copenhagen, but the casualties have not rising correspondingly.

c) Quality of Health
Cycling gives benefits to the cyclists' health by about 4 hours of moderate exercise per week. Many Copenhageners can achieve this by cycling to work. The physical benefits which are brought by the moderate excise of cycling are reduction of blood clots, keeping one’s general condition and mental well.

Air pollution is also a potential factor to cause health risk. As the number cycling in Copenhagen is increasing, the car use will be decreasing correspondingly. Then the emission of the autos will be less. The health risk may be reduced.

d) Quality of Cycling Speed
Travelling speed for cyclists is crucial in the competition between means of
transport. This is reflected in the Bicycle Account, which mentioned the number of unsatisfactory of bicycle track width is increasing. The narrow bicycle tracks would reduce the speed of travelling speed by bike, and increase the traffic congestions. Currently, there are about two or three places where the cycling tracks are narrow.

e) Quality of life
Experiencing the city and its life also play a role when people choose a transport mode. The natural environment is changing constantly, and the different seasons make the city more attractive. When people are on the way to someplace by bike, he or she is much close to the city. This experience will enrich the life.

2) Hard Policy
Cycling in a city need have other facilities besides bicycles, such as: cycle track and parking area. These infrastructures need some spaces, and relate to some specific polices in plans.

Cycling is integrated into all the levels of the Copenhagen’s urban and regional plan. In 1947, the municipal authority has proposed to develop cycling tracks in Copenhagen. Then, in 1980 Copenhagen municipality agreed to create an advanced cycling network. In 1997, encouraging Copenhageners to use bicycles and public transport to instead of private cars has been stated in a plan, which is named by traffic and environment plan. Further more, there is a series of plan and sub-plan of increasing cycling, which has been established since 2000.

There is a policy called Cycle Policy 2002- 2012 in the sub-plan in Copenhagen which sets five objectives should be achieved. (Table: 3-2-2)

<table>
<thead>
<tr>
<th>Objectives in Cycle Policy 2002-2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cyclists feel safe of cycling</td>
</tr>
<tr>
<td>2. Cycling risk of serious injury and death</td>
</tr>
<tr>
<td>3. Cycling speed &gt; 5 km/h</td>
</tr>
<tr>
<td>4. People cycling to work</td>
</tr>
<tr>
<td>5. Quality of cycle track</td>
</tr>
</tbody>
</table>

Table: 3-2-2
(Source: Cycle Policy 2000- 2012; Edit: by Author)

To fulfill these aims, the city of Copenhagen has established several complementary plans, such as: cycle track priority plan (2001-2016).

a) Cycle Track:
What is Cycle track? “Cycle track is the infrastructure that combines the user experience of separated path with the on- street infrastructure of a bike lane,
separated from vehicle travel lanes, parking lanes and sidewalks, provides space exclusively for bicycles.” --- Alyse Nelson & Valle Scholar (Image 3-2-1-a & 3-2-1-b)

There are some policies of combining land use planning and bicycle in Copenhagen. Policies such as placing stop lines 4 meters back from crossing pedestrian to give cyclists priority at intersections or providing cyclists with two tracks for the two opposite directions on streets can improve the quality of cycle infrastructure and the number the bicycle users. (Alyse Nelson & Valle Scholar, 2007)

![Image 3-2-1-a: Cycle Track (Source: by Mia Birk)](Image 3-2-1-a)

![Image 3-2-1-b: Cycle Track in Copenhagen (Source: by Mia Birk)](Image 3-2-1-b)

- **Cycle Track Priority Plan**
  A Cycle Track Priority Plan 2001- 2016 (Municipal Council Resolution 2001) in the city of Copenhagen has been established in order to create the network of cycle tracks. In this plan, there are a lot of solutions to cyclists have been edited. In the city of Copenhagen, there are approximately 70 kilometres new cycle tracks and lanes that will be established. According to the plan, 51 km of “reinforced cycle lanes” and some other cycle tracks are going to be done in the next 15 years. (Image 3-2-1-c)
Plan for green cycling routes

The plan for green cycling stated there would be about 100 km of green cycling routes established when the network was completed. There are 21 routes to compose this network. This plan integrates the walking pedestrians and cycling tracks together. The 37 km of existed green routes through the city will be reinforced. The routes inside of the inner circle of the city will be regards as the key elements. (Image 3-2-1-d)
b) Bicycle Parking Plan
A plan for bicycle parking will be developed to determine the need for more parking spaces in the city. The demand for bicycle parking should be shaped into different forms according to the requirements. Since more bicycle parking is required at train stations, shopping hubs and residential areas. In the urban planning, the planners should be responsible to the planning for the parking areas.

