URBAN AIR QUALITY MANAGEMENT IN ÖSTERSUND

-- FINDING THE SUITABLE PARTS FOR CHINESE CITIES TO LEARN FROM ÖSTERSUND

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Abbreviations

CH₄: Methane
CO: Carbon Monoxide
CO₂: Carbon Dioxide
EEA: European Environment Agency
H₂SO₄: Sulfuric Acid
NO₂: Nitrogen Dioxide
NOx: Nitrogen Oxide
O₃: Ozone
PACs: Polycyclic Aromatic Compound
PAH: Polycyclic Aromatic Hydrocarbon
PM: Particulate Matter
SO₂: Sulfur Dioxide
SOx: Sulfur Oxides
UV: Ultraviolet
VOC: Volatile Organic Compounds
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Abstract

Urban air quality management is a system for governments to lead cities towards achieving good air quality standards in an efficient way. Good air quality can avoid many environmental issues which are regarding air problems. At least, reduce environmental impacts efficiently in some extent.

Carbon monoxide (CO), nitrogen dioxide (NO₂), sulfur dioxide (SO₂), volatile organic compounds (VOC) and particulate matter (PM) are the common elements of air pollution. Topography, weather, the physical and chemical properties of pollutants and emission sources are also accomplices of air pollution.

Östersund was a case study in this thesis because it has satisfactory air quality and won the European Mobility Week Award in 2014.

Weather, winds, transportation and heating systems are the factors that influence urban air quality in Östersund. Green Traffic, Green Energy, and Green Highway are efficient projects in connection with air quality improvement in Östersund. Through successful technical application and institutional management, Östersund became one of the best climate cities in Sweden.

This study is main focus on how Östersund municipality manages the local urban air quality then tries to find the suitable parts for China to learn. Here learn means find the suitable ways to improve urban air quality in China. It doesn’t mean copy all these projects.

Emissions from vehicles, dust and the old style structures of energy are the main factors to reduce urban air quality in China. China did similar projects like Östersund did to improve urban air quality but the results were not so distinct so far. Vast land and large population are significant characteristics in China which make China’s ability slow to solve the air problem. Controlling the dust and emission from vehicles, using renewable resources and clean energy, optimizing industrial structure and complete legislations are beneficial projects to improve urban air quality in China.

The projects of Green Traffic and Green Highway, and public participations are significant parts in Östersund which worth to learn for Chinese cities.

Keywords:
Urban air quality management, Östersund, China, Air quality, Emission
1. Introduction

Clean air is the basic requirement for human health and wellbeing. The epidemiological studies gave evidence that many premature deaths are caused by air pollution in Europe. Although there are many cleaner technologies applied to industries, air pollution is still a healthy risk. (WHO, 2000).

Thus, air quality became one of most important index in daily life. Many countries make clean air as an objective in environmental management. Poor air quality is not only causing environmental issues but also influencing human health (Kampa & Castanas, 2008).

Air problem is a global environmental issue, not only for regional. The serious air pollution is alarming. It brings many influences during the serious air pollution such as the impacts of efficiency, economy, health and environment. It could also break the balance between society and environment. If the pollution stays in a long term, environment will lose its self-repairing capability. Climate change and global warming are all directly and indirectly caused by bad air quality.

1.1 Motivation

The air pollution occurred in China in 2013 is terrible and alarming. People who live in polluted areas are really worried about the local air quality and their health. The primary schools were suspended for several days in many cities during that time (Xinhua, 2013). Many people feel uncomfortable during the air pollution periods, especially for their respiratory system (Gao, et al., 2014).

Poor air quality, air pollution, global warming and climate change are strongly inter-related (Holmes-Gen & Barrett, 2009). Solving air pollution and improving air quality became the problems that demanded a prompt solution in China.

As a Chinese student who studies in environmental science, gaining some useful experiences of urban air quality management is significant. Even though solving air pollution and improving air quality in China will take time but it is still worth it to find a successful example like Östersund to learn and find the suitable parts to improve urban air quality in China.

1.2 Aim

The aim of this study is learning how Östersund manages urban air quality in a successful way and analysis the situations of air problems in China then to finds if these successful factors which applied to Östersund are all suitable applies to the cities in China.
1.3 Scope

The case study will focus on urban air quality management in Östersund. It is not only because of the satisfactory air quality in Östersund but also because of the successful factors such as the project of green traffic in technical factor, and the institutional factors. (Östersund, 2011).

Beijing is the main sample of China to describe in this study because Beijing as the capital city has representativeness in China.

This study is directed towards to the air pollution in China in 2013. So 2013 is the time scope for the part of China. For Östersund, there is no specific time scope but focus on recent years.

1.4 Main Questions

Some relevant questions will be learnt in this study. The following questions have the greatest significance in this study.

How does Östersund manage urban air quality?

What are the most important technical and institutional factors for successful application to urban air quality management in Östersund?

What are the main situations of air issues in China?

What are the most successful parts that Chinese cities could learn from Östersund?