3.3.2 Public Transport

1) Metro:
In current urban and regional plan, Ørestad is a crucial area. This area is located on Amager Island. It is about 5 km away from of city centre, and is close to the Copenhagen airport. However, this area is still undeveloped before 1990s. Why? Because of this land is used to military purpose. Now, this area is regarded as the new urban centre. This change is contributed of the new transport mode--- Metro. (Image 3-2-2-a) The area is affected by the metro deeply, and is developed dramatically. (Image 3-2-2-b) Since the Metro was operated in October 2002, the land has been shaped into different kinds to meet diverse demand. The land use has been divided into 20% retail, education, culture, leisure facilities and service, 20% residential and 60%
commercial. (Goran Vuk, Søren Boysen, etc., 2004)

Image 3-2-2-a: Metro in Copenhagen (Source: By author)

Image 3-2-2-b: New land use along Metro route (Source: By author)

2) Train:

The S-train which is run by Danish State Railways (DSB) is planned and designed on the Finger Plan in Greater Copenhagen Region. The train routes are planned to in the radial fingers to connect the Copenhagen city centre, secondary centres and provincial towns. The railways of S-train are established in parallel with the urban sprawl. (Imagine 3-2-2-c& 3-2-2-d)

Image 3-2-2-c: Copenhagen's development (source: John Jøgensen)

Image 3-2-2-d: S-train routes in Greater Copenhagen Region (source: http://www.dsb.dk)
3.3.3 Related Plan of Combining Cycling and Public Transport

1) City Plan 2001
If the transport system in a city is not flexible and sufficient, it still can not meet people’s need of transport. Although cycling and public transport are key components of transport system, in Copenhagen’s City Plan 2001, there are some proposals have been edited, which is to combine cycling and public transport easily. As a result of this, the system of combining cycling and public transport would be better. People would like to use bicycle and public transport to instead of using private car.

2) Copenhagen Transport Plan (1998)
Allowing passengers to carry their bicycles board on commuter trains and Metros is a vital factor in combining cycling and public transport. It can stimulate people to choose bicycle and public transport to instead of private car. Copenhagen Transport Plan (1998) stated that cyclists was valuable for the development of public transport, they are the potential customers to public transport. There were some restrictions to limit bicycle’s board on. However, since today, there are less and less restrictions of carrying bikes on all public transport. Cyclists can carry their bikes on public transport at all hours of the day.

3) Planning Bicycle Parking Facilities
Planning and placing convenient and efficient bicycle parking facilities is helpful for encouraging passengers to use bicycle and public transport and combine them.

In Copenhagen, providing covered, locked bicycle parking facilities at terminals, stations of trains and metro, bus stops and on the new cycle lines are regarded as an important scheme. For example, the relevant objective by Danish State Railways is at the suburban train stations, the bicycle parking spaces should provide lockable facility for 1/4 and coverable facility for 1/2.

The City of Copenhagen, Copenhagen Transport and the Danish State Railways are responsible to plan these parking facilities. They cooperate with each other to plan sufficient parking facilities, and plan some bicycle service shops around these parking places.

3.4 Conclusion
In Copenhagen, public transport is the most significant part of daily transit. The public transport network is composed of bus, metro and train. They are running
well, and cooperated well. It contributes to the various related plans and projects. The Finger Plan also has mobility impact on public transport planning. It shaped the outline of Copenhagen. As a result of it, the public transport routes should be planned and designed in the Finger pattern or along the radical fingers.

More park and ride facilities are proposed. A number of interesting park and ride projects have been identified throughout the region.

Copenhagen is well-known for its bicycle use. The bicycle is seen as a partner, not a competitor in public transport. Combining cycling and public transport is a big progress in creating sustainable transport system in Copenhagen. At the same time, related department of Copenhagen published some plans to improve the capacity of attraction of cycling. As a result, more and more people choose cycling to go to work. The main focus in strengthening the partnership is placed on bicycle parking facilities. By 2005, all train stations have offered locked bike shelters for the safety and comfort of biking passengers. Bike facilities have also been introduced at bus stops in connection with regional bus lines where the average journey distance exceeds 5 km.

Allowing the bicycles to the trains and metros is the most important way to improve the capacity of combining cycling and public transport, and the restriction is less and less.
Chapter 4: Summary of Combing Cycling With Public Transport on Sustainable Development

4.1 Cycling

4.1.1 Cycling benefits on Sustainable Development

<table>
<thead>
<tr>
<th>Sustainable Benefits</th>
<th>Cycling</th>
<th>Car Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Quality</td>
<td>Operating without any air pollution</td>
<td>Emission of Carbon Dioxide, Carbon Monoxide, Sulfur hexafluoride, etc.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- caused global warming through the “greenhouse effect”</td>
</tr>
<tr>
<td>Fuel Saving</td>
<td>Bicycle is a kind of transport mode working without any fuels</td>
<td>Operating needs a large sum of fuel, most of them is non-renewable resources</td>
</tr>
<tr>
<td>Economy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saving Money</td>
<td>Running a bicycle would cost &lt; $300 / year</td>
<td>Running a car would cost &gt; $3000 / year</td>
</tr>
<tr>
<td>Society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health</td>
<td>weight loss, fitness increased, stress reduction and heart benefits and so on by bike</td>
<td>Hard mental Pressure</td>
</tr>
<tr>
<td>Saving time</td>
<td>Cycling can save the time that planned to do exercise</td>
<td>Can’t do anything else when driving a car</td>
</tr>
</tbody>
</table>

4.1.2 More Cyclists on Hard policy Improvement

1) Cycling conditions improvement

“In Copenhagen, Cycling conditions will be improved by building cycle tracks and reinforced cycle lanes along the major roads. Cycle link-ups for through cycle traffic will be established in and around the historical city centre.”
Whenever possible one-way traffic restrictions will be removed for cyclist and bicycle parking will be improved.” --- Niels Jensen, 2002

Meanwhile, improving the quality of the cycling infrastructure, for example, reinforcing the quality and quantity of cycling tracks and lanes and parking areas etc., is to make cycling network working efficient.

The first way to improve the quality and quantity of cycling tracks and lanes is that the related department can draw some plans and projects in accordance with the work of improving and reinforcing, such as: the Cycle Track Priority Plan 2003-2016 in Copenhagen. These related plans and projects can make sure that the reinforced lanes will be built as relatively quick. The other way is concerning cycling traffic in the urban plan. When one city drawing a new city planning, it need plan a few rational space for cycling traffic. According to the Bicycle Account, only just 1/3 of the cyclists are satisfied with bicycle parking areas in Copenhagen. (Niels Jensen, 2002) Improving bicycle parking can make cycling to be more attractive and competitive. Making some plans including bicycle parking in all contexts (at streets of a city, workplaces, shopping malls, homes etc.) and also close to the railway stations and terminals is quite important.

2) Capacity of combining cycling to public transport improvement

The ability to connect with public transport is a crucial factor of why a large number of Copenhageners choose bicycle in Copenhagen. The Copenhagen Transport Public Transport Plan (1998) and the City Plan 2001 have emphasized the combination of cycling and public transport to improve the connection to be more flexible and efficient. As a result, the restriction of allowing bikes on the train would be less and less. Until today, bicycles have been permitted to take on the new Metros in Copenhagen now.

On the other hand, improving bicycle parking facilities is also attaching to the combination of cycling and public transport. Improvement of bicycle parking facilities at terminals, all the new circle line stations, the Metro stations and the railway stations are planned by the City of Copenhagen, Copenhagen Transport, the Danish State Railways. Each authority responses to their own parking spaces, but they still cooperate with each other to provide satisfactory facilities for cyclists in Copenhagen. (Niels Jensen, 2002)

4.1.3 More Cyclists on Soft Policy Improvement

1) Safety improvement: Making people to feel safe is very necessary in
encouraging people to cycle. The department of transport should improve the secure system in a city, such as: security of bicycles and safety of people’s life and so on.