2. Background

2.1 Östersund

Östersund is the only city in Jämtland County located in the middle of Sweden. The population is about 60 000 in 2014. It is the center of culture and economy in the region. Östersund is a commercial city especially for winter sports and outdoor life. The significant characteristic of Östersund is the winter. Although the winter is long and cold here many benefits are from winter, for example, Östersund is one of the cities has cleanest water and freshest air in Europe. (CityÖstersund, 2014).

The coalition of Social Democrats, Green and Center Party govern the Östersund municipality. Östersund was the first city that was environmentally certified in accordance with both ISO 14001 and EMAS (Eco-Management and Audit Scheme) in Sweden. Östersund’s focus is on renewable energy use, district heating and use of
natural gases are the examples. It is one of the most successful municipalities to reduce emissions of carbon dioxide (CO$_2$) in Sweden. (CityÖstersund, 2014).

## 2.2 Air Pollution

Air quality can be affected by air pollution in many ways (EPA, 2014). Air pollution occurs when the air contains amounts of harmful pollutants such as dust, exhaust gases and fumes. The substances which caused air pollution are pollutants. Some pollutants can cause further pollution in the atmosphere (EPAVictoria, 2014). Air pollution can modify natural characteristics of the atmosphere through the chemical, physical or biological characteristics of pollutants (WHO, 2014).

The sources of air pollution are extensive. Factories, power plants and others are considered as stationary sources. Some of the natural phenomena that can also influence air quality are volcanic eruptions, windblown dust and forest fires. Vehicle emissions are considered as the most important sources of air pollution today such as cars, buses, trains and planes. (EPA, 2014).

The common pollutants of air pollution are CO, NO$_2$, SO$_2$, VOC and PM (WHO, 2014).

CO comes from incomplete combustion. Traffic emissions and industrial emissions are the main sources of CO. CO could even come from households. CO increases the ground level ozone if it reacts with other pollutants. CO can cause heart disease and damage the nervous system. (EEA, 2013).

NO$_2$ is a part of NOx. NOx helps to form ozone and particulate matter. NOx mainly comes from fuel combustion such as industrial facilities and road transportation. NO$_2$ has impacts on health, for example, liver, lung, spleen and blood are all affected by NO$_2$. It also affects the respiratory system causing respiratory infection. Acid deposition caused by SO$_2$ and NOx. (EEA, 2013).

SO$_2$ mainly comes from fuel burning, and the electricity generation sector is the most important source. SO$_2$ can reduce lung function and damage the respiratory tract. It affects human health and causes acid deposition at the same time. (EEA, 2013). Acid deposition is another environmental issue needed to be solved. SO$_2$ is not measured any more in Östersund because the percentage of SO$_2$ keeps a constant for many years (Östersund, 2006).

VOC are organic chemicals that are from wide sources. VOC will not described in detail here because they’re numerous and complex. Totally, VOC can damage human health and influence the environment.

Particulate matters include in PM10 and PM2.5. PM10 is particulate matter with a diameter of 10 micrometers. PM2.5 is particulate matter with a diameter of 2.5 micrometers. Particulate matter consists of mixed aerosol particles such as solid and liquid. Most of the particulate matters are from human activities. Both combustion and non-combustion cause particulate matters. Particulate matter affects the central nervous system, cardiac function and causes cancer. Sometimes, particulate matter also affects the climate and precipitation. (EEA, 2013).
2.3 Impacts of Air Pollution

The impacts of the air pollution can be roughly divided into three parts as human health impacts, environmental impacts and economic impacts.

2.3.1 Human Health Impacts

PM2.5 and ground-level O$_3$ are two main elements to influence human health. These two matters can affect the human respiratory and cardiovascular system, especially for the young and elderly (EnvironmentCanada, 2012). The range of the impacts can be from breathing problems to premature death. PM2.5 and ground-level O$_3$ can increase the respiratory mortality rate, cardiovascular mortality and asthma. Also, these two matters can decrease lung function, lung inflammation and change the heart rate variability. (EnvironmentCanada, 2012).

PM2.5 and O$_3$ always have effects on human health because there is no safe level for them. As the concentrations of these two matters increase, the negative health effects are increased for human health. Although the concentrations just have small increases, it will also increase the hospital admissions and premature deaths (EnvironmentCanada, 2012).

2.3.2 Environmental Impacts

Air pollution can cause a lot of environmental impacts including acid rain, haze, eutrophication, ozone depletion, vegetation damage and global climate change (Patrick, et al., 2013).

Acid rain is caused by nitrogen oxide (NOx) and SO$_2$ (EnvironmentCanada, 2012). It can damage vegetation and acidify the environment of soils and water. Acid rain also helps buildings to decay faster. Aquatic organisms and other wildlife are not suitable for the acidic environment so they are more likely to decrease in numbers in an acidic environment as time goes by.

The same, air pollution can affect animals’ life in many ways. If animals live in a poor environment with toxic pollutants in the air or the habitat damaged by acid rain, their health will decrease over time. Toxic air affects animals’ birth defects, disease and reproductive failure, especially for the aquatic ecosystems. (Patrick, et al., 2013).

Besides, air pollution also causes ozone depletion. Ground level ozone can be harmful for humans but the ozone in the stratosphere protects human skin by avoiding the harmful ultraviolet (UV) rays from sun. The thinner ozone in the stratosphere can’t isolate the harmful ultraviolet radiation well which may cause skin cancer, cataracts and impaired immune systems. (Patrick, et al., 2013). The ground-level ozone damages vegetation such as crops, flowers and forests (EnvironmentCanada, 2012). These damages bring stresses to the environment.
Air pollution effects global climate change. Some greenhouse gases like CO₂ and methane (CH₄) increase the average temperature on Earth. Many evidences show that global warming is related to air pollution. Global warming is not only affecting human health but also agriculture, water resources, wildlife etc. (Patrick, et al., 2013).

2.3.3 Economic Impacts

Air pollution affects the economy in both direct and indirect ways. For example, PM2.5 and ground-level O₃ have impacts on human health. These impacts could increase health care costs and decrease work attendance. Thus the worker productivity is going down and makes economic losses. Plants also influenced by air pollution and make economic losses in forestry and agriculture if the effects continue in this way.

2.4 Main Influence Factors of Urban Air Quality

Particulate matter, NOₓ, CO, SO₂ and VOC are the main pollutants to influence air quality and cause air pollution. These pollutants aggravate air pollution under some factors. Even these pollutants play major roles in air pollution but the following factors such as topography, weather, the physical and chemical properties of pollutants, and emission sources are also accomplices of air pollution. However wind, temperature, air turbulence, air pressure, rainfall and cloud cover is all included in the weather factors. (Wanta, 1973).

Generally, increased calm winds in horizontal direction, temperature inversion appears in vertical direction, and the suspended particulate matter increases in city are three factors to influence air quality (Ye, 2012).

Nowadays, city construction develops at high speed. Buildings are taller and taller so that increases the geoclimatic friction coefficient. The wind speed decreases when it goes through this kind of city area. This is calm wind phenomenon. Calm wind goes against air pollutants to spread and dilute so increase the consistence of pollutant in city. Strong wind can’t help this situation because strong wind is not always dispersing the pollutants or transporting the pollutants to a larger area (Ye, 2012).

The pollutants spread from low altitude to high altitude in general. The inversion layer makes high altitude temperature higher than low altitude. This phenomenon makes pollutants stay in low altitude and difficulty to spread to higher altitudes (Ye, 2012). This is another factor that influences air quality. Temperature inversions are very common in mountains and valleys (Wanta, 1973). Temperature inversions occur with calm wind, especially in winter which is why air pollution often occurs in winter (Ye, 2012).

The amount of vehicles is increasing very fast under the industrial development in recent years. The direct results are the fast increases in the pollutant emissions and the amount of suspended particulate matter. The emissions are not only reducing the urban air quality but also decreasing the visibility in the city. Particulate matter is one of the main pollutants from vehicle exhaust. These particulate matters stay in the air which reduces air quality when calm wind or temperature inversion appears.
Emissions are important factors to influence air quality. Vehicle emissions are one of the main emission sources to influence the urban air quality (Ye, 2012).

Since the pollutants have unique attributes, many pollutants will undergo chemical reactions with other pollutants in the air. This is a complex process. In brief, there are two kinds of pollutants — primary pollutants and secondary pollutants. Primary pollutants are pollutants emitted into air directly. (BritishColumbia, 2015). Secondary pollutants are formed in air through the reactions from other pollutants which include primary pollutants. Primary pollutants include CO, oxides of nitrogen (both NOx and NO), sulfur oxides (SOx), VOC and particulate matter. The particulate matter includes dust, ash, salt particles. Secondary pollutants include sulfuric acid (H2SO4), NO2, O3 and particulate matter. (Lew, 2006). For example, ground level O3 is a secondary pollutant that forms from the reaction of primary pollutants (NOx and VOC) (BritishColumbia, 2015). Particulate matters are both primary pollutants and secondary pollutants because they are both emitted directly and formed from other primary pollutants (Lew, 2006).

2.5 Improvement of Air Quality

Regional air quality is influenced by the interaction of topography and weather, and emission sources (Wanta, 1973). The atmosphere is more polluted compared with before. Human activities bring many stresses to the atmosphere. The overloaded atmosphere with pollutants has triggered many air problems (Wanta, 1973). The air pollution in China in 2013 is a warning to everyone. How to improve the air quality became a popular question to solve.

Reducing the emissions is an effective way to improve air quality. Individuals, industries and governments are all part of the solution for this plan. Solving one of the air quality issues can reduce the other relevant problems of air pollution because emission sources and the impacts of air quality problems are interconnected. For example, the particulate matters are mainly from fossil fuel and wood burning, if this kind of combustion would be reduced then particulate matter will be reduced. Reducing combustion could help to reduce both particulate matter and CO2 which come mainly from vehicle exhaust. CO2 is the main factor causing global climate change. So climate change will mitigate because of the combustion reduction.

Improving the air quality is not only work for governments but for industries and individuals. Governments can make some plans for air quality improvement. For instance, Sweden has 16 environmental goals to achieve, clean air is one of them; the Swedish government encourages citizens to use clean energy and renewable resources. Industries should pay attention to their corporate social responsibility to reduce emissions such as follow the standard of emission; reduce emissions by introducing better technologies and practices. Individuals should be aware of the need to improve air quality and do something good for air quality such as using public transportation and saving energy.