The traditional way to improve cyclist safety is to build cycle tracks. A prerequisite, however, for a positive, overall safety impact is that something is also done about intersections since cycle tracks (and cycle lanes) improve safety on the intervening sections without making intersections less dangerous. It might even be claimed that cycle tracks actually move casualties over to intersections.

In Copenhagen there are two fundamentally different types of cycle track design at signal intersections. One kind goes all the way up to the intersection, the other kind stops at a distance from the intersection. A variant of the shortened cycle track is to road mark a narrow cycle lane all the way up to the intersection. Safety, a sense of security, pass ability and motor vehicle capacity at the three different types of intersection are treated at greater length under Intersections.

Work would be done constantly on finding intersection solutions which are not only safe but also make the cyclist feel secure. (Niels Jensen, 2002)

2) Campaigns and information improvement:

The campaign of “we bike to work” has been done in Copenhagen since 1996. There may be around 15,000 participants in the city for this event. (Santos, Pinaud, etc., 2006) If the government or community can draw more events like this kind of campaigns, there will be more people to join in the group of cycling.

On the other hand, the information which is often published such as cycling map and so on can provide people adequate information about cycling system and campaigns as well as encourage people to use their bicycles.

4.2 Why Public Transport?

According to a report of Public Transportation by American Public Transportation Association, 2006, public transport offers many advantages over the private transport.

4.2.1 Environmental benefits

1) Improves Air Quality
Air pollution is an important negative impact on environment because of motor
cars. This kind of pollution would cause serious public health problems and fog.

However, increasing the use of public transportation would reduce the private car use. It helps to promote air to be clean. For example, if someone travels by bus, the emission of CO would be less around 80% than by a car for each mile.

According to statistics, using public transport can reduce the emission of hydrocarbons for about 126,000,000 pounds and nitrogen oxides for around 156,000,000 pounds. Meanwhile, it is also decreasing the number of public disease.

2) Reduces Energy Consumption
If someone who always travels 60 miles/ day by public transport, there would be about 1900 gallons of gasoline saved for one year. Public transport can reduce the individual consumption of gasoline.

4.2.2 Economic benefits

1) Saves Money
According to statistics by American Automobile Association, the cost of one people driving a car is ranging from $ 5000 to $ 10000 per year. However, the cost of using public transport is ranging from $ 200 to $ 2000 for the same miles annually.

2) Stimulates Economic Development
Every $ 1 invested in public transport, there would generate more dollars for about six times.

4.2.3 Social benefits

1) Public transport consists of varieties of modes: Buses, Trolleys and light rail, Subways, Commuter trains, Trams, Taxis, Ferries and so on.

2) Ensures Safety
American Transportation Association argued that using a bus is safer than travelling by a private car for about 90 times. Public transport is proved to be one of the safest transport ways.

Public transportation provides people transportation options to go to work, go to school or go shopping with adequate safety. 6
4.3 Summary of Cooperation of Transport Modes and Plan

4.3.1 Why combining cycling and public transport?

1) Combining cycling and public transport has many benefits. For example:
   - Improving city air environment
   - Increasing the potential destinations available to cyclists
   - Making sure the cyclist to avoid dangerous traffic situation
   - Offering a sustainable transport tool to private car users to public commuter
   - Increased exercise for better health
   - Reducing traffic congestion
   - Reducing demand for car parking at transport hubs

2) The bicycle is an efficient and effective transport tool over short distances. Integrating cycling with public transport makes long distance without private automobiles to be possible. This combination broadens the capacity of cycling and public transport.

4.3.2 Ways to improve combination of cycling and public transport in urban planning

Improving combination of cycling and public transport can be divided into five chains. They are cycling routes to public transport, facilities at public transport nodes, carrying bikes on public transport, cycling routes to final destination and facilities at the final destination. These chains are operating separately and cooperating with each other. (Image 4-4-2)
1) Cycling routes to public transport:
Cycling routes need to be safe, convenient, connected and attractive. All of these need to be considered and improved in the related urban planning.

This is a key factor in successful combination of bicycles and public transport. When the related department and authorities consider how to establish cycling routes, the following principles should be necessary.
The cycling routes should include convenient and safe road intersections. It should be signed clearly, as direct as possible with well designed terminal facilities and convenient bicycle parking areas, as well as not be congested with other routes.