There are many benefits that come from solving air pollution and improving air quality such as improved human health, reduced health costs and better environment. Vice versa, these changes could result in healthier environment and sustainable economy (BritishColumbia, 2015).
3. Method

This study aims to find the suitable parts to improve urban air quality in Chinese cities according to learn how urban air quality management works in Östersund municipality.

Read relevant literatures, learnt relevant documents on the webpage of Östersund Kommun, searched online resources, and written E-mail with interview questions to relevant persons who in charge of urban air quality management in Östersund are used during the study. Unfortunately, there is no reply for the E-mails until the report hand in. The interview questions could find in appendix.

Some relevant knowledge about air pollution is needed in background such as the main pollutants and impacts. The basic knowledge of this part is from the scientific literatures and online resources. This is a prepare section of this thesis.

The results part is the important part of this study. This part is including a case study of Östersund, analysis the situations of air issue in China, and find the usable parts for China to learn from Östersund.

The results of case study of Östersund main come from the online resources. Many documents from the homepage of Östersund Kommun were learnt. This process takes much time compare with other parts in this study because some documents are published in Swedish. Translation and understanding takes time.

The part of situations in China main comes from summary and comparison. This part is summarizing the most important factors which caused air pollution in 2013 through compare with the reports reading. The found solutions are directed towards to the main causes.

The suitable parts which could apply to Chinese cities were found according to compare with Östersund and Chinese cities based on the results above. It is the main outcome of this study. This comparison is giving results that the worth parts should Chinese cities learn from Östersund. If these parts could improve soon, it will give great help to improve urban air quality in China.

A hypothetical question about what urban air quality would be if Östersund has the same situations as Beijing is discussing in the discussion part. This discussion aims to show the significance of prevention work.
4. Results

4.1 Case study on Östersund

The case study is focus on Östersund. The main studies are including the local air problems, influence factors of air quality, solutions and successful factors in Östersund.

4.1.1 Local Air Problems in Östersund

Emissions from road transportation are local environmental problem regarding air quality in Östersund (SMHI, 2014). Particles and exhaust emissions are the main producers of air pollution. NOx, VOC, O₃, CO, PM 10, PM2.5 and CO₂ are the pollutants from vehicles. These pollutants effect on both environment and human health.

A report from European Environment Agency (EEA) shows NO₂ influence urban air quality in Östersund and PM10 is a potential threat for urban air quality in Östersund. The data comes out from capture of at least 75% per calendar year (EEA, 2013). Other pollutants such as CO₂, CO, SO₂ and VOC are also affecting air quality in Östersund (Östersund, 2006).

Excepted CO₂, the impacts of NO₂, PM10, CO, SO₂ and VOC are described in background. CO₂ is naturally present in the atmosphere but human activities make CO₂ increase in atmosphere. CO₂ is a greenhouse gas that is leading global warming and climate change. The emission of CO₂ comes from many different sources such as transportation and industries. The main emission of CO₂ is from the fossil fuels. (EPA, 2015). High CO₂ concentration directly effects plant growth (Taub, 2010).

![Figure 1. The Concentrations of NO₂ and Anticipated Value (Månsson, 2014)](image-url)
Östersund municipality are monitor PM10, NO$_2$, SO$_2$, VOC and polycyclic aromatic hydrocarbon (PAH) to make sure these elements are stay in a safe level (Östersund, 2011). The levels of PM10 have never exceeded the relevant environmental quality standards in annual averages (Månsson, 2014). NO$_2$ is a problem from 2005 to 2011 because the concentrations of NO$_2$ are higher than anticipated value during that time. See Figure 1. The line in Figure 1 shows the anticipated value of NO$_2$. Although the values of NO$_2$ are not 100% perfect but there is no air pollution or other air issues in Östersund from 2005 to 2011 (Månsson, 2014).

### 4.1.2 Important Influence Factors in Östersund

The important factors could influence urban air quality in Östersund include weather, winds, transportation and sometimes because of the heating system in winter (Östersund, 2006).

#### Weather

Geographic location and climate are main factors influencing air quality in Östersund (Östersund, 2006). Östersund is named the winter city because of its special location and the arresting snowfall in winter. In most cases, the temperature is below zero and snow is common in winter. These two factors make the roads very slippery. Sands are usually used for road wear particles in order to anti-skid in winter. About 80-90% of the particulate matters are from road wear particles in the winter (SMHI, 2014).

Cold weather in winter makes increased demands of heating. Many pollutants will exhaust into air and influence air quality in urban area.

#### Winds

Cold weather and mild winds increase the percentage of pollutants in air. These pollutants are from transportation which includes NO$_2$, benzene and small particles. Air quality decreases in highly trafficked streets when these pollutants meet the mild winds in cold weather. If this situation keeps for a longer time, the air quality will go down, even causing air pollution. (Östersund, 2006).

#### Transportation

Air pollutants come from different sources. Emissions from road traffic are a significant source of air pollution in Östersund. Particles and emissions are the pollutants from road transportation. The emissions are not only the exhaust emissions from vehicles but also the emissions from non-exhaust gases. Emissions from non-exhaust gases means the emissions are not from the exhaust gases like emissions from road wear particles. (SMHI, 2014).

#### Heating

Heating could be a factor to influence urban air quality in Östersund because residents are burning wood sometimes. High-emitting wood stoves are not good for urban air quality. General pollutants from heating are CO, NO$_2$, SO$_2$ and particulates (SMHI, 2014). These pollutants are all play significant roles in air pollution (Hawks & Hansen, 2002).
4.1.3 Reactions and Solutions in Östersund

Specific environmental objectives are the most important ways to improve environmental quality. Östersund has certain objectives to reduce the emission of air pollutants. For example, CO₂ emissions are one of the objectives to reduce. In 2004, Östersund had a goal to reduce CO₂ emissions by 15% in 2010 compared with 1998. Östersund has already achieved the goal to reduce fossil CO₂ emissions by 15% from 1998 to 2005; actually the emissions were reduced by 21.7% during that period. Based on this experience, Östersund had extended the goal to 2010 from 2004. The objective has been achieved in 2010 with a satisfactory result. (Östersund, 2006). Now Östersund has the goal to reduce emission of greenhouse gases by 60% between 1990 and 2020 (Östersund, 2011). So making a suitable goal to achieve is one of the ways to improve air quality step by step. Östersund municipality follows Swedish Government to start a long term effort to achieve zero net emissions of greenhouse gases in 2050. Some activities are run for this objective such as modernizing energy and transport systems, reducing the energy use and emissions, and increasing the use of renewable energy (SI, 2014). An important step in this long term effort is year 2030. Swedish Government plans to achieve fossil fuel free transport in 2030.

Reducing the emissions from road transportation is the main solution for air quality improvement in Östersund. Östersund is running many successful projects to reduce the emission from transportation such as Green Energy, Green Highway and Green Traffic. These three projects will describe in detail later in the technical factor section. Some examples are giving as follows.

Green Traffic is a significant proposal to help reduce emissions and improve air quality in Östersund. The aim of Green Traffic is achieving the sustainable transportation. Green Traffic works in different ways include in commuter parking, transportation coordination, transportation counseling, carpools, and encourage people to cycle more. (Östersund, 2006). Östersund municipality improves many infrastructures to coordinate with the Green Traffic project. For example, they added more new parking place for bicycle, built up quick charger stations for electric cars. Renewable energy and energy efficient production is another proposal to help improve air quality in Östersund (Östersund, 2011).

At Göviken sewage plant, biogas and vehicle fuel are produced by the waste. Biogas is used for produce electricity and heat in Östersund. The vehicle fuel is produced by sludge. CO₂ emissions from buses have been reduced by 75% since the biofuel used in buses. Some food wastes are also converted to vehicle fuel. (Östersund, 2011).

Biofuels are the main resources of district heating systems for both combined heat and power plants. Accumulator tanks were installed to reduce emissions. At the same time, installed accumulator tanks deliver reliability and increase the production. (Östersund, 2011).

Reducing emissions of SO₂, NOx, and VOC are important works to do for air quality improvement. The relevant policies regarding energy and economy are useful for emissions reduction. The taxation and license conditions of emissions are very helpful to limit exhaust gases emission. (Östersund, 2011).
All the measures are very successful for helping to reduce emission in Östersund. Based on these works and good air quality, Östersund has other projects to improve air quality. For example, the promotion of work to control emissions from non-road transportation, more strict requirements for traffic emissions, further strategies and economic instruments, improvements on energy efficiency and usage of renewable energy sources.

Many policies encouraged to reduce energy consumption in Östersund. Östersund is not only working hard now but making plans for further. (Östersund, 2011).

Östersund improved its urban air quality step by step according to the certain environmental goals and some successful projects. Östersund has satisfactory air quality but all the relevant works make air quality here even better.

4.1.4 Successful Technical Factors for Urban Air Quality Management in Östersund

Satisfactory air quality in Östersund is thanks to the emissions reduced in a successful way. The most important technical factors are all about emission reduction and low energy consumption. Green Traffic, Green Highway and Green Energy are the main sections of projects related to reduce emissions in Östersund (Östersund, 2011). Exhaust gas emissions are the main source to influence urban air quality in Östersund, so finding the technologies to solve emission problems are the key solutions to improve air quality in Östersund.

Green Traffic

Östersund is converting traffic and transportation to renewable fuels because traffic and transportation are the main sources of emission in Östersund. There are many hypostatic activities and projects running in the Green Traffic section. This project encourages buying eco cars and using renewable fuels. Östersund is promoting the use of biofuel vehicles and was ranked the fourth best in Sweden by Green Drivers (Gröna Bilister) in 2010. (Östersund, 2011).

Östersund encourages reducing emissions. Electric cars are one of the good projects to reduce exhaust gas emissions. Östersund municipality and Jämtkraft are running the electric car projects in Östersund. Jämtkraft is building up some local infrastructures to help run the projects. For example, they installed the CHAdeMO quick-charger in Östersund. This is the first CHAdeMO quick–charger in northern Europe (Östersund, 2011). This quick charger makes the trip more convenient.