2) Facilities at public transport joints
When it comes to the public transport, high quality bicycle parking facilities can encourage people to integrate cycling and public transport. In related planning, the secure bicycle parking facilities within or close to the stations should be well designed, and low cost for cyclists. The following factors should be determined. The facilities should provide enough area for bicycles, but not be conflict with motor traffic and pedestrian facilities. The long-term and high quality parking facilities are required at railway stations, Metro and tram stops, and major public transport nodes are required. The bicycle parking facilities
should be visible to public transport staff and cyclists.

3) Carrying bikes on public transport
Cylists often prefer to take their bicycles on public transport than parking them. Allowing bicycles on trains, Metro, buses and major public transport is an important factor to encourage people to cycle in cities. There is a variety of methods which is used to help carrying bicycles on public transport to be more convenient.
- On trains and Metro:
For example, using policies allows bicycles to be carried on trains and Metro, and encourages cyclists to use folding bicycles. To design some bike storage space with modified seats in carriages is also quite important.
- On buses and tram:
For example, designing some folding and removable seats allows cyclists to carry bikes on buses. Setting some dedicated bicycle storage under buses or bike trailers is pulled along by buses.

4) Cycling routes to final destination
Routes can be designed as same as the routes to public transport nodes. Meanwhile, it is necessary to design a lot of direct cycling routes to key and popular destinations such as shopping centres, parks, entertainment facilities, schools, universities and workshops which can encourage the integration of cycling and public transport.

5) Facilities at the final destination
When cycling to the final destinations, cyclists should be provided with necessary facilities. There should provide convenient and secure bike parking facilities and necessary bicycle maintain stores.

4.4 Conclusion

In current urban planning, sustainability is a crucial guideline. Sustainable transport is a major and basic factor in sustainable urban development. Improving cycling, public transport and combination of cycling and public transport are related to the cities sustainable development.

The Greater Copenhagen Region has a long history of strategic planning on aspects of urban spatial and public transport.

An early existed report is from 1947, which is named as “Finger Plan”. It described the conditions for the future surrounding region and the sprawl of Copenhagen. (Egnsplankontoret, 1947) The Copenhagen Region is represented as a hand, with the palm covering the area of Copenhagen city.
while the radial fingers showed the populated areas outside of the Copenhagen city. According to the related plan, there are a lot of clusters of small towns developing along the radical fingers. Each station is located at the centre of a town. The policy of “Proximity- To- Station” location limits the development of these towns. The main roads are built across the green areas to provide better connections to the Copenhagen’s city centre which are planned between each fingers. The radical fingers of Copenhagen have grown in both width and length for seven decades from 1940s. (Greater Copenhagen Authority, 2004)

Peter Hartoft-Nielsen stated that the obvious economic growth of the 1960s and 1970s resulted in a raise of car use. Meanwhile, the traffic problems became more and more serious in the city centre. As a result, there were a number of secondary centres (like: Høje Taastrup) along a part of radical fingers and a number of ring roads between the radical fingers have been proposed by the Copenhagen’s planning authority in 1973. Later, the ‘proximity to station policy’ was been introduced to the 1989 regional plan. This policy permitted that, in the cluster towns, the service and the buildings of industry could be built along the radical fingers where train stations are located within a radius of 1km. This policy decreased the number of the commuters to the Copenhagen’s city centre and relieved the traffic problems in the city centre. (Peter Hartoft- Nielsen, 2002)

Cycling and public transport leads transport in urban area to be more sustainable which is reflected on all aspects of sustainable development. They bring a lot of benefits on environment, economy and society. On environmental aspect, combining cycling and public transport saves fuels and emission. On economic aspect, it helps people saving money and stimulating economic development. On social aspect, it helps to create a better and safer social environment.

Integration of cycling and public transport offers many benefits of convenient door-to-door transport over longer distances that are associated with car use. How to enhance the integration of cycling and public transport is related to various plan closely. In urban and regional structural plan, the planners and related authorities should determine improving combination of cycling and public transport, setting a lot of polices, designing a lot of routes and parking areas in cities. All above methods are related to urban planning, which can encourage people to combine cycling and public transport.

Copenhagen is a typical successful example of integrating transport modes and urban structural plan. This combination helps Copenhagen to achieve the objective of sustainable transport.
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