Göviken sewage plant could produce biogas by the wastes. Östersund also has biogas filling stations so promotion of the use of biogas seems not so hard because of these preconditions. There are around 260 biogas vehicles in Östersund and Östersund municipality has 83 of 260 (Östersund, 2011). In 2011, there were 30 buses using renewable fuels ethanol and biogas in Östersund.

Bicycling is an important project that was encouraged in the Green Traffic sector. Many different projects are promoting cycling. In order to encourage bicycle using,
Östersund municipality improved many facilities such as building the cycle tracks, providing the cycling maps and signposting, and making sure the roads for bicycles are free of snow in winter (Östersund, 2011).

**Green Highway**

Green Highway is a project about driving fossil free from the Gulf of Bothnia to the Norwegian Sea. This project aims to build a transport corridor that is fossil fuel free. Östersund municipality is doing this project through using efficient fuel for vehicles and traveling with smart technologies. It includes using electric cars and renewable fuel cars. Östersund is good at producing vehicle fuel and electricity with minimal environmental impacts because Östersund could produce biogas, wind power and hydropower by itself. In order to make sure this project runs well, there are many charging stations along the Green Highway to facilitate electric cars. The same, there are many filling stations for both biogas and ethanol along the Green Highway between Sweden and Norway. (Östersund, 2011).

![Charging Stations and Biofuel Filling Stations Along the Green Highway](image)

*Figure 2. Charging Stations and Biofuel Filling Stations Along the Green Highway (Östersund, 2011)*

Figure 2 shows some charging stations and biofuel filling stations along the Green Highway. The symbols shown in the figure are Biogas pump, E85 (Ethanol), Charging station for electric car and RME (biodiesel).

**Green Energy**

Encouraging the use of renewable and clean energy, reductions in energy consumptions and production of these energies in efficient ways are encouraged in the Green Energy part.
The local power production is 100% green and sustainable which includes 76% energy from hydropower, 16% energy by bio-energy and 8% wind power. Hydropower plays an important role in providing a strong grid of electricity in Östersund. Östersund municipality takes some environmental issues as their own responsibility to achieve a sustainable society. Minimizing the use of fossil fuels is one of the measures in the Green Energy part. (Östersund, 2014).

Sometimes heating could be a factor to influence air quality in Östersund. This paragraph is mainly directed towards heating systems in Östersund. Different types of fuel use have different impacts. The heating system used in Östersund is provided by district heating and renewable electricity. Renewable fuel is the main resource to provide energy for the district heating system in Östersund. There was a 90% renewable fuel used in 2010. The renewable fuel is used for providing both hot water to the heating system and electricity for resident in Östersund. (Östersund, 2011).

Östersund has been working with energy consumption proactively over recent years. The results are distinct. It profits from reduced energy consumption. Limiting the usage of oil and electricity to heating makes the energy consumption reduced by 15% square meter between 2004 and 2010. Municipal and public buildings are also following the legislations regarding the reduction in energy consumption in Östersund. (Östersund, 2011).

Östersund municipality is following the new energy management standard ISO 16001 that makes Östersund not only have energy goals but also improve the energy saving at the same time (Östersund, 2011).

### 4.1.5 Most Important Institutional Factors for Urban Air Quality Management in Östersund

Successful institutional factors are one of the reasons that Östersund has good air quality. A certain objective of clean air is the precondition for approaching the goal. A good management system and good citizens’ awareness are the main conditions why municipality Östersund is doing air quality management so successful today.

At the national level, legislation plays an important role in Swedish environmental effort. This kind of legislation aims to promote sustainable development in Sweden and provide a healthy environment for future generations (SI, 2014).

At the municipality level, municipality plays the role to control and make decisions. Östersund municipality set its own city’s goals and makes the overall organization include in air quality management. For example, Östersund municipality set their goals for sustainable development. They are describing the municipality’s environmental work and status in the environmental report each year. In order to work effectively with environmental issues, Östersund municipality has implemented the environmental management system according to ISO 14001 and is registered under Eco-Management and Audit Scheme (EMAS) at the same time (Östersund, 2012).

There are many different conferences regard different issues. All the decisions are from discussion in the City Council meetings. These meetings are open for everyone.
Citizens could just go to the meeting and listen to it if anyone was interested in it. Citizens can describe their questions, comments and suggestions at the public question times. Sometimes, residents can influence the decisions which are decided by municipality here in Östersund. The public participation is an important part to consist of final decision making in Östersund municipality. (Östersund, 2012).

Open meetings are advertised in local newspapers to let citizens know. Public consultation usually works with issues that could directly affect citizens. The public consultation mainly works for the specific issue. Everyone can read the official documents on the internet and the city council webcasts, except the sensitive and confidential personal data (Östersund, 2012). Citizens could also submit their suggestions and comments to the municipality via the homepage of Östersund.

4.2 Situations in China

This section mainly talks about the situation of air problems in 2013. The situations in Beijing will be an example to describe in this part. Only the sources of air pollution and the current solutions in Beijing are describing in this part.

Emission from vehicles, exhausts from coal combustions and industries, and dust are three main principals that caused air pollution in 2013 (Sun & Huang, 2014).

The following parts are describing the solutions which help to improve urban air quality in Beijing.

Control the Emission from Vehicles

Vehicle emissions were the main source of PM2.5. One fourth air pollutions come from vehicles in Beijing because there are many old cars which emitted more exhaust are still going into service (Wang, 2013). Elimination of the old cars is one way to control the pollutant emission of vehicles. The vehicle emissions management center gives examination to cars on road to check if old cars emitted higher exhausts. The test results show the exhausts from old cares are much higher. Another way to reduce emissions is by bus and bicycle as trip mode instead of cars.

Clean Energy

Clean energy is advocated to use in many different fields nowadays. Encouraging the use of clean energy aims to control pollution from coal burning and improves air quality. Especially in winter, coal is the main structure of energy consumption to provide heating to uptown in China (Wang, 2013). The solution is adjusting the structure of energy. For example, using wind energy, biomass energy, solar energy and natural gas to instead of coal. The clean energies are promoted to use stepwise in China. Now, China has the main work to develop the clean energies such as hydropower and wind power.

Optimize Industrial Structure

Many exhausts emitted from factories are over standards. Moving those factories which have pollutant discharges out of city helps to reduce air pollution and improve urban air quality (Sun & Huang, 2014). At the same time, encouraging factories use
clean energy to reduce pollutants emissions. For example, use electric instead of coal combustion is one way to ease off the air pollution problem. Many wind mill generators were established to provide wind power electricity and then to reduce the exhaust of coal combustion and improve the air quality.

**Enhance Control in Dust**

Dust mainly comes from construction dregs especially during the transport process. It is one reason causing air pollution in 2013. There are two suggestions to reduce dust. One way is using clean equipment to wash the car before it drives on the road. Another way is give mantle to the stuff which will transport. Making mantle is the easy and cheapest way to reduce dust. Mantle materials can cyclic utilization. The purpose of installed cleaning equipment is to reduce the dust on the road. Washing tires and chassis before the car goes is an effective way to reduce dust. At the construction field, covering the dust source and working in close type is the way to reduce dust. And stop working when the wind speeds higher than fresh breeze. Road sweeping and watering could reduce the dust.

**Legislation**

There are many relevant environmental standards and legislations in China directed towards air quality improvement such as the limitation of car use and emergency preplans. There is a time limit for cars driving in Beijing. The plates decide if the car can drive or not. Odd and even number on the car plate will decide if the car can drive on a precise day. This legislation aims to reduce private car use and emissions then encourage people using public transports. Making emergency plans are directed towards to those factories which discharge exhaust. These factories have to reduce exhaust following the legislation by them even stand-down when air pollution occurs.

**4.3 Comparisons**

This comparison is between Östersund and Chinese cities. It doesn’t mean those successful projects working in Östersund are 100% suitable to use in the cities of China.

Green Traffic gives great help to improve urban air quality in Östersund. Actually, the similar project is already running on the way with many ancillary sub-projects in China. For example, many cities are using clean energy to run the buses, and electric cars are promoting to customers step by step. The demands of cars are increasing fast with high speed economic development in China, which brings advantage to the green cars industry. It is also an opportunity to implement the green transportation. Some preferential policies regarding green car drive need to make and unveil in order to encourage people to use green cars.

Green Highway is worth to encourage in China. Many low-carbon highways are constructing in process and some are already in service in China (Zhuang, 2013). Compared with the Green Highway from Sundsvall to Trondheim, Chinese low-carbon highway is not so complete because it started later. Vast land of China makes this project take time but this project is already on the way.
Green Energy is working in China. China focuses on renewable energy development and invested in it more than other countries. China spent a total of $56.3 billion on wind, solar and other renewable projects in 2013 (Perkowski, 2014). It is a success for renewable energy development and gives help to reduce the emissions but the result of air quality is not so remarkable. Air quality improvement takes time even in the country with such a large population.

Environmental goals and environmental legislations are all working well in China. There are different goals for different environmental issues. Many different legislation, standards and environmental laws are directed towards specific environmental problems. A question might be asked, why the air pollution appeared if everything was going well? Even everything is in process but significant characteristic in China--the vast land and large population makes everything takes longer time to complete compare with other countries.

Public participation is not so perfect in China. This is a problem needed to improve. The deputy to the national people’s congress have right to take part in some meetings and make some decisions but it is not so perfect. Some deputies don't have relevant knowledge regarding specific environmental issues so sometimes their suggestions are not so rounded. Citizens can send their suggestions, questions and comments to the relevant authority. Some people specifically work for these messages.

### 4.4 Worth Parts to Improve in China

The described parts above in section 4.3 are the successful projects in Östersund which Chinese cities could learn. Although China running the similar projects but Green Traffic, Green Highway and public participation need to be improved more in China.

For the Green Traffic project, China encourages to buying eco cars and eliminating the old cars. The government should offer some preferential policies to encourage people buying eco cars. For example, giving a discount to those people who buying eco cars, giving the old for new service to recycle the old and high emitted cars. It is not easy to implement something if only encourage in oral. Some practical policies are needed for promoting the eco cars use and eliminating old cars. This project is not only needed to promote to public transportation but necessary to private users because the private users are the majority users. Also, the infrastructures of eco cars have to build and improve, such as the charging stations and filling stations. If people would like to using eco car but there is no relevant infrastructures that is possible for customer to give up buying it because it is inconvenience for using. The same as renewable fuels use, China encourages using renewable fuels but if the filling stations are not enough then it is hard to carry out.

The project of Green Highway will takes time to implement in China because there are no completed infrastructures in China and the amount of eco cars are few in China. This is just a provisional problem because China already starts to build some low-carbon highways. This project is based on the Green Traffic, if the Green Traffic is improved then the Green Highway will achieve in China. Green Highway project is necessary to complete in China. The aim should be really green. Low-carbon is not enough for air quality improvement in China.
Public participation needs to improve in China. The huge population makes this section hard but the local government should offer some opportunities to those people who interested in the relevant issues. Open meetings, public questions time, public suggestions and comments are all need to learn from Östersund. Public participation works well in Östersund and it is worth to learn.

5. Discussion

5.1 What Urban Air Quality Would Be If Östersund Has Same Situations as Beijing?

The successful urban air quality management makes sure air quality stay in a satisfactory level but different situations have significant effects on urban air quality. The air quality in Östersund was better than Beijing in 2013. It could say the management system of urban air quality is successful in Östersund. Compared with Östersund, the situations in Beijing are more complex. The amount of vehicles and populations are much more, mixed industrial structures and multiple industries are the characteristics of Beijing. However, the comparison is not so equivalence for subjective opinion because of the different situations in these two cities but Beijing as the capital city has representativeness in China.

Here the situations only talk about the population and amount of vehicles. There are about 60 000 population in Östersund in 2014. The population in Beijing is about 21.52 million in 2014 (Zheng & Cao, 2015). The conservative estimate is that there are 5 million vehicles in Beijing in 2012 (Mu, 2012). The data show these two cities are not at the same level of urban size.

It is just a hypothetical question to discussing if urban air quality still satisfactory when Östersund has the same population and amount of vehicles as Beijing? The answer will be negative for personal opinion. Vehicles emission is the main pollutants to influence urban air quality, if Östersund has 5 million cars the air quality will affected. At that time, the air quality will not so satisfactory like now but it might still be acceptable. There are four reasons why air quality might be acceptable.

Östersund has a satisfactory air quality now. It is a good basic condition for air quality. Comparing with control the polluted air, the prevention work is easier because it is preparedly. The plans and environmental goals are necessary for solving this hypothetical problem. Sweden has the high standards environmental goal to achieve that is why this hypothetical problem will not be worried.

Östersund has many successful projects to achieve sustainable energy use in urban area. Those projects are all efficiency to reduce the emissions. Emissions reduction helps to improve air quality. Östersund is energetically to make the urban air quality
even better. For example, Östersund is promoting the clean energy use and increasing the efficiency of clean energy use.

People have awareness to use sustainable energy and eco cars here. People’s awareness is important for environmental protection. Many people are driving eco cars in Östersund that help to reduce emission from cars.

Östersund municipality has ambitious to manage urban air quality better. Östersund had won the European Mobility Week Award and Green Drivers in Sweden are the best examples to prove the municipality care about the air quality in Östersund.

This hypothetical question is hard to predict and impossible to give a certain answer now. In personally opinion, if Östersund has the same situations as Beijing, the urban air quality might still be acceptable because of the reasons described above.

6. Conclusion

Clean air is the basic requirement for human health. Air pollution is an environmental risk with impacts on human health, environment and economy. Vehicle emissions are considered as the most important sources of air pollution. Urban air quality management is an efficient way to improve air quality.

Östersund municipality is working well on urban air quality management. Green Traffic, Green Highway and Green Energy are the main projects to working with clean air in Östersund. Emissions from Vehicles are the main problem influencing urban air quality in Östersund. Reduction of emissions and energy consumptions, increasing the usage of renewable and clean energies, changing people’s behaviors are the ways to keep air quality at satisfactory level.

China has similar projects to improve urban air quality like Östersund did, but the result of air quality is not so obvious so far. The vast land and large population makes China take longer time to solve the problems but China is on the way. Controlling the dust and emissions from vehicles, using clean energy, optimizing industrial structure and completing legislations are the beneficial projects to improve urban air quality in China.

The projects of Green Traffic and Green Highway, and public participations are the parts that Chinese cities need to improve and worth to learn from Östersund.
7. References


Figure 1. The Concentrations of NO2 and Anticipated Value. Månsson, A., 2014. *Luftmiljö i Östersund stad*, Östersund: Östersund Kommun.

8. Appendix

8.1 Interview Questions for Östersund Municipality

- Has Östersund had air pollution problems? How serious?
- How was this pollution solved? How long did this process take?
- How did Östersund improve the air quality step by step?
- What are the main pollutants influencing urban air quality in Östersund?
- What are the most important factors influencing urban air quality in Östersund?
- Are there any problems of air quality in Östersund now?
- What are the plans for solving these problems?
- How does the urban air quality management system work in Östersund?
- Are there any models of air quality management to reference in Östersund?
- What are the most important technical factors for successful application to urban air quality management in Östersund?
- What are the most important institutional factors for successful application to urban air quality management in Östersund?
- Are there any predictable problems regarding air quality in Östersund?
- What are the plans for solving the predictable problems?